High Level Policy Dialogue on Investment in Agricultural Research for Sustainable Development in Asia and the Pacific

Bangkok, Thailand; 8-9 December 2015

Papers Presented




Organizers

Asia-Pacific Association of Agricultural Research Institutions (APAARI)
Australian Centre for International Agricultural Research (ACIAR)
Department of Agriculture (DOA), Thailand
Food and Agriculture Organization of the United Nations - Regional Office for Asia and the Pacific (FAO RAP)
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Editors

J.L. Karihaloo, Bhag Mal and Raghunath Ghodake

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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: www.apaari.org

Australian Centre for International Agricultural Research (ACIAR)

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

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The Department of Agriculture (DOA), Government of Thailand, has the vision to be the Center of Excellence in the field of crops research and development (R&D) and farm mechanisation, in harmony with international standards and in adherence to the principles of natural resource conservation and environmental protection. DOA has the mandate to: i) conduct research and development studies concerning crops and farm mechanisation; ii) provide services on the analysis, inspection, quality certification and advice on soil, water, fertiliser, crops, agricultural inputs, production and products quality, export promotion and other areas of concerns; iii) enforce the six Regulatory Acts on plant quarantine, plant variety protection, fertiliser, plant variety, rubber regulation, and toxic substances; iv) transfer agricultural technologies to extension agents, farmer leaders and the private sector; and v) implement urgent programmes related to crop productivity. For details, please visit: www. doa.go.th

Food and Agriculture Organization of the United Nations - Regional Office for Asia and the Pacific (FAO RAP)

The Food and Agriculture Organization of the United Nations (FAO) is an intergovernmental organization located in Rome, with 191 member nations and presence in over 130 countries. FAO focuses on four main areas, namely: i) putting information within reach, ii) sharing policy expertise, iii) providing a

meeting place for nations, and iv) bringing knowledge to the field. FAO serves as a knowledge network and utilises the expertise of agronomists, foresters, fisheries and livestock specialists, nutritionists, social scientists, economists, statisticians and other professionals, to collect, analyse and disseminate data that aid development. FAO publishes hundreds of newsletters, reports and books, distributes several magazines, creates numerous CD-ROMS and hosts dozens of electronic fora. FAO lends its years of experience to member countries in devising agricultural policy, supporting planning, drafting effective legislation and creating national strategies to achieve rural development and hunger alleviation goals. FAO mobilises and manages millions of dollars provided by industrialized countries, development banks and other sources to make sure the projects achieve their goals. As FAO is primarily a knowledge-based organization, investing in human resources is a top priority. Capacity building including a leadership programme, employee rotation and a new junior professional programme has been established. Individual performance management, an ethics officer and an independent office of evaluation are designed to improve performance through learning and strengthened oversight. For details, please visit: www.fao.org

Global Forum on Agricultural Research (GFAR)

The Global Forum on Agricultural Research (GFAR) is a multi stakeholder-led initiative that serves as a neutral forum for dialogue and action on strategic issues in agricultural research for development (ARD). It facilitates and promotes cost-effective partnerships and strategic alliances among ARD stakeholders in their efforts to alleviate poverty, increase food security and promote the sustainable use of natural resources. GFAR is comprised of the following groups of stakeholders: the national agricultural research systems from the south (Southern NARS), national agricultural research systems from the north (Northern NARS), the Consultative Group on International Agricultural Research Centers (CGIAR), non-CGIAR international agricultural research centres, farmers' organizations (FOs), non-governmental organizations (NGOs), the private sector, donors and development agencies. To find out more about GFAR, please visit the website: http://www.egfar.org/egfar/

International Food Policy Research Institute (IFPRI)

The International Food Policy Research Institute (IFPRI) is one of the 15 Centers supported by CGIAR, an alliance of 64 governments, private foundations, and international and regional organizations. IFPRI's vision to have the world free of hunger and malnutrition is based on human rights to adequate food and freedom from hunger, and the recognition of the dignity inherent in all human beings. IFPRI has a mission to provide research-based policy solutions that sustainably reduce poverty and end hunger and malnutrition. It flows from the CGIAR mission: "To achieve sustainable food security and reduce poverty in developing countries through scientific research and research-related activities in the fields of agriculture, livestock, forestry, fisheries, policy, and natural resources management." The two key premises that underlie IFPRI's mission are: i) sound and appropriate local, national, and international public policies are essential to achieving sustainable food security and nutritional improvement, and ii) research and the dissemination of its results are critical inputs into the process of raising the quality of food policy debate and formulating sound and appropriate policies. IFPRI prioritises activities that benefit the largest number of poor people in greatest need in the developing world. In carrying out its activities, IFPRI seeks to focus on vulnerable groups, as influenced by class, religion, ethnicity, agroecological location, and gender. Given the large body of national and international food policy research, IFPRI's added-value derives from its own cutting-edge research linked with academic excellence in other institutions, such as other CGIAR centres, universities, other research institutes, and from its application of this knowledge to national and international food policy problems. For details, please visit: www.ifpri.org

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Foreword

The Asia-Pacific region comprises 44 countries of Asia and the Pacific region, most of which fall in the category of developing economies. The population of this region had reached 4.8 billion, comprising 64 per cent of the world's total. Nearly half of its people are directly or indirectly engaged in agriculture and the region as a whole contributes significantly to world agricultural production. While several countries of the region have achieved modest to high economic growth, many still continue to face the problem of poverty and food and nutrition insecurity. The world's largest number of undernourished people (511 million) live in Asia while China and Japan figure among the world's top five importers of agricultural commodities. Thus, there is an obvious need for increasing agricultural output while reducing the cost and environmental impact of production. Agricultural research and innovations are largely underinvested in the region. Hence, there is an urgent need to increase and improve investment as well as its efficient utilization by national and international agricultural research and innovation systems.

In its continuing efforts towards creating consensus on investment related issues impacting agricultural development, food security and farmers' wellbeing in this region, APAARI in collaboration with the Australian Centre for International Agricultural Research (ACIAR), Department of Agriculture (DOA), Thailand, Food and Agricultural Organization of the United Nations – Regional Office for Asia and the Pacific (FAO RAP), Global Forum on Agricultural Research (GFAR) and International Food Policy Research Institute (IFPRI), organized the "High Level Policy Dialogue on Investment in Agricultural Research for Sustainable Development in Asia and the Pacific" at Bangkok on 8-9 December 2015. The objective of the Policy Dialogue was to discuss the direction, needs and mechanisms to enhance investment in agricultural research and innovations. The immediate purpose was to catalyse policy/decision makers, re-sensitize NARS, and create an environment for increased resource allocation and congenial policy environment for agricultural research and innovation. The in-depth deliberations held during this Dialogue resulted in useful recommendations and the way forward relating to financial, infrastructure, capacity development and policy aspects that could contribute to improving the region's agriculture and agri-food systems and contributing to the realization of the Sustainable Development Goals (SDGs).

This publication comprising 24 full papers/abstracts presented at the Policy Dialogue is the Volume II that follows the publication of the Dialogue proceedings and recommendations in Volume I. The papers/abstracts are arranged under five thematic areas: i) Status and Outlook for Investment in Agricultural Research and Innovation; ii) Scoping Investments in Agricultural Research and Innovation - Addressing Current and Emerging Challenges; iii) Scoping Investments in Agricultural Research and Innovation - Climate Smart and Sustainable Agriculture, Knowledge Management for Sustainable Agriculture, Capacity Development for Sustainable Agriculture; iv) Impact Expectations from Investment in Agricultural Research and Innovation; and v) Innovative Funding Mechanisms. The papers include in-depth analyses of the status of investment in agricultural research and innovation by countries in the Asia-Pacific region and also highlight the challenges and opportunities for addressing issues of agricultural productivity and sustainability through wider stakeholder involvement.

The commendable cooperation of co-organizers - ACIAR, DOA Thailand, FAO-RAP, GFAR and IFPRI; and sponsors, Syngenta, and Agricultural Technology Research Institute (ATRI), Chinese Taipei is highly appreciated. On behalf of the Dialogue Organizing Committee, I am also pleased to put on record our gratitude to the chairs/co-chairs, moderators, speakers, discussants and rapporteurs for their

immense contributions. Thanks are due to all the participants and their respective organizations for their participation in the Dialogue. Special thanks are also due to all authors for contributing the papers to this publication. I also express my sincere thanks to the editors, Dr. J.L. Karihaloo and Dr. Bhag Mal for their excellent efforts in compiling, editing and composing the publication. The hard work put in by the secretarial staff of APAARI in organizing the Policy Dialogue and documenting its outputs is much appreciated. We hope that the publication will be immensely useful to the national, sub-regional and regional planners, implementing agencies and scholars engaged in improving the amount and efficiency of agricultural research investment for development in the Asia-Pacific region.

Raghunath Ghodake
Chairman, Dialogue Organizing Committee and
Executive Secretary, APAARI

Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AEC	ASEAN Economic Community
AERE4D	Agricultural Education, Research and Extension for Development
AESA	Agricultural Extension in South Asia
AEW	Agricultural Extension Workers
AFMA	Agriculture and Fisheries Modernization Act
AgGDP	Agricultural Gross Domestic Product
AHRD	Agricultural Human Resources Development
AICRP	All India Coordinated Research Project
AIS	Agricultural Innovation Systems
AKAP	Awareness, Knowledge, Adoption and Practice
AMFRD	Agency for Marine and Fisheries Research and Development,
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APIRAS	Asia-Pacific Islands Rural Advisory Services
AR4D	Agricultural Research for Development
ARI4D	Agricultural Research and Innovation for Development
ARS	Agricultural Research Service
ASEAN	Association of Southeast Asian Nations
ASF	Animal-Sourced Food
ASTI	Agricultural Science and Technology Indicators
ATI-DA	Agricultural Training Institute, Department of Agriculture
AVI	Australian Volunteer International
AVRDC	World Vegetable Center
BARC	Bangladesh Agricultural Research Council
BARD	Bachelor of Agriculture and Rural Development
BCR	Benefit-Cost Ratio
BEN	Bangladesh Extension Network
CABI	Centre for Agriculture and Biosciences International
CAC	Consortium Advisory Committee
CAPEX	Capital Expenditure
CAPSA	Centre for the Alleviation of Poverty through Sustainable Agriculture
CAZRI	Central Arid Zone Research Institute
CCAFS	Climate Change, Agriculture and Food Security
CD	Capacity Development
CDAIS	Capacity Development for Agricultural Innovation Systems
CFF	Crops For the Future

CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CN	Concept Note
COP	Conference of Parties
CRISP	Centre for Research on Innovation and Science Policy
CSA	Climate-Smart Agriculture
CSV	Climate-Smart Village
CTA	Technical Centre for Agricultural and Rural Cooperation
DA	Department of Agriculture
DAE	Department of Agricultural Extension
DAFF	Department of Agriculture, Fisheries and Forestry
DAR	Department of Agricultural Research
DARE	Department of Agriculture, Research and Extension
DEM	Digital Elevation Model
DFAT	Department of Foreign Affairs and Trade
DG	Director General
DICD	Department of Industrial Crops Development
DOA	Department of Agriculture
DPRK	Democratic People's Republic of Korea
DTM	Digital Terrain Model
DUs	Deemed Universities
E&S	Environment and Social
EAP	Externally Aided Project
EAS	Extension and Advisory Service
EBCR	Economic Benefit Cost Ration
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAO RAP	Food and Agriculture Organization of the United Nations - Regional Office for Asia and the Pacific
FBCR	Financial Benefit-Cost Ratio
FDI	Foreign Direct Investment
FES	Foundation of Ecological Security
FFPRI	Forestry and Forest Products Research Institute
FMS	Financial Management System
FORDA	Forestry Research and Development Agency of Indonesia
FP	Full Proposal
FRI	Fisheries Research Institute
FRIM	Forestry Research Institute Malaysia
FSA	Farm Sustainability Assessment
FSC	Forest Stewardship Council
FSM	Federated State of Micronesia

FTE	Full-Time Equivalent
FYP	Five Year Plan
GAFSP	Global Agriculture & Food Safety Programme
GAP	Good Agricultural Practice
GAPAD	Global Action Plan for Agricultural Diversification
GCF	Green Climate Fund
GDP	Gross Domestic Product
GFAR	Global Forum on Agricultural Research
GFR	General Financial Rules
GFRAS	Global Forum for Rural Advisory Services
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GNI	Gross National Income
GODAN	Global Open Data for Agriculture and Nutrition
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GVA	Gross Value Added
GVP	Gross Value of Production
HACCP	Hazard Analysis Critical Control Point
HEI	Higher Education Institutions
IAARD	Indonesian Agency for Agricultural Research and Development
IACT	Increasing Agriculture Commodity Trade
IBM	Integrated Business Model
ICABIOGRAD	Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information Communication Technology
ID	Irrigation Department
IDF	International Diabetes Foundation
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IP	Intellectual Property
IPM	Integrated Pest Management
IPR	Intellectual Property Right
IRA	Internal Revenue Allotment
IRPA	Intensification of Research Priority Areas
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
ISAAA	International Service for Acquisition of Agri-biotech Applications

IVLP	Institutional Village Linkage Programme
IWMI	International Water Management Institute
IWMP	Integrated Watershed Management Programme
JICA	Japan International Cooperation Agency
KM	Knowledge Management
KVK	Krishi Vigyan Kendra
LBVD	Livestock Breeding and Veterinary Department
LEU	Land Ecological Unit
LGU	Local Government Units
LIFT	Livelihoods and Food Security Trust Fund
LLG	Local Level Government
LOI	Letter of Intent
LRD	Land Resources Division
LRI	Land Resource Inventory
LULC	Land Use and Land Cover
M&E	Monitoring and Evaluation
MAFF	Ministry of Agriculture, Forestry and Fisheries
MARDI	Malaysian Agricultural Research and Development Institute
MASTIC	Malaysian Science and Technology Information Centre
MCB	Malaysian Cocoa Board
MDGs	Millennium Development Goals
MIS	Management Information System
MOAI	Ministry of Agriculture and Irrigation
MOF	Ministry of Finance
MPOB	Malaysian Palm Oil Board
MRB	Malaysian Rubber Board
MTR	Medium-Term Review
MVCO	New Modified Virgin Coconut Oil
MyIPO	Intellectual Property Corporation of Malaysia
NAARM	National Academy of Agricultural Research Management
NAFRI	National Agriculture and Forestry Research Institute
NAIP	National Agricultural Innovation Project
NARC	Nepal Agricultural Research Council
NARES	National Agricultural Research and Extension Systems
NARP	National Agricultural Research Project
NARS	National Agricultural Research Systems
NATP	National Agricultural Technology Project
NBSS&LUP	National Bureau of Soil Survey and Land Use Planning
ND	National Director
NDA	Non-Disclosure Agreement
NDCs	Nationally Determined Contributions
NEDA	National Economic Development Authority

NESAC	National Economic and Social Advisory Council
NGO	Non-Government Organization
NPV	Net Present Value
NRCT	National Research Council of Thailand
NRI	Natural Resources Institute
NRM	Natural Resources Management
NSSO	National Sampling Survey Organization
NZAID	New Zealand Agency for International Development
O&M	Operations and Management
ODA	Official Development Assistance
OECD	Organisation for Economic Cooperation and Development
OECD DAC	Organisation for Economic Cooperation and Development - Development Assistance Committee
PAE	Participatory Agricultural Extension
PAFPNet	Pacific Agriculture Forestry Policy Network
PAPP	Pacific Agriculture Policy Project
PARC	Pakistan Agricultural Research Council
PICs	Pacific Island Countries
PICTs	Pacific Island Countries and Territories
PIP	Project Implementation Plan
PIRAS	Pacific Islands Rural Advisory Services Network
PIU	Project Implementation Unit
PMC	Project Management Committee
PME	Project Monitoring and Evaluation
PMU	Projects Monitoring Unit
PNG	Papua New Guinea
PNG Unitech	Papua New Guinea University of Technology
POET	Pacific Organic and Ethical Trade
POETcom	The Pacific Organic and Ethical Trade Community
POMS	Plantwise Online Management System
PPP	Purchasing Power Parity
PRA	Participatory Rural Appraisal
QDAFF	Queensland Department of Agriculture, Forestry and Fisheries
Q-GAP	Thai Quality Good Agricultural Practice
R&D	Research and Development
R&D&C	Research and Development and Commercialization
RBI	Rice Bowl Index
RD&E	Research Development and Education
RDC	Rural Research and Development Corporation
REAS	Research, Extension and Advisory Services
RES	Regional Extension Strategy
RPC	Research Programme Committee

RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
S&T	Science and Technology
SAARC	South Asian Association for Regional Cooperation
SAI	Sustainable Agriculture Initiative
SAPPLPP	South Asia Pro Poor Livestock Policy Programme
SAU	State Agricultural University
SBSTA	Subsidiary Body for Scientific and Technological Advice
SCDP	Second Crop Diversification Project
SCI	System of Crop Intensification
SCU	Southern Cross University
SDA	Sustainable Development Agenda
SDGs	Sustainable Development Goals
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture
SLCARP	Sri Lanka Council for Agricultural Research Policy
SLEM-GEF	Sustainable Land and Ecosystem Management - Global Environment Faculty
SMD	Subject Matter Division
SOC	Soil Organic Carbon
SPC	South Pacific Community
SPC LRD	South Pacific Community Land Resources Division
SPISARD	South Pacific Institute for Sustainable Agriculture and Rural Development
SRI	System of Rice Intensification
T&V	Training and Visit
TAG	Technical Advisory Group
TAP	Tropical Agriculture Platform
TCO	Technology Commercialization Office
TFP	Total Factor Productivity
TOR	Terms of Reference
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	UN Conference on Climate Change
UNICEF	United Nations Children's Emergency Fund
UPLB	University of the Philippines Los Banos
UQ	University of Queensland
USAID	United States Agency for International Development
USP	University of the South Pacific
VAAS	Vietnam Academy of Agricultural Sciences
VRI	Veterinary Research Institute
WDI	World Development Indicators
WDR	World Development Report
WFP	World Food Programme
WOTR	Watershed Organisation Trust in Maharashtra
ZAID	New Zealand Agency for Agricultural Development

1. Agricultural Research and Innovation for Development in the Asia-Pacific Region – An ACIAR Perspective

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ABSTRACT

The Asia-Pacific region is home to almost two-thirds of the world's poor, hungry and malnourished, the majority of whom are, incongruously, dependent on farming and agriculture as their main source of livelihoods. Growth in the agriculture sector is well recognized as a fundamental instrument for sustainable development and poverty reduction. While Official Development Assistance (ODA) has traditionally been the main tool for achieving sustainable economic development, it is becoming relatively less important as economies grow and other flows of capital increase. The emerging aid landscape comprises a complex set of actors – both public and private – with focus moving away from basic service delivery and governance towards economic growth, particularly in agriculture. Australia's aid programme has responded to these important geopolitical and economic shifts, with increased focus on agriculture, human development and innovation, increased engagement with the private sector, and greater emphasis on impact. This paper discusses the implications for investments in agricultural research, including the use of impact pathways, and suggests some characteristics of successful research projects. Continued transformation of agri-food systems in the Asia-Pacific will require rapid innovation, driven by well-targeted research and new approaches to technical cooperation between governments, businesses and agricultural organizations.

Keywords : ACIAR; Agricultural research; Aid; Asia-Pacific; Impact; Innovation.

1. Introduction

Nowhere are the challenges and opportunities for agricultural research for development more important than in the Asia-Pacific. The Asia-Pacific region is home to about 63 per cent of the world's hungry and malnourished, 50 per cent of the world's extreme poor and 70 per cent of the world's undernourished children and women. The region's large populations currently and in the foreseeable future will continue to depend on farming and agriculture as their main source of livelihoods. Providing a healthy diet for the region's people from truly sustainable agri-food systems is going to be one of the greatest challenges in coming decades.

2. Global Development and Official Development Assistance

Official Development Assistance (ODA) has traditionally been the main tool for donors to fight poverty and achieve sustainable economic development. It is instructive to look at recent trends in aid or ODA (Figure 1).

Looking backwards over the last three decades, the value of ODA to agriculture – globally – halved between the mid 1980s and the mid 2000s. The *share* of ODA to agriculture declined even more sharply, from 17 per cent in the late 1980s to six per cent in 2007. Of course, agricultural *research* represents only a fraction of this amount.

The global disinvestment in agricultural research was quite startling considering how important agricultural production has been as a driver of growth, particularly economic growth, in the developing world. As Professor Peter Timmer observed, "*no country has been able to sustain a rapid transition out of poverty without raising productivity in its agricultural sector*" (Timmer 2005).

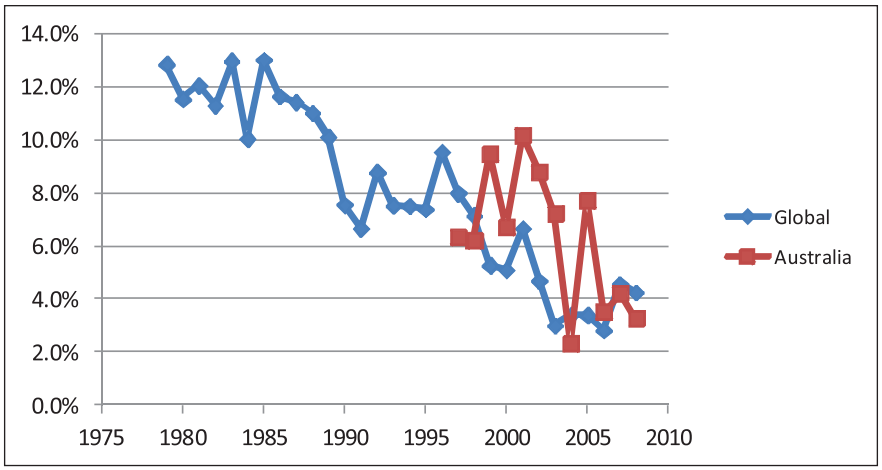

Figure 1. Agriculture's share of Official Development Assistance (ODA) (Source: OECD-DAC, www.oecd.org)

The food price crises of 2007–2008 shook donors out of their complacency. Funds flooded back into agriculture. Donor contributions to the global agricultural research system, the CGIAR, doubled to over USD 1 billion in only a few years.

The World Development Report at that time confirmed agriculture as a *fundamental instrument* for sustainable development and poverty reduction (WDR 2008). But, there are already signs that the increased focus on agriculture may be short-lived. Developed countries now face strong economic headwinds, and new and emerging demands on their aid budgets.

However, aid has never overcome poverty in and of itself. It must be accompanied by economic growth. Strong economic growth has seen extreme poverty halved between 1990 and 2010. Developing countries are now the key drivers of global growth (Figure 2).

Many Asian countries (Indonesia, the Philippines, Vietnam, and Sri Lanka) have all attained middle-

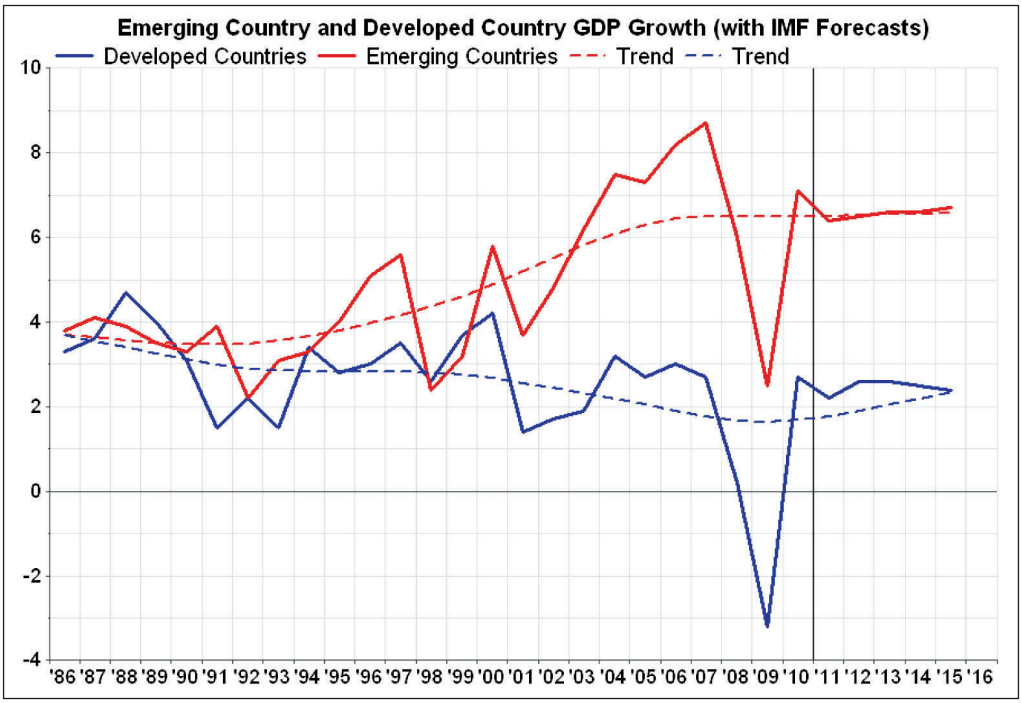

Figure 2. Emerging country and developed country GDP growth

income country status. But, the benefits have not been shared by all. Inequality has grown in recent years, pockets of intractable poverty remain. Inequality threatens growth, particularly in natural resource based economies and fragile and conflict affected states.

3. A New Aid Paradigm

In Asia, we are now entering a new aid paradigm. Aid flows are increasingly being dwarfed by domestic revenue, foreign direct investment, equity flows and remittances. The emerging landscape is one of a complex set of stakeholders beyond traditional donors, including emerging economy donors such as India and China, as well as philanthropy and the private sector.

Aid as a percentage of GDP has declined dramatically over the past forty years. In the late 1960s, ODA comprised more than one per cent of many Asian countries' GDP, and more than 5 per cent for some countries. At the end of the Century, ODA comprised less than half of one per cent of GDP for most Asian countries (Figure 4). While significant progress has been made in Asia towards the Millennium Development Goals (MDGs) – now the Sustainable Development Goals (SDGs) – the Pacific lags behind.

Development challenges are also evolving. A fascinating paper by Davies and Pickering (2015) titled, '*Making development cooperation fit for the future*', suggested some important emerging trends. The authors surveyed 40 developing countries to

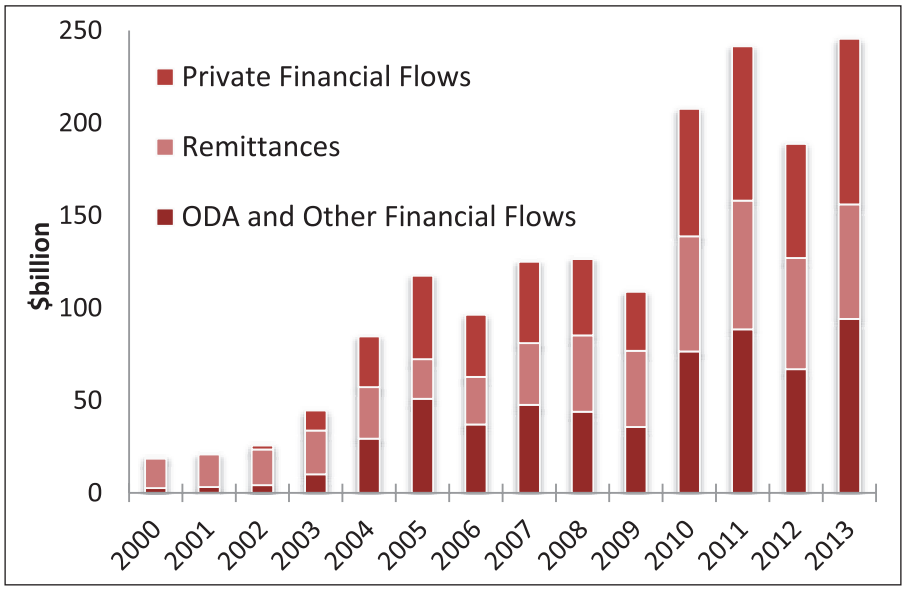

Figure 3. East Asia capital flows (*Source: OECD DAC World Development Indicators*)

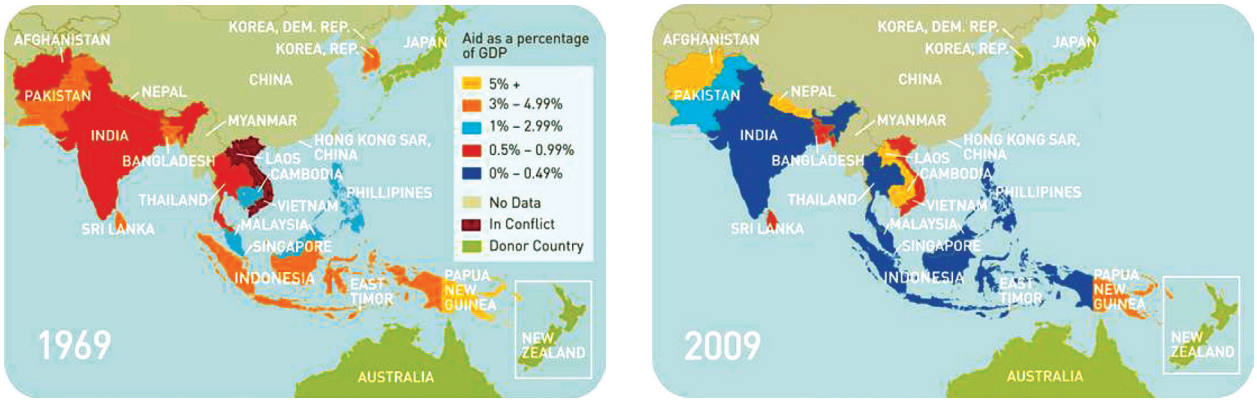

Figure 4. Aid as a percentage of GDP

ascertain the top three development challenges now, and in 5-10 years.

Figure 5 shows that continued economic growth is, and remains, the highest priority in the eyes of the 40 countries. However, a marked shift is predicted away from basic service delivery and governance. Conversely, a major reorientation is anticipated towards agriculture, resource management, climate adaptation, environmental management and meeting the needs of the poorest.

4. So What for Australian Aid

Australia's aid programme has responded to these important geopolitical and economic shifts. There has been a deliberate integration of all foreign policy instruments - diplomacy, trade and development - to promote economic growth and poverty reduction.

The aid programme's objective is unambiguously on promoting Australia's national interest by contributing to sustainable economic growth and poverty reduction (Figure 6). This will be achieved by increased engagement with the private sector (the engine of growth), to achieve shared prosperity. It will also depend on human development; a key consideration for APAARI.

Agriculture, fisheries and water represent one of six focus areas for Australian aid investment, along with gender equality and empowering women and girls.

For each partner country, the balance of investments will be tailored to the country context and reflect Australia's comparative advantage and national interest.

In growing Asia, focus is on building economic partnerships *and leveraging* domestic capacity and resources *to improve development outcomes. In the Pacific, Australia will remain flexible and responsive to country priorities.*

Innovation will increasingly characterise investments – experimenting with new approaches and partnerships.

5. Agricultural Research Impacts

Australia's aid programme, like those of many other donors, has given particular emphasis to ensuring value for money and achieving *impact*. For

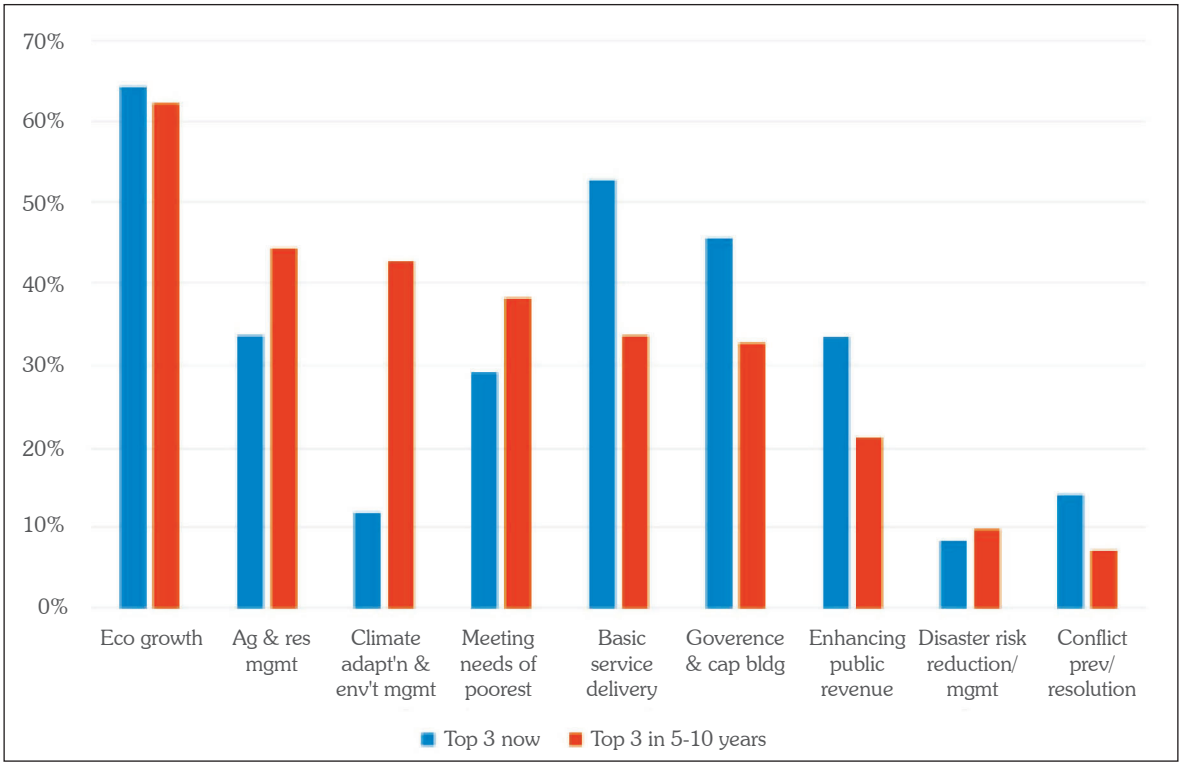

Figure 5. Development challenges – now and in 5-10 years, (*Source: Davies and Pickering 2015*)

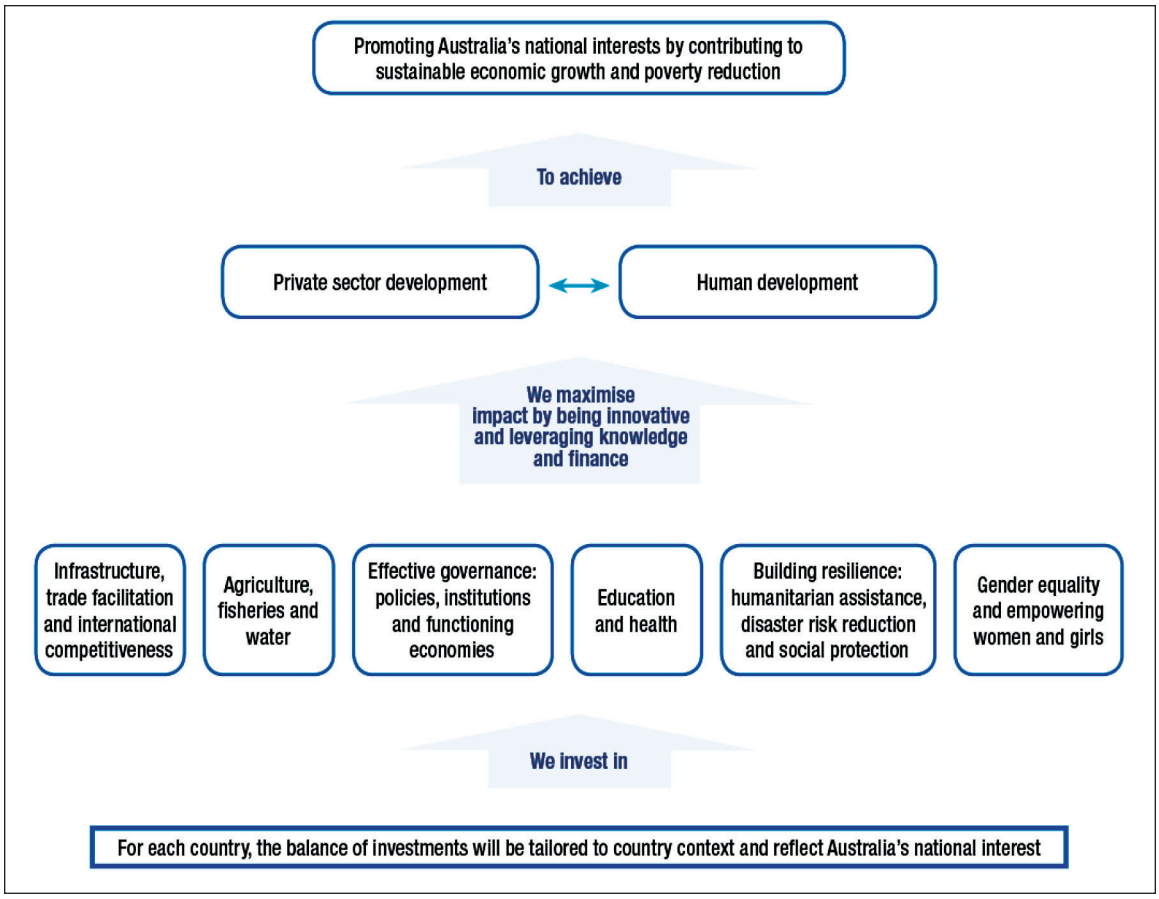

Figure 6. Australia's aid policy (*Source: DFAT 2014*)

agricultural research, this presents both challenges and opportunities.

While research excellence can be measured by the traditional metrics of publications and citations, and by the number of patents, these are necessary but not sufficient conditions for demonstrating impact sustaining and enhancing funding. What is required is an explicit and plausible impact pathway, or causal logic, between research for development, and development impact. Within a research project, research activities lead to outputs, which in turn lead to outcomes and impacts. But, these are generally limited in scale. The research outcomes then need to be transferred to next users and, through development interventions, to end users. Ideally, research outcomes become development outcomes. Only some actions will be the responsibility of the project. Other actors, increasingly the private sector, will have responsibility for utilisation of project results. External influences, such as policy settings and human and institutional capacities, will have significant influence, so success is never assured.

While donor focus on impacts is both understandable and desirable, excessive focus on impacts may lead to short-termism and risk aversion, and can obscure science quality. Experience of the Australian Centre for International Agricultural Research (ACIAR) suggests that it is critical to clearly define the research questions and stay focused on them.

It is also necessary to provide ongoing support on research-for-development processes. This may entail developing structural links inside projects with extension or development oriented agencies.

Impact assessment can be enormously valuable. It is not a panacea, but it facilitates closed-loop learning and assists in better targeting investments. But measuring impact also costs money, so has opportunity costs.

Economic impacts are generally assessed quantitatively, while social and environmental impacts are generally assessed qualitatively (Figure 7). Assessing capacity impacts is rarely attempted, but is a current focus of ACIAR effort, with studies

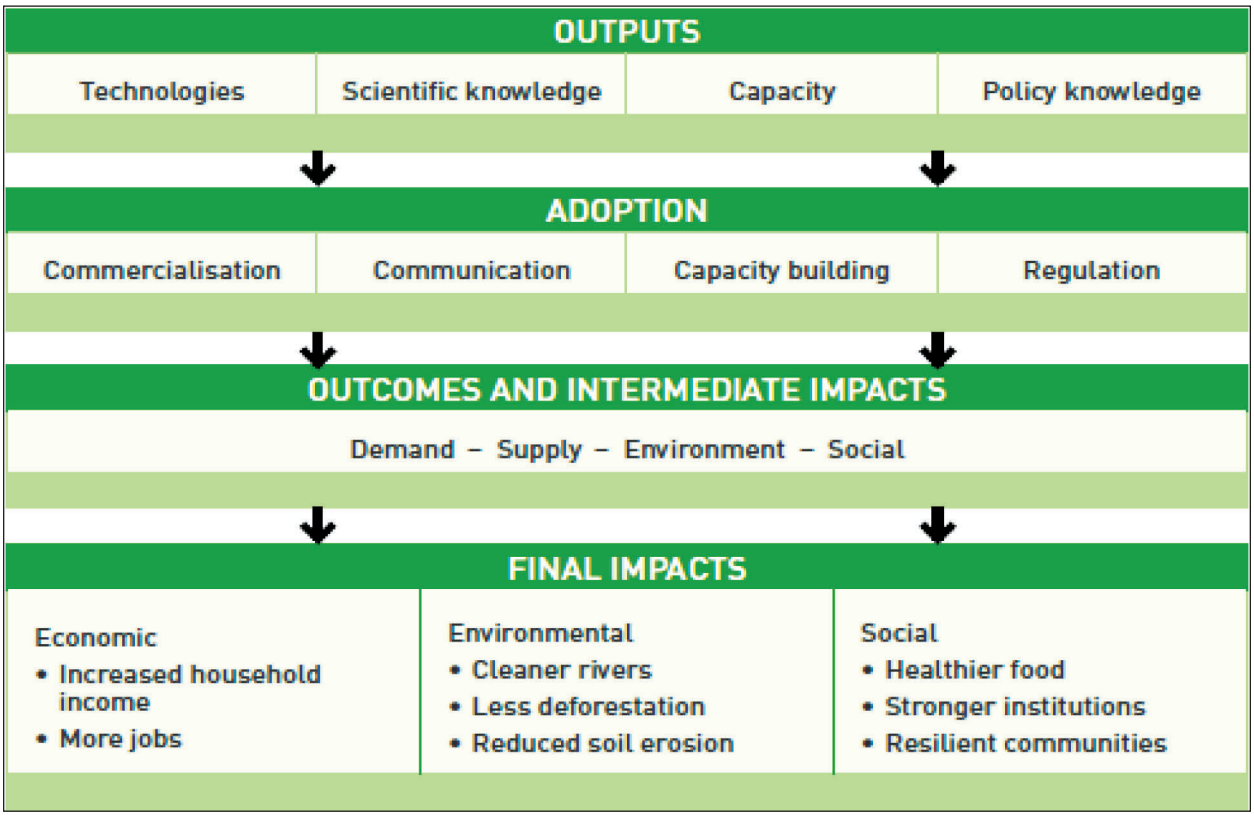

Figure 7. Impact pathway, (*Source: ACIAR 2014*)

endeavouring to measure both individual and institutional capacities built (Dugdale *et al.* 2012).

ACIAR's long history of impact assessment enables some interesting meta-analyses, across themes (for example, plantation forestry); geographies (such as Sub-Saharan Africa), or programmes (such as IRRI).

Independent impact assessments of 156 ACIAR bilateral projects showed total benefits of AUD 12.3 billion attributable to ACIAR. With a total expenditure on all ACIAR projects since 1982 of AUD 2.5 billion (in 2012 dollars), the benefit:cost ratio is very healthy 5:1 (Lindner *et al.* 2013).

ACIAR, from its stable of impact assessments and adoption studies, has found several potential 'lead indicators' or characteristics of research projects that are associated with both successful and unsuccessful projects (Pearce 2010). Key dimensions include:

- Importance of adoption
- Local industry and policy conditions that are accommodating and supportive
- A project champion
- Capacity building

The most frequently cited success factor is knowledge of outputs. This factor alone accounts for more than half of the citations. When combined with user incentives, the two account for around three-quarters of cited factors. This aspect of the adoption studies reinforces the crucial role of incentives and knowledge in influencing levels of adoption.

Interestingly, these two factors have quite different characteristics. Incentives cannot usually be influenced by the project itself but are, in many ways, a function of the economic and institutional structures within the country or region concerned. While incentives cannot necessarily be directly manipulated, they can be studied and understood in advance of the project.

Knowledge of outputs is, on the other hand, within the control of projects through the simple means of communication undertaken within the project or the efforts of champions of outputs (who may be independent of the project).

6. Conclusion

Despite impressive economic growth, the Asia-Pacific Region is home to most of the world's hungry and malnourished, particularly women and children, and most of the poor and hungry are highly dependent on agriculture for their livelihoods.

ODA has traditionally been a main tool for improving livelihoods, but ODA is declining relative to other sources of capital. A new aid paradigm is emerging, with the private sector playing a far more significant role in emerging Asia, and to a lesser extent in the Pacific.

The region is at the threshold of a new era. Economic growth and increasing investment in science and research are opening up new opportunities. We are experiencing a major reorientation towards agriculture and agri-food systems for both development and commercial reasons.

The region's agri-food systems are transforming and that transformation will require rapid innovation, driven by targeted research. New approaches to technical cooperation between governments, businesses and agricultural organizations are needed, particularly to target intractable poverty. Investments in agri-food system research will have to be scaled-up. Effective communication and incentives will be key, and APAARI has a unique and important role to play.

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2. A Snapshot of Agricultural Research Investment and Capacity in Asia

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ABSTRACT

Since the turn of the millennium, Asia has recorded rapid growth in its levels of agricultural research spending. Most of the growth in regional spending was driven by China. Spending in India and Indonesia has also increased substantially since 2000. However, many countries in Asia continue to underinvest in agricultural research. Cambodia, Lao PDR, and Pakistan still invest less than 0.20 per cent of their agricultural GDP in agricultural research, which is clearly insufficient considering the numerous emerging challenges these countries face, including widespread poverty, rapid population growth, climate change, and environmental degradation. On a positive note, the number of Ph.D. qualified agricultural researchers has risen in nearly all Asian countries since 2000, although in some countries–particularly Nepal, Pakistan, and Vietnam–many senior researchers are approaching retirement age. Women remain severely underrepresented in agricultural research in Asia. Many countries have a long way to go to ensure that female perspectives are integrated within research agendas.

Keywords: Agricultural research; Asia; Capacity; Expenditure; Investment; Researchers

1. Introduction

Agricultural research was one of the main drivers behind the enormous increases in food production in South, East, and Southeast Asia (referred to as "Asia" in the remainder of this report) during the twentieth century. The implementation of research-based agricultural methods and new technologies enhanced the quantity and quality of agricultural outputs, and led to rapid economic growth and poverty reduction. Despite these tremendous advances, Asia is still home to more than half of the world's poor. Most of them live in rural areas where agriculture remains the main source of employment and income.

The generation of new agricultural technologies is crucial to sustain economic growth, to increase labour productivity, and to meet the changing food needs of a wealthier (and in some countries rapidly growing) population in the coming decades. Policymakers know that more investment in agricultural research is the key to increasing agricultural production. But, because of scarce resources and competing demands on national budgets, shorter-term goals often take priority over longer-term agricultural research investments. This is why quantitative data are essential to an informed decision-making process. Agricultural research stakeholders need such data to analyse research investment and capacity trends, identify key gaps, set future priorities, promote efficient resource use, and ensure effective coordination and coherence of agricultural research initiatives. The International Food Policy Research Institute's (IFPRI's) Agricultural Science and Technology Indicators (ASTI) is the leading programme globally that provides agricultural research capacity, investment, and output data in developing countries.

ASTI datasets are fairly up-to-date and of high quality for most developing regions around the world, including Africa south of the Sahara, West Asia and North Africa, South Asia, and Latin America and the Caribbean. Funding constraints, however, have prevented ASTI from maintaining datasets with the same level of quality and detail for Southeast Asia (and the Pacific). Until recently, the most recent year for which complete ASTI data were available for the Asia region as a whole was 2009. Based on new (primary and secondary) data from a large number of Asian countries, the current

report provides an updated overview of agricultural research investment and capacity levels in low-and middle-income countries in Asia since 2000.

2. Data and Method

The data in this report only cover public national agricultural research. Staff and expenditure data for private-sector companies and international agricultural research agencies operating in the region, such as the centres of the Consultative Group on International Agricultural Research (CGIAR), have been excluded. ASTI follows the definition of agriculture provided by the Food and Agriculture Organization of the United Nations (FAO), which comprises crops, livestock, forestry, fisheries, natural resources, on-farm postharvest activities, as well as the socioeconomic aspects of primary agricultural production. The figures in this report, therefore, exclude off-farm postharvest, agrochemical, and food processing research. All ASTI datasets as well as those from external sources used in this report are collected and processed using internationally accepted definitions and procedures for compiling research statistics developed by the Organization for Economic Cooperation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

The analysis in this report is based on comprehensive datasets derived from a variety of sources. Data for Bangladesh, India, Nepal, and Pakistan are most detailed and complete as ASTI recently finalized first-hand data collection rounds from a comprehensive set of agricultural research agencies operating in these countries. Funding and time constraints prevented ASTI from collecting recent data with a similar level of detail from other Asian countries. However, in Laos, Malaysia, Sri Lanka, and Vietnam, ASTI was able to obtain detailed recent human resource and expenditure data from the principal agricultural research agencies operating in these countries. By linking these post-2010 data with existing complete pre-2010 ASTI datasets, and extrapolating the data for some of those countries' smaller research agencies to a more recent year based on the trend of the larger agencies, fairly comprehensive long-term country-level time series could be developed. Data series for China, Indonesia, and Thailand were derived from external sources (see Table 1). Recent data for Afghanistan, Bhutan, Maldives, Myanmar, the Philippines, and Timor Leste were unavailable, and these countries have been excluded from analysis in this report. It was not possible to update the information to the same year for all countries. The latest year for which data is available, therefore, differs from country to country.

Table 1. Data sources and availability

Country	Latest year of data availability		
	Human resources	Financial resources	Data source
Bangladesh	2012	2012	ASTI survey conducted in 2013/2014
Cambodia	2010	2010	ASTI survey conducted in 2011/2012
China	NA	2013	National Bureau of Statistics of China (2014)
India	2014	2014	ASTI survey conducted in 2015
Indonesia	2014	2014	ASTI survey conducted in 2011/2012, updated with recent financial and human resource data from IAARD (various years), FORDA (2014), and Industry (2015)
Lao PDR	2014	2014	ASTI survey conducted in 2011/2012, updated with unpublished recent first-hand financial and human resource data from the National Agriculture and Forestry Research Institute (NAFRI)
Malaysia	2014	2014	ASTI survey conducted in 2011/2012, updated with unpublished recent first-hand financial and human resource data from the Malaysian Agricultural Research and Development Institute (MARDI) and MASTIC (2014)
Nepal	2013	2013	ASTI survey conducted in 2013/2014
Pakistan	2012	2012	ASTI survey conducted in 2013/2014

Contd...

Table 1 (Contd.)

Country	Latest year of data availability		
	Human resources	Financial resources	Data source
Sri Lanka	2013	2012	ASTI survey conducted in 2010/2011, updated with unpublished recent first-hand financial and human resource data from a complete set of research agencies under the Sri Lanka Council for Agricultural Research Policy and the Department of Agriculture
Thailand	NA	2013	NRCT (various years) and Suphannachart (2015)
Vietnam	2015	2010	ASTI survey conducted in 2011/2012, updated with unpublished recent first-hand human resource data from agencies under the Vietnam Academy of Agricultural Sciences

Source: Constructed by author; NA denotes that data are not available

3. Institutional Context

The structure of national agricultural research systems (NARS) in Asia is highly complex, comprising a large number of government, higher education, private sector, and international research agencies. China's agricultural research system consists of an array of national-, provincial-, and prefectural-level agencies. The focus of the national research agencies, including the Chinese Academy of Agricultural Sciences, the Chinese Academy of Fishery Sciences, and the Chinese Academy of Tropical Agricultural Sciences is on basic research and technologies that address key national priorities and challenges. Research conducted by the provincial and prefectural agencies is mostly applied.

In India, a considerable share of agricultural research falls under the Indian Council for Agricultural Research (ICAR), which oversees a large number of agencies focusing on crop, livestock, fisheries, natural resources, agricultural engineering, and policy research. In addition, the country has a comprehensive network of State Agricultural Universities, which conduct state-specific research and education. The organization and coordination of the NARS in Bangladesh, Nepal, Pakistan, and Sri Lanka bear some similarities to India's system in that they all have national agricultural research councils that coordinate agricultural research, set priorities, and administer competitive grant schemes. However, their roles and scope of authority vary and in some cases are undergoing change.

The setup of NARS in Southeast Asia differs from one country to the other. In Indonesia, the Indonesian Agency for Agricultural Research and Development (IAARD) oversees nine major research centres that focus on crop and livestock research. The Indonesian Research Institute for Estate Crops–the largest agricultural research agency in the country in terms of expenditures–is linked to IAARD, but not formally part of it. The Forest Research and Development Agency oversees most of the country's forestry research, and the higher education sector (dominated by Bogor Agricultural University) plays a fairly important role in the country's agricultural research as well. Cambodia, Lao PDR, and Malaysia all bear some similarity in that their NARS are anchored by large national agricultural research institutes, complemented by a number of smaller government and higher education agencies. In the case of Malaysia, the palm oil, rubber, and cocoa commodity boards play a particularly important role in agricultural research as well. In Thailand, the bulk of research falls under the Ministry of Agriculture and Cooperatives, which oversees four main research departments that focus on rice, other crops, livestock, and fisheries. The country's universities play a critical role in agricultural research too, Kasetsart University in particular. The institutional setup of agricultural research in Vietnam has undergone significant changes over the past decade. Two consecutive rounds of mergers reduced the number of government research agencies from 28 to 6. The Vietnam Academy of Agricultural Sciences currently oversees the bulk of the country's agricultural research.

In most countries in Asia, the government sector employs the majority of agricultural researchers. One important exception is India, where the higher education sector dominates in terms of number of researchers. Throughout Asia, the role of the

higher education sector has gradually risen in recent decades based on an increase in the number of higher education agencies, both through the creation of new universities and of new departments and faculties within existing universities. Still, many of these universities and faculties employ only a handful of agricultural researchers. A number of non-profit agencies, mostly non-governmental organizations, operate in the region. In Cambodia and Nepal, in particular, they play a fairly important role in national agricultural research.

4.1. Agricultural research spending

4.1.1. Investment levels across countries

In accordance with international standards developed by the Organization for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific, and Cultural Organization (UNESCO), all spending data in this report are expressed in purchasing power parity (PPP) dollars, which measure the relative purchasing power of currencies across countries by eliminating national differences in price levels (see Box 1). Agricultural research spending levels differ broadly across the Asian sample countries. China ranks the highest. In 2014, the country spent 9.4 billion PPP dollars (in 2011 prices) on agricultural research (Table 2). India and Indonesia ranked second and third, spending 3.4 billion and 1.4 billion PPP dollars (in 2011 prices) that year, respectively. Unsurprisingly, spending levels in some of the region's smaller countries are considerably lower.

Asia has recorded rapid growth in agricultural research expenditure levels since the turn of the millennium. However, most of the growth in regional spending was driven by just one country: China. Following a period of stagnation in spending the 1990s, the Chinese government passed some reforms in the early 2000s, which promoted innovation in agricultural science and technology and opened new funding opportunities. As a result, Chinese agricultural research expenditures nearly quadrupled in inflation-adjusted terms during 2000–2013. Agricultural research expenditure levels in India also quadrupled during 2000–2014, when expressed in current prices (chiefly due to increased government support). However, corrected for relatively high levels of inflation, growth in Indian agricultural research spending was considerably lower (75% during 2000–2014). Indonesia also recorded remarkable growth. The country's agricultural research expenditures have more than doubled since the turn of the millennium. In contrast, Sri Lanka's security situation forced the government to divert resources to national security, leading to an overall decline in agricultural research investment levels. In Lao PDR, recent increases in government funding to agricultural research were offset by high inflation levels and reduced donor support, prompting an overall drop in agricultural research spending (in real terms).

Box 1: Purchasing power parity exchange rates as the preferred measure of research investments

Comparing research data is a highly complex process due to important differences in price levels across countries. The largest components of a country's agricultural research expenditures are staff salaries and local operating costs, rather than internationally traded capital investments. For example, the wages of a field laborer or a laboratory assistant at a research facility are much lower in Cambodia than they are in any European country; similarly locally made office furniture in Pakistan will cost a fraction of a similar set of furniture bought in the United States.

Standard market exchange rates are the logical choice for conversions when measuring financial flows across countries; however, they are far from perfect for comparing economic data. When calculating economic data, such as agricultural research spending across countries, the preferred method is the purchasing power parity (PPP) index. PPPs measure the relative purchasing power of currencies across countries by eliminating national differences in pricing levels for a wide range of goods and services. PPPs are also used to convert local prices in individual countries to a common currency. In addition, PPPs are relatively stable over time, whereas exchange rates fluctuate considerably.

