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Information and communication technologies for sustainable agriculture

Indicators from Asia and the Pacific

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Edited by

Gerard Sylvester

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
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Foreword

The demand for food is expected to increase by 60 percent in the next 37 years as the world's population is estimated to reach 9.2 billion by 2050. This has to be attained under existing and foreseeable constraints such as the stagnation of expansion of arable lands, scarcity of water resources, advancing environmental degradation, negative impacts of climate change, natural disasters and emerging diseases, competition between food crops and bio-energy crops in the use of limited natural resources such as land and water, increased use of food grains for animal feed and bio-fuel, rapid urbanization and a declining agricultural labour force, especially young farmers. If we fail to meet this production target, food shortages may occur, and social and political stability as well as world security and peace might be threatened as we witnessed in the recent past. Addressing these challenges requires coordinated responses and concerted efforts among all stakeholders, including the public and private sectors.

The task of feeding the ever growing population is not going to be an easy task. ICTs, GIS, remote sensing, precision farming and many other technologies or processes hold great promises and are our arsenal in the fight against hunger and in feeding the billions.

Achieving improved and sustainable agricultural production and productivity growth largely depends on the advancement of agricultural research and its effective applications at farmer's fields through the transfer of technology and innovation. FAO estimates that 91 percent of the global food production increase towards the year 2050 should come from yield increases of current arable lands based on the advancement of agricultural research, and its application and transmission to farmers through effective research-extension linkages. Indeed, a half billion small family farmers produce most of the food consumed in developing countries. Thus, small-scale farming families play a critical role in increasing food production for our future food security. Yet, they are often constrained in their access to markets, knowledge, new technology and skills, new inputs, emerging value chains and other opportunities. Moreover, few young people are attracted to farming.

Innovation is needed and this can be accomplished through more effective products, processes, services, technologies or ideas. In the recent past, ICTs have been playing an important role in promoting innovation in the agriculture sector. Among others, mobile phones have been very powerful. At present, 6.8 billion mobile connections have been established for a 7 billion world population. In South Asia and East Asia, the growth rate of the actual number of people subscribing to mobile services has increased very rapidly between 2007 and 2012 with an average annual growth rate of 19 percent and 11 percent, respectively. Indeed, mobile phone technology is widely accessible to all populations and has been playing an invaluable role in improving social, economic and environmental development in emerging markets.

By using mobile phone technology, there have been diverse types of innovations taking place in the agriculture sector, which include commodity and stock market price information and analysis, meteorological data collection, advisory services to farmers for agricultural extension, early warning

systems for disaster prevention and control, financial services, traceability of agricultural products, agricultural statistical data gathering, etc. The value of these innovative technologies and services should not be underestimated, as improving agricultural extension services to farmers using mobile technology would effectively improve the transmission of agricultural research results for application in farmer's fields. Timely reporting of transboundary animal diseases using mobile technology would save the lives of a large number of animals and minimize financial losses. Agricultural marketing information available to farmers would not only help farmers to sell their products at better prices, but also provide reliable food price information to policy makers to prevent price volatility and speculation. These all contribute to enhancing food security.

The role that ICT can play as an instrument of change is potentially transformative. Smallholder farmers, particularly women involved in agriculture, have a huge advantage when the right ICTs are brought into the agriculture value chain. The access to the right information at the right time gives them the capacity to make informed decisions that affect their livelihoods and thereby play a major role in ensuring food security.

Together, we must extend successful innovations and good practices widely and think of sensible solutions to address the problem of food security and agriculture.

Hiroyuki Konuma
FAO Assistant Director-General and
Regional Representative for Asia and the Pacific

Preface

Information and communication Technologies for sustainable agriculture : Indicators from Asia and the Pacific on is a two part publication.

Part I contains a synthesis of the outputs from the reports and subregional workshops conducted by FAO, APAARI, GFAR and other partners between 2010 and 2013.

a) Regional Consultation on Collective Actions for Opening Access to Agricultural Information and Knowledge in the Asia-Pacific Region: Proceedings, 2012. Available at http://www.apaari.org/publications/oaaik_bhutan2012.html

b) Workshop on Moving Beyond Strategy to Improve Information and Knowledge Management for Agricultural Development in the Pacific Islands Countries and Territories: Proceedings, 2012. http://www.apaari.org/publications/httpwww-apaari-orgpublicationsict-ws2012_fiji-html.html

c) Workshop on Coherence in Information for Agricultural Research for Development (CIARD) and Strengthening RAIS in the SAARC Countries: Proceedings, 2012. Available at http://www.apaari.org/publications/ict-ws2012_dhaka.html

d) Workshop on Information and Communications Management for Agricultural Innovation in Southeast Asia: Proceedings, 2012. Available at http://www.apaari.org/publications/ict-ws2012_bangkok.html

e) Information and Communication Technologies/Management in Agricultural Research for Development in the Asia-Pacific Region: A Status Report, 2011. Available at http://www.apaari.org/publications/ictsr2011.html

f) Proceedings: Workshop on ICT/ICM for National Agricultural Research Information Systems in the Asia-Pacific Region, 14-16 September, 2010 held at AIT, Bangkok, Thailand, 2010. Available at http://www.apaari.org/publications/ict-proc.html

It also contains a synthesis from the outputs of the FAO's Mobile Technologies For Food Security, Agriculture and Rural Development workshop (http://www.fao.org/docrep/017/i3074e/i3074e00.htm).

Part II contains contributions from many individuals and organizations involved in agriculture or on technologies that assist agricultural development and knowledge sharing. It delivers a collection of initiatives, technologies and processes that hold great promise for agriculture and rural development. These papers outline how various organizations are addressing the challenges faced by agriculture with the help of technology-mediated solutions. The Pacific island countries, for example, have a unique challenge in their far-flung distribution and it is reported that radio still plays a major role in information dissemination among them. The growth of mobile telephones, as we see in the articles by GSMA, CABI and Nokia, hold great promise for information dissemination and knowledge exchange among rural

communities involved in agriculture and allied fields. GIS, remote sending and precision farming helps in capturing and processing information at the plot level to assist in hyper-local advisories.

While this is definitely not an exhaustive list of technologies or interventions that are needed for sustainable agriculture, this section provides a good overview of many innovations that hold great promise for agriculture and rural development.

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Dr Jayashree Balaji assisted us in synthesizing the outputs in part I. My special thanks goes out to her.

The workshops were a joint effort of FAO, GFAR through **Dr Ajit Maru**, APAARI through **Dr Attaluri Srinivasacharyulu**. The immense contribution of Dr Attaluri's efforts and contribution in compiling the outputs of the previous workshops and preparing the status of ICT/ICM for AR4D in the Asia Pacific region provided most of the background material for this publication, is greatly recognized.

I'm very grateful to the valuable contributions of **Dr V Balaji** (COL), **Mr Emil Adams** (SPC), **Mr Bhanu Potta** (Nokia Life), **Ms Irene Ng**, **Mr Adam Wills**, **Ms Victoria Clause** (GSMA), **Mr Sharbendu Banerjee** (CABI), **Mr Radhakrishna Hiremane** (Intel Corporation), **Mr Walter H Mayers** (PROGIS Software).

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Acronyms and abbreviations


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AGRICOLA	Agricultural Online Access
AGRIS	International Information System for the Agricultural Sciences and Technology
AGORA	Access to Global Online Research in Agriculture
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
AR4D	Agricultural Research for Development
ARD	Agricultural Research and Development
ARI	Agriculture Research Institute
ASTI	Agricultural Science and Technology Indicators
BARC	Bangladesh Agricultural Research Council
CABI	Centre for Agricultural Bioscience International
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
CLAN	Cereals and Legumes Asia Network
COL	Commonwealth of Learning
DOAR	Directory of Open Access Repositories
DLIO	Document-like Information Objects
DSS	Decision Support System
DVD	Digital Video Disk
ERP	Enterprise Resource Planning
FAO	Food and Agriculture Organization of the United Nations
GCARD	Global Conference on Agricultural Research for Development
GFAR	Global Forum on Agricultural Research
GIS	Geographic Information System


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GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
HRD	Human Resource Development
IARC	International Agricultural Research Centre
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICM	Information and Communication Management
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
ICT4D	Information and Communication Technologies for Development
ICT/ICM	Information and Communication Technology / Information and Communication Management
IDRC	International Development Research Centre
IFPRI	International Food Policy Research Institute
IGNOU	Indira Gandhi National Open University
IMARK	Information Management Resource Kit
IPR	Intellectual Property Rights
IRRI	International Rice Research Institute
JIRCAS	Japan International Research Center for Agricultural Sciences
KM	Knowledge Management
LAN	Local Area Network
LDC	Least Developed Countries
LEARN-IT	Linking Extension and Research Needs through Information Technology
LTE-TDD	Long Term Evolution Time-Division Duplex
MAIS	Mobile Agricultural Information Services
MANAGE	National Institute of Agricultural Extension Management
NACA	Network of Aquaculture Centers in Asia-Pacific
NAFRI	National Agriculture and Forestry Research Institute
NAIP	National Agricultural Innovation Project
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
NCAP	National Centre for Agricultural Economics and Policy
OA	Open Access
OAI	Open Archives Initiatives
OECD	Organisation for Economic Co-operation and Development
OER	Open Educational Resources
PARC	Pakistan Agricultural Research Council
PCARRD	Philippines Council for Agriculture, Forestry and Natural Resources Research and Development
PDA	Personal Digital Assistant
PDF	Portable Document Format

RAIS	Regional Agricultural Information System
RFID	Radio Frequency Identification
ROAR	Registry of Open Access Repositories
SAARC	South Asian Association for Regional Cooperation
SMS	Short Messaging Service
STI	Science and Technology Information
TD-LTE	Time-Division Long Term Evolution
TEEAL	The Essential Electronic Agricultural Library
TNAU	Tamil Nadu Agricultural University
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USB	Universal Serial Bus
VAAS	Vietnam Academy of Agricultural Sciences
VERCON	Virtual Extension and Research Communication Network
VPN	Virtual Private Network
WAN	Wide Area Network
Wi-Fi	Wireless Fidelity

Status and strategies on ICT/ICM for AR4D in the Asia-Pacific

PART I

Background note

With the increasing challenge of feeding an ever-growing population, agriculture has been continuously re-inventing itself, and more so in the last decade. The farming community has had to deal with declining arable land area, prolific pests and diseases, as well as anomalous and sometimes drastic weather patterns induced by climate change; these issues are juxtaposed by agricultural industrialization, newer value chains and a lack of actionable information, which when bundled together make farming a highly challenging occupation.

However newer varieties that are resistant to certain types of pests, innovations in irrigation technology and improved communication channels, enhanced by advances in information and communication technology and facilitated by greater use of mobile phones, have provided opportunities to address these challenges.

This publication synthesizes the state of and strategies for information and communication technologies (ICTs), information and communication management (ICM) and information and knowledge management (IKM) for agricultural research for development (AR4D) among countries in the Asia-Pacific region. The contents are derived from the inputs of participants at three subregional workshops conducted between 2010 and 2013.

It is important to note that this section should not be treated as a comprehensive review of the status of ICT/ICM in the countries mentioned, rather it should be used as an indicator to the level of preparedness that exists in countries in Asia and the Pacific regarding information management for agriculture collated through surveys and presentation by participants in the ICT/ICM/IKM workshops conducted from 2010-2013 (see Preface).

Chapter 1
Status of ICT/ICM in the Asia-Pacific

Introduction

Application of new and contemporary information and communication technologies (ICTs) for rural and agricultural development in the Asia-Pacific region has been advancing quite rapidly over the last decade. Contemporary analyses accept that ICTs, when applied in agricultural and rural development processes include hardware, software and applications for digital content generation, management and presentation (to the user), knowledge management and sharing as well as aspects of institutional management and organizational structures that are related to information, data and knowledge sharing. This blend of practices and processes can be termed Information and Communications Management (ICM) where digital technologies play a significant, if not dominant, role.

This report aims to present the current levels of deployment of ICT and ICM in agricultural research for development (AR4D) systems among countries of the Asia-Pacific region. This region is known to have the largest numbers of the world's poor who are largely rural and depend on agriculture for a living. This region is more likely to see efforts using ICT/ICM to find solutions to problems facing rural farming communities and an increased likelihood of finding innovative applications that enhance

the value and impact of investments in AR4D. The present report is a synthesis of several previous reports/surveys in this region, published in the main jointly by APAARI, GFAR and FAO, as well as current reports/literature and blogs and results of Internet research on trends emerging from this region. The report most extensively used is the status report published by APAARI in 2011 which covered National Agricultural Research Systems (NARS) from 19 countries in this region through a survey. This survey provided the background with regardto the ICT infrastructure available in the NARS, management of electronic information, online presence, awareness of information sharing and communication, information and communication services, organizational policy, and awareness and adoption of global datasharing standards, upon which the present report is built. Based on information and data gathered, a set of strategies are proposed in this report.

Chapter-wise, the report starts with a summary account of the challenges facing agriculture in the Asia-Pacific region and a perspective of the ICT/ICM position in the region based on the last status report of 2011 and the proceedings of knowledge management meetings held in the region during 2011. In the next chapter, the current status of ICT/ICM in AR4D is reviewed, covering critical areas such as infrastructure and development of human capacities; the existence and accessibility of scientific databases, datasets; research management information and services for extension, advisory and market information needs. The third chapter provides a perspective of global technology trends in ICT/ICM that are relevant to AR4D in the region. Mobile communication technologies (including 3G and 4G), tablet computing devices and sensors, cloud computing, and an overview of innovative applications for information sharing and delivery through different media in the Asia-Pacific region. The contents of this chapter are derived from recent reports, commissioned articles of experts in this area of work, web reports and the proceedings of knowledge management workshops conducted in the region during 2011. The fourth chapter covers the important area of Open Access in Agricultural Research for Development (AR4D) and agricultural education. The visibility of agricultural repositories and the role of the CIARD RING in promoting information sharing through the registering of database services are elaborated. The issues that impede the opening up of research output through Open Access are discussed, highlighting the need for strong policy and human capacity investment. The penultimate chapter elaborates the strategies needed to increase rural agricultural productivity and livelihoods while also responding to the aspirations of the numerous scientific and technical personnel working towards this mandate at the NARS and Regional Agricultural Information System (RAIS) levels.

