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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.

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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/


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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 a spirations 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.

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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

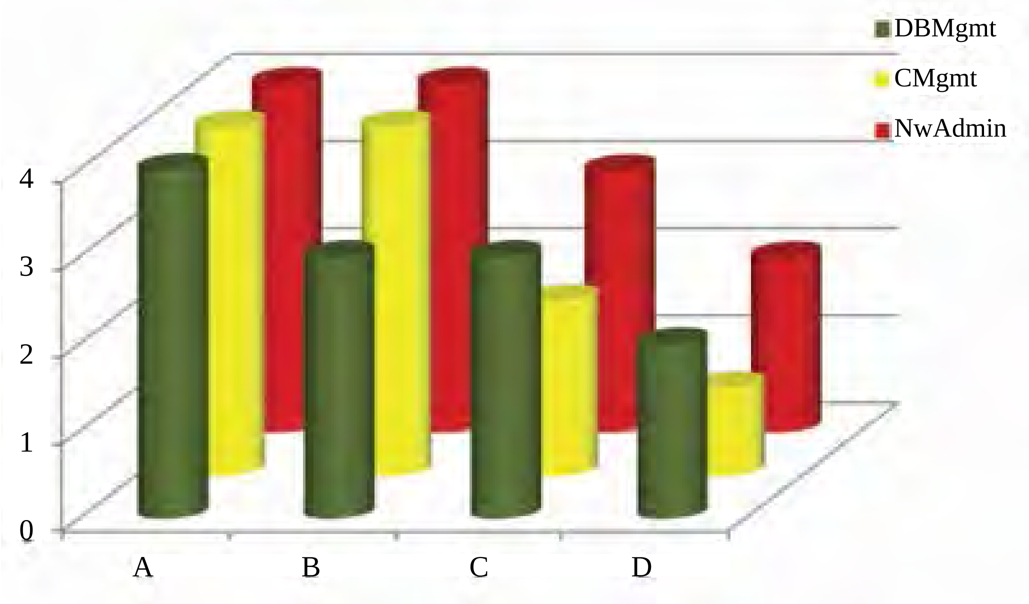
Current status of ICT/ICM in AR4D

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

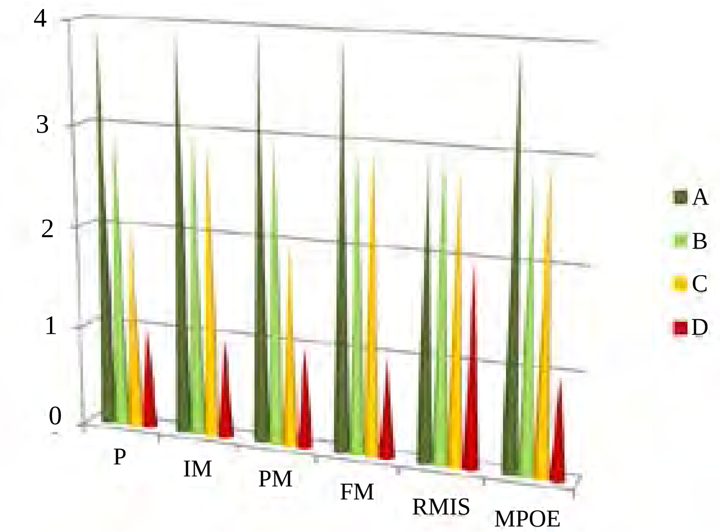


A:	Japan, Malaysia
B:	India, Pakistan, Philippines, Thailand
C:	Fiji, Indonesia, Papua New Guinea, Sri Lanka, Viet Nam
D:	Bhutan, Cambodia, Lao PDR, Myanmar, Nepal, Samoa Capacity measures: 4 developed, 3 emerging, 2 poor, 1 lacking
CMgmt:	Content management (includes Web site, content creation, multimedia, 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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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


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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

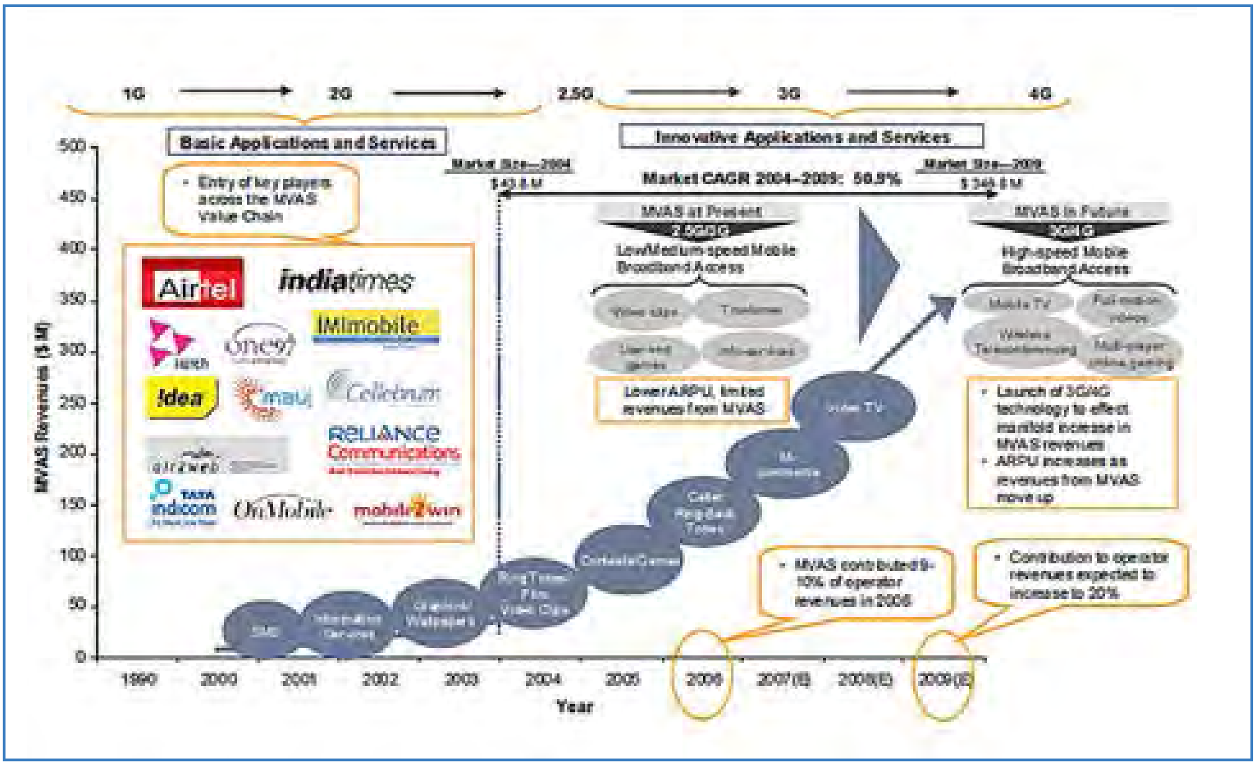
Convergence refers to the erosion of boundaries among previously separate services, networks and business models in the sector. Convergence (as the name implies) blurs the distinctions between the domains of Internet service providers, cable television media companies, fixed-line telecommunication companies 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.

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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.

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)**.

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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.

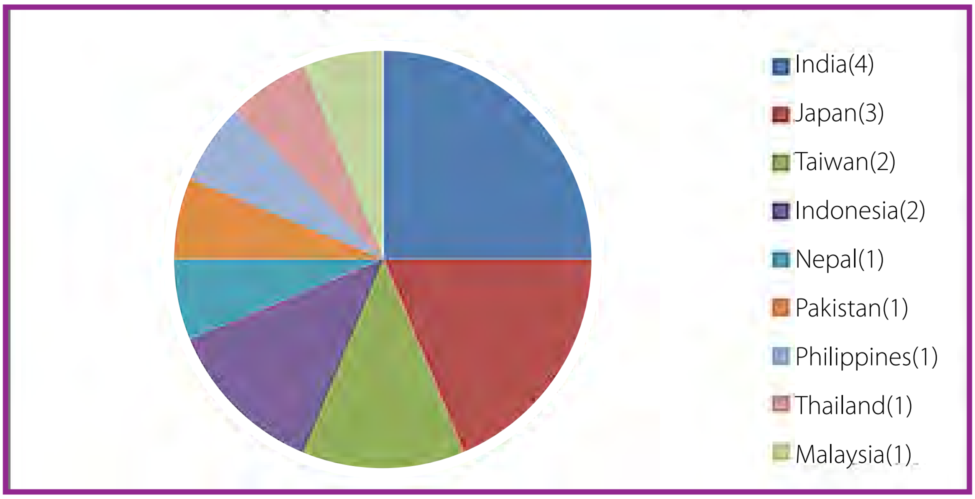
Repository: A Web site that aims to collect, preserve and proffer electronically the intellectual output of a subject or organization without charge to the world.

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)

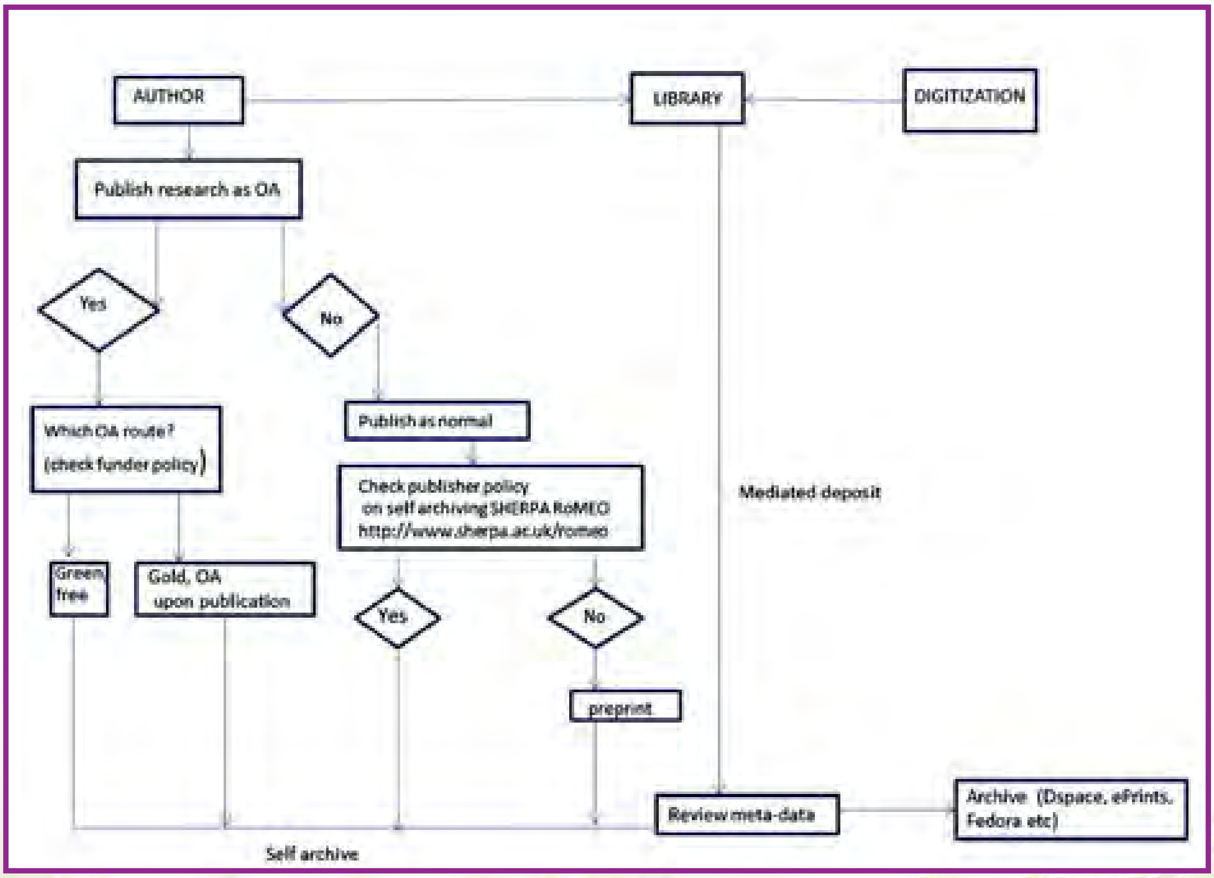
Investment

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&fIDnum=|&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).

