Information and Communication Technologies / Management in Agricultural Research for Development in the Asia-Pacific Region

A Status Report

Asia-Pacific Association of Agricultural Research Institutions
Bangkok, Thailand

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The views expressed in the report do not reflect any opinion whatsoever of the Asia-Pacific Association of Agricultural Research Institutions (APAARI) and the Global Forum on Agricultural Research (GFAR). The opinions expressed and conclusions drawn in this report are based on the perceptions of ICM managers elicited through a survey in addition to the country status reports presented by them.

CONTENTS

Contents *(continued)*

Contents *(continued)*

FOREWORD

In the present context, the role of Information and Communication Technology/Information and Communication Management (ICT/ICM) is highly significant for advances in Agricultural Research for Development (AR4D) through highly targeted and location specific information services. Advances like cloud computing, availability of new generation mobile technology in many developing countries and Geographic Information System (GIS), Web 2.0 technologies and social networking at all levels have increased opportunities for new ways to share and exchange information and knowledge with wide range of stakeholders in Agricultural Research and Innovation Systems in the Asia-Pacific Region.

The use and application of ICT/ICM for AR4D requires strong support by policy makers, ICT experts, scientists and other stakeholder groups to implement proper strategies in their respective institutions for better returns for the investments. This requires well informed-decision making on how to harness advances in ICT/ICM for strengthening agricultural research, extension, education, marketing and other sectors so as to empower all the stakeholders in improving their performance for achieving their objectives.

Asia-Pacific Association of Agricultural Research Institutions (APAARI), as a regional forum, has been promoting the use and application of ICT/ICM in AR4D in the region through one of its major programs called Asia-Pacific Agricultural Research Information System (APARIS). In order to influence all the stakeholders in Agricultural Research and Innovation Systems to promote the use and application of ICT/ICM, APAARI has been advocating use of ICT/ICM, developing capacity of ICM Managers and preparing policy documents.

Realizing the need for policy advocacy, APAARI has brought out the status report on "*Information and Communication Technologies in Agricultural Research for Development in the Asia-Pacific Region*" in 2004 unfolding the status of ICT/ICM in the National Agricultural Research Systems (NARS) in the region which was well received by ARD stakeholders and other groups. Since 2004, there have been rapid advances in ICT/ICM and significant increase in its use and application in agricultural research and innovation systems in the region. Therefore, it was felt necessary to update the previous report based on the current status of ICT/ICM in AR4D in the Asia-Pacific Region.

The current report shows that less developed countries are lagging behind in using more advanced ICTs such as database management, modeling, GIS, remote sensing and knowledge based systems. On the contrary, in number of countries, it is found that the use and application of ICT in extension, outreach and marketing services have considerably expanded due to interventions by governments, private sector, NGOs and other agencies especially to empower people with knowledge. Despite the progress, there are problems in upscaling, outscaling and sustainability of these initiatives.

With agriculture becoming increasingly knowledge intensive, there is a growing digital divide between the more economically developed and developing countries due to lack of leadership, political commitment, investment both in financial and in human capacities, inability to generate new knowledge or make it available, accessible, applicable and useful to learning and use by agricultural communities. There is an urgent need for mainstreaming ICT/ICM at various levels, in the policies, strategies, governance, structures and work processes so that they are more focused on generating the primary output, new knowledge, that is relevant, useful and effective with good impact on agricultural as well as overall development.

APAARI appreciates the contributions of ICM Managers who provided valuable data and perspectives on ICT/ICM in NARS which formed the basis for this report. I also appreciate the efforts of Dr. Ajit Maru, GFAR and Dr. S. Attaluri, Coordinator, APARIS in bringing out this important report. I am sure that this report would be very useful for all the stakeholders engaged in promoting ICT/ICM in Agricultural Research and Innovation Systems in the Asia-Pacific Region.

(Raj Paroda)
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EXECUTIVE SUMMARY

1. The effective use and application of ICT/ICM for AR4D and its transformation require strong support by policy makers, ICT experts, scientists and other stakeholder groups to implement proper ICM strategies in their respective institutions for better results for the investments. The current report assesses the status of ICT/ICM in AR4D in the Asia-Pacific region based on the data elicited from ICM Managers, representing the National Information Nodal Points (NINPs) in NARS of 19 countries in the region, through a questionnaire survey, country status reports and inputs from the experts.

2. The framework for this report employs the key indicators that are assessed to know the status of ICT/ICM at the national level in agricultural research and innovation systems of the Asia-Pacific region. The indicators are related to concepts that constitute the ICT/ICM use of the research and innovation systems viz., 1. ICT infrastructure, 2. Information systems, 3. Policy and strategies, 4. Contents, 5. ICT applications, 6. Information and communication services and 7. Information and communication channels.

3. The report also highlights the larger implications of CGIAR Strategy and Results Framework and GCARD Roadmap for knowledge sharing through use of ICT/ICM in future agricultural research for development programs. Trends in ICTs and ICMs, efforts for improving 'openness' in agricultural data and information sharing, CIARD initiative, global frameworks for sharing data and information, agricultural research information systems in the region with focus on APARIS program and its development phases are also covered which provide the changing context of agricultural research and the role of ICT/ICM for AR4D.

4. It was found that most of the NARS in the region have progressed well in terms of developing the basic ICT infrastructure and support systems including computer systems, broadband internet connectivity etc. However, the advanced facilities like database management systems, Wi-Fi, Videoconferencing and use of satellite and mobile internet are only available with most advanced NARS or developed NARS in the region. As far capacities, all NARS have skills in basic computing, internet and e-mail operation, whereas the skill sets in the areas of programming, database management, network administration, data analysis etc., are emerging in many developing NARS. The gaps in capacity building may be due to inadequate HRD policies which need to be addressed for proper cadre development.

5. Very few countries with strong or emerging economies such as Chinese Taipei, India, Japan, Malaysia and the Philippines have policies and strategies in place at the organizational level which enables them to follow and implement rules, norms, invest in ICT/ICM and engage qualified ICT experts in the national agricultural research and innovation systems. Most of the other national systems are still evolving policies or struggling with poor policy support.

6. Majority of countries are offering print-based content in the form of catalogues, indexes, abstracts etc., but whereas they are slow in shifting these contents, especially related to agricultural projects, experts, and policy information to electronic platform for greater sharing at different levels. Very few national level organizations within the agricultural research and innovation system could take up such initiatives to offer content especially through on-line database. Investment into creation of such contents, motivation by staff, understanding the

users' needs and proper capacities are key issues to be considered for developing content on the electronic platforms.

7. Information on research management is still emerging in majority of the countries. The critical information on research priority setting and need assessment is either poor or evolving in all the countries except Japan, which clearly indicate need for development of such value added information for better management of agricultural research at the national level. The lack of research management information may perhaps be due to high level of human expertise and investment that is needed in generating such decision making information; and collaboration among different subject experts is not so easy task to cultivate in the least developed countries.

8. Countries like Japan and Chinese Taipei develop and maintain all types of information resources in readily accessible form with the application of latest ICT technologies in crop modeling, precision agriculture, knowledge-based systems and information systems that support research management at institutional level. There is inconsistence even among some developed national agricultural research and innovations systems in having important applications like research databases, modeling, and precision farming applications which indicates that these countries have to travel a long way to make use of power of ICT applications for the agricultural research management in real sense.

9. There has been tremendous growth of innovative partnership (public-private-community) initiatives in using ICT-based agricultural information and providing advisory and extension services to the farmers and producers in the region. These initiatives use and apply a variety of ICT tools and technologies (mobile phones, Internet, community radio, cellular telephony, video through Internet etc.) to provide information to farmers related to crop management, disease management, pest control, market prices, input application etc., on regular basis through different business models with and without intermediaries and through the initiatives of NGOs, Farmers' Organizations and private sector. Majority of the countries have poor or emerging systems even to provide market price information inspite of all the rhetoric about how ICTs can and are improving the farming and livelihoods of farmers. This shows that these countries still need to do a lot to really apply ICTs in markets to link new information chains to innovation chains and then have effective learning about innovations so that producers can innovate and participate effectively in markets.

10. Print-based information services are adequately established in majority of NARS. But with the advent of digital information systems and the Internet, the scope of publishing has expanded to include electronic resources, such as the electronic versions of books and periodicals and scholarly journals. Libraries attached to NARS and other institutions in the developing countries need to avail facilities like AGORA and TEEAL to get access to high quality scientific journals at less cost or no cost. Efforts are needed to create enabling environment in institutions to develop Institutional Repositories which promote Open Access to institutional research outputs for all. The new ICT platform such as SMS-based services, mobile communications, Web 2.0 and social media have opened up new frontiers in communications both within and outside the organizations. But majority of the NARS need to develop suitable communication strategies in order to use these new information and communication channels efficiently and effectively to take results of their research to all stakeholders for ensuring intended impact in knowledge, attitude and actions.

11. In the last decade, rural areas in the Asia-Pacific region have witnessed proliferation of village information centers, telecenters, information kiosks, cyber cafes, community radio centers, farmers call centers, on-line help to farmers etc., with the help of several funding agencies and investors. There are initiatives in some countries like India, Malaysia and the Philippines aimed at providing information on market prices, intelligence information services to farmers. However, upscaling, outscaling and sustainability of such successful initiatives will be a challenge. The application of ICTs in agricultural marketing functions across the value chain of a commodity is missing in almost all the countries with an exception to Chinese Taipei and Japan. This shows that majority of the countries still need to do a lot to really apply ICTs to link farmers to markets.

12. The report concludes that with agriculture becoming increasingly knowledge intensive, there is a growing digital divide between the more economically developed and developing countries due to lack of leadership, political commitment, investment both in financial and in human capacities, inability to generate new knowledge or make it available, accessible, applicable and useful to learning and use by agricultural communities. There is an urgent need for mainstreaming ICT/ICM at various levels, in the policies, strategies, governance, structures and work processes so that they are more focused on generating the primary output, new knowledge that is relevant, useful and effective with good impact on agricultural as well as overall development.

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ABBREVIATIONS

ACIAR	Australia Centre for International Agricultural Research
AARINENA	Association of Agricultural Research Institutions in the Near-East and North Africa
ADB	Asian Development Bank
admin.	Administration
AFITA	Asian Federation for Information Technology in Agriculture
AFMA	Agricultural and Food Marketing Association for Asia and the Pacific
AGORA	Access to Global Online Research in Agriculture
AGRICOLA	Agricultural Online Access
AGRIS	International Information System for the Agricultural Sciences and Technology
AIC	Agricultural Information Centre
AICC	Agricultural Information Communication Centres
AIMS	Agricultural Information Management Standards
AIS	Agricultural Information System
AIT	Asian Institute of Technology
AKIS	Agricultural Knowledge and Information Systems
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APAFRI	Asia-Pacific Association of Forestry Research Institutions
APARIS	Asia-Pacific Agricultural Research Information System
APCoAB	Asia-Pacific Consortium on Agricultural Biotechnology
AR4D	Agricultural Research for Development
ARD	Agricultural Research and Development
ASEAN	Association of South East Asian Nations
ASTI	Agricultural Science and Technology Indicators
BARC	Bangladesh Agricultural Research Council
BIID	Bangladesh Institute of ICT in Development
CABI	Centre for Agricultural Bioscience International
CACAARI	Central Asia and the Caucasus Association of Agricultural Research Institutions
CAFRI	Center for Agriculture and Forestry Research Information
CARDI	Cambodian Agricultural Research and Development Institute
CARDiG	Cambodian Agricultural and Rural Development information Gateway
CAS	Current Awareness Service
CD-ROM	Compact Disc Read Only Memory
CeRA	Consortium for e-Resources in Agriculture
CGIAR	Consultative Group on International Agricultural Research

CIARD	Coherence in Information for Agricultural Research for Development
CIARD RING	CIARD Roadmap to Information Nodes and Gateways
CICs	Community Information Centres
CLAN	Cereals and Legumes Asia Network
CMS	Content Management System
CoA	Council of Agriculture
CoL	Commonwealth of Learning
Co-op.	Cooperatives
CoP	Community of Practice
CORRA	Council for Partnership on Rice Research in Asia
CSOs	Civil Society Organizations
CSV	Comma Separated Value
DSS	Decision Support System
DVD	Digital Video Disk
EDMS	Electronic Document Management System
EFITA	European Federation for Information Technologies in Agriculture, Food and the Environment
FAO	Food and Agriculture Organization
FAO RAP	Food and Agriculture Organization, Regional Office for Asia and the Pacific
FARA	Forum for Agricultural Research in Africa
FITS	Farmers Information and Technology Services
FORAGRO	Forum for the Americas on Agricultural Research and Technology Development
FOs	Farmers' Organizations
GCARD	Global Conference on Agricultural Research for Development
GFAR	Global Forum on Agricultural Research
GIS	Geographic Information System
GPS	Global Positioning System
HRD	Human Resource Development
HTML	Hyper Text Markup Language
IAARD	Indonesian Agency for Agricultural Research and Development
IARC	International Agricultural Research Centre
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICM	Information and Communication Management
ICM4ARD	Information and Communication Management for Agricultural Research for Development
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology

ICT/ICM	Information and Communication Technology/Information and Communication Management
IFPRI	International Food Policy Research Institute
IGNOU	Indira Gandhi National Open University
IISAST	International Information System in Agricultural Science and Technology
ILRI	International Livestock Research Institute
IMARK	Information Management Resource Kit
INGER	International Network for Genetic Evaluation of Rice
IPR	Intellectual Property Rights
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
ITU	International Telecommunication Union
JIRCAS	Japan International Research Center for Agricultural Sciences
LAN	Local Area Network
LEARN-IT	Linking Extension and Research Needs through Information Technology
MAAFLF	Myanmar Academy of Agriculture, Forestry, Livestock and Fishery Sciences
MANAGE	National Institute of Agricultural Extension Management
MARDI	Malaysian Agricultural Research and Development Institute
mgmt.	Management
MPI	Ministry of Primary Industries
NACA	Network of Aquaculture Centers in Asia-Pacific
NAFRI	National Agriculture and Forestry Research Institute
NAIS	National Agricultural Information System
NARC	Nepal Agricultural Research Council
NARI	National Agricultural Research Institute
NARIS	National Agricultural Research Information Systems
NARS	National Agricultural Research Systems
NATP	National Agricultural Technology Project
NGOs	Non-Government Organizations
NINPs	National Information Nodal Points
OAI	Open Archives Initiatives
OCLC	Online Computer Library Centre
OPAC	Online Public Access Catalogue
PARC	Pakistan Agricultural Research Council
PCARRD	Philippines Council for Agriculture, Forestry and Natural Resources Research and Development
RAEL	Regional Agricultural Experts Locator
RAIG	Regional Agricultural Information Gateway
RAIS	Regional Agricultural Information System

RDA	Rural Development Administration
RDF	Resource Description Format
RF	Regional Fora
RRNs	Regional Research Networks
RSS	Really Simple Syndication
SAARC	South Asian Association for Regional Cooperation
SACs	SAARC Agriculture Centre
SAUs	State Agricultural Universities
SDI	Selective Dissemination of Information
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture
SLCARP	Sri Lanka Council for Agricultural Research Policy
SRF	Strategy and Research Framework
STI	Science and Technology Information
TAAS	Trust for Advancement of Agricultural Sciences
TEEAL	The Essential Electronic Agricultural Library
UNESCO	United Nations Educational, Scientific and Cultural Organization
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
VAAS	Vietnam Academy of Agricultural Sciences
VERCON	Virtual Extension and Research Communication Network
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal
WAN	Wide Area Network
WCCA	World Congress on Computers in Agriculture
Wi-Fi	Wireless Fidelity

CHAPTER 1

Introduction

1.1 Challenges to Agriculture in the Asia-Pacific Region

The Asia-Pacific region underpins the global agrarian economy. The region is the largest supplier of the world's food and agricultural products. It houses about 58% of the world's population and 74% of the agricultural population, but, has only 38% of the world's agricultural land. Consequently, land availability per person in agriculture in the region (0.3 ha) is almost one-fifth of that in the rest of the world (1.4 ha), and over 80% of the world's small and marginal farmers belong to this region. The Green Revolution ushered in the region in the 1960s, an unprecedented success in multiplying food and agricultural production and productivity and in more than halving the percentages of hungry and poor by the year 1995, has now waned. A second Green Revolution is needed not only to produce more food in the region but to enable participation of its small and poor farmers equitably in markets, reduce poverty, generate more rural livelihoods and improve quality of life and environment.

Innovation systems related to agriculture that are transforming rapidly must go well beyond just raising yields and should be dynamically geared to meet the technological challenges of mitigating the effects of increasing natural resource scarcity of land and water and the structural transformation of the economic and social role of agriculture. Notwithstanding the centrality of generation and transfer of new and improved technologies for attaining sustained productivity gains, science today is thus called upon to address also the new challenges of market volatility, soaring food and energy prices, economic downturn and global climate change.

Asia-Pacific agriculture must liberate the region from the twin scourges of hunger and poverty and from the curse of carrying over 70% of world's undernourished children and women. It must continue to supply its region and world with adequate food and agricultural commodities. Given that the land, water and agro-biodiversity resources have been fast declining and degrading and the environmental footprint of agriculture has been intensifying, the task is difficult, but not insurmountable. Also, agriculture in the region now face new challenges of Climate Change, diminishing water for agriculture, desertification, loss of agro-biodiversity, spread of transboundary epidemic diseases and pests of plants and animals threatening production of major crops such as wheat, poultry and dairy production and increasingly competitive agricultural commodity markets, increasing populations and rising and highly volatile food prices. Accelerated science and innovation-led agricultural growth in the region must be inclusive and address the needs and aspirations of resource-poor smallholder farmers and producers. Most importantly, it must bridge the income divide between farmers and non-farmers which continues to widen from 1:2 about 40 years ago to 1:4 now. Developing Asia-Pacific agriculture, as revealed at the GCARD consultations would need to triple its investment in AR4D, requiring US$ 18 bn/year to generate and adopt agricultural research, technologies and innovations which must be rooted in the principles of economics, equity, and environment to increase productivity, income and livelihoods in perpetuity (APAARI, 2009).

Agriculture has always been knowledge intense and is becoming more so. All challenges to agriculture can only be met by generation of new knowledge and using it effectively. Agriculture in the region is increasingly a knowledge industry. The effective use of new knowledge depends on the

efficiency of its sharing within and across agricultural communities sharing common concerns, values and goals. The role of Information and Communication Management (ICM) in effective and efficient use of new knowledge for rapid development becomes imperative considering the linkage between information availability and access and effective use where it matters most, the agricultural community which participates in contributing to value addition chains of agricultural commodities and also contribute to their innovation.

In today's world, new ICTs have already shown their impact on development, not only economic but social, technological, environmental and political. There is growing potential of even newer ICTs such as the "Semantic" Web, cloud computing and very fast broadband connectivity through large scale use of wireless connectivity such as through WiMax that may further hasten agricultural transformation in the Asia-Pacific region.

1.2 CGIAR Strategy and Results Framework (SRF)

To overcome the challenges to agriculture and exploit the opportunities proffered through application of technology, the Consultative Group on International Agricultural Research (CGIAR), a major International Agricultural Research System, has undertaken a reform process to improve its impact on development. According to CGIAR (2011), agriculture in the developing world faces unprecedented challenges. Rising and volatile food prices, coupled with increasing pressure on natural resources, have emerged as severe threats to the world's poor and hungry. Climate change and variability will exacerbate these threats in the coming decades. At the same time, rapid advances in science and technology, combined with a better understanding of small-scale producers' needs, offer unprecedented opportunities. The new CGIAR Strategy and Results Framework (SRF) defines four system level outcomes – reduction in poverty, increased global food security, improvement of nutrition and better management of natural resources – that will shape the CGIAR's research in the coming years.

The SRF recognized that advances in bioscience and ecology, coupled with progress in the development and application of Information and Communication Technologies (ICTs), are transforming both the processes and products of agricultural research and affecting innovation systems as well as agricultural technology development. The ability to use and apply information technologies for genome sequences and gene marking improved effectiveness of the research process, helped researchers to improve plant breeding methods, construct safer and more effective pest control strategies and develop plants with improved agronomic traits and nutritional characteristics.

Just as biology is shifting the perceptions as to what is possible, so ICTs are scaling up those possibilities by dramatically boosting the capacity to access and use new knowledge. More and more rural people are connecting to the Internet, using it to gain market and related information, understand the threats posed by weather, pests and diseases, and enhance their access to and use of technology. Thus it is obvious that the role of ICT/ICM in agricultural development is going to be significant in the future initiatives in transforming agricultural research for development worldwide. This necessitates the need for assessment of ICT/ICM in AR4D, especially at the national level, to have fair idea of use and application of ICT in agricultural research systems in order to implement intervention strategies for use of ICT/ICM for greater impact in agricultural development.

1.3 The New Context of Agricultural Research for Development

According to FAO and the World Bank (2008), around a billion people still go hungry every day and 1.4 billion live in extreme poverty. Two thirds to three quarters of the poor eke out a living from agriculture and they, and the urban poor, critically depend on sustained productivity growth in agriculture for affordable food. For the poorest people, GDP growth originating in agriculture is about four times more effective in raising incomes of extremely poor people than GDP growth originating outside the sector. 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.

The Global Conference on Agricultural Research for Development (GCARD)[1] is organized by the Global Forum on Agricultural Research (GFAR), in association with the reform process of the Consultative Group on International Agricultural Research (CGIAR). The GCARD and the preceding analyses, consultations and discussions culminating in the Montpellier Conference in March 2010, set out to address the key challenges and opportunities facing agricultural research, technology generation, knowledge dissemination and delivery systems. It identified the transformation required in research and innovation systems so that millions of hitherto unreached resource-poor smallholder farmers and consumers can benefit from environmentally sustainable productivity growth and improvement in systems that can increase their food security and incomes to tackle the root causes of poverty, particularly in rural areas. The GCARD process strongly recommended that a radical restructuring and urgent revitalization of AR4D systems is now urgently required for many to effectively contribute to a significant reduction of hunger and poverty and address the many new challenges emerging in agriculture.

1.4 The GCARD Roadmap

The GCARD process is radically reshaping agricultural innovation and its significance in meeting key Millennium Development Goals globally. The GCARD clearly showed that AR4D systems need urgent transformation to better meet the needs of the poor and in particular those of resource-poor farmers and rural communities. GCARD participants, representing the global community of stakeholders and actors for AR4D, adopted the concept of a “Roadmap” to address these challenges. Participants recognized that, rather than hoping for changed behaviour in others, all stakeholders must play their own respective roles and commit themselves to action in improving AR4D, as a major contributor to goals of eradicating hunger and poverty while ensuring environmental sustainability. The contributions and dynamic interaction of thousands of stakeholders from all sectors have created the GCARD Roadmap, providing a clear path forward for all involved. The Roadmap highlights the urgent changes required in AR4D systems globally, to address worldwide goals of reducing hunger and poverty, creating opportunity for income growth while ensuring environmental sustainability and particularly meeting the needs of resource-poor farmers and consumers.

[1] The first Global Conference on Agricultural Research for Development (GCARD) 2010 was held in Montpellier, France from 28-31 March 2010. It was organized by GFAR in collaboration with the Consortium and Independent Science and Partnership Council of the Consultative Group on International Agricultural Research (CGIAR) and Agropolis International. Visit GFAR website: http://www.egfar.org/egfar/website/gcard for full details.

The GCARD Roadmap aims to transform AR4D globally, from its current fragmented status to more coherent, cohesive and interacting systems for greater impact. Its goal is that agricultural knowledge, science and technology should play their fullest possible roles in removing poverty, hunger and malnutrition from the world. To do so, collective actions are required to develop each of the six essential characteristics (see Box: 1) of well-functioning AR4D systems defined through the GCARD process (GFAR, 2010).

The Roadmap establishes an inclusive, rolling process of reform and capacity development that aims to mobilize the full power of agricultural knowledge and innovation towards meeting agriculture and food-related development needs. It proposes a six-point plan (see Box 1) for transforming agricultural research for development around the world, requiring actions from all those involved in the generation, access and use of agricultural knowledge. This roadmap enables and requires all involved, from resource-poor farmers and consumers to researchers, to now take up their own responsibilities and actions, working collaboratively with others to better meet the huge development challenges ahead.

Box 1. GCARD Roadmap

A well-functioning AR4D system is one that is *committed to action for impact* and that:

1. The need for collective focus on key priorities, as determined and shaped by science and society
2. The need for true and effective partnership between research and those it serves
3. Increased investments to meet the huge challenges ahead and ensure the required development returns from AR4D
4. Greater capacities to generate, share and make use of agricultural knowledge for development change among all actors
5. Effective linkages that embed research in the wider development context and actions enabling developmental change
6. Better demonstration and awareness of the development impact and returns from agricultural innovation.

Source: GFAR, 2010.

The Roadmap identifies need to develop institutional capacities for generation, access and effective use of agricultural knowledge in development. It further noticed that the actors and capacities involved in the dissemination of knowledge and sharing of learning are changing significantly. Civil society and the private sector are playing increasing roles and research/extension/education institutional divides are disappearing. Farmer's own innovation is increasingly recognized in participatory research and experiential-learning, but these need to be linked to wider AR4D knowledge and input access for farmers to benefit from the range of opportunities available. The new roles and partnerships of those compiling, integrating and transforming agricultural knowledge into innovative practices, technologies and enterprises, need to be adequately resourced and supported to deliver the impacts at scale that are now required.

The potential of Information and Communications Technologies (ICTs) to address challenges of agriculture and rural development has been well recognized especially in terms of its immense contribution to the AR4D and related knowledge sharing activities and in enabling the process of Transforming Agricultural Research for Development (AR4D) for Global Impact around the world in the new context of agricultural research for development. The Roadmap indicates that the opportunities of new ICT need to be fully exploited at all levels. Specific actions required include

processes of learning from innovative farmer-centred mechanisms that empower end users to commission or themselves be direct partners in research, building linkage with processes that share and scale out farmer innovation, strengthening national and regional agricultural knowledge and learning systems and their connection to wider knowledge, bringing coherence and cross-linkages between information systems and databases of different forms and fostering blended learning, experiential learning and strengthening of new forms of agricultural advisory services.

The effective use and application of ICT/ICM for AR4D and its transformation requires strong support by policy makers, ICT experts, scientists and other stakeholder groups to implement proper ICM strategies in their respective institutions for better results for the investments. The present report attempts to update information on the status of ICT/ICM in AR4D in the region with inputs from the experts representing the National Information Nodal Points (NINPs) in NARS of different countries in the region. It is expected that this Status Report will enable systems at the National level in Asia and elsewhere learn of the relative status vis-à-vis other Asian countries and in turn help further improve the systems to contribute to agricultural innovation as also make the case for attracting more investment, both financial and in capacities in improving the now critical area of information and communications management in agricultural research and innovation systems.

CHAPTER 2

Review of the Previous Status Report

2.1 About 2004 Status Report

The Asia-Pacific Association of Agricultural Research Institutions (APAARI) is a leading organization striving for improving agricultural research for development in the Asia-Pacific region. An important function of APAARI is sharing and dissemination of agricultural innovations and knowledge to all stakeholders in the agricultural research through a variety of information services and publications through its Asia-Pacific Agricultural Research Information System (APARIS) program. APARIS is mandated to provide a regional platform for efficient information and knowledge sharing among National Systems for Agricultural Research and Innovation in the Asia and the Pacific region besides strengthening agricultural information systems through advocacy, capacity building and training. One of the important objectives of APAARI is to promote the use of Information and Communication Technologies (ICTs) for better Information and Communication Management (ICM) in Agricultural Research for Development (AR4D) in Asia and the Pacific region.

The role of new ICTs such as cellular telephony and the Internet, to enable and enhance as also create new information flows for agricultural development is now gaining more widespread acceptance. These new ICTs play an instrumental role in connecting farming and rural communities in the Asia-Pacific to global information sources and markets. The advances in ICT/ICM such as increase in processing power, decrease of storage costs, improving bandwidth and new tools for data management have further been offering immense opportunities for faster dissemination of information and knowledge in a most cost effective manner. The current use of Social Media, Web 2.0 and Web 3.0 tools offer significant potential in bringing greater openness in sharing, exchanging and effectively using information for agricultural innovation in the Asia-Pacific region.

The use and application of ICT/ICM for AR4D requires strong support by policy makers, ICT experts, scientists and other stakeholder groups to implement proper ICM strategies in their respective institutions for better results for the investments. This requires better informed-decision making on how to harness ICT/ICM for strengthening agricultural research, extension, education, marketing and other sectors so as to empower all types of stakeholders in improving their performance in achieving their objectives. In order to influence all the stakeholders in agricultural research systems to promote the use and application of ICT/ICM for AR4D, APAARI has been advocating through capacity building of national leaders in agricultural development, ICT experts and preparation of policy documentation on the status of ICT/ICM in AR4D in the Asia-Pacific region. The status report on “Information and Communication Technologies in Agricultural Research for Development in the Asia-Pacific Region” brought out by APAARI in 2004 illustrates the status of ICT/ICM in the National Agricultural Research Systems (NARS) in the region with reference to availability of crucial ICT/ICM indicators at the National Agricultural Information System (NAIS) which is synonymous with the information system supporting the NARS at the national level in the region.