Table 2. Agricultural research spending (excluding private for-profit sector), 2000–2014

Country	Total spending (in million 2011 PPP dollars)						
	2000	2005	2010	2011	2012	2013	2014
Bangladesh	200.4	158.0	239.0	256.4	250.6	NA	NA
Cambodia	17.7	19.8	22.4	NA	NA	NA	NA
China	2,614.9	3,769.8	7,887.5	7,768.2	8,918.9	9,366.2	NA
India	1,927.9	2,269.6	2,880.5	3,194.6	3,473.2	3,279.4	3,360.3
Indonesia	579.6	914.7	1,067.7	1,182.0	1,282	1,585.2	1,352.7
Lao PDR	37.2	21.4	16.2	14.5	12.8	8.8	8.8
Malaysia	91.0	117.0	101.6	78.6	83.7	87.9	86.5
Nepal	39.2	29.8	36.5	49.9	53.4	47.9	NA
Pakistan	235.6	305.0	291.5	291.0	332.5	NA	NA
Sri Lanka	90.4	59.4	49.2	51.2	46.4	NA	NA
Thailand	327.0	278.0	439.5	354.4	390.0	423.6	NA
Vietnam	61.6	108.9	136.0	NA	NA	NA	NA

Source: See Table 1

Notes: NA denotes that data are not available. Numbers in italics have been extrapolated based on available recent data from agencies listed in Table 1. In 2010, IAARD, FORDA, AMFR, and Bogor Agricultural University accounted for 50 per cent of Indonesia's agricultural research spending; NAFRI accounted for 80 per cent of total agricultural research spending in Lao PDR in 2010; MARDI accounted for 26 per cent of agricultural research spending in Malaysia in 2011; NARC accounted for 85 per cent of agricultural research spending in Nepal in 2012; government agencies accounted for 89 per cent of agricultural research spending in Sri Lanka in 2009.

4.2. Intensity of agricultural research spending

Analysing absolute levels of research expenditures explains only so much. Another way of comparing the commitment to agricultural research investments across countries and over time is to measure total agricultural research spending as a share of agricultural output (AgGDP). This relative measure goes beyond absolute agricultural research spending levels to indicate the "intensity" of research investments. The United Nations have called for minimum agricultural research investment targets of at least 1 per cent of AgGDP, but none of the twelve Asian sample countries have reached that target in recent years (Figure 1).

China's intensity ratio (0.62 in 2013) was more than twice as high as India's (0.30 in 2014). As previously mentioned, both China and India have recorded considerable growth in agricultural research investment since 2000, but so have their respective AgGDP levels. As a result, the intensity ratio in China has increased only very slowly on the long run, while India's intensity ratio has remained relatively stagnant. At 0.84 per cent in 2014, Malaysia recorded the highest intensity ratio among the twelve sample countries. Nonetheless, this ratio has shown an enormous decline in recent years as a result of a drop in agricultural research expenditures (in real terms) coupled with a rapid increase in agricultural output.

Although intensity ratios provide useful insights into relative investment levels across countries and over time, they fail to take into account the policy and institutional environment within which agricultural research occurs, the broader size and structure of a country's agricultural sector and economy, or qualitative differences in research performance across countries. For these reasons they need to be interpreted carefully within the context of national circumstances. A one-size-fits-all investment target for the region is certainly not desirable given that structural economic differences call for different investment strategies. In fact, countries like China and India have very developed and successful research systems, and can be said to invest sufficiently in agricultural research given the size of their economies and their income levels.

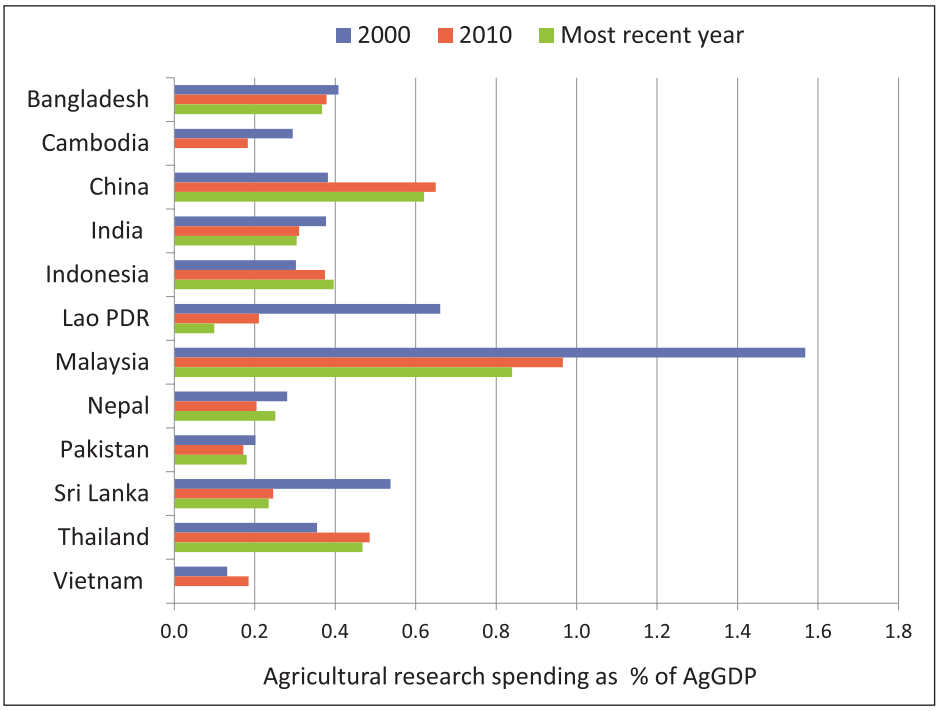


Figure 1. Intensity of agricultural research spending (excluding private for-profit sector) (*Source: See Table 1*)

Note: The most recent year of available data is 2010 for Cambodia and Vietnam; 2012 for Bangladesh, Pakistan, and Sri Lanka; 2013 for China, Nepal, and Thailand; and 2014 for India, Indonesia, Lao PDR, and Malaysia. The 2012 intensity ratio for Bangladesh differs slightly from the one published in the ASTI country factsheet because of recent World Bank revisions to its GDP deflators and AgGDP figures for Bangladesh.

Despite the limitations of intensity ratios, they do reveal that many countries in Asia are underinvesting in agricultural research. Cambodia, Lao PDR, and Pakistan all invest less than 0.20 per cent of their AgGDP in agricultural research, which is clearly insufficient considering the numerous emerging challenges these countries face, including widespread poverty, rapid population growth, climate change, and environmental degradation. Being aware of these challenges, some national governments have set ambitious agricultural research investment targets (India and Nepal, for example, aim to invest 1 per cent of their AgGDP on agricultural research, and Sri Lanka has set itself a target of 1.5 per cent). Although such investment targets can be useful to mobilize resources for agricultural research, simply doubling, tripling, or quadrupling investments should not be misconstrued as the end goal. The real goals are to ensure that research agencies have the necessary human, financial, operating, and infrastructural resources to effectively and efficiently develop, adapt, and disseminate S&T innovations within an appropriate enabling public policy environment in order to maximize their impact on the agriculture sector, on rural and economic development more generally, and ultimately on poverty and hunger.

4.3. Allocation of expenditures across cost categories

A closer look at the composition of agricultural research spending reveals some important cross-country differences in terms of how expenditures are allocated across salaries, operating and programme costs, and capital investments. India, Malaysia, and Pakistan, for instance, spent between 60 and 80 per cent on salary-related costs, while the bulk of agricultural research funding in Cambodia and Vietnam goes towards operating and programme costs (Figure 2). No formula can determine the optimal allocation of agricultural research spending across cost categories: it depends on numerous factors, including country size, agroecological diversity, research mandates, and the composition of staffing. That said, when salary-related expenditures consume more than three-quarters of a research agency's total budget, a clear imbalance exists, such that too few resources remain to support the costs of operating

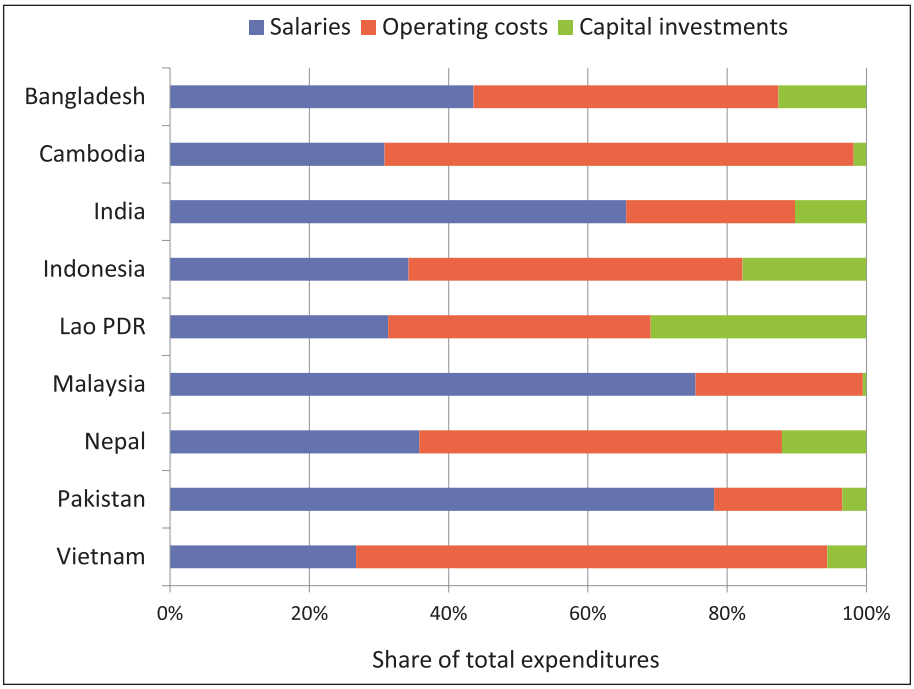


Figure 2. Spending by cost category for the main government agencies (*Source: See Table 1*)

Notes: Data for Cambodia and Vietnam are for 2010; data for Bangladesh and Pakistan are for 2012; data for Nepal are for 2013; and data for India, Indonesia, Lao PDR, and Malaysia are for 2014. Bangladesh, Cambodia, India, Nepal, and Pakistan shares are based on a full set of government agencies operating in these countries. Indonesia data only cover FORDA and agencies under IAARD; Lao PDR data only cover NAFRI; Malaysia data only cover MARDI; Vietnam data only cover agencies under VAAS.

viable research programmes. This is clearly the case in Pakistan, where salaries accounted for close to 80 per cent of expenditures in 2012. This proportion is immense, particularly coupled with Pakistan's low agricultural research intensity ratio (see Figure 1). Few resources are available to fund the day-to-day operation of research programmes or to maintain/upgrade research infrastructure and equipment in Pakistan. The situation in Nepal is similar. Many stations and laboratories of the Nepal Agricultural Research Council (NARC) are constrained in their research efforts due to outdated research infrastructure; equipment that has fallen into disrepair, insufficient access to vehicles to conduct field research, frequent power cuts that disrupt laboratory research, unreliable Internet access, lack of office space, and lack of up-to-date computer equipment and software. Rehabilitation of the country's research infrastructure is crucial as the quality of research suffers because of substandard infrastructure.

4.4. Funding sources of agricultural research

Funding for agricultural research in Asia is derived from a variety of sources, including national and state/provincial governments, donors, development banks, producer organizations, and the private sector, along with internally generated revenues through the sale of goods and services. Governments are by far the most important source of funding for agricultural research in the region. Government funding can reach an agricultural research agency through a variety of channels. In some countries, staff salaries are directly disbursed by the Ministry of Finance, while operating and capital costs are disbursed by the Ministry of Agriculture or equivalent. Many countries in the region have a Ministry of Science and Technology that allocates research funding through one or more science funds, either competitively or through direct budget allocations.

Bilateral and multilateral donor funding as well as funding from the World Bank or Asian Development Bank (ADB) play a relatively important role in funding agricultural research in Bangladesh, Cambodia, Lao PDR, Nepal, Pakistan, and Vietnam. Agricultural research in Lao PDR is particularly dependent on donor funding. During 2010–2014, 55 per cent of NAFRI's funding came from the governments of Australia, Japan, and South Korea, ADB, and

a number of United Nations agencies. Annual levels of donor funding to NAFRI have fluctuated considerably, however. In fact, the short-term, project-oriented nature of donor-funded projects has led to the situation where Lao PDR is the most volatile country in Asia in terms of agricultural research funding.

In Malaysia, commodity levies play an important role in funding research conducted by the Malaysian Palm Oil Board and the Malaysian Rubber Board. One reason for the success of these commodity taxes (or cesses) is that the private sector is directly involved in the research programmes of the commodity boards. Until recently, research on plantation crops in Sri Lanka was funded through cess proceeds as well, but this funding mechanism has been gradually phased out by the government.

Given insufficient funding for the operation of research programmes, some Asian research agencies have no choice but to seek alternative sources of funding such as through the sale of goods (for example seed, vaccinations, or publications) and services (such as laboratory tests and technical assistance). Funding diversification through the sale of goods and services is not encouraged in all Asian countries, however. All internally generated resources through the sale of goods and services by agricultural research agencies in Pakistan, for instance, are channelled back to the national treasury, which creates a disincentive for agricultural research agencies to pursue this revenue stream.

5. Human Resource Capacity in Agricultural Research

Human resource capacity refers to the quantity and quality of scientific and technical personnel employed in national research systems. It is difficult to arrive at an estimate of total human resource capacity in agricultural research in Asia because the necessary data are not available for all countries, and different countries have different definitions of what constitutes an agricultural researcher. Predictably, China has the largest agricultural research system in the region (excluding the private for-profit sector), followed by India and Indonesia (Table 3). Medium-sized countries, employing between 1,000 and 4,000 full-time equivalent (FTE; See Box 2) researchers, include Bangladesh, Malaysia, Pakistan, Thailand, and Vietnam. Agricultural research systems in Cambodia, Lao PDR, and Nepal are much smaller, employing between 100 and 500 FTEs each.

Table 3. Total number of agricultural researchers (in full-time equivalents), 2000–2014

Country	Total researchers (in full-time equivalents)						
	2000	2005	2010	2011	2012	2013	2014
Bangladesh	1,590.4	1,729.0	1,960.8	1,999.6	2,121.0	NA	NA
Cambodia	153.0	266.2	284.4	NA	NA	NA	NA
China	48,355.5	58,064.8	NA	NA	NA	NA	NA
India	13,283.4	12,417.1	12,041.3	12,324.8	12,613.0	12,795.1	12,752.2
Indonesia	4,546.8	4,720.9	4,988.0	5,077.9	5,256.2	5,480.8	5,990.2
Lao PDR	114.0	150.8	176.9	179.7	165.9	157.1	152.1
Malaysia	1,112.6	1,244.6	1,609.4	1,726.4	1,709.7	1,679.1	1,770.9
Nepal	391.2	376.4	419.5	427.4	403.4	423.6	NA
Pakistan	3,453.7	3.338.4	3,438.3	3,515.5	3,678.3	NA	NA
Sri Lanka	517.7	525.0	616.4	624.7	625.0	588.9	NA
Vietnam	2,461.4	3,206.3	3,744.2	3,803.3	3,862.3	3,921.4	3,980.4

Source: See Table 1

Notes: NA denotes that data are not available. Numbers in italics have been extrapolated based on available recent data from agencies listed in Table 1. In 2010, IAARD, FORDA, and Bogor Agricultural University employed 58 per cent of Indonesia's agricultural researchers; NAFRI accounted for 80 per cent of agricultural researchers in Lao PDR in 2010; MARDI accounted for 36 per cent of agricultural researchers in Malaysia in 2010; NARC accounted for 84 per cent of agricultural researchers in Nepal in 2012; government agencies accounted for 89 per cent of agricultural researchers in Sri Lanka in 2009; agencies under VAAS accounted for 34 per cent of agricultural researchers in Vietnam in 2010.

Box 2: The concept of full-time equivalent researchers

ASTI bases its calculations of human resource and financial data on full-time equivalent staffing, or FTEs, which take into account the proportion of time researchers spend on research activities. University staff members, for example, spend the bulk of their time on non-research related activities, such as teaching, administration, and student supervision, which need to be excluded from research-related resource calculations. As a result, four faculty members estimated to spend 25 per cent of their time on research would individually represent 0.25 FTEs and collectively be counted as one FTE.

Since 2000, Bangladesh, Cambodia, Indonesia, Malaysia, and Vietnam have all made considerable progress in building their agricultural research capacity, both in terms of scientist numbers and in terms of average qualification levels. In contrast, agricultural researcher totals in India, Lao PDR, Nepal, Pakistan, and Sri Lanka have been either stagnant or declining.

5.1. Researcher qualification levels

A minimum number of Ph.D. qualified scientists is generally considered fundamental to the conception, execution, and management of high-quality research; to effective communication with policymakers, donors, and other stakeholders, both locally and through regional and international forums; and for increasing an institute's chances of securing competitive funding. With the exception of Malaysia, all countries for which detailed long-term time series data were available have expanded their pool of Ph.D. qualified agricultural researchers since 2000. India employs by far the highest share of Ph.D. qualified researchers among Asian countries (Figure 3). In 2014, three quarters of Indian FTE agricultural researchers were trained to the Ph.D. level. Generally, technical support staff at Indian agricultural research agencies are highly qualified

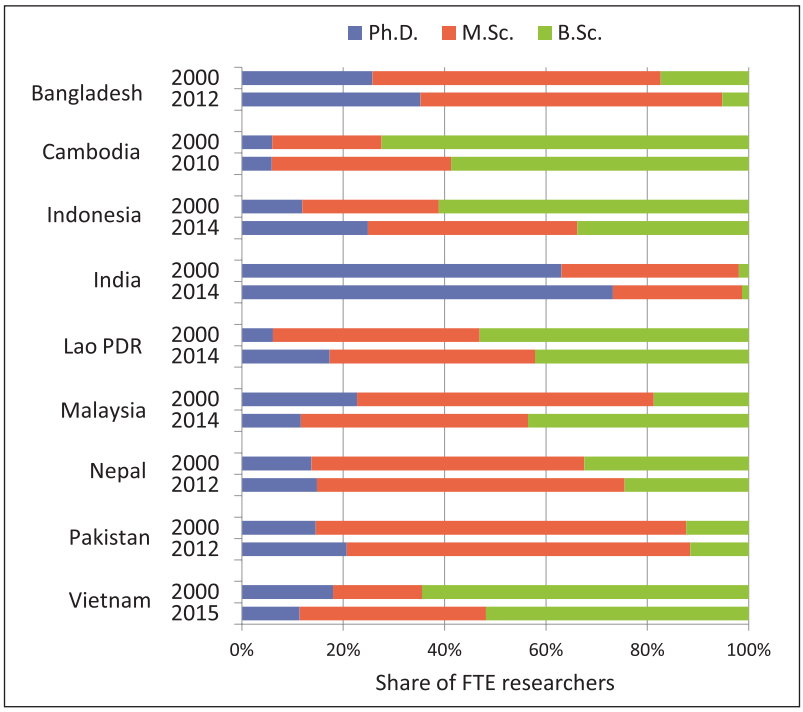


Figure 3. Distribution of researchers by qualification level (*Source: See Table 1*)

Notes: Bangladesh, India, Nepal, and Pakistan shares are based on a full set of government, higher education, and non-profit agencies operating in these countries. Indonesia data only cover FORDA and agencies under IAARD; Lao PDR data only cover NAFRI; Malaysia data only cover MARDI; Vietnam data only cover agencies under VAAS.

as well, often holding M.Sc. degrees and sometimes even Ph.D. degrees. Most other countries in the region employ significantly lower shares of Ph.D. qualified researchers. In China, detailed recent data on researcher qualifications were not available, but of the total number of government researchers and support staff employed in 2009, 12 per cent held Ph.D. degrees, 29 per cent held M.Sc. degrees, and 59 per cent held B.Sc. degrees.

The number of staff with postgraduate degrees have been traditionally low in Cambodia, Lao PDR, and Vietnam, but all three countries recorded progress in recent years. The history of political and economic isolation of these countries has limited training opportunities of scientists abroad. Moreover, lack of foreign language skills with many researchers in these countries–a prerequisite for pursuing Ph.D. training abroad–still presents an impediment, though things have gradually improved over time.

In some Asian countries, differences between research agencies in terms of salary levels or the official status of researchers are major factors determining the ability of a research agency to attract and maintain highly qualified research staff. NARC in Nepal, for example, is considered an unattractive employer by young scientists. Salaries are 2 to 10 times lower than at NGOs or the private sector, and even though university salaries are on a par with NARC's, universities offer researchers more flexibility in terms of consultancies besides their day-time job. Another major factor preventing young researchers from pursuing a career in agricultural research in Nepal is the fact that obtaining a Ph.D. degree currently has no impact on salary. Similarly, in Pakistan, low salaries and a lack of performance-based incentives make provincial research agencies less attractive employers compared with federal government and higher education agencies. Average researcher qualifications at Pakistan's provincial research agencies are, therefore, considerably lower.

5.2. Age distribution of agricultural researchers

Data on research staff by age bracket provide an indicator both of current capacity and potential future capacity needs. Agricultural research agencies should attempt to minimize imbalances among research staff as having too many senior researchers approaching retirement age can jeopardize the continuity of future research, whereas a preponderance of young, inexperienced researchers can negatively affect the quality of research over time. On average, South Asian researchers are older than their colleagues in Southeast Asia (Figure 4). In Nepal and Pakistan, for example, long-term recruitment restrictions have left many research agencies with aging pools of researchers. Given the official retirement age of 60 years in these countries, large-scale capacity losses are imminent in the coming years, especially among Ph.D. qualified researchers. Moreover, low salaries, limited opportunities for promotion and training, as well as a lack of performance-based merit systems, constitute key impediments to staff motivation in these countries. Cambodia and Vietnam, on the other hand, employ a disproportionately high number of relatively inexperienced researchers in their 20s and 30s in need of training and mentoring.

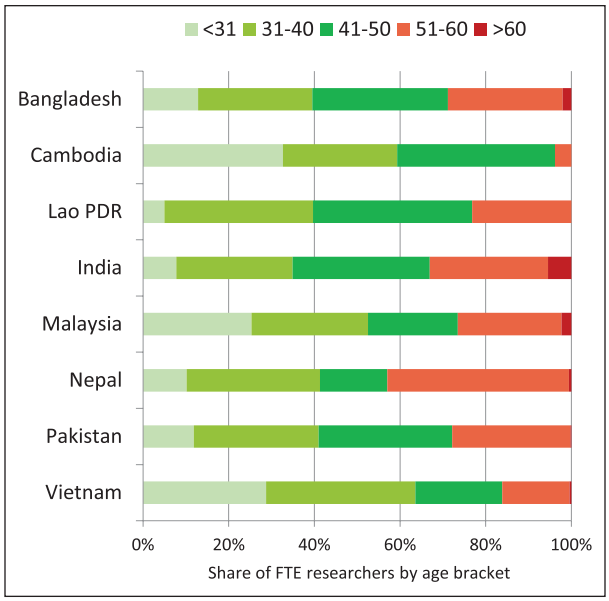
5.3. Female participation in agricultural research

Women account for close to 50 per cent of the agricultural labor force in East and Southeast Asia, and roughly one-third of the agricultural labor force in South Asia. Female researchers, professors, and senior managers offer different insights from their male counterparts, and their input provides an important perspective in addressing the unique and pressing challenges of female farmers in the region. Consequently, it is important that agricultural research agencies employ sufficiently high shares of female agricultural researchers.

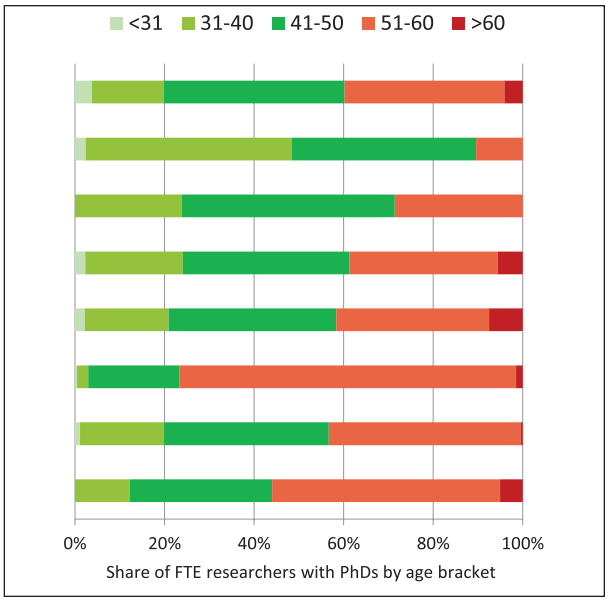
Women have historically constituted significant shares of agricultural researchers in countries like Malaysia, Myanmar, the Philippines, and Sri Lanka; however, in countries like Bangladesh (12%), Nepal (13%), and Pakistan (12%), shares of women scientists remain very low (Figure 5). These countries still have a long way to go in ensuring female participation in agricultural research and integrating gender perspectives into the formulation of related policies.

5.4. Need to continuously monitor Asian agricultural research resources

New quantitative evidence presented in this report demonstrates that total agricultural research spending



a. Total research staff



b. Total Ph.D. qualified research staff

Figure 4. Distribution of agricultural researchers by age bracket (*Source: See Table 1*)

Notes: Data for Cambodia, Malaysia, and Vietnam are for 2010; data for Bangladesh, Nepal, and Pakistan are for 2012; and data for India and Lao PDR are for 2014. Bangladesh, India, Malaysia, Nepal, and Pakistan shares are based on a full set of government, higher education, and non-profit agencies operating in these countries; Lao PDR data only cover NAFRI; Vietnam data only cover agencies under VAAS. The available age distribution data of Indonesian researchers could not be shown in the graphs due to age bracket differences. In 2014, 14 per cent of IAARD researchers were between 25 and 35 years old, 26 per cent between 35 and 45, 39 per cent between 45 and 55, and 21 per cent older than 55. Of the Ph.D. qualified IAARD researchers, 0.3 per cent was between 25 and 35 years old, 14 per cent between 35 and 45, 47 per cent between 45 and 55, and 39 per cent older than 55.

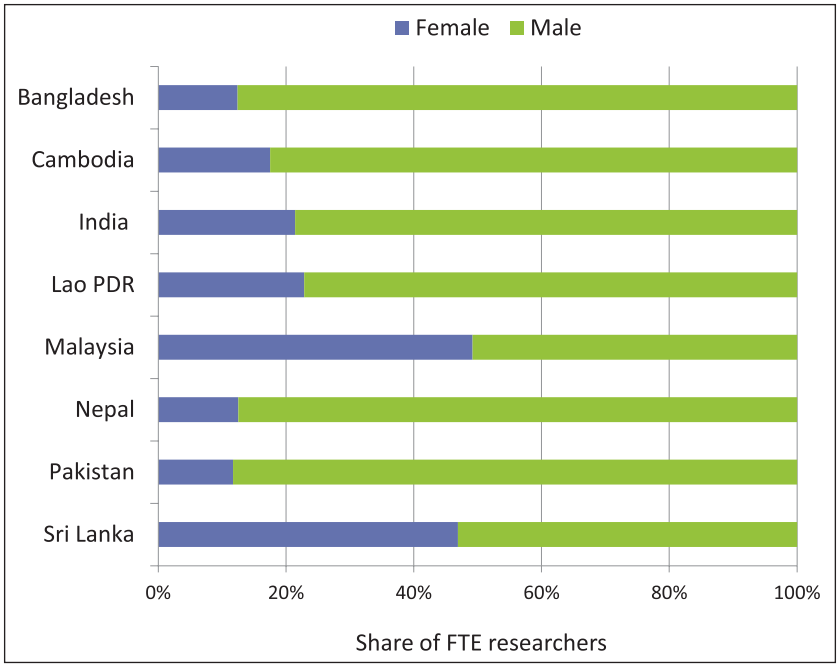


Figure 5. Female participation in agricultural research (*Source: See Table 1*)

Notes: The most recent year of data availability is 2009 for Sri Lanka; 2010 for Cambodia and Malaysia; 2012 for Bangladesh, Nepal, and Pakistan; and 2014 for India and Lao PDR. Lao PDR data only cover NAFRI.

in Asia has increased considerably since the year 2000. Most of this growth was driven by China, India, and Indonesia, all of which have well-staffed and relatively well-funded agricultural research systems. In some of Asia's smaller countries, however, investment levels have stagnated or fallen. A number of countries (Cambodia, Lao PDR, Nepal, and Pakistan in particular) undoubtedly underinvest in agricultural research and are severely challenged by outdated equipment and facilities that impede the conduct of productive research and compromise the number and quality of research outputs. Governments in these countries have to clearly identify their long-term national research priorities and design relevant, focused, and coherent research programmes accordingly. Donor and development bank funding needs to be closely aligned with these national priorities, and consistency and complementarities between donor programmes need to be ensured.

Since the turn of the millennium, a large number of Asian countries have made considerable progress in building human resource capacity in agricultural research, by increasing the number of scientists they employ and/or improving their qualification levels. Some countries will face critical human resource challenges in the near future, however, given that a large share of highly qualified researchers is approaching retirement age. Fundamental to building and maintaining strong capacity across Asia in the coming decades is the development of comprehensive recruitment, training, and succession plans, which take into account existing and anticipated gaps in specific skills and disciplines, the distribution of staffing by age and gender, and degree-level and short-term training needs.

The aim of this report was to give a general overview of where Asia currently stands in terms of agricultural research investment and capacity. Although it gives an accurate insight into developments since 2000, funding constraints prevented ASTI from providing the level of detail and precision the programme is known for in other parts of the world. It was impossible to provide up-to-date detailed trends for every country in the region and data for higher education agencies in Southeast Asian countries have for the most part been extrapolated based on pre-2010 trends. Nonetheless, thanks to the help of numerous in-country partners, ASTI was able to establish fairly decent long-term spending and capacity time series datasets.

It is crucial, however, that agricultural research expenditures, capacity, and outputs continue to be monitored more closely in Asia on the long run. Long-term funding from the Bill and Melinda Gates Foundation has enabled ASTI to establish sustainable, institutionalized systems of data compilation, synthesis, and analysis at frequent intervals in South Asian countries[1]. A solid network of national focal points has been established in these countries to facilitate this process. This has tremendously enhanced ownership of the data, and stimulated further advocacy and analysis at the national level.

Similar institutionalized data collection and analysis systems are needed in other parts of the Asia-Pacific region as well. All countries in the region benefit from clearly established metrics of performance and success, against which progress can be quantified and adjusted to produce the desired outcome. Without accurate data, research stakeholders have no way of knowing whether or not they are on the right track and remain stuck in presumptions. It is, therefore, crucial that sufficient resources are made available in the coming years to build in-country capacity for agricultural research data collection and analysis and to maintain this capacity over time.

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[1]The type of ASTI data collection and analysis in South Asia goes far beyond what has been presented in aggregated form in this short report, and covers a lot more detailed additional information. This includes agency-level data on institutional changes, researcher disciplines, seniority levels of researchers, commodity and thematic research coverage, peer-reviewed research publications, release of new crop varieties and agricultural technologies, number of students enrolled and graduated at higher education agencies, degree programs offered by higher education agencies, as well as extensive qualitative information on the status of national agricultural research systems and the associated institutional and policy environment.

respective countries. Without their commitment, this report would not have been feasible. The author also thanks Hannah Ameye, Nienke Beintema, Kathleen Flaherty, Lang Gao, and Léa Vicky Magne Domgho (IFPRI) for their assistance in data analysis and their comments on a draft version of this report.

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3. A Synthesis of the Status of Agricultural Research and Investment to Support Sustainable Development in Countries of Asia and the Pacific

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ABSTRACT

In order to provide background information about the current policies, strategies, priorities as well as current capacities and trends of investment in agricultural research and innovation to support sustainable development in countries of Asia and the Pacific, a structured questionnaire was sent to 25 countries seeking a brief status report. Twenty two countries responded of which, based on GDP per capita at current prices in 2014, 5 were classified as high income, 7 as medium income and 10 as low income countries.

Responses revealed that major policies that have implications for agricultural research in these countries include food security/food supply, productivity improvement, sustainable natural resources management, sustainable development or sustainability, competitiveness and market development, rural development, rural income generation and livelihood. Specific meaning and implication of each of the above policies vary across income groups and countries. Among the strategies adopted to implement the policies include two broad categories: one is related to research and technology transfer and the other is related to building organization, market development, and regulations. There are differences between countries and income groups in terms of specific strategies adopted.

Among the main focus and priority areas for research and development, top on the list is a broad area encompassing global warming/ climate change/ natural resources management/environment, which is common across income groups. Other areas include frontline research and innovation, strengthening market/value chain/competitiveness, stability of food supply/commodity supply, establishment of advanced facilities/services/ infrastructure, problems of producers/industry. There are differences between income groups in terms of importance of focus areas. Agricultural research and innovation is primarily a public sector activity in nearly all the countries; in high income countries, private sector, NGOs and farmer associations also play some role. Precise information on levels of investment and their sources were not available. However, available cursory information suggests that agricultural research is under-funded and under-invested. Climate change, environmental problems and their consequences are perceived as the most important challenges facing the countries across all income groups. Other perceived challenges fall into two broad categories - technology for productivity improvement and market development, and research staff, facilities and laboratories. All the countries have ongoing plans built on past achievements to address future challenges.

It is recommended that during the discussion on future agenda and priorities, in addition to the above issues, consideration should be given to alignment with sustainable development goals agenda, the increasing importance of livestock sub-sector in the region, the need for strengthening research-policy-end user partnerships and interactions, and the need for stronger collaboration within regional bodies like the ASEAN and SAARC.

Keywords: Agricultural research; Objectives and strategies; Investment; Sustainable development, Asia-Pacific, APAARI

1. Background and Objectives

Over the last few decades, world agriculture produced remarkable results. The availability of food supplies has outpaced the growth in population which enabled millions of people to get out of poverty, hunger and malnutrition. However, continued prevalence of poverty, hunger and malnutrition,

especially in parts of the Asia-Pacific region, pose new challenges for agriculture. Even though the number of hungry people decreased by 43 per cent since 1990-92, the region still contains over 642 million poor and hungry people representing two-third of the world's total poor and hungry. During 2011-13, nearly 1/8th of the population in the region did not have enough food to meet their daily minimum dietary energy needs (FAO 2014). A significant proportion of the people in the region are also suffering from hidden hunger or deficiency in micro-nutrients. In 2013, globally 161 million children below the age of 5 suffered from chronic malnutrition (UNICEF 2015). Among them about two third are located in the Asia-Pacific region. In some countries, incidence of child under-nutrition is over 40 per cent. Paradoxically, overconsumption, especially of some livestock products, among a section of the rich population leading to obesity and other related health hazards are also emerging as new problems in more advanced countries in the region as elsewhere.

Addressing these problems in the future will be doubly challenging because of a number of reasons. The successes in the past have been achieved at great cost to natural resources. Excessive pressure on land and water resources resulted in their degradation; drive towards higher productivity, standardization and uniformity of output resulted in enormous loss of biodiversity in both plant and animal populations. Application of inappropriate production practices led to increased global warming and damage to ecosystems creating new problems for both human and ecosystem health (FAO 2014). These problems are likely to aggravate in the future because estimates suggest that by 2050, the region will add one billion more people; rapid economic growth in some countries will increase income levels significantly and nearly two third of the population will live in urban areas compared with about 42 per cent in 2010.

Meeting the food demands of this larger, more urban and more prosperous population will require doubling the availability of food of both crop and animal origin in the region. Both production and trade will play key roles in future food supplies. Given the scarcity of arable land in the region, much of the increased food needs have to be produced through improving productivity - both specific factor productivity as well as total factor productivity - giving particular attention to improving the livelihoods of the poor and maintaining the integrity and resilience of natural resources. But scientific breakthroughs in agriculture in the region have become fewer in recent years indicating a sign of stagnation. So there is no alternative but to revitalize science, technology and innovation in agriculture to address the emerging challenges.

Designing future plans and actions in science and technology for agriculture and rural development will require an understanding of past trends in investment, development and achievement and the current situation. It is generally known that the countries in the region are diverse in terms of level of development, resource endowment, especially man-land ratio, level of investment and advancement in technology, research and innovation capacity, and importance of trade in national income. So they may have non-equivalent perspectives and policy objectives for the future. But, comprehensive information and systematic assessment about the past achievements and the current situation for the countries in the region is not readily available.

One of the objectives of the High Level Policy Dialogue was to assess current capacities, disparities and levels and trends of investment in agricultural research and innovation to support agricultural development and hence sustainable development in countries of Asia and the Pacific. In order to facilitate the dialogue, an effort was made to gather some basic information on selected aspects of agricultural research and innovation from the APAARI member countries by using a standard questionnaire. In this paper, the methodology used in information collection and a synthesis of key findings are presented to help discussion to identifying priority areas of action to promote and improve investment, policy support and institution building in agricultural research and innovations for sustainable development at both the national levels and in the Asia-Pacific region as a whole.

2. Methodology

A structured questionnaire was prepared by the APAARI Secretariat covering the following aspects: current policies and strategies on agricultural research for development; focus areas and priorities for agricultural research and innovations; institutional roles, responsibilities and partnerships; infrastructure and financial investment; major challenges and opportunities ahead; and short to medium-term plans.

Broad scope for each topic/theme was described in the questionnaire. The questionnaire was sent to the Heads of NARS of 25 countries requesting each to send a 10-15 page report. A deadline for response was given with encouragement for seeking clarification on any topic, if required. Subsequently, further clarifications and amendments were circulated to eliminate any scope for different interpretation of the information sought under a topic.

Out of 25 countries, responses from 22 were received. This high response rate indicated seriousness of the countries invited to participate in the dialogue to share their information and ideas with peers to hold a fruitful discussion on the basis of facts and evidence. The high response rate also indicated that though the responding countries differ in many ways and may have non-equivalent perspectives about various aspects of agriculture, in the increasingly globalized market economy situation, they value the need for cooperation and partnership as essential means to address the problems and challenges facing them by learning from each other's experiences.

Given that the countries in the region are diverse in several ways, grouping them into fairly similar categories was considered useful for meaningful comparison of the responses. For this purpose, two options were considered – geographic (South Asia, Southeast Asia and the Pacific) and level of income as a proxy for economic development. However, the geographic approach appeared less useful because within each sub-region there are significant variations, especially in terms of level of income or development. In the questionnaire, information on national total GDP and agricultural GDP were included and in the responses these data have been provided. However, some countries reported GDP for 2014 using different base years according to their national accounts. Moreover, data on population was not sought hoping to get it from a secondary source. But depending on the source, the population estimate might differ. Taken these deficiencies or discrepancies together, information in the questionnaire appeared inadequate to estimate per capita GDP for grouping the countries.

An alternative source was World Development Indicators (WDI) for individual countries which are generated by the World Bank using a standard approach across countries. WDIs for a country may differ from its national statistics, so choice of WDIs as a data source may carry some sensitivity but these are widely used indicators for international comparison of trends. Moreover, the indicators are regularly updated and amended based on the latest information so figures may change from one date to another, so they are taken as trends, and not as absolutely accurate values. They remain comparable because of the uniform standard approach applied.

Hence, GDP per capita in 2014 at current prices derived from World Development Indicators was used to divide 22 responding countries into three income groups (Table 1). Per capita GDP above USD 20,000 was considered high income, between USD 2,500 and 20,000 as medium income and below USD 2,500 was considered low income. These definitions are not exactly the same as that of World Bank classification of high, medium and low income countries[1]. Information on a number of other parameters for 2014 such as PPP GNI per capita, share of agriculture in GDP, share of livestock in agricultural GDP and share of rural population are also presented in Table 1 as complementary to GDP per capita as a basis for grouping the countries.

Out of the 22 responding countries, 5 are classified as high income, 7 as medium income and 10 as low income. Some important features emerge from the table.

First, relative rank of a country remains fairly similar under both GDP and PPP GNI except minor variation in a few cases. For Australia, GNI is equivalent to about 70 per cent of GDP, and for all other countries, GNI is higher than GDP by different extent: 1.05 times in case of Japan to 3.83 times in case of Pakistan. In general, GNI/GDP ratios are lower for the high income countries and higher for the low income countries, so inequality between countries is less if PPP GNI is used as the indicator of income or economic development.

Second, except a few outliers, there is an inverse relationship between level of income and share of agriculture in GDP and share of population living in rural areas. On the other hand, there is a positive relationship between level of income and share of livestock in agricultural GDP. These trends are consistent with historical experiences in advanced countries. As economies develop, agriculture and

[1]As of 1 July 2015, low-income economies are defined as those with a GNI per capita, calculated using the *World Bank Atlas* method of $1,045 or less in 2014; middle-income economies are those with a GNI per capita of more than $1,045 but less than $12,736; high-income economies are those with a GNI per capita of $12,736 or more. Lower-middle-income and upper-middle-income economies are separated at a GNI per capita of $4,125 (World Bank 2015).

Table 1. Selected attributes of some countries in the Asia-Pacific region

Income level and Country	GDP/capita at current prices, US$	PPP GNI/ capita at current Int. $	GNI/GDP ratio	% GDP from agriculture	% AgGDP from livestock	Rural population (%)
	2014	2014		2014	2013	2014
High income						
Australia	61887	42886	0.69	2.5	47.0	10.7
Japan	36194	37920	1.05	1.2*	16.9	7.0
Korea, Rep.	27971	34620	1.24	1.2	59.1	17.6
Taiwan	NA	NA	NA	1.9*	NA	NA
New Caledonia	NA	NA	NA	1.5*	NA	30.0
Middle income						
Malaysia	10934	24080	2.20	9.1	21.6	26.0
China	7594	13130	1.72	9.2	32.0	46.0
Thailand	5519	13840	2.51	11.6	22.4	50.8
Iran, Islamic Rep.	5315	16140	3.04	8.8*	23.2	27.1
Fiji	4546	8030	1.77	9.0*	41.4	46.6
Sri Lanka	3631	10270	2.82	9.9	12.2	81.7
Philippines	2871	8380	2.92	11.3	33.0	55.5
Low income						
Bhutan	2381	7570	3.18	17.1	6.0	62.1
Papua New Guinea	2108**	2510**	1.19	27.6*	NA	87.0
Vietnam	2052	5350	2.60	18.1	28.6	67.0
Lao PDR	1760	5060	2.87	24.8*	18.3	62.0
India	1596	5640	3.54	17.0	20.5	67.6
Pakistan	1334	5110	3.83	25.1	28.0	61.7
Bangladesh	1093	3330	3.04	15.9	13.0	66.5
Cambodia	1091	3100	2.84	28.7*	10.0	79.0
Nepal	697	2420	3.47	34.3	26.8	81.8
Afghanistan	659	1960	2.97	20.0*	NA	74.0

Note : PPP GNI (formerly PPP GNP) is gross national income (GNI) converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GNI as US dollar has in the USA

NA denotes that data are not available

*Source: World Bank 2015; For livestock share of AgGDP, (FAO 2015) http://faostat3.fao.org/download/Q/QV/E), accessed on 13 November 2015. *Reported in Country Reports for APAARI High Level Policy Dialogue and included in this proceedings. **Reference year 2013*

rural population decline in importance but livestock become more important within agriculture because of changes in people's consumption behaviour propelled by income growth and urbanization.

The relative importance of agriculture, livestock and rural population in countries with different income levels or levels of development has different implication for policies and strategies for agriculture, livestock and rural development. The analysis showed whether and how these characteristics are reflected in the country reports on policies for agricultural research and innovation for development.

3. Key Findings

Before presenting the results of the analysis of the responses in the country reports, some general remarks about the nature of the responses are necessary. It appears that there are significant differences in form, content and quality of information provided in the country reports. A combination of three possible sources may explain this variation. First, in spite of definition of 'broad scope' and additional clarification on various topics, it appears that the questionnaire was not adequately or sufficiently clear about the exact type of information sought under various topics. Perhaps there were still ambiguities. Second, the countries might have interpreted the information needs in their own way to suit their available information rather than tailor information to fit the questionnaire. Third, which is a corollary of the second, the country reports have been prepared on the basis of existing national policy, planning and strategy documents of one kind or another. Based on national situation and preferences, each country may have used unique concepts, narrative and vocabulary in those documents, which were also reflected in the country reports. Therefore, a particular aspect might have been described somewhat differently in different country reports.

The objective of the synthesis was to identify key issues and their patterns across three income groups to see if there are significant similarities and differences. Then explain possible reasons behind the differences to help identify possible options to address them under comparable or similar situations. In order to do so, differently expressed responses on any specific topic were carefully interpreted and sorted using subjective judgment for purposes of grouping. In this process, it has been possible to classify and sort most responses into one or the other category. Some country specific responses might have been left out of the classification exercise if they did not fit any category but have been mentioned in the text if it has special importance for that county or for the region.

3.1. Main current policies

Information on current policies that have implications on agricultural research and innovation for development was sought. In responding to this question, some interpreted this as agricultural policies having implication for agricultural research while some others interpreted it as agricultural research policies *per se*. Major responses are summarized in Table 2. It appears that food security/food supply, productivity improvement, sustainable natural resources management (NRM), sustainable

Table 2. Main agricultural policies and/or policy objectives having implications for R&D in countries in Asia and the Pacific by income level

Policy/policy objective	Number of countries responding by income level			
	High n = 5	Medium n = 7	Low n = 10	All N=22
Food security/food supply	3	7	10	20
Productivity improvement	1	5	7	13
Sustainable natural resource management	2	5	7	14
Sustainable development/sustainability	2	2	1	5
Competitiveness/market development	3	3	1	7
Poverty alleviation/inclusive growth	–	3	4	7
Increase rural income/promote viability of farming/ protection of smallholders	1	3	3	7
Rural development/rural economic growth	2	1	–	3
Promotion of agricultural industry/rural industry for economic development	3	1	1	5
Employment generation	–	1	2	3

Source: Appendix A1. (Because of multiple responses by each country, column totals will not be equal to n or N in this and subsequent tables)

development or sustainability, competitiveness and market development, rural development in its various facets are principal policies/policy objectives in the responding countries.

Food security/food supply for the nation is the paramount policy objective for 20 out of the 22 countries. However, the issue has somewhat different connotation in high income compared to medium and low income countries. For example, for Japan and Taiwan, the primary concern is to assure adequate food supply for the citizens. Both the countries depend on imports for a significant share of food supply, so for them the policy objectives are to maintain the share of domestic food supply. For the low and medium income countries, food security refers to the widely used FAO definition of food security with its four dimensions – availability, access, utilization and quality.

Sustainable natural resources management has been reported as the objective by 14 countries with additional five countries reporting sustainable development or sustainability as the objective. These two policy objectives are grouped separately because conceptually there are some basic differences between the two. While the aim of sustainable NRM is to maintain long-term productivity, integrity and resilience of natural resources, sustainable development or sustainability refers to a much wider agenda encompassing natural, economic and social dimensions of development in a society or country. While sustainable NRM as an objective has been mentioned by countries across income groups, few countries that mentioned sustainable development/ sustainability as an objective belong mostly to high and medium income groups. This pattern of response is probably an indication that there may be different levels or degrees of understanding or appreciation of the issues surrounding sustainability with higher income countries having a more wider perspective than lower income countries. In reality, lower income resource scarce countries probably need to appreciate the wider perspective of sustainable development as much as the high income countries.

Productivity improvement has been mentioned as the objective by 13 countries mostly belonging to medium and low income groups. This is understandable because in such countries productivity is lower than in the high income countries and productivity improvement is a key pathway to assure food security, increase income and reduce poverty.

Competitiveness and market development have been grouped together because these are related. Well-developed markets facilitate and promote competitiveness. This objective has been mentioned by 7 countries, mostly belonging to high and medium income groups perhaps because market and trade, especially international trade in a globalized environment, play key roles in their national economies.

Poverty alleviation, inclusive growth, rural income generation, improving farm income, viability of farming and protection of smallholders have been mentioned as objectives by 14 countries belonging to medium and low income groups with some overlap in a few cases. Though expressed in different ways, these objectives are fairly overlapping focused on improving income and living standard of rural people. On the other hand, 8 countries, 5 belonging to high income group, mentioned rural development, rural economic growth, promotion of agricultural industry and rural industry for economic development as important objectives. These objectives are of a different nature than the objectives of rural development and rural livelihood in lower income countries. In the high income countries, in order to encourage the small number of rural population to stay in the countryside, they need to be supported with appropriate industries and infrastructure to enjoy a reasonable standard of living. On the other hand, in the low income countries, a significant share of the population still live in rural areas, many of them are poor and small farmers, and agriculture sector still plays a major role in the economy especially in the rural economy (Table 1). So, for such countries, the objective of rural development is to create opportunities for rural people, especially the poor engaged in smallholder farming or other occupations, to get out of poverty. Therefore, different strategies will be required to achieve rural development objectives under high and low income countries.

Only three countries belonging to low and medium income groups mentioned employment generation as a policy objective. In theory this objective could be merged with other objectives focused on rural income generation and rural development but there is some merit in keeping it separate as remunerative employment – irrespective of location or sector - is usually a pathway to get out of poverty.

3.2. Major strategies adopted for implementing policies

The nature of responses varied widely between countries. Some responses were clearly stated and included a few items while some other responses indicated that there was some confusion about the meaning of policy, strategy and tools or instruments for policy. In the latter cases, some listed items would qualify more as tools/instruments/activities rather than as strategies. In any case, efforts were made to aggregate all provided information into meaningful groups. It appeared that the strategies pursued to implement adopted policies/policy objectives could be divided into two broad groups: one related to research and technology transfer and the other related to building organization, market development, and regulations (Table 3). Within the research and technology transfer group, there are several sub-categories. Innovation in technology transfer and support services has been the most widely used strategy in all income groups even though it can be reasonably assumed that the mechanisms applied might be different across the groups because of differences in the level of development, institutional and technological capacity and the structure of the agriculture sector with smallholder dominance in low income countries and large scale enterprises in high income countries. For example, for productivity improvement and solving problem of labour shortage due to aging of farmers, Japan is considering the use of robotics while low income countries are considering reduction of yield gap and improvement of factor productivity perhaps through conventional means of technology transfer.

Alongside innovation in transfer of existing knowledge and technology, research and development for generation of new knowledge has also been widely used as a strategy, especially in the medium and low income countries. Some countries belonging to medium and low income groups mentioned using multi-disciplinary/multi-institutional/systems research as a strategy while a few others, half of them in high income group, mentioned using need based or demand driven research that reflected the priorities of farmers, industries and consumers.

Strengthening capacity for climate risk management and natural resource management has been used by 11 countries mostly belonging to high and low income groups. However, actual implementation of this strategy might take different forms in high vs low income countries because of differences in the nature of problems. For example, it is generally well known that nutrient loading, water pollution and high level of greenhouse gas emission are some of the major problems in high income countries while soil degradation, loss of vegetation and water pollution are some of the major problems in the low income countries. So different strategies and tools and relevant capacities are required to deal with these problems in different contexts.

Table 3. Main strategies adopted for implementing agricultural policies/policy objectives in countries in Asia and the Pacific by income level

Strategies	Number of countries responding by income level			
	High N = 5	Medium N = 7	Low N = 10	All N = 22
Innovation in technology transfer/support services	5	6	4	15
Research and development, generation of new knowledge	2	5	7	14
Multidisciplinary/ multi-institutional/integrated systems research	–	3	3	6
Need based/demand driven research	2	1	1	4
Strengthen climate risk management/NRM capacity	4	1	6	11
Develop infrastructure/organization	4	3	3	10
Develop agri-food industry/value chain/market	2	2	5	9
Create fairer farm business/competitiveness	2	–	1	3
Strong IPR/regulatory science/policy advocacy	1	3	1	5
Link urban and rural development/promote land management	1	1	2	4

Source: Appendix A2

Ten countries mentioned infrastructure and organizational development as strategies, 12 countries mentioned development of market, value chain and steps for fairer competition as strategies and 5 countries mentioned strong intellectual property rights, regulatory measures and policy advocacy as strategies. Together these strategies were frequently mentioned by high and low income countries and somewhat less frequently by medium income countries. Four countries, 2 of them in low income group, mentioned linking urban and rural development, and promotion of land management as adopted strategies.

3.3. Specific focus areas covering commodities, enterprises, systems, and research approaches

It was expected that in order to answer this question, the respondents would consider all the four domains (commodities, enterprises, systems and research approaches), then identify focus areas covering one or more or all domains. Essentially, a short rather than a long list of areas of focus was expected. But responses were variable – some countries provided a short list which was self-explanatory, others provided a longer list, indicating that perhaps there were really no focus areas.

Aggregation of all information suggested that the most frequently mentioned focus area is global warming/ climate change/ natural resources management/environment (Table 4). Fourteen countries that reported these areas mentioned either one or more of these related areas and they are evenly distributed across income groups indicating that these are truly common problems in the region, though the actual form and intensity of the problems may differ between countries, between income levels and ecologies. Other focus areas mentioned in descending order of importance include frontline research and innovation, strengthening market/value chain/competiveness, stability of food supply/commodity supply, establishment of advanced facilities/services/infrastructure, problems of producers/industry, and policy/governance/ advocacy. Countries that mentioned these focus areas are fairly evenly distributed across the income groups indicating that at the theoretical or thematic level, there is some degree of convergence of areas of policy and research focus among the countries in the region across income levels though actual nature of the problems and the way they are being addressed may vary across countries and income groups.

It needs to be mentioned that in the country responses, a specific focus area may have been described in more precise or specific manner reflecting country specific situation. For example, Japan mentioned "R&D for promptly solving problems faced by the producers" as a focus area in which strong industry-academia-government collaboration is promoted to link seeds for cutting-edge technologies, such as information communication technology (ICT) and robot technologies, to the value chain of domestic agricultural, forestry and fisheries products. Another focus area is aging and decrease in number of

Table 4. Specific focus areas covering commodities, enterprises, systems, and research approaches in countries in Asia and the Pacific by income level

Specific focus areas	Number of countries responding by income level			
	High n = 5	Medium n = 7	Low n = 10	All N = 22
Global warming/climate change/NRM/environment	3	4	7	14
Frontline research and innovation	3	4	5	12
Strengthen market/value chain/competitiveness	3	2	6	11
Stable food supply/commodity supply	1	4	5	10
Advanced facilities/services/infrastructure	1	3	4	8
Problems of producers/industry	2	4	2	8
Policy/governance/advocacy	2	2	2	6

Source: Appendix A3

workers in rural areas, leading to weakening of the production base of agriculture, forestry and fisheries industries. Hence, the plan is to transform these industries into the advanced "knowledge and information industries" and make them more attractive to young people. This would lead to continued stable supply of quality food while improving the food self-sufficiency ratio. Taiwan also mentioned similar problems due to ageing of rural farming population.

3.4. Major priority areas of agricultural research and innovation for development

Two major priority areas of agricultural research and innovation for development across income groups are sustainability/natural resources management/ climate change and new technology/improved productivity mentioned by 19 and 17 countries, respectively (Table 5). Within the broad sustainability/ NRM/climate change area, a range of issues have been mentioned – soil fertility, soil erosion, soil degradation in general, soil salinity and acidity, draught and soil moisture stress, flood, sea level/ water level rise, water pollution, water scarcity and efficiency in use, loss of biomass and vegetation, loss of biodiversity, incidence of weather induced pests and diseases of plants and animals, degradation of ecosystems in general. Among these, specific priority areas vary between countries and income groups – some having a few of them, others having several or many. Moreover, different countries facing these problems may adopt different research strategies to address them. For example, Bangladesh is conducting research to develop salinity tolerant rice varieties for coastal areas prone to sea water intrusion and submergence tolerant rice varieties for flood prone areas.

Among the other less frequently mentioned major priority areas, only medium and low income countries mentioned market/value chain development and socioeconomics/policy/market research while some high income countries mentioned food supply for citizens/food safety, cost cutting innovations/ competitiveness, technology for rural industries/rural R&D/farmer need based research, innovation in the use of research output/technology, and contribution to global issues such as climate change. Under each of the above broad categories individual responding countries mentioned a few to a large number of specific areas reflecting local situations, which are widely different. However, a fairly clear distinction between high vs low and medium income country priority research areas emerge. While productivity improvement, market/value chain development and associated socioeconomic/ policy/market research are high priorities in low and medium income countries, innovation in the application of knowledge/technology, innovation for cutting cost to enhance competitiveness and innovations for rural industries and farmer needs are major priorities in high income countries.