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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

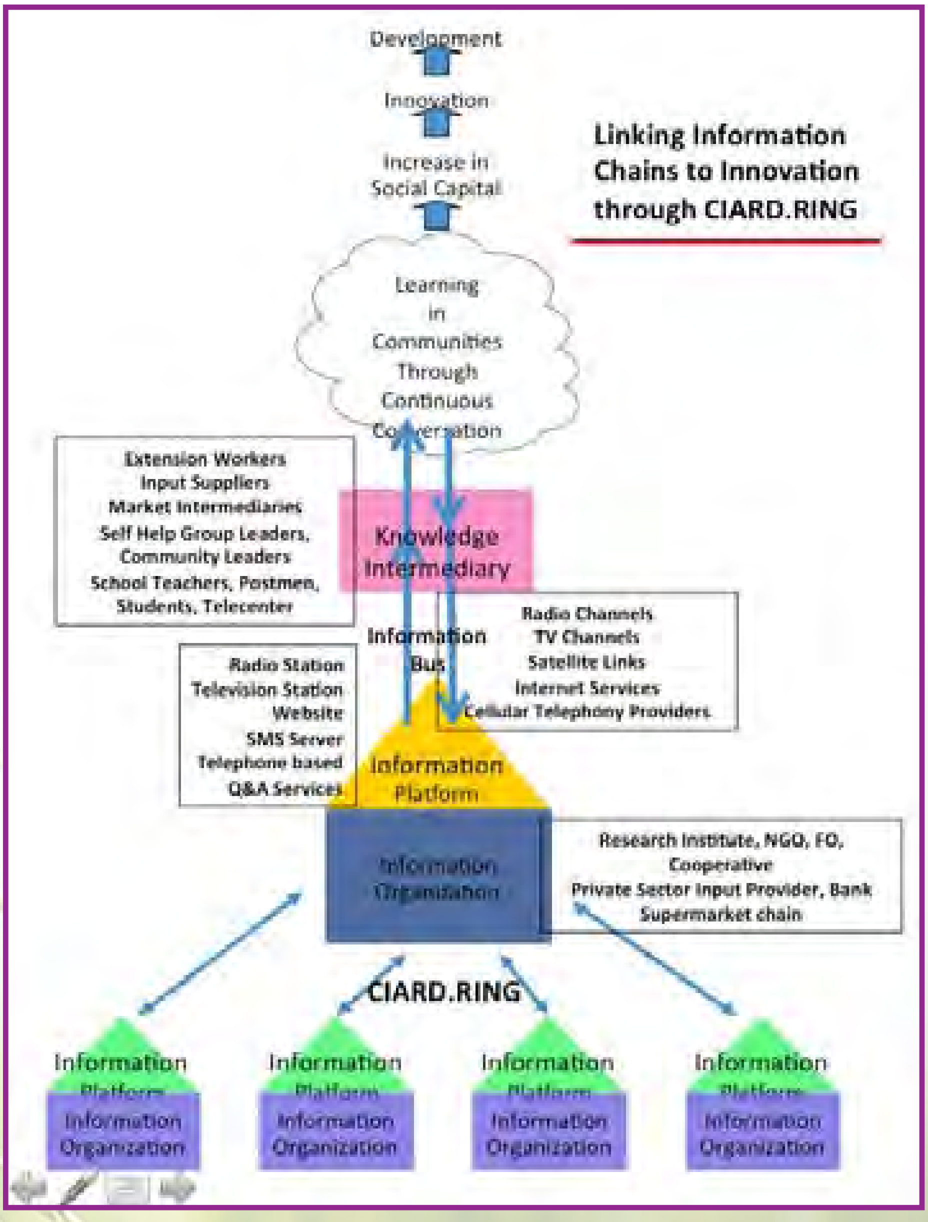


Figure 8. **Asian countries that have registered organizations and corresponding services through the CIARD RING.**

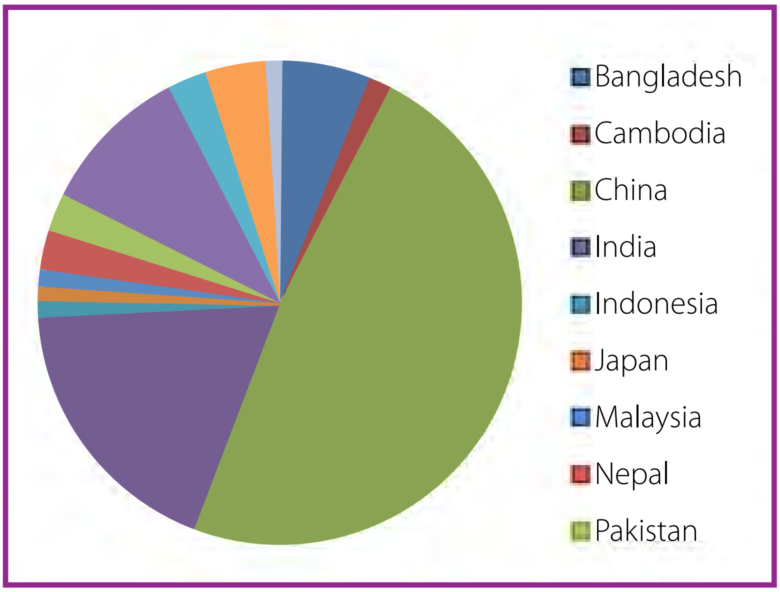
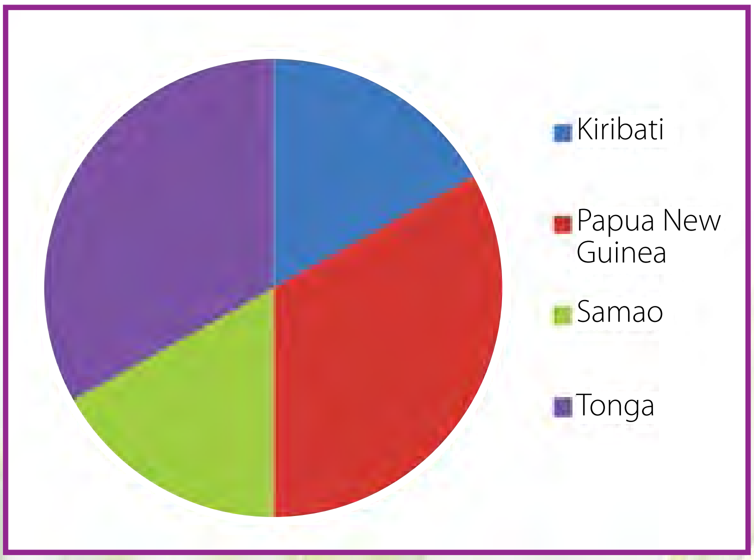


Figure 9. **Pacific country participation in the CIARD RING**



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.

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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.

References

1. The Asian Federation for Information Technology in Agriculture (AFITA). 2012. http://www.afita.org/view.php?id=20110221172739_528499
2. Agricultural Learning Repositories Task Force (AgLR-TF). http://aglr.aua.gr/node/7
3. AgriLORE. http://agropedialabs.iitk.ac.in/agrilore/?q=node/575
4. Akhtar, Nasrin. 2010. SAARC Agriculture Centre activities. Paper presented at the "Workshop on ICT/ICM for national agricultural research information systems in the Asia-Pacific region", Bangkok, Thailand, 14-16 September, 2010.
5. Asia-Pacific Association of Agricultural Research Institutions (APAARI). 2004. Information and communication technology/management in agricultural research for development in the Asia Pacific Region: a status report.
6. APAARI. 2009. Expert consultation on Agricultural Research for Development in Asia and the Pacific – the way ahead. Proceedings. 30-31 October 2009.
7. APAARI. 2011a. Information and communication technology/management in agricultural research for development in the Asia Pacific Region: a status report.
8. APAARI. 2011b. Workshop on information and communications management for agricultural innovation in South East Asia: Proceedings. 27-29 September 2011.
9. APAARI. 2011c. Workshop on Coherence in Information for Agricultural Research for Development (CIARD) and strengthening RAIS in the SAARC countries. Proceedings. 10-12 May 2011.
10. APAARI. 2012. Openness in agricultural information and knowledge sharing: proceedings. In The international conference on innovative approaches for agricultural knowledge management: global extension experiences. 10 November, 2011.
11. ArcGIS: http://www.esri.com/software/arcgis
12. Australian Center for International Agricultural Research (ACIAR) & APAARI. 2011. Workshop on moving beyond strategy to improve information and knowledge management for agricultural development in the Pacific island countries and territories. Proceedings. 21-24 November 2011.
13. Besemer, H., Edge, P., Subirats, I., Tsiflidou, E. & Protonotarios V. 2012. Review of existing agricultural data management practices, lifecycles and workflows. FAO. 2012. http://www.fao.org/docrep/017/aq190e/aq190e.pdf
14. Bientema, N.M. & Stads, G.-J. 2008. Diversity in agricultural research resources in the Asia-Pacific region. ASTI publication.
15. CGIAR Learning Resources Center. http://learning.cgiar.org/
16. CORE. http://www.core.org.cn/en/
17. Dixie, B. & Jayaraman, N. 2011. Strengthening agricultural marketing with ICT in the ICT. Agriculture Sourcebook. WB, 2011.
18. Eicher, K.C. 2007. Agricultural extension in Africa and Asia. Accessed from Worldaginfo.org at http://www.worldaginfo.org/files/Agricultural%20Extension%20in%20Africa%20and%20Asia2.pdf
19. Food and Agriculture Organization of the United Nations (FAO). 2012. Mobile technologies for food security, agriculture and rural development: workshop proceedings. 3-4 April 2012.
20. Global Forum on Agricultural Research (GFAR). 2009. International Consultation on Agricultural Research for Development and Innovation: addressing emerging challenges and exploiting opportunities through information and communication technologies. December 2009.

21. Håklev, S. 2010. The Chinese national top level courses project: using open educational resources to promote quality in undergraduate teaching. Ontario Institute for Studies in Education University of Toronto. Thesis. reganmian.net/top.../Haklev_Stian_201009_MA_thesis.rtf
22. Hayes, B. Cloud computing. Magazine communications of the ACM. Web Science, 51(7) July 2008: 9-11.
23. Information and communications technology in Agriculture e-sourcebook: connecting small holders to knowledge, networks and institutions. 2011. http://www.ictinagriculture.org/content/ict-agriculture-sourcebook
24. Knoth, P. & Zdrahal, Z. CORE: Three access levels to underpin open access. Knowledge Media Institute, The Open University (10.1045/november2012-knoth). http://www.dlib.org/dlib/november12/knoth/11knoth.html D-Lib Magazine Nov/Dec 2012.
25. Meeker, Mary. 2013. http://kpcb.com/insights/2012-internet-trends-update
26. National Agricultural Innovation Project. 2011-2012. http://www.naip.icar.org.in/downloads/NAIP_APR_2011-12.pdf.
27. RFID News. 2009. Organic RFID to cut waste on produce. http://www.rfidnews.org/2009/12/16/organic-rfid-to-cut-waste-on-produce?tag=Sensors
28. Singh, R. & Raja, S. 2010. Convergence in informatics and communication technology: strategic and regulatory considerations. http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/Convergence_in_ICT.pdf
29. Stads, G.-J. & Rahija, M. 2012. Public agricultural R&D in South-Asia: Greater government commitment, yet underinvestment persists. ASTI publication accessed at http://www.asti.cgiar.org/publications/south-asia-regional-report.
30. Suber, Peter. Open access overview. Accessed in March 2013 at http://legacy.earlham.edu/~peters/fos/overview.htm
31. Van de Sompel, H. & Lagoze, C. 2000. The Santa Fe Convention of the Open Archives Initiative. D-lib Magazine, 6(2).