The concluding chapter highlights that much progress has been made in ICT/ICM since publication of the 2004 report. From 2011 to date there has been increasing awareness and investment in infrastructure and personnel and this is making itself felt through the increasing number of services registered with the CIARD RING and the directory of repositories. Success stories emerging from national initiatives are also an encouraging sign. Recent developments in increased participation of the for-profit private sector provide some interesting applications for delivery of rural extension and advisory services. However, it remains clear that much needs to be done in terms of development of basic ICT infrastructure in Pacific countries and the front runners in Asia are grappling with the sheer magnitude of scale.

NOTE :

1. Coherence in Information for Agricultural Research for Development / Roadmap to Information Nodes and Gateways - CIARD RING http://ring.ciard.net/

Challenges for agriculture in the Asia - Pacific

The Asia-Pacific region, comprising 44 member countries of FAO, is characterized by high levels of diversity in size, population, agricultural and economic development. The region is home to the two countries in the world with populations higher than 1 billion (India and China); on the other hand, the region comprises numerous small Pacific island nations with populations of less than 100,000 (Bientema and Stads 2008). Economic development is equally diverse as well as the agro-ecologies which differ in terms of climate, soils, altitude, topography and slope. Despite this wide range of natural endowments, the richness of bioresources and diverse agricultural systems, the region today faces major challenges of food insecurity and high rates of poverty and malnutrition. This region accounts for nearly 70 percent of the world's undernourished children and women. According to FAO , almost 870 million people suffer from chronic undernourishment and hunger around the world. Thus Asia-Pacific agriculture must address the twin challenges of hunger and poverty. The region needs more food production from diminishing land, water and agrobiodiversity resources as the environmental footprint of agriculture intensifies. Climate change has now become a major factor in this context, resulting in reduced water supply, increased desertification and loss of agrobiodiversity; consequent spread of transboundary epidemic diseases and plant/animal pests threatens production of major crops, poultry and dairy products. Increasingly competitive agricultural commodity markets, increasing populations and rising and highly volatile food prices add to the list. Two-thirds to three-quarters of the rural poor eke out a living from agriculture and along with their urban counterparts, depend on sustained productivity growth in agriculture for affordable food and their existence.

The magnitude of the challenge is in the statistics: the region houses about 58 percent of the world's population and 74 percent of the agricultural population, but, has only 38 percent of the world's agricultural land. Consequently, land availability per person in agriculture in the

NOTE :

2. http://www.fao.org/hunger/en/

region (0.3 hectares) is almost one-fifth of that in the rest of the world (1.4 hectares), and over 80 percent of the world's small and marginal farmers belong to this region (APAARI 2009). The green revolution of the 1960s brought unprecedented success in multiplying food and agriculture production as well as productivity; it had substantially reduced the percentages of hungry and poor by 1995. However, there is a demonstrable need for a new revolution that will bring lower prices for consumers (through reduced waste and more-efficient supply chain management), contribute to 'smart' agriculture, and motivate farmers (for example, through higher income) to increase their production. For a long time public and private sector actors have been searching for effective solutions to address both the long- and short-term challenges in agriculture, including how to address the abundant information needs of communities involved in farming, strengthening value chains, innovating and participating in emerging markets. Contemporary digital technologies for information processing and communication, or ICT as a suite of technologies is one of these solutions, and has shown considerable promise in agricultural applications in developing countries specifically. ICT has taken an enormous leap beyond the costly, bulky, energy-consuming equipment once available to the very few, to store, analyse and publish agricultural and scientific data. With the booming mobile, wireless, and Internet industries, ICT has found a foothold even in poor smallholder farms and in their activities. The ability of ICTs to bring fresh momentum to agriculture appears even more compelling in the light of rising investments in agricultural research, the private sector's strong interest in the development and spread of ICTs and increased numbers of organizations committed to the agricultural development agenda.

Science and innovation-led agricultural growth in the region must be inclusive and address the needs and aspirations of resource-poor smallholders and producers. The Global Conference on Agricultural Research for Development (GCARD) Roadmap (GCARD 2010) is premised strongly on the Agricultural Innovation Systems (AIS) framework which recognizes that multiple stakeholders are involved in an intricate structure of synergy and dependency relationships. Farmers, the ultimate producers, are recognized as stakeholders in AIS. Any such framework requires the availability of an equally intricate network of data and information flows to sustain it and this is how ICT/ICM emerge as integral components in AIS. Developing Asia-Pacific agriculture, as revealed at the GCARD consultations, would need to triple its investment in AR4D, requiring US$18 billion/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). In theregional GCARD consultations, farmer organizations from the Central Asia and South Caucasus region as well as Asia and the Pacific made demands for application of cutting-edge technologies for their development. In ICTs, they wanted applications for holistic farm productivity and economic simulations, knowledge-based decision support systems, the ability to access and use information for risk assessment and mitigation including that for climate change, the use of geographical information in planning and monitoring their agricultural activities and market-related information, not only of prices but of appropriate options for increasing productivity and profit and for ensuring food safety and appropriate information for consumers. ICT in AR4D has been identified as an important priority area in the Asia-Pacific region for sharing knowledge and information in order to strengthen research, extension and marketing systems. There are notable ICT attempts in agriculture and rural development which not only provide lessons on connectivity, device and application development but also offer more insights that indicate how ICM practices can help address agricultural challenges in developing countries. Each ICT/ICM initiative provides useful lessons with regard to agricultural content development, end-user needs, policy support, information and knowledge management, application of technologies, the role of institutions and their partnerships besides response to agricultural problems and socio-economic impact.

NOTE :

3. GCARD 2010 Roadmap http://www.fao.org/docs/eims/upload/294891/GCARD%20Road%20Map.pdf

AR4D information and knowledge sharing

An overview from the ICT status report 2011 and a perspective from current literature

The role of ICT/ICM in agricultural development is going to be significant in future initiatives for transforming agricultural research for development worldwide. A top-level view of advances in ICT/ICM in the region reveals that more and more rural people are using community radio, mobile phones and the Internet. In some contexts, farmers have used video through Internet applications to gain advice on crops, animal husbandry, the threats posed by weather, pests and diseases, markets and prices and in the process enhance their access to and use of NARS-derived technology. Analysis of the progress over time in the Asia-Pacific region forms the basis of the ICT status reports of APAARI (2004 and 2011).

The salient features and actionable points in the these reports are:

1. **Between the ICT/ICM status reports of 2004 and 2011, in general, there have been noticeable advances in ICT/ICM in AR4D** among APAARI members.

2. **Of particular note is that some of the countries (notably Bangladesh, Indonesia, the Islamic Republic of Iran, Papua New Guinea, Sri Lanka, Viet Nam and Fiji)** have moved up in the categorization of countries with respect to their status of ICT in AR4D amongst NARS. The parameters used for this grouping included the status of science and technology information systems, research databases, research management information systems, extension and outreach information systems, agricultural education systems, organization management systems, rural infrastructure and human capacity.

3. **Some countries with strong or emerging economies,** namely China, India, Pakistan, the Philippines and Thailand have made significant progress in this regard.

4. **Internet access at NARS is widely available while it is still inadequate in the Pacific islands group** and among less-developed countries (LDCs) in the region. Among those with Internet access, some do not yet have locally managed e-mail and/or Web servers **(Table 1)**.

5. **Where Internet access is available, bandwidth availability across NARS should be viewed as still emerging.** In Japan, Malaysia, Philippines, Thailand and Pakistan for example, adequate bandwidth is reportedly available.

6. **Availability of low-cost video cameras and Web-based services for audio/video conferencing (such as Skype) has improved opportunities for such interactions** wherever Internet access is available.

7. It was also noted that consistent supply (with quality) of electricity is not available in two NARS.

8. Local wireless, WiFi for networking, is also advancing in most NARS although it is more established in developed NARS.

9. Satellite communication is less than adequate.

10. **Human capacities in ICT/ICM are not advancing as rapidly as the ICT infrastructure.** This is because only a few NARS have relevant human resource policies in place to recognize ICT capacities in career-related assessments. While essential ICT literacy is advancing, key skills in ICM, such as database, content management and network administration are not increasing proportionately, thus limiting NARS ability to use ICT in support of AIS (the GCARD roadmap). Potentially, this will lead to skill gaps between private and public sector stakeholders in AIS.

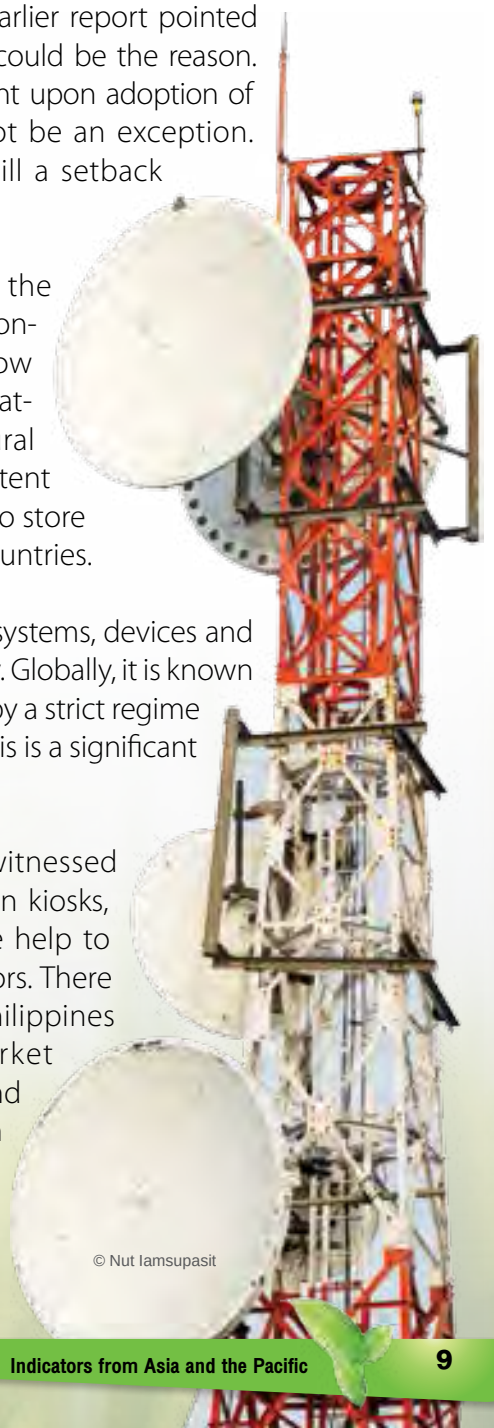
11. **Web 2.0 enables multistakeholder or popular participation** in relation to online content. **Social networking has taken centre stage as an Internet application. NARS are still to take full advantage of either paradigm** owing to limited awareness about developments and their potential advantages in AR4D, especially in AIS, which is a multistakeholder paradigm. This is also reflected in the fact that aggregation of online agri-news using newsfeeds is not still a widespread effort (for example FAO's Agrifeeds, www.agrifeeds.org).

12. **Policies for ICM and strategies for ICT deployment in support are relatively inadequate across NARS. Of note is the observation that global standards in data and metadata exchange have not been adopted.** The earlier report pointed out that lack of clarity of the role of ICT/ICM in agricultural policy could be the reason. Global banking and commerce depend to a very considerable extent upon adoption of core standards by participants and the agriculture sector cannot be an exception. Lack of clarity on intellectual property (IP) matters in ICM is still a setback for global impact of AIS as a paradigm.

13. Non-digital information management is well-established in all the NARS. Most Asia-Pacific countries continue to offer print-based content in the form of catalogues, indexes, abstracts etc., but are slow to realize the benefits of sharing content through an electronic platform. Very few national-level organizations within the agricultural research and innovation system have adopted initiatives to offer content online. Investing to digitize content and building human capacity to store and manage electronic information are key issues in developing countries.

14. There are challenges in widespread adoption of digital information systems, devices and procedures; adoption is uneven across NARS and service outputs vary. Globally, it is known that professional-quality digital information resources are governed by a strict regime of rights and restrictions and the relevant costs are on a steep rise. This is a significant factor besides limited availability of capacities.

15. 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 centres, farmer call centres, online 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, and market intelligence services to farmers. However, upscaling, outscaling and the sustainability of such successful initiatives will be a challenge in the absence of a set of clear policies on ICT/ICM in AIS.



16. Large-scale application of ICTs in agricultural marketing functions across the value chain of a commodity is missing in almost all countries with the exception of a very few, such as Japan. This shows that most countries still need to do much to apply ICTs substantially to link farmers to markets.

17. The report concludes that with agriculture becoming increasingly knowledge-intensive, there is a growing digital divide between the more economically developed and developing countries. This divide is due to lack of leadership, political commitment, investment both in financial and in human capacities and an inability to generate new knowledge or make it accessible for learning and use by agricultural communities. There is an urgent need for mainstreaming ICT/ICM at various levels, in 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 agriculture as well as the community.

Table 1. Infrastructure available for agricultural Information dissemination / extension in Pacific island nations

Country	Conventional (farm visits, training workshops)	Print (newsletter, pamphlets)	Radio/ TV	Internet	Mobile	Data management (record keeping & databases)	Human capacity
Kiribati	NA	X	√	X	X	X	X
Marshall Islands	NA	√	√	X	√		NA
Palau	√	NA	√	√	NA		NA
Papua New Guinea	NA	√	√	√	√	√	NA
Samoa	NA	√	√	√	√	√	√
Solomon Islands	√	√	√	√	NA	√	√
Tonga	NA	NA	√	X	X		X
Tuvalu	NA	√	√	X	X		X
Vanuatu	NA	NA	√	X	X		X

√ Available; X does not exist; NA information not available

Many AR4D networks have been established over the years in the Asia-Pacific region for plant genetic resources/agrobiodiversity, biotechnology, crop improvement, fisheries/aquaculture, livestock, agroforestry education, and incentivizing environmental services. Most of them have been facilitated by the Consultative Group on International Agricultural Research (CGIAR) centres. A list of important AR4D networks is provided in **Box 1** (as derived from http://www.apaari.org/ardnetworks/; March 2013). Of note here is the lack of any networks for ICT/ICM knowledge management.