The National Agricultural Research Systems (NARS) are considered the most important repositories of information and knowledge on agriculture available in the public domain and form the tangible

backbone of Agricultural Knowledge and Information Systems (AKIS)[1] in their respective countries. It was felt necessary to know the capacities of NARS with regard to use and application of ICT/ICM, availability of ICT infrastructure, skills, policies, information and communication services etc., to assess the status of ICT/ICM in agricultural research for development in different countries of the Asia-Pacific region. The lack of such crucial information led APAARI to undertake preparation of a status report on ICT/ICM in AR4D in the Asia-Pacific region during 2004 with the active involvement and contributions from all major national systems for agricultural research and innovation in the region.

The report of 2004 used a conceptual framework of National Agricultural Information System (NAIS) which was considered as a 'system' that organizes and manages the flow of information related to agricultural research and development at the national level (APAARI, 2004). In majority situations, the NAIS was equated to the information management system of the NARS. The reports was based on the assumption that the use of ICT and ICM process can be described by assessing the information services provided to users by NAIS, the application of ICT that support the information service, the management of sources and flow of information content through the ICT-enabled services and the ICT related infrastructure that is needed to provide the services. APAARI carried out a survey in 2003 to collect data on different indicators from its National Information Nodal Points (NINPs[2]) that exists in the NARS belong to countries in the Asia-Pacific region. The reports assessed the indicators related to information services collectively at the NAIS level in the areas viz., scientific and technical information, research data management, research management information system, extension and outreach information, agricultural education, ICT infrastructure and skills. The report depended on data gathered from the survey, status reports and country papers presented by ICT experts of NARS at different regional and international workshops and conferences supported by several information sources both printed and the Internet based documents.

2.2 Findings of 2004 Status Report

The status report of 2004 found that there was great heterogeneity in ICT use and ICM for AR4D in the region due to several factors. It was indentified that the Asia-Pacific has seen significant development in ICT use and ICM for AR4D, but noticed several gaps in the use of ICT use in agricultural research for development in the region. The lack of clear policies, lack of capacities, lack of appropriate technologies and models to use ICT for AR4D were some of the important constraints identified for the slow adoption of ICT/ICM for AR4D in the region. Figure 1 shows a summary table of status on ICT/ICM in AR4D for selected Asia-Pacific NARS in the region reproduced from the 2004 report.

In order to overcome the constraints, the report suggested that there was a need to create awareness and sensitize top policy makers and managers not only in agriculture but also in different sectors such

[1] An AKIS links people and institutions to promote mutual learning and generate, share and utilize agriculture related technology, knowledge and information. Further, the FAO and World Bank (2000) defines that an Agricultural Knowledge and Information Systems for Rural Development (AKIS/RD) is a system that links rural people and institutions to promote mutual learning and generate, share and utilize agriculture-related technology, knowledge and information. The system integrates farmers, agricultural educators, researchers and extensionists to harness knowledge and information from various sources for better farming and improved livelihoods.

[2] NINPs are the National Information Nodal Points identified in each National Agricultural Research System (NARS) of APAARI members institutions in the Asia-Pacific region, which were perceived to be linkage nodes to APARIS program in the region.

Figure 1. Status of ICT in ARD for Selected Asia-Pacific NARS – A Summary Table by APAARI

Codes: ✘ = poor/very poor ↑ = emerging/reported ✓ = exists/developed blank = unknown/not reported

NARS	Science & Technology Information (Library Automation & Networking)	Research Data MS (Databases and GIS use)	Research MIS (Projects, funding, personnel, location)	Extension & Outreach IS (Policy, public and private sector using ICT to reach farmers)	Agricultural Education System (Distance learning opportunities)	Organization MIS (LANs and Websites)	Rural Infrastructure (Electricity, Telecom, Internet Connectivity	Skills (Users, Developers, Managers, Language)	Group
Australia	✓	✓	✓	✓	✓	✓	✓	✓	A
Japan	✓	✓	✓	✓	✓	✓	✓	✓	
Malaysia*	✓	✓	✓	✓	✓	✓	✓	✓	
South Korea	✓	✓	✓	✓	✓	✓	✓	✓	
Chinese Taipei	✓	✓	✓	✓	✓	✓	✓	✓	
China PRC	✓			✓	↑	✓	↑	↑	B
India	↑	↑	✓	↑	↑	✓	↑	✓	
Pakistan	↑		✓	↑	↑	✓	↑	↑	
Philippines	↑	↑	✓	↑	↑	✓	↑	✓	
Thailand	✓	✓		✓	↑	✓	↑	↑	
Bangladesh*	✘	✘	✘	✘	↑	↑	✘	✘	C
Fiji	✓		✓				↑	✘	
Indonesia	↑	↑	✓	✓	✘	↑	✘	↑	
Iran	↑	↑		↑		↑	✘	✘	
Papua New Guinea	↑		↑	↑	↑	✓	✘	↑	
Sri Lanka		↑	↑	↑		✓		↑	
Vietnam	✘	↑	✘	↑			↑	↑	
Afghanistan	✘	✘	✘	✘	✘	✘	✘	✘	D
Cambodia	✘	✘	✘	✘	✘	✘	✘	✘	
Laos	✘	✘	✘	✘	✘	✘	✘	✘	
Mongolia	✘	✘	↑	✘	✘		✘	✘	
Myanmar	✘	✘	✘	✘	✘	✘	✘	✘	
New Caledonia	✓	✓							

Notes: MS = Management System IS = Information System MIS = Management Information System A = Advanced B = Less Advanced C = Developing D = Slowly Developing

* Special Remarks: Border Line Status

as telecommunications, education, governance etc., about the need for cross-sectoral approach for ICT use in agriculture. It was felt very important to focus on improving capacities for effective use of ICTs, information and communications management and use of information for AR4D among NARS leaders, ICT experts and information mangers. It was emphasized that international, regional and national level efforts should be taken to identify appropriate technologies and models to use ICT in agriculture and rural development.

It was suggested to take advantage of the ICTs for library automation and creation of virtual libraries for providing access to scientific and technical information and improve indigenous capacities in the areas of intellectual property rights etc. To support ICT use in research data management and research management information, national level policy interventions and regional initiatives in capacity building were suggested respectively. It was noticed that there was a gradual shift from NARS centric agricultural information systems to information systems around commodities and markets. It was emphasized that NARS need to transform to meet these needs. As far content management, it was suggested to develop data and information exchange standards and governance structures, especially the IPR issues at international and regional levels.

The report concluded that regional networks have a critical role to add value to regional sharing and exchange of information. They need to play a central role in developing conceptual frameworks for effective ICT use and in building networks to share information, knowledge, skills and resources in ICT use for AR4D. It was emphasized that an objective assessment and continued monitoring of ICT use in AR4D is vital to harness the potential use of ICT in agriculture and rural development which is universally recognized. This necessitated APAARI to initiate a survey to update information on the status of ICT/ICM use for AR4D in the Asia-Pacific region in 2010-2011 through responses received from the information managers of NARS for a survey and their status reports presented in different international and regional ICM workshops jointly organized by APAARI, GFAR and FAO during 2010-2011.

CHAPTER 3

Methodology and Framework

3.1 Scope and Methodology of the Report

APAARI has been a pioneering regional organization aimed to strengthen agricultural research systems at the national levels through innovative partnerships and collaborations in the areas of research management, agricultural biotechnology and information and communication management. It believes that adaption of agricultural innovations can be improved with efficient exchange of knowledge and information dissemination. APAARI through its Asia-Pacific Agricultural Research Information System (APARIS) program aimed to improve use of ICT/ICM for agricultural research for development in the region by strengthening capacities of Agricultural Information Systems (AISs), advocating the use of ICT in agriculture, networking of AISs and services and sharing innovations through success stories. It is important to know the status of ICT/ICM in agricultural research and innovation for development so as to understand and foster the application of ICT in agricultural development by different stakeholders. Availability of such information on the status of ICT/ICM in agricultural research systems may improve understanding, help policy making, and adopt better management and technical models to manage agricultural information flows at the national level by NARS and other groups of ARD stakeholders. Realizing the importance of such an advocating tool to improve use of ICT in agricultural development, APAARI initiated to update the information on the status of ICT/ICM in AR4D in the Asia-Pacific which was published in 2004.

The present report assessed the status of ICT/ICM use in agricultural information systems at the national level in the Asia-Pacific region[1]. As stated above, the conceptual framework of AIS level was considered as a 'system' that organizes and manages the flow of information related to agricultural research and development at the national level. Each National level AIS has structures that enable and enhance ICT use and Information and Communication Management (ICM). An assessment of information services at the National level supporting agricultural research and innovation would be one way to know the status of ICT use and ICM processes in for agricultural research and innovation at a country level.

The status of ICT/ICM use at the national level was assessed through the reiterative activities: (i) *Survey of AIS at the national level*: APAARI conducted a survey of use of ICT and ICM processes in national systems of agricultural research and innovation through a structured questionnaire. The questionnaires were served to 19 Information and Communication Managers/Heads of ICT activities in the national systems for agricultural research and innovation who attended the regional ICM workshops conducted by APAARI in 2010 and 2011. All the 19 Information and Communication Managers responded and provided data on indicators on a four point scale indicating the status of ICT/ICM use in their NARS at the national level. The data elicited through this survey were used to assess the status of ICT/ICM in AR4D in the region. (ii). *Country Status Papers*: The country status

1 The Asia-Pacific region in this report is taken to comprise of 19 countries viz., Bangladesh, Bhutan, Cambodia, Chinese Taipei, Fiji, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Samoa, Sri Lanka, Thailand and Vietnam.

papers presented by ICM managers (NINPs and NARS representatives) in the 'Workshop on ICT/ ICM for National Agricultural Research Information Systems in the Asia-Pacific Region' held in September, 2010 at Bangkok were also taken into consideration to describe the status of ICT/ICM use in their respective agricultural research systems. (iii). *Recent Reports and Literature on the Subject*: The report depends on latest information available in reports, websites, articles etc., by several important organizations and individuals. It also depended on the wisdom of selected experts and academicians to present the results in a more meaningful and useful manner.

This report is the synthesis of the integration of the outputs of above three activities. The report reviews and presents the status of ICT use in NARS in the Asia-Pacific region based on a conceptual framework developed by Tugrul and Maru (2003) that was tested in the evaluating the ICT infrastructure and use in ARD in Georgia.

3.2 The Assessment Framework

As stated above, the report used the concept of an Agricultural Information System (AIS) which has its foundation in the National Systems of Agricultural Research and Innovation in a country. The AIS at the national level is considered as a 'system' that organizes and manages the flow of information related to agricultural research and innovation for development at the national level. In majority of situations in the Asia-Pacific region, the AIS may be equated to the information management system of National System of Agricultural Research and Innovation in a country. The National level system for agricultural research and innovation, which is also a conceptual entity, consists of public agricultural research and development institutions, agricultural universities, NGOs and over a period of time included banks, donors, private sector, CSOs, community participation, farmers' organizations, markets, innovative partnerships and all other groups of stakeholders in agricultural development. The AIS at the national level, which has its base in National Systems of Agricultural Research and Innovation System in a country, will also have similar actors, stakeholders and clients.

The AIS at the national level has structures and processes that enable use of ICT/ICM in a national agricultural research and innovation system. It includes infrastructure, skills, information systems, information resources, ICT applications, information and communication services to clients and a variety of communication channels besides institutional processes such as policies, strategies, management practices, information standards, IPR issues, cadre management, investment in ICTs etc., that promote effective use of ICT/ICM in National Systems of Agricultural Research and Innovation System for efficient flow and exchange of agricultural information at the national and global levels.

It is believed that the use of ICT/ICM in AR4D can be assessed better by examining the information services provided to users by AIS at the national level, the application of ICT that support the information service, the management of sources and flow of information content through the ICT-enabled services and the ICT related infrastructure that is needed to provide the services. The management processes that included in the framework are policies, implementation of strategies, application of ICT/ICM for research management, resource allocation, administration etc., which govern the information systems' functions.

In other words the assessment of ICT/ICM in NAIS would therefore be an assessment of the following:

- ICT/ICM infrastructure
- Information services rendered by NAIS
- ICT/ICM applications in NAIS
- Policies and strategies that support ICT/ICM use.

Providing information that is relevant to status of ICT/ICM use in national system for agricultural research and innovation within constraints of time and other factors, and in a form which all ARD stakeholders can accept and use is a major challenge, requiring the selection of information that is directly relevant to the task at hand and necessitating synthesis of this information to be useful for all stakeholders in AR4D with an aim to augment ICT/ICM contribution to agricultural development.

Indicators can help to simplify a complex array of information about the state of a phenomenon. They provide a "synthesized" view of existing conditions and trends which can be used for improving understanding, communicating with the public and decision-makers, and may contribute to improved management and policy development. The framework for this report employs the indicators that are assessed to know the status of ICT/ICM at the national level in agricultural research and innovation of the Asia-Pacific region. The indicators are related to the following concepts that constitute the ICT/ICM use of the research and innovation systems:

1. **ICT infrastructure** – hardware, software, connectivity, skills etc.
2. **Information systems** – website, e-mail domains, use of Web 2.0 tools etc.
3. **Policy and strategies** – organizational policies, adoption of standards, IPR issues etc.
4. **Contents** – Scientific and technical information, research data, research management etc.
5. **ICT applications** – Library applications, applications for research data analysis, applications for research management, applications for extension, marketing, education and organizational management etc.
6. **Information and communication services** – scientific and technical information, research information, research management information, extension and advisory, market information services etc.
7. **Information and communication channels** – various channels used by NARS to communicate and disseminate information and knowledge.

Data on the above indicators were elicited from ICM managers/representatives of national systems for agricultural research and innovation through a structured questionnaire (Annexure-I). The respondents were asked to respond on a four-point scale indicating the status of ICT/ICM use in their NARS. A four-point status scale was used to distinguish the condition of different indicators with colour code and symbols as follows:

Developed = √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

A total of 19 ICM managers representing the national systems in the Asia-Pacific region provided their responses to the questionnaire survey that was conducted during APAARI regional ICM workshops in 2010 and 2011. The countries covered in this report included: Bangladesh, Bhutan, Cambodia,

Chinese Taipei, Fiji, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Samoa, Sri Lanka, Thailand and Vietnam.

The responses were validated by sending the tabular data to all the respondents. Upon reconfirmation from the respondents, the data were categorized according to the above framework for analysis. The report is depended on the data collected from the questionnaire-based survey and the qualitative information from the country status reports presented by the same national level ICM managers/representatives of the countries in the 'Workshop on ICT/ICM for National Agricultural Research Information Systems in the Asia-Pacific Region' held in September 2010 at Bangkok. The information on latest developments from reports, articles, websites and personal discussion with experts was referred to provide the current status of ICT/ICM in AR4D at the global, regional and national levels and to add the dimension of way ahead for future directions. A complete list of respondents who participated in the survey and provided country reports is given in the acknowledgement section of this report. The informative abstracts of country reports are given at Annexure-II. The literature and other materials referred in this report are acknowledged in the bibliography section with proper citation.

CHAPTER 4

Changes in ICT and ICM

ICTs play an important role in any economy today. It is beyond doubt that living is intertwined with and heavily depended on ICTs in today's global environment. The advances in ICT have been virtually revolutionizing the progress of science and technologies in all development sectors including agriculture. These advances offer immense opportunities to transform agricultural research for development and highly relevant for small and resource poor farmers who constitute majority of the farming community in the developing countries in general and in the Asia-Pacific region in particular. It is pertinent here to discuss about major changes in ICT/ICM that transform agricultural science, research and technology generation.

Moore's law[1] (Moores, 1965) describes a long-term trend in the history of computing hardware. The number of transistors that can be placed inexpensively on an integrated circuit doubles approximately every two years. This trend has continued for more than half a century and is expected to continue until at least 2015 or 2020. The number of transistors doubling approximately every two years, has so far held. The same law can be applied to processing speeds of microprocessors, memory capacity and the number of pixels that a digital camera can process. Memory storage capacities in magnetic and optical media have also increased exponentially and solid state drives are already commercialized. Connectivity between computers and through the Internet has similarly increased in bandwidth. The rates at which data can be transmitted, both within buildings and across long distances, grows without apparent limit and ever reducing costs. Parallel and Grid computing have demonstrated huge potentials of processing power available for use on the desktop of an average computer user and this will be multiplied many folds with memristors (already prototyped), photonic and quantum computers (still in the research phase). We are seeing a boom in handheld devices that interface with existing systems. The background paper entitled 'Information and Communication Technologies – Ways to Mobilize and Transform Agricultural Science for Development (Maru, Porcari and Ballantyne, 2009) at the Workshop on ICTs: Transforming Agriculture Science, Research and Technology Generation at Science Forum 2009 at Wageningen identified the following important trends that can transform agricultural sciences for development.

4.1 Ubiquitous Telecommunication Infrastructure

Flowing from the falling costs of all digital things, there has been a steady flow of investment into communications infrastructure around the world. Cell phone and broadband (wired and wireless) Internet networks carrying both voice and data are being deployed in even the poorest countries and with time will expand to cover most rural areas. These systems are sophisticated and manageable by both private and public entities, allowing agriculture and agricultural research to increasingly take communications for granted and being continuously improving in the years ahead.

[1] The law is named after Intel co-founder Gordon E. Moore, who described the trend in his 1965 paper '*Cramming more components onto integrated circuits*' in Electronics Magazine. The paper noted that the number of components in integrated circuits had doubled every year from the invention of the integrated circuit in 1958 until 1965 and predicted that the trend would continue "for at least ten years". His prediction has proved to be uncannily accurate, in part because the law is now used in the semiconductor industry to guide long-term planning and to set targets for research and development.

4.2 “Cloud” Computing

The combination of progress in computing hardware, system software, and Internet communications has now enabled the construction of general-purpose data centres that can be reconfigured by command to support any software application in minutes. There are already data services that allow a user to have hundreds or thousands of computers at their command, and yet pay for them by the hour or minute, without owning or operating the hardware themselves. The costs are far less than even falling hardware prices would suggest, since the cost of the data centre can be shared among many “bursty” users. In effect, the data centre acts like a utility, providing as much computing as requested at just the times when needed. Since these data centres are invariably shared over the Internet, they are sometimes called computing “in the cloud.” These “cloud” data centres are the natural repository for shared data sets, so that users in any location or institution can instantly access, analyze and interpret public information goods without the need to move the data to their own facilities. This can enable a researcher in any location to work with data as well as any other researcher, which can lead to new kinds of collaboration and new sources of project direction.

4.3 Software and Content Management

A far more important frontier achieved through more complex processors, processing speeds, memory capacity and connectivity has been the development of agents, sensors and devices such as Radio Frequency Identification (RFID) Tags that is now reshaping how humans work and interact creating huge potentials in terms of how we can mediate, share and extract value from information and knowledge. Among the others, the semantic Web and its related techniques and applications (e.g. ontologies) are currently working in this sense, trying to re-shape machine-to-machine interaction and the way computers retrieve, manage and share knowledge on the Web. The science of pragmatics – the practical interpretation and use of signs by agents or communities within particular circumstances and contexts – and going beyond conventional semantics, is now allowing ICTs to be used in much more supportive ways. This has been demonstrated in diverse areas such as health, scientific research and business management in modeling, simulation, forecasting and visualization and has implications for agriculture. These potentials bring new challenges on how we understand this new pervasive computing landscape and how we can make use of collective and distributed form of intelligence.

4.4 Biotechnology, Nanotechnology, Materials Science and ICTs

The interaction of ICT with biology, biotechnology, nanotechnology and new materials is enabling the development of high quality information that is created from diverse entities and sources and which is self organizing. This self-organizing collective intelligence – living information – presents new frontiers in effective use and application. Continuous advances in ICT and biology are enabling developments where the relationship between these two disciplines faces a paradigm shift; from ICTs that mimic biology to ICT that use biology for information processing. Progress in synthetic biology – the study of the design and building of novel biological functions and systems – is bringing progress in systematic design methodologies and manufacturing processes. The potential of interfacing ICT with biological systems at the micro/nano scale is now emerging.

It can be argued even with current knowledge that in future Bio- and Nano- technology, Materials Science and ICTs together will define the core direction of agricultural science, research and technology by having impact on plant and animal breeding and improvement, agricultural production

Box 2. 'ICT' Opportunities for AR4D

The Science Forum 2009 highlighted the following promising opportunities that agricultural science could gain from increased use of ICTs:

- Through ICTs, the possibility to make agricultural research and development processes more inclusive, enhancing communication among all agriculture stakeholders. Greater potential for horizontal knowledge sharing among different stakeholders, increasing the likelihood of collaboration.
- Rural communities and farmers empowered through ICTs to enhance their own livelihoods and other opportunities. The emergence of new types of ICT-enabled rural businesses and entrepreneurs, providing services and livelihoods.
- Delivery of various ICT-enabled services to rural people: such as market access; access to international export markets through ICT traceability systems; mobile financial services; mobile extension services
- Improved capabilities to create and store data and information; gaining rapid access to it.
- Enhanced two-way flow of timely, highly-targeted, location-specific and location-intelligent information
- Increased possibilities for public and community to be data collectors; Farmers and producers can contribute data directly.
- Stable and continuous farm (field) data acquisition.
- ICT can help dealing with uncertainty and complexity by integrating large amounts of data
- Science can work on a global workbench; linked to a global library; also engaging NGOs and famers.
- ICT use can support the shift in agriculture from maximization to optimization.
- The possibility to integrate ICTs along the whole research process/cycle
- With new 'social media', there is the promise of more accessible information and richer communication.

Source: at: http://www.scienceforum2009.nl/

systems, risk management and aversion, sustainable use of natural resources, protecting the environment and agricultural market chains and in agricultural innovation in general. See Box 2 for ICT opportunities for AR4D.

4.5 Mobile Revolution in Agriculture

ICTs have penetrated virtually every segment of society and projections suggest increased penetration rates. Though distinctions are often made between new ICTs such as computers and mobile phones, and old ICTs such as radio, television, and landline telephony, the current technological convergences increasingly blur such divisions. Thus, single devices such as mobile phones can now receive, process, store and display text, image and sound together. Mobile phones have the potential to amplify the speed and ease, and to introduce new modes with which information is communicated.

Almost 70% of the world's mobile phone subscribers are in the developing world. As an affordable and accessible means of communication, both men and women are realizing the potential of this technology to create economic opportunities and strengthen social networks in rural areas. The mobile telephone is no longer just an audio communication tool but capable of providing additional integrated functions. The benefits of mobile technology in some rural regions have occurred much faster than other Information and Communication Technologies (ICTs). In countries such as Bangladesh, with high rural population densities, mobile telephony has quickly become much more cost-effective for telecommunication provision (e-Agriculture, 2009).

The overview of e-Sourcebook on ICTs for Agriculture (World Bank, 2011), in the module on mobile devices and services describes five generic functions/categories that mobile applications have taken in the agricultural sector:

- **Advice, education, and awareness**: applications that enable provision of information to farmers and extensionists about good practices, crop varieties, and pest or disease management.
- **Commodity prices, market information, and trading transactions**: applications that prices in regional markets to inform decision making throughout agricultural value chains.
- **Data collection**: applications that enable collection of data into central repositories, potentially from large geographic regions.
- **Pest and disease outbreak warning and tracking**: applications that send and receive data on outbreaks.
- **Financial services**: applications that enable provision of microloans, banking services, and microinsurance for crops and livestock.

CHAPTER 5

Improving 'Openness' in Agricultural Data and Information Sharing

5.1 Global Initiatives in ICM in AR4D

Over the last decade a series of international workshops and consultations have been organized and commitments have been made by a wide range of organizations. Significant ones include the GFAR Triennial conferences, the ISNAR 2003 workshop, two multi-stakeholder workshops on International Information Systems in Agricultural Science and Technology (IISAST) in 2005 and 2007, the Global Network on RAIS (Regional Agricultural Information Systems), and the GFAR-led workshops on ICM4ARD. FAO has realigned its existing initiatives such as the AGRIS network and brought forward its work on Agricultural Information Management Standards (AIMS). The CGIAR has implemented ICM projects involving domain-specific research (e.g. biotechnology, GIS applications, learning resources management). Specific regional and international "ICT for Agriculture" associations (e.g. IAALD, AFITA, EFITA, WCCA etc.) have held seminars and conferences, to consider in detail the challenges in the adoption of ICT in AR4D and have formulated a number of initiatives. The EFITA study on ICT adoption in AR4D of many countries of the world has produced valuable insights. Detailed studies on adoption from various countries of Asia were considered in an AFITA conference in 2006.

In summary, the key insights emerging from this set of conferences were:

- ICT uptake offers many opportunities but still remains a major challenge
- The consequences for not using ICT are recognized as serious
- The economic benefits of ICT are not always perceived
- Training in how to realize economic benefits from ICT is paramount
- Public funding for such ICT training is justified
- Top-down approaches in adoption of ICT need to be coupled with participatory, bottom-up approaches for greater success
- Digital inclusion must be an a priori policy and market forces alone can't guarantee such inclusion and wide adoption of ICT
- Research is needed in identifying practical solutions for ICT uptake
- End-user needs coupled to national policies should determine ICT compatibility.

The Science Forum 2009 at Wageningen devoted significant attention to the role of ICT/ICM in AR4D in a specific participatory session which built on the findings of previous years as above. The AR4D-relevant opportunities arising from ICT advances in recent times were: (a) ubiquitous connectivity, (b) precise tools and applications, (c) accessible data and information, (d) diverse applications in the "cloud" and (e) interconnected knowledge bases. The Forum identified the potential of ICTs to contribute to making AR4D more inclusive through enhanced multiple flows of highly-targeted, location-specific and location-aware information. While recognizing the rise of new types of agri-preneurs who made use of new ICT developments, the Forum emphasized the need to take advantage of potential for delivery of various ICT-enabled services to rural people: such as market

access, access to international export markets, traceability systems, mobile financial services and mobile extension services.

The International Consultation on Agricultural Research for Development and Innovation: Addressing emerging challenges and exploiting opportunities through Information and Communication Technologies, held in December 2009, at ICRISAT, India by GFAR, ICRISAT and APAARI addressed core issues such as need for new strategies, policies, investments, content management and actions to target and sustain the adoption of ICM in ARD that contributes to the livelihoods of resource-poor farmers and other stakeholders in the market and value-addition chains. The Consultation identified 14 priority areas for action and suggested a strategic framework and action plan to: i) make agriculture related information globally available, more accessible, affordable and applicable and contribute to enabling effective use of information by bringing greater relevance and usefulness for by all ARD stakeholders especially the resource poor small holder farmers and producers, ii) improve information and communications management for agriculture related information; generation; storage, processing and use of content in the most economical and effective manner and with equity of access and use by the global community, and iii) conduct research and contribute to innovation to improve use of ICTs and ICM for agricultural development and agricultural research for development. (GFAR, ICRISAT and APAARI, 2009).

The above meetings indicated that the main challenges are in advocating increased investment and targeting it appropriately, generating and managing content that is economically produced and affordable to all involved, rapidly building capacities and bringing organizational change towards more efficient and effective information flows. It also led to the launching in 2008 of an international multi-stakeholder initiative on Coherence in Information for Agricultural Research for Development (CIARD), co sponsored by all the main international organizations and regional fora that had been involved in the discussions to meet these challenges. A CIARD Manifesto, Checklist, Pathways and Virtual Fair were developed through a series of regional consultations in 2009 involving 150 people from 70 countries are now being advocated for adoption by all actors in ARD.

5.2 CIARD Movement

The CIARD is a global initiative working to make agricultural research information publicly available and more accessible. It is a multi-stakeholder collaborative initiative of all major actors in agricultural research for development related information management. The vision of CIARD is *"to make public domain agricultural research information and knowledge truly accessible to all."* The CIARD, as a movement, is a collective commitment to promote and sustain the sharing of agricultural research outputs in a global network of truly public collections, based on a Manifesto and a common set of Values to ensure that public domain research outputs in the form of information, data and knowledge form part of a global "knowledge commons" for agriculture, these outputs should be created, assembled, handled and disseminated in ways that ensure that they will be as Available, Accessible and Applicable as possible (http://www.ciard.net/).