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Technologies for agricultural information sharing

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PART II

Introduction

The previous section provided information on the ICT sector in Asia-Pacific countries. While there is considerable disparity in the capacity to implement ICTs for agriculture in these countries, it should be noted that much development is taking place, as witnessed by World Bank statistics.

The number of cell phone subscriptions has been increasing tremendously over the last few years to the point where mobile phone access has become ubiquitous in almost all countries, especially in the Asia-Pacific region.[1]

With the need for targeted and highly local information related to agriculture, in this section experts reveal some technologies that could generate huge advantages for agricultural information management.

FAO has extensive experience in the use of ICT to improve communication and enhance interaction among agricultural research, extension, farmers and other stakeholders in agricultural innovations and rural development.

- The Virtual Extension, Research and Communication Network (VERCON, http://km.fao.org/vercon/) is a conceptual model developed by FAO. (**Figure 10**) Any country can use and adapt it to strengthen the linkages among extension, research, farmers and other stakeholders of agricultural and rural development systems.

  The model aims at improving access to crucial linkages among these stakeholders in order to facilitate knowledge-sharing and access to agricultural information, with the goal of increasing food security. To ensure this process is successful, collaborative techniques and innovative methods of communication are used in combination with ICT. The VERCON approach brings together two fully integrated and inter-dependent dimensions that need to be combined appropriately: the human and the technological.

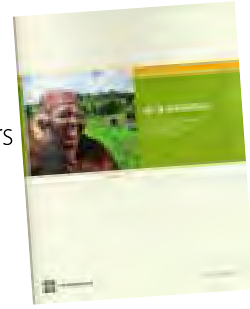
Figure 10 : Conceptual model of VERCON

1 http://data.worldbank.org/indicator/IT.CEL.SETS.P2/countries/1W?display=default

- The e-Agriculture community (http://www.e-agriculture.org) is a global community of practice in which people worldwide exchange information, ideas and resources related to the use of ICT for sustainable agriculture and rural development.

  The role of ICT in agriculture was identified as a key action line during the World Summit on the Information Society (WSIS, http://www.itu.int/wsis/index.html) held in 2003 and 2005. In response, FAO and other organizations established the e-Agriculture community to serve as a catalyst for institutions and individuals in agriculture and rural development to share knowledge, learn from others and improve decision-making about the vital role of ICTs for empowering rural communities, improving rural livelihoods and building sustainable agriculture and food security.

  FAO has also contributed to the ICT in agriculture sourcebook which identifies good practices and provides case studies on connecting smallholders to knowledge networks and institutions.



- The Coherence in Information for Agricultural Research for Development movement (CIARD, http://www.ciard.net) is working to make agricultural research information and knowledge publicly accessible to everyone. The CIARD pathways (http://www.ciard.net/ciard-pathways-opening-agricultural-knowledge) provide an introduction to the ways in which research outputs can be made more widely Available, Accessible and Applicable (also known as the '3As') to stakeholders. Optimizing the reach and use of research outputs has many advantages. The CIARD Manifesto (http://www.ciard.net/ciard-manifesto) and the CIARD Checklist of Good Practices (http://www.ciard.net/checklist-good-practices) are statements on what needs to be done in order to achieve enhancement of the 3As. The CIARD pathways are practical guides, showing how the different elements of the Manifesto and the Checklist can be achieved by institutions around the world. A collection of case studies (http://www.ciard.net/cases) describes efforts by institutions around the world in opening up access to their research outputs. A set of standards and tools (http://www.ciard.net/standards-and-tools-information-and-data-management) makes sure that research outputs/repositories are interoperable with other repositories and that data are interoperable, enabling ease of export to other platforms/applications.

  The CIARD Routemap to Information Nodes and Gateways (CIARD RING http://www.ciard.net/ciard-ring-0) is a global registry/reference for web-based services that affords access to any kind of information sources pertaining to AR4D.

- The Information Management Resource Kit (IMARK, http://www.imarkgroup.org) is a partnership-based e-learning initiative targeting the effective management of information to address the information needs of people who are not in the classroom milieu. IMARK consists of a suite of distance learning resources, tools and communities on information management.

- The AGORA programme (http://www.aginternetwork.org/en/), set up by FAO together with major publishers, enables least-developed countries to gain access to an outstanding digital library collection in the fields of food, agriculture, environmental science and related social sciences. AGORA provides a collection of more than 3,500 key journals and 3,300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books to 2,500 institutions in 106 countries. AGORA is designed to enhance the scholarship of the many thousands of students, faculty members and researchers in agriculture and life sciences in the developing world.

There are more instances of technology-mediated extension services in developing countries, many documented on the e-Agriculture platform (www.e-agriculture.org). Not only do ICTs provide a faster way of interacting, they also provide a **more effective monitoring and evaluation platform.**

The role that ICT canplay as an instrument of change is potentially transformative. Smallholder farmers, particularly women involved in agriculture, have a huge advantage when the right ICTs are induced into the agriculture value chain. 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.

In this publication, the article[2] on 'Emerging contours of new agriculture' outlines how new ICT technologies are assisting in moving agriculture away from an input-intensive to an information- and knowledge-based process. It also highlights the need for more openness in agricultural research information to be able to build smart services to support decision-making in agriculture together with support structures such as the communities/organizations that are needed to sustain this.

The second article[3] on information ecosystems stresses the need for openness in sustaining an information and knowledge system while stressing the importance of policies at institutional and sectoral levels. The science news portal, e-Science News,[4] harvests science-based news and regroups, categorizes, tags and ranks it automatically through an artificial intelligence-based probabilistic classifier. Again, this is made possible through the availability of data that are easily available, accessible and adaptable.

Investing/implementing appropriate technologies is of paramount importance as shown by issues in the Pacific highlighted by Emil Adams in his article[5] 'Radio still viable in a connected world'. It highlights the unique problems faced by Pacific island countries that are compounded by the geography of the region with far-flung islands where infrastructure-related issues are one of the key challenges in implementing emerging ICTs to aid agriculture.

The Economist noted[6] as early as 2008 that a device perceived as a toy for young urban professionals not so long ago has now become a potent force for economic development in the world's poorest countries. The in-depth survey by LIRNEasia[7] on understanding the use of ICTs by the Bottom

2 The emerging contours of new agricultural development, Page 56
3 From the Real Farm to the Server Farm, Page 63
4 http://esciencenews.com/
5 Radio - still viable in a connected world, Page 66
6 http://www.economist.com/node/11465558
7 http://lirneasia.net/projects/icts-the-bottom-of-the-pyramid/

of the Pyramid (BOP), including those engaged in agriculture, provides valuable insights into how smallholders and agricultural microenterprises use ICTs and specifically mobile phones.

NOKIA LIFE has been able to leverage this growth to effectively deploy agricultural information services through mobile phones. NOKIA LIFE's app has been able to deliver specialized and targeted information to many farmers and people involved in agriculture in many countries. The knowledge base needed to sustain such an initiative and the problems faced by handset manufacturers turned into content developers is highlighted.

GSMA outlines[8] the transformative power of mobile broadband for agriculture with in-depth insights into the growth of mobile Internet connections. This is also echoed in CABI's article on mobile telephony in agriculture. Agricultural Value Added Services or Agri-VAS are being delivered through mobile technology in a few countries such as India, Bangladesh and China. This ranges from price monitoring and weather forecasting to facilitating financial services to the rural population.

According to Science Daily, a full 90 percent of all the data in the world has been generated over the last two years.[9] The speed at which these data flows makes it impossible to store and analyse them to support future decision-making. Machines and software with the ability to capture/analyse data 'on-the-fly' is what the near future needs. The sheer volume of data generated is referred to as 'Big Data' and they hold great importance for agriculture. Analysing rainfall data over a period of 50 years or the pest vector could give valuable insights into important issues such as climate change, weather patterns and disease and pest infestation patterns. The re-use of data is an emerging thought that is yet to be addressed by the ICT4D experts. Intel outlines the implication of 'Big Data for Agriculture'.

Precision farming, GIS and remote sensing are touted as the most promising ICT interventions for agriculture. The last article[10] describes how a company has been able to use these technologies to establish an agro-infrastructure throughout a whole country for fostering better agricultural development.

Many other innovations hold great promise for agriculture, such as the use of ICT technologies that provide newer ways to handle disaster response. FAO actively surveilled Highly Pathogenic Avian Influenza H5N1 in Bangladesh with the help of ICTs (see http://www.youtube.com/watch?v=eEj0gVV44V0).

The recently published article,[11] by OpenSignal, a London-based app development group, explains how they were been able to use crowd-sourced temperature information for real-time temperature readings in major cities. The same temperature sensors built into smart phone batteries that prevent them from overheating has been successfully tapped to reveal accurate weather data, much more accurately than widely separated stationary weather trackers. This holds great importance as granular information is urgently needed in present-day agriculture.

The contents of this publication provide an overview of how emerging technologies can be used effectively to facilitate information exchange as well as to support decision-making in agriculture and rural development.

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8 Transformative power of mobile broadband for agriculture, Page 90
9 http://www.sciencedaily.com/releases/2013/05/130522085217.htm
10 Country-wide agro-ICT infrastructure and stakeholder cooperation for the benefit of farmers including smallholders, Page 97
11 http://onlinelibrary.wiley.com/doi/10.1002/grl.50786/abstract

The emerging contours of new agricultural development

Ajit Maru, Senior Knowledge Officer, GFAR Secretariat, Rome

New Information and Communication Technologies (ICTs) are now introducing a discontinuity in agricultural development by enabling an information- and knowledge-based approach rather than focusing on input-intensive agriculture. This brings greater efficiencies in the use of natural resources such as water, soil nutrients and energy, and attenuates damage to the environment. They are defining the emerging contours of new agricultural development – progress that is more intensive and sustainable.

New ICTs are enabling more effective access and use of information; this is improving farming processes by managing inputs, throughputs and outputs from farms, postharvest processing and marketing. Such technologies are ensuring the safety of agricultural products through the monitoring of good agricultural practices and traceability of farm products. They are critical in averting risks from weather anomalies, natural disasters and spread of pests and diseases.

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Effective access and use of information for decision-making

The transformation of agricultural extension

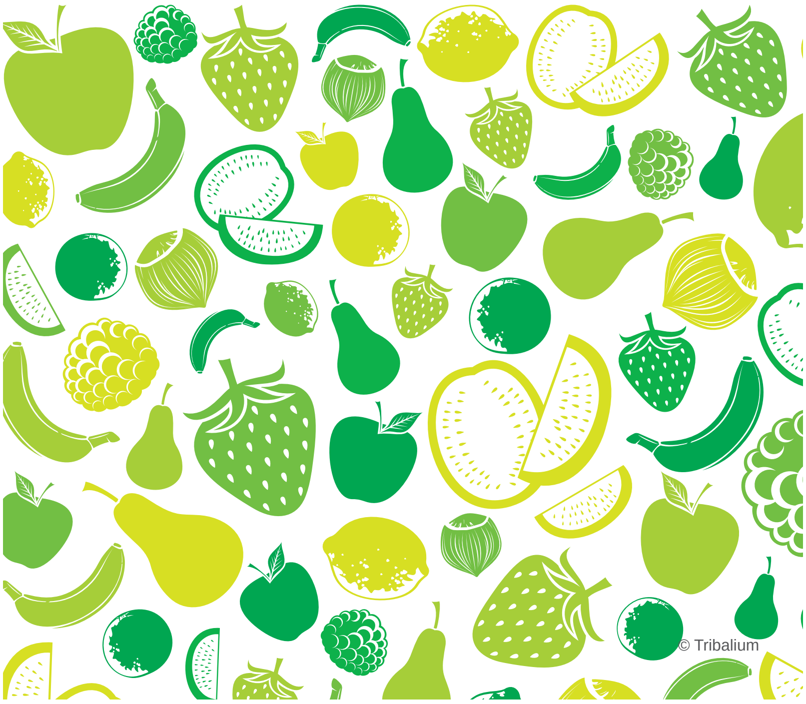
One of the key roles of new ICTs has been in the management and sharing of agricultural information. In the past two decades, ICTs have transformed agricultural extension by changing the flows of agricultural information. Prior to the advent of new ICTs for providing farming-related information, extension was a linear process that passed information from research Institutions through extension agents to farmers. The radio, as used during the 1960s and 1970s, was an extension of this method except that instead of pamphlets and brochures it broadcast the message. The training and visit (T&V) approach, successful in some farming areas, a similar but more face-to-face and customizable approach, was costly in terms of resources – human, financial and logistical – and not easily sustained. Almost all extension was about common practices for farming, not about how to solve the unique problems that farmers encounter. Once the fruits of the green revolution – high-yielding, management-responsive crop varieties for wheat and rice, inputs such as chemical fertilizers and pesticides, irrigation and market subsidies and extension free from government influence – had all been harvested, growth in agricultural productivity stagnated. The linear extension model could not help farmers cope with the more complex, increasingly knowledge-based farming needed to participate in highly competitive globalized agricultural markets. In this form of agriculture, farmers needed on-demand customized solutions to their unique problems and these solutions had to be provided as options for the farmer to choose. The new extension service also had to provide information about how to effectively participate in markets. This needed the most current information about consumer preferences, not only local but also global, and from that, what to grow, when, where and how and where to market it for a profit. The only way to provide information in this context is to use new ICTs that overcome the limitations of broadcast, passive communication and can provide on-demand, customized and active communication.