Box 1. AR4D networks in the Asia-Pacific region

- Alternative to Slash-and-Burn programme http://www.asb.cgiar.org/
- Asia Forest Network (AFN) http://www.asiaforestnetwork.org/
- Asian Network on Sweet Potato Resources (ANSWER) http://www.eseap.cipotato.org/ANSWER/Index.htm
- Asian Rice Biotechnology Network (ARBN)
- Asia Pacific Grouper Network http://www.spc.int/
- 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
- Information support project for soil fertility and fallow management in South East Asia (fallownet) http://www.worldagroforestry.org/Sea/Networks/ifm/default.asp
- Hybrid Rice Development Consortium http://hrdc.irri.org/
- International Network for Genetic Evolution of Rice http://seeds.irri.org/inger/
- 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
- Rewarding the Upland Poor in Asia for Environmental Services(RUPES) http://rupes.worldagroforestry.org/
- South East Asian Network for Agroforestry Education (SEANAFE) http://www.worldagroforestry.org/sea/seanafe
- 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 Asian Maize Network (TAMNET) http://www.fao.org/ag/AGP/AGPC/doc/field/maize/tamnet.htm
- Tropical Fruits Network (TFNet) www.itfnet.org
- Underutilized Tropical Fruits in Asia Network (UTFANET) www.icuc-iwmi.org

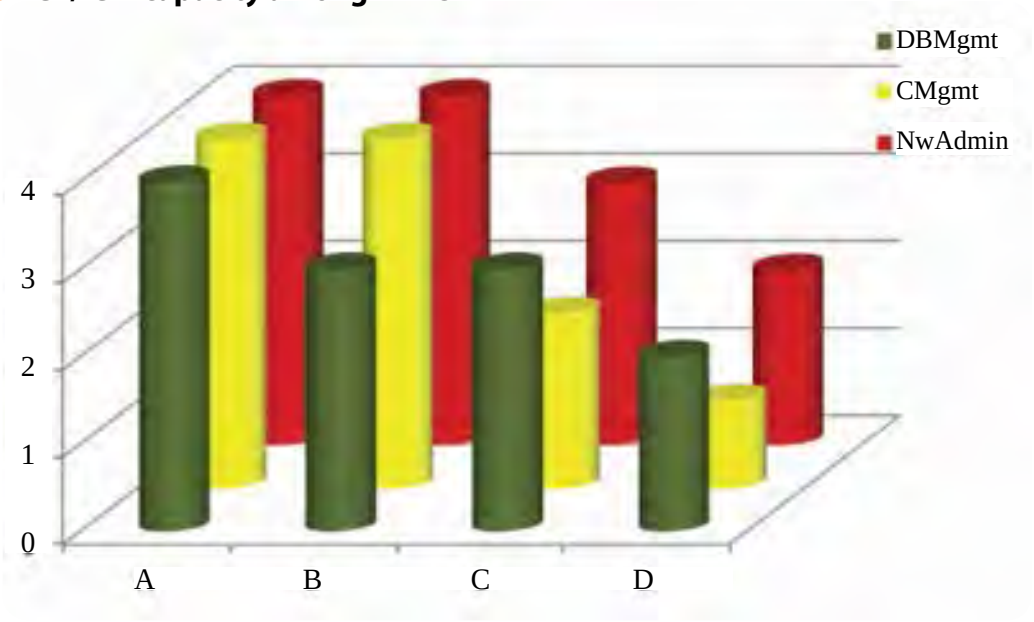
Chapter 2
Current status of ICT/ICM in AR4D

Infrastructure

With the exception of Organization for Economic Co-operation and Development (OECD) countries and a few others, infrastructure for ICT/ICM is still evolving and may be considered inadequate in many subregions. While there is no single source available for a comprehensive review; analysis of the Digital review of Asia Pacific series (1999-2009) reveals that ICT/ICM infrastructure in AR4D has not kept pace with similar development in other sectors. (www.dirap.org). It is known that major infrastructure developments have occurred in a number of countries, especially in China and India, with a large number of pilot efforts taking place in Afghanistan, Bangladesh, Cambodia, Indonesia, the Philippines and Thailand. A comprehensive survey is worth undertaking.

The ICT infrastructure components include hardware, software, networking, wireless, computer systems, Internet access, mailing systems, servers, videoconferencing equipment etc. along with the human capacity that manages and operates the ICT infrastructure. The APAARI report of 2011 indicates that national systems in the Asia-Pacific region have adequate basic support systems and ICT infrastructure. In the more economically-developed countries, these systems are fully available, whereas in developing countries these facilities are either emerging or poor which clearly indicates that still there is room for improving basic ICT infrastructure in least-developing countries. Important new ICT technologies like videoconferencing are only available reliably within a very few developed national systems such as those of Japan, Malaysia and the Philippines. The report notes that community radio is emerging as an 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 now play a major role in disseminating information to communities in remote and rural areas, mostly managed and run by the communities themselves and largely initiated by NGOs or civil society organizations with the financial support of international development agencies. The use of cellular or mobile phones is almost ubiquitous and has become an important mode for communicating content that is adapted to local use and which meets the needs of local agricultural communities and individuals. It can be used in conjunction with printing, postal services, radio (medium-wave broadcasts), TV (cable, direct to home, or broadcast) and newer access routes to the Internet through 3G+ technologies. This approach, namely of opening up multiple and mixed channels for communication, has even greater potential to serve agricultural communities in rural areas. Following the trends in broadband capacities, most of the NARS have well-developed Internet connectivity. Local Area Networks (LAN) are almost established in all the NARS whereas only developed NARS can use Intranet services. Networking facilities such as Wide Area Network (WAN), Virtual Private Networks (VPN) and WiFi connectivity exist in developed NARS and in some of the developing NARS they are still emerging. In terms of human capacity for network administration, database management and content management; these skills are competently available in developed-country NARS as can be seen from the graph presented in **Figure 1**. The data for this chart were derived from the APAARI report of 2011. However, infrastructure for advanced network communication systems like orbital satellite communication and mobile satellite vehicles for agricultural research and extension purposes is limited to advanced countries like Japan and Malaysia.

Figure 1. ICT/ICM capacity among NARS

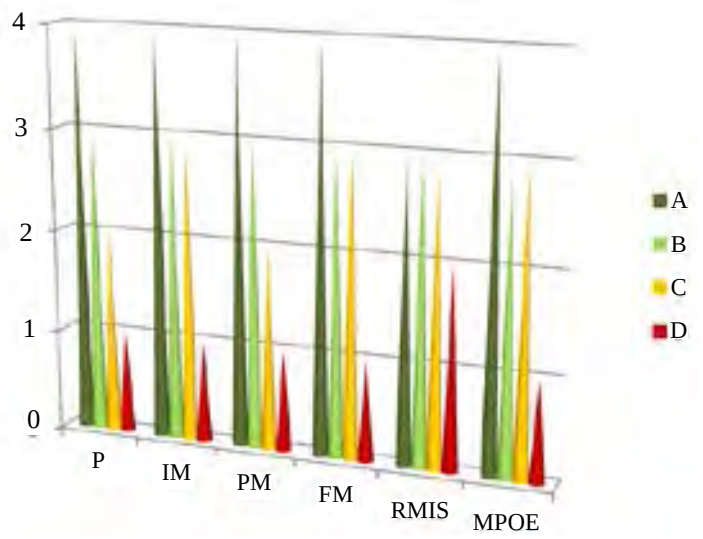


A: Japan, Malaysia
B: India, Pakistan, Philippines, Thailand
C: Fiji, Indonesia, Papua New Guinea, Sri Lanka, Viet Nam
D: Bhutan, Cambodia, Lao PDR, Myanmar, Nepal, Samoa Capacity measures: 4 developed, 3 emerging, 2 poor, 1 lacking
CMgmt: Content management (includes Web site, content creation, multimedia, data analysis)
DBMgmt: Database management
Nwadmin: Network administration Data derived from Table 3; country blocks derived from Figure 1 of the *ICT status report 2011*

Investments and policies

Two challenges that are greater than infrastructure development are the lack of appropriate policies to mainstream ICT/ICM in AR4D and lack of investments that correspond to those policies. Both building human technical capacity and ICM as an organizational priority are required. APAARI and FAO have made significant efforts in enhancing NARS human capacities in ICT/ICM as evident from the ICT/ICM status reports of 2004 and 2011. The APAARI report of 2011 shows that large-scale human capacity developments are taking place in China, India and the Philippines. However, continuing constraints and difficulties in access to good quality, reliable ICT infrastructure for AR4D professionals have in general limited the opportunities for human capacity development. The policy support essential for driving this process has changed positively in the last five years as shown in **Figure 2**, which shows that a few countries (Block A and B) with strong or emerging economies such as Japan, Malaysia, India and the Philippines, have policies and strategies in place at the organizational level that enable them to follow and implement rules, norms and make investments 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.

Figure 2. Management of organizational information in Asia-Pacific NARS



A: Japan, Malaysia
B: India, Pakistan, Philippines, Thailand
C: Fiji, Indonesia, Papua New Guinea, Sri Lanka, Viet Nam
D: Bhutan, Cambodia, Lao PDR, Myanmar, Nepal,
Samoa Capacity measures: 4 developed, 3 emerging, 2 poor, 1 lacking
P: ICT/ICM policy
IM: Institutional management (includes personnel, programmes, institutes, farm business management)
PM: Management of projects
FM: Financial management
RMI: Research management information
MPOE: Management of research programmes, outputs and experts Country blocks derived from Figure 1 of the *APAARI report in 2011*; data derived from Tables 8, 10 and 13

The Indian Council of Agricultural Research (ICAR) now has a Directorate for Knowledge Management which subsumes the previous functions of publication services and information dissemination. This Directorate promotes ICT-driven technology and information dissemination systems for quick, effectual and cost-effective delivery of messages to all the stakeholders in agriculture.

Information subsystems

Availability of and access to research data and information is still an emerging area for NARS in the Asia-Pacific region. There has been wider use of GIS and research databases over the last ten years. Use of crop models and Decision Support Systems (DSS) is catching up, although still lagging behind the former two. Purposeful and wide use of these subsystems requires a higher level of interdisciplinary collaboration and would require engaging with experts with advanced knowledge of mainstream products, applications and professional practices. On the whole, there is recognition of the importance of these subsystems leading to several initiatives to develop the necessary infrastructure and human capacity.

Box 2. Some information and knowledge management initiatives for AR4D in developing Asian economies

Cambodia: Cambodian Agricultural and Rural Development Information Gateway (CARDiG), Cambodia Agricultural Market Information System (CAMIS); Agricultural Information and Documentation Center (AIDOC); Electronic Marketing Information System (EMIS) and CARDI soil database.

Indonesia: Indonesian Agency for Agricultural Research and Development (IAARD) – information systems (CMS-based Web site, mailing system, discussion forum for researchers, library and information network and access to scientific journals), research management information system (e-programme, e-money, e-assets, personnel MIS and e-repository); research data and information services (GIS, crop models, Indonesian food crop knowledge banks for rice, maize and soybean, germplasm database and expert database), agricultural marketing information services (SMS centre, advisory services and e-products).

Lao PDR: The Agrobiodiversity Initiative (www.tabi.la), Information Sharing Mechanism on Plant Genetic Resources in Lao PDR (www.pgrfa.org/gpa/lao), Lao Agriculture Database.

Philippines: Quick Information Dispatch (QID) which facilitates information exchange in the Agriculture, Forestry, and Natural Resources (AFNR) sectors through mobile SMS technology.

Thailand: Call Centre services via # 1170 for farmers and the general public, SMS-based information services to farmers through '*1677 Farmer Information Superhighway' on market trends, commercial crops, new farming techniques, interesting know-how, important news update, and warnings on weather conditions, and mobile application ('BaiKhao'), compatible with the Android 2.2 operating system, which provides estimation of nitrogen requirements of rice to farmers through calibrating the amount of fertilizer and urea by measuring the timing of the colour of rice leaves (Leaf Color Chart) with four standard colours through mobile phone application.

Viet Nam: The initiatives include Rural Today on VTV1 weekly, 'Friends of Farmers' on VTV1, VTV2, The 'Voice of Vietnam' on radio, Web sites of different ministries and institutions related to agriculture and rural development. Linking Extension and Research Needs through Information Technology (LEARN-IT), Vietnamese Rice Knowledge Bank and Vietnam Maize Knowledge Bank.

Scientific and technical information services

Science and Technical Information (STI) in various NARS is generally available as structured documents in the form of traditional printed material (for example books, journals, abstracts, indexes and so forth) or in electronic format (CD-ROMs, DVDs, external hard drives, Internet-based electronic journals) made available through repositories, digital libraries etc. that are shared via computer-/telecommunication-based networks. The status reports find that many countries have established library or information centres affiliated to constituent organizations or often maintain a national agricultural library with designated arrangements for collection, organization and dissemination of both printed and electronic information. These centres are very active in some countries and act as nodal points or clearing houses to cater to the information needs of national agricultural research, education and innovation systems. Table 2 lists information services made available through the CIARD RING. Most Asia-Pacific countries are in the process of developing cataloguing and indexing services on agricultural literature, abstracts and bibliographies through their library and documentation centres. However the availability of institutional repositories and participation in the open archive initiative is negligible. Only developed national systems are able to take open archiving initiatives under special projects with the help of different partners to open up research information to the public (see Chapter 4). This is probably associated with the cost of generating or acquiring electronic information resources and the technical expertise needed to develop and maintain a repository or archive.