The "CIARD Checklist" is part of a broader treatment of content flows, including the need to understand researchers' and other actors' needs through assessments, acquisition of appropriate information etc. The Checklist represents a set of items through which organizations, research systems and individuals can progress towards achievement of the CIARD Manifesto and Values. It is not a set of requirements. There are many different ways in which the Checklist agenda can be achieved, according to the specific scope of an organization's work. The Checklist actions are aimed at developing necessary institutional readiness, as well as approaches to managing digital content,

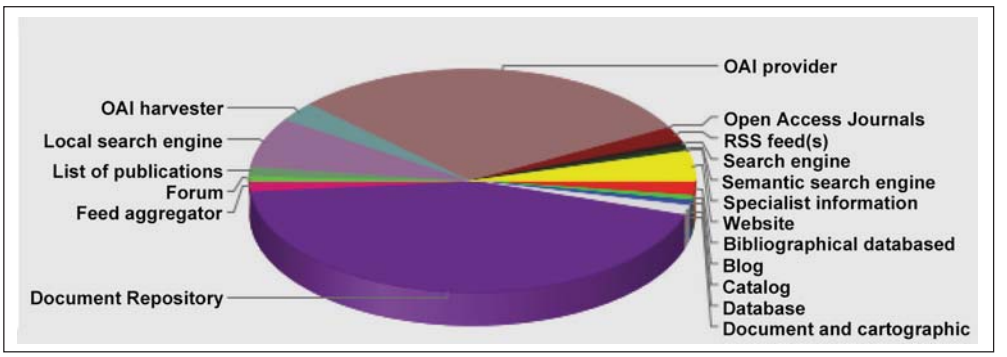
licensing and “opening up” that content, and then disseminating it. They address the applicability of research outputs to a range of stakeholders, setting out approaches that will ensure that research outcomes are more likely to be sustainable.

In addition to the Checklist, a range of targeted “CIARD Pathways” are provided showing the ways in which the Checklist actions can be achieved. The CIARD Pathways are given under three groups viz., i) Developing Institutional Readiness, ii) Collection and Preservation, and iii) Making Content Widely Accessible on the Web. The CIARD Pathways provide an introduction to the ways in which research outputs can be made more available, accessible and applicable for the stakeholders who will derive benefit from this knowledge (http://www.ciard.net/pathways).

5.3 CIARD RING

The CIARD Routemap to Information Nodes and Gateways (RING) (http://ring.ciard.net/) is a project implemented within the CIARD initiative and is led by the Global Forum on Agricultural Research (GFAR). The RING is a global registry of web-based services that give access to any kind of information pertaining to agricultural research for development. It is the principal tool created through the CIARD initiative to allow information providers to register their services in various categories and so facilitate the discovery of sources of agriculture-related information across the world. The RING aims to provide an infrastructure to improve the accessibility of the outputs of agricultural research and of information relevant to ARD management.

Figure 2. Distribution by type of service in CIARD RING



Source: http://ring.ciard.net/home, 2011

CIARD RING allows information service providers to publicize their services by registering them and provides technical metadata on information services registered by the providers and thus facilitates discovery and use of publicly accessible information to enrich other services. As a first step, Institutions are encouraged to register and describe their current publicly accessible information sources and services. Later advanced services such as a global harvester of all registered providers of Open Archives; a viewer/navigator for registered RDF stores; sample thematic aggregators that harvest from registered RSS feeds; and sample consumers of web services etc., can be built directly on the content of the RING website.

The services registered in the RING are described in details and categorized according to criteria that are relevant to the use of the service and its interoperability (such as metadata standards adopted, subject vocabularies used, technologies used, protocols implemented etc.). The RING facilitates the

discovery of sources of agriculture-related information across the world. As of now, the CIARD RING has 140 registered service providers and offer 162 services/resources (see Figure 2). It provides access to 4107941 bibliographical records and 79034 full-text documents available in the registered services.

5.4 CIARD Framework for Data and Information Sharing

The recent international expert consultation organized on June 20-23, 2011 in Beijing by the CIARD partners advanced the development of a framework for data and information sharing and exchange for Agricultural Research for Development (AR4D). Nearly 50 experts from around the world identified priority actions for the development of the framework, drawing on the findings of an e-consultation on the subject. Participants at the consultation agreed that the current key concept in data and information sharing is interoperability based on Linked Open Data. The "Open Data[1]" movement aims to make data freely available to everyone and the CIARD movement shares this ideal and is working to make agricultural research information publicly available and accessible to all. There was recognition among participants that achieving the ideal objective of sharing all global data as "Interoperatable Linked Open Data" will be a gradual process that will develop in stages at a varying pace in different organizations and countries.

The CIARD Issues Paper (2011) on "Building a Framework for Data and Information Sharing in Global Agricultural Research – and Enabling Collaboration" suggests a framework for sharing of agriculture-related data and information around three important dimensions: *(i) technical aspects and technologies, (ii) institutional and organizational aspects, and (iii) community building and participation*. This framework would offers accessible solutions that could handle the multiplicity of types of information and the growing complexity of digital technologies in a variety of organizational, economic and political environments. Such a framework would greatly reduce the amount of investment and work required by each individual organization to learn, create and sustain digital platforms for sharing data and information, and it would provide a lifeline for poorly resourced organizations, especially in developing countries. In this context, the CIARD movement offers an excellent platform to develop the framework, whereby the partners of the movement can work individually or collectively within a collaborative agenda and see the benefits of such collaboration in making public goods even more accessible. The following areas of action are identified under each dimension that would structure collaborative work on the framework:

(i) Technical Aspects and Technologies

a) Services, Tools and Infrastructure: CIARD partners should engage more content providers to extend the CIARD RING as a comprehensive and easy-to-use registry for agricultural information resources with enhancements so that the community can add annotations on quality and provenance of materials. Services for hosting content on behalf of actors with less local capacity could also be created at regional/global level. These actors should establish a service on the Web in the form of a "Tools-Wiki" under the CIARD banner to present the most useful content management tools that meet the most common requirements, together with a mechanism for management of the service. With linkages to this service, development of plug-ins and customized versions for mainstream

[1] 'Open Data' is the idea that certain data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control. The goals of the open data movement are similar to those of other "Open" movements such as open source, open content, and open access. (http://en.wikipedia.org/wiki/Open_Data).

software should be developed for the CIARD 'community', along with prototypes of information sharing platforms with capabilities for combining data from different sources and for handling local languages. A survey in the wider CIARD 'community' should be conducted on the need for 'cloud' services for specific processes, followed by a feasibility study on the viability and value of specific cloud services being offered by single partners.

b) Standards and Systems Architecture: There is a need to adopt a collaborative approach to the development and adoption of standards and systems architecture. Building on such existing platforms, such as the FAO AIMS that signpost existing standards and the areas/tasks to which they apply, the collaborative effort of the international community should endorse open standards for protocols, ontologies, vocabularies that are used across domains, and engage the wider community with the process for setting open standards. The community should develop standards that are specific to agriculture, following processes as they have been adopted by other communities (e.g. Dublin core). High-priority information types should be identified and descriptive templates developed (or re-used) and promoted. Recommendations should be developed for (a) metadata to describe datasets and (b) formats for packaging and documentation of data (e.g. how observations were made), and an efficient automated tagging/indexing service should be created. Guidelines should be formulated on how to produce efficient Linked Open Data, written in non-technical style and with illustrative case studies. A system of mapped vocabularies should be created and made openly available as Linked Open Data for the purposes of classifying and organizing information in agriculture, and inputs made into improving automatic translation services for agricultural topics. Recommendations should be made for methodologies for digital preservation, including formats. Aggregating services etc., should be identified to certify quality and provenance of materials for data providers.

(ii) Institutional and Organizational Aspects

a) Policy/Strategy and other Institutional Structures Development: The CIARD partners should continue to promote the adoption of the CIARD Manifesto for information access and sharing, and its adaption as appropriate to suit national policies. To support national initiatives, a review should be undertaken of current national level cases which should be documented of (a) policies on access to public goods and copyright, (b) possible incentives and benefits of sharing. Generic guidelines on process for creating policies should also be developed. Organizations should work towards the enactment of national, regional and international laws and policies which mandate open access to agricultural knowledge wherever possible and promote interoperability, with specific policies and plans for sharing public domain information and data and ensuring quality of information that embed information sharing activities into organizational processes and systems. National and local organizations should consider developing a well-defined copyright/IPR statement, with due consideration of Creative Commons licenses and publishers' copyright policies, and make such statements public. Such organizations should define the incentives/benefits for their scientists to share their data and information.

b) Development of Skills and Competencies: National, sub-regional, and regional organizations should assess training needs and design training programs to foster better information sharing, linking to policy, the organizational context and team building approaches to ensure newly acquired skills can be applied. They should develop training programs for national information professionals on data/information interoperability etc., and other related issues, and they should use e-learning approaches where appropriate. They should seek to coordinate capacity development activities among CIARD partners and others, where possible. At the international level, curricula for

information management and interoperability should be revisited, linking to faculties in universities if possible, and a list of training materials targeted on the different 5 star levels (Berners-Lee) compiled (see Box 3 for Five steps to open data and information as proposed by Berners-Lee). The platforms offering advice and learning in content management in the CIARD community (e.g. AIMS, IMARK) should continue to be supported, and establish linkages among platforms/sources.

Box 3. Five steps to open data and information

*	Your content is available on the Web, in whatever format, under open licenses
**	Your content is available as machine-readable structured data [i.e. MS Excel table is better than an image of the same]
***	Your content is available in non-proprietary formats [i.e. Comma-Separated-Values (CSV) format in preference to MS Excel]
****	You use RDF standards and URLs (URIs) to identify your content so that people can point to it.
*****	Your content is linked through RDF to other people's content to provide context and add value.

c) Appropriate organizational structures and work practices: These form a crucial component for embedding better practices in information and data sharing in organizations and agricultural information systems at national and International levels. These include investing appropriately in hardware, software, connectivity and skills development, appropriate content (data and information objects) management as it flows through the organization and system, managing information systems security, adhering to laid out norms, standards, rules and regulatory mechanisms, and creating appropriate governance structures for data and information flow.

d) Improving data and information flows globally: The above agenda for action around the technical framework implicitly involves influence at all levels on policy, strategy, Institutional structure and work practice in information sharing and opening up access – in organizations, countries, regions, and globally. The types of information provider and user will need to be carefully defined and/or recognized, especially since such types are shifting along with changes in the community of actors in agricultural innovation systems and value/market chains. The global role of public domain 'trust' organizations (e.g. CGIAR, FAO, GFAR) in improving and enhancing the flow of data, information objects and information should be supported in defining and sustaining core data sets and information in areas such as plant germplasm, agronomy, spatial data, weather and climate.

(iii) Community Building and Participation

a) Advocacy/Evidence: Advocacy for sharing data openly requires that a wide variety of stakeholders and actors be addressed. These included senior policy-makers and research managers; information specialists; and generators and users of data and information. Organizations need to advocate for change in the particular context of their existing information sharing policies in relation to their mandates and strategic plans. With reference to CIARD, it was felt that the initiative could support national/local advocacy efforts by developing generic arguments, materials, evidence that can be customized to specific contexts.

Existing advocacy initiatives at national level already using interoperability should be identified and supported as learning processes, onto which new aspects can be built. An advocacy toolkit addressing each of the wide variety of agricultural information actors and stakeholders should be developed as a collaborative initiative to support national/regional activities, with resources in diverse formats of messages/stories that can be adapted and used universally, with accompanying case study evidence demonstrating value (cost-benefit) of sharing and interoperability, and measures/ indicators of networking/uptake/use through current and new CIARD Pathways leading to changed practices with concrete economic/social/environmental results/outcomes. The CIARD initiative should further facilitate sharing of advocacy experiences at national level across countries. At a global/ regional level, advocacy events for senior decision-makers should be organized, taking advantage of existing high-level events where possible to convey key messages and catalyze action at a high level, such as the GCARD 2012[1].

National and local organizations will require a tailored approach in defining and taking forward advocacy for greater openness with the elements of (a) assessing barriers to change, (b) assigning roles and tasks especially to senior staff as champions, (c) defining and prioritizing advocacy targets, (d) defining the key messages and accumulating the supporting evidence, using a diverse variety of media as advocacy tools, and (e) organizing advocacy opportunities that take advantage of existing events where possible. Organizations could document their own case studies to provide evidence for advocacy and attract funding.

b) Partnerships for community-building and participation: The direction of the CIARD initiative is decided by all the participating organizations, and the main individual sponsors within those organizations. Coherence is needed in information and data, but coherence is also needed between the organizations and among systems. The technical framework will facilitate coherence in both these areas, but more needs to be done to foster a sense of community with a common purpose. Global actions to be undertaken by CIARD international and regional partners include establishing and strengthening 'open' means of communication (virtual and face-to-face) among interested individuals and organizations involved in information sharing (including CIARD) to record, discuss and share developments in agricultural information management. Such action would strengthen the sense of partnership in enhancing information sharing through a global initiative, with regional and national dimensions.

To provide a platform for communication, the partners should establish a virtual space for the community that leverages existing facilities that enable collaboration and discussion, in particular the AIMS and e-Agriculture sites and the main CIARD sites themselves. The main functions would be to share experiences and new approaches in information sharing (technologies, incentives, policies, etc.), provide an observatory and timeline of technologies, standards, tools and concepts that describes advances, share success stories (case studies); and good practices e.g. about collaboration and convergence across disciplines and value chains (traceability).

[1] The Second Global Conference on Agricultural Research for Development (GCARD 2) to be held at Punta del Este, Uruguay on 29 October – 1 November 2012. GCARD 2's theme is "Foresight and partnership for innovation and impact on small-holder livelihoods". For more details visit: http://www.egfar.org/egfar or contact the organizers at GFAR-Secretariat@fao.org

CHAPTER 6

Agricultural Research Information Systems in the Asia-Pacific Region

6.1 Agricultural Research and Development (ARD) Networks in the Asia-Pacific Region

Collaboration in agricultural research for development among diverse stakeholders is necessary to strengthen research partnerships to address emerging issues of common concern. Based on shared vision, partnerships have been established involving scientists, other stakeholders and the institutions in the form of research networks or consortia. Such initiatives have been useful in accelerating technology generation, transfer, sharing information/knowledge, and buildup expertise. In the Asia-Pacific, wide array of ARD networks have been established over the years in the areas of plant genetic resources/agro-biodiversity, crop improvement, fisheries/aquaculture, livestock and agricultural biotechnology. Most of them have been facilitated by the CGIAR centers. Though many of them are quite active and have made good progress, some have faced both operational and financial difficulties (APAARI, 2007). A list of important ARD networks is given in Box 4.

Box 4. ARD Networks in the Asia-Pacific Region	
• Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB)	www.apcoab.org
• Asia-Pacific Forest Genetic Resources Programme (APFORGEN)	www.apforgen.org
• Banana Asia and Pacific Network (BAPNET)	www.bananas.bioversity-international.org
• Biosaline Networks	www.biosaline.org
• Cereals and Legumes Asia Network (CLAN)	www.icrisat.org
• Coconut Genetic Resources Programme (COGENT)	www.cogentnetwork.org
• Council for Partnerships on Rice Research in Asia (CORRA)	www.irri.org/corra/default.asp
• Inter-regional Network on Cotton in Asia and North Africa (INCANA)	www.cottonnetwork.org
• Network of Aquaculture Centers in Asia-Pacific (NACA)	www.enaca.org
• Pacific Agricultural Plant Genetic Resources Network (PAPGREN)	www.spc.int/pgr
• Regional Cooperation in Southeast Asia for Plant Genetic Resources (RECSEA-PGR)	www.recsea-pgr.net
• Regional Network for Conservation and Utilization of Plant Genetic Resources in East Asia (EA-PGR)	www.eapgr.net
• Rice-Wheat Consortium for the Indo-Gangetic Plains (RWC)	www.rwc.cgiar.org
• South Asia Network on Plant Genetic Resources (SANPGR)	www.bioversityinternational.org/
• Tropical Fruits Network (TFNet)	www.itfnet.org
• Underutilized Tropical Fruits in Asia Network (UTFANET)	www.icuc-iwmi.org

APAARI has been striving to foster such research partnerships among institutions and other stakeholders in the region. Based on shared vision, partnerships have been established involving scientists, and/or institutions in the form of either research networks or consortia, which have been playing critical role in disseminating agricultural research information and knowledge in the Asia-Pacific region. The region has many information systems and programs which focus on information and knowledge sharing and exchange on the topics of agricultural importance (see Box 5). These information systems strengthen appropriate interactions among scientists and policy-makers, provide scientific input to policy decision-making, scientific knowledge to the public, and improve the scientific and technical capabilities of nations in the region including the transfer of know-how and technology and function as clearing houses of information and knowledge on agricultural subjects in the region.

Box 5. Information Networks related to Agricultural subjects in the Asia-Pacific Region	
• Agricultural and Food Marketing Association for Asia and the Pacific (AFMA)	www.afmaasia.org
• Animal Production and Health Commission for Asia and the Pacific (APHCA)	www.aphca.org
• Asia Forest Network	www.asiaforestnetwork.org
• Asia-Pacific Adaptation Network (APAN)	www.apan-gan.net
• Asia-Pacific Agricultural Research Information System (APARIS)	www.apaari.org
• Asia-Pacific Association of Forestry Research Institutions (APAFRI)	www.apafri.org
• Asia-Pacific Forest Invasive Species Network (APFISN)	www.apfisn.net
• Asia-Pacific Network for Climate Change	www.climateanddevelopment.org/ap-net
• Asia-Pacific Network for Global Change Research (APN)	www.apn-gcr.org
• Knowledge Networking in Asia and the Pacific (ENRAP)	www.enrap.org
• Network of Aquaculture Centers in Asia-Pacific (NACA)	www.enaca.org
• SAARC Agrinet	www.saarcagri.net

Though most of the above networks focus on information exchange, a brief look at these networks reveals that most of them are limited to one-way communication. The information available through these networks mainly contains published literature, reports, manuals, program related information and other static information. The databases are not regularly updated and developed by using different software tools. Most of the members of these networks at the national level are mere partners and they do not share or exchange information on these networks due to lack of awareness, lack of capacities at NARS, lack of integration tools, institutional issues etc.

6.2 Asia-Pacific Agricultural Research Information System (APARIS)

Realizing the importance of information and knowledge management in agricultural research for development, APAARI has established the *Asia-Pacific Agricultural Research Information System (APARIS)* in 1999 with an aim to serve as a regional de-centralized platform for efficient information and knowledge sharing among the National Agricultural Research Systems (NARS) in the

Asia and the Pacific region. The Australian Centre for International Agricultural Research (ACIAR) and the Global Forum on Agricultural Research (GFAR) have been supporting the APARIS program. The objectives of APARIS are:

- To serve as regional platform for efficient information and knowledge sharing among National Agricultural Research Systems (NARS) in the Asia and the Pacific region
- To strengthen agricultural information systems in Asia and the Pacific region through advocacy, capacity building and training for agricultural information professionals of National Agricultural Research Information Systems (NARIS)
- To promote the use of new Information and Communication Technologies (ICTs) for better Information and Communication Management (ICM) in Agricultural Research for Development (AR4D) in Asia and the Pacific region
- To act as regional node linking National Agricultural Research Information System (NARIS) to other Regional Agricultural Information Systems (RAIS) and global agricultural information systems.

APAARI recognizes that the success of APARIS will depend largely on involvement of national agricultural research systems in the region. Therefore, a bottom-up approach has been adopted in developing APARIS. In this regional knowledge network, NARS are represented by their respective National Agricultural Information Systems (NAIS) designated as National Information Nodal Points (NINPs). APARIS also acts as a regional node linking NAIS to global information systems and services.

APARIS is an important program of APAARI. It is governed by a Steering Committee comprising of experts in agricultural research, extension and information management representing national agricultural research systems, ACIAR, GFAR, FAO, APAARI and special invitees from reputed organizations dealing with information and communication technologies and agricultural information management. The Steering Committee meets every year and provides necessary guidance and approves the activities of APARIS. A brief account of APARIS development phases and progress since its establishment is given below:

6.2.1 APARIS Phase-I (1999-2001)

In phase-I, establishment of APARIS, assessment of NARS needs, design and development of web-based information system, building databases on research networks etc., were undertaken as follows:

1. Establishment of *Asia-Pacific Agricultural Research Information System (APARIS)* in 1999 as an important program of APAARI.
2. First ICT Expert Consultation on development of APARIS held in November 2000 (Figure 3).
3. APAARI website http://www.apaari.org/ was set up to provide access to information on several in-house activities and information resources for APAARI stakeholders and ARD professionals. The website was developed with more than 300 linkages to various national, regional and international institutions, networks and other relevant organizations.
4. Regional Research Networks (RRNs) Database has been developed and made available on APAARI website. This database provides access to major regional research networks, and it continues to develop in order to cover all the networks that effectively operate at

both the regional and the sub-regional levels (i.e., South Asia, Southeast Asia and the Pacific). Some examples of RRNs included in this database are NACA, APAFRI, INGER, COGENT, the Regional Network on Plant Genetic Resources, CLAN, CORRA, the Rice-Wheat Consortium and others. This database also provides access to the websites of the RRNs, and to the information resources that these networks offer such as the NARS Database; Regional Associations Database; ARD Projects Database; Daily Agriculture News; Database on Agricultural Research and Development Indicators. APARIS also provides access to ASTI (Agricultural Science and Technology Indicators) project of IFPRI.

Figure 3. First ICT Expert Consultation on Development of APARIS, November 2000

5. Information on regional events related to ARD provides two databases, namely, meetings and events related to ARD and ICM; this database also covers APAARI activities and events, and provides general information on scientific and technological events that are being organized by stakeholders in the region, and ICM training activities in the region.
6. Access to scientific publications and e-journals publications generated by agricultural research in the region was provided besides access to all APAARI publications; expert consultations, success stories and other publications.
7. Access to electronic forums to facilitate dialogue among stakeholders of ARD in the region on issues of strategic importance has been provided. These included access to Electronic Forum on Information and Training Requirements in the Asia-Pacific region; Access to the EGFAR-NARS Forum; Specialized Thematic Electronic Forums.
8. Access to Gateway/Portal Services provided through APARIS including portal to Regional Research Networks (RRNs) to facilitate access to the websites of the information resources available in the research networks that operate in the region; websites of NARS Institutions in the Asia-Pacific region; web-enabled information on key topics/themes of ARD and access to knowledge networks of research organizations (NACA, APAFRI, INGER, Rice-Wheat Consortium, etc. and pilot project on the Development of Knowledge Networks in specific areas of ARD.

6.2.2 APARIS Phase-II (2002-2006)

In phase-II, APARIS Steering Committee was constituted and terms of reference for the National Information Nodal Points (NINPs) were identified. Subsequently, programs on the advocacy for fostering use of ICM/ICT for AR4D, capacity building on ICM/ICT for NARS and integration of agricultural information resources in the Asia and the Pacific region have been undertaken as follows:

1. *Second ICT Expert Consultation* on further development of APARIS in October 2002 (Figure 4).
2. *Formation of APARIS Steering Committee*: An APARIS steering committee was formed in 2002 to provide policy support, undertake strategic planning, provide overall technical guidance, source external funds, and monitor the progress of APARIS work plan.

Figure 4. Second ICT Expert Consultation on Identification of National Information Nodal Points (NINPs) in October 2002

3. *Identification of National Information Nodal Points (NINPs):* The Steering Committee in its first meeting in October 2002 reviewed and accepted the terms of reference (ToR) for NINPs which were developed during the expert consultation. The ToR of NINPs are as follows:

    - Assess the status and needs of respective NARS with regard to ICT in ARD
    - Monitor and update information to improve relevance and effectiveness of APARIS contributions to APAARI vision and mission
    - Identify, collect, organize and make accessible information systems within the subject scope of APARIS
    - Establish and operate information services for national and regional clientele based on APARIS processed information
    - Share skills, knowledge and experiences in handling and management of information among NINPs.

4. *Developing Regional and International Collaboration/Identifying Support Group*: As a follow-up of the recommendations of the second ICT expert consultation, in April 2003

APAARI organized a meeting to formalize the bilateral cooperation between APAARI and the members of its support group in the area of ICT (FAO, GFAR, ISNAR and AIT). This exercise resulted in identification of specific areas of collaborative activities that synergize the resources of support group members and APAARI.

5. *Third ICT Expert Consultation in December 2003*: The third expert consultation assessed the progress made by various NARS in the areas of ICM; explored the opportunities for enhancing the role of ICM in ARD; and discussed potential improvements in APARIS by focusing on expanding its user-base to include the learning communities and their information needs.

6. *Status Report on Information and Communication Technologies in Agricultural Research for Development in the Asia-Pacific Region*: APAARI has undertaken a survey to assess the status of ICT in AR4D in Asia and the Pacific. Data and information on ICT/ICM infrastructure, policy and strategies, content, applications and information services have been solicited from the NARS in the region. Under this, National Information Nodal Points (NINPs) of APAARI members participated in the survey and prepared a status report for their respective NARS. These reports were later analyzed with the support of data from published/internet sources and organized as per an ICT/ICM framework for assessing the status of ICT/ICM in AR4D in Asia and the Pacific region. The status report was published in 2004 and widely circulated among NARS members for improving use of ICT/ICM in AR4D in the region (Figure 9).

7. Development of *Regional Agricultural Expert Locator (RAEL)* and *Regional Agricultural Information Gateway (RAIG)*: NINPs serve as links between APARIS and the member NARS for sharing information of general nature. RAEL was initiated with an aim to creating multiple input points (within a NARS) for APARIS for establishing database of agricultural experts and their profiles. RAIG was aimed to locate agricultural information resource by keyword; research institution by name; by acronym; by areas of specialization; by country etc. In August 2003, NINPs were requested to provide summaries and URLs of digital information resources available in their respective NARS.

8. *Improving and popularizing APAARI website:* The main objective of this activity is to check and update the site content, ensure validity of linkages from APAARI website, add search facilities and new relevant links at appropriate places. In order to popularize use of information on the website, 'APAARI on CD' has been developed to provide off-line access to APAARI website to those who lack adequate internet connectivity. Copies of APAARI on CD have been distributed to APAARI's diverse stakeholders. This has now become an annual publication of APAARI. Along similar lines, NARS on CD is also published, which provides a detailed directory of NARS institutes of the region in a user friendly searchable format.

9. *Expert consultation on Strengthening Regional Agricultural Information System: Role of ICT in ARD* was held in December 2003 at the Asian Institute of Technology (AIT), Bangkok. Participants from Asia-Pacific region, representatives from regional agricultural fora of West Asia and Africa also participated. The workshop emphasized on the need of using conventional and new ICTs together for information and knowledge sharing vis-à-vis role of APARIS in improving the efficiency and effectiveness of the information and knowledge flows related to agriculture in the region with greater participation of NINPs.

Figure 5. Training Workshop on Capacity Building for Developing National Agricultural Information Systems (NAIS) in August 2004

10. *Training Workshop on Capacity Building for Developing National Agricultural Information Systems (NAIS)* of Cambodia, Lao PDR, Myanmar, Bhutan, East Timor, Mongolia and Vietnam was held in August 2004 in Asian Institute of Technology (AIT), Bangkok in collaboration with GFAR, AIT, FAO, UNESCAP-CAPSA, SDLEARN and JIRCAS/NARO, to assist NARS of the above mentioned countries by training their appropriate officers in ICM and building NAIS. During the workshop, trainees were assisted in defining their respective NAIS and in developing prototype websites of their respective NARS as a delivery medium for NAIS. Training material, including video-recorded lectures on key topics, has been collected and organized in web-based and CD-based formats (Figure 5).
11. *Role of ICT in Taking Scientific Knowledge/Technologies to the End Users* was organized in January 2005 in New Delhi, India in collaboration with APAARI, Trust for Advancement of Agricultural Sciences (TAAS), India, National Academy of Agricultural Sciences (NAAS), India, and Indian Society of Agricultural Statistics (ISAS). This workshop recommended that there is need for access to value added information/knowledge dissemination through a well coordinated national system (stressed on establishing NAIS) so that farmers gain through ICT networking and are linked to national, regional and global markets for better value of their products in order to get higher income and come above poverty scenario. It also stressed on improving village level ICTs through promotion of rural information clinics by young entrepreneurs and capacity building of extension functionaries for the transfer of knowledge dissemination to the end users/farmers (Figure 6).
12. *Training Workshop on Integrating National Agricultural Information Systems (NAIS):* In order to build capacity for improved information exchange and communication in agricultural research in the region, a training workshop on Integrating NAIS was held at AIT, Bangkok in November 2005. The workshop recommended further development of APARIS integration tools through Regional Agricultural Expert Locators (RAEL) and Regional Agricultural Information Gateway (RAIG) and also developing some success stories on ICT (Figure 7).
13. *Inter-regional cooperation for ICT and ICM in ARD:* In July 2006, APAARI organized an inter-regional workshop on 'Advocacy and inter-regional cooperation for information and communication technologies/management in agricultural research for development' at AIT, Bangkok with GFAR's support. The workshop's objectives were to: (i) identify the role of Regional Fora (RF) in the emerging global alliance for ICT and ICM in ARD through their

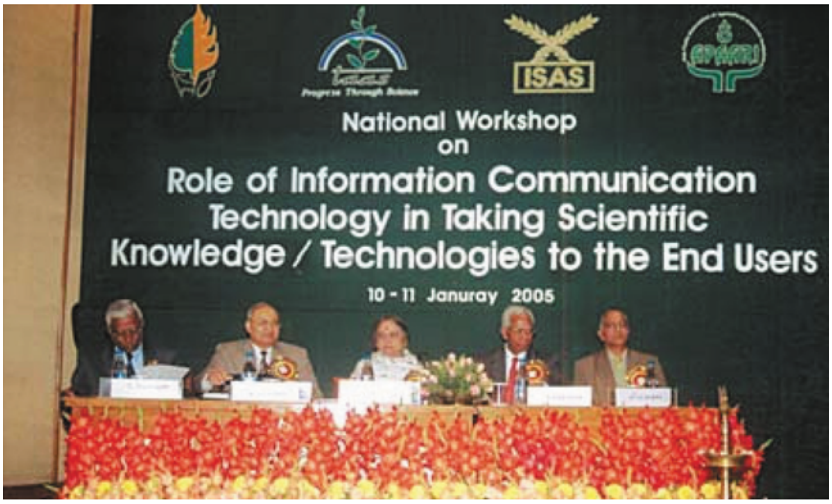


Figure 6. National Workshop on Role of ICT in Taking Scientific Knowledge/ Technologies to the End Users in January 2005 in Delhi, India

Figure 7. Training Workshop on Integrating National Agricultural Information Systems (NAIS) in November 2005

Regional Agricultural Information Systems (RAIS); and (ii) develop collaborative activities of RAIS, such as APARIS, AARINENA-RAIS, FARA-RAIS, InfoSys+, AgroWeb, CAC-RAIS, and FORAGRO-INFOTEC. The workshop was also an opportunity for the new AGRIS Task Force on Advocacy to discuss with RFs the future direction and actions. The workshop was attended by 21 participants from various RFs, selected Asia-Pacific NARS, GFAR, FAO, and representatives from other international initiatives on ICM for ARD (Figure 8).