Table 5. Major priority areas of agricultural research and innovation for development in countries in Asia and the Pacific by income level

Priority areas of research and innovation	Number of countries responding by income level			
	High n = 5	Medium n = 7	Low n = 10	All N = 22
Sustainability/NRM/climate change	4	6	9	19
New technology/improved productivity	2	6	9	17
Market/value chain development	–	3	4	7
Socioeconomics/policy/market research	–	1	3	4
Food supply for citizens/food safety	2	1	1	4
Technology for rural industries/rural R&D/farmer need based research	3	–	1	4
Cost cutting innovations/competitiveness	2	1	–	3
Innovation in use of research output/technology	1	2	–	3
Contribution to global issues such as climate change/more effective aid investment in agriculture	3	–	–	3

Source: Appendix A4

3.5. Major targets set to be addressed through agricultural development

In the questionnaire, targets set to be addressed directly or indirectly through agricultural development were illustrated with the following examples:

- Food and nutritional security (by increased agricultural productivity and production; genetic enhancement, and/or value-added processing of foods to mitigate malnutrition and under-nutrition)
- Poverty reduction (by enhancing farmers' income)
- Reduced environmental degradation (by adopting measures such as biocontrol, bioenergy, conservation agriculture, biosafety and other environmental safeguards/applications)
- Any other major target for inclusive growth and development

Further, it was clarified that target is a time bound number or figure or rate to be achieved. However, most respondents reported target in terms of issues/problems/areas without any time bound number perhaps because no time frame or date was mentioned for reporting target numbers. Eighteen, 17 and 12 countries mentioned three broad target areas, which are stable food supply/food security/food safety, sustainable development/natural resources management, and generation of new technology/improvement of productivity, respectively (Table 6). These three types of targets were mentioned evenly by three income groups. Nine countries, all belonging to medium and low income groups, mentioned poverty reduction/rural income generation as the target area. Only a few countries, mostly in high income group, mentioned competitiveness of agriculture/market performance, funding priority for rural R&D/improvement of R&D capacity, and improvement of aid effectiveness as targets.

Within each of the above target areas, responding countries listed various specific targets numbering a few to many. The actual meaning or implication of a specific target area may be different in different income groups or countries. Some examples are given for illustration.

Japan mentioned that its plan is to lower her food self-sufficiency target to a more attainable ratio and establish a new indicator, "food self-sufficiency potential (*Shokuryo Jiky uRyoku*)" to evaluate latent food production capability. The new target for the calorie-based food self-sufficiency ratio has been lowered from the previous 50 per cent by 2020 to 45 per cent by 2025 (actual: 39% in 2013). Japan also mentioned that in its research plan, there are 21 key targets set for realizing models of efficient and stable farming and for promptly solving production and distribution problems in different fields.

Australia mentioned several specific target areas under strengthening rural R&D, and another set of specific targets for improving aid effectiveness to create impact both on the aid beneficiary countries as well as domestic agriculture.

Thailand mentioned 10 specific target areas most of which have been included in the three top groups mentioned above. However, no specific number or figure or rate against any target area has been mentioned. Vietnam mentioned that the strategy is

Table 6. Major targets set to be addressed directly or indirectly through agricultural development in countries in Asia and the Pacific by income level

Targets set to be addressed through agricultural development	Number of countries responding by income level			
	High n = 5	Medium n = 7	Low n = 10	All N = 22
Stable food supply/food security/food safety	4	5	9	18
Sustainable development/NRM	3	6	8	17
Generate and use new technology/improve productivity	2	4	6	12
Poverty reduction/rural income generation	–	4	5	9
Competitiveness of agriculture sector/market performance	2	1	2	5
Funding priority for rural R&D/improve R&D capacity	3	–	–	3
Improve aid effectiveness	1	–	–	1

Source: Appendix A5

to develop science and technology in agriculture and rural development as a key driving force for industrialization and modernization of agriculture and rural development; raising contribution to the value-added agriculture from 40 per cent in 2015 to 50 per cent in 2020; contribution of high technology products in agriculture rising from 15 per cent in 2015 to 35 per cent by 2020. Then several more specific targets to achieve the above have been mentioned.

India reported that there are various projections of increase in demand for food commodities in the country. One scenario suggests 7 per cent growth rate in national GDP, though the demand for food grains will only grow by about 50 per cent, and the rise in demand for fruits, vegetables and animal products will be more spectacular, the range being 100-300 per cent. Achieving these will require high productivity increase, especially total factor productivity (TFP), and one-third of TFP must contribute to the agricultural growth. Food safety is an integral part of food security. Twelve specific target areas have been mentioned by India to achieve food security and safety without mentioning any number or figure or rate.

Nepal has mentioned targets with number or figure or rate on several policy goals like food self-sufficiency ratio, poverty incidence, land and labour productivity, soil degradation, agribusiness share in Ag GDP and a number of others. Bangladesh mentioned several broad target areas and specific target areas under each but without any time bound number or figure or rate. On the other hand, Bhutan mentioned targets in terms of area, yield and output of different enterprises and also target in terms of number of technologies/innovations to be delivered or released. Similar examples can be given with respect to other countries.

Thus, it appears that information provided under this topic is generally complementary or consistent with information provided on policy objectives, specific focus areas and priority research areas in so far as topics/themes/issues are concerned though the specific priority problem/area within a broad theme may differ between countries and income groups. And most did not mention about quantification to indicate the target.

3.6. Institutional roles, responsibilities and partnerships

The type of information expected on this topic included types of agencies/ organizations doing different kinds of research and kind of partnership/ collaboration that has been adopted. Types of agencies/organizations could be public sector (state/province/central), private sector, Civil Society Organizations, Farmers' Organizations, regional and international programmes.

The responses show that all the countries have national level research institutions, and most also have provincial or local government level institutions (Table 7). It is not clear whether in some cases local/ provincial branches of any national institution have been treated in the same way as autonomous local/ provincial institutions. Fourteen countries reported having universities and agricultural colleges doing research. There may be under reporting in this regard as apparently in some countries universities are not included in the definition of NARS, hence they have been left out even though they undertake important research.

Table 7. Types of institutions for agricultural research and innovation for development in countries in Asia and the Pacific by income level

Types of research institutions	Number of countries responding by income level			
	High n = 5	Medium n = 7	Low n = 10	All N=22
National research institutions	5	7	10	22
Provincial/local government research institutions	4	5	8	17
Universities/colleges	3	4	7	14
Private industry	4	3	1	8
NGO/farmer associations/collectives	4	4	2	10

Source: Appendix A6

Only 8 countries, mostly in high and medium income groups, reported that private industries undertake agricultural research and innovation activities. On the other hand, 10 countries, also mostly in high and medium income groups, reported having NGOs/farmer associations/collectives doing agricultural research and innovation activities. This pattern seems reasonable because, in low income countries, large scale agricultural production and processing industries may be only a few and they are not matured enough to undertake or sponsor significant research and innovation activities. A few NGOs/collectives and farmer associations in low income countries may be involved in research activities *per se* other than routine development and knowledge dissemination activities.

On partnership, the questionnaire basically sought information on the nature of inter-institutional partnership. The responses are of varied nature and not precise enough to undertake any quantitative aggregation. However, based on the narratives and specific information in some country reports (Appendix A6), a few general observations on the nature of partnership can be made.

First, inter-institutional partnership appeared to be strong in the high income countries, emerging or medium in medium income countries and low in low income countries. Such a pattern seems consistent with reported strategies for implementation of adopted policies discussed earlier. The high income countries reported strategies that are more focused on addressing problems and needs of the farmers, consumers and industry based on consultation with those stakeholders, while the strategies reported by low and medium income countries for implementing their policies appeared to be more generic and supply driven in nature.

Second, only six countries – 2 from high income, 1 from medium income and 3 from low income groups- reported having good or strong connection with policy in designing and implementing research and innovation. In reality, such linkage of varying degrees may exist in other countries but did not come through explicitly in the responses.

Third, all the high income countries except New Caledonia are international donors of varying degrees. Each has partnership with several medium and low income countries in the region and elsewhere through technical aid projects. New Caledonia is a beneficiary of French support. It has been mentioned earlier that one of the focus target areas of Australia is to improve its aid effectiveness through making better impact on the recipient country as well as make it beneficial for domestic economy. On the other hand, nearly all the medium and low income countries have bilateral and/or multilateral aid funded projects of one kind or another.

Fourth, in addition to bilateral/multilateral partnership, link and partnership with centres of the Consultative Group on International Agricultural Research (CGIAR) system has special significance. For over the last five decades, the system has played a key role in addressing problems of poverty, hunger, malnutrition, and aspects of natural resources and ecosystems management in the developing countries through technology, institutional and policy research. The system is mandated to generate global public goods for the benefit of the poor in the developing countries. Out of the five high income countries in the Asia-Pacific region, Australia, Japan and Korea are donors to the system and Taiwan hosts the HQs of The World Vegetable Centre (AVRDC). Among the medium and low income countries, Philippines, Malaysia, India and Sri Lanka hosts the HQs of International Rice Research Institute (IRRI), World Fish, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and International Water Management Institute (IWMI), respectively. China, Thailand, India, Bangladesh and Iran are donors to the system. And nearly all the medium and low income countries, including those with HQs of a centre, have collaborative projects with one or more CG Centres (Appendix A6).

3.7. Financial investments and infrastructure

This question was expected to generate brief information on level of investment, important infrastructure related to research institutions and agricultural universities, and available human resources. Responses to these questions were highly incomplete and inadequate for aggregation for any meaningful analysis. However, based on some preliminary information that is summarized in Appendix A7, a few observations can be made.

First, with the exception of Australia, the government seems to be the primary source of funding for agricultural research and innovation in all the

countries. Information on the share of government in total expenditure on research and innovation is not available. Only one or two countries provided some general information. In China, 90 per cent of research expenditure comes from the government – both central and provincial governments. Remaining 10 per cent comes from collectives, and more recently from private industries. In India, agriculture is a state government subject so major share of the research budget comes from the state governments but the central government has many countrywide projects and also supports state governments on priority issues and projects. Some large NGOs have research programmes. In Bhutan, 63 per cent of research budget comes from the government, the rest through donor projects.

In recent times, Australia has developed a unique funding mechanism for agriculture and rural development. It is implemented through a partnership between the government, the industry and producers through the Rural Research and Development Corporation (RDC). The RDCs are funded primarily by statutory R&D levies (or charges) on various commodities, with matching funding from the Australian Government. To expand Australia's rural R&D efforts, the government matches expenditure on eligible R&D, generally up to 0.5 per cent of the determined industry gross value of production. RDCs are accountable to both industry and government. Funding is allocated on the basis of performance and accountability. Also, aid-for-trade is a major criterion for research budget allocation – any research that has potential to increase trade is supported.

However, overall, the lack of detailed information on funding allocation and investment may be partly explained by problems in defining what constitutes investment in research and innovation. Different countries may define this differently in their national budgets. Some countries may also include expenditure on extension/dissemination in research and innovation budget, others may not.

Secondly, only China, Bangladesh and Papua New Guinea provided the information that their agricultural research expenditure is equivalent to 0.5-0.6 per cent, 0.67 per cent and 0.60 per cent of agricultural GDP, respectively against 2 per cent of AgGDP recommended for developing countries. Out of China's agricultural research budget, 50 per cent is allocated to crops, and 6 per cent to livestock. Nepal reported that spending on research as a share of the agriculture sector budget has declined from 10-12 per cent in the past to about 8 per cent at present. Generally speaking, agriculture research and innovation is under invested in the low and medium income countries.

Third, several countries have reported the number of scientists engaged in agricultural research and innovation (Appendix A8). But, these are possibly incomplete and underestimates because some countries mentioned only staff employed by government institutions leaving out universities/ colleges, NGOs and private sector, even if they may be small in number. Because of differences in size of the country, the economy, and level of development, these absolute numbers are also not directly comparable without some common denominator.

However, there are a few important observations about the quality of the research staff in some of the reporting countries. In Korea, Taiwan and Japan, 72, > 40 and 38 per cent of research staff, respectively, have Ph.D. degrees compared to less than 10 per cent in most low income countries. In Pakistan, only 18 per cent of staff in government research institutions are Ph.Ds. compared to over 45 per cent in universities. Nepal reported that Ph.D. degree has no additional value in the system in terms of salary or promotion criteria, so there is either lack of interest in higher degrees or if the degree is acquired, it is difficult to retain the Ph.D. holders as they usually leave to join better paid NGOs/development agencies. China reported that about 50 per cent of all research staff in the country is employed in the agriculture sector. Some countries mentioned that they do not have adequate personnel in terms of number and types of skill required, though no actual figures were provided. Some mentioned that staff are aging as training for replacement is inadequate. In Japan about 15 per cent of research personnel are woman. No other country has provided this information.

Thus, the preliminary information available suggests that agriculture research and innovation is heavily under budgeted and under-invested, and the number of available personnel is inadequate in many low and middle income countries and those available are not adequately skilled or qualified.

3.8. Major challenges and opportunities

Responses on perceived major challenges and opportunities are summarized in Table 8. It appears that climate change, environmental problems and their consequences are perceived as the major challenge by 13 countries spread evenly across income groups. In reality, the exact nature of the challenges may vary between countries. Other perceived challenges are of a varied nature and only a few countries mentioned each of these. The challenges can be divided into two broad categories - one related to technology for productivity improvement and market development, the other related to research staff, facilities and laboratories.

However, there is a general pattern of the responses. It appears that for some high and medium income countries, the main perceived challenges are aging and declining rural population, generation of ICT/ biotechnology and other advanced technology to deal with productivity and other problems, food supply, food security and food safety, and maintenance of farm income to retain agriculture as an attractive occupation. It is interesting to note that some high income countries also perceive poverty, hunger, malnutrition as challenges. For example, Australia's perception of the challenges has a domestic as well as an international dimension as below:

"Agricultural productivity must increase if the world is to continue to feed, clothe and support a growing population from fixed or shrinking land and water resources. Research is an essential driver of productivity growth in agriculture, and well-managed agricultural research can deliver innovative, lasting solutions that bring sustainable change to those who need it most. Research also provides new knowledge, technologies, capacities and policies to deal with rapidly changing contexts, such as increased globalization of the agriculture and food-sector markets, new and emerging food safety and quality issues, changing diets, and the rapid rise of supermarkets and consolidation within food supply chains.

Investment in agricultural research for development is a highly effective option for reducing poverty for a relatively large beneficiary population: net sellers of food receive greater income through increased production, while net buyers have greater access to, and possibly pay lower prices for, food. This aligns with and supports Australia's foreign policy objectives–regional prosperity and security, global peace and an open international economic system.

The inseparable challenges of poverty, malnutrition and hunger remain among the

Table 8. Major challenges and opportunities facing the countries in Asia and the Pacific by income level

Major challenges and opportunities	Number of countries responding by income level			
	High n = 5	Medium n = 7	Low n = 10	All N = 22
Climate change/environmental problems	2	6	5	13
Aging/declining rural population/rural transformation	3	1	–	4
ICT/biotechnology/other advanced technology	2	1	1	4
Food supply/security	2	2	–	4
Food safety	2	1	–	3
Maintain farm income	1	1	–	2
Poverty/hunger/malnutrition	1	2	–	3
Productivity improvement/value addition	1	2	3	6
Yield gap/use of knowledge	–	1	3	4
Market development/competitiveness	1	2	4	7
Inadequate/aging research staff	1	2	6	9
Inadequate/reduced funding for research	–	2	5	7
Inadequate/aging labs/facilities for research	–	2	4	6

Source: Appendix A7

world's greatest challenges. Australia, as a wealthy nation with a strong heritage of agricultural innovation, has an active role to play in overcoming these challenges by building mutually beneficial agricultural partnerships with developing countries."

It is in the above context that problems of poverty, hunger, malnutrition, gender equality feature as challenges in Australia's perspective.

Paradoxically, the above challenges are either not mentioned by low income countries or mentioned very infrequently perhaps because poverty, hunger, malnutrition and gender inequality are part of their life, so for them the challenges are rather to find ways to overcome them. Hence, for some medium and low income countries, the main perceived challenges are productivity improvement and value addition, reducing yield gap and use of knowledge for that purpose, market development and improvement of competitiveness, inadequate and aging research staff, inadequate and reduced funding for research, inadequate and aging facilities and laboratories.

Beyond this general classification of challenges, some countries mentioned specific challenges facing them. For example, Japan mentioned post-earthquake rehabilitation in northern Japan as a major challenge. Nepal mentioned, balanced budget allocation between sectors and regions as a challenge perhaps because of the newly adopted constitution with provisions for decentralization of governance. Some countries mentioned land scarcity and loss of land to urban development as a major challenge.

Few countries mentioned specific opportunities perhaps because the identified challenges implicitly indicate opportunities for development as well as potential for cooperation and partnership, especially on those challenges which are broad and common to several countries, if not all. Some countries mentioned specific opportunities, for example, Bhutan intends to develop organic farming as a mechanism to promote trade given its natural and until now undisturbed pristine environment.

3.9. Looking ahead: road map for short and medium-term

The responses to this question indicate that all the countries have ongoing plans and programmes built on past achievements to address future challenges (Table 9). There is no general pattern of the plans – some are operating within the framework of

Table 9. Looking ahead – short and medium-term plans

Level of income and country	Short and medium-term plan in view
High income	
Australia	More effective monitoring and emphasis on agriculture and human health and agriculture and mining
Japan	Existing road map to be updated with stakeholder consultation i.e. government, industry, academia
Korea, Republic of	Several specific plans are in action
Taiwan	Usually research and development are planned in 2-6 year cycles
New Caledonia	A stakeholder consultation based problem identification and plan is underway
Medium income	
Malaysia	Tenth Malaysia Plan period (2010-2015) will continue to implement the National Agrofood Policy (NAP4), 2011-2020
China	Both short and long-term projects that address priority national or local government issues are funded through annual budget mechanism
Thailand	More proactive engagement with ASEAN for AEC is envisaged
Iran, Islamic Rep. of	The national research system will be reformed to adopt a more holistic approach to research for development during 6th plan 2016-20

Contd...

Table 9 (Contd.)

Level of income and country	Short and medium-term plan in view
Fiji	Fiji 2020 Agriculture Sector Policy Agenda Modernising Agriculture prepared in 2014
Sri Lanka	No formal road map, R&D guided by 2016-18 production plan with national policy goals stated earlier
Philippines	Will continue to implement industry specific S&T programme as R&D is vital for development
Low income	
Bhutan	Progress is mostly on target, short-term goal is to implement current plan activities, long-term is to reprioritize based on experience
Papua New Guinea	Implementation of current strategy and projects and efforts to increase funding planned
Vietnam	Agriculture sector restructuring plan to 2020 is underway to make research more systematic and effective, and increase level of investment
Lao PDR	Recognize need to mobilize more funds, increase research collaboration with domestic and outside partners
India	Continue implementing current plans and strategy and strive to increase level of investment in agricultural research
Pakistan	More effective participation of stakeholders and increase in funding level envisaged.
Bangladesh	Implementation of current strategies planned within the framework of 7th five year plan and country investment plan adopted earlier
Cambodia	Recognize need to develop national agricultural research plan
Nepal	More collaboration with CG centres planned with possibility to increase outside funding
Afghanistan	No formal road map but intends to build research capacity in its various dimensions

Source: Country reports for APAARI High Level Policy Dialogue

five year plans or on longer term strategic plans or on indicative plans operationalized through annual budgets or a combination of the above. Some countries emphasized more stakeholder engagement in future planning, some mentioned specific issues for focus such as agriculture and human health and agriculture and mining, some mentioned more collaboration with CG centres while others expected more interaction within regional bodies such as Association of South East Asian Nations (ASEAN), and some envisaged restructuring national research system. This information is to some extent helpful to understand priorities and current thinking about preparedness and gaps to address ensuing challenges.

4. Summary and Recommendations

4.1. Summary of findings

Analysis of the information received from the 22 countries having revealed that major policies that have implications for agricultural research in these countries include food security/food supply, productivity improvement, sustainable natural resources management, sustainable development or sustainability, competitiveness and market development, rural development, generation of income and rural livelihood in its various facets. However, specific meaning and implication of each of the above policy/policy objective vary across income groups and countries.

Among the strategies adopted to implement the policies/policy objectives include two broad categories: one is related to research and technology transfer and the other is related to building organization, market development, and regulations. Within the research and technology transfer related strategies, there are several sub-categories such as innovation in technology transfer and support services, research and development for generation of new knowledge, multi-disciplinary/multi-institutional/systems research, need based or demand driven research that reflect the priorities of farmers, industries and consumers, and strengthening capacity for climate risk management

and natural resource management. There are differences between countries and income groups in terms of the strategies adopted.

Among the main focus areas for research and development reported, top on the list is a broad area encompassing global warming/climate change/natural resources management/environment which is common across income groups. Other focus areas include frontline research and innovation, strengthening market/value chain/competitiveness, stability of food supply/commodity supply, establishment of advanced facilities/services/infrastructure, problems of producers/industry, and policy/governance/advocacy. There are differences between income groups in terms of importance of different focus areas.

Among the main priority research areas, sustainability/natural resources management/climate change and new technology/improved productivity are the most frequently mentioned areas across all three income groups. Among the other less frequently mentioned major priority areas, only medium and low income countries mentioned market/value chain development and socioeconomics/policy/market research, while some high income countries mentioned food supply for citizens/food safety, cost cutting innovations/competitiveness, technology for rural industries/rural R&D/farmer need based research, innovation in the use of research output/technology, and contribution to global issues such as climate change. Within each of the above priority areas, there are more specific areas and their nature varies across income groups and countries.

Agricultural research and innovation is primarily a public sector activity in nearly all the countries; in high income countries, private sector, NGOs and farmer associations also play some role. Precise information on levels of investment and their sources were not available. However, available information suggests that agricultural research is under-funded and under-invested in relation to its potential contribution to the economies. In the low income countries, laboratories, facilities and personnel are inadequate, of poor quality and aging.

Among the major challenges facing the countries in the region, climate change, environmental problems and their consequences is perceived as the most important area across all income groups. Other perceived challenges fall into two broad categories - one includes technology for productivity improvement and market development, the other includes research staff, facilities and laboratories. However, there is a general pattern of the responses. For some high and medium income countries, the main perceived challenges are aging and declining rural population, generation of ICT/biotechnology and other advanced technologies to deal with productivity and other problems, food supply, food security and food safety, and maintenance of farm income to retain agriculture as an attractive occupation. On the other hand, for some medium and low income countries, the main perceived challenges are productivity improvement and value addition, reducing yield gap and use of knowledge for that purpose, market development and improvement of competitiveness, inadequate and aging research staff, inadequate and reduced funding for research, inadequate and aging facilities and laboratories.

All the countries have ongoing plans and programmes built on past achievements to address future challenges. There is no general pattern of the plans – some are operating within the framework of five year plans or on longer term strategic plans or on indicative plans operationalized through annual budgets or a combination of the above. Some countries emphasized specific areas of action in the future e.g. more stakeholder engagement in future planning, restructuring national research system, more collaboration with CG centres or within regional bodies such as ASEAN.

4.2. Some issues deserving strong consideration

Because of the design of the questionnaire, some issues perhaps did not come through or did not come through as strongly as they deserved to be considered. A brief account of some such issues is given below:

- Alignment with the sustainable development goals (SDG) agenda
- Structural change in the agriculture sector in the region
- More investment but where and how?
- Collaboration within regional bodies

4.2.1. Alignment with the sustainable development goals (SDG) agenda

The SDGs have been adopted at the United Nations General Assembly only recently and all the

member countries are committed to the agenda (United Nations 2015). Among the 8 Millennium Development Goals (MDGs) that preceded SDGs, only Goal 1 (eradication of extreme poverty and hunger), and Goal 7 (ensure environmental sustainability) had implications for the agriculture sector, especially for R&D. The set targets and indicators for Goal 1 indicated that the linkage with agriculture was somewhat indirect. The targets and indicators for Goal 7 indicated that awareness building and appreciation about climate change was the main objective. Goal 3 (promote gender equality and empower women) was primarily focused on equality in school enrolment, wage employment and political representation. Even then, as time passed, the potential role of agriculture in addressing MDG Goals 1, 7 as well as 3 increasingly, came to the forefront of discussion, which partly contributed to the shape of the SDG agenda.

The SDG agenda is a plan of action for people, planet, dignity and prosperity and there is also expectation to strengthen universal peace and larger freedom. Among 17 SDG Goals, the following have direct and indirect implications for agriculture, climate change and the environment:

Goal 1 : End poverty in all its forms everywhere

Goal 2 : End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Goal 5 : Achieve gender equality and empower all women and girls

Goal 6 : Ensure availability and sustainable management of water and sanitation for all

Goal 8 : Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 12 : Ensure sustainable consumption and production patterns

Goal 13 : Take urgent action to combat climate change and its impacts

Goal 14 : Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15 : Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 17 : Strengthen the means of implementation and revitalize the global partnership for sustainable development

It is recognized that implementation of the agenda will require resources, investment, technology, infrastructure and institutions including rules and regulations, partnerships – local, regional and global- and coordination and harmonization. It is recognized that each country has primary responsibility for its own economic and social development and that the role of national policies and development strategies cannot be imposed from outside. At the same time, national development efforts need to be supported by an enabling international economic environment.

In that context, it is important that national agricultural research and development plans consider the importance of alignment with the SDG agenda. From the perusal of country reports, it appears that the major policies, strategies, focus areas and priority research areas contain elements that are consistent with the SDG agenda. But, they are not well-expressed and some aspects may be missing. So, more systematic alignment needs to be made.

One possible approach to deal with this is to take the relevant SDG goals, associated targets and indicators, and see how current national agricultural policies, strategies, priorities fit the SDG framework, what elements are missing and then see how missing elements can be addressed. If all individual countries adopt the same approach, a coherent bigger picture will automatically emerge.

4.2.2. Prospective structural change in the agriculture sector in the region

It was mentioned in the introduction that as economies develop, agriculture and rural populations decline in importance but livestock become more important because of changes in people's consumption behaviour propelled by income growth and urbanization. This is reflected in falling share of rural population, falling share of agriculture in GDP and rising share of livestock in agricultural GDP. The relative importance of agriculture, livestock and rural population in countries with different income levels or levels of development has different implication for policies and strategies for agriculture, livestock and rural development.

The present livestock agenda for the rich and poor nations are polarized and quite different. In the developed countries, demand for livestock products, especially for meat, has levelled off, there is substantial efficiency gains in production due to advances in technology, major infectious diseases have been progressively controlled and food safety are major concerns. There is increased sensitivity to natural resources management and there is progressive improvement in management of antimicrobial use. On the other hand, in the poorer countries, demand for livestock products is growing rapidly, and livestock can be a pathway to improve nutrition, reduce poverty and contribute to development. But for that to happen, many challenges relating to genetics, feed, disease management and market development need to be addressed.

Globally, out of top ten agricultural commodities in value terms, half are livestock commodities like milk, chicken, pork, beef. Among the top ten commodities, maize and soybean are important crops and a significant portion of these are used as animal feed – hence connected to livestock. In various sub-regions of Asia, of the top five agricultural commodities, 2-3 are livestock commodities though the rank of a specific livestock commodity differs between the sub-regions. For example, in South Asia, milk is the top most commodity in value terms among all agricultural commodities, while in East Asia it is pork (Figure 1). So the historical pattern can also be observed in the sub-regions reflecting different levels of development. Among the high income countries, Australia is a major net exporter of livestock products. Among medium and low income countries in the region, only Thailand and India are net exporters of meat; all others are net importers of meat and milk. Various projections indicate that net import will increase if investment in livestock sector is not given due attention.

Although in some country reports, livestock has been included as a priority research focus area the significance and implication of the prospective structural change in the agriculture sector in the region with livestock becoming a more important activity in value terms in many countries has not been adequately captured. So this deficiency should be corrected and proper attention be given to the livestock sub-sector within broad agriculture sector to address SDGs.

4.2.3. More investment but where and how?

Though statistics on investment in R&D in agriculture and rural development was scanty in the country

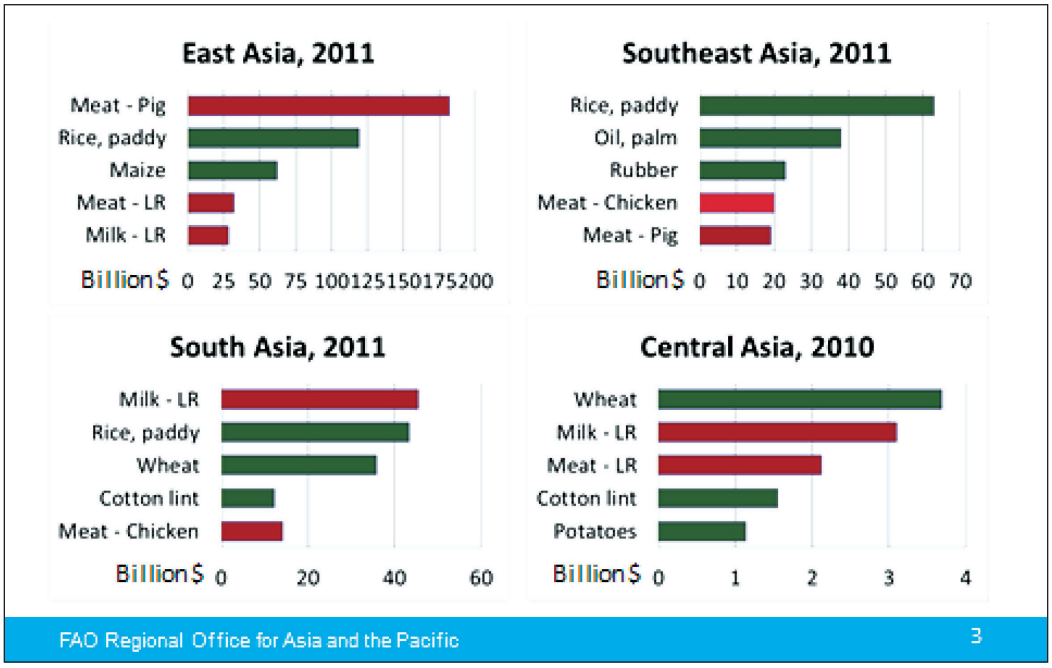

Figure 1. Top 5 agricultural commodities in value terms in all Asian sub-regions (*Source: Vinod Ahuja, personal communication*)

reports, it is recognized that the current level of investment is low and needs to be enhanced significantly. Rationale for increased investment in research is well known. Many studies have shown that rates of return on research expenditure are higher than returns in other fields of expenditure. Results of a more recent comprehensive study are reported by Yu *et al.* (2013). The authors have also studied impact of public expenditure on agriculture in China, Indonesia, Thailand and Uganda and found that expenditure on R&D has the highest impact followed by expenditure on roads, education, irrigation, extension, electricity, soil-water and health (Table 10).

However, high level of investment *per se* may not lead to high impact. Scientists involved in basic research may not embark on research with 'application in mind' or under the 'nagging opportunities of need and use'[2]. But at the end, knowledge generated by basic research is eventually applied for the welfare of people and society. For much of downstream adaptive and applied research, logic of uninhibited basic research just for generating knowledge does not apply. Many low income countries may have to prioritize where and how their limited research resources should be allocated to make impact and earn best possible returns for tax payers' resources.

Development is an outcome of the interplay of ideas, institutions and beneficiaries (Figure 2). Science and research fall in the idea category, institutions are primarily represented by policy and beneficiaries are represented by producers, consumers and industries who are end users of science and policy. If science and research community are to influence the course of development, they must be aware of its dynamics. Identifying emerging issues is a critical role for science in informing policy based on needs and demands of the end users. In the literature on science-policy-industry interface, there are several models of how researchers interact with policy and beneficiaries or end users to influence the pathways for development.[3]

There may not be any ideal model for demand-led teaching and research but the bottom line is that if researchers and teachers want to influence the policy and development process, they need to understand and respond to what is going on in the 'institutions' and 'beneficiaries' domains (right half in Figure 2). If the actors in the three domains remain in their silos and act without adequate interaction with each other (left half in Figure 2), every domain will end up using society's resources inefficiently or sub-optimally.

Donors to the CGIAR system now-a-days demand science quality, impact and innovation

Table 10. Rank of the impact of public spending on agriculture

Expenditure domain	China	Thailand	Indonesia	India	Uganda
R&D	1	1	1	1	1
Education	2	3	–	3	–
Roads	3	–	–	2	–
Telecommunication	4	–	–	–	–
Irrigation	5	4	2	4	2
Extension	–	–	3	–	3
Electricity	6	2	–	8	–
Rural development	–	–	–	5	–
Soil and water	–	–	–	6	–
Health	–	–	–	7	–

Source: Yu et al. (2013)

[2]See the following two statements quoted in Perry (2015) :"Science can flourish only in an atmosphere of complete freedom, protected from the nagging importunities of need and use, because the scientist must travel where his imagination leads him". Peter Medawar, Nobel Prize in Physiology or Medicine, 1960. "We do science best when we don't have an application in mind". Thomas Südhof, Nobel Prize for Medicine, 2013.

[3]Based on a series of lectures by Mohammad A. Jabbar given at a FAO RAP sponsored training course on Building Policy Capacity Towards Sustainable Livestock Sector Development in Asia, held in Bangkok, Thailand on 26-30 July, in Vientiane, Lao PDR on 2 -6 November, 2015 and in Bogor, Indonesia on 9-13 November, 2015.

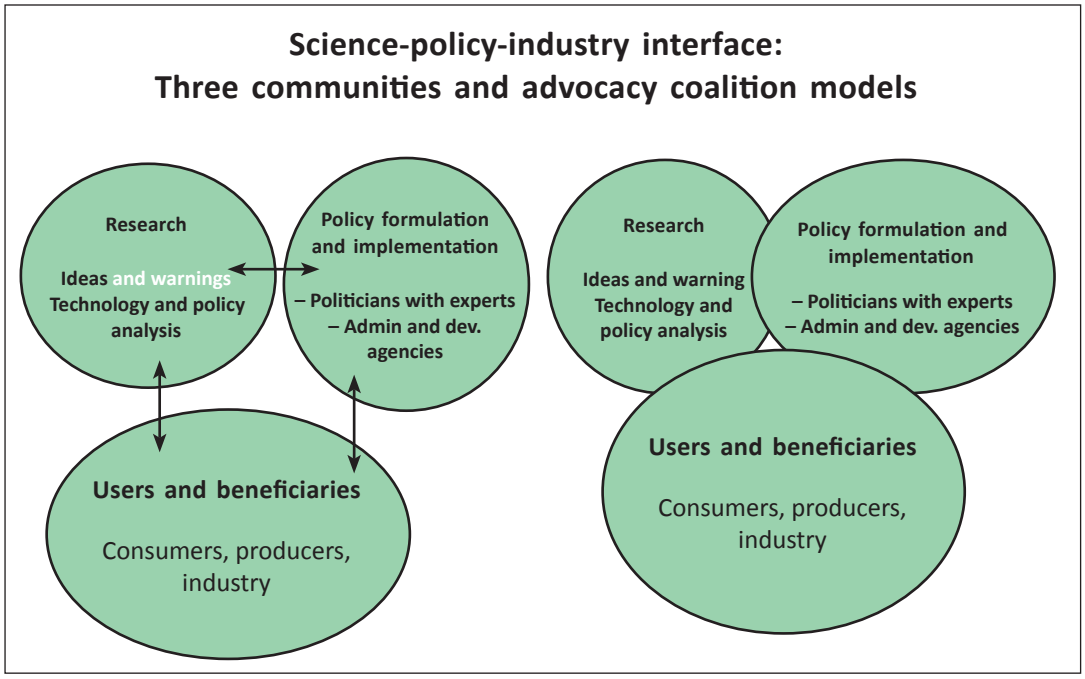

Figure 2. Science-policy-industry interface

simultaneously, and also quickly. The CGIAR works in partnership with governments and institutions in medium and low income countries, institutions in high income donor countries and with other international organizations. Therefore, the responsibility for delivery of output is quite diffused and complex with problems of attribution. Yet without demand for quality and impact, the system would be less successful than it has been.

Donor demand for science quality, impact and innovation in bilateral technical aid projects implemented in low and medium income countries is less effective because in such countries national research systems often work under an environment of weak partnership and interaction between science, policy and end users. So, national research systems deliver less than their potential output and impact. There are enough knowledge and technologies on the shelf in low and medium income countries that can be packaged and put into use to solve existing problems while undertaking new research to generate new knowledge and technology. Overall impact can be enhanced in such countries if more expenditure on R&D is accompanied by more demand for performance, accountability and effectiveness of the expenditure. More effective interaction among science, policy and interests is likely to increase effectiveness and accountability of R&D expenditure. Such an approach will induce a change from a dominantly disciplinary structure of science and research to problem and results oriented multi- and interdisciplinary approaches to research and development.

4.2.4. Collaboration within regional fora

The ASEAN and the South Asian Association for Regional Cooperation (SAARC) are two major sub-regional bodies. The ASEAN Economic Community Blueprint (ASEAN 2013) envisaged a major role for the agriculture sector for creation of a single market and production base which is regionally and globally competitive. Among three strategic objectives for the Food, Agriculture and Forestry Sector to achieve ASEAN Economic Community (AEC) goals, the second one is "to promote cooperation, joint approaches and technology transfer among ASEAN Member Countries and international, regional organizations and private sector". A review of achievements up to 2014 showed that many activities have been successfully completed and others are in progress but there are a few, if any, inter-country collaborations in agricultural research that have been initiated and funded by the ASEAN. Only in donor funded multi-country projects, there is collaboration. Among the ASEAN Member states that sent country reports, only Thailand mentioned intention for

more inter-country collaboration within ASEAN in the future.

SAARC agreement also envisages strong inter-country collaboration in science and technology, especially in the agricultural sector. But in reality not much progress has been made.

Both the bodies should consider possibilities of stronger inter-country collaboration in agricultural research and technology transfer to reduce cost by avoiding duplication, by achieving economies of scale in handling bigger issues by pooling together financial and human resources rather than trying to do bits and pieces individually due to inadequate scientific and financial resources.

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Appendix A1. Main agricultural policies and/or policy objectives having implications for R&D in countries in Asia and the Pacific

Income level and country	Food security/ food supply	Sustainable development/ sustainability	Sustainable NRM	Productivity improvement	Competitiveness/ market development	Agric industry/ rural industry for economic development	Rural income/ viability of farming/protect smallholders	Rural development/ rural economic growth	Poverty alleviation/ inclusive growth	Employment generation
High income										
Australia		√		√	√	√				
Japan	√	√				√		√		
Korea, Republic of					√		√	√		
Taiwan	√		√			√				
New Caledonia	√		√		√					
Medium income										
Malaysia	√	√	√	√	√	√	√		√	
China	√			√			√	√		
Thailand	√	√		√	√					√
Iran, Islamic Rep. of	√		√	√			√			
Fiji	√		√						√	
Sri Lanka	√		√	√						
Philippines	√		√		√				√	
Low income										
Bhutan	√	√	√						√	
Papua New Guinea	√		√	√			√			
Vietnam	√			√	√	√				
Lao PDR	√		√				√		√	
India	?		√				√		√	
Pakistan	√			√					√	√
Bangladesh	√		√	√						√
Cambodia	√		√	√						
Nepal	√			√						
Afghanistan	√		√	√						

Source: Country reports for APAARI High Level Policy Dialogue

Appendix A2. Main strategies adopted for implementing agricultural polices/policy objectives in countries Asia and the Pacific

Income level and country	Need based/ demand-led research	R&D/ generation of new knowledge	Innovation in technology transfer/ support services	Multi-disciplinary/ multi-institutional/ integrated systems research	Strong IPR/ regulatory science/ policy advocacy	Develop infrastructure/ organization	Create fairer farm business/ competitiveness	Strengthen climate risk/NRM capacity	Develop agro-food industry/ value chain/ market	Promote land management/ link urban-rural development
High income										
Australia		√	√			√	√	√		
Japan	√	√	√		√	√				
Korea, Rep. of	√		√			√		√		
Taiwan			√			√	√	√	√	
New Caledonia			√					√	√	√
Medium income										
Malaysia		√	√			√			√	
China		√	√					√		√
Thailand			√	√	√					
Iran, Islamic Rep. of		√	√	√		√				
Fiji			√	√					√	
Sri Lanka	√	√			√					
Philippines		√	√		√	√				
Low income										
Bhutan			√			√			√	
Papua New Guinea		√	√			√			√	
Vietnam								√	√	√
Lao PDR		√						√		
India		√		√	√			√		
Pakistan		√	√	√		√				
Bangladesh		√						√		√
Cambodia		√							√	
Nepal	√			√			√	√		
Afghanistan		√	√					√	√	

Source: Country reports for APAARI HIgh Level Policy Dialogue

Appendix A3. Specific focus areas covering commodities, enterprises, systems and research approaches in countries in Asia and the Pacific

Level of income and country	Problems of producers/ industry	Global warming/ climate change/NRM/ environment	Strengthen market/ value chain/ competitiveness	Frontline research and innovation	Policy/ governance/ advocacy	Stable food/ commodity supply	Advanced facilities/ services/ infrastructure
High income							
Australia		√	√	√	√		
Japan	√ Aging	√					
Korea, Rep. of			√	√		√	
Taiwan			√	√			√
New Caledonia	√	√			√		
Medium income							
Malaysia			√	√		√	√
China		√				√	
Thailand	√	√	√	√			
Iran, Islamic Rep. of	√			√		√	
Fiji		√				√	√
Sri Lanka	√	√			√		
Philippines	√			√	√		√
Low income							
Bhutan			√			√	√
Papua New Guinea				√	√	√	
Vietnam	√	√	√				√
Lao PDR		√	√			√	
India		√	√	√	√		√
Pakistan		√				√	
Bangladesh		√		√			
Cambodia			√	√			√
Nepal	√	√	√	√			
Afghanistan		√				√	

Source: Country reports for APAARI High Level Policy Dialogue

Appendix A4. Major priority areas for agricultural research and innovation for development in countries in Asia and the Pacific

Level of income and country	Food supply/ food safety	Cost cutting innovations/ competitiveness	Technology for rural industries/ Rural R&D/ farmer need based research	New technology/ improved productivity	Market/ value chain dev	Socio-economics/ policy/ market research	Innovation in use of research output/ technology	Sustainability/ NRM/climate change	Global issues/ effective aid investment
High income									
Australia			√						√
Japan	√	√	√	√				√	√
Korea, Rep. of	√	√						√	√
Taiwan				√			√	√	
New Caledonia			√					√	
Medium income									
Malaysia				√			√		
China	√			√	√		√	√	
Thailand		√			√			√	
Iran, Islamic Rep. of				√				√	
Fiji				√				√	
Sri Lanka				√		√		√	
Philippines				√	√			√	
Low income									
Bhutan			√	√	√			√	
PNG					√			√	
Vietnam				√	√				
Lao PDR				√				√	
India				√				√	
Pakistan				√				√	
Bangladesh				√		√		√	
Cambodia				√	√	√		√	
Nepal				√		√		√	
Afghanistan	√			√					

Source: Country reports for APAARI High Level Policy Dialogue

Appendix A5. Major targets set to be addressed directly or indirectly through agricultural development in countries in Asia and the Pacific

Level of income and country	Stable food supply/food security/safety	Funding priority for rural R&D/improve R&D capacity	Poverty reduction/ rural income	Generate & use new technology/improve productivity	Competitiveness of agric sector/ market development	Sustainable development/ NRM	Monitor aid effectiveness
High income							
Australia		√					√
Japan	√			√			
Korea, Rep. of	√			√	√	√	
Taiwan	√	√			√	√	
New Caledonia	√	√				√	
Medium income							
Malaysia	√						
China				√	√	√	
Thailand	√		√	√		√	
Iran, Islamic Rep. of	√			√		√	
Fiji			√	√		√	
Sri Lanka	√		√			√	
Philippines	√		√			√	
Low income							
Bhutan	√			√			
Papua New Guinea	√		√			√	
Vietnam	√		√		√	√	
Lao PDR	√				√	√	
India	√			√			
Pakistan	√			√		√	
Bangladesh	√		√	√		√	
Cambodia	√		√			√	
Nepal	√		√	√		√	
Afghanistan				√		√	

Source: Country reports for APAARI High Level Policy Dialogue

Appendix A6. Types of institutions and their roles, responsibilities and nature of partnership for agricultural research and innovation for development in countries in Asia and the Pacific

Level of income and country	National research institutions	Provincial/ Local research institutions	Universities/ colleges	Private industry	NGO/farmer associations/ collectives	Stakeholder partnership strength	Good Link with policy	International aid/ partnership	CGIAR connection
High income									
Australia	√	√	√	√	√	Strong	√	Supplier	Donor
Japan	√	√	√	√	Minor	Strong	√	Supplier	Donor
Korea, Rep. of	√					Strong		Supplier	Donor
Taiwan	√	√	√	√	√	Strong		Supplier	AVRDC HQs
New Caledonia	√	√		√	√	?		French Support	
Medium income									
Malaysia	√		√	√		Emerging		Anticipated	World Fish HQs
China	√	√	√	√	√	Medium	√	Beneficiary	Donor, CG projects
Thailand	√	√		√	√	High		Beneficiary	Donor, CG projects/AIT HQs
Iran, Islamic Rep. of	√	√	√	Anticipated	√			Beneficiary	Donor, CG projects
Fiji	√								
Sri Lanka	√	√						Beneficiary	IWMI HQs
Philippines	√	√	√		√	Medium		Beneficiary	IRRI HQs
Low income									
Bhutan	√	√	√					Beneficiary	?
Papua New Guinea	√	√	√			Anticipated		Beneficiary	?
Vietnam	√	√				Medium	√	Beneficiary	CG projects
Lao PDR	√		√			Low		Beneficiary	CG projects
India	√	√	√			Medium		Beneficiary	Donor, ICRISAT HQs
Pakistan	√	√	√			Low		Beneficiary	CG projects
Bangladesh	√	√		√	√	Low		Beneficiary	Donor, CG projects
Cambodia	√		√			Low	√	Beneficiary	?
Nepal	√	√	√		√	Low	√	Beneficiary	CG projects
Afghanistan	√	√				Low		Beneficiary	CG projects

Source: Country reports for APAARI High Level Policy Dialogue. For CGIAR donor information http://www.cgiar.org/who-we-are/cgiar-fund/fund-donors-2/

Appendix A7. Major challenges and opportunities facing the countries in Asia and the Pacific

Level of income and country	Climate change & environment	Productivity improvement/ value addition	Food supply/ food security	Food safety	Fill yield gap/use of knowledge	Poverty/ hunger/ malnutrition	Aging/ declining farming population/ rural transformation	Inadequate/ reduced funding	Inadequate/ aging labs/ facilities	Inadequate/ aging staff	ICT/ biotech/ other techs	Market/ Competitiveness	Maintain farm income
High income													
Australia		√	√			√							
Japan	√						√				√	√	
Korea, Rep. of				√			√						√
Taiwan	√		√	√			√				√		
New Caledonia										√			
Medium income													
Malaysia	√	√	√	√									√
China	√						√						
Thailand	√										√	√	
Iran, Islamic of Rep.	√							√	√				
Fiji									√	√			
Sri Lanka	√	√	√			√							
Philippines	√				√	√		√		√		√	
Low income													
Bhutan								√	√				
PNG					√			√				√	
Vietnam		√						√				√	
Lao PDR	√								√	√			
India	√				√							√	
Pakistan	√	√									√		
Bangladesh	√	√			√					√			
Cambodia								√	√	√			
Nepal								√		√			
Afghanistan	√								√	√		√	

Source: Country reports for APAARI High Level Policy Dialogue

Appendix A8. Sources and level of investment and human resources

Level of income and country	Government	Others	Investment as % of AgGDP	Number of researchers	Number with PhD
High income					
Australia		Govt-industry			
Japan	Primary	Minor industry		8425	3096
Korea, Rep. of	Primary	Minor industry		1165	837
Taiwan	Primary	Minor industry		200*	>40%
New Caledonia	Major plus French			70	12
Medium income					
Malaysia	Primary				
China	Primary 90%	Coops/industry	0.5-0.6	52240	
Thailand	Primary				
Iran, Islamic Rep. of	Primary	Donor		5000	
Fiji	Primary			49	1
Sri Lanka	Primary			519	
Philippines	Primary				
Low income					
Bhutan	Primary 63%	Donor 37%			
Papua New Guinea	Primary		0.60		
Vietnam	Primary	Donor		10895	600
Lao PDR	Primary			256	22
India	Primary	Coops/NGOs		25000	
Pakistan	Primary			3500	18%, 46% in university
Bangladesh	Primary	Donor	0.67	Inadequate	
Cambodia	Primary			312	14
Nepal	Primary	Donor	<10% of ag sector budget	412	88
Afghanistan	Primary	Donor		120	1

*Source: Country reports for APAARI High Level Policy Dialogue *at the Taiwan Agricultural Research Institute only*

4. Agricultural Research Raises Productivity and Reduces Rural Poverty: Empirical Evidence from Indonesia and Thailand

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It is often said that raising agricultural productivity is important for reducing poverty in developing countries, especially among people living in rural areas. Propositions of this kind seem reasonable but they are seldom backed by solid empirical evidence. This issue was examined empirically, in the context of Indonesia and Thailand, where reduction of poverty incidence in both rural and urban areas has been an extraordinary success story. Data was compiled on rural and urban poverty incidence at a provincial level and related to data on productivity growth in agriculture and also data on food relative to non-food prices, all at a provincial level, over time. It was found that both higher rates of productivity growth in agriculture and lower prices of food contribute significantly to poverty reduction in rural areas. The study also examined the effect of agricultural productivity growth on economic inequality in rural Indonesia and again found the effects to be highly significant.

5. Patterns and Trends in Agricultural Investment – Leveraging Whole-System Impacts

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ABSTRACT

Current policies for agricultural investment harbour a lexicon of euphemisms, cliches, dubious assumptions, conflicting beliefs and a façade of political correctness used to reinforce thinking that is best described as highly conservative if not bordering on the obsolete. Moreover many of the assumptions informing this thinking, invariably presented as innovative and strategic, is nothing of the kind.

The world is awash with money if you know where to look and who to ask. But philanthropy of all kinds, private equity, government funding and the allocation of capital for so-called "essential projects" from non-government entities are all shifting their emphasis and expectations quite dramatically in response to unprecedented and volatile global socioeconomic conditions. If the organizers of the Policy Dialogue are serious about attracting additional investment into agricultural research, or even sustaining current levels of investment, orthodox thinking will simply not suffice. But is more money the only answer?

Our species has reached a crossroads – largely as a result of our achievements and ingenuity. The issue of whether we can survive such success or whether, ironically, hubris might lead to our own extinction, is as yet unknown. Certainly the major problems of our time are impacting humanity's most life-critical systems - food production and water security among them - in ways we failed to anticipate.

As participants at this high level policy dialogue will attest, those regions of the world where hunger and poverty are most widespread are trapped in dormant or decreasing rates of agricultural investment and production. And so the real issues we must face are concerned with how we provision for the impossible. *How can we rapidly redesign our systems, cooperatively, in ways that benefit all of humanity, without further damage to each other or to the environment? What changes will we need to make to our most fundamental belief systems in order for us to be able to see possibilities that have eluded us thus far?* And, even more significantly given today's burgeoning global population of 7.2 billion people, *what does it mean to be human?*

This paper explores the differences between much orthodox thinking underpinning investment in agricultural research and recommends alternative beliefs and practices that hold clues to the emergence of a future viable system.

Keywords: Investment trends; Decreasing rate; Agribusiness; Resilience; Bottom-up; Smallholder farmers

1. Harsh Realities

The global food system is an immensely complex organism of interdependent motives, exchange and distribution mechanisms, relationships and interactions touching every dimension of society, from economics, commerce, culture and politics, to science, technology and the environment.

This life-critical system as currently configured is regulated by a few positive feedback loops all of which are designed to advantage business – particularly in the form of financial earnings that can then be used to generate shareholder wealth. As a result the food system has descended into an econocentric monoculture, reliant on fossil fuels for its continuation. It is highly efficient - but only from the point of view of maximizing profits for a relatively small cadre of corporations and their investors.

This might be reasonable if it were not for the fact that the system is actually biased against

other stakeholders - particularly those who are socially or economically vulnerable. Most other parties have become subordinate to the strategic intentions of big business and are held captive by these dynamics. This is not a predicament unique to food. It actually reflects a universal trend, starting immediately after the second World War, embracing the financialisation of every aspect of our lives.

Some of the largest and most powerful agribusiness companies in the world, including Monsanto, Nestle and Cargill, for example, have taken advantage of this situation by controlling every aspect of the upstream value chain - from the farm to the supermarket. Other powerful corporate players, such as farm machinery manufacturers John Deere, and large retail chains like Tesco and Wal-Mart, hold sway over all downstream processes. The downstream features increasingly dubious and even openly unethical practices, producing chemically saturated foods thought to be causing diabetes, malnutrition and obesity. Today more and more people are claiming with great certitude that processed food presents a serious factor in terms of human morbidity.

The organizations to whom I have alluded also benefit in other more subtle ways. By maintaining the status quo they effectively quarantine the food system from badly needed reform. They shape government food policies to reflect their particular needs. They send small producers to the wall. And by prolonging energy-intensive industrial agriculture they create a system of production and distribution that is increasingly unsustainable.

The impulse to maintain the status quo as a pre-requisite for creating shareholder wealth differs from the moral imperative of governments to care for their citizens. Furthermore, the United Nations declaration that access to food and water is a human right is still not a view commonly shared by private enterprise. Indeed there is a fundamental divergence between private and public sector aims when it comes to food: while corporations take care of their investors, the latter are more concerned with the public good. At least that is the theory.

This inherent conflict is now routinely acknowledged. And yet the unintended consequences that flow from such inconsistencies are casually ignored – glossed over for fear of damaging the relationship with big business or causing offence.

So we increasingly see corporate spin and slick marketing campaigns projecting false impressions of unity, solidarity and a shared purpose with the aims of the state. The resulting narrative is a fiction. It assumes corporations and governments alike are intent on pursuing identical aims. Nothing could be further from the truth.

Because of this wilful deception some governments - predominantly those who are financially impoverished and are also subject to ballooning public debt – witness agribusiness companies pouring billions of dollars into research projects with explicitly grandiose outcomes, such as their ambition to feed the world, for example, and then use that in justifying their reluctance to spend taxpayers' money duplicating what they perceive to be the same ends.

This means that most investment in agriculture today is channelled into a one-dimensional quest to produce more food or increase yields. Research in alternative agrarian technologies, agroecology, and poverty-reducing forms of agriculture are unlikely to receive anything other than token funds from the agribusiness industry for one very simple reason: the results would potentially weaken the industry's supremacy by freeing communities from the yoke of serfdom, thereby constraining corporate profits. Neither is the research community likely to get adequate government funding while research goals are perceived to be identical to those being pursued by the private sector.

In order to win the future agricultural investment game, the high level goals and outcomes of the non-aligned research community must be significantly different from those of the major corporate players and must be seen to produce different and better results. This is a hazardous playground politically speaking. But it is also one that is vital if the world, and the Asian region in particular, is to develop any kind of resilience in the face of what John Beddington, Senior Adviser to the Oxford Martin School, refers to as the *Perfect Storm of 2030*, where a world in which 50 per cent more food, utilizing 50 per cent more energy and 30 per cent more fresh water, will be required in a climate constrained future. The logic is bizarre!

Unless the various organizations represented within APAARI can point to inherent differences between their clients' needs and the self-serving goals of the agribusiness conglomerates, thus providing a

reasoned justification for why alternative investment strategies, currently avoided by the corporate world, are so crucial to humanity's wellbeing, nothing will radically change. No plea for additional funds based upon scientific rigour, nor emotional arguments however well-crafted, are likely to overcome the current deficit.

There is no single solution to eliminating hunger, poverty and malnutrition, nor of improving the productivity of agricultural systems. So much depends on context, resources and capabilities, a willingness to collaborate, and access to relevant innovations. But, if APAARI's strategies are not sufficiently distinctive the ability to compete against a deeply ingrained belief system that is virtually impossible to dislodge will prove futile. Fewer resources will come the way of NGOs as a consequence. But, if your strategies are not systemically leveraged you will fall still further behind. This is the most critical of your present day and future dilemmas.

Currently you are on a losing wicket. While CGIAR has enjoyed considerable success in boosting funding for agricultural research, this goes against the overall trend which is far more depressing. Copycat strategies, whereby you mimic the goals of the large agribusiness corporations and align your cause to theirs, only serves to weaken your authority and distinctiveness in the long run. So you should not try to feed the world by tweaking the current system. You should not directly pursue greater yields. And your quest should not even be to produce more and more food. Those are corporate strategies. You should leave them to the large agribusiness players.

Your mission should be complementary to the extent that it assists grass roots growers to place less reliance on industrial methods - encouraging them to move into deploying low-cost, culturally-enhancing, commons-based, and poverty-reducing agricultural innovations in the management of sustainable agro-ecosystems.

2. Risk Mitigation

This strategic dilemma is fraught with risk. The large agribusiness companies have their own research agendas. If you do not support their short-term goals (for that is invariably what they are) they may well cast you as the enemy - refusing to play game in any way that would hasten reform of the food system. That could result in them protecting their intellectual property more vigorously than before and opposing the development of alternative, albeit viable, systems at every juncture – especially in terms of agroecology.

On the other hand if you fail to impose your own unique role in the system public sector funding may stall and dry up altogether. In this case the risk is that you will be perceived to be irrelevant or, at best, superfluous fringe players, in comparison with the mainstream industry.