The development of ICT in agricultural information service

The advent of small computers in the 1980s contributed to information processing and decision support. Initially they were used by major aggregates such as cooperatives but soon large farms could afford them. In developing countries, experiments, such as those of the MS Swaminathan Research Foundation in Pondicherry, India, were made to use them initially in a collection of villages and then at village and community levels. The mobile computer, with reduced dependence on electrical power and combined with a Compact Disc (CD) drive, enabled farm-related customized information sharing and decision support as needed by each community. Internet connectivity facilitated access to market-related information, usually prevailing wholesale prices.

A significant leap forward was the development of the cellular telephone which allowed farmers could access and share information they needed. However the conventional linear extension systems, even now in place in many developing countries, have not been able to use the potential of this new ICT and its more recent developments, the smart phone and 'Phablets' with their mixed media and information-processing capacities. This potential, when coupled with widespread broadband connectivity and 'cloud' computing, is bringing hitherto unimagined new capacities for farmers and all actors involved in complex agricultural market chains to access and use information for decision support. It therefore important to understand how the potential of smart phones with broadband connectivity and cloud-based computing can be effectively used to transform smallholder agriculture in developing countries.

Cellular telephony primarily provides voice - and short messaging service (SMS)-based functions for multicasting, i.e. sending messages to a defined community and question-and-answer services. In some cases multimedia messaging (MMS) services with photographs, voice and video mail are also used. SMS messages are short and therefore limited such as for alerts to change in weather, pest and disease outbreaks and market prices. Voice-based question-and-answer services provide more customized and specific answers to queries but can be constrained by human and organizational infrastructure in the same way as T&V extension.



The use of smart phones can overcome the shortcomings of current cellular telephone-based services. With broadband Internet, 3G and 4G connectivity and cloud computing, they can provide Web-based services and apps using centralized databases, knowledge-based systems, decision-support systems (with models and simulation) and GIS/map-based systems; also audio- and video-based services for disseminating new agricultural technologies and enabling diagnostics of pests and diseases. These apps and services can help farmers make informed decisions and plan, monitor and evaluate their farm productivity and for agricultural service providers and agribusiness entrepreneurs, seamlessly link to markets both for farm inputs and outputs. This can optimize the entire production and market chain for agricultural commodities while ensuring food safety and quality, thus reducing wastage in every stage of production from input, processing to consumption.

New ICTs such as smart phones are also bringing another revolutionary change, the ability for the multiple actors and stakeholders in agricultural production and market chains to participate, as a community, in information management. Each actor, from the input supplier, the farmer, the wholesaler, processor to the consumer generates information, which, when shared improves the efficiencies of the production system and the market chain, which contributes to innovation. Smart phones support social media or sharing of user-generated content such as through forums, blogs, Wikis, social network Podcasts, bookmarking, sharing of videos and photos. A recent development is participatory GIS and mapping. High resolution-based maps in applications such as Google Maps/Earth and Microsoft Bing that are available in the public domain can be used to map landownership, soil profiles, watersheds, cropping patterns and profiles at seasonal levels, routes of farm service providers such as for equipment and transport. With locally available interoperable datasets generated through user participation and uploaded through Smart phones and 'Mashups', locally relevant new information visualized on maps can be generated. For example, when transportation will arrive to collect a harvest or when a veterinarian can arrive to visit a sick animal. Greater efficiencies in terms of time, cost and quality of services and products can be attained in farming by using these technologies.

Constraints in using new ICTs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It is predicted that the availability of broadband Internet, 3G and 4G connectivity will soon be available in rural areas. The prices of smart phones are decreasing and they are becoming affordable. Technology therefore is not considered a major constraint although its adoptionand adaptation to local needs are.

The most critical constraint now is appropriate agricultural content. There is a need for more availability and openness in accessing data and information, making it 'interoperable' and development of relevant apps to effectively and easily process and present this information in a useful way. In most developing countries, public sector agricultural organizations, including those for research, education and extension are the main repositories of data and information. These organizations, through their lack of capacities, infrastructure and inadequate investment, are not able to make data and information available, accessible and applicable and they do not contribute to enabling the effective use of this information for agricultural development. These organizations urgently need to change their policies and strategies for providing data and information, their key products, and reorganize and restructure themselves to manage and share information effectively and efficiently. There may even be a need for the establishment of new organizations.

A key issue missed in examining the discontinuities in agriculture being generated by new ICTs is the shift in the economic value of agricultural information it creates. In most agricultural systems in developing countries information related to agriculture and farming is collected by government and public sector organizations. Technically this information is a 'public good' in the public domain and a public resource. The same applies to information for agricultural development and progress generated by public sector research organizations. In the linear model of extension, all information, for example, on common farm practices is a public good. However, when customized to solve a unique problem of a farmer, the information has to become a 'private good' and there is always a transaction cost for this process. For example, there may be a recommendation that a hectare of a particular variety of wheat requires 90 kg of nitrogen. But a farmer might have a richer nitrogen soil and may need only 70 kg of nitrogen. To know this, she has to have her soil sampled, analysed and the results interpreted by an agronomist. She may save 20 kg of nitrogenous fertilizer for her crop but there is the cost of the soil analysis and expert advice or information that is only for her 'good' and is useless to any other farmer. The question arises who should bear the cost of this information. Should it be considered a public good and thus the cost borne by the public or private sector or should it be borne by the farmer? This question comes to the fore significantly when ICTs are used to provide customized services and in market-oriented agriculture. It is further complicated when user-generated data and information are shared and expected to be used by everyone in the market chain. There is a significant cost in organizing the necessary infrastructure, organizations and systems to share and create capacities to use this information effectively. Should this information service then be public operated or a private enterprise? Apparently, it has been observed that the public sector is withdrawing from agricultural extension and as an information provider. The emerging vacuum can be filled either by the private sector or by the cooperative sector or both through collaboration. This is an area that now needs attention. There is huge potential for agricultural knowledge services providers but the key question at the moment is who and how this emerging vacuum can be filled?

ICTs embedded in farm and agricultural processes

Precision agriculture for the smallholder farmer and producer

The embedding of ICTs in farm processes using sensors that can measure soil nutrients, soil moisture and temperature, ambient environment and even pest and disease attacks and control equipment are enabling more precise farm management. These processes are also linked through GPS and mobile GIS to cultivate, fertilize and spray pesticides and monitor harvests. Robotics and automation have reduced human labour in many tedious farm operations. Video cameras help monitor crops remotely. As the cost of sensors declines, networks of embedded sensors to continuously monitor irrigation, fertilizer and pesticide application, nutrient intake in livestock, environmental conditions such as air and water quality and pollution are being used in farming in developed countries. Coupled with maps of less than 0.25 m resolution, real time data input from sensor networks and the ability to process 'big data' that are generated by new ICT systems, farmers can improve the efficiency of all their operations significantly by reducing water, nutrient and energy wastage and improve the quality and safety of their produce.

A key issue for global agriculture is when can this technology now used in large farms in developed countries be made available for smallholder agriculture in developing countries? There is evidence that not only are sensors becoming cheaper, but they are also becoming more versatile, multifunctional and robust and more easily networked. It is only a matter of time owing to reduction of cost and increases in functionality that they can be acquired by smallholder farmers in developing countries. However, to bring more precise agriculture to smallholder agriculture and optimize the use of the community's shared natural resources would require significant aggregation and sharing of data and information. This becomes possible by using higher resolution 3-dimensional maps now available at the plot level. Previously maps could only be used at farm or large field levels. In conjunction with sensor networks, via automated local meteorological stations and maps, soil, water and even pests and diseases can be measured more accurately, availability of and resource needs identified and costs estimated and shared more rationally and equitably.

As indicated, the core issue in using these technologies for smallholder farming is in aggregation, not only of the resources for shared community use but also of data and information. At the moment most community-based organizations lack the capacities to manage and effectively use the massive sets of data and information that these new ICTs will bring. The solution lies in enabling new organizations where all stakeholders involved in a community's resources can collaborate and share equitably not only the tangible resources but also data and information. These organizations could be community-based such as cooperatives and farmer/producer companies, small and medium enterprises or in the public sector. Such farmer cooperatives have emerged in Germany and Austria where these organizations have been dealing with commodities and finance as well as data and information management with comprehensive linkage for more efficient and productive farming among their members.

Other applications of new ICTs

There is significant potential for new ICTs to be used by smallholder farmers in developing countries to improve their farming systems and outputs. Traceability and identity preservation using low-cost radio frequency identification devices and near field communication can help smallholder farmers and producers to participate in organized markets and ensure the food safety and quality of their produce. Logistics for farm inputs and outputs as well as farm services such as those provided by veterinarians and extension agents can be made more efficient when locator services are available through maps on mobile devices. Even fresh parceling of agricultural plots using more specific data such as those for potential land productivity – a serious problem in re-organizing smallholder agriculture for governments – can be resolved using these new ICTs.

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Conclusion

There is now growing evidence of how new ICTs are creating a discontinuity in agricultural development in developed and developing countries. The issues that lie beyond adopting and adapting technology as its cost declines for use by smallholder farmers are in availability and access to relevant, timely and useful content. This requires significant transformation of current agricultural organizations and how they address farming. These organizations will need to be able to manage and promote effective use of data and information that new ICTs will generate to bring greater productivity efficiencies to all actors from producers to consumers. These organizations will also need to be able to make the entire information-sharing process participatory. The agricultural information manager now has to consider the challenges not only of using new ICTs but how to transform organizations and enable community participation for agricultural development and progress.

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B

From the real farm to the server farm and back: *The critical role of openness in sustaining an information and knowledge ecosystem in AR4D in the Asia-Pacific region*

V.Balaji, Director of Knowledge Management, Commonwealth of learning (COL)

Innovation and information ecosystem concepts are no longer metaphors or analogies in AR4D in the Asia-Pacific region. They provide viable models to advance the discourse. Knowledge ecosystem is a term used occasionally in knowledge management as an organizational practice. It should be possible to deploy concepts such as stocks and flows in ecosystems more meaningfully. If we adopt this perspective, what is the equivalent for energy which is the core flow in an ecosystem?