Table 2. STI services offered by institutions in the Asia-Pacific region accessible through the CIARD RING

Database/ repository	URL	Type	Information domain
LAO agricultural database	http://lad.nafri.org.la	DLIOs	Agricultural, animal production and health economics and policy, plant production and protection, rural and topical development, farming practices, food security, forestry, natural resources and the environment
Agropedia	http://www.agropedia.net	DLIOs	Crop information
Bangladesh Agriculture Research Council	http://www.barc.gov.bd/home.php	DLIOs	Agriculture – general
Network of Aquaculture Centres in Asia Pacific	http://www.enaca.org	DLIOs	Fisheries and aquaculture
PhilAgriNet	http://www.bar.gov.ph/philagrinet/index.html	DLIOs	Agriculture – general
Chinese Agriculture Soil Technology Documents database	http://www.nais.net.cn	DLIOs	Agriculture – general

Library of Beijing University of Agriculture	http://db.lib.bua.edu.cn/opac/cls_browsing.php	DLIOs, bibliography	Agriculture – general
Aquatic plasm resources platform	http://zzzy.fishinfo.cn/	Research data	Fisheries and aquaculture
China Rice Data Centre	http://www.ricedata.cn/	Research data	Agriculture
Electronic theses and dissertation, University of Dharwad (India)	http://etd.uasd.edu/	DLIOs	Agriculture, economics and policy; education and extension; engineering technology and research; farming practices, food security, forestry, geography and regional information, plant production and protection
NACA Podcast feed	http://www.enaca.org/modules/podcasts/rss.php	Audio recordings	Fisheries and aquaculture
NACA Newsfeed	http://www.enaca.org/modules/news/rss.php	News	Fisheries and aquaculture
Asia Pacific Association of Agricultural Research Institutions	http://www.apaari.org	DLIOs, news	Agriculture
Pakistan agriculture database and other bibliographic services of the Pakistan Agricultural Research Council (PARC)	http://www.parc.gov.pk/data/catPak/catalog.asp	DLIOs	Agriculture – general
Plant database of Pakistan	http://www.parc.gov.pk/data/PGRI/PGRI2.ASP	Research data	Plant production and protection
National Agriculture Research Institute (NARI)	http://www.nari.org.pg	DLIOs, news, events, projects, institutions	Agriculture
National Centre For Agricultural Economics and Policy Research (NCAP)	http://www.ncap.res.in	DLIOs	Economics and policy

As one way to avoid expensive online databases, 'CD-ROM Collections' is an initiative tried in India through the Consortium for e-Resources in Agriculture (CeRA) (http://www.cera.jccc.in/, 2011), for the use of all consortium members. There is a centrally-negotiated set of subscriptions with key publishers who agree to provide online access to all staff in the centres that are members of the consortium. This results in significant savings through economy of scale. This is could be tried in other countries. Another worthy initiative is the South Asian Association for Regional Cooperation (SAARC) agriculture centre that offers Agricultural Bibliographic Information Service (ABIS) – an e-mail service among South Asian countries based on important international CD-ROM databases (AGRIS, AGRICOLA, BEAST, Biological abstracts, CABI abstracts, TEEAL, AGORA etc.) (Akthar 2010).

Research data

Research data and information (for example genomics, economics, field data etc.) are usually made available in the form of raw data, often organized in structured databases that can be queried to generate outputs suitable for analysis. These data are suited to a variety of users such as scientists, student-researchers, policy-makers, development workers etc., who are engaged in research activities, research governance and in policy-making and priority setting. From the reports of 2011 it is clear that except for the most advanced countries like Japan, all other countries are in the process of making available such information in the public domain. There are encouraging signs that AR4D systems have started taking interest in database management, development and deployment of crop 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, departments and institutions to be functional and useful. The building and use of these applications indicate a trend towards digital tools and technologies and knowledge sharing between partners at the project, institute and system level.

Research Management Information System (RMIS)

Management and governance of agricultural research depend considerably on high quality information on projects, project locations, experts, funding sources and research priorities. These are components of a research management information system. This information is crucial for the institutional change process, project monitoring and evaluation and management of outputs etc. It is meant for directing and monitoring needs-based research, planning and prioritization of investments, capacity building, aggregating thematic focus as well as for effectiveness in collaboration and partnerships. Generally RMIS is vital for improving the efficacy of AR4D systems at the national and, in case of collaboration, at the international level. Such information is not available openly and publicly, which is hindering the inclusiveness of various actors and stakeholders in formal research processes and inhibiting collaboration within and outside research systems – it is an essential requirement for the viability of AIS. Critical information on research priority setting and needs assessment is either poor or evolving in all countries, except Japan. A concern is that its importance is not yet visible in NARS strategies and plans. Multilateral agencies, when supporting particular projects, are able to persuade NARS to build RMIS. However, there is still a dearth of appropriate structures and workflows to build a durable RMIS. This may perhaps be due to a mismatch of investments and the high level of human expertise and support systems that are needed in generating such decision-making information. Intensive collaboration among different subject experts is not so easy to achieve in least developed countries. Without a clear policy direction, there is likely to be a lack of appropriate structures, work processes tools and applications to generate and manage this information.

Extension and advisory services

The public agricultural extension system in most Asia-Pacific countries is mandated to provide agricultural advisory and extension services to farmers or the actual producers who are generally furthest away from sources of expert information. In general, the agricultural extension systems in the region have witnessed declining investment and a consequent drop in performance since the 1990s (Eicher 2007). The number of qualified cadres available to serve huge farming communities with diverse problems under the pressure of market-oriented economies is small. Thus the use of ICT applications has much potential and holds the promise of improving the performance of agricultural advisory and extension services for farmers. In the last decade, rural areas in the Asia-Pacific region have witnessed a proliferation of village information centres, telecentres, information kiosks, cyber cafes, community radio centres and so forth, with the help of several funding agencies and investors. These ICT-enabled mechanisms to support rural communities have opened up avenues for publicly-funded research organizations to re-engineer their information and knowledge systems and flows in a manner that can most easily facilitate advisories in reaching the end-users in rural areas. As can be seen from **Table 3** (data derived from the APAARI report of 2011), there have been several initiatives in South and East Asian countries in the use of ICT to provide agricultural extension services.

Table 3. ICT in extension and advisory services.

Country	Initiative	URL available	Delivery of services
Bangladesh	Agriculture Information Service of the Department of Agriculture through Agricultural Information Communication Centres (AICCs)	http://www.ais.gov.bd (in Bengali)	Web-based, SMS
Bhutan	Community information centres by Min. of Agriculture, Forests, the Virtual Extension & Research Communication Network (VERCON)	(Note: this Web site is no longer accessible) Information at the time of launch (2005) is available at http://km.fao.org/vercon/vercon-experiences/vercon-bhutan/en/	Web-based
India	Krishi Vigyan Kendra, AGRISNET, several NGOs and the private sector	http://vkvk.iitk.ac.in (ICAR) http://agmarknet.nic.in (prices); www.mcxindia.com (commodity exchange); http://www.reutersmarketlight.com/index.html (private); http://agricoop.nic.in/dacdivision/guidelines10.pdf (Central Govt); http://agritech.tnau.ac.in (Ag U); www.iksl.in (public sector enterprise with private partners)	Web-based, mobile
Indonesia	Information centres at district agriculture offices linked with the information network of the MoA	No URL	Traditional media
Japan	Agriculture, Foresry, Fisheries Research Information Technology Centre (AFFRIT), JAC	http://sto.affrc.go.jp/en	Web-based, mobile
Lao PDR	Lao44 (Lao Information, communication, knowledge)	www.lao44.org	Online, offline and SMS
Malaysia	Tanyalah Doktor, Agfood, eNelayan, ePengasytiharan, eAquaculture	http://www.zpmc.com.my/productsolution.htm (private company providing solutions for subsidies management)	
Nepal	Nepal wireless network project, rural information centres by High Level Commission for IT (HLCIT)	www.olenepal.org	
Pakistan	National radio network, 'Sohni dharti' exclusive TV channel, toll free help services		Radio, TV, phone
Sri Lanka	Cyber extension (MoA), toll free agricultural advisory service 1920	http://www.agridept.gov.lk/index.php/en/cyber-extension	Mobile, phone and off-line resources on CD's

Agricultural education

The importance of learning via ICT is growing globally with the introduction of online learning and with the advent of Open Educational Resources (OER) and Massive, Open Online Courses (MOOCs). The distinction between online learning, e-learning and distance learning have tended to diminish over the last decade. Asia has already emerged as a leader in the OER movement. However, the inclusion of ICT in agricultural colleges, universities and open universities in formal, structured, on-campus or off-campus education or in non-formal learning is only starting to happen. Innovations in the digitization of material is taking place, one such effort being the National Agricultural Innovation Program (NAIP) in India; approximately 358 undergraduate courses (agriculture, horticulture, fisheries, veterinary and animal sciences, home science and dairy technology) have been fully digitized (NAIP annual report 2011-2012). This corresponds to well over 12,000 lecture hours. Agricultural courses are also offered through distance learning mode by Indira Gandhi National Open University (IGNOU), which provides facilities for online admissions, access to study material, bulletin board services, Wiki and 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 such distance learning programmes is minimal. Initiatives like the Information Management Resource Kit (IMARK) by FAO and Lifelong Learning for Farmers (L3 Farmers) by the Commonwealth of Learning (COL) are some good examples that utilize ICTs for better delivery of learning contents in subjects related to agriculture. Agrilore (www.agrilore.org) is a joint effort of open universities and agricultural universities in India to implement OER practices in agriculture.

Perhaps the largest and most organized effort in this regard is in China. Jing Pinke located at http://jingpinke.com (National Top Level Courses in Google translation, **Figure 3**), is today a multi-faceted and rich site, with very advanced functionality, offering course materials in agriculture. A total of 591 courses are listed, covering all sectors of agriculture, horticulture, veterinary and animal sciences, forestry and fisheries. For each course, the portal has imported a number of resources into a resource database, so that one can look at individual PDFs, videos and other resources without leaving the portal. There are also many social 'Web 2.0' features: Logged-in users can save courses to their personal pages, rate courses or leave comments. Users can also leave comments or questions about specific resources (individual documents and videos) (Håklev 2010).

Figure 3. The Chinese National Top Level Courses Project: Using Open Educational Resources to Promote Quality in Undergraduate Teaching: jingpinke portal

Market-related needs

Market information covers the nature of the market in terms of size, value and growth rate, the divisions between sectors and competing suppliers. Also addressed are product specifications; grading and packing standards; consumer and market preferences (taste, colour, size, season); typical prices and seasonal price patterns; quality premiums and marketing channels; prognosis on future prices and changes occurring in the supply chains for the market; names, address of key contacts particularly buyers, agribusiness and traders plus

Table 4. Current and future roles of ICT in agri-marketing

ICT delivered function	Enabling or deliberate	Technology	Future
Real time market research	Enabling infrastructure	Fixed line, mobile	Extending usage of mobiles, ICT
Coordination of logistics	Enabling infrastructure	Fixed line, mobile	Specialist applications, training organizations
Market information	Deliberate: public, private sector	Web-based, SMS	Applications and public private sector partnerships, training organizations
Market intelligence	Deliberate	Web-based	Applications and development of market intelligence services, training and organization
Inputs	Enabling infrastructure	Fixed line, mobile	Target SMS messaged by private sector, e-vouchers for subsidies

Source: Dixie and Jayaraman (2011).

specialist input suppliers and transport operators. Market intelligence is one of the building blocks for stronger knowledge of the changing market for agricultural products; the information is relatively slow to change. Farmers need a package of information that changes as their priorities change throughout the agricultural seasons. However market information on its own is not enough to make farmers both more productive and more profitable. An integrated approach to information generation and delivery is required. Both the private sector and governments are having difficulty in delivering ICT-based information in a sustainable, effective way. **Table 4** provides a plausible list of roles where ICT can function in agri-marketing.

Other roles for ICT include an important place in product traceability; data capture; recording, storage and sharing of traceability attributes on processing, genetics, inputs; disease/pest tracking and measurement of environmental variables. The product traceability data may be captured and stored in structured database systems that permit precise data queries to isolate the sources and location of products that may be contaminated. Emerging trends in ICT, such as the use of cloud computing and 'software as a service' (SaaS) solutions, have reduced the cost of owning enterprise resource planning tools and database management solutions to capture, record, store and share traceability data. Conventional traceability methods using barcodes and labels or reduced space symbology also involve ICT. Radio Frequency Identifications (RFIDs) offer promising opportunities for traceability in the developing and the developed world and are seen as an alternative to older barcode systems. Products tagged with RFID may also be fed with data through an interface with wireless sensor networks. Sensors, also called motes, may transmit data on motion, temperature, spoilage, density, light, and other environmental variables sliced by time to the RFID tag (RFID News 2009). ICT applications which satisfy the information needs of farmers, extension agents and agri-entrepreneurs to provide relevant market-related information, commodity exchanges or products are not fully developed or non-existent in many agricultural research and innovation systems in the region (APAARI report of 2011). The application of ICTs in agricultural marketing functions across the value chain of a commodity is missing in almost all countries with the exception of a few like Japan. Most countries have poor ICT use or are at emerging levels, even to provide market price information, though trends indicate much promise.

Chapter 3
Trends in ICT/ICM

Convergence of data, audio, video technology and mixed media

Convergence refers to the erosion of boundaries among previously separate services, networks and business models in the sector. Convergence (as the name implies) blurs the distinctions between the domains of Internet service providers, cable television media companies, fixed-line telecommunication companies and operators of mobile telephony networks. Convergence has far-ranging implications for ICT service providers and users. It changes business models, expands markets, increases the range of services and applications available to users, and alters market structure and dynamics. The fundamental technology drivers for convergence have been the digitization of communication and the falling costs of computing power and memory. Both factors have increased a network's capacity to carry information while bandwidth remains fixed. Consequently, the capacities of telephone, cable TV and wireless networks have grown steadily. The growing use of Internet protocol (IP)-based packet-switched data transmission has made it possible for different devices and applications to use any one of several networks and for previously separate networks to interconnect. Together, these factors have facilitated the growth of multimedia or mixed media communication. This has reduced costs and eased the design and deployment of multimedia access devices, and has thus led to a proliferation of increasingly inexpensive digital devices. For example, personal computer or mobile telephones can now receive and transmit different types of media and services because of enhanced processing power and memory capacity (Singh and Raja 2012[4]).