14. *Success Stories on Agricultural Information Systems:* In 2006, with the support from GFAR and ACIAR, APAARI has published a collection of success stories and best practices of ICT and ICM in AR4D. In addition to a descriptive list of several current initiatives on agricultural information systems, the publication provides two different case studies—one on linking farmers with the researchers (RDA, South Korea's Agricultural Information Service) and the other on linking farmers to markets (India's e-Choupal initiative) (Figure 10).

Figure 8. Workshop on Inter-regional Cooperation for ICT/ICM in AR4D in July 2006

15. *Information services and publications: CD-ROM publications:* APARIS has been bringing out annual CD-ROM publications such as *APAARI on CD* and *NARS on CD* since 2004 targeting users in the developing countries of the region. Access to information services and publications was also provided through APAARI website.

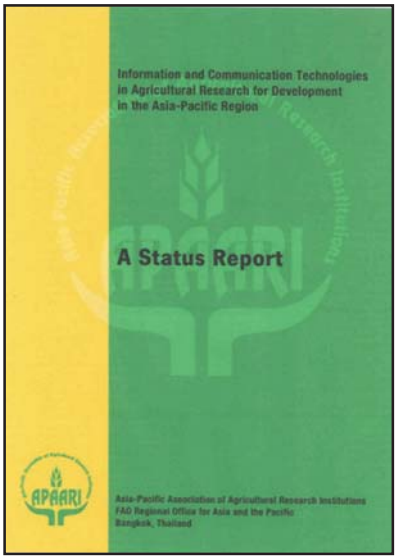


Figure 9. ICT/ICM in AR4D in the Asia-Pacific Region: A Status Report (2004)

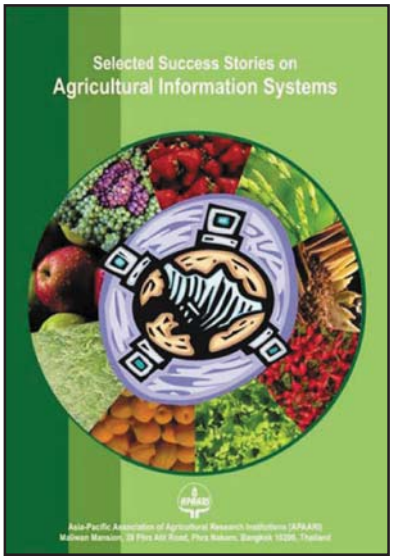


Figure 10. Success Stories on Agricultural Information Systems (2006)

6.2.3 Phase-III (2007-2011)

1. *Sensitization and Awareness Building Workshop for NARS Leaders and Senior Managers on Information and Communication Technologies and Management (ICT/ICM), August 2007, PCARRD, Philippines*: Twenty two NARS leaders and senior mangers representing 10 countries and 3 sub-regions of the Asia-Pacific participated in the workshop. The workshop provided a good opportunity to discuss progress of various national ICT/ICM projects and share development experience of National Agricultural Information Systems (NAIS). The major recommendations of the workshop included: APARIS should continue to focus its activities on advocacy, capacity building and regional knowledge sharing through involvement of NAIS; strengthening linkages between APARIS and NAIS; adoption of new web technologies and tools for cost effective updating of agricultural research information; promotion of information resources among various stakeholders; need for objective feedback mechanism to evaluate the regional and national agricultural research information systems for their continuous development.

2. *APARIS Technical Workshop on Development and Decentralised Management of ARD Information Resources, April 2008, Bangkok*: Ten participants from National Information Nodal Points (NINPs) from Bangladesh, Nepal, India, Malaysia, Pakistan, Philippines, Papua New Guinea, Sri Lanka, and Thailand have been participated in the workshop to strengthen APARIS and its linkages with the National Agricultural Information Systems (NAIS) of the Asia-Pacific using the de-centralization approach of the Global ARD Web Ring. The workshop was facilitated by resource persons from GFAR, FAO and AIT, and APARIS Coordinator. GFAR and FAO emphasized the critical role of NAIS in this web ring as most of the agricultural knowledge is created at a research institute level. ACIAR advocated that greater adoption of agricultural R&D by farmers is possible if improved communication at various levels leads to cooperation among the development stakeholders. Through a group exercise, the participants came up with several recommendations for further development of the Global ARD Web Ring in which APARIS and its NAIS may participate using newly available tools/applications/ frameworks such as RSS feeds, AgriFeeds, and CIARD. APARIS, through its own applications, demonstrated how these can be incorporated and implemented in NAIS (Figure 11).

Figure 11. Technical Workshop on Development and Decentralized Management of ARD Information Resources in April 2008

3. *Design of APAARI new website:* APAARI has launched its new website in August 2009 with new design, user-friendly information and navigational options. It is available at www.apaari.org. The new website provides access to more than 30 success stories, 35 issues of APAARI Newsletter, and more than 40 reports and proceedings of expert consultations. The website provides links to NARS in Asia and the Pacific region, partners like FAO, CGIAR, GFAR, AARINENA, FARA, CACAARI and directories such as research networks, projects database, ASTI databases, regional research networks etc. The website is being updated on regular basis with upcoming events, activities completed and latest publications.

4. *APARIS involved in e-Consultation of GCARD process in Asia-Pacific region:* With the support from GFAR and FAO, APARIS has been actively involved in facilitating the e-Consultation of GCARD process for Asia and the Pacific region during September 2009. Nearly 300 participants representing all types of ARD stakeholders participated in the e-consultations and over 350 messages have been shared on ARD issues in Asia and the Pacific region. Information on face-to-face meeting, regional reports under the GCARD process in the region have been shared through APAARI website.

5. *International Consultation on ICT/ICM by APAARI-GFAR-FAO-ICRISAT:* An International Consultation on Agricultural Research for Development and Innovation: Addressing emerging challenges and exploiting opportunities through Information and Communication Technologies was jointly organized by APAARI-GFAR-FAO-ICRISAT, 7-11 December 2009, ICRISAT, Hyderabad, India. APARIS Coordinator participated and presented the progress report of APARIS. He also attended the CIARD Asia-Pacific Regional Consultation, ICM4ARD Inter-regional meeting and meeting of EGFAR Taskforce (Figure 12).

Figure 12. International Consultation on Agricultural Research for Development and Innovation: Addressing emerging challenges and exploiting opportunities through Information and Communication Technologies by APAARI-GFAR-FAO-ICRISAT, 7-11 December, 2009, ICRISAT, India

6. *Workshop on ICT/ICM for National Agricultural Research Information Systems in Asia-Pacific region*: APAARI-FAO-GFAR-AIT jointly organized a three-day Workshop on ICT/ICM for National Agricultural Research Information Systems in the Asia-Pacific Region during 14-16 September, 2010 at the Asian Institute of Technology (AIT), Bangkok, Thailand. Twenty one Senior Information and Communication Managers from the National Agricultural Research Systems (NARS) of 17 countries in the Asia-Pacific region attended the workshop. An important outcome of the workshop had been the endorsement of APAARI Communication Strategy 2010-2015 which was thoroughly discussed and endorsed by the Information Managers of NARS for its implementation. The workshop recommendations emphasized that

Figure 13. Workshop on ICT/ICM for National Agricultural Research Information Systems in the Asia-Pacific Region jointly organized by APAARI-FAO-GFAR-AIT on 14-16 September, 2010, AIT, Thailand

the needs of small-holder resource poor farmers should be given high priority while implementing the ICT/ICM in AR4D; strengthening APARIS through networking and sharing of ARD information in the region; need for advocacy and capacity building programs for improving use of ICT/ICM for AR4D and facilitation of CIARD process in the region (Figure 13).

7. *Training Workshop on Coherence in Information for Agricultural Research for Development (CIARD) and Strengthening RAIS in the SAARC Countries:* It was organized jointly by SAARC Agriculture Centre (SAC), APAARI, Bangladesh Agricultural Research Council (BARC), FAO and GFAR at SAC in Dhaka from 10-13 May 2011. The purpose of the workshop was to improve capacities for Information and Communication Management (ICM) among national systems for agricultural research and innovation using concepts, pathways, tools and applications developed and made accessible under the Coherence in Information for Agricultural Research for Development (CIARD). The workshop was attended by 32 participants from SAARC member states viz., Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka including Iran (Figure 14).

   Workshop focused on the CIARD movement, its vision and mission as well as on how agricultural research and innovation institutions can be effective, participative members of CIARD using CIARD concepts and contributing to CIARD activities such as pathways, the CIARD.RING and the CIARD Fair. Some CIARD pathways such as those contributing to the development of "open" access repositories with examples from Bangladesh, India and FAO were illustrated in depth. India also presented its approach to "open" access to scientific journals published by the Indian Council of Agricultural Research (ICAR).

8. *APAARI Contact Database:* APAARI launched Contact Database on its website. It helps to search contact details of APAARI Members by sub-region, country, category, area of activity etc., and allows downloading of contact information. NARS and National Information Nodal Points (NINPs) are welcome to register in this platform and add contacts of their constituencies. Efforts are also on to create ARD Experts and ARD Projects Database under the implementation of APAARI Communication Strategy 2010-2015. The contact database is available at: http://www.apaari.org/ard-database/

Figure 14. Training Workshop on CIARD and Strengthening RAIS in the SAARC Countries jointly organized by APAARI-FAO-GFAR-SAC-BARC on 10-13 May 2011 at SAARC Agriculture Centre, Dhaka, Bangladesh

9. *APAARI Communication Strategy 2010-2015:* It lays a strategic and systematic approach to communicate with all the stakeholders and audiences with an aim to increase the impact of APAARI's programs through greater involvement of all stakeholders in the whole research process, improved knowledge management, and more effective communication. It presents the situation analysis, communication goals and objectives, principles, stakeholder analysis, information needs and channels, and a communications plan.

The APAARI Communication Strategy has been developed in a consultative process. It was shared among the experts for comments in the month of June 2010. The comments and suggestions of the experts have been incorporated in the draft and the same has been presented to Information and Communication Managers from the NARS in the Workshop on ICT/ICM for Agricultural Research Information Systems in the Asia-Pacific Region held at the Asian Institute of Technology, Bangkok during 14-16 September 2010. A Group Discussion has been organized exclusively to discuss on the APAARI Communication Strategy during the workshop. After thorough reviewing, participants provided valuable suggestions and endorsed the APAARI Communication Strategy for its implementation (Figure 15).

Later, the draft APAARI Communication Strategy along with suggestions of the workshop participants was presented to the APARIS Steering Committee in its IX Meeting held on 16 September 2010 at AIT, Bangkok. The APARIS Steering Committee considered it to be realistic and suggested that the Strategy be implemented during the years 2010-2015 after prioritizing the activities depending on the availability of resources. The APAARI Communication Strategy has also been presented in the XI Meeting of the APAARI General Assembly held at Suwon, Republic of Korea on 12 October 2010. Members of the General Assembly appreciated the communication strategy and desired to have it implemented soon for the benefit of all ARD stakeholders in the region.

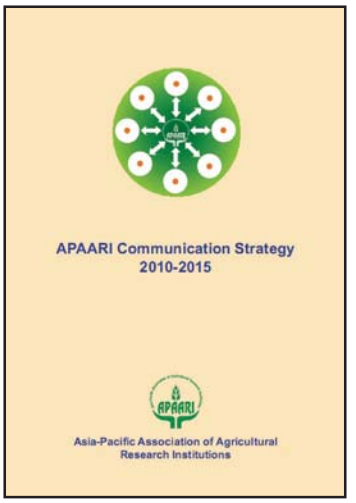


Figure 15. APAARI Communication Strategy 2010-2015

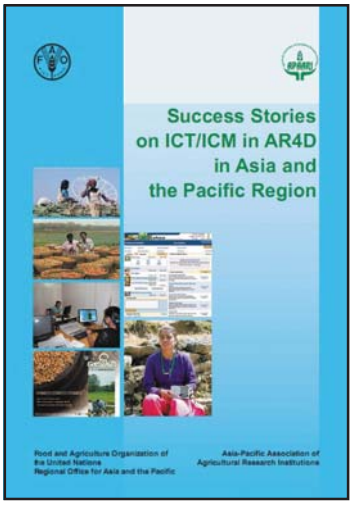


Figure 16. Success Stories on ICT/ ICM in AR4D in Asia and the Pacific Region

10. *Success Stories on ICT/ICM in AR4D in Asia and the Pacific Region (2011):* It attempts to document five success stories on a variety of ICT/ICM initiatives in agriculture, namely, innovative television program Mati-O-Manush in Bangladesh, ICT-enabled information services to farmers through aAQUA initiative in India, improving adoption of technologies and marketing in vegetables with the help of Krishi Community Radio in Nepal, appropriate use of ICT tools and methods through Farmers Information and Technology Services (FITS) in the Philippines, and Cyber Extension in support of agricultural extension system in Sri Lanka.

    These success stories highlight the role of ICT/ICM in strengthening the present agricultural extension system in the respective countries for efficient transfer of technologies to the farmers and thus empowering them through useful lessons on the use of new information and communication technologies, public-private partnerships in ICT initiatives, impact of ICT/ICM in agriculture, orientation and participation of farmers and mechanisms and better practices of ICT/ICM initiatives for AR4D. The publication (Figure 16) is available on APAARI website.

6.2.4 APARIS Activities in 2011

1. Training Workshop on “Coherence in Information for Agricultural Research for Development (CIARD) and Strengthening RAIS in the SAARC Countries” will be held on 10-12 May 2011 at Dhaka, Bangladesh jointly by APAARI-FAO-GFAR-SAC-BARC.

2. Workshop on “Information and Communications Management for Agricultural Innovation in Southeast Asia” will be held on 27-29 September 2011 at Asian Institute of Technology (AIT), Bangkok jointly by APAARI-FAO-GFAR-AIT.

3. Workshop on “Moving Beyond Strategy to Improve Information and Knowledge Management for Agricultural Development in the Pacific Islands Countries and Territories” will be held on 21-24 November 2011 in Fiji jointly by APAARI-ACIAR-FAO-GFAR-SPC.

4. Implementation of APAARI Communication Strategy 2010-2015. Under this activity, development of databases on ARD Experts and ARD projects will be taken up in addition to strengthening the APARIS web space to enable exchange of information and organize consultations on ARD issues in the region in addition to advocacy and capacity building programs on CIARD under the GCARD Roadmap activity 'Bridging the Knowledge Gap".

5. Survey on Agricultural R&D in Southeast Asia. In collaboration with the Agricultural Science and Technology Indicators initiative of the IFPRI, APAARI has been associated in a survey in Indonesia, Malaysia, Philippines, Thailand, and Vietnam for collection of data and preparation of the reports on agricultural R&D investment and capacity in the government, non-profit agencies and higher education in the Southeast Asian sub-region. The data collected will feed into an update of the status of public agricultural R&D investment levels in the Southeast Asian region, which will be published in a new global update for the Global Conference on Agricultural Research for Development (GCARD) in 2012.

6. Documentation of success stories on ICT/ICM in agricultural research and innovation systems in the Asia-Pacific region from the countries India, Malaysia and the Philippines.

CHAPTER 7

Status of ICT/ICM in AR4D in the Asia-Pacific Region

This chapter analysizes and interprets data and information gathered from the National Systems of Agricultural Research and Innovation through a questionnaire survey country status papers presented by ICM managers (NINPs and NARS representatives) in the 'Workshop on ICT/ICM for National Agricultural Research Information Systems in the Asia-Pacific Region' held in September 2010 at Bangkok, documents available on Internet and websites of agricultural research and innovation systems, including those of APAARI members in the region and references from recent reports and review of literature on the subject conducted by APAARI.

The following sections synthesize, review and present the status of ICT use and ICM at the National level related to agricultural research and innovation in the Asia-Pacific region based on a conceptual framework as mentioned in the Assessment Framework in the chapter 3. It deals with discussion on several important indicators which are crucial for augmenting use of ICT/ICM in agricultural research and innovation in the region. The indicators were grouped in seven dimensions of ICT and ICM use in agricultural research and innovation systems in a country:

1. **ICT infrastructure and capacity** – which includes the perceived status of availability and access to hardware, software, connectivity, skills etc.
2. **Information systems** – which includes the availability of websites, e-mail domains, use of Web 2.0 tools etc.
3. **Policy and strategies** – which indicates with whether there are organizational policies in place, the status of adoption of standards, official consideration of IPR issues in information management etc.
4. **Contents** – which indicates management of information content related to scientific and technical information, research data, research management etc.
5. **ICT applications** – which indicates use of library applications, applications for research data analysis, applications for research management, applications for extension, marketing, education and organizational management etc.
6. **Information and communication services** – which indicates whether scientific and technical information, research information, research management information, extension and advisory, market, information services etc., are available and accessible for use etc.
7. **Information and communication channels** – which indicates various channels used by national systems to communicate and disseminate agricultural information and knowledge.

The following sections discuss the results of the study along with observations with the support of relevant information from country papers and references from various sources.

7.1 ICT Infrastructure and Capacity

The ICT components that included hardware, software, networking, wireless, computer systems, Internet access, mailing systems, servers, videoconferencing equipment etc., are the building blocks that constitutes ICT infrastructure in an organization. Basic infrastructure such as electricity and

communications facilities other than computers also indicate national infrastructural support to use of ICTs. Similarly, the human capacity that manages and operates the ICT infrastructure is very critical for successful implementation of any ICT initiative in an organization.

Many national systems indicated that they have basic support systems like electricity, telephone and fax in their organizations. It is observed from Table 1 that availability of hardware and other ICT components in the NARS is adequate with regard to computer systems, peripherals, Internet connectivity, and network equipment. In the more economically developed countries, these systems are fully available, whereas in the developing countries these facilities are either emerging or poor which clearly indicates that still there is room for improving basic ICT infrastructure especially in least developing countries. Similarly, Web servers and mail servers which are essential parts of networking and communication for both within and outside national agricultural organizations are fully available in developed countries. In the developing countries national systems, Web servers and mail server are either poorly managed or are still emerging for satisfying the needs for Internet based communication. An important new ICT technology like videoconferencing facility is only available reliably with a very few developed national systems such as of Chinese Taipei, Japan, Malaysia and the Philippines. The videoconferencing facility is mostly poor or emerging in rest of the countries and hence is not used for communication within the national systems of agricultural research or with the outside world domestically or internationally.

It is interesting to note that the community radio is now emerging as important tool for communication in all the developing national systems. This shows that the ICTs which are cost wise pro-poor and enable greater community participation such as community radio are now playing a major role in disseminating information to communities in the remote and rural areas, mostly managed and run by the communities itself and largely initiated by NGOs or civil society organizations with the financial support of international development agencies. Similarly, the cellular phones are almost fully available in all the NARS, which perhaps reflects the use of mobile phones by the staff and other partners that truly match with the exponential growth of mobile cellular subscriptions which is almost 70% in the Asia-Pacific region (ITU, 2011) in 2010. These are very important developments for communicating content that is adapted to local use and meets the needs of local agricultural communities and individuals. When and if connected to other sources of information and communication both traditional such as print and postal services, radio (medium wave broadcasts, Internet), TV (Cable, Direct to Home, Broadcast) now largely in place and new ICTs such as the Internet through 3G+ technologies and Wimax broadband can open up multiple and mixed channels for communication to communities in rural areas including those related to agriculture.

An in-depth assessment of network components and software systems is made to find out the status of network readiness and software availability in NARS. As shown in Table 2, the Internet connectivity in almost all the NARS is mostly well established or emerging in some of the developing NARS. In terms of broadband access, Asia-Pacific has made remarkable progress in the past few years, with subscriber numbers growing almost five-fold in five years: from 27 million at the beginning of 2003 to 133 million at the start of 2008. In the region's high-income economies, ubiquitous access is progressing through a competitive race to provide ever faster fixed broadband access (ITU, 2008). Following the trends in the broadband capacities, most of the NARS have well developed internet connectivity.

Table 1. ICT Infrastructure: Availability of hardware and other ICT components in NARS

	NARS	Computer systems	Computer peripherals	Network equipment	Internet	Web server	Mail server	Video equip.	Video-conferencing	Comm. Radio	Cellular phones	Telephone	Fax	Electricity
1	Bangladesh	↑	0	0	√	x	√	x	X	√	√	√	√	√
2	Bhutan	↑	0	0	↑	0	0	0	0	x	↑	↑	↑	↑
3	Cambodia	0	↑	↑	↑	0	0	↑	0	↑	√	√	↑	↑
4	Chinese Taipei	√	√	√	√	√	√	√	√	↑	√	√	√	√
5	Fiji	↑	0	0	0	0	0	↑	X	↑	√	√	√	√
6	India	√	√	↑	√	√	√	↑	↑	√	√	√	√	√
7	Indonesia	√	√	√	√	√	√	↑	↑	√	√	√	√	√
8	Japan	√	√	√	√	√	√	√	√	√	√	√	√	√
9	Loa PDR	0	0	0	0	0	0	↑	0	↑	↑	↑	↑	0
10	Malaysia	√	√	√	√	√	√	√	√	√	√	√	√	√
11	Myanmar	0	↑	0	0	0	0	√	X	↑	0	↑	0	√
12	Nepal	√	↑	0	↑	↑	↑	↑	0	√	↑	↑	↑	↑
13	Pakistan	√	√	√	√	√	√	↑	↑	↑	√	√	√	↑
14	Papua New Guinea	↑	↑	↑	↑	↑	↑	0	X	↑	↑	↑	↑	0
15	Philippines	√	√	√	√	√	√	√	√	√	√	√	√	√
16	Samoa	↑	↑	↑	0	0	0	0	0	√	√	√	√	√
17	Sri Lanka	↑	↑	↑	√	↑	√	0	0	↑	√	√	√	√
18	Thailand	↑	↑	↑	√	√	√	√	↑	√	↑	√	√	√
19	Vietnam	√	√	↑	√	↑	√	√	↑	√	↑	√	√	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** X

Table 2. ICT Infrastructure: Availability of networking components and software in NARS

	NARS	Networking components									Software			
		LAN	Intranet	Internet connectivity	Bandwidth facility	WiFi	WAN	VPN	Satellite communication	Mobile satellite vehicles	Operating System	Office Automation suits	Application software	Open source software
1	Bangladesh	√	x	√	↑	x	x	x	x	x	√	√	√	x
2	Bhutan	↑	↑	↑	↑	0	↑	0	x	x	↑	√	↑	↑
3	Cambodia	↑	↑	↑	↑	0	↑	↑	x	x	↑	↑	↑	↑
4	Chinese Taipei	√	√	√	√	√	√	√	0	√	√	√	√	√
5	Fiji	↑	↑	0	↑	↑	0	0	0	x	↑	0	↑	0
6	India	√	↑	√	↑	↑	↑	↑	√	0	√	√	↑	√
7	Indonesia	√	↑	√	↑	↑	√	↑	↑	↑	√	√	√	↑
8	Japan	√	√	√	√	√	√	√	√	√	√	√	√	√
9	Loa PDR	↑	↑	↑	↑	↑	0	0	0	0	0	0	0	0
10	Malaysia	√	√	√	√	√	√	√	√	√	√	√	√	√
11	Myanmar	0	0	0	0	0	0	0	↑	0	↑	↑	↑	↑
12	Nepal	0	0	↑	↑	↑	↑	0	↑	x	0	0	0	x
13	Pakistan	√	√	√	√	↑	↑	↑	x	x	√	√	↑	x
14	Papua New Guinea	↑	↑	0	↑	↑	↑	↑	↑	x	↑	↑	↑	↑
15	Philippines	√	√	√	√	√	√	√	↑	x	√	√	√	√
16	Samoa	0	x	x	x	x	0	x	x	x	0	x	x	x
17	Sri Lanka	↑	x	√	0	0	x	x	x	x	√	√	↑	↑
18	Thailand	√	√	√	√	↑	√	↑	↑	↑	√	√	√	√
19	Vietnam	√	↑	↑	↑	↑	√	↑	↑	↑	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

Local Area Networks (LAN) are almost established in all the NARS whereas only the developed NARS could use intranet services. Networking facilities such as Wide Area Network (WAN), Virtual Private Networks (VPN) and WiFi connectivity exists in developed NARS and some of the developing NARS still in emerging phase. Advance network communication systems like use of satellite communication and mobile satellite vehicles for agricultural research and extension purpose is limited to most advanced countries like Chinese Taipei, Japan and Malaysia.

With regard to software availability, most of the NARS have operating systems, office automation suits and database application software tools. These are ranged from highly proprietary software such as Microsoft Windows; Windows XP; UNIX based operating systems, MS Office, commercial database software for database development. It is reported that use of Open Source Software is not so encouraging in the region especially among least developing or developing NARS. Perhaps, this relates to lack of capacities in these countries which hinder the use of Open Source Software tools and applications which are otherwise free of cost and can be customized as per the local needs. It also denote that there is a need for advocating spread of such Open Source Software tools and applications which are now become standards for greater integration and coherence in data sharing and information exchange.

Human capacity is vital for efficient use and management of ICT/ICM in NARS. Capacities of information and communication managers, who generate, process, organize and disseminate information with the help of ICT tools and technologies need to have basic computing skills in addition to expertise in the agricultural subject domain. They need to posses advanced skills related to programming, database management, network administration in addition to soft skills related to website content management, multimedia production and data analysis and interpretation which need not only highly ICT skills but also specialized expertise related to information management, content creation and organization to disseminate information efficiently across the network platforms. As indicated in Table 3, developed NARS in the regions have required skills in basic computing, internet and e-mail, programming, database management, network administration etc. But in the remaining NARS the skills are still emerging or poor in all most all the areas.

This clearly indicates the need for improving capacities of ICT cadre in agricultural organizations in the region. Perhaps, it may be due to poor human resource development strategies adopted by NARS to develop ICT capacities within their systems. It is evident from Table 3 that very few NARS belongs to Chinese Taipei, India, Japan and the Philippines have HRD policies in place to develop cadre in ICT/ICM area.

Thus it may be concluded that most of the NARS in the region have progressed well in terms of developing the basic ICT infrastructure and support systems including computer systems, broadband internet connectivity, LAN facility equipped with software operating systems and office automation software. However, the advanced facilities like database management systems, Wi-Fi, Videoconferencing and use of satellite and mobile internet are only available with most advanced NARS or developed NARS in the region. As far capacities, all NARS have skills in basic computing, internet and e-mail operation, whereas the skill sets in the areas of programming, database management, network administration, data analysis etc., are emerging in many developing NARS. The gaps in capacity building may be due to inadequate HRD policies which need to be addressed for proper cadre development.

Table 3. ICM skills and capacities in NARS

	NARS	Basic computing	Internet and e-mail access	Programming	Database mgmt.	Network admin.	Website mgmt.	Content creation	Multimedia production	Data analysis and interpretation	HRD policy for ICT/ICM
1	Bangladesh	√	√	0	↑	↑	↑	0	0	√	↑
2	Bhutan	↑	↑	0	0	↑	√	√	√	↑	0
3	Cambodia	↑	↑	0	↑	↑	↑	↑	↑	↑	↑
4	Chinese Taipei	√	√	√	√	√	√	√	√	√	√
5	Fiji	√	↑	↑	0	0	↑	↑	↑	↑	0
6	India	√	√	↑	↑	√	√	√	√	√	√
7	Indonesia	↑	↑	↑	√	↑	√	↑	√	√	↑
8	Japan	√	√	√	√	√	√	√	√	√	√
9	Loa PDR	↑	↑	0	0	0	0	0	↑	0	0
10	Malaysia	√	√	√	√	√	√	√	√	√	↑
11	Myanmar	0	↑	0	↑	0	0	x	0	0	x
12	Nepal	↑	↑	0	0	0	0	0	0	0	x
13	Pakistan	√	√	↑	↑	√	√	√	√	√	↑
14	Papua New Guinea	↑	↑	x	↑	↑	↑	↑	↑	↑	0
15	Philippines	√	√	√	√	√	√	√	↑	↑	√
16	Samoa	0	0	0	0	↑	↑	0	0	x	x
17	Sri Lanka	√	√	0	↑	↑	√	↑	√	√	↑
18	Thailand	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
19	Vietnam	√	√	√	↑	↑	↑	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** X

7.2 Information Systems

An information system is defined as combination of information technology and people's activities using that technology to support operations, management. In a very broad sense, the term 'information system' is used to refer to not only to the ICT an organization uses, but also to the way they share and exchange information with the stakeholders and interact with them in a NARS environment.