This situation is not all downside risk. In fact there are considerable advantages in pursuing dissimilar strategies to the corporate agribusiness industry. For example, traditional know-how and techniques, like permaculture, are often superior to industrialised farming practices. Almost all technologies are getting cheaper, especially those that enable collaboration, communication, and the sharing of information. Some are free as in The Global Innovation Commons - a massive repository of over two million inventions that are out of patent. Originally catalogued by David Martin of M.CAM, and now held in trust by my own Centre for the Future, these discoveries, ranging from clean energy and health care to foreign aid and farming, are collectively worth around U.S. Dollar 2 trillion. And they are available for anyone to use, anywhere, without restriction, at no cost.

The conventional funding mix is also changing in ways that could work well to your advantage. Corporations are becoming much more narrowly focused in their spending. The need to remain viable in highly competitive global markets, together with the fickle nature of customer loyalties, are permanent distractions for them.

Meanwhile as public debt grows, and governments begin to take the pursuit of a low carbon economy and the provision of free public services such as health and education more seriously, liquidity will shrink. Tax will shift from labour and consumption towards capital and wealth. Private equity firms, funds managers and venture philanthropists are ready to step into this void. Many investors already see agriculture as a key component in their portfolios - especially as we expect agricultural earnings to outperform equities and bonds over the coming decade.

In that context, it is important to appreciate a novel philosophy that is beginning to gain ground

in the investment community. As the conscience of ultra high-net-worth individuals, persuaded by a few celebrity investors with an humanitarian ethos - like Bill Gates, Warren Buffet, and Warren's son Peter - shifts deeply ingrained attitudes about how wealth might be better used, philanthropy is being reinvented. Today's impact investors aspire to leverage massive social change where revenue-generating portfolios are used to channel funds into more principled "not-for-profit" ventures that can scale once the source idea is proven to be effective.

Seen purely from this perspective, the time-honoured arms-length competitive process regarding the giving of large grants is increasingly considered a blunt instrument. Outcomes are difficult to measure and appear to have little enduring impact. The use of small and micro investments to prototype new products, processes, and relationships, on the other hand, is gaining in popularity.

An acupuncture-like appreciation that small, well-targeted, donations can release entrepreneurial energy within a community, thus effecting system-wide transformation in ways that large grants often fail to do, is also becoming prevalent. This opens up new options for philanthropists and sponsors to directly engage with their beneficiaries while educating and freeing local groups to embrace new responsibilities, rather than passively accepting their plight as serfs in a system controlled and operated by a coalition of big business and government.

Another trend that cannot be ignored is the cumulative amount of money being spent on dealing with systemic emergencies. Global heating is making disasters such as floods and droughts more frequent and intense, land and water more scarce and difficult to access, and increases in agrarian productivity even harder to achieve. These effects increase the risk of hunger and the breakdown of food systems.

In this situation, it is not hard to imagine a future where a significant proportion of all monies invested will focus on the resilience of our most life-critical systems, like food production, distribution and security, for example, which is already struggling to come to terms with a global population of over seven billion people at a time when the cost of food is rising and farmers are having to adapt agricultural techniques and apply disaster management strategies.

3. Three Wild Cards

3.1 Climate

When most of us think about climate change we imagine gradual increases in temperature and only marginal shifts in other climatic conditions, continuing indefinitely or even leveling off at some stage in the future.

Conventional wisdom has persuaded us that modern civilisation will either adapt to whatever weather conditions we face, and that the pace of climate change will not overwhelm the adaptive capacity of society, or that our concerted efforts, such as those embodied in the Kyoto protocol, will be sufficient to mitigate the most severe impacts. Optimists assert that the benefits from technological innovation should be able to outpace the negative effects of climate change.

Climatically, the gradual change view of the future assumes that agriculture will continue to thrive and growing seasons will lengthen. Northern Europe, Russia, and North America will prosper agriculturally while southern Europe, Africa, and Central and South America will suffer from increased dryness, heat, water shortages, and reduced production. Overall, global food production under many typical climate scenarios increases.

This view of climate change may be a dangerous act of self-deception, as increasingly we face weather related disasters - more hurricanes, monsoons, floods, and heat waves and droughts - in every region around the world.

Past examples of abrupt climate change suggest it may be prudent to consider abrupt climate change as entirely plausible, especially because some recent scientific findings and new records suggest that we could be on the cusp of such an event.

This past October in Australia was the hottest recorded for any month since 1910. Nationally, the maximum temperatures were 3.4 degrees Celsius above average for the month and 2.7 degrees warmer than previous years. This is simply another factor that could expedite changes already noted in the way funds are allocated and investments are made.

3.2. Coal

One of the most powerful outcomes from the heightened awareness of our changing climate has

been the recent shift away from fossil fuels by a diverse group of powerful investors. The institutional shift away from is the fastest growing global divestment movement in history. This movement has already seen pension funds, universities, churches and local governments worth USD 2.6 trillion commit to pulling their investments out of coal, oil and gas companies.

As this wave of institutional divestment accelerates, individual investors will begin to embrace the same thinking - and a global investor-driven push for a new low carbon economy will become a powerful driver of change.

What is not yet ordained is where this money will be reinvested. At the moment the renewable energy industry is benefitting from early reinvestment patterns. But other options, compellingly communicated, could see huge inflows of capital to agriculture – especially as this would be viewed as a risk-reduction tactic by the markets.

3.3. Connected

The dire situation concerning food cannot be quarantined from emergencies in other life-critical systems. Investment in agricultural research and associated fields could benefit from an explicit association in the public's mind with other well exposed issues. Foremost among these today are climate change, natural disasters, terrorism and the links between food, poverty and conflict.

Arundhati Roy and others argue that the World Bank and the International Monetary Fund (IMF) under the guise of philanthropy are complicit in the development of approaches that privilege the "free market" systems of just a few global conglomerates. Currently, the World Bank is helping 130 countries to act on climate change. In 2014, it doubled financial lendings targeting adaptation. The Bank-administered USD 7.2 billion Climate Investment Funds are now operating in 48 countries, leveraging an additional USD 43 billion in clean and ethical investments.

However, while the World Bank is intent on supporting action on the ground to finance the kind of projects that help the poor find their way out of poverty, greater care must be taken to ensure that such actions do not consolidate the non-viable systems that have caused problems in the first place.

Making the connection between grass roots farming, climate change, and alternative models of distributed capital, based upon fostering community rather than reinforcing *vertical* institutional power still further, could well lead to additional funds being made available from organizations like the World Bank and the Asian Development Bank (ADB). This is acutely the case of organic, chemical-free, local agriculture as a key strategy for shifting large numbers of people out of the poverty trap.

4. Future Pathways

So what should those organizations attending this high level Policy Dialogue do that is different? How should your thinking change? How can you craft a future that continues to access available institutional and government funding for a set of unique strategic imperatives? How can you adapt to an investment landscape that is changing quite dramatically?

In the end, all strategies are temporary, because the external world is so dynamically complex the most effective strategy today is frequently navigational – a flow of real-time responses to the ever-shifting fluctuations and nuances in the food system and its context. But, the point of this Policy Dialogue is to discuss the future of agricultural investment: where is it to come from, and how should it be used for the greatest impact? To that end my advice has to do with a shift in strategic emphasis.

Members currently espouse the importance of cooperation and innovation. I would urge putting greater emphasis on reinvention, particularly the prototyping of alternative systems, processes and relationships that can spring without too much effort from a connected communal base and networks, keeping a close eye on Beddington's *Perfect Storm* as an unwavering focus.

In terms of content, a number of strategic options present themselves. These are all relatively straightforward to envisage yet require courage and determination to execute – particularly if you conclude that a move away from what previously brought success is warranted, or that you should now highlight the need for grass roots collaboration and innovation with even greater passion than before.

Taking a longer view, the main game will be to forge a revitalised and unique strategic role for those of

you attending this forum – both individually and collectively. One that heals the more destructive effects of industrial agricultural practices that have mined the earth and plundered its natural resources in a manner seemingly blind to the aftermaths. One thing is certain from a purely strategic viewpoint: you must refrain from espousing and then duplicating corporate goals. Finding appropriate alternative themes worthy of support in their own right, and projects that invite collaboration on your terms, are critical.

Your mission should be to liberate a suite of systemically forceful, financially viable, culturally acceptable and socially engaging strategies that are internally consistent, focused on outcomes that local communities find compelling and inspiring, and that help neutralise or reverse the more toxic elements resulting from the worst excesses of industrial agriculture.

This needs to start with an appreciation that the term *agriculture* has lost almost all its original meaning. Large corporate farms are fundamentally different than those of smallholders, niche producers (organics), intensive farms and urban producers. Future investment and research, therefore, needs to be framed against this more complex matrix of understanding.

For example, starting from the bottom-up, focusing on innovation that occurs as a result of reinventing management and organizational systems, and always remembering that one size does not fit all, you might focus your efforts on co-creating the following with relevant stakeholders:

- Designing ways of supplying diverse, culturally-appropriate foods to different regions
- Legitimising food democracy by securing the ability of smallholder farmers to prosper and reducing dependence on imports
- Encouraging poverty-reducing forms of agriculture that suit local conditions
- Helping cities become self-sustaining by using disintegrated supply chains; innovative composting; alternative forms of production such as agroponics, etc.
- Sharing knowledge freely in appreciation that different cultures have often pioneered solutions to present-day problems but that these are often forgotten or outlawed owing to the pressure from a highly litigious agribusiness lobby
- Advocating open source and commons-based innovations (rather than just scientific breakthroughs) that are low-cost or even free to implement – as exemplified by the Global Innovation Commons
- Finding strategies for sustaining soil and water resources and for connecting urban consumers with local organic food producers
- Strengthening cooperatives so as to sell to large buyers under dependable contracts
- Raising food security levels within areas that are currently vulnerable.

Needless to say these initiatives can only succeed if they are supported and openly complemented at national and regional levels, accompanied by an international willingness to provide a coherent framework that integrates and aligns new strategic imperatives. This is best done by designing changes into the food system that create enduring value whatever external factors prevail.

They can help, for example, by introducing natural capital accounting into national accounts; doing more to encourage local resilience; persuading affluent nations to move away from export-driven agricultural policies, thereby making space for small producers in local markets; curbing the desire of wealthy countries to purchase large tracts of global farmland for industrial purposes; containing the demand for animal feed and agrofuels; and reducing food waste.

All these examples are worthy of consideration in the context of a revitalised grass roots response to the problems facing us. They also have the advantage of fitting more suitably into an agenda concentrating on entrepreneurial activities leading to greater social impacts that are occupying the new generation of philanthropists and impact investors.

6. Investing in Agri-Biotechnology: Research for Entrepreneurship

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Many factors and trends influence the growing demand for agri-biotech products originating from both public and private sectors. These demands are fuelled, *inter alia*, by the increased need for quality and safe food and feed, improved stability of food security, for technologies to increase agricultural productivity with less fertilizer, less arable land and reduced water resources, for climate-adapted agricultural technologies (including climate-smart crop varieties) and for sustainable food production systems. Demographic trends such as population growth to nine billion by 2050, and a predominantly urban, middle-class Asia by 2030, further lead to an increased demand for diverse and high protein diets. All these needs are to be fulfilled by a greatly reduced and aged farming population. As a group of technologies, agri-biotechnology offers much scope to meet these demands. Agri-biotechnology includes conventional biotechnology (such as tissue culture, fermentation-based technologies, mushroom culture, improved crop varieties and animal breeds) and novel biotechnologies (genetically engineered organisms, marker aided selections of plants and animals, bio-diagnostic tools, new vaccines and synthetic food). The global biotechnology industry is valued at over USD 300 billion, of which biotechnology seeds are estimated to contribute USD 15 billion on 2014, approximately 35 per cent of the global market for improved seeds. Generation of agri-biotech products commonly emanates from lab-based research to prove a concept. However, the "lab to farm to consumer" pathway requires appropriate investment in R&D and the development of a new paradigm of "farmers as entrepreneurs". To enable this pathway requires supportive policies for investment, infrastructure for conventional and novel biotechnologies, public sector financial support or investment funding by the private sector, the development of human resources (especially in science), regulatory frameworks to guide the development and deployment of new agri-biotechnologies, intellectual property regimes, and finally, consumer education and public awareness of the safety of new products. Many Asia-Pacific countries have developed modern "state of the art" capacity to tap into science for supporting economic development. Examples are the Biotechnology Research Institute, Chinese Academy of Agricultural Science in China, BIOPOLIS in Singapore, National Center for Genetic Engineering and Biotechnology in Thailand, and the Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRAD). Research resource allocation is a challenging process in both the public and private sectors. Generally, the public sector tends to adopt a "science/technology - push" approach while the private sector is predominantly "demand - pull". Investment in research is, however, only one element of a complex, multi-step system that eventually leads to useful products for farmers and consumers.

7. Five Necessary Policy Changes to Help Achieve Improved Nutrition and Sustainable Agriculture through Smallholder Vegetable Horticulture

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ABSTRACT

The potential of vegetable horticulture to contribute to improved nutrition and sustainable agriculture is largely unexploited because of a chronic lack of investment in vegetable research and development. Five policy changes are necessary to correct this situation. First, reorient food policies from having a focus on staple food production towards the promotion of healthier, better-balanced diets and collection of better statistics to monitor the outcomes of such new practices. Second, invest more in horticultural research and focus on overcoming long-term priority constraints to production including the generation of sufficient well-trained human resources. Third, strengthen market opportunities for smallholder farmers through better market integration and the adoption of improved pre- and post-harvest technologies. Fourth, strengthen policy and monitoring frameworks to ensure safer pesticide use that helps protect the environment and both smallholder farm families and consumers alike. Fifth, reconsider the need for appropriate investment in vegetable germplasm development to safeguard long-term improvement in the horticultural sector and to better align new emerging varieties with the need for better nutrition in the face of climate change in a warming world. Policy change in these directions will help to unleash the substantial potential of smallholder vegetable farmers to improve the income of the poor and to provide better nutrition for all.

Keywords: Agricultural policy; Asia-Pacific; Food and nutrition security; Research investment

1. Introduction

Sustaining profitability and resilience of smallholder farm enterprises, abolishing malnutrition, ensuring food safety, maintaining environmental integrity, minimizing postharvest losses, empowering women and maintaining stable markets, are the key components of efforts by national and international agricultural research centres and regional organizations such as APAARI to contribute to the attainment of the Sustainable Development Goals (SDGs). In particular, the second goal of ending hunger, achieving food security and improved nutrition and sustainable agriculture (United Nations 2015). Yet the chronic lack of overall investment in vegetable research and development (R&D) acts as a major brake to capacity-building and widespread long term impact throughout the Asia-Pacific region. National and international policy changes are now urgently required to allow smallholder vegetable horticulture to contribute to improved nutrition and sustainable agriculture.

2. Policy Change Recommendation #1: National Policies for Food and Nutrition Security and Health that Move Beyond Staple Crops

2.1. Shift the focus from hunger to encouraging people to take up healthier, better balanced diets

National policies for food security in the Asia-Pacific region continue to have a traditional "Green Revolution" view. As a result they generally only show funding commitment for staple crops that contribute to the fight against hunger, but not so much to addressing other forms of malnutrition. For example, many governments give active long-term support to grains or roots and tubers research yet their horticultural sectors are by comparison poorly and inconsistently supported. This attitude no longer makes sense when malnutrition due to

imbalanced diets rather than hunger is the dominant constraint to poor people attaining good health. Feeding people but not nourishing them at the same time is a self-defeating policy if population wellbeing is to be promoted. Vegetables and fruits contain the vital vitamins and minerals which, when consumed in suitable diversity and in conjunction with the necessary balance of starch and protein foods, are able to maintain humans in good health (Keatinge *et al.* 2014).

Unlike food staples, which are consumed 'almost without thought', increasing vegetable consumption often needs thoughtful, intense and targeted promotion. This now requires substantial policy change from the highest levels of government downwards as, in almost every case globally, it is clear that national and international efforts to encourage people to take up healthier, better balanced diets have not worked well. The current global 'epidemics' of increased obesity and type II diabetes in India, China and the Pacific are the direct result of human induced ill health (International Diabetes Foundation 2014) from either ignorance and through poor choices of diet (Hughes and Keatinge 2013). Previously there was education targeting good nutrition in the home through home or household economics classes. These classes have largely been eliminated from national curricula. So further efforts in the education of women (who will usually be in control of the food prepared for the household) specifically on nutrition, cooking and subsequent bioavailability of vitamins and minerals is of considerable importance. Thus, vigorous policy interventions at local, national and regional levels are needed to bridge across the spheres of agriculture, health and education, whose government ministries generally do not interact sufficiently. A recent study of AVRDC's home gardens project in Bangladesh (funded by USAID), which had reached over 8,000 households by 2014, showed that training poor rural women in nutrition and gardening increased the supply of garden vegetables per capita per year from 20 to 37 kg (+86%) and increased the garden supply of plant proteins by 171 per cent, iron by 284 per cent vitamin A by 189 per cent and vitamin C by 290 per cent (Schreinemachers *et al*. 2015). Furthermore, projects such as AVRDC's "Vegetables Go to School" funded by Swiss Development and Cooperation and operating in five countries in Africa and Asia influence the dietary choices of children at a young age and makes them appreciate the importance of vegetables and fruits (see http://vgts.avrdc.org/). School and community gardens also play an important social role in communities by involving parents, local farmers and other residents (Bellows *et al.* 2010). Policies to replicate such efforts would be highly desirable (Keatinge *et al*. 2012). They would help educate children about the role of agriculture and the possible opportunities for a successful and profitable career in horticulture or agriculture which in turn may help to stem the flow of youth looking for employment from rural to urban communities.

The 2007-2008 world food crisis caused severe spikes in food prices and was caused by low grain supplies due to drought and rising fuel prices. The crisis showed us that high grain prices did not stop poor people in both developing and developed countries from eating rice and other staples but rather they cut out the more expensive items in their household budgets such as meat, fruit and vegetables. For example, a survey by HelpAge International in Cambodia in this period (Weinberger *et al*. 2009) revealed an increase in rice price for consumers from USD 0.25 to USD 0.62 per kg. The behavioural response of the poor was to shift from three meals to two meals a day, to consume less meat and only consume vegetables derived from home gardens. Violent staple food price instability, therefore, risks undermining any policy which promulgates either food or nutritional security. Yet the issue of price volatility is not unique to food staples. Some vegetables, such as onions in South Asia, are critical to national cuisines and high prices in these commodities can also result in civil unrest (Weinberger *et al*. 2009).

2.2. Collecting regular quality statistics on horticultural production

Most countries collect regular and high quality statistics on the area, production and yield of staple crops. Such data are important to detect production trends, to forecast food prices and to determine the need for imports or opportunities for exports. No comparable statistics are collected for vegetables. Such data collection is also difficult because of the large diversity in vegetable crops, strong seasonal variation and small size of production areas. Further, a substantial share of vegetable production is home garden production, which remains 'hidden' or ignored in national statistics.

Yet, more detailed data collection on vegetables is important if we are to take the challenge of addressing malnutrition seriously. Per capita vegetable availability is a good indicator of the adequacy of nutritional supplies in a country (e.g. Arsenault *et al*. 2015) and the information is needed to stabilize the supply and demand of horticultural produce to avoid price fluctuations. Good data are also important to track the impact of increased investment in vegetable R&D, which is important for government and donors with regard to Policy Change Recommendation #2.

3. Policy Change Recommendation #2: Substantially Increase Investment into Horticultural Research

3.1. Investment in human resources for horticultural research

Within the educational institutions in both developed and developing countries, commitment to horticultural capacity building is substantially neglected. This problem is now also common across many specialist scientific disciplines in agriculture with virology, entomology, plant pathology, agronomy, conventional plant breeding, soil science and crop physiology being specific examples. The loss of such trained capacity in universities in Europe and USA is particularly marked. In most Sub-Saharan African countries, there are less than 0.6 vegetable breeders per country who have to cover an extremely wide range of crop species. In contrast, the situation is slightly better for maize (and other staple crops) with an average of 2 - 2.5 breeders per country. Educational and agricultural policies need to be formulated which will encourage young people to choose an agricultural education because there will be a successful future ahead of them in a dynamic agricultural sector.

3.2. Ensure long-term funding for horticultural research and development

Current experience in horticultural R&D suggests that project funding for short-term developmental work with vegetables is presently attainable because international donors and governments feel they can see immediate attributable impact from their investments. Yet donor or national government support for longer-term research may in reality be much more important in the face of increasing trends in malnutrition and global climate uncertainty. Funding for critical subject areas such as genebank maintenance, breeding of global and traditional vegetables, modernization of available rootstock collections, the combating of pests and diseases, and ensuring environmental integrity with high value crops is much more limited. These critical areas cannot depend on project funding for their long-term stability and effectiveness. Longer-term, non-project funding is much rarer and harder to acquire in the present donor environment where short-term outcomes provide the 'stories' needed for their constituents, whereas these important areas could give much more substantial and credible impact with longer-term, assured funding.

Yet, often, relatively simple innovations can give a high pay-off, as in the case of vegetable grafting or off-season vegetable production technologies. For example, the rate of return to research investment in the UK NRI/AVRDC "Malle Roga" project which introduced tomato varieties resistant to tomato yellow leaf curl virus disease in South India was estimated soon after the project's closure to be at least 764:1. By now it will be very much higher as the improved varieties were subsequently introduced into 13 more countries and the germplasm has been included into numerous private sector hybrids throughout Asia (see http://projects.nri.org/malleroga/index.htm).

4. Policy Change Recommendation #3: Strengthen Market Opportunities for Smallholder Farmers

4.1. Link smallholders to domestic and international markets

The adoption of a diverse range of high-value crops is essential for smallholder farmers to increase their economic wellbeing under conditions of low staple crop prices and land fragmentation; yet market access remains a key constraint in many locations. It requires concerted action by public sector partners to improve road infrastructure, setup well-managed wholesale markets, facilitate farmers' access to credit and inputs, and improve the overall quality of the produce supplied. This is particularly critical for vegetable horticulture due to the perishable nature of produce and food safety issues.

An AVRDC study in Cambodia, Lao PDR and Vietnam estimated postharvest losses to be about 17 per cent of the harvested quantity and most of it was lost on the farm due to poor pest and disease control measures that led to low quality produce that farmers were unable to sell (Weinberger *et al*. 2008). Postharvest losses were the highest in Cambodia. It is noteworthy that vegetables sold in Phnom Penh are frequently imported from neighbouring Thailand and Vietnam as infrastructure and input supplies remain underdeveloped in Cambodia.

Postharvest research for vegetables is largely underfunded, but is critical for the successful development of smallholder horticultural systems. Without good postharvest management, vegetable horticulture can be very risky to farmers who become vulnerable to falling back into poverty if they had borrowed money to buy inputs. Smallholder farmers need training on how to meet market standards and how to reduce financial risk through proper management and record keeping. The effort of Thailand to expand its public GAP standard ("Q-GAP") aimed at improving the quality of food supplies in the domestic market is noteworthy, although more effort is probably required to give farmers a price premium for high quality produce.

4.2. Create incentives for smallholder farmers to adopt protected cultivation

Smallholder farmers with less than one hectare of land will probably never be able to grow enough rice or maize to escape poverty or to be resilient in the face of environmental risks or economic challenges. Yet, cultivating higher value crops such as fruits and vegetables, even on a small area of land, can be a much more consistently profitable experience, especially if they can achieve multiple cropping within a given season, or can extend the normal season by overcoming crop seasonality issues. However, to achieve this transformation it is important that horticulture is practiced in an appropriately knowledge and input intensive manner. Government policy should create incentives and credit-opportunities for smallholders to adopt protected agricultural systems such as small-scale screen/green houses for intensive, safe and sustainable production. Pest and disease management needs to be based on integrated pest management (IPM) methods including biological control; the use of pesticides needs to be judicious and well-informed. Moreover, if such incentives can include assistance at the postharvest level for farmers to transform their basic commodities through value-addition, such as solar drying, processing into pastes, fermentation or chutney making, into highly valuable market commodities with long shelf lives then small-holder prosperity can be more easily assured.

4.3. Make agricultural entrepreneurship an attractive job choice for young people

Policies to stimulate a suitable entrepreneurial environment which will allow a younger generation to enter the agricultural sector and undertake attractive, profitable and sustainable horticultural enterprises are now required. Many of the youth are migrating to urban areas in search of employment. In some cases the exodus of young men is leading to a greater number of women in rural agriculture which in turn means that horticultural research must have a strong gender focus to address the needs of this shifting demography. The rapid aging of the current farming population in Asia-Pacific countries with successful agricultural sectors must be counteracted. The aging of rural societies has detrimental effects on the quality of life of young and old people alike, particularly in societies where smallholder agriculture is a prominent feature of the cultural fabric such as in India, Taiwan, Thailand and more generally in the Asia-Pacific region.

5. Policy Change Recommendation #4: Strengthen and Renew Existing Policy Frameworks to Ensure Safe Pesticide Use

A severe and negative consequence of the Green Revolution has been a rapid acceptance and routine use of inputs, particularly pesticides, and especially in high value crops such as vegetables. This has led to the misuse of pesticides: commonly the wrong product is applied, often not even approved for use on food crops, or in the wrong dose or at the incorrect time. Most governments have been supportive of pesticide use, setting low or zero impact taxes, heavily subsidized or sometimes providing them for free, for fear that restricting pesticide use will harm food production (Carvalho 2006). Pesticide misuse particularly affects high value crops such as vegetables as pesticide application rates are higher on these crops than on staples (e.g. Praneetvatakul

et al. 2013 for Thailand) and many vegetables are eaten fresh, which increases the pesticide residue health risk to consumers.

Means to redress this situation require better education and effective policy development across a broad coalition of agricultural stakeholders. Practical solutions include improved capacity to identify the pest or causal agent of disease and to associate the diagnosis with appropriate control interventions. These can be judicious pesticide use, agronomic practices (e.g. crop rotation and grafting), or use of ecologically based biological products (e.g. pheromone traps or botanicals) and deployment of biocontrol agents. There are examples when bio-pesticides can be combined with chemical pesticides e.g. for control of pod borer on yard-long bean in Thailand (Yule and Srinivasan 2014). Such integrated pest management (IPM) strategies need to be facilitated through significantly more training and participatory research that includes farmers, extension agents, research for development organizations and market representatives. Furthermore, policies are required to support the development of, and access to, ecologically mediated IPM solutions to ensure the integrity of the environment is protected and production systems are sustainable. Incentives for appropriate pest and disease management can be created through more rigorous regulatory systems for pesticides and through increasing awareness of the health risks due to pesticide misuse for farmers and consumers (FAO 2015). This in turn would stimulate more profitable and safer vegetable value chains with increased market demand and access.

6. Policy Change Recommendation #5: Reassess Public Sector Policies on the Provision of Improved Germplasm and Food Safety and Quality Standards

Long-term breeding programmes, fully exploiting the full range of existing cultivated and wild relative germplasm, are essential and must be maintained. But, capacity in vegetable breeding research in both the public and private sectors is frequently lacking in many smaller countries and weaker National Agricultural Research and Extension Systems (NARES) such as are found in the smaller countries of Southeast Asia, Central and South Asia, and the Pacific islands. Support from international research organizations such as AVRDC is still important to such countries even to the level of finished open-pollinated varieties. Also, many small private sector seed companies rely on public sector parental material for creating their own commercial hybrids.

Yet, the private sector rarely makes a contribution to public research organizations such as AVRDC for the germplasm they are using. Most of public sector organizations provide germplasm held in trust to the private sector at minimal or no cost, and yet the maintenance of the collections and characterization of lines is a very expensive undertaking. If this position changes and schemes such as licensing improved germplasm or the strict requirement for royalties are introduced, such changes could be detrimental to small-scale seed companies and some of the NARES in the APAARI region. In the long run, such changes could burden small-scale farmers with higher seed costs. Nonetheless, policy makers should consider the private sector use of public sector resources such as germplasm and consider a more equitable mechanism for the relationship between the public and private sectors in this context.

In addition, the long-term trend experienced in North America of a narrowing range of vegetable varieties has led to a continuous decline in vegetable nutrient density from the 1950s to the present day. Policy to ensure that nutrient density is properly maintained in vegetables by public and private sector breeding programmes is essential (Davis and Riordan 2004). Yet, the private sector maintains that they are unrewarded for maintaining nutrient density, and sometimes even taste, in their prices and thus it is a factor not to be considered as a priority in breeding programmes whereas consistent produce shape, size and colour are demanded for the market.

Yet, in the UK the minimum allowable protein content and other quality standards of wheat are set by the government and failure to attain these minima in bread wheat has serious price consequences both for exporters and for the local bread and biscuit industry (http://cereals.ahdb.org.uk/exports/the-uk-wheat-export-brands.aspx). Some consideration of the demands of the market chain, as articulated by the private sector, needs to be taken into account in the APAARI region to prevent the supply of vegetables which are relatively nutrient poor. Many preferred vegetables, such as cucumber or ball cabbage, are

already relatively low in nutrients and the gradual erosion of the nutrient density in favour of other traits is a complex factor that must be addressed although the practicalities of addressing these issues by legislation across a broad range of vegetable species would be very complex. An educational campaign by Governments to influence their private sector companies might be more a pragmatic approach.

7. Conclusion

Smallholder vegetable horticulture has an important role to achieve improved human nutrition and sustainable agriculture, but this role is not fully supported by the current policy framework in most of the APAARI countries. To exploit the sector's full potential, we formulated five necessary policy changes. First, food security policies must be re-oriented from addressing hunger to addressing malnutrition by encouraging people to adopt healthier and better balanced diets. Second, investment into horticultural research must be substantially increased; ideally with a focus on long-term priorities. Third, comprehensive investment is needed to strengthen market opportunities for smallholder farmers. Fourth, policies must be strengthened or renewed to ensure safe pesticide use. Fifth, funding for research for long-term germplasm supply, pest and disease resistance and quality improvement for sustained vegetable production needs to be reconsidered in the context of how it can be aligned with the need for better nutrition in a warming world.

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8. The Opportunities and Challenges for Livestock and Aquaculture Research for Development in Asia

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The livestock revolution continues unabated, and is centred in Asia. This explosion in demand for livestock and fish products is driven by rising incomes and urbanisation, and is expected to double by 2030 for many commodities in Asia. In terms of value, four of the five top commodities globally are now livestock products, the fifth being rice, with the dairy most valuable commodity globally. South Asia is now the world's largest dairy producer and beef exporter, and East Asia is the fast growing region for livestock product imports. Approximately 60 per cent of the world supply of fish comes from this region where a large proportion is consumed domestically. In spite of increased supply of animal-sourced foods (ASFs) the region houses the majority of the world under-nourished population. ASFs provide the best source for dense and available high-quality protein and micro-nutrients, and in children, contribute to cognitive as well as physical development. Even though the region is now the centre for much of the world's livestock and fish supply, in most of the region the production, especially of ruminants, is dependent on smallholder producers, who typically operate using traditional technologies and experience low yields. Similarly, in large parts of the region, the link between livestock and fish producers and consumers is provided mostly by informal or wet markets, offering raw or traditionally processed products that do not meet modern standards. Finally, the threat to human health from zoonotic disease and other food safety risks potentially associated with livestock and fish products remains. This paper reviewed these trends and identified the opportunities they create for rural producers in Asia, as well as the challenges they pose, and the potential risks. The potential priorities for regional research to address these issues, led by Asian nations supported by the international agricultural research community were also laid out.

9. Innovation in Agriculture in Response to Climate Change: Towards a Global Action Plan for Agricultural Diversification

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ABSTRACT

Current global agriculture practices must be reassessed in the light of two pressing factors of differing nature: climate change and the United Nations 2030 Sustainable Development Agenda (SDA 2030) Goals. The former will affect crop yields, nutritional value and production distribution although the nature of agriculture in a hotter world is not known and may be catastrophic for the major crops. The latter will impact on agriculture as several of the seventeen SDGs must be addressed through agriculture to be achievable. A Global Action Plan for Agricultural Diversification (GAPAD) is proposed to tackle these two factors simultaneously and so must be ambitious, global, inclusive and evidence-based. This paper gives the justification for GAPAD and calls for support for the Paris Declaration on Agricultural Diversification launched at the United Nations Framework Convention on Climate Change (UNFCCC COP 21) in Paris in December 2015.

Keywords: Agricultural diversification; Climate change; Sustainable development agenda

1. Introduction

The two major factors currently affecting global agriculture are: the impact of climate change and the recently announced United Nations 2030 Sustainable Development Agenda (SDA 2030) Goals (SDG) (UN 2015). Although of differing nature, the two factors are interlinked. Indeed, SDG 13 demands urgent action to combat climate change and its impacts whilst the success of many of the other SDG depends on agriculture delivering results in a hotter world.

The APAARI High Level Policy Dialogue on Investment in Agricultural Research for Sustainable Development in the Asia-Pacific Region is a timely event, coming at a time when SDA 2030 is moving through the gears to be the driving force for much of the agriculture research in the foreseeable future. The need for substantial investment in agricultural R&D is implicit in the SDA 2030 generally and is also needed to ameliorate the effects of climate change specifically. How the increased investment is achieved and then deployed is the vital objective of this dialogue. The investment must be directed to those who can have the biggest impact on the SDGs – the smallholder farmers and food processors. Addressing their role might involve diversification of crops, farming systems and landscapes, coupled with emphasis on nutritional value and the value-chain rather than just yield. A Global Action Plan for Agricultural Diversification (GAPAD) is proposed to tackle the two issues simultaneously.

2. Impact of climate change

Let us first consider climate change as this is the major risk factor to food security in the future. There is almost universal accepted evidence that the climate is changing and already disrupting agricultural practices and livelihoods in many parts of the world. Millions of people are affected by environmental degradation, biodiversity loss, rising sea levels, ocean acidification and agricultural stagnation. Furthermore, agriculture is affected by unpredictable and extreme effects of climate, for example, extremes of rainfall with drought and flooding within and between seasons at the same place. Future agriculture will need to cope with increasingly hostile and volatile environments.

The aim of the UN Framework Convention on Climate change (UNFCCC, COP 21) in Paris was arrived to reduce greenhouse emissions to limit increases in global temperature to within 2°C above pre-industrial levels. However, the country targets submitted in advance of COP 21 will lead to global emissions far above that needed to achieve the aim of the event (Climateactiontracker 2015). Global average temperatures in excess of 3°C above pre-industrial levels must be contemplated, yet there is no scientific evidence for exactly which crops will be suitable for these conditions (Global Food Security Programme 2015). Crops have limited tolerance for high temperatures at key stages such as flowering or fruit production and these limits are likely to be exceeded in a hotter environment.

At the moment, four major crops, maize, wheat, rice and soybean provide more than 60 per cent of the world's food, either directly or through livestock and aquaculture feeds and for bioenergy systems. Whilst work will go on to make these crops resilient to climate change and maintain yield (and importantly nutritional value) it is mistaken and unfair to have such reliance on just four crops emanating from just a few producing countries. In brief, "Business as usual" is not an option.

It has been predicted that by 2030, with an increasing population, the world will need to produce around 50 per cent more food and energy, together with 30 per cent more fresh water whilst mitigating and adapting to climate change. This combination, "The Perfect Storm", as described by the UK Chief Science Advisor Sir John Beddington in 2009 threatens of public unrest, cross-border conflicts and mass migration as people flee from the worst affected areas.

As mentioned above, the SDA 2030 addresses climate change specifically in SDG 13 and meeting the challenge will demand a focus on common, cross-cutting and coherent strategies to integrate climate change responses and impact reduction into global plans for agricultural diversification. Specific underutilized crops may help agriculture to adapt to climate change by increasing the resilience of agroecosystems to withstand the combined effects of drought and extreme temperatures.

3. Sustainable Development Agenda 2030 (SDA 2030)

Launched in September, 2015, SDA 2030 sets out a global plan of action for sustainable development that is anchored on ***people, planet and prosperity***. The plan recognizes that development and the application of technology must be climate-sensitive, respect biodiversity and be resilient. It also establishes that its underlying priority is to end hunger, achieve food security and end all forms of malnutrition. SDA 2030 is the new global framework to respond to global challenges and achieve sustainable development. It identifies 17 SDGs and 169 targets. These ambitious SDGs will shape the next 15 years of investment priorities and actions. More than any other sector, agriculture is the common thread that links the 17 SDGs. Table 1 lists the seventeen SDGs and highlights those where agriculture, and hence agricultural diversification, must play a major role.

SDG 2 undertakes to end hunger, achieve food security and improve nutrition and promote sustainable agriculture. The challenge is to do so without destroying the natural resources on which we depend and the current model of global agriculture may not be able to produce enough food to sustain the growing world population with healthy and active lifestyles. Agricultural diversification and sustainable practices will need to contribute towards improved nutrition, food security and poverty alleviation and strengthen global capacities for adaptation to climate change. Greater diversity provides opportunities for more environmentally sustainable agricultural systems for farmers and integration of community knowledge with scientific evidence and novel technologies. Investment in innovative science and social infrastructures is needed for food to be produced sustainably through the integration of new and existing technologies and best practices. Crops For the Future (CFF) has established programmes on how underutilized crops can contribute to food security (BamYIELD), nutritional security (FoodPLUS) and animal nutrition (FishPLUS). GAPAD will provide a delivery framework for meeting the SDG targets for this goal. CFF is a not-for-profit research company based in Malaysia supported by the Malaysian Government and the University of Nottingham in Malaysia.

SDG 7 relates to access to affordable, reliable, sustainable energy and modern energy for all and recognizes the role of energy in sustainable development and poverty eradication. Renewable energy provides the basis for a paradigm shift towards low-carbon energy systems, green economies,

Table 1. Sustainable development Agenda (SDA 2030) Goals

SDA 2030: Goal	Descriptor	Targets
SDG1	No poverty	7
SDG2*	Zero hunger: end hunger, achieve food security & improved nutrition & promote sustainable agriculture	Hunger: 7 Food security: 5
SDG3	Good health & well-being	12
SDG4	Quality education	10
SDG5	Gender equality	9
SDG6	Clean water & sanitation	8
SDG7*	Affordable & clean energy: affordable, reliable, sustainable & modern energy for all	5
SDG8	Decent work & economic growth	12
SDG9	Industry, innovation & infrastructure	8
SDG10	Reduced inequalities	10
SDG11	Sustainable cities & communities	10
SDG12*	Responsible consumption & production	11
SDG13*	Climate action: take urgent action to combat climate change & its impacts	5
SDG14	Life below water	10
SDG15*	Life on land: protect, restore & promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification & halt & reverse land degradation & halt biodiversity loss	12
SDG16	Peace, justice & strong institutions	12
SDG17*	Partnership for the goals	19

**SDG marked by * are directly related to agricultural diversification*
***Adapted from www.un.org/sustainabledevelopment/sustainable-development-goals/*

poverty eradication and ultimately sustainable development. In 2015, 2.8 billion people had no access to modern energy services and over 1.1 billion had no electricity. Furthermore, around 4.3 million people are dying prematurely every year due to indoor pollution resulting from cooking and heating with unsustainable fuels. The challenge is to reconcile demands for modern energy services and their impact on the environment and the natural resource base for the SDGs to be realized. Agricultural diversification provides opportunities to use non-food crops for renewable energy. Biomass feedstock has great potential as a sustainable source of renewable energy, particularly in countries where there are abundant agricultural activities or on lands that are increasingly marginal for more favoured crops. The CFF SAGEPLUS programme (diversification of agricultural landscapes using underutilized crops) addresses the issues of SDG 7 by demonstrating how complementary and sustainable sources of biomass for renewable energy can be produced without increasing the land area used by agriculture. GAPAD will provide a mechanism for international cooperation in clean energy research and technology.

SDG 12 aims to ensure sustainable consumption and production patterns and this applies to agricultural commodities to eradicate hunger and poverty and manage the natural resource base which underpins development. Current pressures on the planet's natural resources will increase with population and economic activity. Sustainable development must decouple economic growth from environmental degradation by improving resource efficiency, reducing waste and promoting a wider range of locally available agricultural species. More diverse agricultural systems will optimize the use of natural resources and minimize costly inputs. GAPAD will provide a broad delivery framework for the adoption of sustainable practices throughout the agriculture value chain and shorten supply chains.

CFF has established programmes to show how underutilized crops can contribute to sustainable food (BamYIELD), nutrition (FoodPLUS) and animal feed (FishPLUS) systems. Its CropBASE programme provides an evidence-base for sustainable consumption and production patterns through agricultural diversification.

SDG 15 aims to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss. Economic activity is one of the major drivers of biodiversity loss, coupled with urban creep exacerbating landscape fragmentation and degrading ecosystem functionality. Other drivers of biodiversity decline are habitat change, climate change, over-exploitation and pollution. A framework is needed for strong collaboration in the development of strategies and action plans for conservation, protection and sustainable management of agricultural biodiversity. Diversification can help conserve agricultural biodiversity and ecosystem services through sustainable agricultural management and innovative technologies and practices, increase the resilience of ecosystems and biodiversity to mitigate the impacts of climate change.

Finally, SDG 17 aims to strengthen the means of implementation and revitalize the global partnership for sustainable development. SDA 2030 applies to all countries, whilst respecting different circumstances, and all are responsible individually and collectively for implementing the 2030 agenda. We need an action plan to diversity agriculture beyond the major crops which must be ambitious, global, inclusive and evidence-based. It needs bold leadership that supports a common vision and agreed activities, timelines and deliverables. These challenges constitute the need for a, "Global Action Plan for Agricultural Diversification (GAPAD) and CFF and partners are taking the lead in establishing this initiative and helping to build a global alliance of stakeholders to implement GAPAD.

4. Implementation of GAPAD

At COP 21 in Paris, CFF launched the, "Paris Declaration", on the importance of agricultural diversification in the era of climate change. Signatories included eminent scientists, industry and political leaders, representatives of international agencies and a wide representation of public and private interests. The Paris Declaration is available for further electronic, "Signature", now via the CFF web site (www.cropsforthefuture.org). We urge APAARI members, collectively and individually, to sign the declaration and contribute to further activities to implement GAPAD. In March 2016, a meeting will be held in Kuala Lumpur to include all stakeholders to develop the details of a GAPAD programme. In mid-2016, a meeting will be held in Rome, hosted by the United Nations International Fund for Agricultural Development (IFAD), to formally launch the GAPAD.

5. Concluding Remarks

The nexus of COP 21 and the SDA 2030 launch gives an unprecedented opportunity for global agriculture to contribute to a shift in food production and distribution patterns whilst preserving nutritional value under climate change and impact on the scourges of hunger, poverty, inequality and environmental degradation across the world.

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10. Achieving National and Global Climate Objectives in Asia and the Pacific Through Investment in Climate-Smart Agriculture

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The agriculture sector remains crucial to the livelihoods and food security in Asia and the Pacific and is both increasingly vulnerable to changes in climate and a significant source of emissions. The Conference of Parties to the UNFCCC (COP 21) and associated negotiations in Paris in December 2015 marked a key turning point for future global action to tackle climate change and deliver an agreement to limit greenhouse gas emissions and set the world on a more sustainable development pathway. It is clear that the agriculture sector, comprising crops, livestock, forestry, fisheries and aquaculture, will be a key focus area for future action under the UNFCCC to foster climate-resilient, low emissions development. Agriculture is a key element of the immediate future work programme of the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) that will guide future advice to the COP. Countries are also identifying agriculture and forestry as key targets for future actions to strengthen climate resilience under their Intended Nationally Determined Contributions (INDCs). As INDCs are expected to transform into Nationally Determined Contributions (NDCs) following the negotiations in December 2015, they will be an important road map for directing future investment and technical support. From a developing country perspective, the UNFCCC negotiation process and the INDCs also highlight where the global financing mechanisms that underpin the UNFCCC – most notably the Green Climate Fund (GCF) – should focus investment. These developments represent a unique opportunity to leverage countries, existing agriculture sector development and investment plans and to drive climate-smart development in the agriculture sector leading to real benefits for agricultural communities and the environment. This presentation summarized these developments and identified potential strategies that developing countries in Asia and the Pacific can employ to use these processes to drive investment in climate-smart agriculture.

11. Potential Areas of Investment in Climate-Smart Agriculture in South Asia

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Agriculture is the major land use across South Asia which contributes about 15 per cent of total gross domestic products (GDP) and employs more than 50 per cent population in the region. In some countries, such as in Bangladesh and Nepal, more than 65 per cent population is engaged in agriculture sector. This sector would be significantly impacted due to increase in temperature, changes in rainfall patterns and changes in the frequency and intensity of extreme climatic events such as floods and droughts. The estimated impacts of both historical and future climate change on crop yields in different regions of South Asia indicate that the yield loss can be from 10 to 60 per cent depending on location, future climate scenario and projected year. Thus, the agricultural production system requires adaptation to climate change and variability in order to ensure food and livelihood security of millions of people in the region. Climate-Smart Agriculture (CSA) is being promoted for adaptation and mitigation of climate change and variability in many places. CSA aims to improve farm productivity and income, increase resilience to weather extremes and decrease greenhouse gas emissions wherever possible. Farmers require to make several adjustments in crop management practices (e.g. changes in sowing time, application of water and fertilizers, tillage practices and inter-cultural operations) to transformation of agricultural production systems (e.g. change in cropping systems and land uses) to adjust with new climatic conditions in a particular location. Despite several options available for adaptation to climate change in agriculture, the uptake of many CSA practices and technologies by farm communities is not adequate to achieve their full potential effect in South Asian regions. There could be many adoption barriers including lack of investments, policy and institutional bottlenecks, and lack of coordinated actions by different stakeholders. Therefore, maximizing the impacts and scaling out the adoption of CSA requires bringing together a number of pieces-including investment in R&D and enabling policy environment. This paper highlights potential areas and investment mechanisms for scaling out CSA in South Asia. Broadly, we categorize investment areas into followings: (i) Research: identification, prioritization, and development of portfolios of CSA interventions based on farming systems in different agro-ecological zones; (ii) Development: tools and models for investment planning and decision support system; (iii) Capacity building: project designing, implementation and M&E; and (iv) Scaling out: horizontal (farmers-to-farmers) and vertical (integration into existing policies and programmes). Climate-Smart Village (CSV) model is a participatory approach of scaling out CSA which converges research, development and capacity building activities at the local level. This approach provides strategic and technical decision supports to the local communities and other key stakeholders for investment in climate change adaptation. The paper also highlighted some potential investment opportunities for private sector such as agro-industries, ICT companies and agriculture input suppliers, and new research needed to attract investment to CSA.

12. Land Resource Inventory of India for Development of Sustainable Agricultural Land Use Plans using Geospatial Techniques – Avenues for Investment

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ABSTRACT

In India, investment in agriculture is growing at the rate of 9 per cent annually. Fertilizer consumption is increasing exponentially; however, productivity is stagnant even with best available management practices. Blanket applications of technologies in the absence of site-specific soil (land) resources data, and of situation-specific recommendations is one of the reasons for yield plateauing. The ICAR – National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Nagpur, Maharashtra, India has taken initiatives through its country level programme, Land Resource Inventory (LRI), to generate data on site-specific soil and land resources. It involves systematic surveys of soils (cultivable land) on 1:10000 scales and collection of other collateral data needed for scientific land use planning in geographic information system (GIS) environment. This is a priority programme of the ICAR-NBSS&LUP and investments thereon are expected to generate rich dividends. The project is being executed in a consortium mode by involving State Governments/State Departments of Agriculture, State Agricultural Universities, National Remote Sensing Centre, Hyderabad, India, State Remote Sensing Application Centres and Soil and Land Use Survey of India. The programme uses the latest time-efficient and cost-effective geospatial technologies and thereby ensures accuracy of the methodology.

The nationwide survey will help in developing perspective land use plans and monitoring their impact at macro (district/state) and micro level (village level). Total investment for executing LRI in the country is estimated to be around USD 176 million. Per unit cost is calculated to USD 1.5/ha which is much lower than the unit cost of USD 176 to USD 220/ha for watershed development or other land based activity.

Keywords: GIS; Investment; Land resource inventory; Land use planning

1. Introduction

Indian agriculture grew significantly during the 1980s and early 1990s, as evidenced by the performance of the crops, livestock and fisheries sectors. The crop sector showed modest growth (3.1%) during the early 1990s, but it consistently slowed down (2.5%) thereafter. The rate of growth in livestock production also began to slow down in the mid-1990s but has remained higher than the corresponding rate of growth in food grains and oilseeds. There is a noticeable decline in growth rates after the mid-1990s across all agricultural sectors, with growth in some sectors (including oilseeds, livestock and fisheries) rebounding in recent years. However, a substantial cause for concern has been the ratcheting down in the pace of growth of cereals output in the recent decades (1.3% during 2002-07), given the fact that the substantial share of agricultural output still derives from this sector and is the mainstay of India's food security (Singh and Pal 2010). Consequently, achieving the target of 4 per cent growth in agricultural gross domestic product (AgGDP) has remained an elusive goal (Singh 2011).

An interdisciplinary approach is a proven vehicle for addressing a wide array of issues of second generation problems arising due to degradation. These are linked with the environment, ecology, agriculture, geology and natural resources. Over the last few decades, there has been growing interest in non-point source of pollution, watershed management, integrated agriculture system, precision

farming, sustainable land use planning, ecosystem restoration, arresting degradation and ensuring food security (Lin *et al.* 2006). For executing such programmes, site specific land resources information and situation specific recommendations are a pre-requisite. Land resource inventory (LRI) involves systematic surveys of soils (agricultural land) on 1:10000 scale and collection of other collateral data needed for scientific land use planning in GIS environment. The detailed database generated at farm level and its subsequent abstraction to village and higher levels will form the basis needed for prioritizing, initiating and executing any land-based developmental programmes.

Studies conducted in different parts of the country indicate that the properties of soils play a major role for planning sustainable precision agriculture. It includes genesis, transformation, geo-chemistry of clay minerals, hydrological properties and morphological characteristics of soils (Singh *et al.* 1994, Singh *et al*. 2001a,b, Singh *et al.* 2002, Singh *et al.* 2003 a,b, Singh *et al.* 2004); soil temperature and moisture regimes, bulk density, water holding capacity, moisture retention at field capacity, soil organic carbon, phosphorus and potassium stock (Singh *et al.* 2013); soil organic carbon (SOC) potentials under different land use systems (Singh *et al.* 2007, Singh *et al.* 2005, Singh *et al.* 2011, Pandey *et al.* 2011); oscillatory behaviour of SOC in different land uses (Singh *et al.* 2008), soil moisture and temperature regime (Singh *et al.* 2013), suitable crops and cropping sequences under set of soil and climatic conditions (Singh *et al.* 2013, Singh *et al*. 2007).

Remote sensing data of coarse resolution was used to map the soils of the country on 1:1 million scale (NBSS&LUP Staff 2002); its states like Rajasthan (NBSS&LUP Staff 1995), Himachal Pradesh (NBSS&LUP Staff 1996), Goa (NBSS&LUP Staff 1999), and Uttar Pradesh (NBSS&LUP Staff 2004) on 1:250000 scale; the districts like Sri Ganganagar (CAZRI 2003), Ajmer (NBSS&LUP Staff 2001), Aurangabad and Rohtas (Bihar), (NBSS&LUP 2011), Bolangir (Odisha) (NBSS&LUP 2011) on 1:50000 scale; the map of natural resources of Western Rajasthan affected by flash flood using coarse resolution Modis data (Kar *et al*. 2007). In LRI, use of high resolution remote sensing data and digital elevation model (DEM)/ digital terrain model (DTM) is providing new dimensions in the soil survey programme.

2. Land Resource Inventory on 1:10000 scales – Methodological Framework

2.1. Conceptual model for LRI

Soil survey is largely dependent on soil-landform relationship (Singh *et al.*1994, Shyampura *et al*. 1994, Sharma *et al*. 1999, Gangopadhyay *et al.* 2012) and the map represents the static soil properties, which are acquired after a series of climatic episodes (Lin *et al.* 2006). However, the Land Resource Inventory (LRI) is basically meant for developing sustainable land use plan, which is dynamic and dependent on present climatic conditions and the prevailing soil forming processes. Therefore, land ecological unit (LEU) is preferred over the landform as the basis of mapping. LEU is the assemblage of landform, slope and land use. Landform is the testimony of climatic events that occurred in the past, whereas slope and land use represent the influence of present climatic conditions on the soil formation. The conceptual model for LRI programme is presented in Figure 1. The assumption is if landform, slope and land use are identical, there is high possibility of getting similar kind of soils.

2.2. Remote sensing data in LRI

In LRI, different kinds of remote sensing data such as Digital Terrain Model (DTM), IRS LISS IV P6 data of 5.8 meter resolution and other data available in public domain are used. In the undulating terrain, Digital Terrain Model (DTM), which is the integral part of LRI, is prepared using Cartosat-1 data of 1 meter resolution. Sahu *et al.* (2014) also used cartosat-1 DTM and IRS LISS IV P6 data of 5.8 meter resolution data for characterization of landforms and land use and land cover (LULC) mapping in the basaltic terrain of Nagpur. In the flat terrain like Indo-Gangetic plains, Thar Desert of Rajasthan and in the coastal region of West Bengal of IRS-LISS IV P6 data of 5.8 meter resolution is used. Recently, methodology was fine-tuned for the part of lower Gangetic plains using IRS LISS IV data of 5.8 meter resolution (NBSS&LUP 2012).

2.3. Status of LRI

Land resource inventorisation programme in the country is being carried out in a phased manner. In

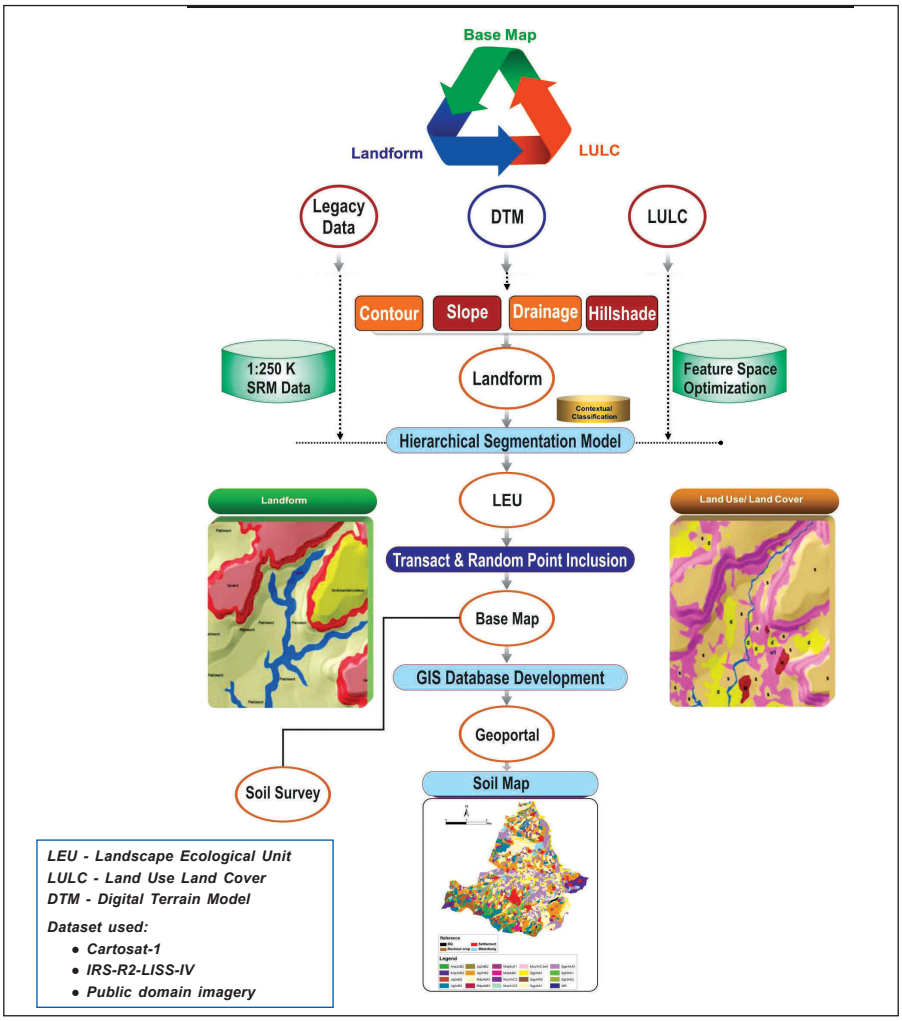

Figure 1. Conceptual model for Land Resource Inventory (LRI)

the first phase (2014-2018) 60 blocks belonging to the different agro-ecological regions and sub-regions encompassing 3.3 million hectares were targeted. During the year 2014-15, mapping was taken up in 34 blocks of the country (Figure 2). In addition, Government of Karnataka and Government of Goa initiated the programme with their own budget while NBSS&LUP Nagpur coordinates the programme. National Remote Sensing Centre, Hyderabad and Bhaskra Institute of Remote Sensing and Geo-informatics are also participating in the programme.