In knowledge management applied to organizational practices in the business sector, data are thought to be equivalent to energy. Data flows in an information ecosystem can be construed as the equivalent of energy flows, which result in modifications of stocks and services in an ecosystem. Flow of data modifies stocks of information in the relevant ecosystem. In the standard ecosystem terminology, changes in stocks affect services that the ecosystem provides. Proceeding further along this line of informal modelling, it is not unreasonable to view agricultural education, extension and research support as important services that arise from the knowledge ecosystem with data as its core flow. Decision support and policy-making can be viewed as processes that require considerably more advanced data flows and services. ICT infrastructure plays the equivalent of material flows in a standard ecosystem perspective, with all the hardware equipment and software applications viewed as components in the flow of matter.

In actual practice, data flow from one component in the knowledge ecosystem to another. This paper considers data flow from the farm, on station or in the village, as the primary source of data, moving through various components facilitated by ICT infrastructure, leading to information services for a number of stakeholders but primarily to the producers themselves. The principal component that facilitates the flow is the data centre at the sector or national level, which can be loosely described as a 'Server' farm. Therefore the flow of data from the farm through various component systems via the Server Farm provides the energy flows that are necessary for sustaining the knowledge ecosystem for Agricultural Research for Development (AR4D). Blocks in the flow of data can and will lead to under functioning of the components and will lead to reduction in the availability and the quality of services from the ecosystem. This is how the critical role of openness emerges in the particular ecosystem of knowledge management in AR4D. Openness that enables flow of data between and across components in a knowledge ecosystem is not a matter of choice. It is essential if the services expected of a knowledge and information ecosystem are to be functional.

Recent APAARI. GFAR and FAO reports clearly show that ICT infrastructure is steadily improving in all the countries of the Asia-Pacific region, even if there is some unevenness in progress across countries. There is also

unevenness inside countries regarding access to ICT infrastructure for AR4D. It is fair to infer from these reports that ICT infrastructural developments in AR4D will continue to improve across countries in this region. While the more conventional desktop computing and applications related to desktop computing will advance in AR4D in the region, the rapid emergence of affordable computers in the form of Tablets will make a fundamental difference. The Asia-Pacific region is the leading manufacturer of mid- and high-end smart phones and Tablets globally and is already home to the largest number of mobile phones of all kinds, ranging from plain voice and text-only phones to the most sophisticated smart phones. Some of the largest telecom service providers in the world are located in this region. A number of governments have launched projects for mass distribution of mobile or laptop computers for school-going children. Stakeholders in AR4D should not ignore the possibility that affordable smart phones and Tablets will become available for a sizeable proportion of farmers in the near or medium term. This will have important implications for education and extension as well as for dissemination and sharing of results and outputs from AR4D stakeholders, especially institutions. A key aspect of coping with this anticipated change would be to enhance openness of information flows into, within and outside the AR4D sector.

Two paradigms of openness are already close to what AR4D stakeholders are regularly occupied with. The Open Access (OA) movement is about making research documents (where feasible, data) universally accessible via the Web. Over the last decade, this movement has matured into becoming a more widely institutional practice. Commercial publishers of research journals, who expressed reservations initially, have accepted various steps that are supportive of this movement. Several academies and research institutes in the region have formally adopted OA practices.

The other important paradigm, Open Educational Resources (OER), promotes publication of peer-reviewed educational materials (learning materials plus documents related to curricular development) at university or college or high school levels. From the time of release of Open Courseware by MIT in 2000 to the World Congress on OER in 2012, this movement has gained wider adherence. The Asia-Pacific region leads the world in terms of the number of full courses published on the Web for re-use and adaptation, with China, India and Pakistan being major publishers.

It should be noted that the AR4D sector is not yet a major player in either the OA or the OER paradigms. Analysis of OER in the Commonwealth countries of Asia shows that science, technology, engineering and management topics dominate the published OER output in the region. (China's Jinpingke project is an exception with over 560 course modules on agriculture; the proportion is still not significant because the total number of published course modules exceeds 11 000). Fewer than a dozen OA repositories are anchored in AR4D institutions while hundreds are active.

Policies at the institutional and sectoral level are important in promoting increased participation of AR4D institutions in these paradigms. Also important is the state of ICT infrastructure. Experience shows that while policies and local infrastructure are important, they are not necessarily the preconditions for wider acceptance of openness in enabling documents and information flow. For example, a number of OER efforts in the region were launched in the early stages without a focused or even an explicit policy at the national level and without advanced or complex infrastructure for ICT at the local level. Instances can be cited from South Asia, especially India and Pakistan, in this regard. In other words, leaders at the institutional level and actors that have the commitment can start using modest resources and can scale up as they proceed.

What would make a substantial difference in the immediate term is the building of relevant capacities among interested stakeholders. Referring to the APAARI, GFAR and FAO reports, one can infer that improvements in ICT and ICM capacities among personnel of AR4D have not kept pace with the improvements in ICT infrastructure. The practice of in-service training remains the optimal channel. However, given the level of procedures involved and the duration necessary to complete them, capability developed may lose its relevance because advancements in ICT/ICM practices are indeed rapid. The emerging practice of Massive Open Online Courses (MOOC) provides new opportunities in ICT/ICM knowledge and skills development with or without certification. The commercial IT sector in many countries of the region regards the MOOC paradigm as one with great potential to develop skills and knowledge for many learners in an affordable way.

APAARI and the FAO are uniquely positioned in the region to advocate openness and to build essential support systems for countries that have relatively less-advanced ICT infrastructure and practices in AR4D. Common services for hosting OA repositories can be considered because standard repository software such as DSpace can be hosted via cloud computing services with data centres in the Asia-Pacific region (Singapore or Australia for example). FAO's long experience in the development and management of iMARK can be an asset in designing and managing open online courses in ICT/ICM for professionals from some of the small- and medium-sized economies in the region. International organizations have significant opportunities to make an impact in the medium term through these means regionally, especially among the smaller economies.

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Radio – still viable in a connected world

Emil Adams, Secretariat of the Pacific Community (SPC)

Radio remains a viable and cost-effective medium for disseminating information on agriculture and rural development to the Pacific's remote and geographically challenged islands. Radio provides up to 90 percent coverage in most Pacific island countries, and is the most common way that most rural communities receive information. However, lack of funds for programming and poor reception in very remote islands can hinder the use of radio for communication.

Fiji and Kiribati at a recent meeting in Nadi in 2010 clearly indicated in their country presentations that radio is the ideal medium for communication, given both countries' many scattered outer islands.

The case for continuing to use radio for mass communication is made because of its portability, inexpensiveness, accessibility, extensive reach (even in remote areas) and longevity. It is especially effective in rural and remote areas where television and print media have not been able to penetrate.

Radio and other forms of media play a key role in bringing agricultural information to poor, rural communities. Vanuatu has five radio programmes every week on agriculture ranging from market information to talk-back shows covering agriculture, fisheries, livestock and quarantine. Kiribati airs an agricultural radio programme fortnightly and Tonga has three agricultural radio programmes each week. Similarly Samoa has a twice-weekly agricultural radio programme airing in the evenings, and repeated on the following day.

'Walkabout' radio was a very popular format in the 1990s in Vanuatu and the Solomon Islands. As the name indicates, the programme hosts visit the farmers' fields and chat with the farmers going about their daily chores such as fixing a broken-down tractor, discussing symptoms of a pest problem or transplanting seedlings. Listeners are taken on an audio experience of the farm work with a real-time soundtrack as the farmer goes about his business. Staffing and equipment constraints forced this popular format to close down.

Community radio with a specific focus, uncommon in the Pacific, has a targeted audience and is usually an extension of the special interest group it represents. Strictly donor funded it has limited coverage of development issues and a narrow audience base. But it is very effective in disseminating knowledge on special interest groups and serving their information needs. By broadening its focus, community radio can reach a wider spectrum of the rural audience with development information.

Radio can help to promote indigenous knowledge in Pacific islands and raise awareness of such arts to pass along in perpetuity. Indigenous knowledge is critical for survival in the face of changing times and extremes of weather brought about by climate change – knowledge of food preservation and crop varieties during times of drought, knowledge of medicinal plants, pest-repellent plants, and planting and harvesting times. Radio forums can be set up to discuss indigenous knowledge for food security. Recorded forums can lever online tools for wider distribution or targeted fora.

Agriculture in the Pacific is a significant contributor to rural employment and food security, and is a foreign exchange earner. Up to 30 percent of the national gross domestic product (GDP) in some Pacific states comes from the agriculture sector. Agriculture accounted for over 50 percent of the Solomon Islands GDP in 2006. Most Pacific island countries have large rural populations, with an estimated 15 percent of the population being engaged in formal employment. Agriculture's contribution to Pacific island economies goes far beyond simply the production of crops and livestock. The multiplier effects of agriculture on the rest of the economy can be many times more than that shown on quantities of primary production alone.

The delivery of information, technical advice and agricultural skills training for farmers rests with national extension services. However, extension activities are typically given a low priority across the Pacific. Extension work continues to face challenges because of the scarcity of human, financial and physical resources. The need 'to do more for less' is a reality, and partnering with the media can help enhance extension services. The extension officer to farmer disparity points to challenges in delivering information. In Papua New Guinea, the ratio is one extension officer per 3,600 people, and in some parts of the northern Solomon Islands this ratio is 1 per 14,000. For medium-size islands such as Samoa and Tonga, the ratio is closer to 1 per 800 people. Extension work is further hampered by lack of transport or fuel for transport.

The production of extension information is the task of the information units of national ministries of agriculture. However, the capacity of national agricultural information units to provide this service have diminished over the years because the service has been made redundant, or because these activities have been absorbed into other technical divisions following structural reforms implemented by national governments in the 1990s.

Research and development on agriculture is carried out at government research facilities. Increasingly, researchers are adopting a holistic and participatory approach, recognizing farmers' input into research and carrying out on-farm trials. The media and Information and Communication Technology (ICT) can help facilitate the link between research and extension.

Partnering with the media offers an alternative for extension agencies to continue with one of their core functions — disseminating information. However, this might be a challenge for smaller atoll countries such as those in Micronesia where media outlets are limited or non-existent. The increasingly important role of the media calls for a closer working relationship with extension workers. Extension officers should also be responsive to new innovations emanating from farmers. ICT can be used to

capture or record these innovations and bring them to a national forum in order to share them with farmers from elsewhere. The Pacific media summit in May 2012 recognized the need for media workers to develop trust and a greater appreciation of efforts in rural development work. Conversely, extension needs to be aware of the operations of the media industry, how information is collected and reported, what is considered to be priority news, how agriculture is reported in the news, and more.

In light of the constraints of human and financial resources and geographical distances, the media and ICT are being promoted as valuable tools in the delivery of extension information. Increasingly, ICT is being regarded as a tool for sustainable development and poverty reduction.

Mobile phones offer another potential for extension workers, with estimates of up to 50 percent of Pacific islanders having access to mobile phones. Mobile phones could help extension workers disseminate information on crop pricing or pests and diseases to farmers.

Recognizing the important role the media and ICT plays in assisting extension and information dissemination, participants at the Pacific Extension Summit held in Nadi in 2009 put forward the following strategies for using ICT and the media in extension transformation.

1. Never use ICT as a stand-alone strategy. It is one of many tools to use in extension work, but the value of face-to-face communication must not be forgotten.

2. Link roundtable media capacity training to major agriculture and forestry events such as the Ministers of Agriculture and Forestry and Heads of Agriculture and Forestry meetings to increase the level of reporting on agriculture and forestry in local media.

3. Identify opportunities for capacity building in media production skills for extension officers. Because many Pacific island countries and territories have non-functional information units, extension officers need basic training in communication skills such as writing press releases for newspapers and radio, interviewing skills, publication and video production skills, and using ICT for extension work.

4. Develop strategies on media convergence and explore cost-effective ICT that will increase intensity and diversity of media coverage of extension activities.

5. Broaden media formats to include:

    - Radio talk shows, using local celebrities and/or champions;
    - Local news on TV and in newspapers;
    - Partnerships with other relevant sectors such as health, education and rural development, to co-sponsor media programmes;
    - DVDs on agricultural practices;
    - Mobile phones and telecentres;
    - Establish a help desk to improve extension services;
    - High frequency radio for outer islands; and
    - The Internet and email groups; and One Laptop per Child (OLPC).