Today, an organization shares information and interacts with its clients in a dynamic way with the help of information systems that are built around new ICT tools and technologies. These included website, e-mail systems, content management systems, use of Wiki, RSS feeds, Web 2.0 and Web 3.0. As shown in Table 4, most of the least developed NARS do not share information through networks. This may be due to poor or inadequate network infrastructure facilities or lack of skills. All the NARS maintain website domains and disseminate information. But it was observed that only these websites are maintained with simple tools such as HTML editors but not with the help of content management systems (CMS) which are meant for updating the content more efficiently to keep the website always dynamic and interactive. The picture about use of social networking tools, Web 2.0 and Web 3.0, Wiki, RSS and blogs which improve participatory content creation and dialogue is not so encouraging. NARS in developed countries are able to exploit the power of these new ICT tools. Perhaps, this may be again due to lack of awareness or capacity on how to harness these technologies or integrate with the existing websites and other information services and systems. The poor utilization of social media and Web 2.0/Web 3.0 tools by NARS may be also due to institutional policies related to intellectual properties, copyrights, or even due to lack of support by institutional heads.

It is understood that though NARS have overcome the initial phase of having a website domain, mail domain and some relevant content on the organizational activities on the website, there are still gaps in the information systems that need to be bridged in the NARS to provide access to dynamic information; ensure interaction/dialogue with stakeholders, participatory content creation, target information at individual level; integrate information services and system with the use of tools such as RSS, social media etc.

7.3 Policies and Strategies

ICT policy generally covers three main areas: telecommunications (especially telephone communications), broadcasting (radio and TV) and the Internet. Policies are at national, regional or international levels and some influence each other hierarchically for example international policies in telephone and Internet based telecommunications. Although policies are formally put in place by International, regional and national governments, different stakeholders and in particular the private sector make inputs into the policy process and affect their out-comes.

The countries that have made most progress in achieving a transition to knowledge-based societies are those that have produced policies that objectively assess the needs of stakeholders and users, develop a vision, identify and define objectives, especially for development, within the country, develop plans to overcome constraints, set timeframes, assign or raise resources, and specify measures that will be employed to achieve policy goals. These include policies on ICTs and e-government, open access policies, national repositories and research information policies. There are many administrative structures (government ministries/departments, or autonomous bodies) in every country that address the various issues related to legislature, legality, policy formulation, policy implementation, regulatory mechanisms and regulations, legal enforcement etc., with multiple and

Table 4. Information systems in NARS

	NARS	Network sharing in NARS	Website	E-mail domain	Use of CMS	Use of Wiki	Use of RSS	Blog	Web 2.0
1	Bangladesh	↑	↑	√	x	x	x	x	x
2	Bhutan	0	√	√	↑	↑	↑	0	0
3	Cambodia	↑	↑	↑	↑	0	↑	0	↑
4	Chinese Taipei	√	√	√	√	√	√	√	√
5	Fiji	0	↑	↑	0	x	x	x	x
6	India	√	√	√	√	↑	↑	√	√
7	Indonesia	↑	√	√	√	↑	↑	↑	↑
8	Japan	√	√	√	√	√	√	√	√
9	Loa PDR	0	0	0	↑	0	0	0	↑
10	Malaysia	√	√	√	√	√	√	√	↑
11	Myanmar	0	0	0	x	x	x	x	0
12	Nepal	0	0	0	0	0	0	0	x
13	Pakistan	√	√	√	↑	↑	↑	↑	↑
14	Papua New Guinea	↑	↑	↑	x	0	0	x	0
15	Philippines	√	√	√	√	↑	√	√	√
16	Samoa	0	0	0	0	x	x	0	0
17	Sri Lanka	0	↑	↑	0	√	↑	↑	x
18	Thailand	↑	↑	↑	↑	↑	↑	↑	↑
19	Vietnam	√	√	√	↑	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** X

varying degrees of authority, autonomy and accountability. The capacity of governance is reflected in the quality of policies that administrative structures generate and implement effectively. There appears to be a new dynamism in the way resource allocations have been made, policies have been reformed, and human resources upgraded to promote ICT-based information and communication policies, even by traditional governance structures (see Box 6).

Box 6. Examples of ICT Policies and Strategies in the Asia-Pacific Region

There are excellent examples from Asian countries that have benefited from the use of new technologies and innovative e-government strategies that have won awards and recognition across the world. In Malaysia the 'One Service, One Delivery No Wrong Door' portal for government services is highly successful in integrating and connecting Malaysians in the capital. In India the e-Lekha System developed by the National Informatics Centre, achieved standardisation and efficiency of financial processing across a large number of government agencies and transaction types. Singapore's Integrated Health Information Systems has a common electronic medical record platform that is used across hospitals, specialist clinical providers and primary healthcare clinics. Vietnam's Sustainable Development Centre's '2-way information delivery' model (2wID) for Vietnamese farmers is an excellent example in the use of e-services. Access to technology to help crop production was limited until the introduction of the 2wID platform helped to bring about a tremendous increase in production. The iSchools project in the Philippines coordinated by the Commission on Information and Communications Technology aims to integrate education by providing ICT infrastructure and training to high schools across the archipelago.

Source: Kiran (2011). Information policies in Asia: Development of indicators, UNESCO.

Across the Asia-Pacific region there has been a steady development in the information and communications policies that support the information technology and more importantly the information sector on the whole. This could also be viewed as related to economic and political development contributing to more rapid social development.

As such, national government initiatives are seen in the establishment of information/ICT ministries at the apex level. In most of the countries of the Asia-Pacific region, the acquisition of technology, creation of infrastructure and improving the quality of human resources are significant engagements, but a lot has yet to be achieved (Kiran, 2011). Almost all the countries in the region have national telecommunication and Internet policies. But in most countries the rural segment faces technology exclusion with limited or no access to any means of communication. The digital divide is widely existent in most countries in the Asia-Pacific and even the more rapidly developing countries in the region are not immune to the manifestation of this divide which has a complex etiology. There is a need not only to frame policies to increase greater contribution from the public sector as also promote greater participation from private and international agencies to bridge the digital divide, especially as related to financial investment for infrastructure, connectivity and content related to rural services and in particular to those related to agricultural development.

Telecommunication facilities such as telecentres are being promoted as an answer to the problems of the digital divide. In the past six years, the Asian telecentre movement has gained tremendous momentum. A national advocacy campaign in India, a very large country with an urgent need for agricultural development, triggered under the auspices of the National Alliance for Mission 2007 launched by Prof. M.S. Swaminathan, has created a ripple effect not only among stakeholders in India but also by the National Governments, extending the idea of national level upscaling to Bangladesh, Nepal, Sri Lanka and the Philippines etc. It is estimated that more than 60% of the world's telecentres are now in the Asian region. There has been a great amount of enthusiasm and

Table 5. Policy and strategy support to ICM in NARS

	NARS	ICM policy at organizational level	ICT/ICM strategy in the organization	ICT/ICM rules	Separate provision for investment in ICT/ICM	Centralized ICM Unit	Appointment of ICTM experts	Metadata standards	Adoption of global standards for managing ARD info.	Implementation of Info. System security	Implementation of IPRs
1	Bangladesh	↑	↑	0	↑	0	0	0	↑	x	0
2	Bhutan	↑	↑	0	0	0	↑	0	0	↑	0
3	Cambodia	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
4	Chinese Taipei	√	√	√	√	√	√	√	0	√	√
5	Fiji	0	0	0	0	0	0	0	0	↑	↑
6	India	√	√	√	√	√	√	↑	√	√	↑
7	Indonesia	↑	↑	↑	↑	↑	√	↑	↑	√	↑
8	Japan	√	√	√	√	√	√	√	↑	√	√
9	Loa PDR	0	↑	↑	0	↑	0	0	0	0	0
10	Malaysia	√	√	√	√	√	√	√	↑	↑	↑
11	Myanmar	0	x	x	x	x	0	x	x	0	x
12	Nepal	0	0	x	x	↑	0	x	x	x	x
13	Pakistan	↑	√	√	↑	√	√	↑	√	↑	↑
14	Papua New Guinea	↑	↑	↑	↑	↑	↑	0	↑	↑	0
15	Philippines	√	√	√	√	√	√	√	↑	√	↑
16	Samoa	x	x	x	x	x	x	0	x	x	x
17	Sri Lanka	↑	↑	↑	0	↑	↑	0	↑	↑	√
18	Thailand	↑	↑	↑	↑	↑	↑	↑	↑	√	↑
19	Vietnam	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** X

new hopes among the emerging Telecentre networks in the Asian region, especially, Thailand, Vietnam, Cambodia, Lao PDR, and other East and Southeast Asian Countries. (www.e-asia.org, 2011). In addition, approaches to reaching the last mile, the rapid growth in cellular telephony in the region enable connectivity at individual and household level, even in the rural areas in the region. However, there are still large sections of society that do not enjoy access to ICTs and are therefore at risk of being excluded from the socio-economic benefits that such access brings. The telecentre has become an important tool for communication and sharing of information/knowledge and delivery of ICT-enabled services in the Asia-Pacific region but there is a need for newer capacities in rural communities to effectively use available and new information.

Agricultural policies of most of the countries in the region do not have adequate clarity and strategies on how ICT/ICM can and are to be used in agricultural development. Though there are ICT initiatives by the governments, these are limited to pilot projects initiated by very vibrant institutions. These have problems in outscaling (increasing coverage geographically and in number of users), upscaling (bring new technology, process and useful content) and being viable and sustainable financially and human capacity and support wise. It is also still necessary to have clear policies laid out at national agricultural research and innovation systems level to integrate ICT/ICM in the agricultural research for development agenda.

Table 5 summarizes the status of policy and strategy support to ICM in NARS. It shows that very few countries with strong or emerging economies such as Chinese Taipei, India, Japan, Malaysia and the Philippines have policies and strategies in place at the organizational level which enables them to follow and implement rules, norms, invest in ICT/ICM and engage qualified ICT experts in the national agricultural research and innovation systems. Most of the other national systems are still evolving policies or struggling with poor policy support.

With regard to implementation of global information standards, security systems and IPR related issues, the trends are not at all encouraging. Even some of the developed NARS do not follow global standards for managing ARD information, metadata standards and adopt proper intellectual property rights for sharing research information. This becomes barrier for data, information and knowledge exchange and integration at regional and global level. It's a matter of great concern that in spite of efforts by international organizations to mainstream ICT/ICM in the agricultural research for development agenda, many NARS do not consider the ICT/ICM as an important discipline that itself impact the agricultural development besides improving the systems, processes and greater sharing of knowledge across boundaries. It is also pertinent to flag here the issues of non-compliance with metadata standards, agricultural vocabularies, classification systems, IPR regulations and Acts etc., which create obstacles in opening up the access to public funded research results to all stakeholders at national, regional and global levels.

7.4 Contents

Agricultural content refers to every possible data, information and knowledge that is useful and applicable to all type of stakeholders in the agricultural research and innovation system. It includes 1. Science and Technical Information, 2. Research Data and Information, 3. Research Management Information, 4. Information for learning in agricultural communities such as for extension and education and 5. Market related information which informs producers how to participate effectively in markets.

Agricultural and related content is generated, processed and disseminated by several actors, intermediaries, and consumers of information and agricultural commodities in the agricultural value chains and associated innovation systems including research that contribute to improving the value chains. It is made available in different forms, in different formats, on different platforms for different clients for different purposes. It flows in many directions through many channels. In other words, content is complex, highly need-based, targeted to specific users for a specific purpose at right time. It is processed and value added at various nodes. The understanding and recognition of this complexity is now even more relevant in the realm of today's and future agriculture where dissemination of location-specific and timely information to the right person is extremely crucial for the adopting and adapting agricultural innovations as well as capturing better marketing opportunities. The following section deals with availability of contents related to science and technical information, research data and information, and research management information:

7.4.1 Scientific and Technical Information

Science and Technical Information (STI) is generally available as structured documents in the form of traditional printed material (e.g.: books, journals, abstracts, index etc.) or in electronic format (CD-ROMs, DVDs, External Drives, Internet based electronic journals) made available through repositories, digital libraries etc. that are shared via computer/telecommunication based networks.

The content may cover from general concepts to include most advanced analytical information meant for different purposes. It is found that many countries have established library or information centres affiliated to the constituent organizations or often maintain a national agricultural library designated arrangement for collection, organization and dissemination of both printed and electronic information. These centres are very active in some countries and form as nodal points or clearing houses to cater the information needs of national agricultural research, education and innovation systems.

Table 6 indicates the county wise status of availability of STI in agricultural subjects in the national agricultural and innovation systems in the region. Most of the countries have been developed or in the process of developing cataloguing and indexing services of agricultural literature through their library and documentation centres on regular basis. The trend is same in case of abstracts and bibliographies. It is observed that the challenges starts from CD-ROM based databases, online-database, electronic journal services. Developed national agricultural research systems could offer these electronic services whereas the least developing systems are still emerging in these services. The situation in institutional repositories and open archive initiative is not promising. Most of the countries are evolving their institutional repositories. Only developed national systems are able to start open archive initiatives under special project with the help of different partners to open up research information to public.

This may be due to that the cost of generating electronic information resources (CD-ROM database, on-line databases, on-line journals etc.). These resources are costly to generate and subscribe to and it is also costly to develop institutional repositories or building open archives to open up research results to public by any single institution or library.

Table 6. Availability of scientific and technical information in NARS

	NARS	Catalogues	Indexes	Abstracts	Bibliographies	CD-ROM databases	Online databases	Electronic journals	Institutional repositories	Open Archive Initiative
1	Bangladesh	√	√	0	0	x	x	x	↑	x
2	Bhutan	0	↑	↑	0	0	↑	0	0	0
3	Cambodia	↑	↑	↑	↑	0	0	↑	↑	↑
4	Chinese Taipei	√	√	√	√	√	√	√	√	√
5	Fiji	0	0	0	0	↑	↑	↑	0	0
6	India	↑	↑	√	√	√	↑	√	√	√
7	Indonesia	√	√	√	√	√	√	√	↑	↑
8	Japan	√	√	√	√	√	√	√	√	√
9	Loa PDR	0	0	0	0	0	0	0	↑	0
10	Malaysia	√	√	√	√	√	↑	↑	↑	x
11	Myanmar	0	x	x	x	x	x	0	x	x
12	Nepal	0	0	↑	↑	0	0	↑	↑	x
13	Pakistan	√	√	√	√	√	√	√	↑	↑
14	Papua New Guinea	↑	↑	↑	↑	↑	↑	↑	↑	0
15	Philippines	√	√	√	√	√	√	√	√	√
16	Samoa	0	0	0	0	0	x	x	x	x
17	Sri Lanka	√	√	√	√	√	0	√	↑	0
18	Thailand	↑	↑	↑	↑	↑	↑	√	↑	↑
19	Vietnam	↑	↑	↑	↑	√	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

One way out for this is to operate through consortium approach at national level to subscribe to costly international CD-ROM and on-line databases for the use of all consortium members as done in India through Consortium for e-Resources in Agriculture (CeRA)[1] Project (http://www.cera.jccc.in/, 2011) may be tried in other countries also. The initiative by SAARC Agriculture Centre offers Agricultural Bibliographic Information Service (ABIS) – a service through e-mail among South Asian countries based on the important international CD-ROM databases (AGRIS, AGRICOLA, BEAST, Biological abstracts, CABI abstracts, TEEAL, AGORA etc.) is noteworthy (Akthar, 2010).

Countries also lack the investment and necessary capacities to generate STI related repositories. There is underinvestment or even lack of investment in ICM for AR4D where even basic investment and capacities related data is unavailable. Content generation in AR4D organizations require recognition that information and knowledge generation are the main outputs of these organizations and generation of this output needs not only appropriate policies but strategies, structures including those of reward and accountability, embedding information generation in various work processes chained together to yield the output through appropriate organizational information chains. This needs new investment that is appropriately targeted at developing and improving organizational information chains and building of new capacities at all levels to manage content that is increasingly in electronic format and flows electronically in a variety of channels.

Table 6 shows that majority of countries are offering print-based content in the form of catalogues, indexes, abstracts etc., but whereas they are slow in shifting these contents, especially related to agricultural projects, experts, and policy information to electronic platform for greater sharing at different levels. Very few national level organizations within the agricultural research and innovation system could take up such initiatives to offer content especially through on-line database. Investment into creation of such contents, motivation by staff, understanding the users' needs and proper capacities are key issues to be considered for developing content on the electronic platforms.

7.4.2 Research Data and Information

Research Data and Information are usually made available in the form of raw data, organized, structured databases and analytical and dynamic information in the formats suitable for the users who are generally scientists, policy-makers, development workers etc., engaged in research activities, research governance and policy-making and priority setting etc. Table 7 shows that except most advance country like Japan, all other countries are in emerging stage with regard to availability of such highly vital data and information publicly and openly.

There are encouraging signs that AR4D systems have started taking interest in database management, developing and using models, GIS systems and Knowledge based systems. These applications require greater collaboration and partnerships which are multi- and cross disciplinary and may span several units, department and Institutions to be functional, efficient, effective and useful. The building and use of these applications indicate a trend towards the use of computer based tools and electronic channels to coalesce and integrate AR4D systems at the project, Institute and system level using common tools, applications and information systems.

[1] The National Agriculture Innovation Project has established a Consortium for e-Resources in Agriculture (CeRA) for providing online access to e-journals and resources to agricultural libraries. It offers access to electronic on-line journals to researchers in 126 National Agricultural Research Institutions and several State Agricultural Universities in India.

Table 7. Availability of research data and information in NARS

	NARS	Research databases	Crop models	GIS	Knowledge -based systems/DSS
1	Bangladesh	↑	x	↑	0
2	Bhutan	↑	↑	↑	↑
3	Cambodia	↑	↑	0	↑
4	Chinese Taipei	↑	↑	↑	↑
5	Fiji	0	x	x	0
6	India	√	↑	√	√
7	Indonesia	↑	↑	↑	↑
8	Japan	√	√	√	√
9	Loa PDR	x	x	↑	0
10	Malaysia	↑	↑	↑	↑
11	Myanmar	0	x	0	x
12	Nepal	0	x	0	x
13	Pakistan	↑	↑	√	↑
14	Papua New Guinea	↑	0	↑	0
15	Philippines	√	↑	↑	↑
16	Samoa	x	0	0	0
17	Sri Lanka	√	√	↑	0
18	Thailand	↑	√	√	↑
19	Vietnam	↑	√	0	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** X

7.4.3 Research Management Information

The management and governance of agricultural research depend on high quality information on projects, project locations, experts, funding sources and research priorities and this information is very crucial for institutional change process, project monitoring and evaluation and management of outputs etc. This information is meant for directing and monitoring the need-based research, planning and prioritization of investment, capacity, thematic focus as also collaboration and partnerships and in general improving the efficacy of AR4D Systems at the national and, in case of collaboration, at the International level. There is a dearth of this information openly and publicly limiting inclusiveness of various actors and stakeholders in the formal research processes and inhibiting collaboration within and outside the research systems.

Table 8 shows that information on research management is still emerging in majority of the countries. The critical information on research priority setting and need assessment is either poor or evolving in all the countries except Japan. This may perhaps be due to high level of human expertise and investment that is needed in generating such decision making information; and collaboration among different subject experts is not so easy task to cultivate in the least developed countries. There may

Table 8. Availability of Research Management Information in NARS

	NARS	Info. on projects	Info. on location	Info. on experts	Info. on funding sources	Info. on priority setting and need assessment
1	Bangladesh	0	x	X	x	0
2	Bhutan	√	√	√	√	↑
3	Cambodia	↑	↑	0	↑	↑
4	Chinese Taipei	↑	↑	↑	↑	↑
5	Fiji	0	0	0	↑	0
6	India	↑	↑	↑	↑	↑
7	Indonesia	√	√	√	√	↑
8	Japan	√	√	√	√	√
9	Loa PDR	0	0	0	0	0
10	Malaysia	√	√	√	√	↑
11	Myanmar	x	x	x	x	x
12	Nepal	↑	↑	↑	↑	↑
13	Pakistan	↑	↑	↑	↑	↑
14	Papua New Guinea	↑	↑	↑	↑	↑
15	Philippines	√	√	√	√	↑
16	Samoa	0	0	0	x	0
17	Sri Lanka	√	√	√	√	↑
18	Thailand	↑	↑	↑	↑	↑
19	Vietnam	√	↑	√	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** X

be lack of appropriate structures, work processes tools and applications to generate and manage this information.

7.5 ICT/ICM Applications

The application of advances in ICT/ICM in agriculture and rural development sector is causing a paradigm shift in the way information and knowledge are exchanged and shared among all ARD stakeholders the world over. With the availability of new ICT tools and applications especially through the mobile telephone and its convergence with the Internet enabling use of mixed media in many developing countries and with improved access to Internet and Web and its dynamic platforms (Web 2.0/Web 3, Social Networking) through high bandwidth broadband through wireless connectivity, Linked and Open Data movements redefine the way information is published on the websites and the way data is put to re-use at the level of institutions, experts and the communities.

ICT/ICM applications in agricultural research and innovation systems include library automation applications, applications for research data analysis using statistical approaches, models, GIS and knowledge based system, applications for research management tools, applications that enable learning applicable extension, education, organizational management marketing, etc., which are considered as the crucial interventions to enable all stakeholders in ARD community to employ knowledge-based agriculture and benefit from it. The following sections discuss the status of ICT/ICM applications in agricultural research and innovation systems in the region:

7.5.1 Library Automation and Networking

The library and information world has traditionally been borderless long before others. However, the Internet and the World Wide Web have pushed libraries to be even more interdependence than before, because of a wider array of sources and providers of information from which they draw their information. The place of libraries as centres for the acquisition, description, organization, preservation and access to information has been challenged by new information services providers such as Google, Yahoo, etc., and subject/thematic Web portals, digital libraries and open access repositories. Library automation and networking is now all about connecting to other libraries and information centres, search engines, peer groups, databases and experts. Thus the scenario today is one of many dispersed digital collections. Libraries and networks use different hardware and software platforms. To enable interconnectivity and interoperability to such a diversity of systems and to enable mutual sharing of resources and exchange of data between them requires that all of them follow internationally agreed upon standards. (Haravu, nil date).

Table 9 indicates that library automation is well established in developed countries and the least developing countries are poor in library automation applications. Perhaps the agricultural libraries in the least developed countries use computers systems for their housekeeping activities only rather than for developing computer based catalogues, networking with other libraries, providing on-line public access catalogues to remote users etc. It was observed that developed countries did full automation and networking of libraries with several information services such as circulation of documents, access to virtual libraries, access to on-line journals, access to open source journals and cooperate with other libraries as consortium members to get access to priced sources of information. The national agricultural systems that belong to less developed countries need to recognize automating and networking their library resources is an important step in the direction of digitization of agricultural content.

The information in Table 9 reflects the differences of development in the ability to develop and use new ICT tools and applications in national systems of agricultural research and innovation. The reasons could, as revealed in discussions during APAARI workshops, be inadequate leadership, poor investments and capacities as also lack of awareness.

7.5.2 Agricultural Research Management

Agricultural research is one of the most widespread forms of organized research in the world, in both developed and developing countries. Management of agricultural research involves many decisions that have scientific, social and political consequences. Every country has established agricultural research priorities based on many complex factors that must be considered when decisions are made on the choice of research problems to be investigated and invested in. Resources must be shared among projects that often compete for the limited funding available that supports the total research enterprise. Research management information is meant for directing and monitoring the need-based

Table 9. ICT/ICM applications in library automation and networking in NARS

	NARS	Library automation	Lib. and Info. Networks	Web-based online library catalogues	Circulation of electronic & hard copies	Search on website content	Access to virtual libraries	Online search for databases	Access to electronic journals	Access to open source journals	Access to info. through consortia
1	Bangladesh	0	x	x	x	x	x	x	x	x	↑
2	Bhutan	↑	↑	↑	0	↑	x	↑	↑	0	0
3	Cambodia	0	↑	0	↑	↑	0	0	0	0	0
4	Chinese Taipei	√	√	√	√	√	√	√	√	√	√
5	Fiji	0	0	0	0	↑	↑	↑	0	0	↑
6	India	√	√	√	√	0	0	0	√	√	√
7	Indonesia	√	√	√	√	√	↑	↑	√	√	↑
8	Japan	√	√	√	√	√	√	√	√	√	√
9	Loa PDR	0	0	0	0	0	0	0	0	0	0
10	Malaysia	√	√	√	↑	√	↑	√	√	√	√
11	Myanmar	x	x	x	↑	↑	x	x	0	0	x
12	Nepal	0	0	0	↑	↑	x	x	↑	↑	0
13	Pakistan	√	√	√	√	√	√	√	√	√	x
14	Papua New Guinea	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
15	Philippines	√	√	√	√	√	√	√	√	√	↑
16	Samoa	0	x	x	0	0	x	x	x	x	x
17	Sri Lanka	√	√	√	√	√	√	√	↑	√	√
18	Thailand	↑	↑	√	√	√	↑	√	√	√	↑
19	Vietnam	0	0	↑	↑	↑	↑	↑	↑	√	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

research, planning and prioritization of investment, capacity, thematic focus as also collaboration and partnerships and in general improves the efficacy of AR4D Systems at the national and, in case of collaboration, at the International level.

The management and governance of agricultural research at the national, regional and global levels heavily depend on high quality information and is very crucial for institutional change process, project monitoring and evaluation and management of outputs etc. There is a dearth of this information openly and publicly limiting inclusiveness of various actors and stakeholders in the formal research processes and inhibiting collaboration within and outside the research systems. This may perhaps be due to high level of human expertise and investment that is needed in generating such decision making information; and collaboration among different subject experts is not so easy task to cultivate in the least developed countries. There may be lack of appropriate structures, work processes tools and application to generate and manage this information.

As shown in Table 10, highly developed countries like Japan and Chinese Taipei develop and maintain all types of information resources in readily accessible form with the application of latest ICT technologies in crop modeling, precision agriculture, knowledge-based systems and information systems that support research management at institutional level. There is inconsistence even among some developed national agricultural research and innovations systems in having important applications like research databases, modeling, and precision farming applications which indicates that these countries have to travel a long way to make use of power of ICT applications for the agricultural research management in real sense. Perhaps, this may be the reason that these countries lack scientific evidence based information to efficiently use in research planning and management of natural resources at the nation as a whole to address emerging challenges these countries face due to climate change, depleting natural resources, dwindling markets, change in consumer habits, rise in food price etc. It is known that technologies such as GIS, GPS, Remote Sensing, very large databases are very high end applications. They require huge investment and highly specialized cadre supported by multi-institutional arrangements. However, it is envisaged that the above ICT applications have potential to transform agricultural research as “business not as usual” process to address the needs of small and resource poor farmers who are in majority in the region.

7.5.3 Agricultural Advisory, Extension and Marketing

To make good decisions about farming and participate equitably and effectively in increasingly competitive markets, farmers need information about what to grow, how to grow, when to grow, where to grow; where, how and when to market etc., from different sources many a times from outside their immediate locality and often need help of intermediaries to interpret and use it to learn and solve problems that are in hand and mostly unique. The public agricultural extension system in most of the countries in the region is mandated to provide agricultural advisory and extension services to farmers. But the agricultural extension systems since 1990’s in the region have not been satisfactorily performing due to several inherent problems. Extension has suffered from low investments in agricultural sectors and inadequate qualified cadre to serve the huge farming communities with diverse problems emanative from an ever increasing market oriented economy even for agriculture in the region. It is here that the use of ICT applications has potential and offers promise to improve the performance of agricultural advisory and extension services to farmers and also strengthen the present agricultural extension systems in the region.