2.4. Expected Investment

Execution of LRI in the country involves an investment of around USD 176 million on strengthening soil testing laboratories using geospatial techniques, undertaking field work and development of geo-portal. Per unit cost is calculated to USD 1.5 per hectare which is much lower than other agriculture related programmes running in the country. For example, watershed development programme under Integrated Watershed Management Programme (IWMP) merged with Pradhanmantri Krishi Yojna involves per unit cost of USD 176-220 per hectare. Also, considering the deliverables LRI would generate in form of soil maps and land use plans undertaking the programme becomes essential.

3. Conclusion

With hardly any scope of horizontal expansion of land area, effective land resource conservation and proper land use planning become indispensable. This necessitates generation of information on nature and extent of soils. LRI, using high resolution remote sensing data provides such information. In the absence of site-specific land resource data and

Figure 2. Selected blocks under LRI programme

situation-specific recommendations, the NBSS&LUP has undertaken a project on Land Resources Inventory of the country on 1:10000 scale. The project plans to fill this vital gap. Understandably, the execution of this project on such a large scale would need huge investments but considering the returns, it is generating or is expected to generate in the form of judicious land use plans, the project assumes much significance.

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13. The Case for Investment in Knowledge Management to Support the Sustainable Development Goals in Asia-Pacific Region – Some Lessons Learned from CABI's Experiences

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ABSTRACT

The ambitions set out in the Sustainable Development Goals (SDGs) demand unprecedented levels of global cooperation and integration, calling for all countries and stakeholders to act in collaborative partnership to implement this new universal agenda. In contrast to the Millennium Development Goals (MDGs), the new goals emphasize the importance of monitoring and measuring progress and the development of appropriate indicators to facilitate this process. The statement calls for quality, accessible, timely and reliable disaggregated data, stressing that "such data is the key to decision-making". Elsewhere, there is a call to enhance knowledge sharing and the use of enabling technology, in particular information and communications technology. Such calls are easy to make, but require considerable investment in technology, knowledge management skills, communication expertise and analytical capabilities, which should not be underestimated when planning SDG implementation programmes. With a 100 year history of serving the information needs of the agricultural research and development sectors, and through the creation of innovative knowledge management platforms such as the Plantwise Knowledge Bank and the Direct2Farm mobile agri-advisory service, CABI has made major investments in its own knowledge management capabilities and as a result is uniquely placed to provide the underpinning data collection, sharing and reporting tools called for in the SDGs. Equally, putting know-how into the hands of smallholder farmers and bringing science from the lab to the field in order to achieve impact at scale requires investment in capacity building at the regional and local level to ensure long-term sustainability and stakeholder empowerment. This paper uses some of CABI's recent knowledge management initiatives to illustrate the scale and type of investment required. It also explains the need for all agricultural research for development (AR4D) stakeholders to embrace the Global Open Data for Agriculture and Nutrition (GODAN) initiative and to embark on the journey towards data-driven and evidence-based programmes.

Keywords: Capacity building; Information literacy; Knowledge management; Open data

1. Introduction

The 2030 Agenda for Sustainable Development sets out an ambitious agenda to transform our world sustainably in the face of pressing global challenges (https://sustainabledevelopment.un.org/sdgs). This paper looks at the vital role to be played by Knowledge Management (KM) strategies not only in monitoring and measuring the impact of development interventions but also in increasing the spread and impact of research outputs, improving the quality of research itself and supporting evidence-based decision-making.

2. Context - The Sustainable Development Goals

Perhaps surprisingly, there is no single Sustainable Development Goal (SDG) which calls for universal access to information or to enabling technologies; rather, implicit in the Agenda is the concept that access to information is a catalyst for development, not a development outcome in itself. I quote, "the spread of information and communication technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies" (UN 2015).

So it is given that the dissemination and application of knowledge through digital means is a core component of the 2030 Agenda, but it would be a huge mistake to think that this will, in itself, transform the agricultural development landscape. KM strategies are not an end in themselves; they only have value if they help to achieve the broader objectives of any development intervention.

Knowledge management skills and the availability of relevant content are just as important. If we do not take this on board, the next digital divide will not be between those who have access to information and those who do not; it will be between those who have the digital skills to make use of that information and those who do not. The skills would also include:

- The ability to distinguish authoritative and evidence-based information from the "noise" of the World Wide Web
- The ability to interpret, monitor and evaluate data to ensure that decisions are based on the best available evidence
- The know-how to convert research findings into practical, relevant and actionable guidance
- The skill to analyse multiple sources of information to create a piece of insight and to make recommendations to policy-makers.

Therefore, KM strategies are much more complex than simply generating, collecting and making new information available and need to include human capacity building and access to appropriate, authoritative and trusted sources of knowledge.

On the specific issue of data, monitoring and accountability, SDG 17 recognizes the need to build capacity in developing countries to increase the availability of high-quality, timely and reliable data, and to develop statistical skills to enable systems of monitoring and evaluation to be implemented and owned within those countries.

Thus, there is an explicit recognition of the need for investment in such skills, but how can we make a case for, and quantify, significant investment in these knowledge management skills? At CABI, we have long pioneered a knowledge management agenda, blending our international development mission with the skills and resources of our publishing business to deliver the best outcomes for all our stakeholders and partners. I would like now to highlight two or three case studies from CABI which illustrate how the inclusion of knowledge management components in broader initiatives increases the overall effectiveness of those initiatives and transfers skills to support the delivery of impact at scale.

3. CABI's Knowledge Management Approach and Some Case Studies

CABI is a not-for-profit international organization with a mission to improve lives by solving problems in agriculture and the environment. We take a highly practical approach to our work, delivering appropriate solutions which are based on scientifically validated information, and by continually assessing the impact and outcomes of our interventions. CABI is owned by its 48 member countries, and implements its projects through a network of some 500 staff in 20 locations, operating in partnership with many national, regional and international organizations to deliver projects in over 70 countries worldwide (http://www.cabi.org).

3.1. Plantwise Knowledge Bank

CABI's flagship Plantwise project is now running in 33 countries, and combines a traditional face-to-face extension service (the Plantwise clinics, operated by CABI-trained but locally employed plant doctors) with a data collection and communication platform, the Plantwise Knowledge Bank (http://www.plantwise.org/KnowledgeBank). The Knowledge Bank plays two roles; firstly it is a reference tool containing a huge number of information resources relating to plant pests and diseases; secondly, it is a management information platform for the gathering and analysis of data for monitoring and evaluation purposes.

At each clinic, the Plant Doctor records the symptoms reported by his clients, together with a pre-defined set of data elements such as the farmer's details, the date, the geographical location of the clinic and of the farm, the weather, the diagnosis made and treatment recommended. These data are then entered into the Plantwise Online Management System (POMS) so that they can be analysed, aggregated, validated and otherwise interpreted by the Plant Doctors themselves, government officers, plant health inspection services and any other agencies who are entitled to have access to this information.

Over time, as the number of clinic records grows, it is possible to carry out a wide range of analysis to monitor the impact of the plant clinics, the accuracy of the Plant Doctors' diagnoses, the spread of plant pests and diseases, and for that information to be presented back to the user in the form of a customisable dashboard.

The data gathered in POMS also enables analysis of gender impact, from a simple breakdown of men and women visiting clinics to a more detailed understanding of the crops they bring to the clinic and their ability to act upon the advice given.

The quality control features of POMS allow us to monitor the quality of the service provided by the Plant Doctor, and deal with underperformance or inaccurate diagnoses. This tool can be used by the doctors themselves, by their managers within the agricultural extension service or by CABI in our quality assurance role.

For example, from the data collected in POMS from Pakistan, we can check to see that so-called "red list" chemicals are not being recommended by the Plant Doctors, and this helps us, and them, to report back on compliance with regulatory standards and training of agricultural extensionists. The data extracted tells us that from 2012 to 2014, the percentage of queries in which a Red List chemical was recommended fell from almost 7 per cent to under 0.5 per cent

These are all examples of how the knowledge management component of Plantwise ensures that the interventions made are measured, monitored and acted upon. In order to accelerate and scale up the collection of data, we now plan to roll out low-cost Android tablets to all plant doctors, making it easier for them to access information, to collect and submit their data and, crucially, to communicate with each other through a social networking app called Telegram.

The use of tablets in pilot studies has been shown to improve the number, quality and timeliness of records entered into the database. The power and uniqueness of the Plantwise Knowledge Bank has been recognized by the programme's donors in several external evaluations.

3.2. The CABI-RUFORUM partnership

Another challenge in the agricultural research and innovation for development agenda is ensuring that agricultural researchers in developing countries are able not only to access and interpret relevant published information, but also to improve the quality of their own research and to communicate it effectively to the rest of the world. In my experience, it is rare for this aspect of a research programme to be given the budget it needs to be delivered effectively.

In a partnership with the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), a consortium of 55 agricultural universities in 22 countries spanning the continent of Africa, we have provided free access to key CABI research publications and also enhanced this through training in how to use them effectively to raise standards in research and in research communication. An independent assessment of this project concluded that simply making e-resources available does not automatically lead to their proper utilization, but that with proper training and capacity building, users reported improvements in the quality of their research, which might include having their papers accepted by major international journals (Muitherero, 2015).

3.3. GODAN - the Global Open Data for agriculture and nutrition initiative

If we are to believe that a data revolution is needed to support the SDGs, there are some immediate challenges to resolve. We know that often, important sources of knowledge are not in the public domain, nor are they necessarily in a format which makes them interoperable or useful. We need to democratise the supply of information, so that it ends up in the hands of those who need it the most, and we need to demonstrate the return on investment that Open Data can deliver.

This is where the GODAN initiative has a role to play. GODAN is a global programme which lobbies for data relevant to agriculture and nutrition to be made available, accessible and usable worldwide.

GODAN members (currently numbering over 190) believe that Open Data can help to solve long-standing problems in agriculture through unprecedented collaboration and cooperation. The open and unfettered sharing of data on a global scale can enable more effective decision-making, can foster innovation and can increase transparency. The whole is surely greater than the sum of the parts.

The GODAN Secretariat, hosted by CABI, has produced a white paper available at http://www.godan.info which sets out some case studies that illustrate how Open Data can address challenges in agriculture and nutrition.

4. Conclusion

In conclusion, it is hopefully clear how these stories illustrate the strong case for investment in Knowledge Management strategies as an essential part of the broader development agenda. I would strongly argue that simply making information available and freely accessible is not enough, and that much more directed efforts are needed to deliver the kind of step change called for in the SDGs. Investments in Agricultural Research and Innovation for Development initiatives must include Knowledge Management as a core component to ensure efficient generation and effective use of existing and new knowledge:

But, KM plans are multi-faceted and need to be carefully planned from the outset. Some essential considerations are:

- Establish what evidence you will need to support your Theory of Change from the outset, so you can build systems to collect data, measure and monitor progress
- If the intervention will create new data, it is essential to have a sustainable data management plan, to enforce data standards and identifiers to ensure knowledge is interoperable and traceable and to participate in Open Data initiatives, especially GODAN
- Ensure researchers in the programme have access to authoritative, technically sound information to support decision-making, and the skills to interpret this information
- Budget may be needed to build the information literacy and data management skills within the teams, or to recruit specialists with these skills to complement the traditional scientific research roles
- ARI4D initiatives should adopt suitable research communication platforms to provide access to existing knowledge and the ability to share new findings

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14. The Rice Bowl Index: Using Open Data to Help Drive Sustainable and Robust Food Security Across Asia-Pacific

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Food security continues to be at the top of many government agendas in Asia-Pacific. Government intervention in all areas of food and agriculture is increasing and whether this intervention is positive or negative depends on effective and robust dialogue. The Rice Bowl Index (RBI) is a tool that brings together open data to inform dialogue on how countries can improve their food security. In line with this the RBI has developed new food security thresholds to provide governments and other stakeholders with more actionable insights.

What has happened to food security over the past 12 months?

Over the past twelve months, the food security robustness of the 15 countries covered by the RBI has continued to improve, though this has been at a slower pace than in previous years. Scores increased by 2.0 per cent compared to 3.6 per cent in 2014, while the 10 year average improvement is slightly above this year's result at 2.9 per cent.

What is causing the slow down?

Lower commodity prices have resulted in reduced investment by farmers in technology which is likely to reduce on-farm productivity, and this may offset the (short term) benefit lower commodity prices bring in terms of lower food prices.

For top performing countries who we consider to be food secure, the scope for further improvement in overall food security robustness is tempered while reduced volatility due to wider macroeconomic improvement can be seen as net positive to food security robustness across the region.

The results tell us that efficient regulatory systems, investment in technology, infrastructure and access to markets are needed, by both the public and private sector, for countries to be able to manage volatility and create a robust food security system.

What lies ahead?

Five emerging challenges to food security in the region have been identified:

- Managing the impacts of climate change within the agrifood system – as considered through the environmental rubric
- Adopting a new business model for smallholder producers – developing models that increase productivity – as considered through the farm-level rubric
- Improving supply chain effectiveness through to market – as considered through the demand and price rubric
- Investing in innovation and infrastructure within a partnership – as addressed through the policy and trade rubric and farm-level rubric
- Creating an enabling policy and regulatory environment to underpin robustness – as addressed through the policy and trade rubric.

Based on these challenges, it is the intention of the RBI to continue to refine its data to ensure that the tool is well equipped to support policy makers in identifying areas for improvement. Food security in Asia-Pacific is not beyond the reach of the region's consumers, farmers, governments, technology providers and relevant support agencies. Achieving food security does however require robust dialogue and sensible policy which the RBI aims to continue to make a valuable contribution.

15. Return from Investment in Agricultural Education, Research and Outreach Extension Systems for Community Development: Some Policy Guidelines in the Context of Pacific Island Countries

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ABSTRACT

This paper reviews some past studies on the contribution of investment in education especially higher education, research system and community extension services in agriculture over the years in different countries. A case study of the PNG University of Technology is also described as a representation of the Pacific Island countries. Finally, recommendations are made on policy guidelines for future investment.

Increased investments in higher education, research system and extension services for community development in agriculture are desirable as economic success is based on the outputs of these activities. Estimated real net benefit of higher education from graduates' income to the government exceeds the cost of higher education in the last two decades or more. There are also quantitative and qualitative benefits of higher education. The main quantitative benefit is the enhanced earnings of the graduates. They pay higher tax on earnings to the government. Qualitative benefits are improved equity, "spill over benefits" and direct external benefits to the community. The spill over benefits from the investment in university education, research system and community extension services are enormous because the university system provides more opportunities to make their outputs public instead of keeping them private. Geographical clustering of innovations in these sectors also results in international knowledge spill over. Studies from several countries over three decades support the claim regarding high return from investment in agricultural extension services for community development, even without considering the impact of inter-farmer communications. Apart from yielding significant financial returns, extension advisory services have also yielded positive social returns, particularly for women, people with low literacy levels, and farmers with medium landholdings. Investment in higher education, research, extension and innovations through university system pays off. Its value is borne out by history across time and space. Policy guidelines to address these issues need to be updated in the context of changing environment. The disadvantaged geographical locations as isolated island countries which are not easily accessible need special attention for investment through policy supports.

Keywords: Investment; Education; Research; Extension; University; Policy issues

1. Introduction

The use of agricultural knowledge through dissemination of information and management practices goes back to thousand years spread over old day China, Mesopotamia, Egypt, Niles, India and other countries. The term "Extension" which was coined around 1862 is also called by other names such as, extension education, adult education, community development, rural development, advisory services, human resource development and so on. The purpose of all these systems is to educate the people for livelihood improvement. The rate of return on investment in education, research and outreach community services is greater if economy is technologically progressive. The economics of education concerns the manner in which choices are made both by individuals/groups who demand education-research-extension services for development and those who provide these services. The rapid transformation of social structure and innovations are raising many

challenges for the government, community, private sectors, research institutions and industries. Some of the challenges are funding, competition, distance and cross-border education and rapidly increasing number of private-profit institutions. The public and private organizations including the community people have to create opportunities to face these challenges and obtain benefit out of the situations. The education-research-extension package has major role to play in it along with policy support. This paper reviews the contribution of agricultural extension, research and education process in development across countries. The experiences of the Papua New Guinea University of Technology (PNG Unitech) in the context of the Pacific island countries have been described. Finally some policy guidelines have been listed for attention of public and private sectors.

2. Investment in Education, Research and Extension Pays Off

Hundreds of country specific studies reported in professional literature over the past 30 years and more reveal a strong association between agricultural productivity improvement and financial spending on agricultural extension and research. Increased agricultural productivity and production are largely related to investment in agricultural R&D (Alston *et el.* 2009). Comparative studies from several countries support the high return from investment in extension services also. Evenson (1997) reviewed 57 studies and visualized extension according to sequence and level of changes of 'awareness, knowledge, adoption and practice' (AKAP) among farmers. Extension services affect each part of the sequence. These can be seen as both substitutes for and compliments to the acquired skills of the farmers. Further the presence of inter-farmer communications, which is quite often not taken into account, while measuring the impact of extension gives an underestimation of extension's contribution. There are evidences that the interaction effects of education-extension-research-innovations accelerate the return from these investments. Hayami and Kikuchi's (2000) village study in the Philippines showed a positive relationship between the increased production of rice and presence of a large complex of higher education-research-extension of the University of the Philippines (UPLB) at Los Banos. The presence of International Rice Research Institute (IRRI) within the proximity of this complex had interaction effects in case of human resource development, research collaboration and providing outreach extension services. The UPLB's education programmes, the extension programmes and the research activities along with IRRI's programs added value to the surrounding barrios (villages). The contribution of State Agricultural Universities of USA through Morill Act in 1862 and the State Agricultural Universities of India are good examples of the contributions of universities in research and extension along with education. A study in the Philippines villages using time series data showed significant contribution of schooling and extension to increased rice production and net farm earnings (Halim 1977). The study covered 40 barrios at three points in time at an interval of 5 years. The intensive extension programme was effective in enhancing "worker effect" while formal schooling developed the "allocative effect" of the client system. In increasing the "worker effect", extension substituted for schooling in less developed barrios, while in developed barrios, the extension and schooling were complementing each other. In case of "allocative effect" schooling and extension were complementing both in developed and less developed barrios. The marginal contribution of schooling in increasing net farm income was higher (Peso 111.78) than increasing the value of rice production (Peso 37.58). The extension contributes more in the programme oriented activities while education contributes more in enhancing quality of living (Halim 1977). A study carried out in Bangladesh villages also showed that the schooling of the farm operator up to grade seven level contributed positively in increasing the yield of rice, jute and net farm income (Halim 1982). Those who were more educated allocated less time to farming and gradually got involved in multifarious off-farm activities.

Apart from yielding significant financial returns, extension advisory services have also yielded positive social returns, particularly for women, people with low literacy levels, and farmers with medium landholdings (David and Heemskerk 2009). Rates of return on extension investments in developing countries have generally ranged from 5 per cent to more than 50 per cent (Evenson 1997). There are also evidences that some extension and research projects and programmes were not as productive as they might have been due to "extension gap", "research gap" and "science gap" (Evenson 1997).

The effect of extension programme is simply to speed up production activities by a few years which would not occur in the absence of the programme. In the short run, i.e., in the initial years after introducing the programme, growth rates will be higher. However, it varies according to programmes, regions and periods. When technology infrastructure levels are adequate, small investments in growth production can have very high returns (Evenson 2001). This supports the need for higher investment in required innovations which add values to the extension-research-education systems with multiplier effects across time and locations. There are some arguments that all the countries experiencing rapid industrial growth have first gone through significant growth in agricultural productivity. Whether or not it came first, the agricultural revolution seems to have made a significant contribution in determining the pace of modern economic growth.

3. Pluralistic Agricultural Extension Approach in the Context of Changed Environment

Several agricultural extension approaches are found around the world. These are 'general agricultural extension approach', 'commodity specialized approach', 'training and visit approach', 'participatory approach', 'project approach', 'cost-sharing approach', 'farming system and development approach', 'educational institutional approach' and so on. But, these approaches have undergone a lot of modifications over time and locations. Extension systems are now extending to broader and more diversified programmes cutting across public, private and civil society institutions to provide broad range of services to cover a variety of issues needed to improve livelihoods. Although clients of extension mostly are farmers, yet many other rural people who are not active in farming are also influenced by extension services. New technologies and markets offer rural households new opportunities, but they require better access to information and needed services to compete with global markets and other situations. They need information on climate change, disaster management, conservation of land, water, and forests; conservation of biodiversity; pesticide safety and residue minimization; livestock waste management; and water quality preservation and watershed protection. The local people are now responsible entrepreneur, managing complex, agricultural and off-farm activities to improve quality of living while facing many constraints. These changed circumstances have resulted in the need of using innovations such as information communication technologies (ICTs) in providing extension services to the community, although ICT might not be primarily aimed for this purpose. Such multidimensional innovations made a big impact in education, research and extension and in the total developmental process around the globe.

4. Outreach Extension Services and Research Programmes through University System

Universities are important "store houses of knowledge" and also drivers of economy where education, research, extension, outreach and innovative activities are organized as inseparable components in a sustainable manner. Investment in any higher education including agriculture provides three types of outputs. These are private benefits for students, social benefits that go to the society at large and research benefits diffused over time cutting across countries. Number of students enrolling for higher education has been increasing over the last two decades. Estimated real net benefit of higher education from graduates' income to the government exceeds the cost of higher education in all of the last two decades. Usually, R&D activities operated by universities are mostly conducted by students and staff whether funded by public or private industries. Spill over benefits of R&D mostly trickle down to industry and farms which can be seen as an external benefits of higher education delivered by staff and students. In practice, almost all graduates will have jobs at some time. The estimated private and social rate of return to a university degree was found high at about 15 per cent in Australia (Borland *et al.* 2000). The components of benefits from higher education include both quantitative and qualitative. The main quantitative benefit is the enhanced earnings of the graduates. They pay higher tax on earnings to the government. Qualitative benefits are improved equity, spill over benefits and direct external benefits to the community. Universities and research institutions need government policy support to maximize social return from higher education, research, extension and innovations. Universities' role to conduct applied research and community services has been increasing over time

due to availability of varying degrees of support services without extra investment. These are also sustainable as staff and students have access to farms, rural communities, scientific laboratories and equipment and media for information collection and dissemination. Linkages with other stakeholders and beneficiaries are also quick and effective due to academic freedom. There is also empirical evidence of geographical clustering of innovative activities (Borland *et al.* 2000) with evidence of international knowledge spill over. The small countries can get benefits from foreign countries and vice versa. University education, research and outreach programmes are not confined only to physical and biological sciences but also social sciences covering economics, extension, communication, humanities, management, business and administration.

5. A Case Study of the Papua New Guinea University of Technology in the Context of Postgraduate Education, Research and Extension Activities

Papua New Guinea University of Technology (PNG Unitech) is one of the four public universities of the country with 13 teaching departments offering degrees in engineering sciences, biological sciences, social sciences and basic sciences. School of Agriculture is one of these and has been offering undergraduate and postgraduate degrees with built-in research and outreach extension programmes for rural community development. The School has two undergraduate programmes, one is science based on campus B.Sc. Ag. degree and the other is Bachelor of Agriculture and Rural Development (BARD) offered in distance mode. The Agricultural School has also postgraduate studies and research programmes leading to M.Sc. and Ph.D. degrees on a limited scale. The programmes of higher education, research, extension and outreach are being operated as a package on the basis of demand. The programme developed recently at PNG Unitech for postgraduate studies, research and extension services may be a model example for other island countries of the Pacific. In addition to offering degrees, the programme shares knowledge and skills with rural communities to train and transfer technologies and develop youth entrepreneurship. A revised educational-institutional approach to transfer knowledge and skills through the extension arm of the university known as South Pacific Institute for Sustainable Agriculture and Rural Development (SPISARD) provides outreach extension to the rural community. Education, research, extension, training and demonstration activities are operated in an interactive manner involving other public and private stakeholders as partners. Between 2005 and 2009, international donor agencies especially Australian Centre for International Agricultural Research (ACIAR) played an important role to develop this model by initiating postgraduate scholarship projects for research and extension in favour of PNG Unitech (Norton 2011). The cost for postgraduate studies at Unitech is low varying from Kina 25,000-30,000 (approx. USD 8000-10,000) per student per year, while the cost for undergraduate studies per student is Kina 20,000 to 30,000 (approx. USD 7000-10,000) per student per year. Government does not provide any additional support for postgraduate studies, research and extension except the staff emoluments and recurring budget. However, this approach developed by the School of Agriculture of PNG Unitech with initial support from ACIAR has become a role model for the University. The number of successful postgraduates during the years is 96 (Table 1). Almost 50 per cent of the postgraduate students in agriculture are now self-sponsored, while initially it was difficult to find a student for postgraduate studies even with full scholarship support. The outreach extension services initiated in 2004-2005 with one village have been extended to 54 villages in eight provinces of PNG without any additional resource allocation from the university or government except some industries as Trukai Rice. The local farmers' organization and Local Level Government (LLG) facilitate the activities in the locality. The technology demonstrations and contents of training vary according to needs of the community but has so far covered 21 broad areas for livelihood improvement and entrepreneurship development (Table 2). The estimated cost of training per farmer varies between kina 37-50 (USD 15-20) depending on the contents and duration of training. The training cost is low because of availability of the existing local resources, staff and students and farms and laboratories of the university along with partners. The contribution of university is visible in local communities through creation of AKAP through SPISARD. Outreach extension programme of the university has also

Table 1. Students graduated in various disciplines of Agriculture under different postgraduate programmes during 2001-2015

Year of graduation	Number of students graduated in each programme			Total	Discipline-wise number of graduates					
	Ph.D.	Masters	PG Diploma		Agricultural Extension/ Economics	Animal Production/ Health/ Nutrition	Crop Protection (Pathology/ Entomology)	Farm Mechanization/ Postharvest	Soil Science/ Environment	Plant Breeding/ Agronomy
2015	1	7	4	**12**	1	1	4	-	3	3
2014	1	8	5	**14**	3	2	2	-	4	3
2013	-	4	7	**11**	4	3	1	1	-	2
2012	-	2	6	**8**	4	3	-	-	1	-
2011	-	2	3	**5**	-	-	2	-	1	2
2010	-	2	3	**5**	3	-	-	1	1	-
2009	2	1	7	**10**	5	1	2	-	-	2
2008	-	1	5	**6**	1	2	1	1	-	1
2007	-	3	7	**10**	2	3	3	-	-	2
2006	-	2	5	**7**	3	1	-	1	-	2
2005	-	1	2	**3**	1	-	-	-	1	1
2004	-	2	-	**2**	-	-	1	-	-	1
2002	-	1	1	**2**	-	1	1	-	-	-
2001	-	-	1	**1**	-	1	-	-	-	-
Total	**4 *(4)**	**36 (38)**	**56 (58)**	**96**	**27 (28)**	**18 (19)**	**17 (18)**	**4 (4)**	**11 (11)**	**19 (20)**

*Note: *(%)*

Table 2. Number of people trained in rural communities in various fields (2004-2014)

Year	Number of training programmes conducted in each region					Fields of training								Participants		Total
	Momase	High -lands	Southern	New Guinea Islands	Training #	Livelihood skills	Nutrition & food security	Book keeping	Health awareness	Livestock & aquaculture	Crops	Flori- culture	Total trainings	Male	Female	
2014	4	–	–	–	**4**	1	1	–	–	–	–	2	**4**	30	53	**83**
2013	2	–	–	–	**2**	1	–	–	–	1	–	–	**2**	30	27	**57**
2012	–	–	2	–	**2**	–	1	–	–	1	–	–	**2**	50	11	**61**
2011	–	5	–	–	**5**	1	1	–	–	2	–	1	**5**	139	69	**208**
2010	7	–	–	–	**7**	2	–	–	1	2	1	1	**7**	278	346	**624**
2009	16	–	–	–	**16**	6	3	1	1	2	3	–	**16**	109	287	**396**
2008	6	4	5	–	**15**	4	7	–	1	1	2	–	**15**	241	330	**571**
2007	11	–	–	–	**11**	3	3	–	2	–	3	–	**11**	195	140	**335**
2006	–	1	4	–	**5**	2	2	–	–	1	–	–	**5**	145	95	**240**
2005	1	–	–	–	**1**	–	1	–	–	–	–	–	**1**	20	12	**32**
2004	–	–	–	6	**6**	1	–	1	–	2	2	–	**6**	190	35	**225**
Total	**40**	**10**	**11**	**6**	**74**	**21**	**19**	**2**	**5**	**12**	**11**	**4**	**74**	**1,427**	**1,405**	**2832**

developed several entrepreneurs in the project villages, especially among the rural youth. PNG is one of the Melanesian countries and is the highest populated among all the pacific nations. Almost 20 per cent of PNG population belongs to youth group between ages 14-24 years (Table 3). The extension arm of the University has also successfully developed rural youth entrepreneurship in the farming community. A case study in entrepreneur development in PNG village has been reported in APAARI Newsletter (Anon. 2015). This reflects the impact of University led outreach extension services to enhance the personal viability and family livelihood in the rural community. The students of the university usually take lead role in developing these entrepreneurs. Other Pacific island countries and isolated educational institution in any other country could initiate similar programs towards Agricultural Education, Research and Extension for Development (AERE4D) through policy supports.

6. Policy Issues and Recommendations

Every government has objectives to enact and pursue policy to maximize returns from higher education, research, extension and innovations. Economic success in the global market is determined more than ever by the pace of innovation. Investment in higher education, research, extension and innovations for development of people must be prioritized. budget cuts in these sectors will not bring any sustainable benefit to people. The higher educational institutions such as universities and their research and extension arms must be utilized along with the national research institutions including private industries at home and overseas. They all need to work as close partners. Farmers are the big stakeholders who need to be involved in all activities from initial stage of any project. Rural youth and women are essentially inseparable components of the society and must be integrated in the development process.

6.1. Recommendations

- Public spending on higher education, research, extension and innovation in agriculture needs to be raised considering the agricultural GDP of the country. It should not be less than 2 per cent of agricultural GDP. Research capacities cannot exist without the minimum investment. This is true for all countries.

Table 3. Youth share (aged 15-24 years) of the populations in countries and territories in the Pacific region in 2010

Sub-region and country/ territory	Estimated population in mid-2010			
	Total	15-24 yrs	15-24 yrs as proportion of total population (%)	15-24 yrs as proportion of total adult population 15-59 yrs (%)
MELANESIA	**8,641,883**	**1,695,272**	**19.6**	**33.7**
Fiji	847,793	155,555	18.3	28.9
New Caledonia	254,525	44,853	17.6	27.5
Papua New Guinea	6,744,955	1,337,953	19.8	34.4
Solomon Islands	549,574	104,910	19.1	35.0
Vanuatu	234,023	45,423	19.4	35.1
MICRONESIA	**547,345**	**106,838**	**19.5**	**32.1**
Federated States of Micronesia	102,624	12,170	20.6	35.1
Guam	187,140	32,134	17.2	27.5
Kiribati	100,835	21,222	21.0	35.6
Marshall Islands	54,439	12,384	22.7	42.1
Nauru	9,976	2,106	21.1	34.2
Northern Mariana Islands	63,072	10,191	16.2	23.9
Palau	20,518	3,365	16.4	23.3
POLYNESIA	**663,795**	**127,871**	**19.3**	**32.3**
American Samoa	65,896	13,602	20.6	35.8
Cook Islands	15,529	2,937	18.9	31.5
French Polynesia	268,767	50,088	18.6	28.3
Niue	1,479	253	17.1	28.9
Pitcairn Islands	66	–	–	–
Samoa	183,123	35,899	19.6	36.0
Tokelau	1,165	228	19.6	35.9
Tonga	103,365	20,281	19.6	36.5
Tuvalu	11,149	2,152	19.3	32.3
Wallis and Futuna	13,256	2,432	18.3	31.0
Total population	**9,853,024**	**1,929,981**	**19.6**	**33.5**

Source: SPC Pacific Island Populations Estimates and projections of demographic indicators for selected years, 2010. The data for Vanuatu are based on the 2009 census. The data for the Federated States of Micronesia are based on the preliminary results of the 2010 FSM-wide Census

- Budget cut in agricultural education, research, extension and innovations is not desirable in any country, especially less developed and geographically isolated ones. The interaction effects of education-extension-research-innovations accelerate the returns from these investments. These have cumulative value adding impacts along the process and always pay off.
- The public and private investment in universities for research is essential especially in the countries where universities' own research potential is still in the process of development. As there are evidences of high return from research investment through the university system, government and donor agencies need to provide sufficient budgetary allocation to the universities for

research. External benefits of higher education to the society delivered by staff and students should also be considered.

- The youth and women must be considered as an inseparable component for agricultural development. Special projects should be implemented for these groups with investment plan and required allocation. The resources including cash money will get circulated in the rural areas through this process.
- Postgraduate education being one of the key sources of human capital development, investment in this sector needs prioritizations. This encourages team-building and interpersonal skills along with sophisticated analytical and forecasting capacities of the team members.
- Investment in rural youth development must be prioritized specially in the countries with large youth cohorts.
- Regular research on policies is desirable to update and adjust them in the context of changed circumstances.

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16. Investment in Extension and Advisory Services in Asia-Pacific Region: Status and Opportunities

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ABSTRACT

Though agricultural production and productivity have generally increased in Asia, poverty and food and nutritional insecurity is widespread in many of the less-favoured agricultural regions. Agriculture thus remains critical for these issues and generally for improved livelihoods in the Asia-Pacific Region. Extension and advisory services are a fundamental institution to support agriculture to achieve these objectives. Countries in Asia, particularly Eastern, South-eastern, and Southern Asia have the largest extension systems in the world. In Asia, extension and advisory service provision is largely in the public domain and most of it is funded and implemented through the national and state level ministries or departments of agriculture. Universities and agricultural research centres are also engaged in limited extension work. However, these services have been traditionally weak, in part because it is difficult to show impact of extension, which could convince policymakers to prioritize and invest in extension and advisory services. Research, regional dialog, and expert opinion show that there are several key areas where extension should be strengthened: in the individual key competencies of advisory service providers, capacities at the organizational and system level within countries, in the development of national extension platforms to share knowledge, participate in innovation processes, and engage in policy dialogue, and in the development of policies and strategies for extension. The major recommendations are: (i) better collect and analyse data on extension systems; (ii) development of advisory services and extension policies, (iii) more investment in extension, and (iv) capacity strengthening especially functional capacity for extension professionals as well as organizational and system capacity.

Keywords: Extension; Advisory services; Status; Assessment; South Asia; Pacific; Southeast Asia; East Asia

1. Introduction

Despite rapid economic growth and structural transformation across the Asia-Pacific region and amidst multiple challenges faced by the agriculture sector in food and nutrition security and poverty alleviation, agriculture continues to be an important engine of growth in most of the region. Agriculture accounted for 14.6 per cent of gross domestic product (GDP) in 2013 (Indonesia 14.4%, Philippines 11.2%,

and Vietnam 18.9%) and provided 33.1 per cent of employment in 2013 (Indonesia 35.0%, Philippines about 31.0%, Vietnam 46.8%, and Thailand 41.7%) (ADB, 2014). As many Asian countries shift from agriculture-based economies to more industry and service-oriented ones, most of the rural and agricultural sector remains left behind. Stronger advisory services for this sector will promote its engagement towards food security and sustainable, inclusive agricultural development in support of national and regional priorities in the region, as called for by various international fora like the World Economic Forum. Stronger and better organized rural advisory services are an important input in the pursuit of inclusive and sustainable agricultural and rural development.

Various stakeholders have highlighted the emerging demand for strengthened agricultural advisory services[1] in the Asia-Pacific region and beyond. For many years, development projects in the region have invested in organizing smallholder farmers to achieve economies of scale to access services (organizing demand for a variety of services); however, there has not been any organized response from service providers to match the emerging demand.

While public and private service providers exist, they are not yet capable to meet the diverse pool of requests for services coming from organized farmers. In fact, many projects have difficulty in mobilizing adequate agro-technology-based service providers. For smallholder producers to access services and goods, and benefit from input and output markets, availability of service providers who have production-related expertise along with agri-business and entrepreneurship skills is critical. For these reasons, advisory services – which for over two decades have received minimal financial support from developing countries and donors alike – are back on the development agenda.

Whereas advisory services policy options may exist in some areas of the Asia-Pacific region, implementation remains a challenge. Now is thus a critical time to invest in innovations and investment in advisory services for public and private good in the region, and to better organize and build capacity and share knowledge among advisory services and other key stakeholders using a systems approach. This implies strong roles for public, private, and civil society sectors to build a sustainable and pluralistic advisory services system.

2. Status (Providers, Main Issues, and Financing)

Too little is known on actual financing of extension programmes for several reasons. Extension is often part of other programmes such as research and not a stand-alone programme. Extension is very pluralistic and even if we have data on government financing, financing by non-governmental organizations, the private sector, and producer organizations remains largely unknown. Finally, many government extension systems are decentralized and thus difficult to aggregate at the national level. Similarly, information on manpower deployed in extension and advisory service provision beyond the public sector is often not available. Even within public sector, the extension staff are often engaged in a number of non-extension activities such as distribution of inputs and subsidies. NGOs do deploy several of their staff in addition to trained community workers to advise farmers. Similarly, field level staff of private companies engaged in agri-input supply and agri-business also advise farmers on use of inputs and production of quality products. Their number are often not available and this also constrain making correct estimates on the number, functions and capacities of extension and advisory service (EAS) staff.

This section examines advisory services in the different Asia-Pacific sub-regions. It looks at the current status of extension: who is providing advisory services and funding? What are the main issues? How many extension agents work nationally? What is known about financing of the pluralistic extension systems? The data come from a worldwide extension study conducted in 2009-2010 by Swanson and Davis (2014).

Countries in Asia, particularly Eastern, South-eastern, and Southern Asia have the largest extension systems in the world. For example, China has more than 610,000 extension workers, India has 115,800 extension workers in the public sector, and Indonesia has nearly 54,000 extension workers. However, smaller countries such as Pakistan and Thailand still have similar ratios of extension workers, given the number of farmers in each country. In the Pacific Sub-Region, it is estimated that 1 extension officer serves 10,000 farmers (SPC 2015b).

[1]Advisory services, also called extension, are defined as "all the different activities that provide the information and services needed and demanded by farmers and other actors in rural settings to assist them in developing their own technical, organizational, and management skills and practices so as to improve their livelihoods and well-being" (Christoplos 2010).

2.1. South Asia

The South Asia sub-region covers eight countries, including: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.

About 80 per cent of South Asia's poor live in rural areas. Most depend on agriculture for their livelihood. Agricultural and rural development is the key to eradicate poverty and creating conditions for sustainable and equitable growth. South Asian agriculture faces several new challenges ranging from deteriorating natural resources base, climate change and increasing de-regulation of trade. Moreover, the sector is dominated by small farmers often with weak bargaining powers and limited political voice. A pluralistic and demand driven extension provision, that offers a much broader support to rural producers, is critical for agricultural development and poverty reduction in South Asia. Though, South Asian countries have a long history of organizing and reforming extension services, much more needs to be done to strengthen their capacities to deal with the rapidly evolving challenges in agriculture. Commitment to pluralism is central to the discussion on extension reform as it is now widely accepted that no single actor or agency is best placed to offer the wide range of services required by the rural communities.

Extension faces challenging times in South Asia. It has been faced with a new set of challenges at a time when public support for its sustenance and growth has been declining. Public sector extension continues to dominate extension provision everywhere. Extension is decentralized to a large extent in Nepal and Pakistan. Most countries with the exception of Maldives and Bhutan have a pluralistic extension system. NGOs, input companies, agri-business firms, producer organizations, micro-finance institutions, universities and research centres do contribute to extension services. ICTs, especially mobile phones are increasingly used for disseminating information and advice to producers. Extension is relatively weak or non-existent in the livestock and fisheries sector. Five out of the eight countries in this region implemented the Training and Visit (T&V) System of extension during the 1980s. Subsequent reforms focussing mostly on devolution of extension from the national level to lower levels (provinces and districts) weakened extension by way of declining farmer-extension agent ratio, weakening links with research and loss of political and financial support. Extension support is increasingly channelized through farmer groups currently (AESA 2014).

Bangladesh and India have developed a highly pluralistic extension system. India has a decentralized, collaborative arrangement between the national government and the state governments regarding public extension services (Swanson and Davis 2014). Though India has a wide diversity of extension service providers representing the public, private and the voluntary sectors, producers are not getting adequate support in addressing their expanding and complex challenges and many remain untouched from many of these initiatives. Despite the variety of agricultural extension approaches that operate in parallel and sometimes duplicate one another, the majority of farmers in India do not have access to any source of information" (Glendenning *et al.* 2010).

The data from the National Sample Survey Organization (NSSO) revealed that about 60 per cent of the farmers haven't accessed any knowledge from any of the listed sources of agricultural knowledge. According to NSSS (2014), "At the all India level, around 41 per cent of the cultivating households accessed technical help from any of the listed agencies/ sources (extension agent, Krishi Vigyan Kendra, Agricultural University/College, Private commercial agent, progressive farmers, radio/TV/ newspaper/ internet, Veterinary Department, NGOs, etc.) during the period July - December 2012. Progressive farmer and radio/ TV/newspaper/ internet were the two main sources accessed by the agricultural households for technical advice".

Approaches such as market-led extension and public private partnerships are experimented in many countries. Almost every country faces the following set of challenges in extension delivery: lack of adequate number of extension staff, limited funding, weak linkages with research, lack of coordination and collaboration among multiple extension providers, lack of adequate capacities among extension staff and lack of professionalism in extension. Except Bangladesh, every country lacks an extension policy. Policies related to human resource development as well as certification and standards in extension provision are lacking everywhere (AESA 2014).

Agricultural Extension in South Asia (AESA) was formed in 2013 in response to the demand for a network of all those interested in extension and advisory services articulated in some of the recent global and regional meetings on extension

organized by the Global Forum for Rural Advisory Services (GFRAS). The AESA web portal (www.aesa-gfras.net) has become a "single window" to understand what is happening in EAS in the region. Apart from this, the AESA has a Facebook group (which has currently over 12,500 members) to promote the latest developments in EAS (https://www.facebook.com/groups/428431183848161/). AESA has recently set-up two country fora, one in Bangladesh (Bangladesh Extension Network) and the other in India (Indian Extension Network).

In Bangladesh, the Bangladesh Extension Network (BEN) was organized by the Second Crop Diversification Project (SCDP) of the Department of Agricultural Extension (DAE) on 1 September 2014. This meeting was attended by 76 extension professionals representing different sectors, agricultural universities, research centres, private sector and NGOs and the meeting constituted an ad hoc executive committee to take forward the activities of BEN[2]. During the second meeting (24 September 2014), the BEN identified two sub-committees, one to work on a draft constitution and the other to develop a webpage. Due to lack of financial support, BEN has not been able to organize a full-fledged meeting of the network to initiate capacity need assessment activities. BEN also needs more professional support and advice to strengthen its activities such as knowledge management, network development, leadership, need assessment and capacity development, fund raising etc.

2.2. Pacific

The Pacific Island Countries and Territories (PICTs) consist of three sub regions, Melanesia, Polynesia and Micronesia. Melanesia (Fiji, PNG, Solomon Islands and Vanuatu) comprise over 98 per cent of the land area and 92 per cent of the population of all PICs. All but Fiji have low per capita incomes, high population growth and declining social indicators (e.g. health), despite large and diverse land resources. Fiji in contrast is one of the wealthiest PIC countries although inequality is high (pockets of poor in urban and rural areas). Polynesia (Cook Islands, Niue, Samoa, Tonga, Tuvalu, French Polynesia, Wallis and Futuna, Tokelau, American Samoa, and Pitcairn) has mostly small populations, but fairly high population densities and like Micronesia, the outer islands in Polynesia lack services. These cultures are very cohesive and social indicators are quite high compared with other PICs. Remittances are a large part of this sub-region's economy coming in from family members in New Zealand and Australia. Agriculture provides 40 per cent GDP in Samoa. Like Melanesia, Polynesia also has rich volcanic soils, but it lacks minerals. Micronesia (Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Guam, and Commonwealth of Northern Mariana Islands) consists of a large series of atolls and islands which are vastly spread with high populations putting pressure on limited land resources. The atolls are also remote from domestic and international markets and are more vulnerable than Melanesia and Polynesia to economic forces and climatic events. Micronesia has medium level per capita incomes although there are big differences between people on urbanized islands and outer islands. With limited land resources, only 3 per cent of the GDP is from agriculture as soils are unsuitable for agriculture and experience harsh climatic conditions, although marine resources are abundant. Anticipated climate impacts are of particular concern for much of Micronesia. Against this backdrop, extension services are challenged by (i) meeting the needs of atolls in comparison to more elevated islands, (ii) food security concerns, (iii) the challenge of remoteness which includes exorbitant travel costs, (iv) fragmentation of information related to disparate engagement in both USA and Pacific political-economic processes (SPC 2015a).

Although Research, Extension and Advisory Services (REAS) are important priorities of the Pacific region, these priorities are not usually translated into government budgetary allocations to meet the increasing demands for expanded role and effective services. As a consequence, most extension services are faced with the challenge of limited institutional and human capacity resulting in low coverage with distant and remote areas often poorly served and also weakly integrated into local and export markets. The often perceived problem is absence of favourable policies and limited linkage and synergy between stakeholders and programmes. Further, limited human resource capacity has been widely recognized.

In November 2005, a first ever Pacific Extension Summit was organized by the Land Resource Division (LRD) of the Pacific Community and supported by CTA, EU, ACIAR, FAO and SPC GTZ Forestry. The main focus of the summit was

[2]http://www.aesa-gfras.net/Resources/file/RS-eds-9-Sept-Extension%20Network%20Meeting%20minutes%20(1).pdf

'Bringing about change – promoting participatory agricultural extension in the Pacific'. The summit identified a number of challenges extension faced in the Pacific and agreed to a number of priorities to strengthen support for Participatory Agricultural Extension (PAE).

In 2007 and 2008, Pacific wide participatory needs assessment was carried out by SPC and ACIAR to identify capacity assessment needs. The assessment found that there were very diverse capacity building needs of individual extension officers among the countries. Three main categories emerged in the study: (i) livelihood, or the context for participatory RD&E, which covers issues relating to climate change and environment, crop and livestock production, processing and marketing, (ii) management of participatory RD&E, which covers issues related to project management, reporting, administration, finance and governance, and (iii) participatory RD&E skills, which consisted of the particular skills, knowledge and attitudes needed to deliver effective and efficient extension, research and development services to the clients of government agencies, NGO's and other institutions. Further capacity building needs have been identified by specific countries since this study, but in general, the findings are similar. For example, in a review of extension undertaken in Vanuatu, capacity building needs identified included skill enhancement of staff in a variety of technical and extension areas, as well as improving skills in gender equity approaches. Other issues identified included weak institutions and governance at all levels, lack of clear policy and strategy, poor office support, and the inability of staff to complete work plans. These are common concerns for all PICs as traditionally extension services in the Pacific have had low priority status. This, combined with a poor image of service delivery has led to limited budgets and limited staff being allocated to extension programmes.

Today, in most PICTs, Rural Extension and Advisory Services continue to face many challenges stemming from limited budgets and staff allocated to extension services. Disasters such as cyclones and drought further affect the availability of funds for non-core government functions. Fiscal pressures and capacity constraints on governments have led to a shift from primarily public sector rural service delivery to a mix of public, private and NGO based service delivery. Private sector service providers often have poor legal and regulatory frameworks and NGOs work very much in isolation with the majority of their funds being spent on grassroots projects and not information sharing or networking. All three sectors have been poor at building partnerships. On average ratio, one extension officer serves 10,000 farmers with a budget allocation of less than 0.5 per cent of the national budget for most countries. Internet communication technologies (ICT), particularly mobile phones, are commonly considered a means of improving small holder agricultural development. In PIC countries access to ICTs varies considerably from country to country. For example, the access and use of ICTs in Fiji are exceptional compared to other PIC countries, however, other countries are catching up (e.g. Samoa). The main issue in terms of access is cost but this changes quickly in the market. Of course, access to ICTs is more restricted if not absent on outer islands (SPC, 2015a).

In 2015, SPC through support from EU, GFRAS, USAID and other development partners, organized a Research and Extension Forum. The forum identified ongoing challenges continuing to hinder effective extension services and agreed to a number of priority areas to foster strengthening EAS in the Pacific and agreed to the development of a Regional Extension Strategy (RES). The priority areas are grouped into several thematic areas, capacity building support for EAS, institutional and policy supports, systematic partnership, knowledge management and research and extension linkages.

2.3. Southeast Asia/Mekong Delta

Asia's Southeastern sub-region covers eleven countries, including Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Vietnam. The South-eastern Asian sub-region, along with East and South Asia, now accounts for the major share of world economic outputs and economic growth. South-eastern Asia's eleven countries are generally divided into "mainland" and "island" zones. The mainland countries (Myanmar, Thailand, Laos, Cambodia, and Vietnam) are actually an extension of the Asian continent. Island or maritime Southeast Asia countries include Malaysia, Singapore, Indonesia, the Philippines, Brunei, and the new nation of Timor Leste (formerly part of Indonesia).

Agricultural extension services are mainly provided by the public sector in Myanmar. The Ministry of Agriculture and Irrigation (MOAI) is responsible for the

development and management of agricultural support services and irrigation and drainage infrastructure and management. With a staff of about 70,000, it is one of the largest ministries and covers a wide range of activities, including water resources management, irrigation, mechanization, and settlement and land records (Sergiy Zorya, personal communication, 12 October 2015). The Irrigation Department (ID) is responsible for the development and management of gravity irrigation systems which includes planning, investigations, design, construction, operation and maintenance of dams and reservoirs for irrigation, river head works, irrigation main and distributary canals, drainage and flood protection. In 2014-15 fiscal year, it received 65 per cent of MOAI Union level budget (with about 70% of the budget for capital expenditures) and has 8,000 staff. The Department of Agriculture (DOA) is responsible for agricultural extension, seed production, soil management, plant protection and biotechnology. It receives about 8 per cent of the MOAI budget and has about 8,000 staff. The new technology development is responsibility of the Department of Agricultural Research (DAR). It has 17 satellite farms and 7 crop research centres and about 700 staff members. In 2012-13, DAR received about 2 per cent of MOAI budget (Sergiy Zorya, personal communication, 12 October 2015).

In Myanmar, the Livelihoods and Food Security Trust Fund (LIFT) is the largest trust fund that offers alternatives to the public extension services (Sergiy Zorya, personal communication, 12 October 2015). For more information, see www.lift-fund.org.

In 2013-14, total budget of MOAI was 438,704,000 Kyats (or USD 452 million). About 70 per cent of funds was for irrigation. The Department of Agriculture, which includes extension division, managed 6 per cent of MOAI funds – 24,653,000 Kyats or USD 25 million. It is likely that about half of this amount (USD 12.5 million) was spent on extension (Sergiy Zorya, personal communication, 12 October 2015).

In 2013-14, total budget was 13,045,135 Kyats and GDP was 53,501,000,000 Kyats. The share of MOAI budget in total budget was 3.4 per cent and in GDP 0.8 per cent (Sergiy Zorya, personal communication, 12 October 2015).

In Myanmar, traditionally there have been two public extension and advisory service providers, the Department of Agriculture (DOA) and the Livestock Breeding and Veterinary Department (LBVD). Since 2012 there are a few private agro-enterprises and several projects working on advisory services. The Extension division of DOA has outreach and education offices in almost each township across Myanmar, focusing very much on rice and mainly oriented towards the achievement of production targets. LBVD is mainly active on animal disease surveillance and control, the activities on animal production, breeding and nutrition are very limited. All Extension and Advisory Service (EAS) providers in the public sector lack a clear strategy, are characterized by a centralized administrative and management structure which is not conductive to initiate and implement extension activities focused on the needs of the farming communities. Seed companies also play an increasing role in the provision of EAS particularly in the maize and vegetable sub-sectors. Some commercial companies have strong informal linkages with the public institutions and their personnel as business partners.

The other EAS providers are agricultural/rural development projects. The Livelihood and Food Security Trust Fund (LIFT) established in 2009 is a major player, which finances a wide range of projects all over the country with various innovative and comprehensive EAS approaches. Other international or bilateral development organizations like IRRI, FAO, JICA and ACIAR have been implementing agricultural projects since a long time as well.

Although many private agro-enterprises, international and local NGOs and Department of Agriculture introduced various high technologies for agricultural production to farmers, these are still weak in extension education and advisory services.

The formal linkages between the three sectors of EAS providers – public, private, projects- are emerging and still at an infant stage, but developing. In the public sector, exchange and linkages between agricultural education, research and extension are weak and both budgetary and administrative regulations and the prevailing management style rather contribute to a wide-spread "silo-mentality".

The overall agricultural and rural development process needs a stronger basis of rational and economic considerations among which the farmers' income needs to be the priority.

Education is the key for modernizing the agriculture sector in Myanmar. The Agricultural education sector is concentrated on 14 State Agricultural Institutes offering a 3-year diploma programme, the Yezin Agricultural University offering Bachelor and Master

of Agricultural Sciences and Ph.D. programmes and the Central Agricultural Research and Training Center offering regular in-service training to employees of Ministry of Agriculture and Irrigation.

The Department of Agriculture (DOA) has undergone a number of structural reforms within the MOAI. The Department of Industrial Crops Development (DICD) is currently being merged with DOA. Industrial crops had been separated from general agriculture in 1994, and the ongoing unification of all crops in one department could be interpreted as a step in the right direction. Farmers should grow the crops they have identified as being most suitable for their farm; real or so-called "national interests" should not force farmers to cultivate crops against their will.

Given the wide range of agro-ecological zones and consequently the wide range of prevailing cropping patterns as well as the different degree of market integration of the farming communities, there is a need for a comprehensive decentralization process in agricultural education, research and – most urgently – in extension. On the one hand, the technical messages need to address issues like the economic drivers of the prevailing cropping pattern, also the approach has to be modified to increase the access to and the acceptability of the messages by the farming community.

The concept that a fully public-financed extension service will operate efficiently and effectively nationwide and covering all major crops is unrealistic and needs to be modified. Other actors will increase their activities in EAS and the roles of the various actors need to be discussed and taken into account during the re-definition of the mission of public EAS.

A number of structural changes and reforms are required to improve the linkages between the agricultural education, research and extension institutions, also adjusting the orientation of agricultural policy in general towards the problems and the needs of the farming community.

According to the World Bank, in Cambodia, agriculture employs 60 per cent of the population and contributes 30 per cent to GDP. Rice is the main crop. Agriculture has great potential to contribute to economic growth and extension is an important contributor to agricultural growth.

Cambodia has an extension model where agents typically lead about 50 farmers to achieve higher adoption rates (World Bank 2011). They use farmer field schools. An important topic is helping farmers adapt to climate change, particularly by changing their cultivation practices and cropping choices. Direct annual costs of government extension agents are roughly similar to those of NGOs, which are about USD 1,000 per person per year. However, this can be up to USD 20,000 per year when local and international overhead costs are included (World Bank 2011). The total average costs per farmer amounted to USD 273 per person.

According to the World Bank (2011: 1), "Cambodia has experienced strong economic growth along with significant poverty reduction over the past decade. Average annual gross domestic product (GDP) growth was about 10 per cent between 1998 and 2008, compared to a 1.8 per cent population growth rate during the same period. Poverty has been reduced significantly (around 10% in a decade) and continues to fall, declining from 35 per cent in 2004 to 30.1 per cent in 2007. Economic growth has been broad-based, covering all key sectors, and per capita GDP has increased from USD 250 in 1998 to an estimated USD 795 in 2008. The country has achieved macroeconomic stability and put in place an open trade regime, which has led to significant inflows of foreign direct investment (FDI)".

Cambodia's Ministry of Agriculture, Forestry and Fisheries (MAFF) developed an extension policy in 2014. Main challenges in extension include lack of investment, lack of trained human resources, and poor links between farmers, markets, extension, and research. The policy's vision is for expanded and effective agricultural extension service delivery for improved wellbeing of Cambodian people.

The country also has an agricultural sector development plan for 2014-2018. Under this, the MAFF's defined policy goal is to increase agricultural growth by 5 per cent per year through enhancing agricultural productivity, diversification, and commercialization, as well as promoting livestock farming and aquaculture while considering sustainable forestry and fisheries management.

Agriculture development remains the major driver of economic development in the Philippines giving the right impetus for growth. Raising productivity is key to structural transformation. Its current performance requires innovative ways of addressing the issues confronting the agriculture and fishery sector. The agriculture sector accounts for 18 per cent of the country's GDP with an average growth rate of

2.6 per cent annually and provides employment to more than 11.8 million Filipinos (31% of total work force). Major employer is crops subsector at 10.4 million (NEDA 2013). Addressing food and nutrition security among the teeming millions of Filipinos remains a daunting challenge. The Philippines with a population of 103,869,870 in October 2015 is the 12th most populous nation in the world with a population growth rate of 1.9 per cent and a dependency ratio of 67.3 per cent (Philippine Statistics Authority 2015). Population density in the Philippines is 334 people per km^2 and the average age of farmers is 57 years which is markedly affect their potential to adopt new technologies and other innovations.