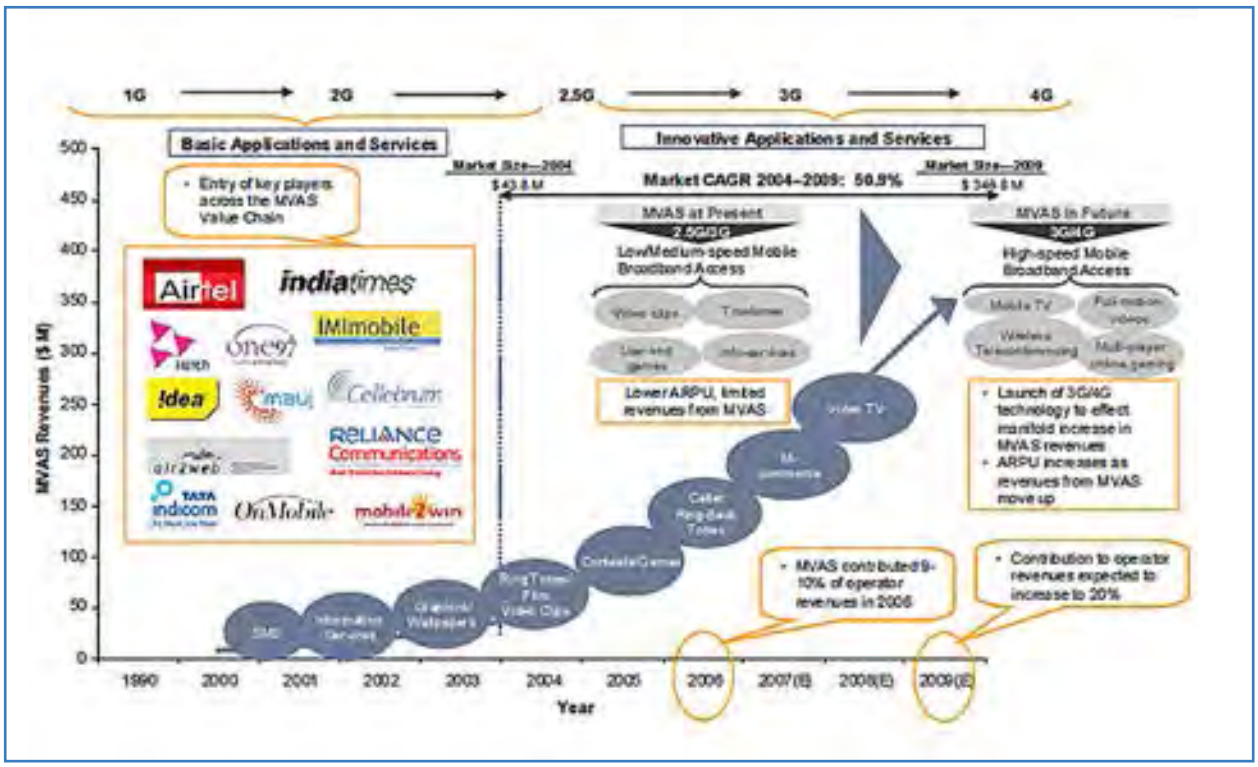
From a user's perspective, device convergence has two main aspects. First, users can access content in different formats (audio, data, location data, pictures, maps, text) and with different dynamic properties, produced by different authors, on the same device. Second, users can take advantage of different options (radio, GSM, Wi-Fi, Bluetooth, satellite) for accessing that content. The potential of convergence in agricultural and rural development has yet to be fully assessed. However, an analysis of value-added services in mobile telephony in India reveals that sale of ring-back tones on Bollywood film music has been the single large factor in attracting very large number of users **(Figure 4)**.

NOTE :

4. Nothing Endures but Change: Thinking Strategically about ICT Convergence, http://siteresources.worldbank.org/EXTIC4D/Resources/IC4D_Convergence_19_34.pdf

Figure 4. Evolution of Value Added Services (VAS) in mobile telephony

From the COL Mobile for Development workshop report held in Pune, India, March 2012



Mobile technologies

3G and 4G and low cost, more powerful mobile computing

2G is short for second generation wireless telephone technology. 2G mobile wireless has basic functionality: voice and short messaging service (SMS); while 3G has advanced functionality: general packet radio service. It finds application in voice telephony, mobile Internet access, fixed wireless Internet access, video calls and mobile television. 4G has broadband functionality – a 4G system provides mobile ultra-broadband Internet access, for example to laptops with USB wireless modems, to smart phones and other mobile devices. Other conceivable applications include high definition mobile television, video conferencing, 3D television and cloud computing. Time-Division Long-Term Evolution (TD-LTE), also referred to as Long-Term Evolution Time-Division Duplex (LTE TDD), is a 4-G mobile-telecommunications technology and standard co-developed, since late 2007, by Datang Telecom, China Mobile, Huawei, ZTE, Nokia Siemens Networks, Alcatel Shanghai Bell, Qualcomm and ST-Ericsson. By September 2011, China Mobile had sealed agreements with 32 international telecom carriers for launching TD-LTE networks. In India, Airtel first introduced 4G services in April 2012.

Portable devices, including but not limited to mobile phones, are starting to allow users dual (or multiple) mode flexibility. Gains in processing power allow functions with higher technology requirements to work on smaller devices (high-end smart phones and Tablet computers). Conversely, bulkier stationary devices such as the desktop computer have evolved functionalities traditionally associated with more portable devices, such as VoIP telephony and on-demand radio and TV broadcasts.

Among rural users in developing countries, the trend is to move from mobile phones with basic voice and text message capabilities to feature phones. Feature phones are low-end phones that access various media formats in addition to offering basic voice and SMS functionality, capturing the functionalities of multiple ICT devices that are also available as stand-alone appliances. Rural consumers prefer the combined devices because of their affordability. Features appreciated by consumers in developing countries include digital camera, voice recorder, flashlight, radio and MP3 player. Bluetooth and General Packet Radio Service (GPRS) are the most widely available connectivity options in addition to GSM. Chinese mobile phone manufacturers tend to be at the forefront of making devices that are particularly affordable and attuned to the needs of rural users in developing countries. The current reality on the ground, with respect to ICT utilization in the Asia-Pacific region, is that access and connectivity to the Internet in the developing world is primarily driven by mobile phones. For example, according to a well-regarded IT industry analyst, mobile access to the Internet in India surpassed PC access to the Internet in 2012 (Meeker 2013). It would be useful to take such facts into account while designing an ICT/ICM strategy for various subsystems, especially for market and extension advisory services.

The Asia-Pacific region has the largest base of subscribers to mobile services in the world. While the proportion of smart phones is rapidly increasing in the region, a very large proportion of the devices used is basic handsets, mainly used for 'voice' communication and text/SMS. In South Asia, the subscriber base is about 1.3 billion, but most handsets cannot display messages in local language script. As a result voice is proving to be an important mode of communicating agricultural messages to farmers. Voice also enhances the trust factor, which is vital in tech-mediated (not face-to-face) communications with the farmers. Proactively promoting voice in a contemporary context can also keep the expert-farmer, farmer-farmer, and farmer-market information exchanges less dependent upon particular telecom service providers or handset/device manufacturers (**Figure 4 and Table 5;** FAO 2012).

Table 5. Use of mobile technologies in providing AR4D services

MAIS	Country	Public partner	Private partner	AR4D services provided	Delivery mechanism
SUONONG search engine (the Construction and Popularization of Agricultural Information-service System)	China	WB funded – Hefei Institute of Physical Sciences		Wholesale farm product prices, crops, climate, pest and disease diagnostic database mining	Text on mobile, PDA, computer
IFFCO Kissan Sanchar Ltd. (IKSL)	India	IFFCO (Indian Farmers Fertilizer Cooperative)	Bharti Airtel, Star Global Resources Ltd	Soil, crop management, dairy and animal husbandry, horticulture, vegetable management, plant protection, market rates, weather forecast, cattle health	Voice-based

Nokia Life Tools	China, India, Indonesia	Government institutions	DOCOMO, Syngenta, Pearson, RML, EnableM	Market price, news advisory, weather	SMS, voice
Reuters Market Light(RML)	India	ICAR postal services	Thomson Reuters	Crops, disease diagnostic, market prices	Text
a-AQUA (almost all questions answered)	India	IIT-B, Vigyan Ashram, KVK Baramati	Agrocom Software Technologies Pvt. Ltd. (ASTPL)	Crops, animals, farmer schemes, KVK recommendations, market information	Voice, MMS, remote photo capture, aAQUA feed reader
Agropedia and VKVK (voice Krishi Vigyan Kendra)	India	WB-funded NAIP		Crop information, VKVK	SMS, voice, text
AGMARK	India	WB-funded TNAU		Price information, commodity grading standAR4Ds, post- harvest technology, export processes, future price estimates	Voice and SMS
e-Choupal	India		ITC	Market prices, weather, pest and disease outbreaks and expert advice	
SAPA mobile for agribusiness	Indonesia	Institut Teknologi Bandung	Nokia	Rice export supply chains	Mobile, networked computers
Tameer Microfinance bank	Pakistan			Easypaisa, microfinance, money transfer, income generation in unbanked areas	Mobile
E-Extension	Philippines	Agricultural Training Institute		Advisory services for agriculture, fisheries, natural resources, e-learning, e-trading	Voice, text, e-mail, online fora
PCARRD	Philippines	Govt. extension, agriculture departments		Crops, fisheries, animal advisory	Text, community radio

Tablets and sensors

The Asia-Pacific region is also home to significant advances in mobile computing. Tablet computers in various sizes, especially in the small form factor (7") are becoming popular and nearly all of them are manufactured by companies in the region. Given that the ARM (the industry leader) processor,used in tablet computers, is of low-cost architecture, there has been a sudden burst of product releases. The prices of small form tablets are dropping while the processor power and display qualities are advancing. Most tablets can be connected to cellphone networks. Their potential in supporting AIS in the region cannot be underestimated.

Sensors that communicate with each other and with a computer have become more versatile in the number of parameters covered. Over the last ten years, prices of sensors have declined very considerably, and the power efficiency factor has drastically increased. Sensors can be deployed quite extensivelyin support of gathering data from remote locations in field-based research or in on-station research. Meteorology, soil nutrient and moisture management are areas where they can be deployed readily. They can also be used to detect contaminants and pollutants. When combined with orbital satellite data, sensor-derived information can be used to make fairly accurate forecasts or diagnosis. Use of sensors may be considered essential in agricultural production that is oriented towards global markets. It will also be useful in promoting aspects of conservation agriculture for high-value products (AFITA 2012).

Cloud computing

Data and programs moving away from desktop PCs or corporate server rooms and getting installed somewhere in 'the compute cloud' are known as cloud computing or on-demand computing, Software as a Service (SaaS) or the Internet as a Platform (IaaP). The common element is a shift in the geography of computation. When we create a spreadsheet with the Google Docs service, major components of the software reside on unseen computers, whereabouts unknown, possibly scattered across continents. Some substantial fraction of computing activity is migrating away from the desktop and the corporate server room. The change will affect all levels of the computational ecosystem, from casual user to software developer, IT manager, even hardware manufacturer. This section quotes extensively from Hayes (2008).

In effect, rise of cloud computing provides certain advantages to NARS in enabling rapid expansion of IT services even while capacities and infrastructure are limited. The unresolved issue of data ownership and custody in relation to vendors located away in other continents will require careful consideration.

Modelling, expert systems and GIS information applications

GIS are extensively used in agriculture, especially in precision farming. Land is mapped digitally, and pertinent geodetic data such as topography and contours are combined with other statistical data for easier analysis of the soil. GIS is used in decision-making for issues such as what to plant and where to plant using historical data and sampling. There is still much primary research taking place here, for example on application of GIS techniques to assess variation of elements in soil. Combination of spectrophotometry techniques with satellite-derived information is believed to lead to rapid testing methods. GIS research and training is very important for AR4D, especially in the context of climate change. GIS applied to drought and flood management is an established area of research although applications are still taking shape. Forecasting/warning for pest attacks is a well-established technology but not practised on a large scale. Part of the reason could be costs of GIS products. Equal reason would be lack of capacities on the ground. GIS applications are limited to pilot or small-scale projects. FAO's geonetwork (http://www.fao.org/geonetwork/srv/en/main.home) is a very valuable source of geospatial datasets and maps. ArcGIS Online is a complete, cloud-based, collaborative content management system that allows organizations to manage their geographic information in a secure and configurable environment. The platform provides infrastructure for creating Web maps as well as sharing maps, data and applications. Organizations purchase a subscription which allows them to configure and manage their own ArcGIS online site and set of resources. ArcGIS is used by several Asia-Pacific NARS, while IDRISI (http://clarklabs.org/products/idrisi.cfm) is also acquiring wider following among some of the NARS. A subscription includes organizational accounts for members of the organization. Personal accounts are available for individuals who want to access content shared by Esri and GIS users and create, store and share maps, apps and data. With open data initiatives and new, affordable tools, departments like the Sustainable Development Network Information Systems (SDNIS) at the World Bank are trying to overcome these problems. SDNIS recently created a central repository for spatial data called GeoSDN. This repository hosts (internally) spatial information from many World Bank projects – allowing all staff to access data used in different projects or in previous years. SDNIS also provides support including spatial analyses and remote sensing, facilitation of data sharing, GIS application development, capacity building and hands-on GIS training courses, which help World Bank staff implement ICT tools in agricultural projects more successfully.

GIS data-specific initiatives in four Asian countries are highlighted in **Box 3**.