Table 10. ICT/ICM applications that enable research management in NARS

	NARS	Research databases	Modelling	GIS	Precision agriculture	Knowledge-based/DSS	Mgmt. of Institutes	Mgmt. of research programs	Mgmt. of projects	Mgmt. of outputs and experts
1	Bangladesh	x	x	↑	0	0	↑	↑	0	x
2	Bhutan	0	x	↑	x	x	↑	√	√	↑
3	Cambodia	↑	↑	↑	↑	↑	↑	↑	↑	↑
4	Chinese Taipei	√	√	√	√	√	√	√	√	√
5	Fiji	0	0	0	0	0	↑	↑	0	↑
6	India	↑	↑	√	↑	√	↑	↑	↑	√
7	Indonesia	↑	↑	↑	↑	↑	↑	√	√	↑
8	Japan	√	√	√	√	√	√	√	√	√
9	Loa PDR	0	0	0	x	x	x	x	x	x
10	Malaysia	↑	↑	↑	↑	↑	√	√	√	√
11	Myanmar	0	0	0	0	0	0	0	0	0
12	Nepal	0	0	0	0	0	0	0	0	0
13	Pakistan	↑	√	√	√	↑	↑	↑	↑	↑
14	Papua New Guinea	↑	0	↑	↑	0	↑	↑	↑	↑
15	Philippines	√	↑	↑	↑	↑	√	√	√	√
16	Samoa	x	x	0	x	0	↑	0	↑	↑
17	Sri Lanka	↑	0	0	0	0	√	√	√	√
18	Thailand	↑	↑	↑	↑	↑	↑	0	0	0
19	Vietnam	↑	↑	0	↑	√	√	√	√	√

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

There has been tremendous growth of innovative partnership (public-private-community) initiatives (see Box 7) in using ICT-based agricultural information and providing advisory and extension services to the farmers and producers in the region. These initiatives use and apply a variety of ICT tools and technologies (mobile phones, Internet, community radio sometimes as separate channels and sometimes through mixed media i.e., Internet through cellular telephony, video through Internet etc.) to provide information to farmers related to crop management, disease management, pest control, market prices, input application etc., on regular basis through different business models with and without intermediaries and through the initiatives of NGOs, Farmers' Organizations and Private Sector. In the last decade, rural areas in the Asia-Pacific region have witnessed proliferation of village information centres, telecentres, information kiosks, cyber cafes, community radio centre etc., with the help of several funding agencies and investors. This new type of ICT-enabled mechanism to support rural communities has indeed opened up avenues to public funded research organizations that they need to really grab to reengineer their information and knowledge systems and flows in a most effective manner to reach the farmers in the rural areas.

Box 7. Examples of ICT-enabled extension and marketing services in the Asia-Pacific region

Bangladesh – Web-based/SMS services on crop protection and production technologies by the Agricultural Information Service of the Department of Agriculture through Agricultural Information Communication Centres (AICC) at the union level; initiatives by Department of Agricultural Marketing (DAM) on market prices; and ICT interventions by organizations like Grameen, Katalyst, D-Net, Bangladesh Institute of ICT in Development (BIID), WIN Computers etc.

Bhutan – Web-based information services, interactive forums, biosecurity systems, bird flue information system and establishment of Community Information Centres (CICs) by the Ministry of Agriculture and Forests; the Virtual Extension and Research Communication Network (VERCON) that attempts to integrate agricultural research and extension with farming communities in Bhutan; and ICT-enabled agricultural market information services that provide information on sales at the six auction yards in Bhutan.

Cambodia – The LEARN-IT Project (Linking Extension and Research Needs through Information Technology) funded by Asian Development Bank (ADB) and in collaboration with Thai, Vietnamese partner institutions; and Cambodian Agricultural Market Information Service that provide price information of 21 markets through website, FM radio and SMS services.

Chinese Taipei – Agriculture Knowledge Managements Web (KMweb) that serves consumers, producers and researchers through a rich information resource base; Agriculture Mobile Service Platform using mobile technologies, GPS and GIS to integrate information, such as agriculture product trading prices, plant pest alerts and professional trainings. Farmers and the public can receive information in multiple ways, via mobile phones, FAX machine and PC/Laptops in the form of SMS, FAX, phone call and email; Micro Precise Production Control System (MPPCS) in crops that combines the cultivate information and Webcam technology for real-time counseling mechanism by experts; Agricultural Real Time Webcam Counseling Service of two-way multiple webcam counseling between 11 Centers in Agricultural Research Institute and Agricultural Research and Extension Stations and 110 Farmers' Associations and Agriculture Production and Marketing Groups.

India – Networking of 98 Research Institutes, 578 Farm Research Centers (Krishi Vigyan Kendra) in addition to 45 State Agricultural Universities (SAUs) involved in regional specific research; Web-based information services, open access to the Indian Journal of Agricultural Sciences by the Indian Council of Agricultural Research; National level projects like AGRISNET, AGMARKNET and several other successful ICT attempts by organizations such as M S Swaminathan Research Foundation (MSSRF), Gyandoot, iKisan, Warna Wired Village, Bhoomi projects; ICT-enabled services by private sector like ITC e-Choupal, TATA Kisan, Uttam Bandhan of Chambal Fertilizers etc.; Farmers Call Centre services; Connectivity of Farm Science Centres

through VSAT technology; and Information through Community Radio and Farmer Mobile Advisory Service to farmers initiated by several NGOs and private sector.

Indonesia – ASEAN Agricultural Research and Development of Information System (ASEAN ARDIS); Initiatives under the Poor Farmer's Income Improvement through Innovation Project (PFI3P), with the support of Asian Development Bank, to upgrade and create agricultural market information system of Ministry of Agriculture (MoA), a national farming website that would become a source of information and eventually a platform for agricultural trade; and Information centers at the district agriculture offices to link with the information network of MoA and disseminate information through traditional media at the local level.

Japan – Agriculture, Forestry and Fisheries Research Information Technology Center (AFFRIT) provides the Network Service System for facilitating the exchange of information on the research on a nation-wide scale; Scientific Computing System for high-speed and large-volume calculation; AGROPEDIA-a comprehensive database site widely available to agriculture, forestry, and fishery researchers; Successful examples: Arida orange database supported by the research institutes and extension organizations in the local government of Wakayama prefecture; Japan Agricultural Cooperative (JAC) Tokyo Group that gives appropriate plant protection advisory on pesticide application through PC or mobile phone; SEICA (http://seica.info) projects implemented by the NARS in Japan which helps to trace the production history of the commodities by inputting the ID number on the SEICA website. About 2,530 farmers and farms registered 10,614 products including rice, vegetables, fruits, legumes, root and tubers, spices, tea and other crops in SEICA.

Loa PDR – The Lao44 – a Coalition for Lao Information, Communication and Knowledge (CLICK) that aims to allow citizens to publicly and freely share their information; and the Lao Agriculture Database (LAD) established by the National Agriculture and Forestry Research Institute (NAFRI) in collaboration with the Thai AGRIS Center, Library of Kasetsart University (Thailand).

Malaysia – Tanyalah Doktor (Ask the Doctor) – a portal for agricultural advisory services; Several good examples of agricultural advisory and marketing platforms: e-Nelayan, e-Pengisytiharan, Agribazaar 2.0, Vessel Tracking and Monitoring System, e-Aquaculture, Supply-Demand Virtual Information (SDVI), e-permit etc., run by different government agencies; Important initiative by MARDI: myFruits, AgroBIS, E-Grading, DNA Finger Print of MRQ 74, PaddyView, Chilli Diagnostic Expert System, AgFood help agricultural R&D and extension advisory and marketing services.

Nepal – The Nepal Wireless Networking Project which connects 42 villages in rural Nepal through wireless networking meant for e-commerce (www.nepalwireless.com.np) used for Open Learning Exchange (www.olenepal.org), Tele-teaching, Tele-medicine and e-agriculture; 100 Rural Info Centres established by High Level Commission for Information Technology (HLCIT) to provide agricultural information to farmers for improving crop productivity, information about nutritional status of rural people and environment protection etc.

Pakistan – Pakistan Agricultural Research Council (PARC) developed "Pakistan Agriculture Database" containing 73000(+) records having bibliographic information with abstracts of articles/documents. It also maintains a web based "Union Database of Journals in Agricultural Libraries of Pakistan" containing information of more than 3000 journals/magazines titles with available volumes/issues in 36 libraries of Pakistan. PARC website (http://www.parc.gov.pk) provides access to databases on "Medicinal Plants of Pakistan" and "Plant Genetic Resources". Pakistan has national radio network that reaches 97% of its population is effectively used for dissemination of production technologies, farmers' awareness messages and marketing information by extension workers, private companies and scientists. An exclusive TV channel on agriculture Sonhi Dharti is very popular. Most of the departments including PARC provide toll free help line services to farmers. NGO World Foundation (Pakistan) is running e-village project http://www.ngoworldpk.com/e-village/. One of the leading mobile service providers Telenor Group also started "farmers help centre" to provide mobile service for farmers (Zuberi, 2011*).

Sri Lanka – Cyber Extension initiated by the Ministry of Agriculture that uses blend of ICT to reach the farming community through more than 85 Cyber Extension Units in the rural areas; Toll Free Agricultural Advisory Service '1920' to famers; establishment of Agro-Technology Parks; attempts such as Govi Gnana Seva – a project of eSri Lanka through ICTA Agency of Sri Lanka intended to improve market efficiency, crop planning and credit facility.

Vietnam – The Linking Extension and Research Needs through Information Technology (LEARN-IT) supported by the Asia Development Bank through International Rice Research Institute (IRRI) aimed to enrich the knowledge for rice farmers in Vietnamese language; and Vietnam-Maize-Knowledge Bank created by VAAS also created to improve production efficiency of corn, which is a second important food crop after rice in Vietnam.

Source: Country reports presented by ICM managers in the Workshop on ICT/ICM for national agricultural research information systems in the Asia-Pacific region. Proceedings, 14-16 September, 2010 held at Bangkok, (APAARI, 2010). See Annexure-II for full abstracts of the papers. * Personal communication.

The role of ICT in market related functions is increasingly gaining importance in the region. ICT applications that enable marketing functions at every stage have mushroomed in all the countries. ICT can be used as a great facilitator in agricultural marketing by providing connectivity between the producers, the market intermediaries, traders, industry and consumers through networks of national and international information systems in order to provide day-to-day information with regard to market demands, commodity arrivals and prevailing market rates etc. Most of the ICT applications are designed around the market information services, automation of market transactions, front-end and back-end market linkages, market intelligence, and commodity exchange operations. e-commerce is another emerging area of application of ICTs in agri-business sector that have totally transform the agricultural marketing systems in several developed countries. There are several initiatives by private sector agri-business companies to link commodity-based farmer interest groups or cooperative to provide one-stop-shop services to farmers.

Table 11 illustrates that ICT applications which satisfy the information needs of farmers, extension agents and agri-entrepreneurs to provide relevant market related information to enable producers participate effectively in markets are not fully developed in many agricultural research and innovation systems in the region. A majority of the developing countries are still in emerging category. The examples of ICT-based initiatives started by the governments and NGOs have been limited to projects to single locations and their upscaling, outscaling and sustainability are challenging issue. Though there have been several ICT initiatives at the village level, the participation and contribution by the public agricultural and research organizations in the region still need to be explored further to know the reason behind why these organizations don't utilize ICTs for agricultural extension and outreach activities. There is very little indication that agricultural research and innovation systems have systematically organized and structured research and innovation programs to develop and improve information systems using new ICTs. This is very much unlike what was done when radio and even TV was introduced for extension use in the region.

The application of ICTs in agricultural marketing functions across the value chain of a commodity is missing in almost all the countries with an exception to Chinese Taipei and Japan, A majority of the countries have poor ICT use or are at an emerging levels even to provide market price information inspite of all the rhetoric about how ICTs can and are improving the farming and livelihoods of farmers. This shows that these countries still need to do a lot to really apply ICTs in markets to link new information chains to innovation chains and then have effective learning about innovations so that producers can innovate and participate effectively in markets. Even the applications that support e-auctioning, on-line markets, commodity exchanges, B2B marketing, and traceability applications which only help large producers, their organizations and the private market intermediaries are almost non existing in all the countries.

There are some good examples of ICT applications that support ICT-enabled agricultural advisory and extension services in the region. However, these initiatives are mostly managed in project/pilot/

Table 11. ICT/ICM applications that enable farm advisory, extension and marketing services

	NARS	Info. needs of extension agents	Info. needs of farmers	Info. needs of Agrientrepreneurs	Networking agri. markets	Market info.	Linking farmers to markets	Input-output mgmt.	Online markets	e-Auctioning	Commodity exchanges	Treceability applications
1	Bangladesh	0	x	x	x	0	x	x	x	x	0	x
2	Bhutan	↑	↑	↑	↑	↑	0	0	x	x	x	x
3	Cambodia	↑	↑	↑	↑	↑	↑	↑	↑	x	↑	0
4	Chinese Taipei	√	√	√	√	√	√	0	√	√	√	√
5	Fiji	↑	↑	↑	↑	↑	↑	↑	0	0	0	0
6	India	√	√	↑	↑	↑	↑	↑	↑	↑	↑	↑
7	Indonesia	↑	0	0	↑	↑	↑	↑	√	x	↑	x
8	Japan	√	√	√	√	√	√	√	√	√	√	√
9	Loa PDR	x	x	x	x	x	x	x	x	x	x	x
10	Malaysia	↑	↑	↑	↑	√	√	x	√	x	x	x
11	Myanmar	↑	0	0	0	x	x	x	x	x	x	x
12	Nepal	0	0	0	0	0	↑	0	↑	x	x	x
13	Pakistan	↑	↑	↑	0	↑	0	0	0	x	x	x
14	Papua New Guinea	↑	↑	↑	0	0	↑	↑	x	x	↑	x
15	Philippines	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
16	Samoa	↑	↑	↑	↑	x	x	x	x	x	x	x
17	Sri Lanka	√	↑	↑	↑	↑	0	0	↑	0	0	0
18	Thailand	0	0	0	0	0	0	0	0	0	0	0
19	Vietnam	√	√	√	↑	↑	↑	↑	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

proof of concept mode by government departments, NGOs, communities etc. The real challenge lies in upscaling and making these initiatives sustainable at national levels. Similarly, the use of ICTs in agricultural marketing is largely steered by the private sector that are into production and supply of agricultural inputs and production of finished goods for consumers but do not contribute to the information and knowledge needs of resource poor smallholder farmers who individually do not effectively participate either at input or output level in markets. The participation of government regulated markets in ICT applications is also very limited or poor.

7.5.4 Agricultural Education

Agriculture is affected by so many factors, actors and stakeholders in its development must always be prepared to react, to adapt, and to think ahead. Is the next generation of leaders in agriculture prepared to address the increasing and ever-changing demands in agricultural systems? How can the future agricultural workforce be recruited and cultivated? Agricultural Colleges and Universities have been in the noble profession of preparing the future leaders of agriculture. Asia which is well known for its successful distance learning education in the world with millions of students enrolled for different courses in Open Universities of India and China. Such institutions must position themselves at the cutting-edge and offer students the opportunity to learn about the complexities of agriculture, grapple with its emerging challenges, and find their opportunity to contribute as leaders and actors in its development. However, there is no clear evidence about the use of ICT in agricultural colleges, universities and open universities in formal structured, on campus or off campus education or in non-formal learning. Table 12 indicates that ICT applications in the campus education, distance education and open education are either mostly emerging or poor in existence in the developing countries.

The importance of learning through use of ICT is gaining more globally with the introduction of on-line distance learning, on-line learning portals, Community of Practices, social networks etc. For example in India, agricultural courses are offered through distance learning mode by IGNOU (Indira Gandhi National Open University), a world's largest Open University, provide facility for on-line admissions, access to study material, bulletin board services, Wiki, SMS-based services to all learners. Other organizations like Yashwantrao Chavan Maharasthra Open University, Dr. Y.S. Parmar University, Annamalai University and MANAGE in India offer different distance education in agriculture. But the use of ICT in running the distance learning is minimal. Initiatives like IMARK[1] (Information Management Resource Kit by FAO and Lifelong Learning for Farmers (L3 Farmers)[2] by Commonwealth of Learning are some good examples that utilize ICTs for better delivery of learning contents to the learners in subjects related to agriculture.

[1] IMARK is a partnership-based e-learning initiative to train individuals and support institutions and networks world-wide in the effective management of information. IMARK consists of a suite of distance learning resources, tools and communities on information management. IMARK learning materials are being developed as a series of modules available online and on CD-ROM. See: http://www.imarkgroup.org/

[2] COL's L3 Farmers program helps rural communities find appropriate technology-based open and distance education to improve their livelihoods. The program revolves around: farmers, learning institutions, ICTs and Banks. Lifelong Learning for Farmers was introduced as a pilot project in four villages in Farmers in Sri Lanka in 2007. Kenya, Mauritius and Papua New Guinea. See: http://www.col.org/

Table 12. ICT/ICM applications that enable agricultural education services

	NARS	Campus education	Distance education	Online-learning	Support to Educational courses	Knowledge Repositories
1	Bangladesh	↑	0	0	0	↑
2	Bhutan	x	x	0	0	0
3	Cambodia	↑	0	0	↑	↑
4	Chinese Taipei	↑	↑	↑	↑	√
5	Fiji	√	√	↑	√	↑
6	India	↑	√	↑	↑	↑
7	Indonesia	↑	↑	↑	↑	0
8	Japan	√	√	√	√	√
9	Loa PDR	x	x	x	x	x
10	Malaysia	x	x	√	√	x
11	Myanmar	x	0	x	0	x
12	Nepal	0	0	0	0	0
13	Pakistan	√	√	0	√	0
14	Papua New Guinea	↑	↑	↑	x	x
15	Philippines	↑	↑	↑	↑	↑
16	Samoa	x	x	x	x	x
17	Sri Lanka	0	0	0	0	x
18	Thailand	↑	↑	↑	↑	↑
19	Vietnam	↑	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

7.5.5 Organizational Management

The use and application of ICT/ICM in national agricultural research and innovation systems, especially in the use of computers, local area networks, access to internet and e-mail are ubiquitous. In order to manage the organizational functions within the NARS, computer-based financial management systems, personal information systems, research inventory management systems etc., are implemented in all the offices and headquarters. However, there is poor integration between different information systems with these organizational management systems.

In other words, these organizational management systems mostly work in isolation in the national Institutes and organizations and its constituents without proper linkage with research management, scientific and technical services, program planning, cadre management and use the information flows for extension and outreach activities at the national agricultural and scientific research systems.

Table 13 indicates that many developing countries still emerging in the use of ICT for organizational management. It is also an observation that the financial management systems, personal management and research inventory management are fully developed only in a few countries and the picture is not satisfactory in majority of countries. Institutional structures, support of ICT in NARS, organizational culture and attitude of people and most importantly the investments in ICTs will decide the proper use of ICT in the organizations.

Table 13. ICT/ICM applications for organizational management systems

	NARS	Financial mgmt.	Personnel mgmt.	Farm business mgmt.	Farm/research inventory mgmt.
1	Bangladesh	0	0	x	x
2	Bhutan	↑	↑	0	↑
3	Cambodia	↑	0	0	0
4	Chinese Taipei	√	√	↑	√
5	Fiji	√	√	0	0
6	India	↑	↑	↑	↑
7	Indonesia	↑	↑	↑	↑
8	Japan	√	√	√	√
9	Loa PDR	x	x	x	x
10	Malaysia	√	√	↑	↑
11	Myanmar	x	x	x	x
12	Nepal	0	x	x	x
13	Pakistan	√	↑	x	0
14	Papua New Guinea	↑	↑	↑	↑
15	Philippines	↑	√	↑	↑
16	Samoa	x	x	x	x
17	Sri Lanka	x	x	x	x
18	Thailand	0	0	0	0
19	Vietnam	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

7.6 Information Services

An information service is a service, which collects, organizes and stores the data/knowledge/information (maybe with the help of an administrator), serves this data/knowledge/information to users. It's a combination of information technology and people's activities that support operations, management, and decision-making. In an agricultural organization, information services deals with providing processed or published information on specific topics to its internal users, its customers and general public.

The National Agricultural Information System at national level is responsible for providing such information services on research, extension and marketing aspects to scientists, extensionists, intermediaries, different stakeholder groups and farmers. Usually, a national level agricultural library and information centers attached to agricultural organizations, agricultural research information centers, premier IT organizations of the government, NGOs and other development agencies provide different types of information services to meet the information needs of different types of users. The following sections deals with availability of information services related to scientific and technical aspects, research management, extension advisory and marketing to all ARD stakeholders.

7.6.1 Scientific and Technical Information Services

Science and Technology Information (STI) Services are generally provided by agricultural libraries, attached to national agricultural research institutes, often designated as the national agricultural library and information centers. They provide different types of information services such as indexes, abstracts, catalogues, research journals, current information services, specialized information dissemination services to selected users, access to CD-ROM/on-line databases, electronic journals, virtual libraries and institutional repositories.

Table 14 shows that paper based information services that included indexes, abstracts, catalogues and research journals are reasonably established or in the process of development. The research journals at the national level are significant in publishing results of the research in all the countries. Most of the NARS undertake publishing of research journals to disseminate research findings and render information services based on scientific and research journals received in their library and information centers. The information services such as indexing of research articles appeared in the journals, abstracting of research articles are value added services and require expertise and investments. Perhaps because of this reason, these services are not fully available in less developed countries. Moreover, subscription to all relevant journals by any single organization is not possible with meager financial resources meant for collection development.

With the advent of digital information systems and the Internet, the scope of publishing has expanded to include electronic resources, such as the electronic versions of books and periodicals and scholarly journals. But the costs of these services are not affordable by any single organization. The availability of information services based on the on-line full text and electronic journals are therefore either emerging of poor in majority of the countries in the region. To enable developing countries to gain access to global scientific journals free of cost or in less cost, initiative like Access to Global Online Research in Agriculture (AGORA) (see Box 8) started by Food and Agriculture Organization is a good opportunity for developing countries in the region. Several agricultural institutions in the Asia-Pacific region are availing the AGORA facility and yet many institutions in the region need to exploit this service.

Similarly, initiative like The Essential Electronic Agricultural Library (TEEAL) (see Box 9) is a full-text database of articles in agriculture and allied subjects and it is available to the lowest income countries. The library and information centers in the Asia-Pacific region need to come forwards and make use of such initiatives to improve access to research information. At national level consortium approach to subscribe to costly international on-line databases and scientific journals for the use of all consortium members, as done in India through Consortium for e-Resources in Agriculture (CeRA) Project (http://cera.jccc.in/), is a good example that helped agricultural institutions to optimally utilize their financial resources for accessing costly on-line journals at cheaper rates.

Table 14. Scientific and technical information services

	NARS	Index service	Abstract services	Catalogue service	Research journal	Selective dissemination of info.	Current awareness service	Online full text	Electronic journals	Insti. repository	Virtual libraries
1	Bangladesh	0	x	0	√	0	0	x	x	0	x
2	Bhutan	0	0	0	↑	↑	↑	↑	0	0	x
3	Cambodia	↑	↑	↑	↑	↑	↑	0	0	0	0
4	Chinese Taipei	√	√	√	√	0	0	√	√	0	√
5	Fiji	0	0	0	0	0	0	0	↑	0	↑
6	India	√	√	√	√	√	√	√	√	↑	↑
7	Indonesia	√	√	√	√	√	√	√	√	√	√
8	Japan	√	√	√	√	√	√	√	√	√	√
9	Loa PDR	0	0	0	0	0	0	0	0	0	0
10	Malaysia	√	√	√	√	↑	↑	√	↑	↑	↑
11	Myanmar	x	x	x	0	0	0	x	x	x	x
12	Nepal	0	0	0	↑	↑	↑	x	↑	↑	x
13	Pakistan	√	√	√	√	√	√	√	√	√	√
14	Papua New Guinea	↑	↑	↑	↑	x	x	0	↑	↑	x
15	Philippines	√	√	√	√	√	√	√	√	√	√
16	Samoa	0	0	0	x	x	0	x	x	x	x
17	Sri Lanka	√	√	√	√	↑	↑	0	0	0	0
18	Thailand	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
19	Vietnam	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

Box 8. AGORA

Access to Global Online Research in Agriculture (AGORA) is a program to provide free or low cost access to major scientific journals in agriculture and related biological, environmental and social sciences to public institutions in developing countries. Launched in October 2003, the AGORA program, set up by the Food and Agriculture Organization of the UN (FAO) together with major publishers, enables developing countries to gain access to an outstanding digital library collection in the fields of food, agriculture, environmental science and related social sciences. AGORA provides a collection of 1900 journals to institutions in 107 countries. AGORA is designed to enhance the scholarship of the many thousands of students, faculty and researchers in agriculture and life sciences in the developing world. Through AGORA, researchers, policy-makers, educators, students, technical workers and extension specialists have access to high-quality, relevant and timely agricultural information via the Internet.

Many developing National Agricultural Research Systems in the Asia-Pacific Region have been availing the AGORA facility. These include premier agricultural research organizations, Agricultural Ministries and Departments, other organizations related to agricultural development, universities, colleges, information and documentation centers, libraries etc. As in 2011, the countries and number of organizations availing AGORA include: Cambodia (14), Bangladesh (59), Bhutan (17), Fiji (1), Loa PDR (6), Myanmar (8), Papua New Guinea (10) and Vietnam (132). Samoa and Sri Lanka are yet to join this service.

Source: www.aginternetwork.org/en, 2011

Box 9. TEEAL

TEEAL, or The Essential Electronic Agricultural Library, is a full-text and searchable database of articles from 200 high-quality research journals in agriculture and related sciences spanning several years. It arrives on an external hard drive that you can run on one computer workstation or make available to multiple computers via your local area network or intranet. For the past 10 years, TEEAL has been improving access at institutions with limited Internet time and/or financial resources. It is a searchable, offline, digital library which contains mainly agriculturally focused reference journals updated annually and delivered on the 1TB hard drive by Cornell University's Mann Library. This non-profit digital library includes some of the most prestigious full-text agriculture journals that leading publishers have gifted to TEEAL users. TEEAL is available to public sector and not-for-profit educational and research institutions in 116 of the lowest income countries (as listed in the World Bank's 1998-99 World Development Report) to support their agricultural development.

Some of the countries which subscribe to TEEAL in the region included: 1. Asia – Afghanistan, Bangladesh, Cambodia, Georgia, Indonesia, Iraq, Jordan, Myanmar, Nepal, North Korea (DPR), Philippines, Sri Lanka, Syria, Vietnam, West Bank/Gaza etc. 2. The Pacific – Fiji, Micronesia, Papua New Guinea, Samoa, and Western Samoa. The library and information centers of the agricultural research organizations or Ministries in these countries avail TEEAL facility.

Source: www.teeal.org, 2011

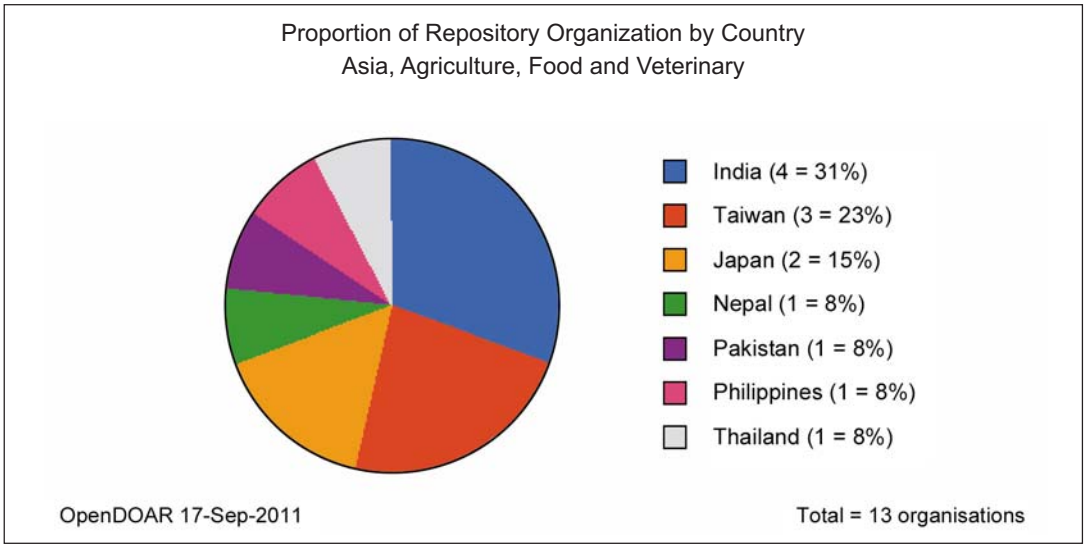
The Open Access Movement has become an increasing visible prospect for digital collections of scholarly communication. Peter Suber, an open access leader and advocate, notes that the creation of an IR can maximize the visibility and impact of materials, maximizes their researchers' access, and accelerates the transition to self-archiving, which leads to a reduction of dependence on purchasing serial packages (2007). The two main categories of Open Access (OA) are institutional repositories and journals. An Institutional Repository (IR) is an online platform for collecting, preserving, and disseminating intellectual output of an institution, particularly a research institution, in digital form. An IR is a set of services and technologies that provide the means to collect, manage, provide access to, disseminate, and preserve digital materials produced at an institution. Several open source software tools such as DSpace, Fedora, EPrint etc., are popular IR development platforms, which are widely used by institutions world over. The Open Archives Initiatives Protocol for Metadata Harvesting (OAI-

PMH) promotes interoperability to connect distant IR content through search engine capabilities. A major factor for a successful IR is to meet the universal standards of OAI-PMH in orders to make content more accessible.