Similar to most Asian countries, poverty in the Philippines is largely a rural phenomenon. Majority of the farms are engaged in smallholder agriculture. The poverty rate in 2014 was at 26 per cent. Every two out of three income poor persons in the country are located in the rural areas and are predominantly dependent on agriculture for employment and incomes (Balisacan 2015). Any increase in food prices consequently hits most the poor because the effect of food price inflation is the highest on them since more than 20 per cent of their income is spent on food.

Challenges that continue to hamper desired growth in the agricultural sector include serious constraints in production growth and productivity, risk and vulnerabilities due to extreme weather events, and flawed policies and institutions that undermine its development (NEDA 2013). The high cost of production inputs, inefficient supply chain and logistics systems, inadequate provision of irrigation system, low rate of adoption of technologies including mechanization and limited access to formal credit are limiting opportunities of farmers. Extreme weather events, exacerbated by an average of 20 typhoons that visit the Philippines annually, the El Nino phenomenon that comes every alternate year, had reduced crop production in the first quarter of 2015. Higher sea levels and storm surges are expected to affect 42 per cent of coastal population which accounts for 45 per cent of the country's urban population. This group is particularly vulnerable to floods, due to less secured infrastructure, reduced access to safe drinking water, and lack of health insurance. Fishing communities and their livelihoods are affected by global warming and acidification of coral reefs because these are natural habitat and serve as spawning grounds of fishes.

In the Philippines, there are several projects[3] working on advisory services. Philippine agricultural extension is dominantly pluralistic and decentralized. Governance and practice are guided by two important laws of the land. The Republic Act 7160 (also known as "The Local Government Code of 1991" fully devolved delivery of extension services to the local government units (cities and municipalities) and granted autonomy to local government units (LGU) to plan their own programmes for agriculture and fisheries. It is tasked to generate its own funds basically from local taxes and partnerships with the private sectors and NGOs, state and local colleges and universities, collaboration with national agencies on *in situ* implemented projects, and some friendly donors. Salaries of devolved agricultural extension workers (AEW) come from tax collection known as the Internal Revenue Allotment (IRA) which is 15 per cent of total revenue collection in a given year. The amount is shared among other devolved functions such as health and nutrition, social welfare services, and agriculture, among others. Five per cent of this amount goes to the agriculture and fishery sector including provision of extension services. The Philippine Extension and Advisory Services Network (PhilEastNet, formerly Philippine Extension Network), is an organization of extension professionals that helps with professionalization and certification of extension in the country.

The devolution has impacted negatively on the delivery of extension services particularly among the low class municipalities. There is demoralization, due to low salaries (underpaid) and lack of material support to undertake extension functions. Governance and interference of local politics are real problems. Local government units in the Philippines are classified into six categories according to their income levels. Agricultural extension workers (AEW) receive monthly salary the amount of which depends on the income classification of municipalities. The AEW from 1st class municipalities receive an average monthly income of PHP 16,846 (USD 374.00) while the

[3]Integrated Natural Resources and Environmental Management Programme, with the objective of reversing degradation of natural resources and development of watersheds; has a livelihood component for upland dwellers, particularly indigenous people. The second project is the Cordillera Highland Resources Management Programme which covers 170 barangays in the Cordillera region and will terminate in 2016. Its objective is agribusiness development and extension providers include LGUs state university in the region (for thematic studies on root crops). This is implemented together with the Department of Agriculture.

AEW from the 6th class municipalities receive PHP 10,274 (USD 228.00) (forex is PHP45.00 = USD 1.00) (ATI-DA, 2015) which is below the poverty threshold of PHP14,903 (USD 331.00).

Under the Republic Act 8435 (The Agriculture and Fisheries Modernization Act (AFMA) of 1997), extension became focused on the provision of technical assistance, training, farm and business advisory services, farm demonstrations and ICT particularly the use of tri-media. It defines the important complementary roles of state colleges and universities, the national agencies involved in extension, private sectors and community-based organizations in the provision of extension and advisory services. It recognizes the presence of multiple extension providers and emphasizes multidisciplinary/interdisciplinary team work among them. It assigns the DA and the SCU to assist the LGUs by providing, technical assistance, training of LGU personnel, improvement of physical facilities, and extension cum research.

Several studies had established the significant contribution of extension in national productivity. An analysis of 512 estimated rates of return for agricultural research combined with extension, 18 of which were from extension-only investments, showed an average rate of return of 47 per cent for research and extension investments, while for extension-only investments, this was 80 per cent (Balisacan 2015).

As mentioned earlier, the AFMA law specified the financing of agriculture and fishery through allocation of multi-year budgets treated as grant; transfer of funds from DA as grants, and placing the budget for agriculture and fishery at, minimum of 1 per cent of GVA which was at PHP1,423 billion in 2014. National commodity programs are implemented through the LGUs, and thus the collaboration among DA units, LGUs, SCUs, NGOs and private sector is able to augment whatever limited funds the LGUs have. It is common knowledge that there are only pronounced extension programmes in the LGUs if there are national programmes coursed through them for implementation. This added task to LGU agricultural technicians also provide for salary augmentation among AEWs in terms of honorarium. However, this benefits only a few involved in project implementation.

In 1992 when devolution took effect, there were 17,000 devolved extension workers. Today there are only about 11,000 working in LGUs comprising 42,028 barangays or villages, 144 cities, 1,490 municipalities and 81 provinces. Given the classification of the LGUs, the average monthly salary of provincial agriculturist is USD 494.00, municipal agriculturist is USD 361.00, and city agriculturist is USD 450.00. Computed expenditure of local government units in terms of salaries alone per month is PHP146,612,799.00 or USD 3,258,062.00 (Table 1). With this cost of personnel, production of extension materials, travel, and training almost no amount is left to run extension programme by the LGU especially the 5th and 6th class municipalities.

Higher education institutions (HEI) in the Philippines perform trilogy functions: instruction, research and extension. To date, there are 537 state universities and colleges, 79 local colleges and universities, and 1,523 private sectarian and non-sectarian HEI. Some full time extension specialists or media specialist could also be recruited to update professors in their extension function e.g., training, action research, and production of extension materials. Owing to this, it is difficult to determine expenditure in extension alone from higher education institutions. A review of the government appropriations of selected leading Universities in the Philippines (Anon. 2014) with known and regular extension programmes, show that an average of only 2.28 per cent of the total University appropriation from the national government is devoted to Technical Services and Extension (Table 2). Other amounts are allocated to research and advancing higher education. However, a closer look at the allocation to extension covers expenses in personnel, infrastructure such as farm to market road, animal sheds, and the like.

The Agricultural Training Institute of the Department of Agriculture is the apex extension organization of the government. It orchestrates the National Extension Agenda and Programmes of the Department of Agriculture and serves as the focal agency for extension under the AFMA. It has laid down the Philippine Agriculture and Fisheries Extension Strategic Plan 2017-2022. The Plan covers thematic goals on enhancing access to agriculture and fisheries knowledge products and services, strengthened competitiveness and capacities of the sector in preparation to the country's participation in the ASEAN integration starting, expanded partnerships in advancing excellence in extension delivery of scaled-up extension innovations, strengthening stakeholder's resiliency to climate change, and improved enabling environment and quality governance.

Table 1. Expenditure in salaries of LGU-based extension workers in the Philippines, 2015 (Per month)

Region	Provincial Agriculturist (PA)	Municipal Agriculturist (MA)	City Agriculturist (CA)	Total
CAR	141,948	1,097,195	3,5574	1,271,717
I	93,876	1,931,788	173,574	2,199,171
II	120,988	1,382,615	173,547	1,593,695
III	120,988	1,888,944	363,132	2.373,104
1V a	105,995	2,206,332	401,508	2,713,885
IV b	105,995	1,146,295	36,828	1,289,118
V	115,904	1,605,321	120,822	1,773,547
VI	139,092	2,335,320	202,912	2,677,324
VII	60,513	1,733,388	24,672	1,818,573
VIII	108,208	2,024,224	124,544	2,252,976
IX	54,453	1,102,954	117,855	1,275,262
X	114,975	1,342,068	175,743	1,632,786
XI	102,320	6,93,891	105,204	901,415
XII	87,340	672,885	90,520	850,745
CARAGA	123,880	1,047,411	1,13238	1,284,529
Total monthly expenditure (Salaries)				25,907,799
Salaries for agricultural technicians (No. 9285) × PhP13,000x/month				120,705,000
Grand Total				**PHP146,612,799.00 USD 3,258,062.00**

In the last 5 years, the total budget of the Department of Agriculture for extension support and training services had been increasing (Table 3). However, most increases were devoted to support services such irrigation, postharvest facilities and other infrastructure including farm to market roads.

A number of externally funded projects were likewise implemented by ATI in collaboration with other government, NGOs, SCUs, and the private sector. Recently, ATI is collaborating with the Philippine Rice Research Institute, International Rice Research Institute (IRRI) in the project "Improving Technology Promotion and Delivery through Capability Enhancement of the Next-Gen Rice Extension Professionals". This learning event aims to produce development catalyst competent in science-based and locally appropriate strategies for managing and adapting rice-based farming systems to achieve competitiveness, sustainability and resiliency. It is a learning event designed to meet the challenges of complex and challenging rice production environment, the aging and declining number of extension workers and farmers, as well as declining enrolment in agriculture and improve the performance in agricultural (rice) extension. Further, the ATI was also chosen as the national partner of the Asia-Pacific Islands Rural Advisory Services (APIRAS) Network in a proposed IFAD grant to study the institutionalization process into local institutions of innovative practices, information and services gained from the implementation of other externally funded projects for sustainability.

However, the provision of agricultural extension and rural advisory services in the Philippines is one of the weakest services in the agriculture and fishery sectors. It is challenged by high population rate, aging farmers and extension workers (59 years old), high population density (334 persons/ sq km) and a high technician: farmer ratio. One technician is assigned to one league equivalent to 7-8 barangays or villages, and every barangay

Table 2. Proportion of the allocation of technical services and extension *vis-à-vis* total allocation for programmes of lead state colleges and universities in the Philippines (2014)

Higher Education Institution	Proportion of allocation (%)
University of the Philippines System	2.85
Mariano Marcos State University	3.11
Benguet State University	1.78
Isabela State University	3.14
Central Luzon State University	5.40
Palawan State University	1.10
Cavite State University	1.70
Central Bicol State University of Agriculture	1.80
Aklan State University	1.71
Visayas State University	3.02
West Mindanao Sate University	1.40
Central Mindanao University	3.20
University of Southern Mindanao	0.68
Mindanao State University	1.10
Average rate (%)	2.28

Table 3. Budget for extension support and training services, Department of Agriculture, the Philippines (2010-2015)

Year	Budget (In billion Pesos)
2010	2.48
2011	3.11
2012	2.43
2013	3.11
2014	3.57
2015	3.89

Data Source: DA-ATI, 2015

consists of an average of 500-700 farmers. This gives a technician: farmer ratio of 1:3,500-5,600. This leads to problem of manpower, and lack of mobility due to limited travel support to technicians under the devolved set-up. Consequently, technicians have difficulty in monitoring conditions of small farmers and their problems.

Globalization and the ASEAN economic integration in 2015 calls for more inclusive approaches to agriculture to empower and mainstream small farmers through their producers' organization to reach competitive levels in the world market. Expanding opportunities to help them cope with the changing market conditions shall be a great challenge to agricultural extension and advisory services. However, the lack of evidence-based policies seem to stall our understanding of what needs to be undertaken when and by whom.

It is recommended that more resources are poured into extension research particularly to support policy research that would yield evidence-based policies, advocacy and promotion activities.

Supportive policy choices and investment decisions undoubtedly shall multiply a thousand fold the contribution of extension and rural advisory services in achieving food and nutrition security.

2.4. East Asia

The East Asian sub-region covers the People's Republic of China, Japan, North Korea (Democratic People's Republic of Korea-DPRK), South Korea (Republic of Korea), Mongolia, and Taiwan. The agricultural extension arrangements in East Asian countries differ significantly. Well-established extension infrastructure exists in Japan, South Korea, and China. A diversity of agricultural extension and advisory services in East Asia is seen in China (with a public-private partnership), Japan, and the pluralistic extension systems in South Korea and Taiwan (Swanson and Davis 2014).

In China, the agricultural extension system has been transformed towards pluralism. Before 1980, the agricultural extension system at the county level was centralized. During 1980 and 1992, to overcome budget constraints, the Chinese government decentralized its extension system from county agricultural bureaus to the township level. After this, many extension staff were taken off the government payroll and reassigned to township governments (Zhi *et al.* 2007). This greatly undermined the incentives and accountability of delivering public eco-agricultural extension services at the local level, and led to extension staff becoming increasingly involved in commercial activities. During 1993 and 2001, due to the mounting concerns of food security and recognized importance of technology in agricultural production, the Chinese government strengthened the capacity of agricultural extension system by retrieving management control at the county level. The Law of Agricultural Technology Extension was promulgated for providing a

legal basis to the public extension in agricultural sector.

During 2002 and 2011, decentralization at the township level backfired in counties where government budget at the local level was not sufficient and this caused great regional variation in the governance of the public agricultural extension system at the local level. Recognizing the importance and value of other providers in agricultural extension, on Aug. 31, 2012, the Amendment of "Law of Agricultural Technology Extension" was passed at the 11th National People's Congress (28th Standing Committee Meeting). In the Amendment, major revisions in the law were made and the legal framework confined the role of the extension system of government for only the public interests; other stakeholders (such as agribusiness companies, farmer organizations, research institutes and universities) were recognized to be complementary to the public agricultural extension system.

The public agricultural extension system faces great challenges in meeting the needs of sustainable agriculture. By the end of 2014, the public extension system was staffed by 331,000 people (Chen 2015). For the 30,278 extension stations at the township level, 57 per cent of them received government payroll at the county level and the management of the remaining was decentralized at the township level. Meanwhile, the financial support to the extension system is not increasing significantly. For example, to stabilize the public extension stations at the local level, the Ministry of Finance initiated "The Programme of Reforming Agricultural Extension at the Local Level and Establishing Demonstrating Counties" and budgeted 770 million Yuan in 2009. The financial support increased to 2.7 billion Yuan in 2012. In addition, another programme was budgeted with 5.8 billion Yuan in 2010 to strengthen the capacity of township extension system. As the capacity of providing matching funding at the provincial level varies, the institutions and finance are different and the system becomes regional and pluralistic.

In summary, extension has played and continues to play a critical role in Asia and the Pacific, contributing to agricultural growth but also expanding services to climate-smart agriculture, rural livelihoods, and other areas. Table 4 shows the number of reported extension agents in Asia in 2009.

Table 4. Number of reported public extension agents by country in Asia between 2009 and 2012

Country	Number of extension agents
Bangladesh	13,905
Bhutan	500
Cambodia	1,302
India	90,000
Indonesia	53,944
Japan	7,172
Lao PDR	752
Mongolia	1,100
Myanmar	4,554
Nepal	2,606
Pakistan	19,000
People's Republic of China	617,706
The Philippines	25,000
South Korea (Republic of Korea)	4,584
Sri Lanka	583
Thailand	16,986
Timor Leste	452
Vietnam	34,747
Total	**894,893**

3. Assessment and Recommendations

A series of recommendations are made to strengthen extension and thus improve livelihoods and growth in the region. These include:

3.1. Collect more and better data on extension and advisory services in the region

In Asia, extension and advisory service provision is largely in the public domain and most of it is funded and implemented through the national and state level ministry or department of agriculture. Universities and agricultural research centres are also engaged in limited extension work. Public sector extension and advisory services mostly focus on promoting new technologies through demonstrations, training, and use of ICTs. As part of some of the ongoing programmes, farmers are also organized into groups either for managing natural resources or for organized marketing. However, there is an increasing trend towards pluralistic delivery of extension service provision in almost every country in the region. Agribusiness companies, NGOs, and

producer organizations are currently engaged in extension delivery, but these activities are quite often concentrated in a few select regions. There is very limited coordination among the different organizations involved in extension.

Data on investments and human resources in extension are often available only from the public sector. This information is, however, not available with respect to other actors in the pluralistic extension landscape. Even within public sector, there is no clear data on how much time and investments really goes for EAS provision. There are no serious efforts to systematically collect data on investments and human resources in the pluralistic extension systems, and lack of these data constrain efforts to strengthen extension provision in Asian and Pacific countries.

3.2. Develop appropriate extension policies

Though extension is an important policy instrument for agricultural and rural development, very few countries have formulated extension policies to articulate and strengthen its role. Only Bangladesh, Cambodia, and Timor Leste have an explicit policy on extension in the region. In most cases, extension is discussed in a separate chapter or within a few paragraphs of each country's national agricultural/ livestock/fisheries policy. Extension faces several challenges and needs considerable strengthening. Public investments will continue to remain important to ensure that all farmers - especially the large majority of small-scale farmers - receive adequate advisory support. This does not mean that all public funds for extension services must to be spent through public services. Enhanced public investments (private too) in extension provision, development of new capacities among extension providers, and better coordination of actors within the pluralistic systems are possible only if there is a clear policy articulation of the role of extension services in agricultural innovation and how extension is going to be strengthened. Though regional/sub-regional networks and country fora of extension and advisory services are emerging in the region, they need adequate capacities for engaging in policy advocacy for extension services.

3.3. Increase investments in extension and advisory services

Both public and private investments are important for extension and advisory services and both types of investments have to be enhanced if Asian and Pacific farmers have to ensure sustainable agriculture and compete in regional and global markets. Though lack of data constraints the estimation of the current investments in extension, there is a clear indication of reduction in human resources for extension in the public sector in general with the possible exception of China and India. Reduction in human resources has mainly arisen due to low or reduced investments in extension. Decentralization of extension to provincial/local governments (Pakistan, Sri Lanka, the Philippines, South Korea, etc.) and weakened donor support for extension services since the early/mid 1990s have considerably weakened public extension in several countries. Enhanced investments are important not only to enhance the number of extension staff, but more importantly, to develop new capacities among pluralistic extension providers so that they could effectively support farmers to meet their emerging needs for support.

3.4. Strengthen capacities in extension and advisory services individuals, organizations, and systems

Though agricultural production and productivity have generally increased in Asia and the Pacific, poverty and food and nutritional insecurity is widespread in many of the less-favoured agricultural regions. Managing the natural resource base in a sustainable and integrated manner is essential to maintain and improve land productivity. Opening of agricultural markets has further increased the vulnerability of poorer countries, especially small farmers, who have weak bargaining power and limited political voice. There has been an increase in women's participation rates in the agricultural sector, either as self-employed or as agricultural wage workers during the last two decades. Climate change has made agriculture more vulnerable to extreme weather events and managing scarce water resources is an increasing challenge.

These new challenges also mean that extension and advisory services need to tackle a diversity of objectives that include, but go well beyond, transferring new technology. The Global Forum for Rural Advisory Services (Davis and Sulaiman, 2014) has identified new capacities for extension and advisory services, considering the evolving challenges in agriculture and the new roles, functions, and reform strategies

envisaged. Extension professionals and organizations should have technical and functional capacities to promote appropriate agricultural technologies, apply participatory approaches, help organize producers, understand market and value chains, and address changing forms of social and economic vulnerability and climatic and market forces. The FAO Framework for Capacity Strengthening (FAO 2012) envisages functional and technical capacities across three levels–individual, organizational, and enabling environment or system level. At the individual level, extension services need staff with good understanding of technical knowledge plus skills to manage social processes. At the organizational level, extension should have capacities to put in place systems and procedures to manage human and financial resources, institutions to facilitate partnerships and learning, and frameworks to deal with institutional, legal, and regulatory issues. At the enabling environment level, capacities for interaction, learning, and adaptation are important. Though capacities at all the three levels are equally important, most of the efforts are aimed at developing new capacities at the individual level and through staff training only.

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17. Agricultural Sustainability Through Collaboration, Beyond Competition

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The Sustainable Agriculture Initiative Platform was founded by three companies in 2002 and now in 2015 has more than 80 members representing the entire supply chain and sourcing from countries all around the world. Our vision is to implement secure and thriving agricultural supply chains and protect the earth's resources through widespread adoption of sustainable practices that deliver value to our members, farmers, farming communities, and consumers.

At its conception, it was an unprecedented and experimental effort of collaboration between fierce competitors in the market. They had the vision that they could not solve the issues they faced alone. Since, SAI Platform has developed the trust and clear precompetitive space among members to leverage collective knowledge and develop practical tools for sustainable sourcing. By working through crop specific working groups and thematic committees, we started to develop a common understanding of sustainable agricultural challenges and directions for solutions. This has been a long technical and consensus building process that concluded in 'Principles and Recommended Practices' for several agricultural raw materials as well as many other supporting tools and guidance (Technical briefs, Practitioner's guide for sustainable sourcing, Executive Training and more)

Ambitious members started to implement these principles and practices in their respective supply chains – which resulted in swamping the market with dozens of sets of good sustainable agricultural practices. All were slightly different, which in some supply chains has led to confusion, frustration, and unintended bureaucracy. Add to this the already existing private (third party) standards and labels with very similar (intentions or goals), and it is safe to state the well-intended yet diverse and complex systems not always created the improvement we all wanted to see at farm level. To address this, SAI Platform decided to develop one common global tool for assessing, improving and communicating sustainable agriculture, the Farm Sustainability Assessment (FSA), based on the commonly agreed Principles and Practices.

FSA is now being built an online universal database, in multiple languages and with multiple filtering options to allow for tailoring the use of FSA to regional situations and crops. This IT system will offer a complete supply chain mapping and the ability to communicate data on on-farm sustainability throughout the supply chain, from farm to retailer. Users of the database can also blend in other standards and labels in several ways through benchmarking exercises and filters, which can result in a significant simplification and reduction of duplication.

The FSA system is ambitious, yet only a first step of an exciting journey. It provides the foundation for many more opportunities, like training facilities, knowledge exchange between farmers beyond their direct neighbours, avoidance of multiple audits, links to governmental programs or the base for improvement plans, both individual and structural, and finally a base for secure financing.

18. Agricultural Research in a Transforming Country: Views from the Vietnamese (Rice) Field

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Vietnam is a middle income country that continues to demonstrate impressive rates of economic growth and poverty reduction. Yet it remains heavily dependent on agriculture and natural resources as a source of growth, employment (both rural and, through agri-based processing, urban) and foreign exchange earnings. Moreover, the majority of Vietnam's poor and near-poor remain dependent on agricultural livelihoods, especially among its ethnic minority groups. Yet many bilateral donors have left Vietnam, and the terms on which multilateral donors are continuing to provide official development assistance (ODA) are less concessional. This is affecting both the broad strategy of remaining donors, and the attitudes of the Government in terms of the priority sectors for the use of more costly (but still concessional) ODA, with the result that ODA-financed agricultural research projects are declining. At the same time, the ability of Vietnam to invest itself is increasing and continued agricultural research can be expected to deliver important results in the future. Yet the domestic structures for impactful agricultural research are not yet well configured to fill the gap, and Vietnam is arguably not fully leveraging partnerships with the relevant CGIAR centres. This presentation illustrates some of the emerging trends and opportunities for improvement with reference to Vietnam, but which has relevance to other countries on similar development pathways across the region.

19. Investing in Agriculture to Feed Asia Securely

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Two-thirds of the world's hungry or 512 million undernourished people in 2014-2016 are found in Asia, roughly 1 in every 8 Asians. By 2050, Asia's population is expected to increase by about 1 billion, requiring an increase in food production by 70 per cent to meet the calorie requirements of the region's population that is estimated to reach 5.2 billion. Other demand factors also come into play. Growing economies lead to an expanding middle class especially in urban areas where 64 per cent of the Asian population is expected to reside by 2050. Rising incomes spawn more diversified lifestyle and diets with the more affluent consumers in urban areas consuming more resource intensive food, such as meat, dairy and processed food. On the supply side, land, soil, natural resource base and ecosystem on which agriculture relies are degraded, limited, and are also needed by other sectors in society, and are threatened by the impacts of climate change. Post-harvest losses in South and Southeast Asia reach one-third of food production with most of the losses or waste occurring during the handling and storage phase of the value chain. Going forward, investments in agriculture within the Asia context should result in ensuring access to safe and nutritious food at an affordable price. The paper discussed areas where research and development, and investment in agriculture are needed to address the food security issue, citing the Asian Development Bank's intensified response to the food security challenge by committing USD 2 billion annually to meet the rising demand for nutritious, safe, and affordable food in Asia and the Pacific.

20. Expectations from Investments in Agricultural Research and Innovation: An NGO Perspective

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ABSTRACT

Over the last 60 years we have seen an overdose of interventions in agriculture and livestock sectors, mostly technical in nature, in a massive effort to maximize food production, farmers' income being an offshoot. The focus was on high production goals with little or no recognition of the farmers' capacities, resource availability, traditional knowledge, aspirations or what is happening to the land. When crises related to the farmers surface, which have been quite often over the years, ad hoc solutions are provided with no vision in place so that they are not repeated. Indian agriculture depends on the monsoons and it is well-known that monsoons are erratic and will get worse with increasing variability of climate. Even after achieving the full irrigation potential, nearly 50 per cent of the net sown area will remain dependent on rainfall. The concentration of research has been on well-endowed arable areas in terms water and land and they have been deluged with subsidised chemicals (fertilisers, pesticides and the like) besides electricity and machines (tractors, combined harvesters etc.) in order to increase the food supply. The results have been that large tracts of land remain fallow due to increased salinity and water logging. The same formula has been co-opted for the drylands. Public investments in real term have been declining fast in agricultural research in general and in the rainfed areas in particular. However, the contingency payments are increasing. In the livestock sector, the persistent model has been introduction of exotic breeds in spite of there being more than sufficient evidence from the colonial era itself that this is not the path to be trodder. However, we have continued the same only to realize at least in the small ruminants that it is not going to work, but still we continue to persist with it in cattle. The irrigated areas have peaked in production and the increase in national food production is taking place from newer areas coming under irrigation. The need of the hour is that farming today has to be treated as an entrepreneurship. Research investment needs to engage realistically with dryland variability, support the logic behind the dryland food production and understand integration as multitude of paths. The legacy of the past interventions in drylands has to be acknowledged and investments to be made on furthering it. Investments have to engage with the dynamic correlations, to build social capital and complementarity rather than in isolation or competition. Small scale producers should be given real chance because with inheritance laws, land holding may get further fragmented. Heavy and meaningful investments are required for agricultural research and extension with suitable provision for course correction and impact assessment.

Keywords: Agricultural research; Innovation; Livestock; NGO

In India, there has been a mushrooming of research institutes from 93 Indian Council of Agricultural Research (ICAR) Institutes and All India Coordinated projects, and 35 State Agricultural Universities (SAUs) in 2003 (Beintema *et al.* 2008) to 94 ICAR institutes and All India Coordinated Research Projects and 45 SAUs in 2008 (Pal *et al.* 2012). Today, they stand at 100 ICAR Institutes and All India Coordinated Research Projects and 70 SAUs (www.icar.org.in). However, there has been only a marginal increase in real term research funding and a decline in the number of researchers (Pal *et al.* 2012), the end result being that finances for research are declining massively since there is a large increase in administrative, salaries and other overheads due increased number of institutions. To complicate matters further, there has been substantial increase in the number of specialisations and emphasis on the so called cutting edge technologies. Consequently, little funds are left for research on understanding and resolving what has been described as by Beintema *et al.* (2008) as 'second-generation technological

problems like degradation of land and water resources and changing pest problems.

The budgetary allotments in terms of percentage of agricultural Gross Domestic Product (GDP) has remained at about 1 per cent for a long time while it needs to be at least at 2 per cent. However, even within this allocation, there is an anomaly in that although livestock contributes above 40 per cent (in arid and semi-arid regions) to the Agricultural GDP (AgGDP), only about 14-16 per cent is being spent on research on livestock and that too mostly on cattle.

The green revolution of the seventies saw massive all round input in wheat and rice. The introduction of improved genetic material, irrigation infrastructure, subsidised fertilizers and pesticides coupled with minimum support prices saw huge increase in food grains. In the process, the country built major food grain buffer stocks. However, that mind set created due to food grain shortages in the fifties continues to haunt our research policies. This has resulted in continuing major emphasis and money being spent on food grain research to the detriment of other crops, livestock and fisheries.

The rainfed area in India is going to remain more than 50 per cent of the arable land even after all the planned irrigation projects are in place. Although we have a number ICAR Institutes and SAUs engaged in drylands research yet the real investments in drylands are dismally low. Even the general attitude is to engage with dryland research through the same concepts and solutions as for irrigated areas. However, that approach is not yielding results and an immediate course correction is required. Since drylands are synonymous with variability, there is a need to work with the variables. This is possible only if concerted efforts are made to understand in depth the agricultural production systems in drylands and engage with the diverse pathways and integrations available to optimize production (Krätli 2015). Two interesting examples from north Karnataka are relevant. One, when rainfalls are normal the farmer pays the shepherds to stay overnight in his fields (manure contract).But when there is just one rainfall and the crops start stunting due to a missing shower the farmer harvests the field for stalks for his cattle, if they are long enough, and the shepherd pays the farmer to graze his animals on his fields. Second, when the regular crop has been harvested and there is a shower the farmer gets an opportunity for another short duration crop. Even if the crop does not mature there is enough fodder to support the feeding of livestock. Therefore, the legacy of the past interventions needs to be acknowledged, real time management issues understood and investments made to furthering them.

India today is the highest producer of milk and exporter of meat in the world. Importantly, almost 70 per cent of the milk and 98 per cent of the small ruminant meat and quite a sizable portion of the large ruminant meat comes from the extensive grazing based livestock systems. A study in about 1,000 households across seven States in the arid, semi-arid and sub-humid areas of the country conducted by Foundation of Ecological Security (FES) and its partner in 2010 ('In the shadow of the green revolution' at www.fes.org.in) showed that almost 88-99 per cent of the milk and meat production is dependent on commons lands and crop residues (Table 1). Perusal of Table 2 shows that not only the small ruminants but also other livestock species are supported on grazing based production systems. Even the archetypical stall fed animals, buffaloes and crossbred cattle depend on commons for meeting more than 20 per cent of their fodder requirements.

It is important to accept the reality that to replace this system on which at a conservative estimate around 200 million cattle and buffaloes (of the total of 300 m in the country) and about 190 million sheep and goat are dependent for feed with stall feeding is only marginally possible. Also, it would have to be done at the cost of land being used for food and other crops. We need to analyse how these fodder systems are able to achieve so much with negligible intervention and research inputs from research institutes. We need to understand the working of these systems, the traditional knowledge and practices being used.

Table 1. Assessment of livestock feed sources

	Common property resources (%)	Crop residues (%)	Purchased (%)
Arid	66	22	12
Semi-arid	35	60	5
Sub-humid	67	32	1

Table 2. Percentage of annual fodder requirement met from commons – across regions for different livestock in India

	Draught animals	Indigenous cattle	Crossbred cattle	Buffalo	Sheep and goats	Camel
Arid	33.1	62.9	44.6	65.1	83.8	68.25
Semi-arid	31.1	40.8	29.9	30.0	51.8	29.2
Sub-humid	67.9	74.0	11.1	58.2	79.3	0

Only then can we hope to improve them and optimize (not maximize) the production levels to meet future needs. Further, serious research efforts on developing a commons policy needs to be put in place since the commons are going to remain an integral part of the existing livestock system in the country for a long time.

Watershed development has been a continuing effort of the Indian Government for the last 30-35 years. NGOs such as FES (www.fes.org.in) and WOTR (www.wotr.org) have shown that with dedication, concerted efforts and working with local community and government departments the biomass produced in these dryland watersheds can be tripled. These efforts have also resulted in increased water holding capacity as well as increase in the availability of water to the extent that the local farmers switch from dryland crops to water guzzling cash crops such as onions and vegetables and to even start rearing crossbred cows for milk production since they have means to grow green fodders (SAPPLPP, 2012). However, critical analysis and agri-research in these watersheds is conspicuously missing as no effort is made to inform the kind of vegetation to encourage in these watersheds so that it results in higher quality and quantity of edible biomass (for livestock) as well as keeping the local biodiversity intact. There is a need to develop the water regimens resulting in the optimal use of water and the kind of crops to be grown so that it meets both the needs of the farmer and remains sustainable in the long run. Excellent results are being achieved by large number of NGOs across many States in India in terms of not only higher production, but beating climate change factors, efficient utilisation of water, soil improvement through the use of SCI and SRI methodologies (SRI-Rice 2014). The research and development organizations need to step intensively into this promising area and help create packages for different climatic zones and find answers to the 'second-generation technical problems' in irrigated areas too.

Agriculture including livestock keeping is an entrepreneurship and has to be treated in the manner of an industrial unit, instead of treating as a subsistence farming. There has to be an exchange of ideas, understand capabilities, capacities, investment opportunities and the abilities to assimilate and undertake changes. Associations and institutions need to be created around farming communities, for them and empowering them to decide not only what they require but also how it needs to be delivered. An apt example is that of sheep improvement programmes which for several decades involved crossbreeding with exotic sheep introduced from all over the world. The only place where these breeds have been accepted are the Himalayan regions but there too it has not been for the targeted objective of improving the wool quantity and quality but for higher meat production. Practically the only intervention that the agricultural research has been able to contribute to the small ruminant is the PPR vaccine. In spite of lack of institutional research contributions, the small ruminant population has steadily been growing and it remains one of the most profitable enterprises in an extensive grazing based system against propagated intensive farm based system. Sheep rearing in this system is quite complex and needs a large amount of *apriori* knowledge but the profitability of this production system is apparent from the steady flow of other non-traditional communities taking up this enterprise.

Agricultural extension is the weakest link and there is a need to move away from '*lab to land*' or the top down approach to '*land-to-lab*'. The researcher needs to identify the best use of land and offer alternatives, and the State should give incentives to the farmer to grow a particular crop. There is a need to create a basket of packages comprising an amalgam of prior knowledge and recent advances for the farmer to choose from. A critical network of farmer-extension workers-researchers needs to be formed. In recent years,

there has been a large increase of private players entering the agricultural markets, this has been both beneficial and harmful. The public sector research institutes need to remain in know of what is happening on the farmers' fields. From the recent episode of severe white fly attack on cotton crop in Punjab, it appears that seed and every other input is supplied by the private sector with no standards checks. It is high time that the required certifying/regulatory body/bodies and testing facilities are created.

More than 80 per cent of the land holders are small scale farmers and of these quite a large number are marginal farmers. As years go by, their numbers are going to increase due to the Indian inheritance laws. The situation becomes more difficult as the marginal farms are no longer viable and cannot sustain fully due to which the farmers migrate in search of work and do not till the land any more. Due to very high land prices, other farmers cannot afford to buy the vacant lands to increase their holdings nor are the original owners ready to part with them. Appropriate policies need to be developed so that leases/contracts safeguard the owners. This would help leasers to consolidate their landholdings and allow them to approach the banks for agricultural credit. This would support economies of scale and together with adequate agri-insurance in place cover risks against climatic and other adverse conditions of crop failure.

In conclusion, agricultural research for development needs not only higher and more targeted funding but also proactive involvement of researchers with the farmer/livestock keeper. There is a need for understanding ground realities, giving credence to prior knowledge and offer a basket of opportunities and not just a narrowly targeted *fait accompli*. Farmer institution building and empowerment is critical for research to be deliverable and properly targeted.

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21. Developing Capacity for Change to Enhance the Potential of Investments into Agricultural Innovation

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ABSTRACT

Findings of regional assessment in South Asia and in two other regions undertaken by Tropical Agriculture Platform (TAP) and its partners in 2013 revealed that several tropical countries lack the resources and capacities to fully develop their Agricultural Innovation Systems (AIS). In Asia and the Pacific region, the development of the agricultural sector of a group of the least developed countries (Bangladesh, Cambodia, Laos, Myanmar and Timor Leste) is hampered by the adverse effect of climate change and especially by the weakness in the countries' agricultural research, development and extension services. The smallholder farmers, who mostly live in poverty-stricken rural areas, are often suffering from shortage of food supplies, poor access to agricultural support (input supply and technology) and lack of advisory services and agricultural training. Supporting smallholder family farmers is crucial to the emergence of functioning AIS that improve farmers' income, food security, nutrition and environmental sustainability. To develop the capacity for agricultural innovation in the least developed countries of Asia and the Pacific region, TAP advocates for increasing investments in agricultural research and development (R&D) and more coherent, efficient and coordinated capacity development interventions that address individual, organizational and institutional capacity needs.

The paper will present the Common Framework on Capacity Development for Agricultural Innovation Systems (CDAIS).The framework is a core component of the Action Plan of the TAP, a G20 Initiative, aiming to increase coherence and effectiveness of capacity development for agricultural innovation that lead to sustainable change and impact at scale. The framework developed with contributions by TAP Partners including APAARI consists of a conceptual background document and a practical guide for the operationalization of the framework. It is planned to apply the framework initially in eight countries in Africa, Asia and Central America with support of the EC funded CDAIS project, jointly implemented by AGRINATURA and FAO in collaboration with local organizations from 2015 to 2018. Countries in the region include Bangladesh and Laos, where the framework will be applied and needed capacity development interventions will be undertaken. APAARI will facilitate the application of the common framework, policy dialogue for improved capacity development for agricultural innovation in Asia and the Pacific region.

Keywords: Agricultural innovation systems; Capacity development; Common framework; Foreign assistance; Research and extension

1. Introduction

Innovation in agriculture is a precondition for meeting the challenge of feeding 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. Innovation also has a role to play in achieving gender equality, ensuring healthy lives for all and contributing to economic growth, but process and product innovation cannot simply be transferred from one place to another. Nonetheless many countries are not fully exploiting their innovation potential. In order to do so, they must strengthen the capacity of individuals and organizations, create an enabling environment and, crucially,

reinforce or set-up efficient agricultural innovation systems.

In Asia and the Pacific region, the development of agricultural sector of a group of the least developed countries (Bangladesh, Cambodia, Laos, Myanmar and Timor Leste) is hampered by the adverse effect of climate change and especially by the weakness in the countries' agricultural research, development and extension services (Aerni *et al*. 2015). The smallholder farmers, who mostly live in poverty-stricken rural areas, are often suffering from shortage of food supplies, poor access to agricultural support (input supply and technology) and lack of advisory services and agricultural training. Supporting smallholder family farmers is crucial to the emergence of functioning Agricultural Innovation Systems (AIS) that improve farmers' income, food security, nutrition and environmental sustainability.

In 2012, the Agriculture Ministers of the G20 called for the creation of the Tropical Agriculture Platform (TAP) to promote the development of national capacities for agricultural innovation in the tropics, where almost all low-income countries are located. The aim of TAP is to enhance the overall performance of Agricultural Innovation Systems, with particular focus on small- and medium-scale producers and enterprises in the agribusiness sector. TAP's ultimate objective is to make agriculture more sustainable and improve livelihoods.[1]

2. Investments into Agricultural Innovation

Food and Agriculture Organization of the United Nations' (FAO's) 2014 State of Food and Agriculture report highlights that public investment in agricultural R&D and extension and advisory services should be increased and refocused to emphasize sustainable agricultural intensification and closing yield and labour productivity gaps (FAO 2014). However, overall investments into agricultural research and development (R&D) have remained consistently at low levels and are concentrated in high-income as well as in larger middle-income countries.

[1]For a full description of the Tropical Agricultural Platform membership, objectives, overall approach and plan of work, see http://www.tropagplatform.org/

2.1. National Public Expenditures

While public sector investments in agricultural R&D exhibited little growth in the 1980s and 1990s, evidence suggests that this trend was reversed to some extent over the consecutive decade (Fuglie and Wang 2012). Between 2000 and 2008, the figures for total global public spending went up by 22 per cent (Beintema *et al*. 2012). This growth has been mainly driven by increased spending in middle income countries, such as China, India, Brazil, Argentina and Nigeria for example. More recent data suggests that the trend observed from 2000 to 2008 has slowed down.

Through national institutional surveys, the Agricultural Science and Technology Indicators (ASTI) initiative collects detailed data on public spending on agricultural R&D related to three categories: salaries, operating and programme expenditures and capital investments. In terms of spending on agricultural R&D relative to agricultural GDP, data for the developing countries covered by ASTI dataset provide evidence that the research intensity ratio has not increased but remained relatively constant, exhibiting some fluctuation from year to year. The interquartile range of the research intensity ratio over the period from 2000 to 2011 as shown in Figure 1 demonstrates that, for a wide range of developing countries, there is the lack of sustained growth in investments into agricultural R&D.

For Asia and the Pacific region, the ASTI database only contains information on a limited number of countries. Figure 2 shows that the average research intensity ratio for the years 2006 to 2011 for Cambodia, Vietnam, Nepal and Bangladesh is below or at 0.4 per cent. Relative to agricultural GDP, Malaysia invests considerably more into agricultural R&D, with an average value well above of 1 per cent, which is beyond the upper quartile for developing countries that can be seen in Figure 1.

2.2. Foreign assistance

Results obtained from three regional needs assessments undertaken by TAP in 2013 reveal that capacity development for agricultural innovation initiatives are often funded exclusively through foreign aid programmes and are hardly embedded in national innovation strategies (Aerni *et al*. 2015).

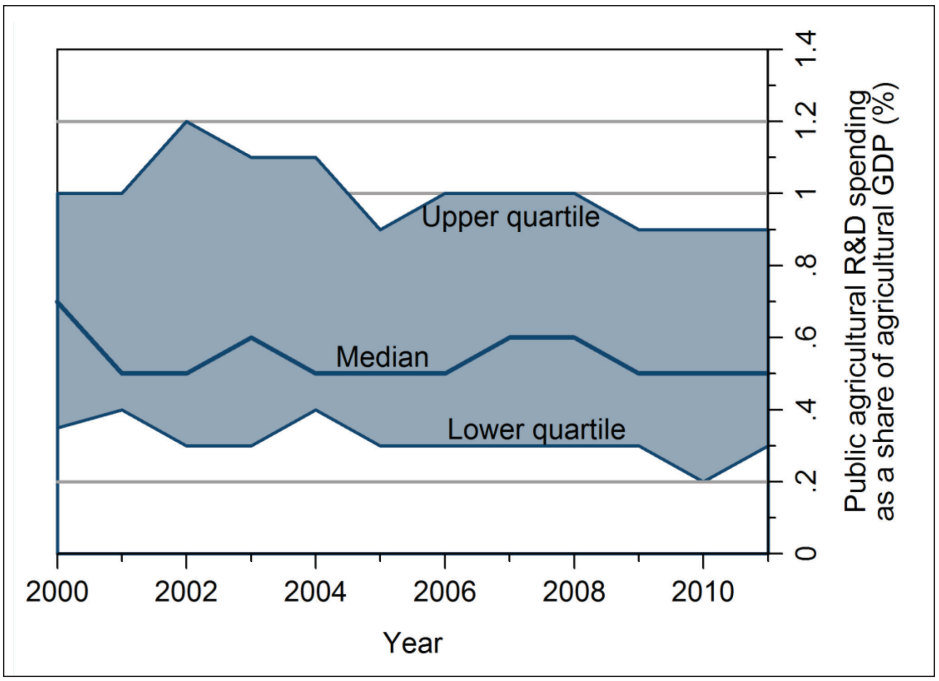

Figure 1. Research intensity ratio in developing countries (median and interquartile range)

Note: The research intensity ratio figure is based on the dataset for developing countries available through the ASTI website and omits countries with a population of less than 500,000 inhabitants.

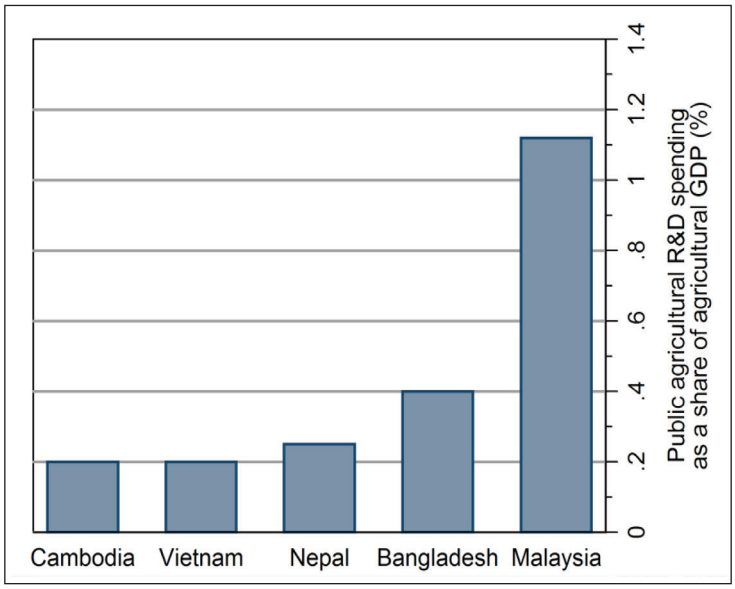

Figure 2. Research intensity ratio for selected Asian countries (average 2006 to 2011)

A recent FAO study used The Organization for Economic Cooperation and Development (OECD) data to analyse, during the period of 2002 to 2012, the amount and variability of foreign aid directed to agricultural research and extension, as well as to forestry and fishery research (Angelico *et al.* 2015). It shows that the findings of consistently low public investments in agricultural research and development also apply to foreign assistance. Out of the total Official Development Assistance (ODA) that went to the agriculture, forestry and fishing sector, on average, seven percent was allocated to research and two percent to extension. The top ten contributors to ODA for agricultural, forestry

and fishery research are France, the World Bank, UK, Australia, the EU Institutions, USA, Canada, Germany, Sweden and the Netherlands, while the top ten contributors to ODA for agricultural extension are the World Bank, IFAD, Canada, Sweden, Norway, UK, Germany, USA, Belgium and Australia.

As Figure 3 illustrates, over the period from 2002 to 2012, the share of foreign assistance invested into research and extension has decreased or remained steady rather than increased. Furthermore, aid flows are also concentrated in high-income as well as in a few middle-income countries.

In absolute numbers, the overall ODA commitments to research in agriculture, forestry and fishery increased markedly between 2005 and 2008, when they reached USD 839 million, but then dropped dramatically to USD 523.9 million in 2009. After this year, a slight increase was recorded in 2010, but was further cut in 2012, when ODA to agricultural, forestry and fishery research amounted to USD 486.7 million. As shown in Figure 4, the reduction of commitments in 2009 followed a decline in disbursements after 2007. This trend is mainly driven by external assistance to agricultural research.

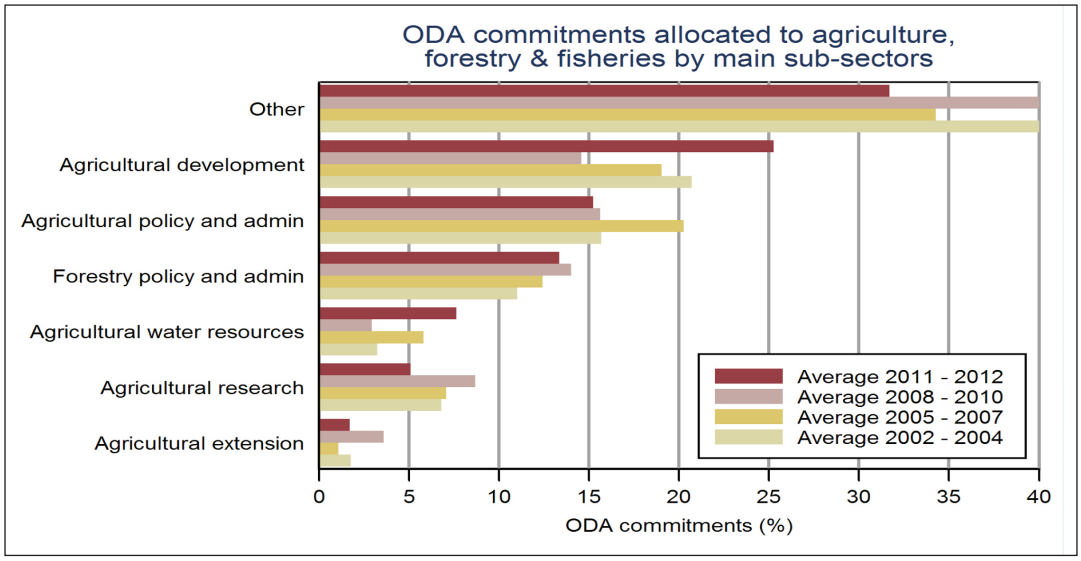

Figure 3. ODA commitments to agriculture, forestry and fishing by main subsectors

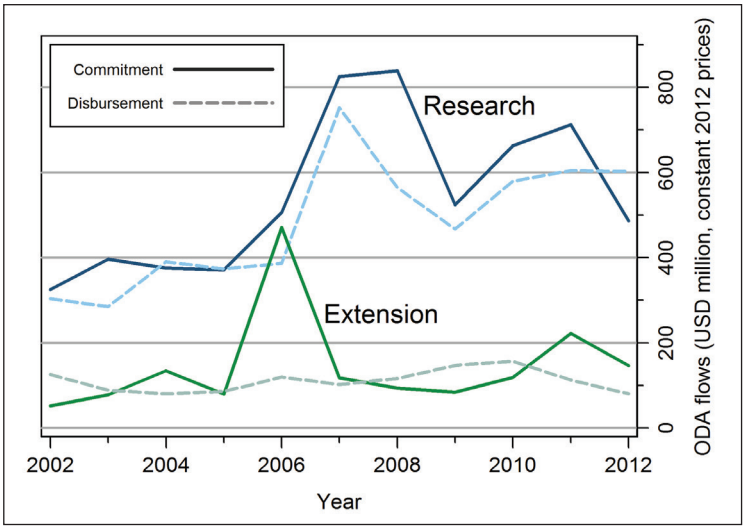

Figure 4. ODA commitments and disbursements to agriculture, forestry and fishery research and agricultural extension from 2002 to 2012

Like public and private spending, foreign assistance proved to be volatile, causing challenges for planning and implementation. This corroborates existing evidence of sizable deadweight loss for developing countries due to volatile aid flows. Even if the volatility of ODA commitments is, in relative terms, lower for the least developed and other low-income countries than for other regions, it remains high. Also, it has a comparatively more profound impact, since these countries are more reliant on foreign assistance. The international community needs to give more priority to addressing the problems brought about by insufficient and unpredictable investments in research and extension.

Figure 5 shows how ODA to agricultural, forestry and fishery research was allocated across regions. During the period 2002-2012, 29 per cent of commitments to agricultural, forestry and fishery research have been directed to Africa South of Sahara, 4 per cent to South America, 8 per cent to Far East Asia, 7 per cent to South and Central Asia, and 3 per cent to Oceania; while Europe, North and Central America and Middle East received only a small portion of the aid. In addition, 41 per cent was reported as unspecified developing countries and 5 per cent as regional projects.

3. Capacity Development

A survey conducted by TAP in 27 countries in Africa, Asia and Latin America found that capacity development (CD) for Agricultural Innovation Systems (AIS) is seldom designed and implemented in an integrated manner and consequently fails to capture the full complexity of innovation processes (Aerni *et al*. 2015). The needs assessments in the three regions identified constraints that all the selected low-income tropical countries seem to have in common:

- CD interventions from internal and external actors are not sufficiently targeted to meet the AIS capacity needs of tropical countries.
- CD interventions are frequently implemented independently from each other, and are often too small in scale, narrow in scope, and neglecting institutional and organizational capacity dimensions.
- Lack of high-level political and operational mechanisms to coordinate interventions for capacity development.

As far as Asia and the Pacific region is concerned, the assessment covered five low-income countries, namely, Bangladesh, Cambodia, Lao PDR, the People's Republic of Myanmar, and the Democratic Republic of Timor Leste (Cardenas and Bellin 2013). Besides the features in common with the other regions, the study on Asian countries suggests that capacity development of the various actors in agricultural should focus on the following areas: i) organizational and management skills at central and local levels; ii) curriculum, agricultural/vocational

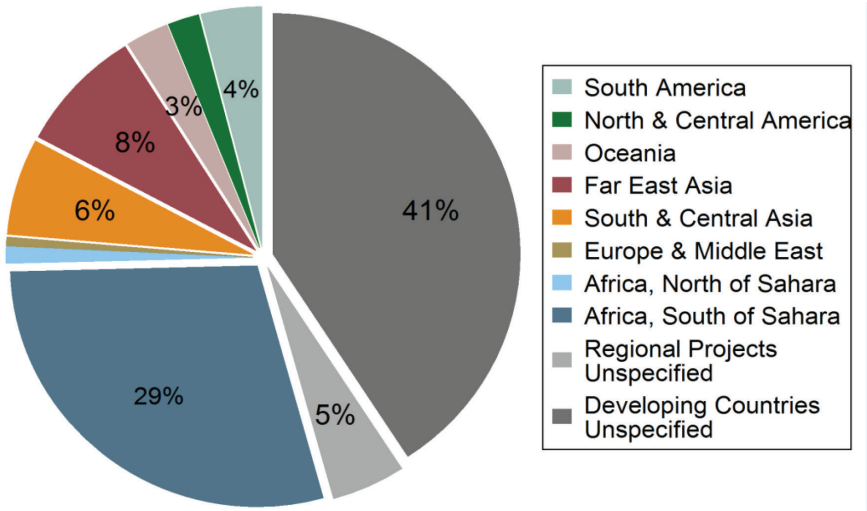

Figure 5. Percentage of total ODA commitments to agriculture, forestry and fishery research by region, average values 2002-2012

Note: Regional projects include Europe, Oceania, Africa, America, and Asia

and extension education; iii) research and extension services; iv) micro-finance and small and medium-term enterprises; and v) the supply and value chain development.

3.1. The Common Framework

Taking into consideration the results of the need assessment, the 44 TAP partners agreed to develop a Common Framework on Capacity Development for Agricultural Innovation Systems (CDAIS), among other activities[2]. The objective of the Framework is to harmonize and coordinate the different approaches to CD in support of agricultural innovation. Such harmonization would promote optimal use of the resources of different donors and technical cooperation agencies.

The development and thus the validation of the TAP Common Framework is supported by the Capacity Development for Agricultural Innovation Systems (CDAIS) project, funded by the European Commission (EC) and jointly implemented by the European agricultural research alliance AGRINATURA and the FAO. The validation at country level will be implemented in 8 developing countries, including Bangladesh and Lao PDR for Asia and the Pacific region.

The Framework promotes a shift of mind-set and attitudes among the main actors and provides concepts, principles, methodologies and tools to better understand the architecture of AIS, to assess CD needs and to plan, implement, monitor and evaluate CD interventions. It emphasizes the crucial role of facilitation, learning, documentation and knowledge management issues for enabling agricultural innovation. All this should lead to more sustainable and efficient AIS (Ekong *et al*. 2015).

3.1.1. The AIS perspective

The Common Framework builds conceptually on the AIS perspective, which emphasizes that agricultural innovation, as opposed to linear approaches, results from a complex, multi-stakeholder process of interaction. Conceptually, the AIS, as outlined in Figure 6, comprises four components: knowledge and education, business and enterprise, including small-holder farmers, bridging institutions, such as stakeholder platforms and advisory services, and the enabling environment, consisting of policies as well as practices, mind sets and attitudes. Innovation, in order to take off, requires the right mix of different actors, social mechanisms and policies. An endogenous process, it cannot rely only on spin-off from foreign research, but needs local capacities to generate knowledge and develop new technologies and business processes.

3.1.2. The capacity for change

'Capacity' is defined simply as "the ability of people, organizations and society as a whole to manage their affairs successfully" (OECD 2006). And for that to happen, individuals, organizations and society as a whole need to acquire competencies – core knowledge, skills, attitudes and energies – through capacity development. One widely accepted definition of *'Capacity Development'* is that it *'is the process whereby people, organizations and society as a whole unleash, strengthen, create, adapt and maintain capacity over time'* (OECD 2006).

As with agricultural innovation, capacity 'emerges' over time, driven by multiple factors. No single element such as incentives, leadership, financial support, trained staff, knowledge or structure can alone lead to the development of capacity. But if capacity is understood as involving collective learning and adaptation to numerous opportunities and challenges, then it cannot be designed and implemented by external actors with a well-defined and standardized set of products and services. Accepting this fact calls for a fundamental change in our perception of CD – not just as a vehicle for results but a way of facilitating processes that enable stakeholders to seize opportunities, build trust and take joint action.

Conventionally, capacity is often viewed as a sort of hierarchy with individual, organizational, inter-organizational and system-wide levels. It was usually assumed that competencies at individual level would, through a knock-on effect, enhance capacity at other levels, creating an enabling environment. But this rather static categorization fails to describe the interconnections between the various dimensions involved. As shown in Figure 7, the Common Framework recognizes three dimensions: Individuals, Organizations and the Enabling Environment. Within the context of

[2]For a full presentation of the approved TAP Action Plan see http://www.tropagplatform.org/sites/default/files/TAP%20ACTION%20PLAN%2022August2013_0.pdfAccessed 29 October 2015.