Box 3. GIS information management: some developments

Lao PDR: New approaches to computerizing land records and delivering e-government services are helping to expand the land information services offered to Lao PDR's urban and rural communities. In 2004, with support from UNDP, Lao PDR's Science, Technology, and Environment Agency (STEA) developed the ICT for Development Project, with the objective of developing a policy framework for the management, standardization and exchange of national digital information to implement the government's ICT master plan and strategy for 2006-2010. A critical component of the national information base was information on land and natural resources, Lao PDR's comprehensive strategy for land information coordination and management centres on the development of the Lao Spatial Data Infrastructure (LSDI), a framework of land information, access policies, data standards and ICT infrastructure that will benefit a range of users and agencies. Two key organizations are building the LSDI: the National Geographic Department and STEA.

Philippines: The Unified and Enterprise Geospatial Information System (UEGIS), which is a database that hosts spatial information (such as biophysical indicators) and non-spatial information (such as socio-economic indicators).

Bangladesh: In 1996 BARC initiated a project on Utilization of Agro-Ecological Zones (AEZ) Database and Installation of GIS for Agricultural Development with support from UNDP and FAO. The main objective was to create a National Agricultural Land Information System Database in a GIS environment to fulfill agricultural planning and research needs. The project had a GIS setup with ARC/INFO, ArcView and IDRISI as the key GIS software. An important activity was to convert the Land Resources Inventory (LRI) and non-spatial AEZ database into a spatial GIS/AEZ database. A GIS-based crop or cropping pattern suitability database has been developed based on the improved models and data. A GIS-based decision support system (DSS) has been developed using cropping pattern suitability and socio-economic factors to assist in agricultural planning and research. The Dhaka Metropolitan Development Plan (1995-2015) is comprised of three components – the Dhaka Structure Plan (1995-2015), Urban Area Plan (1995-2005) and Master Plan. GPS-based modern digital survey techniques are being used for physical feature and topographic survey of the Dhaka Metropolitan Area. Real Time Kinematics (RTK), GPS and Total Station are being used for survey and all data are kept in a GIS-based database using ArcGIS 9 software. Urban Planners and other experts use this database for plan preparation.

Thailand: AIT partnership programmes – GIS was used in the project Spatial and Temporal Analysis for Area-Wide Integrated Pest Management of Fruit Flies in South and Southeast Asia, and Cassava Pink Mealy Bug Project in the Mekong sub-region.

Social media for inclusive community computing and communications

Social media and Web 2.0 are two developments in cyberspace that have grown very rapidly in the last ten years. Wikipedia provides the best example of Web 2.0 platforms that are premised on generating positive values from crowd-sourcing of content. A number of lesser-known platforms incorporate collaborative content creation as a key aspect of their services. Rise of platforms like Wikipedia was preceded by Blogs which have now become mainstreamed in contemporary web-based communication. Facebook is a highly significant presence in cyberspace with hundreds of millions of users as a platform of choice for individuals and organizations. The role of Facebook and Twitter as a web-to-web and web-to-mobile social networking platform in fostering higher levels of political awareness is well-documented in the media. YouTube, as the dominant video-sharing platform, has strengthened its social media features in the last few years and the emergence of new platforms such as Google Plus are also notable. In some important instances, media organizations prefer social media platforms to reach their clients and followers more than through use of standard web-based communication. The rapid increase in the popularity of social networking and media sites has led to many professional expert bodies, for example the American Physical Society, closing their own social platforms in favour of using the popular ones such as Really Simple Syndication (RSS). Aggregation of online news, earlier confined to feeds, has now acquired new strengths through integration with Web 2.0 and social media.

A preliminary survey of the social media space and Web 2.0 platforms indicates that these paradigms are yet to capture the attention of NARS in the region. The human development and livelihood research sectors, of which NARS are a part, have generally not made significant use of these technology developments in Asia and the Pacific. There is huge potential for organizations such as FAO, GFAR and APAARI to explore this paradigm for many opportunities. The rapid advancement in the use of smart phones, which drive the increased use of social media, is possibly an opportunity for bringing markets and farmers closer. Engagement with aggregating newsfeeds online from multiple sources will contribute to widening regional cooperation. Currently, the only viable newsfeed aggregation is operated by FAO (www.agrifeeds.org) and more work is possible and will be relevant to AIS stakeholders in the region. A well-focused social networking platform such as Researchgate (www.researchgate.com) has a wide following among scientists and research professionals from all over the world. Recent developments in voice-based web-browsing could provide opportunities for farmers and extension personnel in forming local area social networks using basic mobile phones. Among NARS efforts in harnessing Web 2.0, ICAR's agropedia is an initiative that has been operating for over five years now, and is set to expand to horticulture and fisheries.

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Chapter 4

Opening access in sharing agricultural data and information

'Openness' of agricultural information and knowledge in the context of the emerging paradigm of agricultural innovation should mean that a large part of relevant and useful information (barring those that, when ethically considered, can harm the individual or the community) generated by and through public sector investments, should be available and also accessible as a public good with equity to all its users (APAARI 2012). Opening up information access in agriculture would help tackle the emerging challenges: improving efficiency in market supply chains, climate change and shrinking natural resources. This calls for fundamental recognition by all AIS stakeholders that: 1) the increasing market orientation in agriculture also makes it increasingly information-and knowledge-intensive, 2) it is the capability to intensify information and knowledge use that defines the ability of agricultural communities to respond through innovation and participate more effectively in markets. In the following sections, we shall look at how Open Access can be implemented in AR4D organizations in the region.

Agricultural open archives and repositories

It is useful to start with defining two key concepts in Open Access. One is the concept and practice of metadata; the other is interoperability. Both these are founded on the premise that digital means (that is, use of a device like a computer (desktop/laptop/Tablet) or a smart phone or an e-reader) is involved in reading a document. Metadata, simply put, are data about data; an example is the bibliographic citation of a research paper. If the paper is data, then the citation is its metadata. Interoperability means ability to reproduce the metadata and data (document) across various devices and software platforms.

An institutional repository is an online locus for collecting, preserving and disseminating – in digital form – the intellectual output of an institution, particularly a research institution. Each individual repository is of limited value for research: the real power of Open Access lies in the possibility of connecting and tying together repositories, which is why we need interoperability (Knoth and Drahal 2012). In order to create a seamless layer of content through connected repositories from around the world, Open Access relies on interoperability, the ability for systems to communicate with each other and pass information back and forth in a usable format. Interoperability allows us to exploit today's computational power so that we can aggregate, data mine, create new tools and services, and generate new knowledge from repository content. Interoperability is achieved in the world of institutional repositories using protocols to which repositories should conform, such as OAI-PMH (http://www.openarchives.org/pmh/). This allows search engines and open access aggregators (a site or software that aggregates a specific type of information from multiple online sources) to find index repository metadata and content and provide value-added services on top of this content (for example OAIster, http://quod.lib.umich.edu/o/oaister/about.html). Interoperability is a crucial feature of repositories or archives which are needed to realize the Open Access vision. Institutional repositories are one of the recommended ways to achieve Open Access, referred to as self-archiving (Green OA). See **Box 4** on glossary of Open Access terms used.

There are registries online that maintain information on repositories. The Registry of Open Access Repositories (ROAR) promotes the development of Open Access by providing timely information about the growth and status of repositories throughout the world (http://roar.eprints.org/). Another is DOAR (http://www.opendoar.org/find.php). From the APAARI report of 2011, the number of Asia-Pacific countries with institutional repositories listed in the OpenDOAR, has not been very encouraging. In 2011, only 13 organizations were listed; as of writing this report 16 organizations have listed their institutional repositories in the field of agriculture, food and veterinary services in the Asia-Pacific region **(Figure 5)**.

Box 4. Glossary of Open Access terms used

Fedora: (Flexible Extensible Digital Object Repository Architecture): A software technology that may be used for building Open Access repositories. It was originally developed by Cornell University and the University of Virginia. It is now managed by Fedora Commons. www.fedora-commons.org

Gold publishers: Publishers of Open Access journals. The author or author institution can pay a fee to the publisher at publication time, the publisher thereafter makes the material available 'free' at the point of access.

Green publishers: The author can self-archive at the time of submission of the publication (the 'green' route) whether the publication is grey literature (usually internal non-peer-reviewed), a peer-reviewed journal publication, a peer-reviewed conference proceedings paper or a monograph.

Metadata: Data that describe other data. For items in Open Access repositories, this usually consists of a full bibliographic reference, abstract, keywords, and similar information.

OAI (Open Archives Initiative): An organization dedicated to managing and promoting the Open Source trademark for the good of the community. www.openarchives.org

OAI-PMH: (Open Archives Initiative Protocol for Metadata Harvesting): Widely used standard protocol for harvesting metadata from OA repositories. www.oaforum.org

OAIster: Combined searching of multiple repositories – from University of Michigan Library oaister.umdl.umich.edu/o/oaister/

Postprint: The final version of an academic article or other publication – after it has been peer-reviewed and revised into its final form by the author. As a general term this covers both the author's final version and the version as published, with formatting and copy-editing changes in place.

Preprint: In the context of Open Access, a preprint is a draft of an academic article or other publication before it has been submitted for peer-review or other quality assurance procedures as part of the publication process. Preprints cover initial and successive drafts of articles, working papers or draft conference papers.

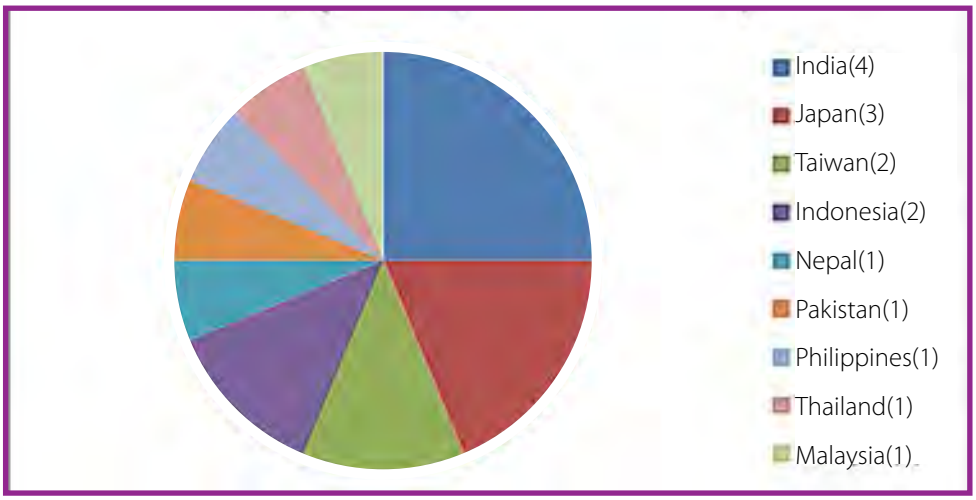
Repository: A Web site that aims to collect, preserve and proffer electronically the intellectual output of a subject or organization without charge to the world.

Self-archiving: The process by which an academic author deposits the metadata (bibliographic reference, abstract, etc.) and an electronic full text for one or more of his/her publications in an Open Access repository.

SHERPA: Securing a Hybrid Environment for Research Preservation and Access UK Project dedicated to promoting the implementation and use of Open Access repositories. www.sherpa.ac.uk

SHERPA/RoMEO: SHERPA Rights MEtadata for Open archiving – database of the copyright transfer policies of academic publishers and their journals. www.sherpa.ac.uk/romeo.php

Figure 5. Agricultural institutional repositories in the Asia-Pacific region available in DOAR



Issues in Open Access (OA)