Institutional repositories not only bring prestige with their presence to local communities; they bring greater value to the output of research and accompanying materials. Libraries play a leading role in the IR effort. Though there are good initiatives of institutional repositories in agriculture created by some advanced institutions the scenario is not encouraging in all the countries in the region. These initiatives have been largely taken up as project works and limited to some digital resources within an institute. The *OpenDOAR*[1] , an authoritative directory of open access repositories, indicates that there are hardly 13 organizations, which developed institutional repositories in the field of agriculture, food and veterinary in the Asia-Pacific region (Figure 17).

This reveals that launching an IR is not a small endeavor. Creating enabling environment in institutions that promote policy support, IPR issues, strategies for content management, preservation, access issues, capacities of staff besides investment of resources both in terms of money and staff are crucial for successful development and maintenance of an IR.

Figure 17. Agricultural Institutional Repositories in the Asia-Pacific Region



Source: http://www.opendoar.org/, 2011

[1] The OpenDOAR (http://www.opendoar.org/) service provides a quality-assured listing of open accessrepositories around the world. It maintains a comprehensive and authoritative list of institutional and subject-based repositories. Users of the service are able to analyse repositories by location, type, the material they hold and other measures. OpenDOAR is maintained by SHERPA (Securing a Hybrid Environment for Research Preservation and Access) Services (http://www.sherpa.ac.uk), based at the Centre for Research Communications at the University of Nottingham.

7.6.2 Research Management Information Service

The management and governance of agricultural research depends on high quality information services. It is very important for institutions to change work processes, monitoring & evaluation of projects, management of outputs etc. Research management information is made available in the form of databases, GIS data, crop models, knowledge-based/decision support systems, and information on research programs, projects and experts. The development of these information services requires application of ICTs and greater collaboration and partnerships. Table 15 shows that except advanced countries like Chinese Taipei and Japan all other countries are in emerging stage with regard to availability of these information services. The lack of research management information may perhaps due to high level of human expertise and investment that is needed in generating such decision-making information; and collaboration among different subject expertise is not so easy task to cultivate in the least developed countries.

7.6.3 Farm Advisory and Extension Information Services

There has been tremendous growth of innovative partnership (public-private-community) initiatives in using ICT-based agricultural information and providing advisory and extension information services to all stakeholders including farmers. These initiatives use and apply a variety of ICT tools and technologies (mobile phones, Internet, community radio, mass media like television channels and sometimes through mixed media i.e., internet through cellular telephony, video through Internet etc.) to provide information to farmers related to crop management, disease management, pest control, market prices, input application etc., on regular basis through different business models with and without intermediaries and through the initiatives of NGOs, Farmers' Oganizations and Private Sector. In the last decade, rural areas in the Asia-Pacific region have witnessed proliferation of village information centers, telecentres, information kiosks, cyber cafes, community radio center, farmers call centers, on-line help to farmers etc., with the help of several funding agencies and investors. This new type of ICT-enabled mechanism to support rural communities has indeed opened up avenues to public funded research organizations that they need to really grab to reengineer their information and knowledge systems and flows in a most effective manner to reach the extension workers and farmers in the rural areas.

Table 16 shows that agricultural advisory and extension information services are provided efficiently through television live programs in all the countries. It was observed that though there are good examples of ICT-enabled advisory and extension information services, these initiatives are mostly managed in project mode by governments, NGOS or communities. The important services like toll free Farmers Call Centers started in some countries are no doubt useful to address immediate problems of farmers and extension workers, but their performance in providing timely, authentic and responsive information service is not adequate to meet the information needs of farmers.

7.6.4 Market Information Services

The relevance of market information services is increasing as agriculture is becoming more and more market linked. The flow of information across innovation chains and its linkage with market chains is crucial for maximizing profits to producers and to ensure quality food at reasonable price to consumers. Market information enables farmers to make informed decisions about what to grow, when to harvest, to which markets produce should be sent and whether or not to store products. Famers need information on markets prices, market intelligence, and market forecasting etc., to sell their produce for better incomes in the competitive markets. Whereas consumers also need important

Table 15. Research dara and research management information services

	NARS	Research databases	GIS services	Weather and crop models	Expert/ DSS	Knowledge banks	Info. services on research institutions	Info. services on programs	Info. services on projects	Info. services on experts	Info. services on project outputs
1	Bangladesh	↑	↑	↑	x	x	x	x	x	x	x
2	Bhutan	↑	x	x	x	x	↑	√	√	√	↑
3	Cambodia	↑	↑	0	x	↑	↑	↑	↑	↑	↑
4	Chinese Taipei	√	√	√	√	√	√	√	√	√	√
5	Fiji	0	0	0	0	0	↑	0	0	0	0
6	India	↑	√	↑	↑	↑	↑	↑	√	↑	↑
7	Indonesia	√	↑	↑	↑	x	√	√	√	√	√
8	Japan	√	√	√	√	√	√	√	√	√	√
9	Loa PDR	0	0	0	0	0	x	x	x	x	x
10	Malaysia	↑	↑	√	↑	↑	√	√	↑	√	↑
11	Myanmar	x	x	x	x	x	0	x	x	x	x
12	Nepal	0	0	0	0	0	0	0	↑	↑	↑
13	Pakistan	↑	↑	↑	x	↑	0	0	↑	0	↑
14	Papua New Guinea	↑	↑	x	x	x	↑	↑	↑	↑	↑
15	Philippines	√	↑	↑	↑	↑	↑	↑	√	√	√
16	Samoa	x	x	x	x	x	0	0	0	x	x
17	Sri Lanka	↑	0	√	0	x	√	√	√	√	0
18	Thailand	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
19	Vietnam	↑	↑	↑	↑	↑	√	√	√	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

Table 16. Farm advisory and extension information services

	NARS	Online help to extension workers	Online documents to farmers/ extension workers	FAQs to farmers	Help desk services	Pest and dsease diagnosis	Farmers call center	Live TV programs	Village information centers	ICT-enabled extension services	Weather information services	Decision support services
1	Bangladesh	x	x	x	x	0	↑	↑	x	0	√	↑
2	Bhutan	√	√	√	↑	↑	x	↑	↑	↑	0	x
3	Cambodia	x	0	↑	0	0	0	↑	0	0	↑	x
4	Chinese Taipei	√	↑	√	↑	√	√	√	0	√	√	↑
5	Fiji	↑	↑	↑	√	↑	√	↑	↑	↑	↑	↑
6	India	√	√	√	↑	↑	√	√	↑	√	√	↑
7	Indonesia	√	√	↑	√	√	√	√	√	√	√	√
8	Japan	√	√	√	√	√	√	√	√	√	√	√
9	Loa PDR	x	0	x	x	x	x	↑	0	x	0	x
10	Malaysia	↑	↑	↑	↑	↑	↑	√	√	√	↑	↑
11	Myanmar	x	x	x	x	x	↑	↑	x	x	↑	x
12	Nepal	0	0	0	0	0	0	√	↑	0	↑	0
13	Pakistan	√	√	√	√	√	√	√	↑	↑	√	↑
14	Papua New Guinea	x	0	0	↑	↑	0	↑	↑	0	↑	x
15	Philippines	√	√	√	√	↑	√	↑	√	√	√	√
16	Samoa	0	x	↑	0	0	0	↑	x	x	↑	0
17	Sri Lanka	√	√	√	√	√	√	↑	√	√	↑	↑
18	Thailand	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
19	Vietnam	↑	↑	↑	↑	√	↑	√	√	↑	√	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

information related to quality, standards, price information, traceability information of a product. There are several intermediaries, traders, industry and consumers etc., who also need market related information in time to take better decisions. The role of ICT in market related functions is increasingly gaining importance in the region. ICT applications that enable marketing functions at every stage have mushroomed in all the countries (see section 7.5.3). ICT can be used as a great facilitator in agricultural marketing by providing connectivity between the producers, the market intermediaries, traders, industry and consumers, through networks of national and international information systems in order to provide day-to-day information with regard to market demands, commodity arrivals and prevailing market rates etc. There are several initiatives by private sector agri-business companies to link commodity-based farmer interest groups or cooperative to provide one-stop-shop services to farmers.

Table 17 illustrates that ICT information service on market prices is available through Internet platform in developed countries and it is still emerging in majority of the least developed countries. The value added information services such as market intelligence and advisory services based on market forecasting are fully developed in almost all the countries with exception to countries like Japan and Indonesia. There are initiatives in some countries like India, Malaysia and the Philippines aimed at providing information on market prices, intelligence information services to farmers. But these attempts are limited and do not cover all the commodities and markets. Information services targeted to agri-processors and consumers is still evolving. Information to consumers is well established in countries like Chinese Taipei, Japan and Indonesia. The application of ICTs in agricultural marketing functions across the value chain of a commodity is missing in almost all the countries with an exception to Chinese Taipei and Japan. A majority of the countries have poor ICT use even to provide market price information inspite of all the rhetoric about how ICTs can and are improving the farming and livelihoods of farmers. This shows that these countries still need to do a lot to really apply ICTs in markets to link new information chains to innovation chains and then have effective learning about innovations so that producers can innovate and participate effectively in markets.

7.7 Information and Communication Channels

Information and communication channel refers to medium through which a message is transmitted to its intended audience, such as print media or broadcast (electronic) media. With the advances in telecommunications and computer technologies, the powers of sharing data/information/knowledge have transformed the way institutions and individuals interact and share information.

The new ICT platform such as Internet-based communications, websites, e-mail systems, electronic discussion groups, teleconferencing, videoconferencing, SMS-based services, mobile communications, Web 2.0, social media have opened up new frontiers in communications both within and outside the organizations. The new online channels allow information to flow freely between researchers and between researchers and the general public. All most all the NARS in the region developed their websites and offer basic information on their activities and programs on regular basis. A look at these website reveal that some of the advanced institutions introduced value added information services through their website which promote dissemination of dynamic information, interaction, and dialogue with the users.

Table 18 shows that all the NARS established websites and e-mail based communication systems for dissemination and communication purposes. It shows that only the developed NARS could use intranet services, discussion forums, and electronic document management systems to effectively use communication channels for greater impact of their research outputs. Use of teleconferencing,

Table 17. Market information services

	NARS	Market price information thru internet	Market intelligence and forecasting	Market advisory services to farmers	Market info. service to processors	Market info. to consuments	Info. on traceability of agri. produce
1	Bangladesh	x	x	x	0	0	0
2	Bhutan	↑	0	↑	↑	↑	0
3	Cambodia	↑	↑	↑	↑	↑	↑
4	Chinese Taipei	√	↑	0	↑	√	√
5	Fiji	↑	↑	↑	↑	↑	0
6	India	√	↑	↑	↑	0	↑
7	Indonesia	√	√	√	√	√	√
8	Japan	√	√	√	√	√	√
9	Loa PDR	0	x	0	0	0	0
10	Malaysia	√	↑	↑	↑	↑	↑
11	Myanmar	x	x	x	x	x	x
12	Nepal	↑	0	0	0	↑	x
13	Pakistan	√	0	↑	0	0	0
14	Papua New Guinea	x	↑	↑	↑	↑	↑
15	Philippines	↑	↑	↑	↑	↑	↑
16	Samoa	x	↑	0	0	x	x
17	Sri Lanka	√	0	0	↑	x	x
18	Thailand	↑	↑	0	0	0	0
19	Vietnam	↑	↑	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

videoconferencing, SMS-based services and community of practice are exploited by countries like Chinese Taipei, India, Indonesia and Japan partly for effective communications with their stakeholders. Effective information and communication can no longer be seen as information dissemination alone. It's a two-way process involving participation of all stakeholders. The first step in the process of efficient use of information and communication channels is to have a communication strategy. A good communication strategy identifies target audiences, assesses users' information needs, determines which communication channels and tools are well suited and proposes a communication plan for implantation. It was noticed that a very few NARS and its constituent institutions in the region have such communication strategies for better use of new information and communication channels to address the needs of their audiences. Therefore, these institutions need to develop suitable communication strategies in order to use new information and communication channels efficiently and effectively to take results of their research to all stakeholders for ensuring intended impact in knowledge, attitude and actions.

Table 18. Information and communication channels used by NARS

	NARS	Intranet services	Internet services	E-mail services	Website	Electronic lists	Discussion forums	EDMS	Teleconf.	Videoconf.	SMS-based services	Community of practice
1	Bangladesh	x	√	√	√	0	0	0	x	x	x	0
2	Bhutan	↑	√	√	√	↑	√	0	↑	↑	↑	0
3	Cambodia	↑	↑	↑	↑	↑	0	↑	x	x	↑	↑
4	Chinese Taipei	√	√	√	√	√	√	↑	0	√	√	0
5	Fiji	√	↑	√	√	↑	↑	↑	0	0	↑	↑
6	India	√	√	√	√	√	↑	↑	↑	√	√	↑
7	Indonesia	√	√	√	√	√	√	√	√	↑	√	√
8	Japan	√	√	√	√	√	√	√	√	√	↑	√
9	Loa PDR	x	x	0	0	0	0	x	x	0	0	0
10	Malaysia	√	√	√	√	√	√	√	↑	↑	↑	↑
11	Myanmar	0	0	√	√	↑	0	↑	0	0	0	0
12	Nepal	x	↑	√	√	0	0	x	x	x	x	0
13	Pakistan	√	√	√	√	√	↑	√	↑	↑	√	↑
14	Papua New Guinea	↑	↑	↑	↑	↑	0	↑	x	↑	↑	↑
15	Philippines	√	√	√	√	√	√	√	√	√	√	√
16	Samoa	x	0	0	0	0	x	x	x	x	x	x
17	Sri Lanka	√	√	√	√	√	√	↑	0	0	↑	0
18	Thailand	↑	↑	↑	↑	↑	↑	0	0	0	0	0
19	Vietnam	↑	↑	↑	↑	√	↑	↑	↑	↑	↑	↑

Symbols and Colour Codes Used: **Developed =** √, **Emerging =** ↑, **Poor =** 0, **Not exists =** x

CHAPTER 8

Conclusion

"Well, in our country," said Alice, still panting a little, "you'd generally get to somewhere else – if you run very fast for a long time, as we've been doing."

"A slow sort of country!" said the Queen. "Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

– Red Queen's Race – Alice Through the Looking Glass.

This episode from the Lewis Carrol's classic "Alice Through the Looking Glass" aptly sums up the dilemma facing the development of ICM for agricultural research and innovation systems and also for agricultural development in most of the Asia-Pacific region. They have to run faster and faster just not to keep up but progress rapidly in development as their increasing populations expect and need to improve livelihood, reduce poverty and eliminate hunger. Huge proportions of their population depend on agriculture directly or indirectly and there is no alternative for them to develop their agriculture and related businesses, services and industry. The previous paradigm of evolving from agriculture to manufacturing and services sectors for economic growth is now not true. There is recognition that agricultural, manufacturing and service sectors should develop together and in an interacting manner each enabling the other's growth. A large part of today's developed countries economies are contributed by agriculture, agri-business, agro-industries and agro-services – a fact not very widely broadcasted. The new paradigm of interdependent agriculture-service-manufacturing economies are just being recognized and are apt to be further accepted as advances in biotechnology, nanotechnology, ICTs, space sciences and material sciences increase their contribution in the amalgamation and integration of bio-industries, manufacturing and services.

The report reveals the perception among ICM managers and national representatives that the application of ICT in agricultural research, extension, marketing, education, library services and organizational management has considerably improved over a decade. However, these perceptions also reveal that poor and less developed countries are lagging behind in using more advanced ICTs such as for database management, modeling, GIS and remote sensing, knowledge based systems and for agricultural research management. It is found that the use and application of ICT in extension, outreach and marketing services have considerably expanded due to interventions by governments, private sector, NGOs and other agencies especially in developing countries to empower people with knowledge but they have problems in upscaling, outscaling and sustainability. Though there are bright spots here and there, it is challenging to outscale these successes to national level in case of big countries with several complexities such as of culture, language, soci-economic conditions etc. The use of ICTs in agricultural education needs large investments and initiation by the universities and academic institutions to create digital course content, teaching and learning, assessments etc., so as to offer on-line courses for spreading the agricultural education to the masses. This shows there is great need for mainstreaming ICT applications in agricultural research and innovation systems in the region.

This report reveals that in the face of an agriculture that is becoming increasingly knowledge intensive, there is a growing divide between the more economically developed and developing countries in the region in a primary and core capacity for agricultural development; the ability of national systems for agricultural research and innovation to provide information and enable learning to actors for agricultural development.

The reasons for this growing divide are the lack of leadership, possibly also political commitment, investment both in financial and in human capacities, inability to generate new knowledge or make it available, accessible, applicable and useful to learning and use by agricultural communities. There is clear lack of ability to integrate information systems and information usefully for actors in agricultural development to effectively and efficiently use it. There is an inability to develop more inclusive information systems based on social networks and media and new Web and cellular telephony based technologies. The use of these technologies have huge potentials for contributing to economic, social and political development of communities and for retarding and improving the environment as also bring greater efficiencies in use of natural resources.

Most national systems for agricultural research and development have very weak coordination in developing, implementing, operating and managing their information systems. They lag behind, sometimes by a few generations, in implementing new concepts and technologies to improve their information services, which in a very rapid developing area is fatal for the usefulness of these systems. There is an urgent need for transforming these systems at various levels, in the policies, strategies, structures and work processes so that they are more focused on generating the primary output, new knowledge, that is relevant, useful and effective in impact of agricultural and their country's overall development.

Many national systems do not also recognize that in an interconnected world facing common challenges of climate change, water scarcity, increasing desertification, spread of trans-boundary disease, loss of agro-biodiversity and the growing need for their producers to participate in globally competitive markets, they have a responsibility to the world to improve and further develop their information systems related to agriculture and contribute jointly to meeting these challenges. Today, sharing of data, tools and applications is needed to apply advances in biotechnology, nanotechnology, space sciences, metrology, material sciences and also ICTs to meet these challenges. Countries with lesser capacities to share information and knowledge will have lesser capacities to participate effectively in the emerging knowledge based global economy and will therefore suffer not only economic but social and political adverse effects.

The solutions for improving ICM in national systems for agricultural research and innovation in the region lie in:

- **Increased political commitment to transform AR4D systems** with appropriate policies and strategies. The GCARD Roadmap provides the generic direction for transforming AR4D systems that may be adopted and adapted to meet national needs.
- **Increased, improved and targeted investment**, both financial and in human skills and capacities, in information and communications management for agricultural development at the national level through appropriate policies, strategies and structures.
- **Development of capacities** in information and communications management as related to agriculture and its development. This includes infrastructure, hardware, software, connectivity, skills, generation of new content that is structured, organized and interoperable within and across research and innovation and information systems,

improving coordination of information flows and systems and enabling effective learning from information made available and accessible through use of new ICTs.

- **Improving governance of agricultural information systems** at the national level including those of national systems of agricultural research and innovation systems.
- **Enabling greater sharing of data, information objects and information** across Institutes and research organization and information systems at national, regional and global levels. There are several activities at the regional such as of APAARI and at the global level of GFAR, FAO, CGIAR and CIARD partners that contribute to improving national, regional, international and global ICM capacities and sharing and exchange of information. National systems should use these regional and international activities to support development of their ICM abilities.

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Annexures

Annexure-I

Status of ICT/ICM in AR4D in Asia-Pacific Region					
Questionnaire					
Country:					
NARS:					
A. INFRASTRUCTURE, INFORMATION SYSTEMS, POLICY, INTEGRATION, CONTENTS, AND APPLICATIONS					
Sl. No.	**Area**	**Status**			
		Not exists	**Very poor**	**Emerging**	**Developed**
INFRASTRUCTURE INDICATORS					
	Hardware				
1	Electricity				
2	Telephone				
3	Cellular phones				
4	Fax				
5	Computer systems				
6	Video equipment				
7	Computer peripherals				
8	Radio station & Broadcast facility				
9	Community Radio				
10	TV studio and Broadcast				
11	Network equipment				
12	Webserver				
13	Mail server				
14	Internet				
15	Videoconferencing				
16	Any other:				
	Software				
17	Operating System(s)				
18	Office automation suites				
19	Application software				
20	Open Source Software				
	Connectivity				
21	Local Area Network (LAN)				

Sl. No.	Area	Status			
		Not exists	Very poor	Emerging	Developed
22	Wide Area Network (WAN)				
23	Virtual Private Network (VPN)				
24	Intranet				
25	Internet: mention type of connectivity				
26	Bandwidth facility				
27	Wireless connectivity (Wi-Fi)				
28	Cellular telephone				
29	Satellite communication				
30	Mobile satellite vehicles				
	Skills				
31	Basic Computing				
32	Internet and e-mail access				
33	Programming				
34	Database management				
35	Netwok management				
36	Website management				
37	Content creation with different tools				
38	Multimedia production				
39	Data analysis and interpretation				
40	HRD policy for ICT/ICM in Organization				
	INFORMATION SYSTEM INDICATORS				
41	Netwoked information sharing in the Organization				
42	Website domain				
43	E-mail domain				
44	Use of Content Management System				
45	Use of Wiki				
46	Use of RSS feeds of website content				
47	Maintenance of Organizational blog				
48	Use of Web 2.0 technologies				
49	ICM Policy at Organizational level				
50	ICT/ICM Strategies in the Organization				
51	Maintenance of Metadata Standards				
52	Following of ICT/ICM rules and norms				

Sl. No.	Area	Status			
		Not exists	Very poor	Emerging	Developed
53	Separate provision for investment in ICT/ICM in the Organization				
	INTEGRATION INDICATORS				
54	Centralized ICM Coordination Unit				
55	Appointment of a Group or Experts for ICT/ICM activities in the Organization				
56	Adoption of global standards in managing ARD information resources				
57	Implementation of Information System Security				
58	Implementation of Intellectual Property Rights				
	CONTENT INDICATORS				
	Scientific and Technical Information				
59	Catalogues				
60	Indexes				
61	Abstracts				
62	Bibliographies				
63	CD-ROM Databases				
64	On-line Databases				
65	Electronic journals				
66	Institutional repository				
67	Institute wide ICT-enabled Information				
68	Open Archives Initiatives (OAI)				
	Research Data, Analytical Tools and Information				
69	Research Databases – mention areas (genetic resource management; natural resources management; disease suveillance; farming systems management)				
70	Crop models				
71	Geographic Information Systems (GIS)				
72	Knowledge-based Systems/Decision Support Systems				

Sl. No.	Area	Status			
		Not exists	Very poor	Emerging	Developed
	Research Management Information Systems				
73	Information on projects				
74	Information on location				
75	Information on experts				
76	Information on funding				
77	Information on priority setting and need Assessment				
	APPLICATIONS INDICATORS				
	Scientific and Technical Information System Applications				
78	Library Automation				
79	Library and Information Networks				
80	Web-based on-line library catalogues				
81	Circulation of electronic and hard copies				
82	Search on website content				
83	Access to virtual libraries				
84	On-line search for databases				
85	Access to electronic journals				
86	Access to open source journals				
87	Access to information through consortiums				
	Research Data, Analytical Tools and Applications				
88	Research Databases				
89	Modelling				
90	Geographic Information Systems (GIS)				
91	Precision agriculture applications				
92	Knowledge-based Systems/Decision Support Systems				
	Research Management Information System Applications				
93	Management of Institutes				
94	Management of Research Programs				

Sl. No.	Area	Status			
		Not exists	Very poor	Emerging	Developed
95	Management of Projects				
96	Management of outputs and experts information				
	Farm Advisory & Agricultural Extension Information				
97	Management of Information needs of Extension Agents				
98	Management of Information needs of farmers				
99	Management of Information needs of Agri-entrepreneurs				
	Agricultural Marketing Information System Applications				
100	Networking agricultural markets				
101	Management of Market Information				
102	Linking farmers to markets				
103	Input-Output management				
104	On-line marketing				
105	e-Auctioning applications				
106	Commodity Exchages				
107	Traceability applications				
	Education Information System Applications				
108	Management of campus education				
109	Management of distance education				
110	On-line learning/education				
111	Support to educational courses				
112	Management of Repositories of Learning Objects/Resources				
	Applications for Organization Management and Administrative Information System				
113	Financial management				
114	Personnel management				
115	Farm business management				
116	Farm and Research Inventory management				

Sl. No.	Area	Status			
		Not exists	Very poor	Emerging	Developed
B. INFORMATION AND COMMUNICATION SERVICES					
	Scientific and Technical Information Services				
117	Indexing service				
118	Abstracting service				
119	Cataloguing services				
120	Research Journal				
121	Selective Dissemination of Information (SDI)				
122	Current Awareness Service (CAS)				
123	On-line full text service				
124	Electronic journals service				
125	Institutional repository service				
126	Virtual Libraries service				
	Research Data and Information Service				
127	Research Databases. (mention)				
128	GIS applications. (mention)				
129	Weather and Crop models				
130	Expert/Decision Systems. (mention)				
131	Knowledge Banks. (mention)				
	Research Management Information Service				
132	Information service on research institutions				
133	Information service on programs				
134	Information on research projects				
135	Information service on experts				
136	Information service on project output				
	Farm Advisory & Agricultural Extension Information Services				
137	On-line help to Extension Workers				
138	On-line documents or guides to farmers and extension workers				
139	FAQs to farmers				
140	Help Desk service				
141	Pest and Deisease Diagnestic services				

Sl. No.	Area	Status			
		Not exists	Very poor	Emerging	Developed
142	Farmers Call Centre service				
143	Live Television Programs for farmers				
144	Village information centres				
145	ICT-enabled extension services				
146	Weather information service				
147	Decision support system services				
	Agricultural Marketing Information Services				
148	Market price information through Internet/website				
149	Market intelligence and forecasting				
150	Market advisory service to farmers				
151	Market information service to processors				
152	Market information service to consumers				
153	Information on traceability of agricultural produce				
	Information and Communication Channles				
154	Intranet services				
155	Internet services				
156	E-mail service				
157	Website				
158	Electronic lists				
159	Discussion forums				
160	Electronic Document Management System (EDMS) services				
161	Teleconferencing services				
162	Videoconference services				
163	SMS-based services				
164	Community of Practices				

Annexure-II

Abstracts of Country Reports on the Status of ICT/ICM in Asia and the Pacific Region

APAARI, the Global Forum on Agricultural Research (GFAR) and the Food and Agriculture Organization (FAO) jointly organized a three-day "Workshop on ICT/ICM for National Agricultural Research Information Systems in the Asia-Pacific Region" on 14-16 September 2010 at the Asian Institute of Technology, Bangkok. The objectives of the workshop included orientation of participants to the potential opportunities of new ICT/ICM for AR4D; orientation on Coherence in Information for Agricultural Research for Development (CIARD) initiative and equip them to contribute to the CIARD Roadmap to Information Nodes and Gateways (CIARD RING); and identification of mechanisms to strengthen Asia-Pacific Agricultural Research Information System (APARIS) for efficient exchange of data, knowledge and technologies in the region and present the status of ICT/ICM in AR4D in the Asia-Pacific region. Twenty one Senior Information and Communication Managers of the National Agricultural Information Systems (NAIS) representing the National Agricultural Research Systems of 17 countries from the Asia-Pacific region and representatives from SAARC Agriculture Centre (SAC) attended the workshop.

The workshop provided opportunity to Information and Communication Managers of NAIS to present the country reports on the status of ICT/ICM in AR4D followed by discussions on each country paper. This report depended on the qualitative information of country status reports presented by the ICM managers besides data collected through a questionnaire survey. The following section gives informative abstracts of the country reports:

1. SAARC Agriculture Centre (SAC), Bangladesh

Ms. Nasrin Akter, Senior Program Officer, SAC

SAARC Agriculture Centre (SAC) (renamed from SAARC Agricultural Information Centre, SAIC) is the first regional Centre under the South Asian Association for Regional Cooperation (SAARC). The Centre has been given an enhanced mandate for agricultural research and development, policy planning, and knowledge management. The paper presented indicated the program building and implementation process followed by SAC and shared full details of on-going and future programs. Presentation shared information on important information resources and services that include database of agricultural institutions, experts in SAARC countries and Agricultural Bibliographic Information Service (ABIS) based on the major CD-ROM databases (AGRIS, AGRICOLA, BEAST, Biological abstract, CAB abstract, TEEAL, AGORA etc.) through e-mail request to SAARC member countries. It emphasized the efforts of SAC in ICTs for agricultural development in the SAARC region and highlighted its future initiatives in the areas of exchange of best practices in rural entrepreneurship, marketing information systems and knowledge-based technology forecasting etc. SAC's presentation also briefed about its willingness to collaborate with APAARI and other regional organizations for partnership programs.