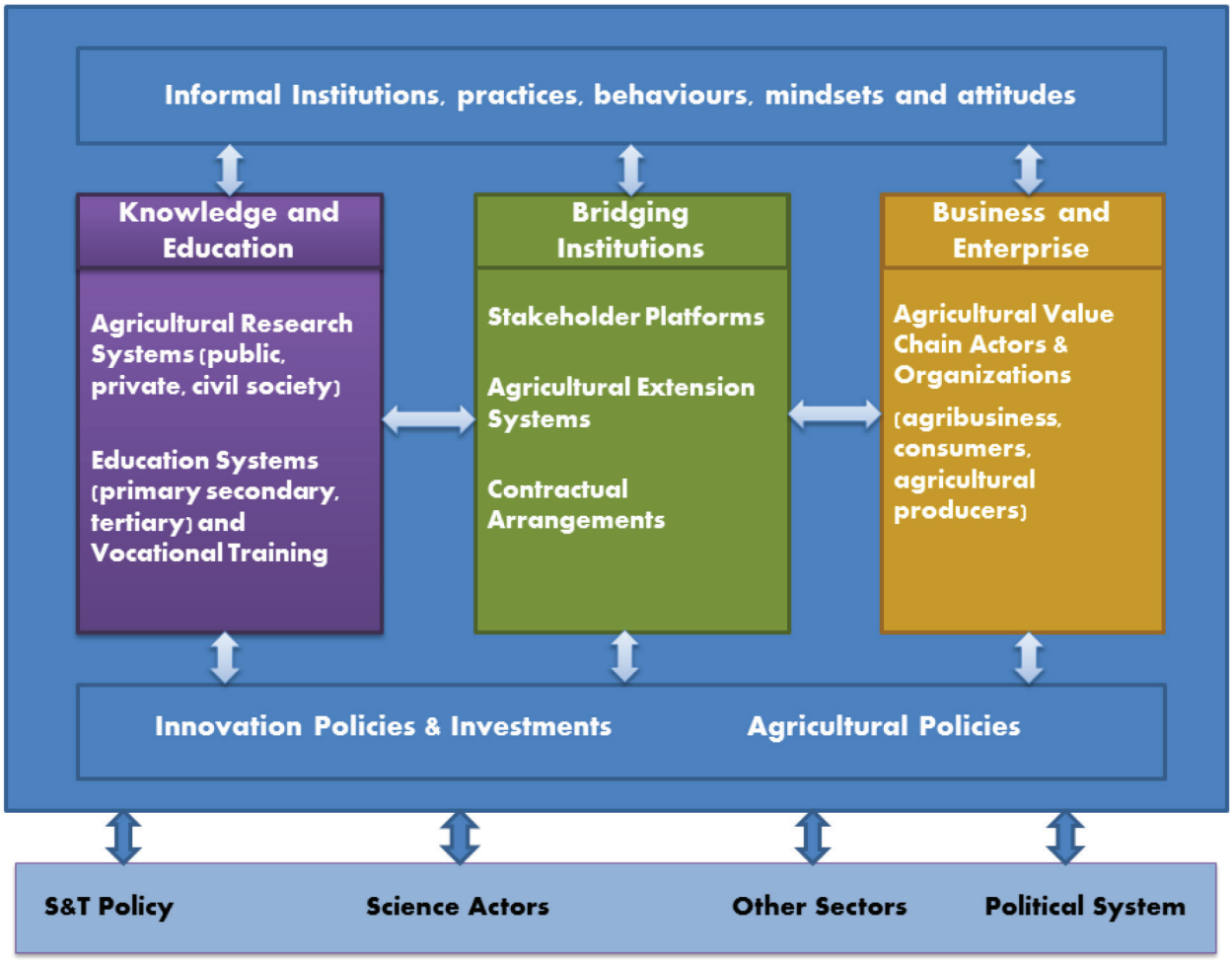

Figure 6. The Agricultural Innovation System (Source: Ekong *et al.* 2015, modified from Spielman and Birner 2008)

Figure 7. The Dimensions of Capacity Development (Source: FAO, 2010)

AIS, it is pertinent to stress the crucial importance of partnerships and networks in creating that interconnectedness, and in bringing together the three dimensions to create new knowledge. The Framework emphasizes the interdependent relationship between these dimensions as a way of strengthening 'system-wide' capacity.

For AIS to perform effectively, four key capacities are required:

- **Capacity to navigate complexity.** A shift in mind-sets, attitudes and behaviour to comprehend the larger system and to create an understanding of the whole system, as well as a shift from mainly reductionist understanding of the parts to systemic understanding of the relationships among the parts; viewing change as an emerging property that cannot be predicted or planned for in a linear fashion.

- **Capacity for collaboration**. Enabling actors to understand each other's perspectives and managing conflicts, manage diversity in order to combine individual skills and knowledge, and create an awareness of their complementarity; and building synergetic partnerships and networks to enhance collaboration. It also involves communication skills and strategies, both internally and externally.
- **Capacity for reflection and learning.** Bringing stakeholders together, designing and leading processes of critical reflection and following a double-loop learning process leading to action and change. It requires respect for different opinions and an atmosphere of trust for those opinions to be voiced. It also requires a systematic tracking of processes and progress to enable reflection to take place. Interventions need to be sufficiently flexible and adaptable to changing conditions, and analysis undertaken in an iterative fashion so as to promote experimentation and adaptive capacities as new opportunities for learning emerge.
- **Capacity to engage in strategic and political processes.** CD for transformational change is inherently political, and involves questioning the status quo. Power relations need to be understood in a number of dimensions, including: economic interests; the balance of power among elites; and civil society-state relations. Understanding and influencing the politics and power relations between individuals, within organizations and of the wider society, is crucial for bringing about new forms of interaction among stakeholders. It includes the conscious empowerment of vulnerable and often marginalized groups.

These four capacities are the core of an overarching capacity to adapt and respond in order to realize the potential of innovation, shifting focus from reactive problem solving to co-creating the future. This requires facilitative leadership to enable all of the above to happen. The five capacities, illustrated in Figure 8, are interdependent and are relevant at each of the three dimensions of CD.

3.1.3. Capacity development for AIS

The concept of AIS not only calls for a shift in the roles of various actors in agricultural innovation, but also calls for innovative and systemic approaches to capacity development itself. The basic principles that inform the Common Framework of CD for AIS are presented in Box 1.

The conceptual model distinguishes two levels of CD, the:

- ***Innovation niche:*** Niche – the locus of learning and experimentation and micro-level transformation – developing innovation that has the potential, if managed strategically, to seed sustainable transformation. Innovation niches are spaces in which small groups of actors become part of a learning process in which alternative socio-technical practices can be experimented with and developed in such a way that they subsequently inform and influence mainstream. The strength of the

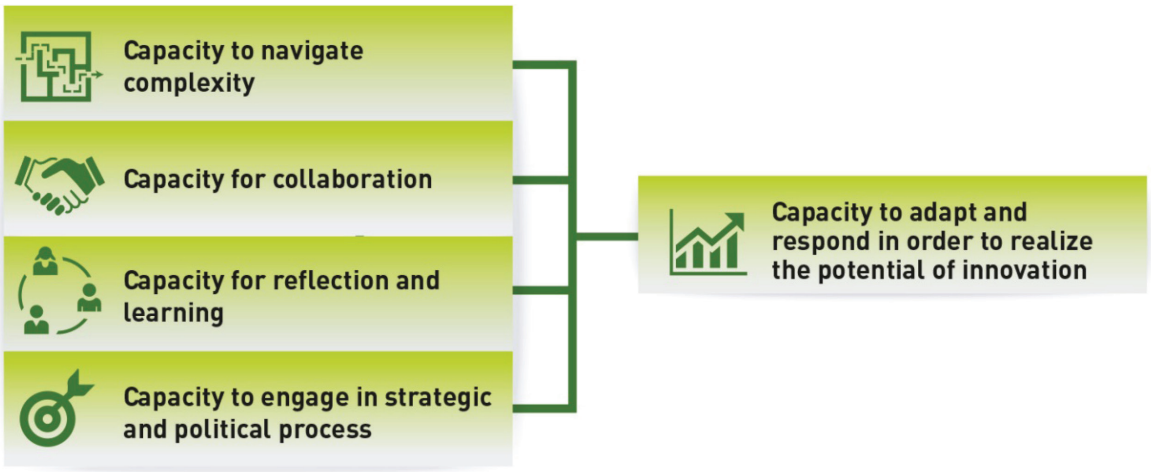

Figure 8. The 4 + 1 capacities

Box 1 : Basic CD for AIS principles promoted by the Common Framework

- Agricultural innovation is critically required for increasing agricultural productivity along with sustainability of agricultural systems
- Innovation cannot rely only on spin offs of foreign research, but needs endogenous capacities to generate, systematize, and adapt knowledge and to adopt and up-scale new practices
- CD for AIS interventions must respond to expressed needs of actors. It cannot be designed and implemented by external actors with a well-defined and standardized set of products and services
- CD for AIS process is an endogenous one, ownership by local actors is paramount to its success; collective energy, motivation and commitment of stakeholders to engage in a process of change are crucial
- CD for AIS is not politically neutral, it involves questioning and sometimes upsetting the status quo and may lead to conflict; it therefore needs strong, facilitative leadership and commitment
- CD for AIS is an iterative process rather than a one-off time-bound intervention. Capacity needs of today will change tomorrow based on experience gained in the face of new challenges or emerging opportunities
- It is a multi-dimensional and multi-actor process that goes well beyond the direct transfer of knowledge and skills at the individual level and addresses in an integrated manner organizational and institutional dimensions
- It enhances interaction, builds trust and the creation of synergy between research institutions and public and private sector actors, smallholder farmers and development organizations to enable them to address a whole range of activities, investments and policies and avail of opportunities to make change happen
- CD for AIS interventions go beyond improving immediate performance and develop the capacity to adapt to new and constantly changing environments, to learn and analyse the internal and external context and to relate and build partnerships and pro-actively plan the future
- CD for AIS is context-specific and no blueprint or one-size-fits-all recipe can be applied

niche results from the interplay among three niche processes: (i) articulation and negotiation of shared expectations by participating actors giving direction and legitimacy to the niche; (ii) a growing social network, including all relevant types of actors within the niche, both creating opportunities for stakeholder interaction and a micro-market that provides the resources necessary for experimentation and temporary protection; and (iii) a learning mechanism (between experiments, between actors, etc.) that is a vital ingredient for the establishment of new rules and design heuristics

- ***System level:*** The wider system of which the niche is a part consists of the multiple and diverse actors within the boundaries of a defined AIS. Learning from the innovation niche is one input to inform actors at system level in their own interactions to create an enabling environment for AIS. CD at system level recognizes social, cultural and political structures in which power relations, social and institutional dimensions determine opportunities for different groups of actors to initiate an innovation niche, and then acting upon the interventions to attain sustainability.

A purposeful intervention is necessary that enhances capacities of individuals and organizations (actors in the innovation niche) on the one hand, and capacities of other social, institutional and political actors for improving enabling environment on the other hand. The CD of individuals and organizations will be linked to their involvement within niches or at system level, as can be seen from Figure 9.

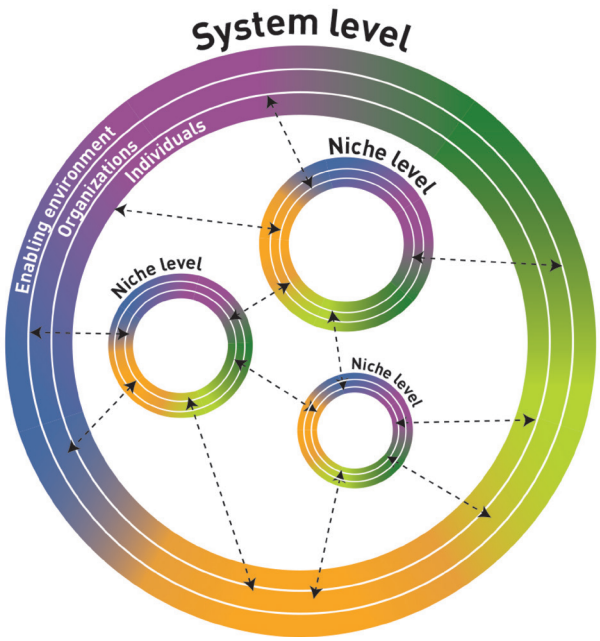

Figure 9. CD at niche and system level

3.1.4. An operational approach

The Framework proposes a cycle of five stages for implementing CD for AIS interventions: "Galvanizing Commitment", "Visioning", "Capacity needs assessment", "CD strategy development" and "Implementation". The cycles will be substantially identical for each of the three dimensions (Individuals, Organizations and the Enabling Environment) although the actors involved and the methods used may vary. Figure 10 shows that, as moving forward in the cycle from one stage to another, capacities are continuously enhanced.

The cycle is proposed as a guide for contextualized action rather than as a blueprint for achieving effective CD for AIS. Country approaches may differ significantly in content and process according to of context, opportunities, commitment and resources. The practicalities of the proposed approach need to be piloted and the CD cycle further refined in the light of experience. But the key element common to all countries should be a systemic approach through dual pathways ensuring that all actors within the system have the opportunity to participate, to learn together and to formulate joint solutions.

Given the importance of skilled facilitators in the CD process, it is vital that the process described by the cycle is accompanied by the identification and strengthening of individuals and organizations that can act as effective agents of change. They can be extension services, private consulting firms,

Figure 10. The five stages of the CD cycle

university departments, capacity development organizations or NGOs.

The Framework includes also a monitoring and evaluation scheme, which should accompany CD for AIS projects along all their phases.

4. Conclusion

There is large consensus within the international community about the fact that agricultural innovation is critically required for increasing agricultural productivity and reducing the environmental pressure of agricultural systems and, consequently, for meeting the internationally agreed goals. Nevertheless, the support provided to the AIS in least developed countries is quantitatively and qualitatively insufficient and erratic. TAP is a major international undertaking aimed at conferring better coherence and coordination to current and future capacity development projects. It is, therefore, expected that TAP activities in general, and the development of the Common Framework on CD for AIS in particular, will have a significant impact on the capacity for change that can be deployed in developing countries. All the same, the resources allocated to strengthen AIS' of developing countries, both at national and international level, should be substantially increased and made steadier. The magnitude of the challenges in front of us justifies the necessary effort.

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22. Time for a Step-Change: The Agricultural Innovation and Enterprise Facility

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The global fragmentation and under-resourcing of public innovation, education and advisory processes, and weak linkages with wider development processes and with farmers, NGOs and the private sector, are major bottlenecks constraining the value and impact of agricultural innovation on the lives and livelihoods of the poor. Chronic public underinvestment in agricultural research for development in low-income countries has resulted in weak national agricultural research and innovation systems that will not be able to cope with the massive challenges that lie ahead.

The FAO/IFAD/WFP 2015 Report: "Achieving Zero Hunger by 2030" estimates 17 per cent of new rural development investments, i.e. USD 17,628 million, should be in agricultural research, development and extension, plus other essential investments to turn innovation into impact. IFPRI estimated that national investments in the sector need to triple by 2025 to meet future food and nutrition security needs, alongside a similar increase in support to international research. However, national investments have only grown 20 per cent in a decade. Spending in many countries is stagnating or declining and many are re-investing well below the UN recommended 1 per cent of agricultural GDP.

The Agricultural Innovation and Enterprise Facility, now being developed through many partners from all sectors involved in the Global Forum, will establish a multi-stakeholder convening mechanism to directly create effective and integrated innovation systems, enabling effective scale-out of appropriate innovations and turning innovation into enterprise opportunity for rural women and youth. The Facility will coherently integrate the resources, education and capacity development, technical assistance, equitable partnerships and enabling environment required to transform the lives and livelihoods of rural women and youth across a range of countries, and at a significant scale.

In so doing, the Facility will directly address the 'Missing Middle' between agricultural research, innovation and their impacts at scale in ending poverty and hunger, promoting gender equality and economic empowerment for women, girls and rural youth and fostering more resilient and sustainable systems, to transform the lives of the rural poor and poor consumers. Driven by the needs of national systems and in programmes managed and delivered by national partners, the Facility will mobilize the resources and identify appropriate capacity development support to strengthen and transform local and national agricultural innovation systems, in line with the GCARD Road Map.

Funds will be managed through established multilateral financial institutions such as IFAD, GAFSP and the World Bank, in association with other development investments, and subject to the same rigorous quality control and supervision as other funds. Through our multi-stakeholder governance, the extensive networks of partners involved in GFAR from each region will catalyse, engage and mobilize the delivery partnerships required and provide effective multi-stakeholder oversight of programme activities with the financing agencies concerned. Essential principles are the equitable inclusion of public, private, producer and civil partners – particularly smallholder farmers. The Facility concept has gained much traction and is now being developed into practical actions in a range of countries, with considerable potential value in Asia and the Pacific regions.

23. Innovative Funding Mechanisms of Public Sector: The Case of National Agricultural Innovation Project (NAIP) of Indian Council of Agricultural Research

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ABSTRACT

ICAR is a premier apex public sector agricultural research organization of India. Along with other partners of National Agricultural Research System (NARS), by effectively providing science and knowledge inputs, it has significantly contributed to accelerated and sustainable agricultural development of India. In this endeavour, one of its strategies particularly for addressing emerging and anticipated challenges through out of box solutions has been to seek and utilize external funding support particularly from the World Bank to reform and reorient the NARS. An earlier project supported with credit assistance from World Bank, National Agricultural Technology Project (NATP), was implemented during 1998-2004 to augment technologies and strengthen agricultural extension system, while National Agricultural Innovation Project (NAIP) was implemented during 2006-2014 to put technologies into effective and wider use through innovations. NAIP was implemented at a total cost of USD 250 million which included USD 200 million credit assistance from the World Bank.

The NAIP project development objective was to facilitate an accelerated and sustainable transformation of the Indian agriculture so that it can support poverty alleviation and income generation through collaborative development and application of agricultural innovations by the public organizations in partnership with farmers' groups, the private sector and other stakeholders. It was planned to achieve this objective through excelling in basic and strategic science (Component 4), market orientation (Component 2), social inclusion (Component 3) and strengthening institutional capacity (Component 1). The main focus of NAIP was on innovations some of the notable of which included strong project design; consortium approach; use of help desk; bigger projects; massive capacity development in advanced institutions in India and developed world; research on value chain, sustainable livelihood security, and hard core basic and strategic sciences; effective and elaborate monitoring and evaluation (M&E) and (environment and social) E&S frameworks; responsive and transparent project management; and establishment of business planning and development units. The NAIP worked with 203 consortia, 653 consortia partners covering public sector institutions (about 60%), private sector and NGOs (25%) and State/Central/International institutes (15%) working in 856 institutions all over India.

Among other several deliverables, the project developed and validated 51 diverse value chain models, 36 livelihood models in the most backward regions of India, and 272 production and processing technologies; piloted 62 rural industries; promoted 5 producer companies; commercialized 80 technologies/products; filed 149 patents, published 635 papers in high impact international journals besides several innovative e-products like e-courses, agro-pedia, e-Granth, etc. and supported capacity development of 1000 scientists in advanced labs/institutions in India and the developed world. With these remarkable achievements, the project has ended up with an overall Financial Benefit: Cost Ratio (FBCR) of 1.81 and Economic Benefit: Cost Ratio (EBCR) of 1.75. The economic and financial benefit which accrued from the project is estimated to be INR 23,808 million on an initial investment of INR 13,291 million with an overall internal rate of return (IRR) of about 40 per cent.

Keywords: Innovative funding; Pubic sector; NAIP; Impact; Lessons learnt

[1]The views expressed in the paper are personal and not of ICAR

1. Introduction

Indian Council of Agricultural Research (ICAR) is the premier, apex agricultural research organization of the Department of Agricultural Research and Education, Ministry of Agriculture and Farmer Welfare, Government of India for coordinating, guiding and managing ARI4D in India. With 99 ICAR institutes and 65 agricultural universities spread across the country as major partners of the Indian National Agricultural Research System (NARS), ICAR has made significant impact on food and nutritional security of the country. Its main strategy includes promoting science-led, technology driven agriculture to enhance production through productivity breakthroughs/ revolutions beginning with green revolution in 1960s and culminating in rainbow revolution around 2000. Some of its strategic initiatives covering science, institutional and management options include All India Coordinated Research Projects (AICRPs) (1957), Deemed Universities (DUs) (1958), State Agricultural Universities (SAUs) (1960), Department of Agriculture, Research and Extension (DARE) (1973), Krishi Vigyan Kendras (KVKs) (1974), Agricultural Research Service (ARS)(1975), National Agricultural Research Project (NARP) (1979), Institutional Village Linkage Programme (IVLP) (1995), Agricultural Human Resources Development (AHRD) (1989), National Agricultural Technology Project (NATP) (1998) and National Agricultural Innovation Project (NAIP) (2006). These initiatives while targeting the main strategy of improvement in productivity and production, also progressively addressed the changing national needs of nutrition security, social (small farmer, gender, etc.) inclusion, natural resource management including climate change, and foreign exchange earnings. However, around the year 2000, India faced the problems of steep fall in productivity growth rates, deepening of the farmers' distress, increasing market risks and weakening of the basic and strategic research in NARS. These problems made especially the poor further vulnerable, Millennium Development Goals (MDGs) unattainable against the target and time dead-line, and thus shook and moved the policy makers for change in the strategy. NAIP, a response of the public research system to these problems (Mruthyunjaya 2014), was implemented during 18 September, 2006 - 30 June, 2014 at a total cost of USD 250 million with the credit assistance (80%) of the World Bank. The overall objective of NAIP was to facilitate an accelerated and sustainable transformation of the Indian agriculture from self-sufficiency to market orientation, so that it could support poverty alleviation and income generation through collaborative development and application of agricultural innovations by the public organizations in partnership with private sector, NGOs, farmers' groups, and other stakeholders (ICAR 2014). Besides strengthening AR4D, the NAIP contributed significantly to capacity building (institutional and individual), improving coordination, bringing synergy among players and promoting partnership (pluralism) among unconventional partners (private sector, NGOs). NAIP was about innovative actions not only doing different actions but also doing actions differently.

2. The Strategy

Innovative strategies of NAIP were designed to push the frontiers of excellence in science (Component 4: Basic and strategic research), commerce (Component 2: Production to consumption system), livelihood security (Component 3: Sustainable rural livelihood security) and organization and management reforms (Component 1: ICAR as a catalytic agent of change). A project implementation unit (PIU) was established with National Director (ND) as the Head of NAIP with decentralized powers to operate the project under the direction and supervision of Project Management Committee (PMC) with Director General, ICAR as its Chairman. ND was supported with 4 National Coordinators one for each Component and Senior Officers for Administration including procurement and financial management (Mruthyunjaya 2014).

3. Notable Innovations

3.1. Strong design and approach

NAIP had a strong design and approach of doing the business of science differently by following science plus approach. The plus approach included, market orientation (Component 2), social inclusion (Component 3) and O&M (process) reforms (Component 1). Even under core science component (Component 4), the routine approach (smaller, limited objective, publication oriented projects) was not pursued. Emphasis was given to basic and strategic research in frontier areas of agricultural sciences to attain global competitiveness with larger spin-off benefits to India (publication in high impact journals, patent applications, product innovations). They aimed at keeping scientific competence in the forefront to meet all emerging, anticipated and un-anticipated problems. NAIP strongly believed in pushing scientific

frontier by attaining scientific excellence as the surest and enduring way to contribute to science led inclusive and sustainable growth. Since a big NARS like ICAR and associated institutions (about 25,000 scientists working in around 200 institutions spread all over India) has several O&M system problems requiring structural/process reforms on continuous basis, Component 1 was designed not only to consolidate O&M reform gains made under the previous NATP (with components like PME, Information System Development, Public Private sector Participation) but also to add important newer developments/ideas like IPR management, business planning and development, policy and visioning, explicit gender concerns, online MIS, e-learning and governance, decentralized procurement, systematic costing of projects for definitive funding, and massive international capacity development plan in frontier science areas (27 areas) in the advanced laboratories of the world.

3.2. Compatible with 11th five year plan (FYP) of Government of India

NAIP was also a plan scheme of Government of India and therefore had to respond to 11th FYP (2006-11) objectives by contributing to increase in productivity and production in agriculture and allied sectors (crops, horticulture, livestock and fisheries).

3.3. Consortium approach

NAIP was organized using consortium approach by pooling talents and resources. A consortium is a formal collaborative arrangement of like-minded partners from diverse backgrounds and experiences but having skills and expertise to bridge missing links/gaps in solving a complex, multidimensional problem. All the consortium partners were chosen to bridge the missing links and share the required resources with a tacit understanding and agreement. In NAIP, the sub-projects were jointly planned with diverse partners of public research organizations with private sector, NGOs and other stakeholders.

3.4. Competitive funding and rigorous, multilayer peer review

There was emphasis (60%) on national competitive funding under NAIP. However, under special conditions, a few consortia under Component 3 and several under Component 1 were sponsored. Competitive funding has not only encouraged creative ideas to blossom into projects but also contributed to sincere, serious, quick and quality revision of project proposals from the proponents. Right from concept note (CN) stage, the project proposals went through multilayer, transparent and rigorous review with objective criteria and scoring through score card system. In the NAIP as a whole, nearly 17 per cent of the total of 1414 CNs submitted got shortlisted for full proposals (FP) development; and 80 per cent of the FPs were finally approved. Though initially it took 12-14 months for processing and selection of projects, on an average it took 10 months to complete the project selection process. In all, 203 sub-projects with 203 consortia leaders and 653 consortia partners were approved under NAIP.

3.5. Extensive awareness campaign

Extensive awareness/sensitization campaign on special features of the project for nearly two months across the country was conducted involving sufficient number of stakeholders representing different interest groups. Further, involving experts and relevant stakeholders, NAIP developed Project Implementation Plan (PIP), Guidelines documents on PME, Financial Management and Procurement, much before inviting the CNs. Separate working groups were constituted for finalizing PIP and other guidelines documents relating to research, PME, Financial Management and Procurement, and they were put on NAIP project website after extensive e-consultation much before the national call for proposals. In other words, the rules of the game under NAIP were known to the potential players well in advance.

3.6. Help desk

Since national research system was not accustomed to conceive and propose projects in consortium mode especially in unconventional areas/components like value chains and livelihood security with adequate details on results framework, social and environmental safeguards framework, a help desk was created to guide the process of sub-project formulation right from concept stage. The help desk created at the National Academy of Agricultural Research Management (NAARM), Hyderabad with assistance from an internationally well-known professional consultant was an innovative idea to sensitize prospective project proponents about how to prepare concept notes and detailed project proposals. Its efforts in

matching partners from diverse background and skills in the sub-projects proved very useful. Help Desk also assisted NAIP in management of on-line submission of CNs and developing analytical report on the submitted concept notes/ projects to the PMU. It also organized periodic web chats with project partners spread all over India to clarify the multiple queries on procurement and financial management. The Help Desk continued throughout the project period to meet the changing needs/trouble shooting of partners and project management as the project progressed.

3.7. Bigger projects for wider, visible impact

It was felt that complex problems require wide range of options, competencies, partners and resources. A few but well financed consortia would be able to galvanize greater interest from different partners to address the complex problem from all angles with benefits of economies of scale. About 800 projects with an average budget outlay of about ten million rupees were funded under NATP, the project that preceded NAIP. They were all very good projects with useful information and research results. But they were carried out with limited scope, budget and scale and hence they could not make bigger economic impact in the system. Based on NATP experience, it was felt during NAIP preparation that the projects should be of bigger size and scope to make system wide, visible impact. In fact, initially it was planned to fund about 50 research projects of INR 150 to 200 million (2.5 to 3 million USD) each. But while preparing, processing and approving the projects, it was realized that planning bigger projects cannot be sudden, but a gradual process. There was not adequate capacity in the system to think big and formulate bigger projects with broader scope. In NAIP, the average outlay of the projects was about INR 55 million (nearly 1 million USD; 5 times bigger than erstwhile NATP sub-projects) and in general they reasonably addressed the problem in an end-to-end fashion. In a way, NAIP built the capacity of scientists in NARS to think big, plan and work for holistic change moving beyond science and their comfort zone.

3.8. Massive human resource development

Apart from building capacity in project planning and working with non-conventional partners, one of the rare opportunities planned in NAIP was upgrading scientists' domain knowledge, experience and exposure through international training in core areas of work in the approved projects as well as 27 cross cutting priority frontier areas in agricultural sciences in international centres of advanced research and training. These cross cutting areas were identified through national consultation as well as discussion and decision at the senior management level of ICAR, including the Director General of ICAR. A total of 428 scientists were trained internationally under the approved consortia, 472 scientists in priority cross cutting frontier area selected through national call using transparent guidelines for nomination from ICAR/SAU institutions and final selection by concerned Subject Matter Division (SMD) and DG, ICAR, and inviting about 80 international experts to India for training about 1000 scientists in cross cutting frontier areas in agricultural sciences. The capacity building on such a large scale and kind was happening in Indian agriculture after more than 50 years.

3.9. Research on value chain (production to consumption system)

For the first time, the agricultural research system in India piloted action research on commodity value chains following end-to-end approach covering production, processing, marketing, consumption, including quality and safety (NAIP 2014b). Fifty one commodity value chain projects having targets of income augmentation and employment generation, export promotion, agro-processing and resource use efficiency were supported with full details of present value chain, proposed value chain, activities, actors, value addition and net benefits at each stage/level and finally the benefits to the primary producers (farmers). As expected, nearly 50 per cent of the partners in these value chain projects were from outside ICAR/SAU system, mostly private sector. Two issues that got sorted out which enabled/attracted private sector entry into NAIP sub-projects as partners to the extent of 43 per cent were, IPR management and sharing of capital expenditure (CAPEX). The transparent intellectual property rights (IPR) policy of ICAR and sharing of the CAPEX on the basis of research content/ emphasis in the projects clinched the participation issue. These value chain projects would serve as models for replication to enhance profitability and entrepreneurship in farming.

3.10. Research on sustainable livelihood security

This is yet another bold initiative of ICAR under NAIP to pilot research through 36 projects on livelihood security of vulnerable sections of society situated in 150 most backward districts in the country (NAIP 2014a). All these 36 research for development (action research) projects focused on development and validation of sustainable farming systems with emphasis on on-farm action research and diversification, natural resources management, food, nutritional, employment and income security, strong knowledge management activities, marketing tie-up, synergy with other on-going development programmes and their sponsors for pooling and synergizing the human and financial resources to attack rural poverty. Several institutional innovations in mobilizing people, resources and partnerships, like formation of village resource centres, self-help groups, involving rural youth, establishing producer companies and commodity interest groups, creation and operation of various types of post-project sustainability funds with varied but farmer friendly rules were planned in these projects. As expected, nearly 50 per cent of the partners in these projects were reputed NGOs with long experience of committed working with farmers in rural settings.

3.11. Scientific excellence and leadership in science

The Indian NARS had the vision to not only find solutions to the immediate problems of farming but also keep its scientific competence in the forefront to meet all continuously emerging anticipated and unanticipated problems. It is intended to remain globally competitive in its agricultural science base besides taking the lead in the world in areas of its demonstrated advantage. Solutions to these problems require focused and highly innovative basic and strategic research and their application. Fifty one sub-projects of Component 4 focused research in well-defined 27 areas of frontier science, with strong bearing and leads on Indian agriculture (ICAR 2014).

3.12. Elaborate monitoring and evaluation (M&E) system

Realizing the critical importance of M&E system to ensure deliverables for a mega, complex and time bound project like NAIP, elaborate M&E planning was implemented. A professional consulting firm with expertise in M&E was hired to serve the project during its life cycle. An on-line project monitoring tracking system was developed which captured the M&E framework, results framework at NAIP level, Components level, sub-projects level progress on quarterly, half yearly and yearly basis. In addition to the regular monitoring, owing to their special nature, selected projects under Component 2 and Component 3 were monitored extensively. For concurrent evaluation of projects, a score card was prepared for all the projects and used to classify them into three groups: highly satisfactory, satisfactory and not satisfactory based on objective and transparent criteria, including performance on procurement, financial and technical aspects; and effectiveness of partnerships. Further, there was periodic review by peer review teams of Components 2 and 3 sub-projects. In addition to these, there was regular reviews of progress by the World Bank, and annual review by Department of Economic Affairs, Ministry of Finance (MOF), Government of India. Further, the project had provisions of 2 medium-term reviews (MTRs) at 18 and 36 months of operation and yet another useful innovation was Component-wise annual review involving all the stake holders, Research Advisory Committee (RPC), Technical Advisory Group (TAG), Consortium Advisory Committee (CAC) members and the final appraisal of NAIP by the World Bank at the end of the Project.

3.13. Baseline survey to fix the benchmarks for interventions and impact

A systematic base line survey was made in the beginning at the project level and consortia level to plan for interventions and at the end of project to indicate the impact of interventions with reference to base line indicators.

3.14. Responsive project management

There was a continuous and commensurate response by the project management to the problems, comments and suggestions for on course improvement. Some of the operational problems faced by the project management included, very low fund utilization and claims for reimbursement from the World Bank in the beginning; delays in conceptualizing, developing and evaluating projects in components 2 and 3, delays in establishing on-line Financial Management System (FMS) for the project, delays in procurement of goods services,

inadequate staff, low skills, competency, commitment and archaic bureaucratic rules and procedures in FMS and procurement. Though periodic trainings helped to minimize FMS and procurement problems, yet poor attendance in training programmes, right people not attending training programmes, and frequent change of finance and administrative staff resulted in delays and some lapses.

3.15. Facilitation for smooth entry of private sector

Private sector will be keen to become partners if clear IPR guidelines exist and there is support to capital expenditure in case of research project funding. ICAR had already finalized the IPR guidelines which became applicable to the approved projects under NAIP. As regards sharing capital expenditure by private sector in NAIP sub-projects, it was agreed for sharing provided the project proposal contained at least 50 per cent researchable issues on the logic that research is risky. The arrangement for dealing with capital assets subsequent to project completion was also amicably decided.

3.16. Business planning and development

To promote partnerships for new technology with entrepreneurs and start-up companies, the capacity for business planning and development was strengthened. BPD units were established in ICAR Institutes and SAUs assisted by professional business managers, formulation of policies and guidelines to handle legal, IPR and business management issues with incubator units to encourage, nurture and support technologists with potential to turn their innovative research ideas into sound commercial ventures.

3.17. Policy, gender analysis and visioning

The capacity of NARS was strengthened through a project to contribute to providing policy inputs for accelerated and inclusive growth, strengthen the role of women in research and farm decision making, strengthening the capacity for visioning, impact assessment, technology forecasting and decentralization of agricultural research, remodelling financial and procurement systems, etc.

3.18. Transparency and communication

The project had a creative and informative disclosure system, website (www.naip.icar.org.in) which was regularly updated. It is important to note that in a mega-project with a spending of about INR 12,000 million (USD 250 million), where about 1,500 concept notes were submitted but only about 17 per cent got finally selected, there was not even one public complaint of favouritism. The costs of the projects were rationalized by constituting a Cost Committee which helped in reducing the scope of parking of funds at the spending units owing to usual overestimation and also to reduce the savings/ surrenders in the sub-projects at the end. Flexibility was also permitted to relax financial certification norms, audit norms, opening up of the special bank account, enhancing the limits of petty purchase from USD 100-400 on par with GFR provisions as practiced by ICAR in regular projects, simplifying the purchase procedures with the concurrence of the World Bank. In fact these were the areas of reforms required in World Bank rules and procedures, especially in case of research projects.

3.19. Co-financing facility

The NAIP had co-financing from International Fund for Agricultural Development (IFAD) to facilitate participation of 6 CGIAR Institutions in 6 selected NAIP Component 3 projects to provide cross country experience and soft skills like resource analysis, PME capacity, documentation etc. It had also co-financing from SLEM-GEF initiative to support 3 Component 3 projects (out of a total of 36) to address natural resource management (NRM), land and eco-system, climate change and biodiversity issues.

3.20. Environment and social safeguards

The NARS under NAIP, for the first time followed a rigorous environmental and social safeguards framework to address environmental risks and capitalize environmental gains. Similarly, there was social impacts assessment, positive to be harnessed and negative ones to be avoided. Each sub-project had a clear E&S safeguards framework and a check list of impacts likely to occur which were monitored.

4. Impact

The NAIP is perhaps the world's biggest innovation project in agriculture ever to be funded by the World Bank till date. The complexities of the project implemented in one of the largest agricultural

research systems in the world provide several lessons for future design, implementation and utilization of results of the project. In all, 203 consortia leaders and 653 consortia partners working in 856 institutions spread over 364 centres all over India participated in the project (NAIP 2014a).

The outputs comprised a steady stream of new technologies/processes/products emanated including 51 value chain models covering cereals, fruits, vegetables, flowers, meat, fish, dairy foods, bio-colours, nutraceuticals, bio-energy, etc. (NAIP, 2014b) directly guided 200,000 farmers besides indirectly benefitting 20-40 per cent of additional farmers through horizontal expansion during the project period to improve income, better quality of life and livelihood and nutritional security through 33 sustainable rural livelihood security models (NAIP 2014a,c) development and validation of 130 production and 142 processing technologies, d) piloting 62 rural industries, e) commercialization of 80 technologies/products, f) filing of 149 patent/IP protection applications, g) publication of nearly 635 research papers in high impact international journals, and h) establishment of about 165 public-private partnerships, 22 business planning and development units and 5 producer companies. The other major outputs included a dedicated portal on e-courses covering 7 disciplines; a data base of meta data and abstracts of about 7,627 dissertation and more than 6,000 dissertations with full text; a digital library (e-Granth) by connecting 37 libraries of NARS; creation of on-line platform (CeRA) for literature search of 3,490 journals; development of e-Publishing portal; development of agricultural knowledge management portal (agropedia); development of commodity (rice) portal (RKMP); first supercomputing hub for Indian agriculture (ASHOKA) and training of 904 scientists in advanced domestic and international institutions of repute.

The outcome focused impact evaluation of NAIP was conducted by an independent professional external consultant. The consultant conducted mid-term impact assessment of a systematic sample of 65 selected consortia covering all the 4 components across 25 states (ICAR 2014). The impact analysis clearly indicated that: Component 1 had yielded an overall Benefit: Cost Ratio (BCR) of 1.65 and positive Net Present Value (NPV); Component 2 has yielded an overall Financial Benefit: Cost Ratio (FBCR) of 2.05 and Economic Benefit Cost Ratio (EBCR) of 2.07; Component 3 yielded an overall FBCR of 1.91 and EBCR of 1.67; and Component 4 yielded an overall BCR of 1.73 and a positive NPV. Based on the extrapolation of sample sub-projects to the whole of NAIP, the estimated overall FBCR is 1.81 and EBCR of 1.75. The final snap shot of the economic and financial benefit which accrued from NAIP as a whole is estimated to be INR 23,808 million on an initial investment of INR 13,291 million with an IRR of about 40 per cent (ICAR, 2014).

5. Lessons for Future Design and Execution of Mega Innovation Projects

- Agricultural Innovation Systems (AIS) concept is workable and highly beneficial to NARS to address challenges of monsoon, market, mind set and management for accelerated and sustainable agricultural development
- Well planned, well-spaced, externally aided projects (EAPs) though insignificant in terms of total outlay for ARI4D of the national system (less than 4-5% in case of India), but serves as tonic and trigger to the national systems to pilot reforms for needed reorientation of science, capacity development and O&M systems
- Selecting right partners, projects with end-to-end solutions, clearly defining objectives, results framework, operating procedures ensures project success
- Research consortia with diverse partners (PPP) promotes pluralism; breaks silos among scientists, NGOs and private sector; synergy, value addition, pooling of efficient work culture, talents, skills and resources
- Competitive funding promotes creative ideas, quick and quality revision of project proposals/ progress reports, response and continued interest of the partners
- Transparent, strong and responsive governance with well-planned governance structure is important to guide and control project management, to build credibility, public trust, smooth project management, saving time for review and approval process
- Decentralization of power empowers the system down the line, ensures accountability, timely action, trains project staff in research project management

- Flexible/evolving rules and procedures by the national governments and the World Bank or any outside funding agency is critical for the overall success and timely completion of the project
- The main implementation issues especially in EAPs are not technical progress but relate to frequent change of key staff, procurement, financial management, strengthening M&E system/mechanisms/practices, E&S safeguards, poor documentation, dissemination and media management
- Organizing frequent learning workshops to share the learning and take on course corrections is necessary
- Pre-project funding/scoping exercise to explore and establish sound and clear project fundamentals in terms of project goals, objectives, components, transparent criteria, governance structure, diversity of partners, to handle new ways of doing business (like value chain research, livelihood security research in case of NAIP), new operational innovations (competitive funding, costing of projects, addressing CAPEX in case of involvement of private sector units), operating guidelines/modalities, financial and procurement procedures, post-project sustainability mechanisms (sustainability fund, social mobilization, capacity development in case of NAIP), etc. is necessary to avoid major hiccups including time and cost overruns, tensions to project management in not utilizing the funds on time, when actual project begins
- Cross-component learning and horizontal expansion during the project has to be well planned and promoted to enhance the value of project outcome
- Planning and executing bigger projects is important for making wider and greater impact but to be attempted in phases to gain experience and confidence to think big
- The involvement of development departments/ agencies in ARI4D projects is generally poor in developing countries posing a big challenge for project implementation, uptake and sustainability. Tactfully involving them at every stage of the project may help in mobilizing their support.

6. Conclusion

Externally aided projects particularly in India from World Bank like NATP and NAIP have served a specific changed agricultural development context, contributed to systematic planning, more focused research, improved research processes and methods, better monitoring, evaluation, documentation and reporting of research results, economic benefits and more importantly human resource development. NAIP was an outstanding opportunity to Indian NARS for transformation. ICAR has capitalized the gains from such opportunities, each time better than previously. ICAR has also learnt the skills of designing such projects suiting them to its changing needs. But the internalization of the good ideas and practices in our regular projects is still slow and fragmented. Often times fixed mind set and rigid and inflexible administration and financial rules and procedures constrain smooth and timely completion of time bound projects affecting expected outputs and their uptake. The NARS need to work towards changing the of scientists and staff and reform the internal rules and procedures suitably as permitted in EAPs, sustaining the gains from such uncommon opportunities. The role of the national governments to adequately fund NARS with needed freedom, flexibility and supportive rules and procedures to use funds becomes extraordinarily important to properly promote ARI4D.

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24. Regional Partnership to Address Food Production Crisis in the Pacific Islands

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ABSTRACT

The Pacific region has reached a juncture where food production is in crisis. Per capita crop production has been falling in nearly all the Pacific countries over the past decade, even in countries with just a little population growth. The food production crisis has been caused largely by socioeconomic and political factors as well as agro-ecological factors such as: (i) downward spiral of soil productivity as a result of increasing deforestation, high rates of soil erosion, and declining soil levels of organic carbon caused by intensive use of soils; (ii) loss of biodiversity as a results of changing modes of production from traditional mixed cropping to mono-cropping, increasing bush fires, increasing pests and diseases, and climate variability/extreme events; (iii) increase in food waste; and (iv) the need to build capacity of land users in how to properly manage crops, livestock, land, soils, and forests.

In order to sustain this intensification of food production there is a need to develop and adopt technologies that will improve or sustain productivity while enhancing natural capitals and ecosystem services. But, the proportion of national budgets allocated to agriculture development is quite low ranging from less than 1-3 per cent. This means that national budget for research is insufficient and is heavy reliant on already limited donor support. The Pacific Community Land Resources Division (SPC LRD) with its technical human resources cooperates with national ministries of agriculture and international agencies like Food and Agricultural Organization of the United Nations (FAO), Australian Centre for International Agricultural Research (ACIAR) and The International Fund for Agricultural Development (IFAD) and donor agencies like European Union (EU), Australian Department of Foreign Affairs and Trade (DFAT), New Zealand Agency for International Development (NZAID) in developing and implementing research proposals addressing priority research issues in the countries. Recognizing that farmers are at the front of and central to agriculture, SPC LRD is also forging new strategic partnerships with key farming organizations, entrepreneurs, farmer field schools and training centres to promote research and development in the sector. All these partnership are very successful and donor agencies use SPC LRD as a hub to channel funding for agricultural research in the Pacific Islands.

Keywords: Food production; Regional partnership, Pacific island

1. Introduction

The agricultural sector including forestry is of vital importance in the Pacific nations. Crop production is the most important sector in Melanesia, including Timor-Leste, where it is the main source of employment, and also important in Polynesian countries like Samoa and Tonga, and Micronesian countries like Kiribati, and Federated State of Micronesia (FSM) (SPC 2011). Subsistence food production forms more that 50 per cent of household income in some countries, although it varies widely among and within countries.

The traditional agricultural systems are combinations of sequential cropping and intercropping (Halavatau and Asgher 1989). Usually a piece of land is cleared by slash and burn method or ploughing and then planted with a succession of root crops. In some of the cropping patterns, root crops are grown in a sequence and relay intercropped with tall growing crops like *Alocasia*, plantain/banana (*Musa* spp.), other fruit trees, kava (*Piper methysticum* Forst.) and paper mulberry (*Broussnetia papyrifera* L.). These structurally complex agroforestry systems, buffer crops from large fluctuations in temperature, keeping crops closer-to-optimal growing conditions, and protect crops from extreme storm events.

The widespread commercialization of agriculture over recent decades has removed much or all these

benefits. It has also led to shortening of fallow period with consequent soil fertility loss and weed and pest problems (Halavatau and Asgher 1989).

Agriculture production has been steadily increasing in the Pacific Region since the 1960s but annual growth rates of production in the overall agriculture sector have slowed down since the 1990s in most countries for which data are available, except for modest gains in Kiribati, Solomon Islands and Tonga (Rogers and Martyn 2009). There has been actual decline in agricultural production in this period in Fiji and Samoa. Since 1990s, the contribution of agriculture to GDP has also declined steeply in some countries, except in PNG where the share has increased (Table 1).

It is important to note that since 1990s, food production per capita has declined in all countries except Kiribati and Samoa and has been associated with increased import in several countries (Figure 1). The decline in food production per capita is occurring even in countries like Tonga with little net population growth.

Livestock production, especially poultry and egg production has been increasing around the Pacific Islands since the 1960s. Poultry and pigs form a potential source of protein for many Pacific Islanders but instead are being utilized mostly for social and religious occasions. Farming of ruminants, such as cattle, sheep and goats is carried out mainly in Melanesia and the larger Polynesian countries (FAO 2010). The livestock production index has shown

Table 1. Land area, annual growth rates of agriculture, proportion of national budget allocated to agriculture and forestry, and contribution of agriculture to GDP

Country	Land area (km²)	Annual growth rate of agriculture (%)		Proportion of budget allocated to agriculture and forestry (%)	Contribution of agriculture to GDP at current prices (%)
		1990-94	2000-08		
Cook Islands	180	8.3	3.2	1.09 (2011 - $1.42 millions)	2.7 (2010)
FSM	702	NA	NA	0.7 (2012)	14.1 (2010)
Fiji	18,376	1.0	-0.9	3.1 (2012 - $55 million)	9.4 (2011)
Kiribati	726	-2.4	1.3	2.6 (2012 - $2.5 million)	17.1 (2008)
PNG	461,690	4.8	1.6	1.5 (2011 - $171 million)	35.4 (2008)
Samoa	2,934	1.9	-2.4	2.02 (2011 - $12 million)	4.9 (2011)
Solomon Islands	29,785	2.3	4.9	2.47 (2011 - $54 million)	23.6 (2009)
Tonga	696	0.3	1.6	2.52 (2011 - $8.6 million)	15.0 (2011)
Vanuatu	12,189	3.0	1.9	2.9 (2011)	19.1 (2009)

Sources: FAO data bases and SPC NMDI

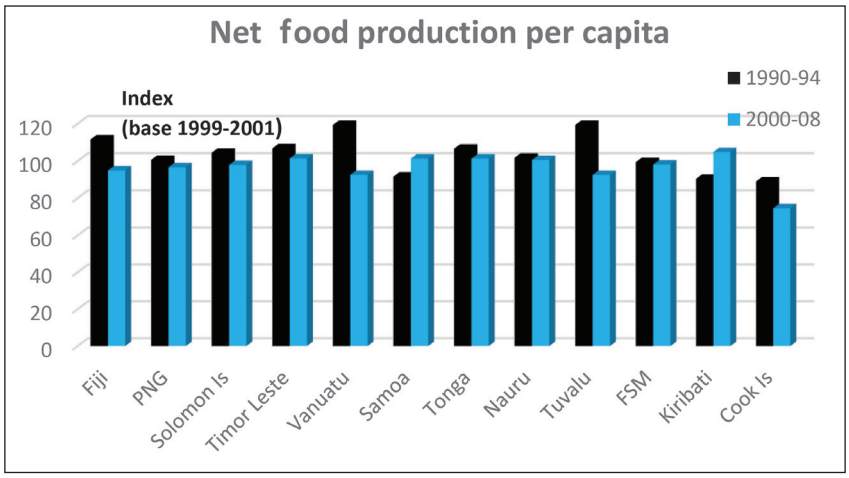

Figure 1. Comparison of country net food production per capita for the periods 1990–1994 and 2000–2008, (*Source: faostat.fao.org, Sombilla 2010*)

strong gains in nearly all countries (Figure 2), except FSM and Vanuatu.

2. Causes of the Food Production Crisis

Small farmers in the Pacific Island countries face many problems in their struggle to produce enough food for food security and improved household livelihoods. These include socioeconomic and political factors and agro-ecological factors.

2.1. Socioeconomic and political factors

2.1.1. Population increase and urbanization

The total number of people in the region is predicted to increase by around 50 per cent by 2030. Most of the increase will be in urban areas especially in Melanesia (Figure 3). This will present a major challenge to produce adequate local foods for urban areas, otherwise there will be an increase in food imports to meet the food requirements.

Urbanization and high population growth rates (in excess of 2% in Melanesian countries) accompanied by stagnant agricultural productivity is severely challenging existing farming systems to produce enough food to meet the needs of growing populations.

2.1.2. Land ownership

Land ownership and land tenure policies affect the allocation of land and thus access to agricultural, forestry and aquaculture production, which have implications on local food production and economic development potential.

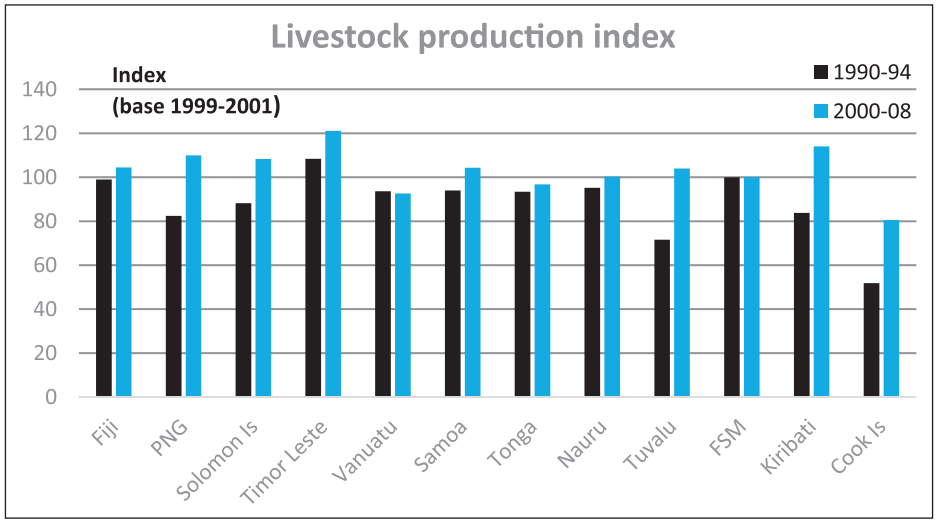

Figure 2. Comparison of livestock production for the periods 1990–1994 and 2000–2008 (*Source: faostat.fao.org; Sombilla 2010*)

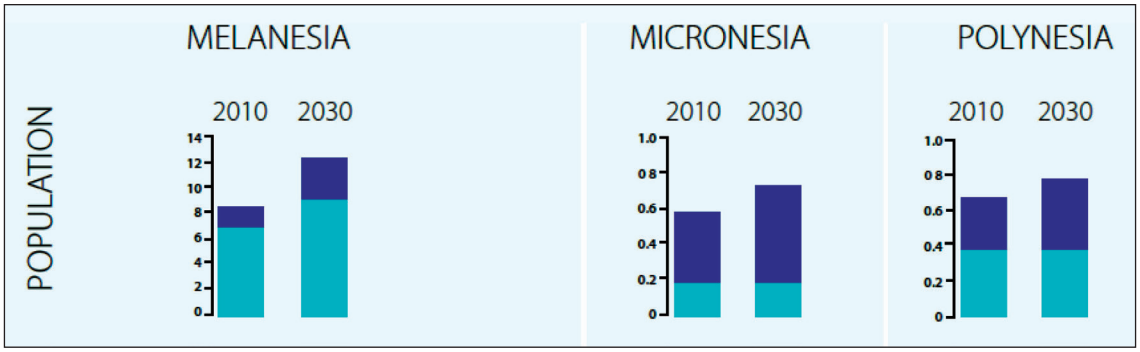

Figure 3. Forecast of population growth in rural ( ) and urban ( ) areas of the Pacific (*Source: SPC 2008*)

2.1.3. Increasing consumption of imported foods

Imports of affordable (e.g. rice, wheat), low quality (e.g. lamb flaps, turkey tails) and convenient (e.g. ready-to-eat) foods now compete with domestic foods (e.g. root crops) that often have higher production costs and are less convenient to store and prepare (Figure 4).

As a consequence of increased consumption of low quality cheap imported foods the Pacific Islanders have some of the highest incidences of non-communicable diseases coupled with the emerging vitamin and mineral deficiencies like iron.

2.1.4. Rising global food prices

The increasing reliance on food imports is of special concern particularly for Polynesian and Micronesian region countries that have limited agricultural production and export earnings. The increasing reliance on imports to meet the demand for food has heightened the Pacific's susceptibility to food and fuel price levels. There has been a steep rise in food prices of even local produce in recent years in (Figure 5). Some countries are still recovering from the effects of the global food prices of 2008 and 2011.

Many poor people are faced with higher food prices in the midst of a global economic slowdown. This is significant as one third of the total Pacific population lives below national poverty lines. With real gross domestic product (GDP) growth rates are forecasted to remain low or negative in most countries because of weak to moderate agricultural

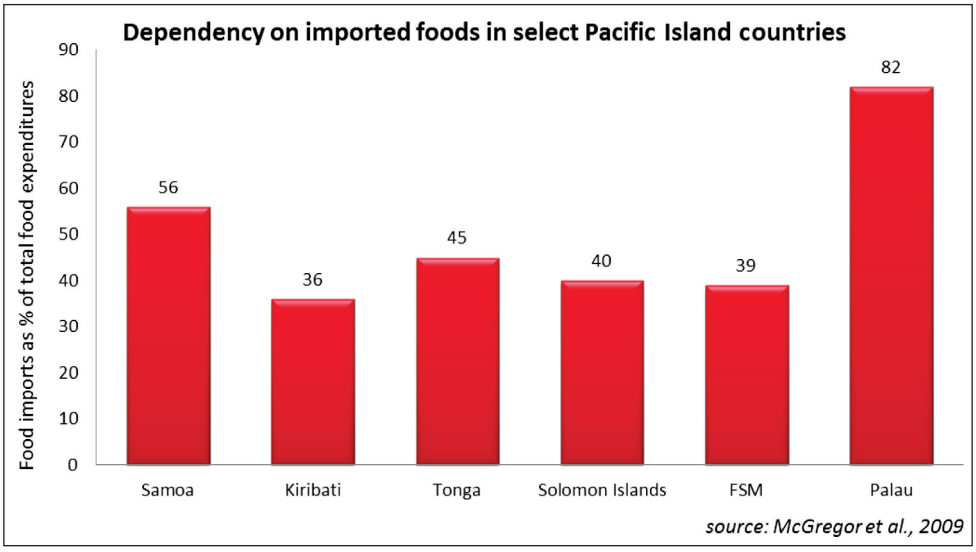

Figure 4. Dependency on imported foods in selected Pacific island countries

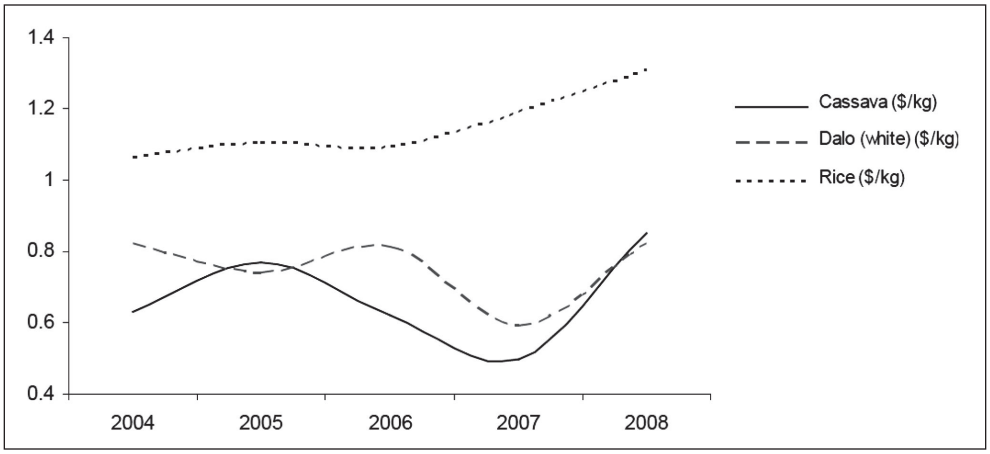

Figure 5. Cassava, dalo and rice prices in Suva in the years leading up to the 2008 global rise in food prices (*Source: McGregor et al. 2009*)

economy performance, reliance on food imports will be very expensive for these island nations.