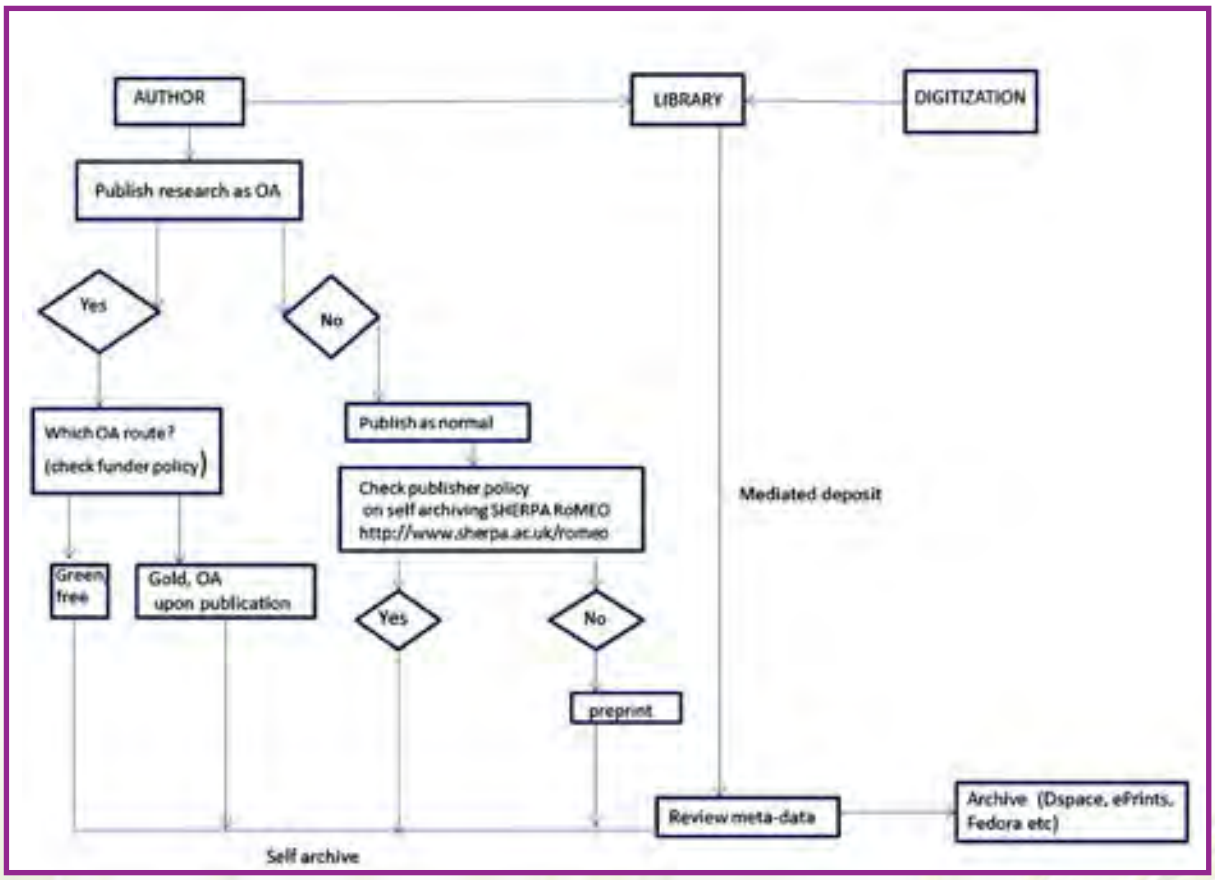
Investment

Funders invest in research in order to accelerate the pace of scientific discovery, encourage innovation, enrich education and stimulate the economy – to improve the public good. They recognize that broad access to the results of research is an essential component of the research process itself. Research advances only through sharing of results, and the value of an investment in research are only maximized through wide use of its results. There are two primary vehicles for delivering OA to research articles, data and products; one is by publishing them in OA journals (the DOAJ or the Directory of Open Access Journals (http://www.doaj.org/) allows searching of over 8,800 journals across 121 countries), the second is the institutional OA repository. The primary investment in making information OA is a mandate or institutional policy on it. The second requirement is in infrastructure, setting up and running a repository. OA repositories are economically sustainable because they are inexpensive; there are many systems of free and open-source software to build and maintain them (DSpace (http://www.dspace.org/), EPrints (http://www.eprints.org/), Fedora (http://fedora-commons.org/) etc). However, the cost is in human capacity. Installing and maintaining a repository may require considerable IT skills. But once a repository is installed, people can easily deposit new articles, data and documented research output; it can be done by individual data producers, not skilled personnel or archive managers. OA repositories can include preprints and postprints of journal articles, theses and dissertations, course materials, departmental databases, data files, audio and video files, institutional records, or digitized special collections from the library. Estimates of the costs of running an institutional repository depend critically on how many different functions they take on. OA repositories benefit the institutions that host them by enhancing the visibility and impact of the articles, the authors and the institution.

Structures (local workflow)

To self-archive is to deposit a digital document in a publicly accessible Web site, which could be an institution's archive or repository that is OAI (Open Archives Initiative) compliant (van de Sompel and Lagoze 2000). The OAI develops and promotes interoperability standards that aim to facilitate the efficient dissemination of content (http://www.openarchives.org/OAI/OAI-organization.php). OAI-compliance means using the OAI metadata tags. All OAI-compliant documents in OAI-compliant archives are interoperable. This means distributed documents can be treated as if they were all in one place and one format. All that the author/depositor of the material needs to do is provide the full-text document and some metadata relating to the document such as date, author-name, title, journal-name, etc. A simple flowchart that an author could use to make her/his research output OA is provided in **Figure 6**.

Figure 6. Flow chart - a potential process for self-archiving



Both archives and repositories provide long-term physical storage and management of digital items. It is possible to store documents in any common format that the archive administrator defined to be accepted. Each individual research paper/e-print can be stored in more than one document format. In conjunction with metadata, the repository/archive becomes OAI compliant. Currently DSpace supports only the Dublin Core metadata element set, while EPrints can use any metadata schema; the administrator/repository manager decides what metadata fields are held about each electronic document.

Policy

An open-access mandate is a policy – adopted by a research institution, research funder or government – that requires researchers (such as university faculty or research grant recipients) to make their published, peer-reviewed journal and conference papers OA by self-archiving their final, peer-reviewed drafts in a freely accessible central or institutional repository. Open access materials are freely accessible to potential users online.

Box 5. Sample policy/mandate from an ARI (Harvard University) and an international agricultural research centre (ICRISAT)

The Harvard University: Each Faculty member will provide an electronic copy of the author's final version of each article no later than the date of its publication at no charge to the appropriate representative of the Provost's Office in an appropriate format (such as PDF) specified by the Provost's Office. (http://osc.hul.harvard.edu/sites/default/files/model-policy-annotated_01_2013.pdf)

The ICRISAT OA mandate: Every ICRISAT scientist/author in all locations, laboratories and offices will send a PDF copy of the author's final version of a paper immediately upon receipt of communication from the publisher about its acceptance. This is not the final published version that certain journals provide postprint, but normally the version that is submitted following all reviews and just prior to the page proof (http://oar.icrisat.org/mandate.html).

Box 6. ICAR's Open Access Policy

- Each ICAR institute to setup an Open Access Institutional Repository.
- ICAR shall setup a central harvester to harvest the metadata and full-text of all the records from all the OA repositories of the ICAR institutes for one stop access to all the agricultural knowledge generated in ICAR.
- All the meta-data and other information of the institutional repositories are copyrighted with the ICAR. These are licensed for use, re-use and sharing for academic and research purposes. Commercial and other reuse requires written permission.
- All publications viz., research articles, popular articles, monographs, catalogues, conference proceedings, success stories, case studies, annual reports, newsletters, pamphlets, brochures, bulletins, summary of the completed projects, speeches, and other grey literatures available with the institutes to be placed under Open Access.
- The institutes are free to place their unpublished reports in their open access repository. They are encouraged to share their works in public repositories like YouTube and social networking sites like Facebook ®, Google+, etc. along with appropriate disclaimer.
- The authors of the scholarly articles produced from the research conducted at the ICAR institutes have to deposit immediately the final authors version manuscripts of papers accepted for publication (pre-prints and post-prints) in the institute's Open Access repository.
- Scientists and other research personnel of the ICAR working in all ICAR institutes or elsewhere are encouraged to publish their research work with publishers which allow self- archiving in Open Access Institutional Repositories.
- The authors of the scholarly literature produced from the research funded in whole or part by the ICAR or by other Public Funds at ICAR establishments are required to deposit the final version of the author's peer-reviewed manuscript in the ICAR institute's Open Access Institutional Repository.
- Scientists are advised to mention the ICAR's Open Access policy while signing the copyright agreements with the publishers and the embargo, if any, should not be later than 12 months.
- M.Sc. and Ph.D. thesis/dissertations (full contents) and summary of completed research projects to be deposited in the institutes open access repository after completion of the work. The metadata (e.g., title, abstract, authors, publisher, etc.) be freely accessible from the time of deposition of the content and their free unrestricted use through Open Access can be made after an embargo period not more than 12 months.
- All the journals published by the ICAR have been made Open Access. Journals, conference proceedings and other scholarly literature published with the financial support from ICAR to the professional societies and others, to be made Open.
- The documents having material to be patented or commercialised, or where the promulgations would infringe a legal commitment by the institute and/or the author, may not be included in institute's Open Access repository. However, the ICAR scientists and staff as authors of the commercial books may negotiate with the publishers to share the same via institutional repositories after a suitable embargo period.

Intellectual Propety Rights (IPR)

Archives, repositories can hold preprints and postprints of journal articles, theses and dissertations, research databases, data files, audio and video files, digitized collections. The legal basis of OA is the consent of the copyright holder (for newer literature) or the expiration of copyright (for older literature) (Suber 2012).

- The author holds the copyright for the pre-refereeing preprint, so that can be self-archived without seeking anyone else's permission. Sixty-nine percent of journals (http://www.sherpa.ac.uk/romeo/statistics.php?la=en&flDnum=|&mode=simple) already give their green light to postprint self-archiving. With the remaining 31 percent, the author can either try to modify the copyright transfer agreement to reserve the right to self-archive the postprint, or, failing that, can append or link a corrigenda file to the already self-archived preprint.

- Because OA uses copyright-holder consent or the expiration of copyright, it does not require the reform, abolition or infringement of copyright law.

- One easy, effective and increasingly common way for copyright holders to manifest their consent to OA is to use one of the Creative Commons licences. Copyright holders could also compose their own licences or permission statements and attach them to their works (though there are good reasons not to do so without legal advice). All World Bank research outputs or knowledge products use a Creative Commons CC BY licence (http://creativecommons.org/tag/world-bank); the Asian Development Bank also uses the CC licence).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- When copyright holders consent to OA, they are consenting in advance to the unrestricted reading, downloading, copying, sharing, storing, printing, searching, linking and crawling of the full-text of the work. Most authors choose to retain the right to block the distribution of mangled or misattributed copies. Some choose to block commercial re-use of the work. Essentially, these conditions block plagiarism, misrepresentation and sometimes commercial re-use, and authorize all the uses required by legitimate scholarship, including those required by the technologies that facilitate online scholarly research.

Interoperability

The routes to discovering the existence of an online resource are many and varied, and may in some cases even be serendipitous. To be discoverable, usable, flexible and effective they should have associated metadata that allow interoperability between repositories and other resources. OAI-compliant repositories share the same metadata, making their contents interoperable with one another. Their metadata can then be harvested into global 'virtual' archives, such as OAIster (https://www.oclc.org/oaister.en.html), making the information seamlessly navigable by any user.

With regard to implementation of global information standards for information exchange and IPR-related issues, the trends among the NARS leave much tobe desired (APAARI report of 2011). Some of the developed NARS do not follow global standards for managing AR4D information, metadata standards, agricultural vocabularies, classification systems and IPR regulations for sharing research information. This becomes a barrier for data, information and knowledge exchange and integration at the regional and global level. It is 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 ICT/ICM as an important discipline that impacts agricultural development let alone improving the systems and processes for greater sharing across boundaries.

Open Education Resources (OER)

This is the practice of making available learning materials for reuse and adaptation through the Web. There are several initiatives in the region promoted by FAO, IARCs and some national initiatives for information sharing that are worth enumerating (Besemer et al. 2012).

Agricultural Learning Repositories Task Force – AgLR-TF: The Task Force was set up under the umbrella of FAO's AIMS programme. The aim has been to create a network of organizations that promotes the development of an open and interoperable global infrastructure to facilitate sharing and reuse of learning resources on topics related to agricultural and rural development worldwide.

China Open Resources for Education (CORE): This is a non-profit organization with a mission to promote closer interaction and open sharing of educational resources among Chinese and international universities. CORE aims to provide Chinese universities with free access to global OERs and correspondingly to make high quality Chinese resources available globally. Currently there are eight Chinese agricultural universities participating in the programme. The consortium is working now to open up the programme to hundreds more universities.

AgriLORE is part of the National Agricultural Innovation Project (NAIP) being implemented by ICAR in India. The project has three objectives: (a) to generate, review, manage and publish approved learning materials for wider use and re-use by distance learning institutions and interested rural and community organizations and extension agencies; (b) to build a national pilot repository for digital content on agrohorticulture, for use in distance learning programmes aimed at rural learners and extension workers; (c) to assess the impact of new methods of ICT and extension approaches on rural livelihoods and on partnerships. This project aims to evidence the value of OER in the extension environment.

CGIAR Learning Resources Centre: Learning materials from across CGIAR centres are searchable within the ARIADNE repository where they are stored. Some resources, which have been developed using Moodle, are available directly on the CGIAR Web site.

China National Top level Courses use OER to promote quality in undergraduate teaching (www.jingpinke.com).

CIARD initiative: Asia-Pacific region

The CIARD movement is a global approach to information management and knowledge exchange related to agricultural science and technology. CIARD brings together institutions and people who want to make the outputs of agricultural research more accessible. In agriculture, there is a major barrier that effectively stops people getting what they need. Many agricultural innovation organizations invest only a small fraction of their resources in communicating their results and ensuring they are well adapted to the needs of rural society, and most provide less than 10 percent of their available information on the Internet. CIARD is a collaborative venture among more than 150 of the world's leading agricultural agencies and can draw on expertise from all the important disciplines. CIARD's three priority areas are: (1) to improve investment through introduction of sound policies and coordinated approaches through the documentation of 'Good' practices in the CIARD 'Checklist'; (2) to develop the information-sharing capacities of organizations, and foster the formation of networks; (3) to make data and information accessible by promoting open content and common standards and tools that support sharing of agricultural information. The CIARD 'Advocacy Toolkit' is offered to national stakeholders working to achieve policy change. Current initiatives and tangible benefits of sharing data and information are being documented in case studies.

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 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.

CIARD's 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-relatedinformation 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 AR4D management (**Figure 7**). Almost a million full text documents, three million bibliographic details and several databases are registered with CIARD RING from all over the world. Similarly developed national RINGS using the CIARD RING as a guide and template, can be used to collaborate better with other similar rings subregionally, such as in South Asia, regionally (for example Asia and Pacific) and also globally through the GFAR-led CIARD RING.