2. Bangladesh Agricultural Research Council (BARC), Bangladesh

Mr. Rafique Mostafa Kamal, Agricultural Information Centre, BARC

The paper presented the status of ICT/ICM in Agricultural Research for Development in Bangladesh. It briefed in details about the present National Agricultural Research and Extension Systems under the Bangladesh Agricultural Research Council (BARC) and its constituencies. It explained that almost all the NARS institutions have established Local Area Networks, websites, e-mail systems and provides information services on crop management, agricultural technologies, information on animal diseases, poultry and fisheries besides several databases on agricultural organizations, technologies and attempted to explain the role of Agricultural Information Centre (AIC) of BARC. The paper highlighted the ICT/ICM initiatives implemented by the Agricultural Information Service of the Department of Agriculture through ICT enabled web-based/SMS services on crop protection and production technologies at the community level through Agricultural Information Communication Centres (AICC) at the Union level. It also shared some of the important ICT initiatives by Department of Agricultural Marketing (DAM) on agricultural marketing information to farmers and other stakeholders; initiatives by organizations such as Grameen, Katalyst, Bangladesh Institute of ICT in Development (BIID), WIN Computers, D-Net etc. were also discussed.

The paper emphasized that there is a need for improving capacities of information mangers on modern ICTs and suggested to have coordination between IT professionals and information managers. It finally suggested that APAARI should undertake capacity building and training programs on new technologies for information management and studies to analyze the impact of existing services for further improvement of information services.

3. Ministry of Agriculture & Forests, Bhutan

Mr. Motiraj Gurung, Deputy Chief ICT Officer and Webmaster, Information and Communication Services, Ministry of Agriculture & Forests

It highlighted that role of ICTs is indeed significant in reaching the farmers in the villages which are scattered across very difficult terrains in Bhutan. The paper describes different ICT initiatives of the Ministry of Agriculture and Forests, The Royal Government of Bhutan which included web-based information services, interactive forums, biosecurity systems, bird flue information system and establishment of Community Information Centres (CICs) etc. It highlighter the efforts such as Virtual Extension and Research Communication Network (VERCON) that attempts to integrate agricultural research and extension with farming communities in Bhutan and ICT-enabled agricultural market information services that provide information on sales at the six auction yards in Bhutan. The presentation opined that real challenge is in reaching the farmers in remote and difficult terrains in Bhutan for which more investment, human resources and coordination between organizations are needed in order to harness ICTs for agricultural development besides other infrastructure development such as roads, electricity etc.

4. Cambodian Agricultural Research and Development Institute (CARDI), Cambodia

Mr. Mom Sovanna Deputy Head of Training and Information Center, CARDI

The paper indicated the role of National Information Communications Technology Development Authority (NiDA) and Council for Agricultural and Rural Development (CARD) in promoting use of

ICTs for rural and agricultural development in Cambodia. It presented the Cambodian Agricultural and Rural Development information Gateway (CARDiG) established by CARD to provide a portal for information sharing on agriculture and rural development and boost information and knowledge management on agricultural and rural development among stakeholders through better access to web-based information. Initiatives such as the LEARN-IT Project (Linking Extension and Research Needs through Information Technology) funded by Asian Development Bank (ADB) and in collaboration with Thai, Vietnamese partner institutions that aimed to improve the food security and incomes, and enhance the livelihoods of poor farmers in Cambodia. The LEARN-IT is instrumental in transferring new technologies to farmers by empowering farmer intermediaries to effectively use information and communication technologies. It highlighted the Cambodian Rice Knowledge Bank (CRKB) initiative which provides information through different forms such as CD, website and printed documents in 15 provinces and Cambodian Agricultural Market Information Service that provide price information of 21 markets through website, FM radio and SMS services. It pointed that important challenges for implementation of ICTs in agriculture include lack of Internet connectivity, language barrier and inadequate human resources.

5. Council of Agriculture (CoA), Chinese Taipei

Mr. Jian-Chih Chiu, Technical Specialist, CoA

The paper presented important advances in ICT in agricultural development in Chinese Taipei with regard to use of ICTs in improving contents of agricultural information, food safety and agricultural knowledge management, increasing food production and efficiency of government services. It shared that in line with the rapid development of information and communication technology and the Internet, the department is exploiting ICTs to speed up the exchange of agricultural information and create a technology-based information system and hoped that ICTs would link the entire agricultural chain and will improve production and processing, and inspire the development of new products, new services and new outlets. The presentation highlighted functioning of Agriculture and Food Traceability System that helps consumers to easily track the traceability records and information when they buy the products; Agriculture Knowledge Managements Web (KMweb) that serves consumers, producers and researchers through a rich information resource base containing 40 thousands of agriculture knowledge documents and more than 70 thousands of video clips and photos; Agriculture Mobile Service Platform using mobile technologies, GPS and GIS to integrate information, such as agriculture product trading prices, plant pest alerts and professional trainings. Farmers and the publics can receive information in multiple ways, via mobile phones, FAX machine and PC/Laptops in the form of SMS, FAX, phone call and e-mail. Micro Precise Production Control System (MPPCS) for Lychee that combines the cultivate information and Webcam technology is used for real-time counseling mechanism by experts; Agricultural Real Time Webcam Counseling Service provides two-way multiple webcam counseling between 11 Centers in Agricultural Research Institute and Agricultural Research and Extension Stations and 110 Farmers' Associations and Agriculture Production and Marketing Groups. It was pointed that most of the farmers are smallholder farmers and not familiar with modern technologies such as Internet that causes major challenge to develop and implement ICTs in agriculture. It opined that there farmers need highly professional information in agricultural production and business management.

6. Ministry of Primary Industries (MPI), Fiji

***Ms. Riteshni L. Singh, Acting Senior Information Officer, Information & Communication* Section, MPI**

The paper indicated the status of ICT/ICM in agriculture in Fiji with reference to on-going efforts of the Ministry of Agriculture through different channels that include websites, print, radio, television and other electronic media to disseminate agricultural information. It highlighted the radio programs in Fijian and Hindi languages, television magazine programs, Government's Information & Referral Centre and Agriculture Ministry's Agri-Help Desk. It noted that extension officers are using laptops to access latest information to help farmers. The paper pointed out that the Fiji is facing several challenges such as lack of connectivity, lack of ICT infrastructure, lack of systems for sharing databases and information, low capacities in ICTs and computer illiteracy. It envisaged that use of mobile phones for agricultural marketing information services initiated by Secretariat for the Pacific Community funded by the EU and promotion of Public-Private Partnerships in sharing agricultural information and knowledge will be undertaken in the near future. It concluded that the Government is supporting the use of ICT for AR4D through its policies, capacity building programs and strengthening ICT initiatives to generate, manage and disseminate information and suggested that APAARI may assist in sharing information and knowledge resources through networking arrangements.

7. Indian Council of Agricultural Research (ICAR), India

Dr. T.P. Trivedi, Project Director, Directorate of Information and Publications of Agriculture (DIPA), ICAR

It illustrates the functioning of the Indian Council of Agricultural Research (ICAR) with its wide network of 98 Research Institutes and 578 Farm Research Centers (Krishi Vigyan Kendra) in addition to 45 State Agricultural Universities (SAUs) involved in region specific research and academic pursuits. It noted that ICT is playing a key role in agricultural growth and development in the country by providing timely and useful information in a demand-driven mode. The papers shares many successful initiatives by the ICAR that include web-based information services, open access to the Indian Journal of Agricultural Sciences, experiences of AGRISNET, AGMARKNET and several other ICT initiatives implemented by organizations such as M S Swaminathan Research Foundation (MSSRF), Gyandoot, iKisan, Warna Wired Village, Bhoomi projects in India. It mentioned several new initiatives such as Agropeadia which developed 11 knowledge models and uses them for tagging and searching the repository objects; e-Granth project aimed at creating Online Public Access Catalogue (OPAC) under Indian Agricultural Research Group Catalogue of all 12 library resources with Online Computer Library Centre (OCLC) partnership; Consortium for e-Resources in Agriculture (CeRA) which is providing free online access to 2600 journals from 8 publishers to 126 NARS libraries. It also indicated connectivity of Farm Science Centres through VSAT technology, information through Community Radio and Farmer Mobile Advisory Service that provide information services to farmers through mobile technology besides details of several printed and mass and electronic media products and services of the ICAR.

8. Indonesian Agency for Agricultural Research and Development (IAARD), Indonesia

Dr. Marhendro, Head, General Affairs Division & Mr. Rino Hermawanto, Head of Information and Reporting Subdivision, IAARD

The paper elaborated on different ICT initiatives started by the Indonesian Agency for Agricultural Research and Development (IAARD). Noted among them are its collaboration with ASEAN Agricultural Research and Development of Information System (ASEAN ARDIS) and initiatives under the Poor Farmer's Income Improvement through Innovation Project (PFI3P) with the support of Asian Development Bank. Under this project, agricultural market information system of Ministry of Agriculture (MoA) upgraded; a national farming website that would become a source of information and eventually a platform for agricultural trade was initiated; and information centers at the district agriculture offices were established that would be linking the information network of MoA and disseminate information through traditional media at the local level. The presentation highlighted the application of ICT within the IAARD and in its experimental farms. It reported that frequent change of ICT staff, poor telephone/internet connectivity, electricity problem at the local level and remoteness of project sites are some of the challenges. It concluded that issues like sustainability, suitability and applicability should be considered while implementing ICTs for agricultural development.

9. Japan International Research Center for Agricultural Sciences (JIRCAS), Japan

Mr. Tomohide Sugino, Representative, Southeast Asia Office, JIRCAS

The presentation attempted to share application of ICT/ICM in agricultural research, extension, education and related institutes in Japan. Each organization provides an internet access to its staffs and establishes its own database which contains technical information. Most of these recourses are open to public through websites. Through the Ministry of Agriculture, Forestry and Fisheries Research Network (MAFFIN), the Agriculture, Forestry and Fisheries Research Information Technology Center (AFFRIT) provides the Network Service System for facilitating the exchange of information on the research on a nation-wide scale; Scientific Computing System for high-speed and large-volume calculation; AGROPEDIA-a comprehensive database site widely available to agriculture, forestry, and fishery researchers (http://www.affrc.go.jp/en/agropedia/public) and Research Information Open Source System providing research information to a wide scope of domestic and foreign interests. Various organizations provide farm advisory and extension services by using ICT/ICM. As one of the pioneers among those service providers is Arida orange database (http://www.mikan.gr.jp/idea/top.htm). The database is supported by the research institutes and extension organizations in the local government of Wakayama prefecture. The database consists of information about orange production (the daily observation of orange growth, plant management manual, newly developed orange varieties, know-how about pest control etc.) marketing (the latest market prices etc.) and other technical information (weather data etc.). If farmers have any questions, they can send inquiries to the website and can get answers on line from the relevant staffs in the extension organizations. Another notable case is a technical support system established in 2008 by the Japan Agricultural Cooperative (JAC) Tokyo Group in order to promote appropriate plant protection. It consists of two parts, namely 1) Recording system of crop management history and 2) Diagnosis system for appropriate use of pesticides. If farmers send information about their plant protection activities such as pesticide application to the system from their PC or mobile phone, the system immediately inform the farmers if their pesticide use is appropriate or not in reference to the guideline established by the Japan Plant Protection Association. Also farmers can search the possible plant protection options

based on their crop management history. With regard to ICT applications at JIRCAS, it mentioned the ICT/ICM collaboration in GIS studies in the Asia-Pacific; Database (opened to public) on local vegetables of Thailand, soybean genetic resources in Northeast China and food production and consumption data in China; and several online publications for free use. SEICA (http://seica.info) is one of the notable ICT/ICM initiatives/projects implemented by the NARS in Japan. The consumers can trace the production history of the commodities by inputting the ID number on the SEICA website. About 2,530 farmers and farms registered 10,614 products including rice, vegetables, fruits, legumes, root and tubers, spices, tea and other crops in SEICA.

The paper noted that though ICT/ICM became very popular, most information which is available online focused on the researchers and there are only few technical information packages which can be immediately used by extension workers and farmers. JIRCAS emphasizes that there is a need to formulate package of applicable information on new technologies, which can be accessed online. It was felt that future ICT/ICM applications should target on sensing technology on leafy vegetables, plant management system through automation, development of Robot suits for reducing the burden of farming practices, and development of the integrated information systems which provide consumers' information to producers and provide the information about environmental impacts of agricultural production to consumers and traders. It concluded that JIRCAS would promote ICT/ICM through open databases and on-line publications and promoting mobile internet services to small holder resource poor farmers in the region.

10. National Agriculture and Forestry Research Institute (NAFRI), Lao PDR

Mr. Manoluck Bounsihalath, Head of ICT Unit, Center for Agriculture and Forestry Research Information (CAFRI), NAFRI

The paper attempted to present the ICT initiatives led by the National Agriculture and Forestry Extension Service and the National Agriculture and Forestry Research Institute with support from the Laos Extension for Agriculture Project and the Upland Research Development Program (Swedish-funded) that uses various ICT tools for information and communication services. It highlighted two important case studies. The Lao44 – a Coalition for Lao Information, Communication and Knowledge (CLICK) that aims to allow citizens to publicly and freely share their information. It contain more than 1500 documents and 300 videos available on agriculture, forestry, health, education, training and extension materials, statistics, indigenous knowledge, environmental issues, laws, economics, gender and government policies. The Lao Agriculture Database (LAD) established by the National Agriculture and Forestry Research Institute (NAFRI) in collaboration with the Thai International Bibliographic Information System for the Agricultural Sciences and Technology (AGRIS) Center, Library of Kasetsart University (Thailand) to improve the collection and dissemination of agriculture and forestry related information in Lao and English languages. The database contain information on research results, surveys, training and extension materials, working papers, as well as policy and strategy reports. It was pointed that though there are ICT applications, very less information services are available in local Loa language which is very essential for target audience and emphasizes the need for improving capacities of staff to manage ICT/ICM in agriculture. It concluded that use of Web 2.0 technologies seems promising in order to provide efficient information and communications in the near future and stressed the need for access to information for development through individual commitment; open source software and use of global commons.

11. Malaysian Agricultural Research and Development Institute (MARDI), Malaysia

Ms. Faizah Patahol Rahman, Information Resources Division, MARDI

The paper presented that the current status of ICT/ICM is promising in the rural areas with the launch of National Broadband Initiative which consists of two components namely Broadband for General Population (BBGP) and High Speed Broadband (HSBB). BBGP is now being expanded and innovated through new wireless technology such as 3G/HSPA and WiMAX. HSBB is being implemented in selected areas for economic and business reasons. MyRen – Malaysia Research Network provides high-capacity broadband to universities, colleges, research organizations and scientific laboratories. It aims to provide accessible broadband to the Malaysian researchers to achieve the country's k-economy aspiration. This super highway enables researchers to run data-intensive applications, share computing equipments and run advanced applications within Malaysia as well as overseas. Use of remote sensing technology, GIS and ICT is gaining its popularity. It mentioned that a large number of organization currently involved in data collection and information initiatives related to agriculture that included: MePIS-a database of herbs and medicinal plant; I-Smart – a database of technologies generated by MARD; Ag-Food-a directory of machines invented by MARDI; and Palm Oil OnLine Services – a comprehensive online database services on palm oil data, information and knowledge. Use of ICT tool by farmers, extension workers and researchers are very encouraging through portal for advisory services like Tanyalah Doktor (Ask the Doctor). It indicated that application of ICT/ICM is wide in the areas of research management, data management, agricultural libraries, financial management, agricultural extension and outreach activities. Though every organization implements ICT applications there is still lack of smooth information exchange mechanism such as standard formats for data storage, retrieval and analysis.

The paper flags very important concerns such as low visibility on agriculture information, low synergy among agencies, lack data governance and negative perception on farming which cause gaps in agricultural information systems. It suggested that APARIS should strengthen the agricultural information professionals through advocacy, capacity building and training. All participating countries should identify and make accessible their information systems or databases which are within the subject scope of APARIS.

12. Myanmar Academy of Agriculture, Forestry, Livestock and Fishery Sciences (MAAFLF), Myanmar

Ms. Daw L. Nang Kha, Assistant Director, Head of Data Management Section, Myanmar Seed Bank, Department of Agricultural Research, MAAFLF

ICTs are being used to some extent in NARS for research data management, scientific and technical information, research management, agricultural extension and outreach services and agricultural education. The paper indicated that Myanmar Academy of Agriculture, Forestry, Livestock and Fishery Sciences (MAAFLF) and Department of Agricultural Research (DAR) organizes annual research conferences, and publishes proceedings and undertake technology transfer. In collaboration with FAO, the National Information Sharing Mechanism on Global Plan of Action (NISM-GPA) has been initiated to share plant genetic resource information. Myanmar Agriculture Service (MAS) is also participating in knowledge dissemination through radio and TV networks, journals of agri-business news and market information. Department of Agriculture Planning (DAP) and Settlement of Land Record Department (SLRD) are implementing food security information system, regional data exchange project in ASEAN, e-governance, Electronic Document Management System (EDMS),

Government Personnel Management System (GPMS), e-commerce and establishing MOAI website (http://www.MOAI.GOV.MM). The Yezin Agricultural University (YAU) applies e-library and network learning for educational purpose. ICT infrastructure in Myanmar is an infant stage; there are several challenges for upscaling application of ICT/ICM in national agricultural research system for the improvement of food security and livelihoods. Myanmar needs appropriate national ICT/ICM policy; ICT infrastructure development for NARS; capacity building; private-public partnership; integration of current development in ICT/ICM into NARS; (two-way information exchange through radio, TV networks, phones, fax, e-mail); investment strategy to establish ICT/ICM in NARS; client oriented agricultural information system (agricultural knowledge banks/knowledge centers). In order to fulfill the vision of emerging commercial & competitive agriculture through better informed farming system, the roadmap for ICT should consider: Formulating appropriate policy, organizing national seminar workshop for establishing ICT/ICM in NARS, immediate action plans for ICT/ICM development for NARS; developing a roadmap. It suggested that the action plan should include activities such as innovative use of existing radio, TV networks in NARS (Farmers' forum Agri-business talk-show), development study through the establishment of ICT/ICM model villages, providing farmers-centered agricultural consultation services through ICT/ICM and developing investment strategy for ICT/ICM in NARS. It expressed that Myanmar would look forward to have collaborations with APAARI for developing better informed farming community.

13. Nepal Agricultural Research Council (NARC), Nepal

Mr. Manoj Thakur, Senior Scientist, Communication, Publication and Documentation Division (CPDD), NARC

The paper explains the role of Communication, Publication and Documentation Division (CPDD) under the Nepal Agricultural Research Council (NARC) in implementing different ICT initiatives in Nepal agricultural research, extension and other services to farmers. It described contributions of CPDD through electronic and mass media (Radio, Television, FM, Community Radio, Print and online media). It also mentioned the library and documentation services rendered by CPDD that include CD-ROM-based literature search service, web-based information services through NARC's website. The Nepal Wireless Networking Project which connects 42 villages in rural Nepal through wireless networking meant for e-commerce (www.nepalwireless.com.np). The network has been used for Open Learning Exchange (www.olenepal.org), Tele-teaching, Tele-medicine and e-agriculture. The High Level Commission for Information Technology (HLCIT) established 100 Rural Info Centres, which provide agricultural information to farmers for improving crop productivity, information about nutritional status of rural people and environment protection (www.telecentres.org.np). It was underlined that infrastructure, human resources, investment and policy support are some of the challenges for implementing ICT/ICM in NARS in Nepal.

The paper reported that several ICT/ICM activities are planned for future that include production of video programs on successful technologies, establishment of in-country NARC knowledge centers, organization of media field visits at outreach sites, dissemination of project information through Web platforms, production of print and electronic materials and strengthening networking system to share and exchange information with the support of regional/international agencies. It was pointed that poor access to ICT by farmers, low investment, lack of updated information and weak linkages cause gaps in agricultural information systems. In order to overcome these problems, training support to NARS, hardware and software support and proper network management are felt necessary. Sharing and exchanging of agricultural databases, success technologies and other information resources are

emphasized. It was envisaged that establishment of rural tele-centres, use of Community Radio and production of video clips on success technologies (in local language) and sharing it by translating in regional as well as in international language would help improve information and knowledge services to small holder resource poor farmers in the Asia-Pacific region

14. National Agricultural Research Institute (NARI), Papua New Guinea

Mr. Seniorl Anzu, Information and Communication Officer, NARI

It presented the background of Papua New Guinea and the importance of agriculture in the country. The national infrastructure in telecommunications by government owned Telikom PNG Ltd., Mobile Phony (BeMobile, Digicel Ltd.), the PNG (.pg) internet gateway to the world, PNGARNet (PNG Academic and Research Network) Company, Local Televisions (EMTV, NTS) and Radio Broadcasting (public/NBC, commercial, church-owned) found encouraging though the country is characterized by poor infrastructure facilities with unreliable power supply, poor quality of Internet connectivity, poor access to telephone networks and lack of broadband technology. It was reported that few NARS have websites and most of the organizations use internet for communication purposes, involve in development of databases and use print and electronic mass media such as radio and television for extension and outreach activities. Notable initiatives included RAIS – Regional Agricultural Information System for 3 Western Pacific countries – PNG, Vanuatu and Solomon Islands; Research Management Information System (Major NARI projects); Prioritization of Information and Knowledge function under refocused institutional structure by all NARS; NARI Communication Strategy (draft); production of videos on promising agricultural technologies and SMS Mobile project on accessibility of market information for vegetables (FPDA, Digicel, AIGS/AusAID). The constraints for ICT implementation included lack of skilled manpower, poor ICT infrastructure, limited resources for ICTs in most of the NARS etc., and suggested that efforts are needed to improve ICT infrastructure facilities, human resource development, creation of Resource Centres at Provincial, District and Community levels and stressed for a need to organize capacity building program for the benefit of the Pacific countries.

15. Ministry of Agriculture and Fisheries, Samoa

Mr. Misa Konelio, Assistant CEO-Crops, Ministry of Agriculture and Fisheries

In Samoa, the Ministry of Agriculture and Fisheries Information Section ensures access to agricultural information by all users, utilizing appropriate infrastructure and technologies such as farmer trainings, on-farm advisory visits, hard copy publications and mass media, in particular utilizing radio, television and newspaper. The internet access is now progressing at a rapid rate in Samoa, with infrastructure and support networks available in the main cities of Apia and Salelologa and their surrounding districts and readily accessible by NGO, other Government Ministries, tertiary institutions and internet cafes. Unfortunately, computer hardware and internet connectivity is not accessible for the vast majority of farmers in Samoa. This is largely due to low financial capability, insufficient personal computer skills or lack of infrastructure. The Ministry of Information, Communication and Technology is working on a project for the implementation of tele-centres in the rural villages. The majority of farmers do have access to mobile phones and television offering useful technologies through which agricultural development can be communicated in Samoa. In Samoa, there are government policies that exist which guide all government ministries ICT/ICM. Policy and strategy on the use of ICT/ICM within the Ministry of Agriculture and Fisheries in Samoa is currently in draft form. Computer hardware

and software is now accessible by many of the Research, Development and Advisory Officers within the Samoan Ministry of Agriculture and Fisheries although access to the internet and external databases is restricted for some officer lever. Mass communication methods utilizing radio, television, newspaper, DVD documentaries, trainings and on-farm demonstrations are well adapted to agricultural extension in the Samoan culture. These are the main communication methods by MAF for undertaking agricultural development across all stakeholders, in addition to publishing of technical information in the form of pamphlets, manuals and posters. Networks such as PestNet, PAPFNet, etc. are accessible. Mobile phones are widely used for general communication however in Samoa they are not currently used as a tool for agricultural extension. The Ministry of Agriculture and Fisheries received assistance in ICT/ICM from the ACIAR, SPC, FAO, UNDP, etc.

Challenges for the adoption of ICT and ICM in Samoa include need for National Information and Communication System Policy for agricultural development, centralized information centre, and partnerships with other organizations. It concluded that Agricultural Information Systems could be improved in Samoa through coordination and linkage with internal and external information sources, development of personal skills in information systems, sought support from the APAARI in building the capacity of the staff in information and communication management tools and emphasized need for creation of a Central Database for all NARS and improvement of networking of NARS through APARIS.

16. Sri Lanka Council for Agricultural Research Policy (SLCARP), Sri Lanka

Dr. (Mrs.) P.H.A.P. Chandrakanthi, Senior Scientist, SLCARP

It explained the status of ICT/ICM in the NARS in Sri Lanka and mentioned initiatives such as Web-based services, INFORM, CD-ROM based information services and access to on-line journals, TEEL database and use of Web 2.0 technologies in agricultural research. It highlighted the role of ICTs in agricultural extension and marketing through cyber extension. It noted that ICT infrastructure is at medium level in NARS and it needs to be improved along with other aspects such as increasing investment, capacity building and networking of institutions. It recognizes that Mahinda Chinthana Policy promotes ICT use in Agriculture Development and stressed need for favourable policies related to Internet/Cellular Telephone/Radio/TV that support rural and agricultural development in Sri Lanka. It was opined that lack of awareness on ICTs, language barriers, low capacities to manage ICT/ICM, lack of coordination and the issue of sustainability of ICT projects form major challenges. It was suggested that APAARI may assist in development of suitable databases for NARS, undertake training on new ICT Tools and help introduce common policies/strategies and share good practices to foster ICT/ICM for AR4D in the region.

17. Department of Agriculture, Thailand

Dr. Isiwat Bandrapiwat, Head of Agricultural Information Group, Department of Agriculture, Thailand

It presented the status of ICT infrastructure in the country. The rapid developments in broadband services and mobile phone usage are driving the development of technology infrastructure in Thailand. Advances such as Internet Protocol version 6 (IPv6), grid computing, broadband wireless, Web 2.0 and Web services, 3G mobile services, WiMAX and digital broadcasting are rapidly gaining importance. The Thai Government recognizes that ICT has an important role to play in the enhancement of economic productivity, as well as in the transformation of Thai society into

a knowledge-based society. Thus, ICT, telecommunications, broadcasting, and innovation issues are well addressed in the Constitution of Thailand. In addition, Thailand's second ICT Master Plan (for 2009-2013) is currently being drafted. There are various organizations in Thailand responsible for agricultural research and development such as Department of Agriculture (DOA), Department of Agricultural Extension (DOAE), Rice Department, The Queen Sirikit Department of Sericulture, Department of Livestock, and Department of Fisheries. Farm advisory and extension services through use of ICT to the NARS are implemented through systems to improve the present Research-Extension-Farmer linkages. It noted that the Thailand e-Government Interoperability Framework (TH e-GIF) developed by MICT/Thailand, defines the technical policies and specifications governing information flows across governments. As an apex agricultural research body, DOA uses ICT/ICM for development of DOA Refbase, Agriculture Technical Database, Agricultural Library, Information and Documentation Services through Libnet, marketing information services through www.thethaifruit.com and use of Web 2.0/social networking tools and technologies for dissemination of agricultural information. It was suggested that APARIS may involve in setting the standard of agricultural research information interchange at the regional level and motivating National Agricultural Information Systems (NAIS) to use the standard; Advocating ICT/ICM use in agricultural research and development; use social media to enhance communication among NAIS and guide on information security, ethics etc.

18. The Vietnam Academy of Agricultural Sciences (VAAS), Vietnam

Dr. Nguyen Van Van, Director, Department of Information and Communication, VAAS

The presentation explained the salient feature of agriculture in the 7 agro-ecological zones with details of agricultural situations in Vietnam. It gave a glimpse of agricultural research systems in the country under the Ministry of Agriculture and Rural Development. Information Communication Technology Program promises good opportunity for the development of ICT application in agricultural research systems. There are many ICT projects funded by Ministry of Agriculture and Rural Development of Vietnam. These projects support computer for farmers in villages, training farmers on use of computers. ICTs such as radio, television, electronic & mass media and web-based technologies are widely use in order to transfer advanced technologies from research findings into agricultural production through ICT in Vietnam. Vietnam Television regularly and timely inform guidelines and policies of the State for agriculture production development through "Rural Today" program on VTV1 weekly and "Friends of Farmers" Program on VTV1 weekly and VTV2 Program on "Dissemination of sciences technical knowledge" daily, including agriculture techniques. Radio the Voice of Vietnam broadcast agricultural information daily to the remote areas where is no electricity and no television.

Currently there are 63 websites for agriculture for 63 Provinces in Vietnam. Websites of Ministry of Agriculture and Rural Development (www.agroviet.gov.vn); Vietnam Academy of Agricultural Sciences – VAAS (www.vaas.org.vn); Department of Cultivation (www.cuctrongtrot.gov.vn); Plant Protection Department (www.ppd.gov.vn); Department of Cooperatives and Rural Development (www.dcrd.gov.vn); Vietnam Agriculture Newspaper (www.nongnghiep.vn); National Agriculture Extension Center – NAEC (www.khuyennongvn.gov.vn) are popular sources of information. The Linking Extension and Research Needs through Information Technology (LEARN-IT) supported by the Asia Development Bank through International Rice Research Institute (IRRI) aimed to enrich the knowledge for rice farmers in Vietnamese language. It provides rice farmers with overall-knowledge on rice cultivation techniques and production. VAAS also created Vietnam-Maize-Knowledge Bank aimed to improve production efficiency of corn, which is a second important food crop after rice in Vietnam. It recommends that there is a need to establish regional network to support and share

experiences between countries; human resources development and training skills needed in ICT and ICM, setting up small projects to assist member countries to build community information club models with farmers' groups and training farmers on how to use computers and internet for agricultural production.

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