6. Encourage media groups at national and regional levels to assist with information dissemination. Some of these groups include: Journalists Association of Western Samoa, Pacific Islands News Association, PACNEWS, Islands Business, Radio New Zealand International, Radio Australia, and Pacific Regional Organisations Media Officers. Encourage participation and send out press releases on national and regional agricultural events, farmer field days, agricultural shows, workshops, farmer success stories, and environmental and health issues. The purpose of these measures is to promote the formation of media focus groups that are specific to agriculture and rural development, as a means of addressing the lack of specialized media reporting in this sector.

7. Establish media awards that acknowledge and encourage agricultural reporting.

8. Incorporate a media component into national agriculture and forestry strategies to allow for the dissemination of outputs and reporting of best practices.

9. Develop partnerships with international organizations, local funding agencies, business houses and NGOs to co-fund newspaper supplements, TV programmes, video documentaries and radio broadcasts of field days.

D

Mobile telephony in agriculture:
Unlocking knowledge capital of the farmers.

Sharbendu Banerjee, CABI

Sophisticated communication skill is one factor that distinguishes us, humans, markedly from other live forms in the world. Since the dawn of human evolution, men and women always have used various communication tools for seeking and sharing information and building of communities; critical factors for the successful survival of our race.

Information and communication have always mattered in agriculture as well. Ever since people started growing crops, raising livestock or caught fish, they have sought information from one another for everyone's benefit. Using simple communication tools, such as storytelling, wisdoms of the village elders have passed on generations after generations, with continuous knowledge addition from the community in each stage.

However, in today's world, changes are too fast and overwhelming for the rural people, to mitigate these challenges and survive using traditional or conventional practices. Farmers in a village may have planted the "same" crop for centuries, but over time, weather patterns and soil conditions have changed and new epidemics of pests and diseases have appeared; producers rarely find it easy to obtain solutions to such problems, even if similar ones arise season after season.

Agriculture is facing new and severe challenges in its own right; with rising food prices that have pushed over 40 million people into poverty since 2010, more effective interventions are essential in agriculture (World Bank 2011). The growing global population, expected to hit 9 billion by 2050 has heightened the demand for food and placed pressure on already-fragile resources. Feeding that population will require a 70% increase in food production (FAO 2009)[1].

Apart from filling the food basket, agriculture also plays a big role to the livelihood of the world's poor. Even after years of industrialization and growth in services, agriculture still accounts for one-third of the gross domestic products (GDP) and three-quarters of employment in sub-Saharan Africa. Over 40% of the labour force in countries with per capita incomes in the US$ 400 to 1,800 range works in agriculture (World Bank 2008). In, India, over 60% of the population is directly or indirectly employed in the agriculture sector.

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Smallholder Farms:

The emerging trend in agriculture in developing countries:

There are approximately 525 million farms worldwide, though data about small farm are only available for only 470 million of them. Of these, smallholders who operate plots of land of less than 2 hectares currently constitute 85%. The overwhelming majority of these farms are located in Asia (87%), while Africa is home to another 8% and Europe to approximately 4% & US 1%[2].

The average size of operational holdings in India has diminished progressively from 2.28 ha in 1970-71 to 1.23 ha in 2005-06. As per Agriculture Census 2005-06, the proportion of marginal holdings (area less than 1 ha) has increased from 61.6% in 1995-96 to 64.8% in 2005-06.

Diminishing landholdings impedes farmers' capacity to leverage available resources for managing cost of production and compete in the market to maximize profit, thus making agriculture an unattractive vocation.

Availability of effective ICT, such as mobile telephony, at the hands of the farmers can be postulated as a key driver for improving farm productivity by diminishing information search cost and increasing efficiency. A study of the value chain of poor vegetable farmers in Sri Lanka measured the information search costs for all core enterprise operations, such as land preparation, growing and harvesting, as well as for seed purchase and selling (de Silva and Ratnadiwakara, 2009). It found that the relative proportion of information search costs in the total costs of production, were highest in the early decision stages and the latter selling stages. Overall, information search costs amounted to 70% all transaction costs (the transaction costs themselves were recorded at 15% of total costs incurred)[3].

Figure 11 : Type of mobile Phone usage is Bihar (%), INDIA

The study concluded that better quality and more timely information, combined with faster and cheaper communication, would help to reduce operational costs. There is growing evidence that enhanced access to ICTs has helped farmers address some or all of these needs. In many instances, this has been achieved through the spontaneous uptake of mobiles by farmers; in other cases information supply has improved as a result of deliberate assistance by government or other actors. There are also many examples of ICT initiatives aimed at improving relevant information that have failed to produce the desired results.[4]


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Mobile telephony at the bottom of pyramid:

> "Om Pandey of Dihira village, Palamu district in Jharkhand, India, gives a missed call on a toll free number 0800097458. He gets a call back immediately. There have been three deaths due to malaria in his village, he talks into the phone. His message is automatically recorded. A moderator with the Jharkhand Mobile Radio in Ranchi validates the message and puts it on the mobile radio network called Goonj. The message is conveyed to the concerned health authorities who promptly send medical assistance, an ambulance and equipment for fumigation. (Sarita Brara, The Hindu, April 8, 2013)"

During 2009-2011, the UK Department for International Development (DFID), the Sustainable Consumption Institute (SCI), the Chronic Poverty Research Centre (CPRC) and the Economic and Social Research Council (ESRC), funded a project under which The Institute for Human Development (IHD), New Delhi, conducted a large-scale survey in the Indian states of Bihar and Punjab among the rural households, most of which were farmers[5].

The survey results in Bihar show that almost every single respondent used the mobile phone for keeping in touch with friends and family members (social networking). Around one-fifth of the respondents were found to be using mobile phones for economic purposes like securing information on agriculture, employment, trading and credit. One-tenth of respondents mentioned that they used mobile phones for improving their livelihood skills through education and securing information on healthcare[6].

The above two examples throws open a new window to the lives of people in villages and how they use this ubiquitous technology to improve their livelihood and life.

The two key dimensions of mobile telephony are the ease and economy of communication. Before mobile phones, people had to tether themselves with the point of communication (for example a public phone booth or a post office) and as the points of communications were far and few, the total cost of communication, including the fee for communication (call charge) and the indirect costs such as travelling cost and cost of time spent on such activities. With the advent of mobile phones, communication has become personal in true sense, as people have now been able to carry the point of communication with them and can communicate whenever and wherever they feel like.

This has opened a new opportunity for peer to peer communication using mobile phone, especially among the people at the bottom of pyramid, for most of whom, mobile phone is the first digital device they have ever personally owned.

In agriculture, mobile phones can play many important roles towards improving the overall efficiency of the value chain. One of the key impediments, inherent to the conventional agriculture value chain is asymmetry of information among the various actors. This result in wastage and quality degradation, which in turn result in economic losses, especially for the smallholders, who typically stays at the far end of the valuechain and are deprived of resources to integrate their operation both in forwardly and backwardly.

The smallholder farmers mostly depend on their own and family members' labour for undertaking the farming activities. Moreover, in many cases, they are geographically dispersed and even isolated. Under this circumstance, very less communication and interaction happen between the smallholders and the other actors in the value chain, such as researchers, input suppliers and agribusinesses. Hence smallholders typically depends on the on the small network of suppliers and buyers who provides them services at the farm gate and in the process miss out the greater economics of the organized agro-commodity or agro-processor markets.

Firefly Kenya, a new unit of Millward Brown East Africa, has offered an insight of how Kenyans have experienced a fundamental shift in how they communicate. Through social media, Kenyans have contributed to the massive global conversation. According to a social media survey carried out across 15 countries by market research firm Firefly Millward Brown, Kenyans are increasingly using social media to get local and international news, keep up to date with their favourite football clubs, find out what's on at their local bar or "nyama choma", and importantly, keep up to date with small fashion retailers who use Facebook as their marketing tool of choice.

Kenya has just over one million Facebook users - 2.8 per cent of the population. This is higher than Nigeria and India, with 1.8 per cent and 1.7 per cent respectively. Facebook penetration in South Africa is at 7.5 per cent. With half of Kenyan Internet users accessing the Web via their cell phones and the high penetration of cell phones v/s computers in this market (63 per cent v/s 3.6 per cent), Firefly expects Internet usage to grow in this market.

Source: Mobile Africa Report 2011, Dr Manmohan Rao.

However, using mobile phones, even smallholder farmers can easily increase their circle of communication without being physically moving out of their farms. In a 2011 study by the Institute of Human Development (IHD) India, it was observed that using mobile phones, the farmers in the states of Punjab and Bihar have been able to get better yield and price from the market. The mobile technology can


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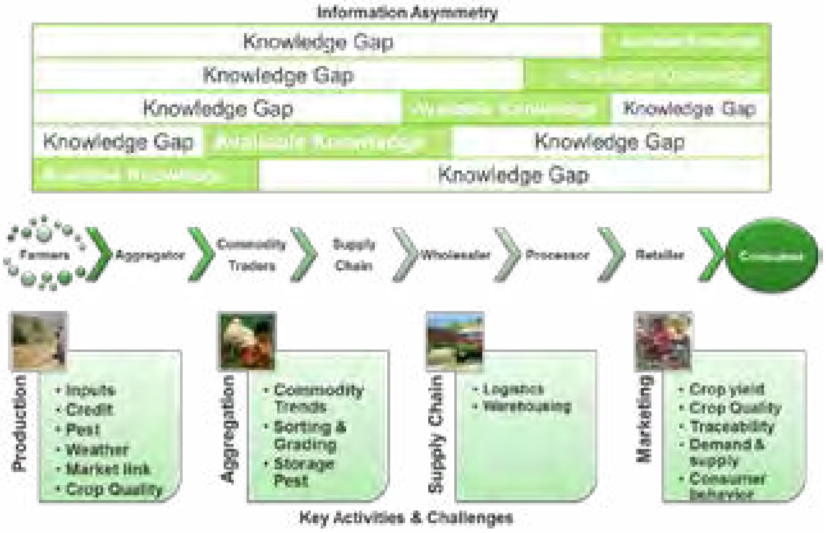
also develop a new vocation of knowledge brokering through village entrepreneurs using mobile social media for buying and selling information to the fellow farmers. This will not only help the communities to adopt new technologies faster, but also will facilitate transfer of best practices and indigenous knowledge to other communities. A case in point is the Agriculture Knowledge Management System (AKMS) set up in the coastal district of Bangladesh in 2006. Through AKMS, information is provided to the farmers via Knowledge Brokers; who are educated youths from the communities and embedded in the community through family ties, hence respected and trusted within the community. Knowledge Brokers map the agriculture, economic and social information and communication needs of the client communities, locate the information if and when needed, provide the information in accessible terminology and the local language at a price that are realistic, given the limited resources of the communities[7]. The program has been able to train 176 youths and 73 of them are working as knowledge brokers. 96% of AKMS revenue is generated through its products and services and it achieved a 20% profit margin in 2008.

- 'I call other knowledgeable farmers and dealers for soliciting information on the high-yielding varieties of seeds, fertilizers and pesticides' (farmer in Punjab).
- 'During the crop-growing season, I enquire about diseases in crops and available pesticide remedies in the market from other farmers and traders' (farmer in Punjab).
- 'Because of mobile connectivity, I now receive specific orders for vegetables from people living in my village, which has contributed to a growth in my income' (vegetable seller in Punjab).
- 'I used to go to Punjab during the harvest season. Earlier, we had to either contact local contractors or visit Punjab and stay unemployed for a few days before getting work. Now, we are able to save time and money, apart from bargaining for higher wages and better working conditions' (respondent working as a casual labourer in Bihar).
- Those found to use mobile phones for farming purposes in Bihar, though small in number, reported that they had saved time, improved farming techniques, reduced production costs and struck better bargains with middlemen and traders, all of which resulted in their garnering higher profits.