Figure 7. Linking information through the CIARD RING

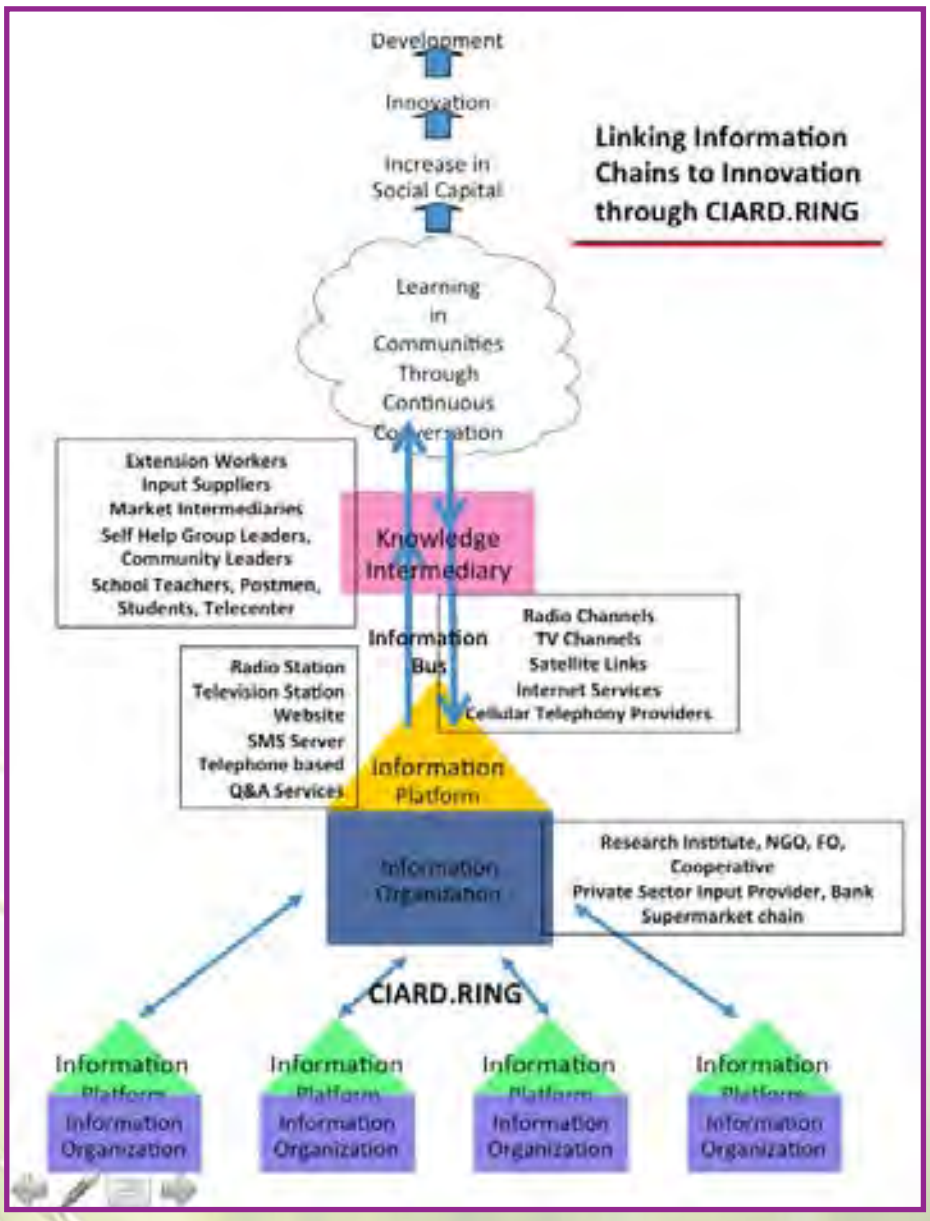


Figure 8. **Asian countries that have registered organizations and corresponding services through the CIARD RING.**

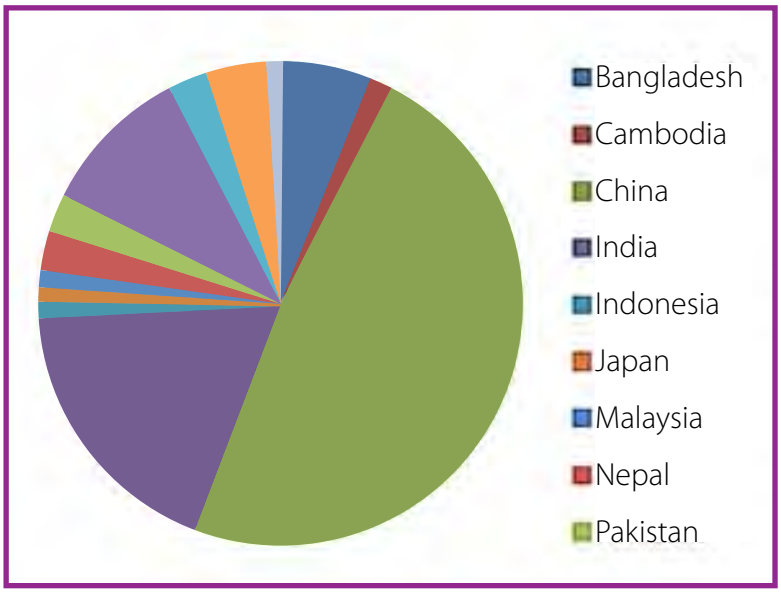
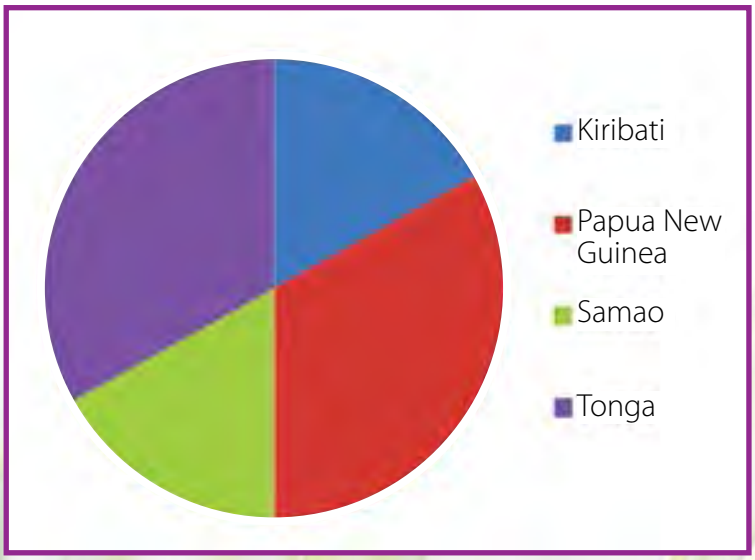


Figure 9. **Pacific country participation in the CIARD RING**



NOTE :
Colours indicate the percentage of organizations registered in the CIARD RING from each participating country. The chart reflects data available as of 20 March 2013.

Chapter 5
Strategies for ICT/ICM in AR4D

The analysis reveals that the Asia-Pacific region is one of the most advanced regions in terms of emerging ICT infrastructure and innovations as well as being a region where large areas are uncovered by the impact of frontline developments in ICT. Therefore, it would be important to consider a multipronged strategy for the region (GFAR 2009). It would be more practical for regional and international organizations to identify strategies that can bring visible benefits and advantages to relatively uncovered areas which may comprise whole countries (such as LDCs, the Pacific Island countries) or specific areas within national economies (in South Asia and Central Asia, for example). A review of strategies and recommendations proposed in various workshops organised by APAARI in the last ten years reveals the need for a new perspective on ICT/ICM in AR4D in this region. Firstly, it is important to recognize that production and dissemination of data, information and knowledge in AR4D cannot be regarded anymore as a subsidiary activity, secondary or tertiary to the mission. The ICT/ICM roles and functions need to be recognized as both parts of mainstream research as well as support structures. This is a fundamental necessity arising from the adoption of the GCARD roadmap of positioning AR4D as an integral component of AIS. Information and knowledge exchange processes are, so to speak, the glue that holds various components of AIS together. Secondly, policy-makers in AR4D should dispense with the notion that there are readily-available, prepackaged and off-the-shelf ICT solutions available for many challenges in data, information, knowledge management and sharing in AR4D. The ICT sector in the Asia-Pacific, region being primarily driven by the for-profit, export-oriented services industry, has not built ready-made solutions in support of research for improved food security or to improve income through agricultural production. A reasonable amount of adaptive and applied research is necessary, similar to the way standard civil engineering practices were adapted through practical research to develop the disciplines of agricultural and irrigation engineering that are mainstream research subjects in AR4D in the region.

From this perspective, what emerges from an analysis of earlier recommendations are four strategic directions. These relate to Capacity, Content, Connectivity/Infrastructure and Policy.

Capacity

All recommendations from APAARI consultations have repeatedly identified lack of capacity as the most important gap in taking advantage of the power and potential of ICT/ICM in AR4D. This has been observed to span various levels from the working researcher/associate upwards. Incremental filling of the gaps through occasional, on-the-job training programmes are helpful but only in the short term. This is because developments in the ICT sector are rapid and skills often have limited shelf-life. It is useful,

therefore, to think of a system to deliver continuous training programmes that can be delivered online, using local contacts on occasion. Many such programmes are indeed available from development organizations such as the International Development Research Centre (IDRC) or COL and can be easily adapted for use by AR4D personnel. What is needed to launch and sustain this effort is a focused leader from top management of NARS organization(s).

With basic capacity development conducted in this manner, more specialized efforts for specific groups of personnel (in data management, in GIS, in Learning Management Systems etc.) can be provided on a periodic basis. It is important to recognize that even advanced skills can be eroded fast because of the nature of ICT developments today. One size does not fit all, and one-time training is not adequate for a lifetime in all these interest areas. Therefore, according priority for capacity building and strengthening must proceed on the basis of willingness to make regular and adequate investments.

A serious gap at global and regional levels is the inability of ICT professionals to comprehend the complexity of challenges in AR4D and AIS. Experience shows that ICT professionals tend to make oversimplified assumptions about the production and value-addition processes in agriculture and therefore tend to offer off-the-shelf solutions that often would not meet the requirements of AR4D. It is therefore necessary to establish a dialogue with interested ICT experts and help them build their capacities to understand the nature of agricultural production. A beginning can be made if the AR4D sector, through APAARI, can generate suitable learning/training materials that can be used in engineering, technology and management institutions. In the same way, training materials on adaptation of ICT techniques and methods for on-farm/on-station research can be generated and made available for use in formal education systems in NARS. These steps will help gain optimum or even maximum impact for investments that may be made. For Pacific island countries, LDCs and certain regions in South and Central Asia, the first step in this context will be particularly relevant.

Content

Previous recommendations revealed that the availabilty of digital content in the sector in general is inadequate to sustain information services on a very large scale. This needs to be addressed on a priority basis. Organizations and agencies in the NARS are known to produce sizeable volumes of data and information. However, only a part of them are produced digitally or transferred to digital domains. It is very important to enable NARS to adopt digital production of information as the primary means. To make it available for other stakeholders in the AIS, it is essential to adopt the OA practices and standards. CIARD is a crucial resource in this endeavour. NARS organizations should be made aware of the strengths that CIARD can bring to NARS in making their digital information products widely noticed and in their use for sustaining information services.

NARS in more advanced and emerging economies may consider generating content that is responsive to mobile devies (Tablets and smart phones). With the continuing drop in prices and the simultaneous continued increase in computing power and storage in mobile devices, IT industry leaders are convinced of the possibility of wholly new services being thought of and launched. While the AR4D sector may have been a late-starter in the PC/laptop era, it has everything to gain by moving fast into the rapidly emerging paradigm of mobile computing and communication. A specific programme to build Apps for smart phones and Tablets can be conceived of and launched in the short term on a trial basis.

Infrastructure/connectivity

There has been noticeable advancement in NARS in provision of essential ICT infrastructure and connectivity throughout the region. This is continuing at a differential pace in almost all the countries as mainstream activity. There is a known lag in connectivity provisioning in the Pacific island countries which is not limited to AR4D alone. With the steady increase in availability of cloud-computing services in many countries, the AR4D sector may refocus its efforts to provide basic computing services via the cloud, thus reducing the complexity of network operations and management in extended and remote locations. There is concern about the custodianship of data with the service providers. A set of expert consultations, in this regard, to develop a start-up guide for NARS would be beneficial. It would also be very important for NARS to refocus connectivity provisioning in view of the increase in the availability of a range of data services via mobile telephony infrastructure.

Policy/organizational change

A number of recommendations from previous APAARI, FAO and GFAR consultations relate to policy. These are presented in a summary form below:

- Developing an accountability-based leadership system through an appropriate recognition and reward system;
- Advocacy through success stories/policy briefs;
- Introducing change in work flows, processes compatible with digitalization efforts;
- Fostering top-down as well as bottom-up community-participatory efforts in ICT/ICM knowledge-sharing efforts;
- Active and consistent advocacy of 'openness' in agricultural information management;
- Introducing strategies to build new online and offline services using agricultural information;
- Promoting linkages and exchanges between experts and workers in ICT and in agriculture, involving the staff of universities and NARS institutions;
- Setting forth core issues in contemporary digital intellectual property management in agriculture and outlining how awareness programmes can be organized (these should include non-research personnel as well); and
- Emphasizing the importance of developing and negotiating standards in information exchange across stakeholders.

What is important for a policy-maker is to recognize the two perspective statements made at the beginning of this chapter. It is also important for policy-makers to recognize that the rapid advancement in mobile communications and computing in the region provide unprecedented opportunities to mainstream ICT/ICM in support of AIS. The value of CIARD as an essential as well as advanced resource cannot be overemphasized in policy matters.

Chapter 6

Conclusions

It is clear that ICT use in AR4D in the Asia-Pacific region remains uneven across the region, with some countries remaining untouched and others showing considerable growth in awareness and use. For example; according to an Agricultural Science and Technology Indicators (ASTI) publication, the scientific competence of South Asia's agricultural R&D agencies is high, but as in many developing regions of the world, stronger linkages are needed to connect agricultural research agencies and their staff with the end-users of their research to improve the relevance, effectiveness and efficiency of research outputs (Stads et al. 2012). To link the existing competence to sustainable socio-economic impact, ICT/ICM practices need to be mainstreamed in AR4D. Analysis presented in this report indicates that capacity and compatible policy are required to enable NARS to absorb benefits from ICT/ICM.

The report also emphasizes that capacity development in ICT/ICM on a significant scale is necessary to enable AR4D researchers, innovators and extension personnel to make better use of a host of new developments. Very large increase in digital content is almost a precondition for developing consistent and reliable information services, so digital content generation must be undertaken in a substantial manner. Fostering the development of such capacities will be helpful in designing new knowledge-intensive agricultural world, information is now even more critical for the resource-poor, smallholder farmers and producers. It is evident that new kinds of leaders are needed to bridge the expert-farmer communication and exchange gap, and cross-sectoral training is critical. Online social spaces and networking could be considered a platform of choice in AR4D.

There are ever-growing opportunities for improved extension/advisory services and for farmer-to-farmer learning. The AR4D sector in the Asia-Pacific region must now contribute to the development of new standards for the organization and operation of rural information delivery services, and there is the promise of helping to foster a new class of farmer-entrepreneurs that can mediate in information flows.

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