2.2. Agroecological factors

2.2.1 Downward spiral of soil productivity

The traditional fallow or shifting cultivation in the Pacific Islands has changed considerably. However, the productivity and sustainability of many cropping systems is threatened by a decline in the fertility, structure and biological health of soils. In volcanic islands, soil fertility was traditionally maintained through long 'bush fallow' periods (Figure 6); on atolls, leaf-fall tended to sustain shallow but fertile soils in diverse agroforestry systems or growers assembled large amounts of organic matter in heaps or pits for intensive horticulture. This phenomenon was once described as cost free effortless regeneration of productivity (Ruthenberg, 1983). Both systems have tended to break down with increasing population pressure and migration.

Problems have in some cases reached crisis point as farmers have evolved from subsistence production of staple foods for local consumption to selling crops off the farm to supply growing urban and export markets for staple crops such as taro, sweet potato and cassava, as well as high-value vegetable crops, without adopting new technologies to sustain this more intensive production. Moreover, traditional knowledge of actively managing and investing in organic residues has been lost. The results have been 'nutrient mining' and a decline in the physical, chemical and biological properties of soils; the loss of biological functions of soil is reflected in increasing problems with nematodes and soil-borne pathogens (e.g. *Pythium* spp. in ginger and *Erwinia* in taro); quality and biosecurity problems in fresh export products (especially taro); and declining productivity from existing land, stimulating farmers to open new land, leading to deforestation and associated negative environmental impacts.

With increasing intensity of cultivation, many countries also increase rate of deforestation and the use of machinery which hasten the loss of organic carbon and the breakdown of soil structure. Figure 7 shows the relationship between loss of soil carbon and water stable aggregates (>0.25 mm) breakdown

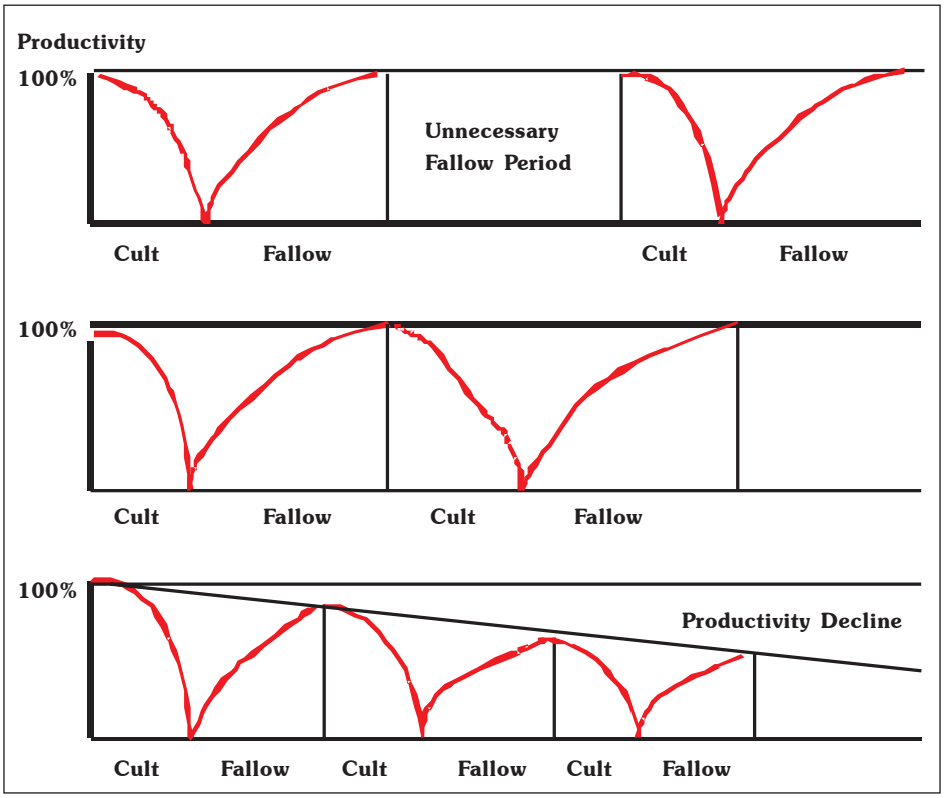

Figure 6. Graphs showing how shortened fallow periods do not regenerate soil productivity (*Source: Halavatau 2015*)

due to cultivation in a study by Halavatau and Asgher (1989) in Tonga.

With shorter fallow periods, more deforestation and more use of machinery, the loss of organic carbon increases as along with more degradation of water stable aggregates which render the land more prone to soil erosion. Figure 8 shows the rates of soil erosion in some of the Pacific islands.

Downward spiral of soil productivity was the most important issue adversely impacting agriculture in the Pacific region. This issue boils down to loss of soil organic carbon which is also found to be associated with a cascade of secondary problems like water availability, structural degradation, increasing pests and diseases, etc. (ACIAR 2010).

2.2.2. Loss of biodiversity

With increasing commercialization of agriculture production and import markets demanding specific crop varieties, farmers are forced to grow only the varieties demanded by the markets and many times in mono-cropping systems. This results in narrowing genetic base and the loss of some of the traditional varieties.

During extreme droughts many crop varieties die and disappear and if not sourced from outside will disappear from that community. During droughts, the incidences of bush fires are high which can further decimate an area and kill some of the crop varieties.

An increase in the incidence of a pest and/or a disease can destroy a crop or some of its varieties. In 1987, sweet potato scab disease almost devastated

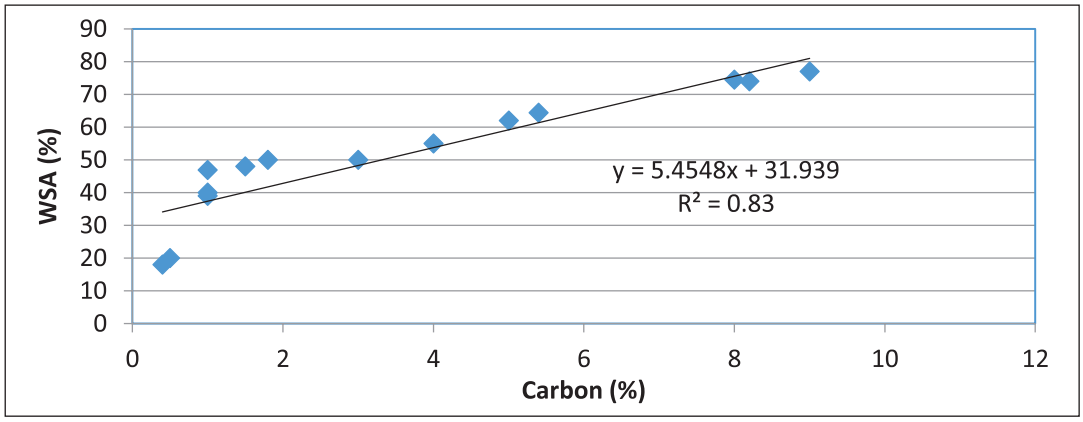

Figure 7. The relationship between aggregate stability and total carbon of soils (*Source: Halavatau and Asgher 1989*)

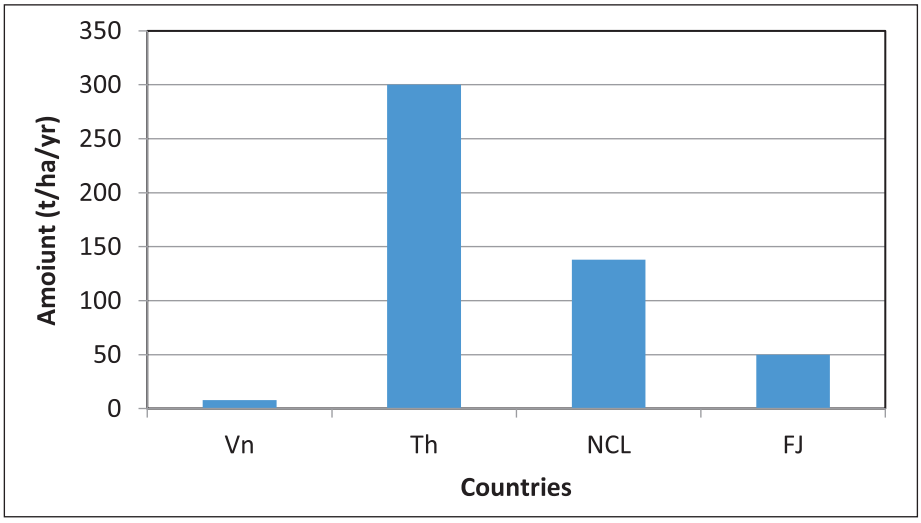

Figure 8. Soil erosion in some of the Pacific Islands (Vanuatu, Tahiti, New Caledonia, Fiji) (*Source: Dumas and Fossey 2009*)

sweet potato in Tonga. Taro leaf blight temporarily wiped out taro from Samoa in the late 1990s.

Climate change or variability is also a major threat to biodiversity. There is a need to select for varieties adaptable to impacts of climate change as well as harsh conditions of atolls.

2.2.3. Livestock production

There are three major problems affecting livestock production in the Pacific, both ruminants and non-ruminants. The first is the adjustment of animals to the local climate when many of the introduced animals find certain periods of the year sub-optimal and lose weight (seasonal weight loss). With good selection countries have got breeds adaptable to harsh island conditions. The second is availability of quality feeds which can account for 70-75 per cent of the cost of production of non-ruminants. The third is diseases and much of the expenses on livestock production is on purchasing drugs and medical equipment. On the other hand, in the Pacific we are free from many of the diseases having economic implications.

2.2.4. Food waste

The Food and Agriculture Organization of the United Nations (FAO) estimates that 32 per cent by weight of all food produced in the world was lost or wasted in 2009. When converted into calories, global food loss and waste amounts to approximately 24 per cent of all food produced. Essentially, one out of every four food calories intended for people is not ultimately consumed by them. About 40 per cent of the food losses occur at post-harvest and processing levels in developing countries including the Pacific Islands (SPC 2013), while in industrialized countries, more than 40 per cent of the food losses occur at retail and consumer levels (FAO 2011).

Food loss and waste have many negative economic and environmental impacts. Economically, they represent a wasted investment that can reduce farmers' incomes and increase consumers' expenses. Environmentally, food loss and waste inflict a host of impacts, including unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide.

2.2.5. Build capacity of land users to properly manage land, soils, and forests

Knowledge of soil, land and forests resources is the foundation for achieving sustainable soil management. It should be integrated into formal education, preferably at all levels of schooling. Countries should develop comprehensive and imaginative curricula that use an understanding of soils as a basis for teaching a wide range of cultural, social, scientific and economic subjects. At a more advanced level, the training has to encompass a range of soil science sub disciplines (e.g. soil physics, soil chemistry, soil biology and pedology) as well as connections with related disciplines such as ecology, forestry, agronomy, geology, hydrology and other environmental sciences. The formal education system also requires mechanisms for outreach, vocational training and extension. In some regions, knowledge of the land is deeply embedded in indigenous cultures and traditions. This knowledge requires nurturing and support.

3. Key Leading Research Questions to Guide Agricultural Research in the Region

Based on the above analysis, it is very clear that the Pacific is at a no return juncture in food production crisis. We need to develop appropriate technologies that will improve or sustain productivity while enhancing the natural capitals and the ecosystem services. To achieve this, we need to ask the right research questions (Table 2). The right questions are selected according to potential economic and environmental impacts of the research products; the likelihood they will be adopted by stakeholders; the potential for scientific advances, better tools and research techniques; and research capacity - the skills available, ability to put together high performing research teams, efficiency of running research, quality of infrastructure, equipment and information systems, and quality and efficiency of support staff. Currently, the proportion of national budgets allocated to agriculture development by countries is quite low ranging from less than 1-3 per cent (Table 1). This means that national budget for research is insufficient and heavily relies on donor supports.

4. Partnership in Research to Address Food Production Crisis in the Pacific Islands

The Pacific Community Land Resources Division (SPC LRD) with its technical human resources

cooperate with national ministries of agriculture and international agencies like FAO, ACIAR and IFAD and donor agencies like EU, DFAT, USAID, and NZAID in developing and implementing research proposals addressing priority research issues in the countries. These partnerships are in research areas related to genetic resources, crop production, animal production, agroforestry, plant health, soil health, biosecurity, agribusiness and trade. The objectives of these research projects are to address one or more of the leading research questions in Table 2.

SPC LRD has adopted an approach called Integrated Business Model (IBM) which is underlined by three priorities (Halavatau 2014): (i) greater decentralization to allow good response to and flexibility with both public and private sectors; (ii) participation within the division and between the divisions of SPC and its clients; and (iii) development of strategic alliance. The IBM approach advocates that the development of agriculture is not confined to on-farm activities solely; rather it must be the whole supply chain in its entirety i.e. from the production of inputs and equipment to production and to the purchase of fresh and/or processed products by the final consumer. The integrated aspect of the approach merely means implementation in partnership. It stresses the direct and indirect linkages to other sectors, such as tourism, health, education and other services. The model promotes working in partnership within LRD amongst thematic teams (Figure 9) and with other SPC divisions and programmes as well as with key stakeholders in the countries and international stakeholders and donors. This is in contrast to delivering services to the communities in a top-down fashion, trying to integrate the many public services required for development through the role of an implementation

Table 2. List of leading questions developed based on the context of food production crisis in the Pacific Islands

1.	What are the best uses of organic amendments by subsistence/commercial farmers in cropping systems to improve soil health (soil nutrients and water-holding capacities) and thereby assist in restoring agro-ecosystems?
2.	What are the best integrated cropping and mixed system options (including fallow rotations and other indigenous cropping systems for tubers and other staples, agroforestry, crop-livestock) for different agro-ecological and socioeconomic situations, taking account of climate and market risk, farm household assets and farmers' circumstances?
3.	How can increasing both crop and non-crop biodiversity help in pest and disease management?
4.	What is the comparative effectiveness of different genetic approaches to the development of crops with tolerance of abiotic stresses such as heat, drought, water-logging, acid infertility and salinity?
5.	What are the priority efficiency targets for livestock production systems (e.g. the appropriate mix of activities in different systems, the optimal numbers and types of animals) that would enable these systems to meet the demand for livestock products in an environmentally sound, economically sustainable and socially responsible way?
6.	What are the predicted critical impacts of climate change (e.g. changes in temperature, wind speed, humidity and water availability, storm intensity, crop water requirements, seasonal runoff, pests, water-logging, agro-ecosystem shifts, human migration) on agricultural yields, cropping practices, crop disease spread, disease resistance and irrigation development?
7.	What are the best social learning and multi-stakeholder models (e.g. farmers field schools) to bring together farmers, researchers, advisors, commercial enterprises, policy makers and other key actors to develop better technologies and institutions, for a more equitable, sustainable and innovative agriculture?
8.	Where food waste is the highest in food chains in the countries and what measures can be taken significantly to reduce these levels of food waste?
9.	How can market-based food supply systems be developed that offer economically sustainable levels of financial reward to all participants in the food chain (i.e. farmers, processors and retailers) while simultaneously providing safe nutritious, natural resource-stewarding and affordable food to consumers?
10.	How effective are experiential learning programmes (e.g. garden-based learning, forest schools, home gardening, and outdoor learning) in promoting child nutrition, healthy child development, and prevention of obesity and diabetes?

agency, usually the Ministry of Agriculture. The approach will result in ecologically regenerative, economically viable and socially sound management of land, agriculture and forestry resources. Table 3 shows the research partnerships to address different research areas and the results and impacts of those research partnerships.

4.1. Paradigm shift

Any component of a farming system can become the limiting factor to sustainability. It is, therefore, essential that those who work with farmers to develop sustainable systems are knowledgeable about the systems with which they work. This is not to say that everyone must be a generalist, but it is essential that highly skilled specialists such as breeders, pathologists, and soil scientists understand the full context in which their interventions are made and the need for contributions by others. This implies a blending of research disciplines in teams of scientists seeking collective outcomes that are appropriate and have an immediate impact in farmers' fields.

To more readily develop integrated solutions to complex problems, SPC LRD has adopted a new research paradigm, based on (Reeves 1997):

$$G \times E \times P \times M$$

Genotype Environment People Management

Whilst each of these components of an agricultural system can produce significant improvements to sustainable intensification, it is their optimal combination on which the sustainable intensification of food production in the Pacific will be based. Such a combination would consist of the best variety of a crop for a given environment, incorporated into an improved soil and grown using appropriate crop management, and both the technology and the desired outcomes would be appropriate to the farming people to whom it must be effectively delivered. This paradigm is indeed a participatory technology development approach.

It is essential that all those who seek to foster sustainable agriculture in the Pacific Islands recognize the interdependence of these factors, because most organizations individually cannot

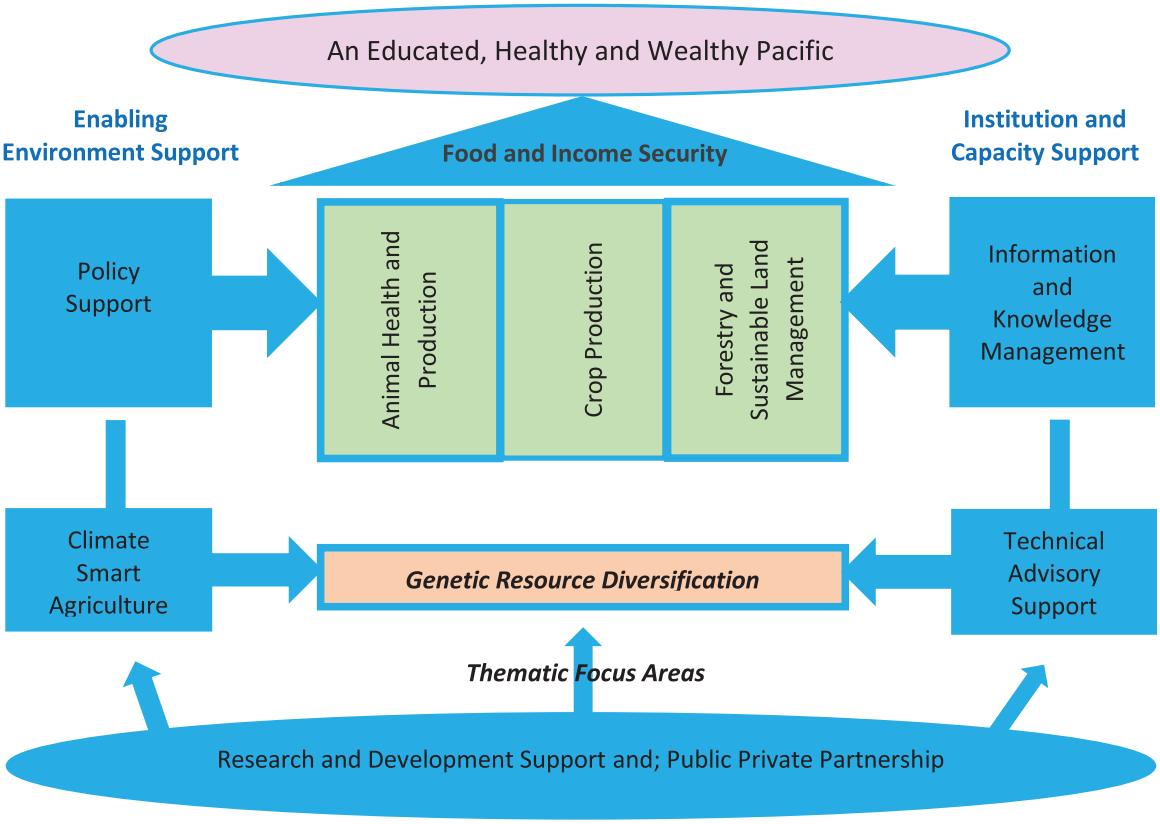

Figure 9. SPC-LRD integrated business model (*Source: Susumu 2015*)

Table 3. SPC LRD partnership in research and the impacts on food production in the Pacific Islands

Research areas	International agencies	Regional agencies	Countries involved	Fund available for 4-6 years including the current fiscal year	Results/impacts of the research Sources: SPC LRD M and E reports
Soil health and organic recycling	Australian Centre for International Agricultural Research (ACIAR), Queensland Department of Agriculture, Forestry and Fisheries (QDAFF); Australian Volunteer International (AVI), Scope Global Australia, University of Adelaide, University of Tasmania, IFAD	University of the South Pacific (USP), SPC LRD Crop Production and Plant Health Teams, The Pacific Organic and Ethical Trade Community (POETcom)	Fiji, Samoa, Kiribati, and Tuvalu	A$2 million	• Soil health technologies are improving taro production in Samoa and Fiji and sweet potato in Kiribati • **Fiji -** 400 farmers (25% women) in Fiji (TeiTeiTaveuni) • Organic fertilisers superior to urea, NPK - improved soil health, increased dalo yields • **Kiribati -** no fertilizers allowed in order to protect quality of fresh water lens • 70 households in South Tarawa, 3 villages in Abaiang • Composting - improved soil fertility and water-holding capacity, increasing sweet potato and vegetable yields, more household consumption of fresh nutritious produce, greater water-use efficiencies • **Samoa -** soil profiling of 80 farmers with recommended nutrient regimes (taro exports) • **2015 : International Year of Soils -** Pacific Soil Learning Exchange (50 farmers from FJ, PNG, Samoa, SI, Tonga)
Integrated crop management (ICM)	Food and Agricultural Organization (FAO), ACIAR, University of Queensland (UQ), World Vegetable Centre (AVRDC)	USP, SPC LRD Crop Production and Plant Health Teams	Tonga, Samoa, Solomon Islands, and Vanuatu	A$3 million	• Increased integration of natural enemies of *Brassica* pest management through the introduction of the "Insecticide Resistance Management" strategy. • Improved new tomato variety "Melrose" which is resistant to disease Tomato mosaic virus and birds released in Fiji.

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Table 3 (Contd.)

Research areas	International agencies	Regional agencies	Countries involved	Fund available for 4-6 years including the current fiscal year	Results/impacts of the research Sources: SPC LRD M and E reports
Genetic resources • Building resilience to climate change and pests and diseases • Developing taro clean seed systems • Developing commercial breadfruit production systems • Adapting clonally propagated crops to climate and commercial changes (INEA) • Conservation and global regeneration of crop diversity	DFAT, ACIAR, EU, FAO, NZAID, Global Crop Diversity Trust, Consultative Group of International Agricultural Research Institutes (CGIAR)	USP, SPC LRD Centre for Pacific Crops and Trees	All Pacific Island countries, Costa Rica, Nicaragua, Cuba, Trinidad & Tobago, Burkina Faso, Ghana, Nigeria, South Africa, Madagascar, India, Indonesia, Philippines, Kenya, Portugal, Germany, France	F$9.5 million	• 3 new taro export varieties (Talo Fusi, Talo Lani, Talo Tanu) launched in Samoa (14 October 2015). Increase from 4 to 14 containers/month (ACIAR) • 16 taro varieties among best in 8 countries (Burkina Faso, Costa Rica, Cuba, India, Madagascar, Philippines, Saint Vincent/ Grenadines, PNG.(EU INEA) • Provided climate resilient crops to FSM, Marshall Is, Tuvalu as part of TC PAM rehab • 7 breadfruit varieties selected for all year round production by CePaCT
Agribusiness and trade Whole of a supply chain approach – identifying bottlenecks to production and marketing and develop appropriate solutions	European Union (EU), FAO, ACIAR, UQ, University of South Australia, University of Sunshine Coast	USP, FNU, Increasing Agriculture Commodity Trade (IACT), SPC LRD Crop Production Thematic Team, SPC LRD Forestry Team	Cook Islands, Federated States of Micronesia (FSM), Fiji, Kiribati, Nauru, Niue, Palau, PNG, Marshall Islands, Samoa, Solomon Islands, Timor Leste, Tonga, Tuvalu, and Vanuatu	Euro 8.5 million	• 42 SME across 15 PACPs, export forestry & agri-products, • 31 new products exported from 9 PICTs • High price niche cocoa products, international awards (SI, Fiji) • Innovative solutions to funding leverage – linking agribusiness to banks and development partners, flexible funding options, enhancing collateral positions for operational and financial sustainability, enhanced business confidence essential for economic growth • Certifications: 7 enterprises (HACCP), 5 (FSC) and 1 (ISO 22000), 5 for third-party organic certification, 3 new PGS (FJ, SI, CI) • Consistent biosecurity support to Cook Islands Noni Marketing Pty Limited • Enabling the export of more than 100 tonnes of noni • Vanuatu has started producing chocolate of good export quality.

Research areas	International agencies	Regional agencies	Countries involved	Fund available for 4-6 years including the current fiscal year	Results/impacts of the research Sources: SPC LRD M and E reports
Land use, agroforestry (tree seed technology, and tree improvement)	EU, FAO, ACIAR, GIZ, USAID, FFPRI, Royal Botanic Garden of Kew	USP, SPC LRD Forestry Thematic Team	All PICTs	Euro 9 million	• Increased awareness, knowledge and skill on sustainable land use, forestry and agroforestry practices • Increased knowledge on tree seed technology and forest biodiversity
Animal production and health Development of feed from local ingredients Improve disease reporting and detection DNA characterization of poultry and pigs Conservation of native chickens and pigs	EU, DFAT, FAO, James Cook University, International Livestock Research Institute (ILRI)	SPC LRD Animal Health and Production Team	Cook Islands, Fiji, Niue, PNG, Solomon Islands and Vanuatu	Euro 8.5 million	• Enhance livelihoods and food security, i.e. use of local feed ingredients ensure sustainability • Improve public and animal health, i.e. app. 70 per cent of disease in humans originate from animals • Identification of unique native breeds of livestock that are at risk of extinction • Ensure future use for breeding and enhance food security through multiplication of native livestock species
Policy research and development	EU, FAO, ACIAR	SPC LRD PAPP Team, Crop Production Thematic Team, Forestry Thematic Team	Pacific ACP countries	Euro 8.6 million	• LRD's policy support to members is through its core technical strength in land use, forestry, livestock, and crop research development • Agriculture Policy Banks (Vanuatu, Solomon Is.) - enabled through ICT support and Participatory Rural Appraisal (PRA) for greater ownership of development destinies • http://www.spc.int/pafpnet/resources/policy-bank/country-policies • Leading to the Regional Agriculture Policy Strategy • Pacific Agriculture Forestry Policy Network (PAFPNet) – increased participation of small-holder farmers in policy discussions • Initial work begun on the Regional Agriculture Statistics Strategy

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Table 3 (Contd.)

Research areas	International agencies	Regional agencies	Countries involved	Fund available for 4-6 years including the current fiscal year	Results/impacts of the research Sources: SPC LRD M and E reports
Food security and climate change	USAID, DFAT, IFAD	SPC LRD	Fiji, Kiribati, Samoa, Solomon Islands, Tonga, Vanuatu	US$4 million	• Develop local adaptation plan of actions for communities. • Resilience of farming systems improved with incorporation of trees • Improve food security with cultivation of vegetables and fruit trees
Agricultural extension	EU, Global Forum for Rural Advisory Services	SPC LRD PAPP Team, Crop Production Thematic Team,	All PICTs	US500,000	• Regional agriculture extension strategy developed which contains priority extension research areas.

contribute fully to each component of G×E×M×P. Partnerships that assemble the best possible teams to execute the G×E×M×P paradigm will underpin the timely and successful achievement of sustainable farming systems. This has major ramifications for research and development institutions in the Pacific Region.

Many of the national and regional agricultural research institutions are not only structured by commodities and/or disciplines but conduct research, albeit high quality research, within these frameworks – in silos. A few research organizations have the resources, skills, and knowledge to be the best at all facets of G×E×M×P, but the achievement of sustainable agriculture is so urgent for the Pacific that only the best will do. If sustainable intensification of agriculture in the Pacific is to be achieved and maintained, institutions must be willing to form effective partnerships (public/private; research/development/extension; and their various combinations) to which they are enthusiastically committed. At SPC LRD, we believe that some internal capacity in the various aspects of the G×E×M×P paradigm is critical for us to partner other key institutions effectively. We have strengthened our resources in the areas of genetic resources, soil health and management, plant health, animal health, agroforestry, and economics to build a "credible mass" of scientists with whom outside agencies would wish to work. In addition, we have established an interdisciplinary team, incorporating skills in crop and soil management, plant health, climate change, and participatory research broadly adaptable to all regions of the Pacific. As a result of this approach, plus the introduction of a multidisciplinary operation structure, we believe that SPC LRD is effectively positioned to take leading role in agricultural research in the region.

4.2. Case study of the new paradigm

'Soil health' refers to the ability of the soil to function for a given purpose, in this case to support the growth of crops, and includes the chemical, physical and biological processes necessary for this. The degradation of the soil in any of these dimensions impacts on the economic viability and environmental sustainability of agriculture and in turn on agriculture's ability to support food security and livelihoods. The approach of this project is seen as a way of addressing problems

of 'cropping systems in crisis' - where incautious intensification has already led to crop production problems associated with declining soil fertility and a loss of 'ecosystem functions' provided by soil (especially the suppression of soil-borne pests and diseases).

The approach was participatory where scientists from SPC LRD (soil scientist, entomologist, and nematologist) Queensland Department of Agriculture, Fisheries and Forestry (DAFF) (soil scientist, pathologist, and nematologist), Australian Volunteer International (soil scientist) and Fiji MPI (research scientists and extensionists) and TeiTeiTaveuni farmers identified the soil related problems to production of taro for export and then devised soil improvement tactics to be trialled. The evaluation of soil improvement tactics was an iterative and evolving process. The results of each growing season's trials fed into the design of the next season's trials, resulting in refining of the 'best bet' tactics and modification or abandoning of those that were ineffective. Finally the recommended results were fed into the education/extension effort.

The result was that organic fertilizers (*Mucuna pruriens* fallow, fish manure and rock phosphate) were superior to urea and NPK in increasing taro yields as well as improving soil properties such as bulk density, labile carbon, earthworm counts, and decrease in parasitic nematodes (Halavatau *et al.* 2014).

5. Conclusion

SPC LRD has demonstrated that it has the capacity to partner with international, regional and national agriculture research stakeholders and even take the lead in some of the research initiatives.

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25. Intellectual Property Management and Commercialization of Agricultural Research: A Case of MARDI

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ABSTRACT

Agriculture continues to represent an important source of income for Malaysia. The government provides the majority of funding for agricultural research and development (R&D). The relatively high and increasing R&D investment in Malaysia has strengthened its agricultural productivity, particularly in terms of the country's major export commodities. The country's main public agricultural R&D agency is the Malaysian Agricultural Research and Development Institute (MARDI), accounting for more than a quarter of national agricultural research investment. Narrowing down to commodity-based research agencies, the Malaysian Palm Oil Board (MPOB), the Malaysian Cocoa Board (MCB), and the Malaysian Rubber Board (MRB) come into the picture. These three agencies' research investment mainly focuses on high value export crops and other related commodity-based resources. Investment in R&D will fully benefit from strong intellectual property (IP) and commercialization regimes. Similarly, it will also propel more R&D investment. Meanwhile, the main purpose of the National Intellectual Policy of Malaysia is to harness IP as a new engine of growth for the enhancement of economic and social prosperity. The focus on the development of proficient IP management capabilities covers the whole IP chain activities from creation to protection with support of good infrastructure for IP transaction, protection of national IP interest and at the same time promote foreign investment and technology transfer to ensure IP as a stimulant for innovation. Thus, to ensure the relevancy in the mainstream of national invention and innovation arena, MARDI has proactively strengthened its in-house IP management portfolio. This paper aims to share an overview of agriculture research investment in Malaysia, MARDI's IP and commercialization management, focusing on managing the research, and development and commercialization (R&D&C) as well as innovation effectively thus stimulating and fostering technology transfer. It also provides an overview of operational approaches, success stories as well as the issues and challenges in IP management and commercialization in the context of MARDI.

Keywords: Intellectual property; Agriculture research investment; Research and development (R&D); Commercialization; MARDI

1. Overview of Agricultural Research Investment in Malaysia

Agriculture continues to represent an important source of income for Malaysia especially to the rural population, propelling its continued importance in the overall economy. Government spending has become more volatile in recent years due to fluctuations in government funding levels. However, investment in agricultural research and development (R&D) still remains intact. The proportion allocated by Malaysia is considerably high compared to many other developing countries. The relatively high and increasing R&D investment in Malaysia has strengthened its agricultural productivity, particularly in terms of the country's major export commodities. Malaysia's R&D expenditures are basically generated through internal sources such as

government budgetary allocations. In other words, the Malaysian government provides the majority of funding for agricultural R&D. Competitive research grants under the Intensification of Research Priority Areas (IRPA) programme, and revenues levied on oil palm and rubber exports are part of the source. Besides, donor funds are received for joint research activities with international and regional partners.

Compared with other developing countries, bilateral and multilateral donor funding played only a marginal role in agricultural R&D investment in Malaysia. The country's main public agricultural R&D agency is the Malaysian Agricultural Research and Development Institute (MARDI), accounting for more than a quarter of national agricultural research investment and 36 per cent of human resource capacity in 2010, MARDI, administered by the Ministry of Agriculture and Agro-Based Industry, encompasses three branches (Research, Technology Transfer, and Commercialization, and Operations) oversees and 29 regional research stations. Year-to-year spending levels fluctuated moderately at MARDI throughout the past three decades.

Narrowing down to commodity-based research agencies, the Malaysian Palm Oil Board (MPOB), the Malaysian Cocoa Board (MCB) and the Malaysian Rubber Board (MRB) come into the picture. These three agencies' research investment mainly focuses on high value export crops and other related commodity-based resources. The Forestry Research Institute Malaysia (FRIM) is also a large government research organization covering the aspect of forestry and the environment, as well as forest and other natural products. Other agencies include the Veterinary Research Institute (VRI) and the Fisheries Research Institute (FRI). Sabah and Sarawak, two of Malaysia's states, operate their own research agencies. Sarawak's public agencies include the Department of Agriculture, the Forest Research Centre and the Sarawak Fisheries Research Institute. Sarawak Biodiversity Centre, the policy advisory arm of the government, could also be included in the list. The investment for agricultural research in Sabah is largely channelled to Sabah's Department of Agriculture and Department of Fisheries. Besides these R&D institutions, higher education institutions also conduct extensive agricultural research activities in Malaysia.

On the other hand, the private sector undertakes limited research in the agriculture sector. The private sector entities are mostly government-linked companies or subsidiaries of government agencies. Felda Agriculture Services Sdn. Bhd. is one such example, conducting oil palm research. Sime Darby Plantation, formed by the merging of Sime Darby Berhad, Golden Hope Plantations Berhad and Kumpulan Guthrie Berhad, provides most of the private sector R&D investment. In the Eleventh Malaysia Plan (2016-2020), the private sector has been identified as a key driver for innovation and productivity. Private investment across all sectors, including the agriculture sector, will therefore be promoted to spearhead economic growth.

Relatively high and increasing research and development (R&D) investment in Malaysia has strengthened agricultural productivity, particularly in terms of export commodities such as oil palm and rubber. In 2010, public investment in agricultural R&D in Malaysia was 696 million ringgit or 401 million purchasing power parity (PPP) dollars, both in 2005 constant prices (Table 1). As of 2010, government spending on agricultural R&D had doubled since the 1980s while it has been more volatile in recent years due to fluctuating government funding. As part of this growth, public agricultural research capacity reached 1,609 full-time equivalent (FTE) researchers in 2010. This growth occurred across all institutional categories. Investment in R&D will fully benefit from strong IP and commercialization regimes. Similarly, it will also propel more R&D investment.

2. National Intellectual Property Policy

The main purpose of the National Intellectual Property (IP) Policy is to harness IP as a new engine of growth for the enhancement of economic and social prosperity. The policy is needed to facilitate the formation of an environment that stimulates and fosters the creation, protection, enforcement, management and the maximum exploitation of IP aimed ultimately at developing a vibrant IP industry as a future driver of growth of the nation. There are several objectives of the policy which will put in place the highest standard of IP protection through strengthening the IP administration of the Intellectual Property Corporation of Malaysia (MyIPO) as well as promotion of IP generated

Table 1. Overview of public agricultural R&D spending and research staff levels, 2010

Type of agency	Total spending			Total staffing	
	Malaysian ringgit	PPP dollars	Shares	Number	Shares
	(million 2005 prices)		(%)	(FTEs)	(%)
MARDI	183.0	105.5	26.3	578.0	35.9
Commodity boards (3)	304.3	175.5	43.7	305.0	19.0
Sabah and Sarawak (7)	28.9	16.7	4.2	109.4	6.8
Other government (9)	110.1	63.5	15.8	379.8	23.6
Sub-total government (20)	626.3	361.2	90.0	1,372.2	85.3
Higher education (13)	69.4	40.0	10.0	237.3	14.7
Total (33)	**695.6**	**401.2**	**100**	**1,609.4**	**100**

Notes:
1. Figures in parentheses indicate the number of agencies in each category. Data exclude degree-qualified technicians lacking official researcher status.
2. Unless otherwise stated, all dollar values presented have been calculated using PPP exchange rates, which reflect the purchasing power of currencies more effectively than do standard exchange rates because they compare the prices of a broader range of local, as opposed to internationally traded, goods and services.

and commercial exploitation activities. These activities are focusing on managing the research and development of innovation more effectively among the research institutions, universities and individuals by providing incentives, grants, enforcement and dispute settlement. Furthermore, the suitable valuation methods, contractual and licensing rules to facilitate commercial exploitation of IP are also emphasized. The policy is also focusing on the development of proficient IP management capabilities covering the whole IP chain activities from creation to protection with support of good infrastructure for IP transaction. On the other hand, protection of National IP interest, promotion of foreign investment and technology transfer, play a vital role to ensure IP as a stimulant for innovation (Anon. 2015).

3. MARDI's IP Management

The history of MARDI's IP generation and management started in 1994 when MARDI first filed her IP in the MyIPO for an invention entitled *"Method of Producing Dietary Fibre Powder from Oil Palm Trunk and Function Food Thereof"* (22 April 1994 and obtained Patent no. MY 129137-A). Ever since, MARDI has given full consideration and equal accent on technology generation and invention and technology protection under various IP laws locally and overseas.

IP matters in MARDI are managed by Research and Innovation Management Programme of Strategic Planning and Innovation Management Centre placed directly under the Director General's Office of MARDI. This placement indicates strong commitment on improving and strengthening IP management.

3.1. MARDI's IP policy and manual

To ensure every employee comprehends the same vision and to synergistically replicate success in R&D&C of technology and innovation, MARDI has published her own version of the Intellectual Property Policy and Manual. MARDI's IP Policy and Manual elucidate Top Management views, the Technology Management Committees' role, IP Management Office's function, employees' TOR and responsibilities. Further, MARDI IP Policy and Manual elaborate and demonstrate the process and flow of technology/innovation management from the ideation stage to commercialization. MARDI IP Policy and Manual will be the source and guideline for any IP development, protection and exploitation inclusive of references for profit sharing and/or dispute settlement. The manual contains templates of technology declaration forms, template of commercialization agreement, collaboration agreement and non-disclosure agreement as well as a few other items. In brief, the objectives of MARDI's IP policy are:

- To protect MARDI's integrity and interests
- To promote, facilitate and encourage creativity and innovative capability among employees
- To create a secure environment where original inventions/innovations can be protected and rightfully owned
- To provide the employees with fair and reasonable recognition, awards and incentives to encourage them to develop new inventions/innovations
- To encourage and develop the Institute's growth, progress and success through active application of research, development and commercialization activities
- To facilitate and enhance the transfer of Institute inventions/innovations derived from research and the dissemination of knowledge to the food and agriculture sector

The ownership will be claimed by MARDI if the Intellectual Property is:

- Created from a specific project funded by MARDI or funds obtained by MARDI
- Created from substantial use of its resources and/or services
- Created by employees during the course of study which is sponsored by MARDI
- Resulted from the use of pre-existing Intellectual Property owned by MARDI
- That forms part of Intellectual Property created by a team of employees and non-employees; and
- From any courses that are printed, videotaped or recorded using any other media and may not be distributed without permission

3.2. The operational procedure

Operationally, IP management in MARDI is a certified process and procedure adhered to Quality Management Standard of ISO 9001:2008. This is to guarantee all IP related issues and matters to be well managed. To ensure all generated technology and inventions are properly protected and managed, MARDI has established a clear process flow for technology management. It is a process to declare generated technology to a Technology Management Committee whereby the committee will eventually decide on the way forward of technology. The committee will recognize the generation of said technology, give endorsement on IPR protection whichever necessary and give judgment on the commercial strategies and approaches. However, prior to that, a few experts will assess on the novelty, patentability, market potential, market feasibility and technology viability and commercialization mode and will compile a report for the Technology Management Committee for their reference during the Technology Management Meeting. By having a technical assessment stage, the pathway of generated technology will be clear and aid the committee to make decision, recommendation and endorsement, i.e. either to be patented or not, to which country deemed to be protected in, and the commercial mode and strategy to be adapted. Further, budget allocation for IP management will be utilized in appropriate cases only avoiding wasting of resources on technologies unfit for IP protection and commercialization. Furthermore, along the way, the technologies are also assessed for their fitness to enter national and international technology competitions, exhibitions, conferences or publication.

3.3. Output from proper IP management

Currently, MARDI has generated 183 IPs in various IP categories, protected in various countries (Figure 1). With proper IP management, MARDI will gain benefits from profit sharing by commercializing the technologies.

MARDI has also actively involved in creating IP awareness among its stakeholders. This is done by conducting and participating in various IP related activities such as seminars, workshops, consultations, and clinics. MARDI also works closely with MyIPO in nurturing IP in Malaysia. MARDI's IP Office has been honoured with the "National Intellectual Property Management Award" during Malaysia Intellectual Property Day 2015. It is the highest recognition to IP related practitioner/organization/management in Malaysia.

4. Commercialization of MARDI's Technology

Commercialization is a process of transferring research outcome to a successfully marketable product. MARDI was established on 28 October 1969 and with the amendment of MARDI Act in

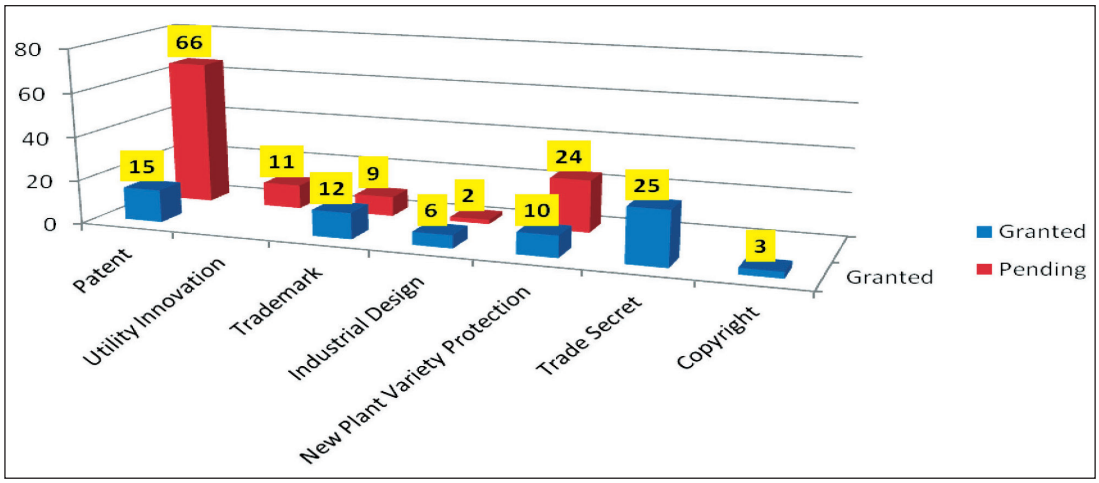

Figure 1. Summary of the MARDI's portfolio in IP management

2002, the initiative of technology commercialization was started of promoting and exploiting research findings. It is essential that any patentable invention be analysed for its industrial relevance and commercial potential. The technology transfer unit of a R&D institution should endeavour with the inventor, to answer the following questions (Nor Kamariah and Alina 2013):

- Does the technology offer a cheaper and/or a better way of accomplishing something?
- Are there competing technologies available and if so how much better is the invention?
- Does the invention provide a technological answer to an existing problem?
- Does it have the potential for creating a new market?
- How much investment, in terms of both time and money, will be required to bring the invention to the marketplace?
- Will the inventors continue to work on the invention?
- What will be the potential pay-off for a company that makes an investment in the development of the invention?

Commercialization of MARDI's technology is managed by the Evaluation and Upscaling Programme under the Centre of Promotion and Business Development. The technology commercialization is guided under MARDI Commercialization Policy. This policy is intended to ensure that the rules and procedures for MARDI's technology commercialization are being followed.

The flow of commercialization will start from an ideation stage until the determination of commercialization mode. The ideas from MARDI's pool of experts in relevant fields will have to pass several development stages in order to successfully transform into innovation. This innovation takes into consideration the needs of pre-commercialization, commercialization or public good. Generally, the commercialization of MARDI's technologies is carried out through licensing, consultation, outright sales and arrangement of contract manufacturing (OEM). The majority of commercializations (more than 80%) are effected through licensing which is the key driver in MARDI's commercialization success.

4.1. Technology Commercialization Process

There are seven major steps in commercialization process practised in MARDI:

Step 1. Technology package evaluation including evaluation of viability, feasibility and current market accessability.

Step 2. Technology promotion to enhance "technology in offer" and to find the potential partners by business matching, forum, exhibition and business talk which are common vehicles for technology promotion.

Step 3: Potential investors or partners will submit the letter of intent (LOI) with information such as the company status, financial capability, the availability of the interested technology and the company expertise.

Step 4: Preparation of terms of business and Non-Disclosure Agreement (NDA). The terms of business will be reviewed by the company prior to the confirmation. Meanwhile the NDA is crucial to secure the secrecy of the technology from the third party.

Step 5: Preparation of Technology Licensing Agreement based on the agreeable licensing terms and conditions including specific technology Intellectual Property Right (IPR).

Step 6: Upon agreement by both parties, the Technology Licensing Agreement which includes the agreeable royalty fees and management fees is signed to complete the licensing process.

Step 7: Scheduled monitoring of commercialization status and progress is conducted to identify any arising issues and challenges faced by the commercial partner. This step is subjected to royalty payment as stated in the technology licensing agreement.

4.2. The Impact of MARDI Technology Commercialization

From 2005 to mid-2015, a total of 85 technologies were commercialized involving 47 companies and 66 licenses given out. The value of technology involved is worth RM 42.6 million. A total of RM 6 million has been collected in the form of royalties. Examples of commercialized technologies are given in Table 2.

5. Issues and Challenges

MARDI has increasingly deployed the tools of patenting and technology transfer to advance practical use of technologies and appropriate benefits therefrom. Patents for research outputs are sought for novel processes and products, while plant variety protection is sought for new crop varieties. Copyrights and trade secrets are protection for the use of experimental techniques and formulations. This is to ensure the ownership of IP used by a research organization is respected by all who use the property, and organizations are in a position to identify, secure, manage, and exploit the IP that they generate. However, there are also underlying issues and challenges that need to be addressed.

Firstly, despite participation in workshops and forums, researchers still seem to lack awareness and understanding of the importance of IP and IPRs related to their research. Lack of awareness of IP concerns indicated that researchers are missing out, failing to commercialize their own ideas and sometimes failing to prevent others unfairly exploiting their research. Research output can only be effectively leveraged by making IP a key focus.

Table 2. Examples of commercialized technologies

	Technologies generated	Beneficiary/ Commercial partners
1	Rice varieties: MR 219, MR 253, MR 263, MR 269, MARDI 284	Rice farmers, Rice Regional Authorities
2	Rice clear field system: MR 220CL1 and MR 220CL2	BASF International, farmers
3	Rice foundation seed	12 rice seed producers
4	Specialty rice varieties: MARDI Wangi 74 and 76	5 anchor companies
5	Exotica papaya	Exotic Star and Far East Company
6	Josapine pineapple	South Fruit Sdn Bhd
7	Minimal processing of jackfruit and durian	Libro Agro Sdn Bhd and others
8	Starfruit under netted structure	Sri Balakong Sdn Bhd
9	Growpine fertilizer for pineapple	PK Fertilizers Sdn Bhd
10	Omega 3 eggs	LTK Bhd
11	Nitrohumic acid	CCM Fertilizers Sdn Bhd
12	New Modified Virgin Coconut Oil (MVCO)	EVCO Sdn Bhd
13	Tiger milk mushroom	Ligno Biotech Sdn Bhd
14	Salmonella Detection Kit (MicroTez)	OPHC Holdings Sdn Bhd

In the joint venture research scenario, contract negotiation arrangement and intellectual property ownership are the biggest drawback. Similarly, in the licensing of technology, negotiations between parties are very important in ensuring successful transactions. However, research organizations frequently lack the skills in negotiating with potential users and business counterparts which contribute to the failure of exploiting the full potential of IP commercialization to maximize its impact on innovation. The challenges also lie in the insufficiency of experience and knowledge in managing IP for the organization. The absence of a dedicated department or body, technology office (TTO) or technology commercialization office (TCO), which functions by offering assistance with the IP issues relating to research contracts, providing access to expert information on IP and helping researchers to protect and exploit their IP may also contribute to the inability to fully exploit the full potential of IP.

Funding for IP is crucial. In the Malaysian context, there seems to be a lack of sufficient funding for IP filing and maintenance especially for international applications. Patent applications are costly, and more so for international applications. Also, the process for international patents is more complicated creating hesitation to invest in the IP filing. However, if the government is willing to initiate a patent fund policy, it can effectively stimulate patent output, which would further increase utilization of the patent system, provide market incentives, and promote diffusion of technological innovations. For example, China has issued a policy of providing special government-backed funds for individuals or enterprises who file international patent applications which are also the vital drivers for China's pattern surge. The policy also helps to optimize patent structure which has its great positive impacts on promoting innovation in China (Jin *et al*. 2013).

Another area of constraint is the lack of competent workforce on authority and enforcement portfolio, especially IP judge and expert witness. For instance, policies aimed at improving IP management capabilities at research organizations are unlikely to have a big impact unless the legal protection of IP is sufficiently strong and enforcement of IPRs is effective. Authority should, therefore, address flaws in the IP regime along the entire continuum from the management of IP in research organizations, enterprises and financial firms to the legal and institutional system for IP protection, and enforcement.

6. The Way Forward and Conclusion

Concerns about agriculture investment, return to investment, IP generation and commercialization of research are rising. Commercializing IP is about getting products or services into the market place. Commercialization strategy depends on many variables such as individual circumstances, business capabilities, competitive environment and access to finance. Licensing is the most common commercialization method, but it is just one of many options for taking IPs to the market place. Questions that are crucial and need to be considered are such as whether to commercialize in-house or with a partner; manufacture, market or sell own product or outsource. There are also different issues to consider when commercializing internationally.

Concerning the future direction, MARDI is planning to establish Technology Commercialization Office (TCO) combining the current IP Management Unit in Research and Innovation Management Programme with the Evaluation and Upscaling Programme as a one-stop centre to manage IP and commercialization activities. By embarking on this step would mean more efficient and effective protection and management of IPs, partners for licensing, partners for supporting research contracts and funding as well as support new technology-based spin-offs. Moreover, it would further enhance and strengthen the key success elements such as technology internationalization and prototype support as well as active support for IP protection.

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26. A Comparison of Public/Private Agricultural Research Partnerships

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The Rural Research and Development Corporation (RDC) model of joint industry and government funding has been a vital element in the success of Australia's research effort in the agriculture, fisheries and forestry sectors for over thirty years. Co-funded public/private research has helped Australian agriculture to double its productivity over the past twenty five years. There are currently fifteen RDCs co-ordinated by a Council of Chairs, but with each RDC focussed on particular farm sectors covering crops, horticulture, livestock, forestry and fisheries. Producers in each farm industry pay levies for collective research. This recognizes that individual farmers are not normally positioned to undertake such research or to appropriate the benefits of the investment.

This presentation outlined the main features of the government and industry research working alliances, and considered whether this approach, or variations on the model, may be applicable more widely in the Asia-Pacific region.

The RDCs commission agricultural research on a competitive basis amongst public and private providers using investment funds from farm based production levies matched up to a formulated limit by Federal government grants. Currently, the government provides dollar for dollar matching of industry funds up to a maximum of 0.5 per cent of each industry's gross value of production (GVP). This joint public/private funding system enables close partnerships to determine and agree on research investment priorities that address triple bottom line (economic, social and environmental) outcomes. There is also an enhanced capacity for research adoption, commercialisation and uptake when both industry and government are collaborating closely to research common challenges.

The RDC model today comprises a mix of statutory agencies and industry-owned companies. While both versions are levy based, the industry-owned R&D companies are independent corporate entities. They were formed in response to an industry desire to have more control over their business operations and increased flexibility, together with industry representation to foster market driven research that will be widely adopted by the agriculture and food industries. Both statutory and industry corporations are accountable to the Minister for Agriculture for research expenditures and performance.

Australia's RDCs can fund research into either production (on-farm) or processing (off-farm) issues based on project portfolios that have a suitable mix of both public (community) and private (farm and food industry) benefit components. This recognizes that both farmers and taxpayers invest funds through the compulsory industry levies and matching government contributions respectively. In turn the RDCs engage and consult with a diversity of stakeholders to deliver a shared and agreed position on future directions and activities. These are regularly updated in five year corporate plans reinforced by annual operating plans and with annual reports on achievements.

The RDC model allows for a targeted approach to research fund allocations by collaboration with industry at all levels. This includes the selection of merit based multi-skilled boards in each of the fifteen industry specific corporations combining research, financial, farming, marketing, communications and other skills on each board. This joint funding and participation further encourages uptake of research by the private stakeholders by allowing farmer levy payers to approve and advise on RDC strategies, including the amount of levy collected.

Major successes of this Australian case study include:

- More effective research, development, innovation and extension of results than would be possible without such partnerships in areas that are priorities for both industry and government such as productivity growth, climate change and natural resource management
- The ability to tackle projects jointly increases efficiency and effective communication of outcomes thereby contributing directly to productivity growth
- Increased funding incentives to leverage higher total research investment than would be possible by each party acting alone.

While this public/private partnership model has been generally regarded as a success, the presentation gives consideration to whether the Australian model, or an adapted version of the model, could be usefully applied in other Asia-Pacific countries. This raises a number of structural, commercial and financial considerations, as well as administrative challenges for regional countries and industries to consider.

Consideration of Issues in Asia-Pacific Region

The agricultural sectors in many Asia-Pacific countries are predominantly smallholder farmers rather than the larger commercial family farm structures as in Australia. This raises practical questions over the willingness and capacity of such smallholder farmers to pay voluntary or compulsory levies to fund research undertakings. Compulsory levies are essentially an industry specific purpose tax based on farm crop production per tonne or per animal slaughtered. As such smallholders may have limited ability to pay such levies, and there could be excessively high administrative costs involved in raising such levies which are normally collected at the point of sale.

Not all farmers in Asia-Pacific are smallholders, and consideration could be given to industry based levies for larger commercial undertakings above a certain financial size. Some farm industries are more likely to have commercially sized enterprises or plantations (including for example coffee, palm oil, intensive chicken and pig enterprises, beef feedlots) which could more realistically enter joint research funding agreements with national governments. To an extent this already happens in some countries, but this tends to be on a short-term rather than the sustained basis which is needed to maximize research outcomes.

As in Australia, it is important that regional national governments are prepared to provide incentives for farm industries to commit funds to joint research arrangements. Equal funding commitments are one way, but other options such as tax incentives are feasible. Either way there are national budget implications, and the best options will depend on national circumstances and farm industry structures. This in turn requires a political commitment to research by governments in terms of agricultural development and wider community benefits, while recognizing the need for commercial opportunities for private sector partners to engage as a basis for partnerships.

In this context, the presentation outlines a selection of commercialisation pathways for public/private research agreements that can be used to develop joint research undertakings with both community and industry level benefits. Various types of contractual arrangements between the parties underpin most operations.

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