Source : Balwant Singh Mehta, Working Paper 29, Capturing the Gains 2013

Figure 12 : Information asymmetries in the agri-value chain



Key Challenges of mobile agriculture (mAgri):

There are two levels of challenges that mobile agriculture is facing today; at both the design and deployment level.

Challenges at design level:

This can be summarized as DNA: the Device, Network and the Architecture.

- **Device:** In 2012, out of about 1.9 billion handsets sold, 50% were basic and feature phones. This means although more than 90% of world's population is today covered by either 2G or 3G, the ownership of handsets has not coped up with this pace. Handsets plays a key role in delimiting the capability of the users in terms of what functions, the user can perform using mobile telephony. A basic phone, in most of the cases, is not capable of handling voice calls and simple text messages (in Unicode fonts only). Hence, social media applications have to be adopted for functioning though basic handsets are most effective for the rural populations. Group messaging and Interactive Voice Response based social networking tools or search tools are successful when dealing with bottom of pyramid people having basic handsets. However with increasing penetration of feature phones, simple Java based applications and native applications in the handsets that make use of internet connectivity can catapult the users' capacity to perform complex tasks, using relatively simple and economic handsets.

- **Network:** The second most important factor for designing successful mAgri application is the network dependency. Although more than 90% of world's population are covered by 2G network7 and about 45% are covered by 3G network, this coverage is largely skewed towards the developed nations. In developing nations, the coverage is mostly non homogeneous, leaving about many pockets of low or no coverage areas, especially in the remote or isolated areas, for which, farmers residing in those areas are still not been able to avail the benefits of mobile telephony. Hence, designers should keep in mind the network dependency of the mAgri applications, as data-heavy applications will not run in such sparsely covered areas and will not be accepted by the users.

- **Architecture:** While designing mAgri applications, architecture should be designed in such a way that gives maximum benefit to the users as well as the mobile network operators (MNO). A case in point is the unpopularity of SIM based applications, although they work efficiently in basic phones. The major difficulty with the SIM-based application approach is also that it requires an agreement with the mobile operator. Most large MNOs are not interested in partnering with start-up technology companies unless there is a clear value-add for the MNO. With start-ups often still struggling to build up their user base, it can be difficult to convince an MNO to partner with such an organization. If an MNO can be convinced of the value add of the application, however, a partnership with an MNO can be an incredible asset to help a start-up scale their product. However, there is a growing user base of mobile Internet amongst the BoP. Developers should explore options for linking applications onto free platforms and social networks such as Facebook Zero, which might provide an avenue for further scaling out to BoP[8].

Challenges at deployment level:

- **Information:** Farmers most of the time are not sure about where/whom to approach for solutions to their problems. Coupled with their inability to access information from sources beyond their immediate neighborhood, they are also not sure information provided to them is the best and most appropriate as per their situation. Hence developing trust among the farmers is very important for any mAgri service to succeed. Involvement of community into knowledge and experience sharing using mobile based social media can be an easy and effective ways of building up trust.

- **Interaction:** Extension Agents/researchers are not available to farmers "all the time". With most of the developing countries having gone extensionist for more than 1000 farmers, it is practically impossible for the extensionists to handhold the farmers during the time they try to adopt new technologies. However, mobile phone, especially mobile social media can to large extent, help solving this problem. Using mobile phones, farmers can not only interact with extensionists and agriculture experts in real time, but can also share their experience between each other, thus making adoption faster and more impactful.

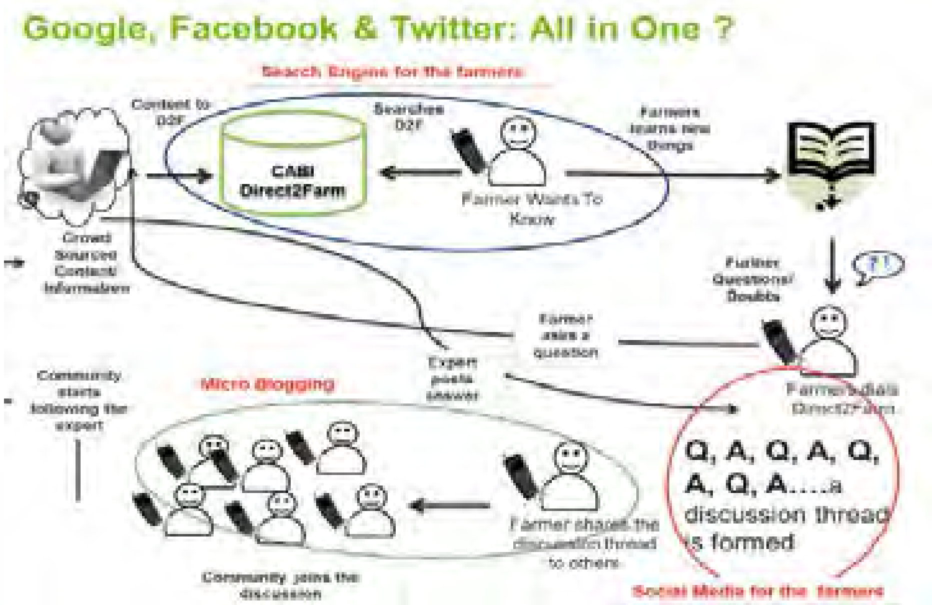
Case studies of CABI's work in empowering farmers through mobile based interventions:

Case Study: Café Móvel mExtension service (India)

In 2012, CABI's Direct2Farm Service was customized into a mobile extension service for the coffee farmers of India. This service, named Café Móvel is aimed at providing information and advisory support around 150,000 coffee farmers in southern India. This programme is supported by the Coffee Board of India, the International Coffee Organization and Common Fund for Commodities.

Features of the service include an interactive FAQ (Frequently Asked Question) section, accessed by an IVR, a private discussion thread between planters and experts, functionality to broadcast voice casts of the discussion threads to a community, and market and weather information voice feeds. The picture here, depicts how using simple voice based system hybridized with SMS, a service has been created that acts as a search engine, a social media and a micro blogging for the farmers.

Figure 13 : Social media for the farmer.



CABI is providing the end-to-end mobile Infomediary solution for the service and is responsible for the overall knowledge management and analytics. The Coffee Board of India is the major content and advisory service provider and with other providers such as the Indian Meteorological Department, supplies weather based advice and information.

In future, the service will integrate coffee processing and marketing businesses, thus offering a complete one-stop-shop solution for the coffee farmers.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Case Study: E-Zaraat mobile extension service (Pakistan)

About 4 million farmers in the Punjab region of Pakistan rely on government extension officers as the main source of agricultural information. However, the officers often have difficulty reaching all the farmers due to the geographical spread of the region. If rural small holder farmers are to succeed, they need timely access to the latest information on crops, weather and market prices.

The E-Zaraat project, in partnership with the Directorate General of Agriculture Extension and Adaptive Research, Pakistan, is developing Information and Communication Technology (ICT) solutions to support the extension services to get these farmers the information they need, when they need it.

The project is being piloted in three districts in the Punjab region: Vehari, Sialkot and Sargodha. To date, a baseline survey has been completed, documenting the profile of farmers, their information needs, current agricultural practices and women's role in the rural economy. A web application for data entry and analysis, and a mobile application for data collection from the field have been developed; and a call centre has been deployed to provide extension services to the farmers.

The E-Zaraat service will create better linkages between extension experts and the farmers, in order to help them produce better crops that can fetch better prices. E-Zaraat will enable a more on-demand extension advisory model that will help deliver scarce extension resources to where they are most needed.

Case Study: GSMA mFarmer initiative– mKisan (India)

In 2011, CABI joined with Handygo Technologies, International Livestock Research Institute and Digital Green, in a consortium, to develop and implement mKisan, a mobile enabled agri-service for 1 million farmers in India. This consortium is funded through the mFarmer grant of the GSMA Foundation, under its mAgri programme supported by the Bill & Melinda Gates Foundation and USAID.

The service delivers authentic and validated agriculture information through an Interactive Voice Response (IVR) system accessible from any mobile phone. The service is overcoming low levels of literacy in the country by using voice as the primary communication medium, and therefore targeting the poorest population. Through using the service, farmers are able to learn directly from agriculture experts through a real-time and interactive helpline. An added feature of the service is the ability to watch mobile videos (provided by Digital Green) demonstrating farming best practices and techniques. These videos help facilitate community learning at a large scale.

Since its launch in July 2012, the service has been used by over a million farmers and about 300,000 of them have continued their subscription. In order to support continual improvement of the service, a baseline survey using mobile and face to face methods has been organized in the states of Uttar Pradesh and Madhya Pradesh in India to capture farmers' profiles and information needs.

In July 2013, a Farmer's Helpline using Hindi language was added to the service. This will enable farmers to call a short code from their mobile phone and speak directly to a subject matter expert in their own language. CABI is the principal knowledge partner in the mKisan service and the Diretc2Farm database forms the backbone of the content development and quality assurance process. The database not only captures information on crops, but also on livestock, provided by International Livestock Research Institute (ILRI). In addition, CABI also provides scientific backstopping to mKisan service, and provides agriculture experts to the mKisan Farmers' Helpline.


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Conclusion:

The various literature studies and practical deployment experience, suggests that there is a vast potential for the smallholder farmers to expand and unite themselves using innovative ICT tools such as mobile telephony, especially mobile social media. The benefit of mobile technology is that it helps people to virtually connect to each other without displacing them from their place and activities. However mobile technology should not be viewed as a "silver bullet" to solve all problems. Technologies are enablers to the pre-existing capabilities of human beings and unless used intelligently and wisely they do not bring any meaningful result. Hence technologies should be viewed as extension of human processes and designed in such a way that it seamlessly fits into people and their activities and acts as a multiplier of their effort.

Particularly in case of mobile technology, the mobile network operators play a key role of enabler, although in most of the cases, indirectly. Hence any mAgri designer should keep the operators in mind while designing the service or product. If the mobile operator can be convinced of the value add of the application, then, a partnership with the operator can be an incredible asset to help mAgri services to scale up. The trust, resources, and customer franchisee, that the operators have, will help mAgri services significantly improve their product awareness and uptake through such partnerships.

Sources acknowledged :

1. Source : The Next 4 Billion, IFC & World Resource Institute, 2007
2. ICT In Agriculture, World Bank e-Source book, 2011
3. Nagayets, O. 2005. Small farms: current status and key trends
4. Tuning in : Radio on mobile in Jharkhand. Photo: Sarita Brara, The Hindu, April 8, 2013 (photo & news article)
5. ICTs, Enterprises and Poverty Alleviation, UNCTAD, 2010
6. Balwant Singh Mehta, Working Paper 29, Capturing the Gains 2013
7. Patrice Braun and Md. Faisal Islam, ICTEnabled Knowledge Brokering for Farmers in Coastal Areas of Bangladesh, Centre for Development Informatics (CDI), University of Manchester, UK, 2012 International Telecom Union, 2013
8. Text and image sourced from: Angela Crandall, Albert Otieno, Leonida Mutuku, Jessica Colaço, Mobile Phone Usage at the Kenyan Base of the Pyramid, 2012

mAgriculture in India - the contribution of mobile telephony for dissemination of agriculture - related information to farmers

NOKIA LIFE

Criticality of information in agriculture

The agriculture sector is a critical component of the Indian economy with over 60 percent of the country's population dependent on agriculture for their livelihoods. With the huge and disparate climatic and crop diversity across India, it is a challenge to keep the farmers informed about the best practices in agricultural processes. Lack of timely information also affects their ability to achieve better income by selling their produce at the best possible prices.

Performance of the agriculture sector is the key to livelihood and food security. Although food production has grown by leaps and bounds, the yields of major crops have stagnated and farm incomes are coming down, leading to frustrations among rural communities.

Some of the reasons for rural stagnation are:

- Unsustainable farming practices due to knowledge gaps
- Unpredictable climatic conditions
- Poor management of production costs

One of the major issues among the farmers is the lack of easy access to advisory and information services on sustainable farming, regular and reliable market information and weather forecasts.

There is a need to create an information system that can provide farmers with significant amounts of information and education throughout the crop cycle, to produce high crop yields as well as quality crops of uniform grade for use by target consumers.

For the Indian farmer to be able to easily access and utilize such relevant information on a daily basis there needs to be an efficient channel for information dissemination with the following characteristics:

- Accessibility: It should be accessible by most farmers without requiring additional effort or travel;
- Personalization: It should be customizable to align with the needs of individual farmers;
- Localization: It should be adaptable to local needs, such as local language, specific crops and livestock breeds, soil and weather conditions;
- Usability: The service should be easily understood and usable by most farmers;
- Low cost of access: The service should be cost-effective to both the information provider and farmers;
- Aggregation: Integrating and leveraging knowledge available with various public and private sector bodies.

Traditional media-based solutions for agriculture

Traditionally, agriculture-related information has been available only in 'silos' (a management system incapable of reciprocal operation), which leads to loss in agricultural productivity. Over 40 percent of farmers in India, in particular those with small, marginal landholdings do not have access to reliable sources of information that is customized for their needs.

Most agricultural information has been disseminated through broadcast media such as radio, national television and local publications. Most of these media suffer from lack of personalization of the content, thereby making them quite ineffective in providing a complete solution for each farmer

Alternative approaches such as kiosks at Community Service Centres (CSCs) have also been tried as an interactive and personalized electronic medium with some amount of success. Although such solutions have been effective in bridging the information gap, their usage frequency is not very regular. This is mainly because the average distance to a CSC is 6 km.

Also, new interactive media such as Internet and mobile data services have traditionally not been used in rural areas due to their low penetration and usage rates. However, with the surge of mobile telephony in the last decade, this is a good time to leverage mobile solutions as a medium for agricultural information dissemination.

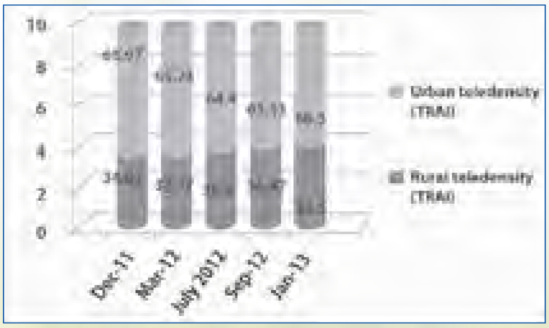
Mobile usage – statistics and growth pattern

Before building long-term mobile-based agricultural solutions, it is essential to look at the usage of mobile telephony in rural India.

As the predominant livelihood activity in rural India is agriculture-related, it is safe to assume that rural statistics and growth patterns will be similar for farmers and the agriculture sector.

As of January 2013, India's rural tele-density was at 40 percent, out of which only 1 percent of subscribers were using landline services, with the majority using mobile telephone. Just two years ago, the rural tele-density was 26 percent. The rural sector has witnessed higher growth in recent years due to saturation of the urban markets so telecom operators are expected to focus their attention on further growing the rural subscriber base.

Figure 14 : Wireless telecom tele-density in India (Dec 2011-Jan 2013)



Data source: TRAI

In this trend, we can expect most Indian farmers to be reachable through their mobile phones over the next two to three years, and adoption of appropriate agricultural solutions can ensure that they have relevant personalized information that is always accessible to them.

Mobile telephony solution

Among mobile phone-based services, information can be sent as a text message or a recorded voice message. Both these channels have their own advantages.

Recorded voice messages are easily understood by farmers, including semi-literate and illiterate counterparts, but this method suffers from similar personalization issues faced by broadcast media, such as television and radio.

Text-based messages manage to provide far more customization and can be accessed, as convenient, because the message is stored on the device. This can also be provided in vernacular script, and most farmers are also comfortable viewing numeric values in English (such as for crop prices), due to familiarity with numeric phone keypads.

NOKIA LIFE mAgriculture experience

Given the high growth and penetration of mobile phones in rural India, as well as ease of accessibility and simplicity of usage, it was proposed by Nokia to introduce a system using mobiles for dissemination of personalized agricultural information to individual farmers. NOKIA LIFE's Agricultural Service was launched to address this information gap across all stages of cultivation, right up to the sale of produce in the market.

NOKIA LIFE Agricultural Service provides farmers with personalized information pertaining to market prices of nearest mandis (market places), local news, important information on schemes and subsidies, comprehensive and localized crop and advisory on a regular basis. Twenty-four-hour weather alerts/forecasts are also provided.

To avoid information silos and to ensure that relevant information on each topic is provided by the most trusted source, Nokia has partnered with more than 30 agriculture ecosystem partners, across government, private and non-profit organizations. Nokia's agriculture editorial desk provides dedicated support to all the NOKIA LIFE ecosystem partners by providing both technical and editorialsupport in aggregating, validating,translating and publishing contents. This helps partners in minimizing efforts while ensuring that only verified content is sent out to subscribers.

Ecosystem experience

Nokia needed to bring expertise in aggregating agriculture-related content through a set of qualified partners. A field study was conducted to learn about the farmers' viewpoints and it was clear that Indian farmers seek agricultural information from a trusted source, preferably a known organization or government agency.

Additionally, there were progressive farmers who wanted to get information from private and non-government organizations pertaining to recent advances in agriculture to improve their crop productivity.

Nokia reached out to all of the aforesaid organizations to build the ecosystem. As this was a new and innovative solution, there were both champions and sceptics within these organizations. However, a clear articulation of Nokia's plan and vision for the service ensured full cooperation from all of the partners.

Each partnership with government organizations and departments has been unique and this has really improved the farmers trust in the mAgriculture service. Many research institutes have been partners from an early stage, while state agriculture boards and universities have been added over the years.

NGOs like National Agro Foundation, Datamation and private agri-businesses like Syngenta and ITC have been strong content and expertise contributors as well.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NOKIA LIFE experience

NOKIA LIFE provides an easy to use graphical interface to interpret information in English plus 11 Indian languages **(Figure 15)**.

Figure 15. Example of NOKIA LIFE interfaces

NOKIA LIFE advantages

- Timely and up-to-date information;
- Personalized information;
- Provides comparisons and trends;
- Can cover a variety of information and educational inputs required by the farmer;
- Can be used anywhere (the tool can be used in the field);
- Store and retrieve received information.

Benefits of mobile agricultural information

Users of the NOKIA LIFE Agriculture Service described that they were well-informed about market rates for their produce. Farmers found that getting prices daily on their mobile phones reduced their dependency on agents for basic information. Greater awareness on market conditions afforded newfound confidence in their negotiations with agents. There was also considerable appreciation for the time and money saved from not having to make multiple trips to the market place to obtain the latest rates.

Benefits from the agriculture service were having advanced information about local news, schemes and subsidies; crop advisory from experts, including information about probable diseases; and weather-based advisory and tips for more successful harvests. Farmers could plan labour, sowing, harvesting and more profitable retail of products, and with more predictable results than they tried to obtain before they started using NOKIA LIFE.

User testimonial:

Name : Mr K.K. Mathai

Village : Arakkapady, Ernakulam district, Kerala

Mr Mathai was an engineer before becoming a full-time farmer. He faced a lot of hardship such as lack of knowledge in culvation, vagarles of climate and uncertainty of market prices for commodities. He consulted the near-by farmers. Department of Agriculture centers and officers to get more information. He felt that while information was available, it was not timely.

"When I became a cluster member of an organization called Vegetable and Fruit Promotion Council Kerala (VFPCK), I became aware about NOKIA LIFE. I was excited by the way localized Agriinformation was made available on the mobile phone. Additionally, the service was in Malayalam, my native language. I first signed up for 30 day free trial and then subscribed for this service. I am happy with the Market prices of commodities, Weather forecast and crop cultivation information as these are all accurate.

It saves me a lot of time and I use the information to develop my farms. I also advise my neighbouring farmers about what I learnt on the NOKIA LIFE AgriService"

Users have also confirmed the following positive impact from mAgri services:

- Many farmers have already started seeing significant benefits through increased earnings (~15 percent increase), better contact with traders in distant areas (up to 45 km) and savings (~ INR150 per trip to markets) by using these m-Agri services.

- Increase awareness and best practices – knowledge transfer: State Governments and departments have also taken proactive measures to use the mobile channel to supply information (for example NOKIA LIFE works closely with the National Bank for Agriculture and Rural Development in many states for their farmer communities).

- Traders and buyers are able to reach out to procure produce from even small and marginal farmers who are based in deep rural and remote areas.

To further drive adoption of these services, Nokia invites both government and private organizations to be part in this ecosystem for empowering farmers and improving agriculture sector productivity.

F

Big data and agriculture

Radhakrishna Hiremane, Intel Coporation

Big Data has passed through a cycle of extravagant promotion – meaning many things for many people. However in the course of the past year or so Big Data has come to represent massive volumes of data generated by computing and connected devices, or embedded devices that monitor or control machines and the environment. Accumulation of data from these multiple types of sources infers that Big Data refers to data that not only are structured (organized and typically the same type of data) but also unstructured (pictures, message feeds and a variety of data that may not all be similar).

More importantly for businesses and governments, Big Data goes beyond just the existence of data. It represents an opportunity for these groups to mine data, perform analytics and derive meaningful new insights and decision points that lead to better monetization for revenue as well as improved services or product/service innovations. Better services may not be all commercial. For a government they could be better or faster e-governance services. Most are looking at analytics of Big Data to derive proactive predictive analysis and outcomes rather than just reporting or reviewing past activities.

Big Data-related spending in Asia and the Pacific (excluding Japan) is expected to reach US$600 million by 2013. In this region and worldwide the growth in spending is expected to rise by more than 40 percent in the context of compound annual growth rate.

Intel Corporation as an innovator in technology space has been at the forefront of the Big Data trend. We have been working in more ways than just delivering leading processing power for analytics of Big Data. We are focused on improved responsiveness, real-time capabilities and reducing the cost of being able to deploy Big Data analytics solutions.

Intel's philosophy is that Big Data in many ways is a paradigm shift around three vectors – volume, variety and velocity. Large volumes, variety of data and velocity are critical to delivering near real-time analysis of data for immediate outcomes. We have been driving distributed scale out storage solutions and higher capacity networking such as 10 Gigabit Ethernet to be able to store and handle the volume of data in a cost-effective manner. Intel offers the Intel Distribution of Hadoop software solution that is capable of handling the variety (structured and unstructured) of Big Data. This software is not only tuned for performance to increase the velocity of analytics but also for reliability and high availability of data, ease of deployment and security. In more detail this means ensuring capabilities such as hardware-assisted encryption of data and tokenization of data, where tokenization allows analytics to be performed by tokenizing privacy sensitive information such as names, citizen IDs and other personal information and not directly exposing these data.

In this digital age there is a wide variety of industries that generate large volumes of data. For example the financial, retail and e-commerce, manufacturing (automation and sensors), telecommunication, social media, health care, smart cities and agriculture sectors.

As digitalization continues, almost all areas will be accumulating enough data and in many situations most of them can be analysed for something beneficial. Advances in Big Data solutions (such as Hadoop) have resulted in genomics analysis to be accomplished in minutes or a few hours. Many of the complex algorithms such as survival analysis used in biological fields are being applied in other sectors like marketing, trying to analyse customer positioning and retention.

There are many applications of Big Data analytics in agriculture. In Asia-Pacific countries, agriculture can be divided into two types – traditional agriculture and modernized agriculture (with technology adoption). Weather pattern analysis, crop disease recognition, spread and demand-supply analysis are some of the examples that could benefit both types of agriculture. Modern agriculture typically has considerable machine automation and sensors that monitor and control the agricultural environment, thereby generating much information. For example ground sensor data when correlated with information such as weather patterns could result in a 'smart' way of utilizing invaluable resources like water.

Weather data obviously come in large volume. Weather pattern analysis also has been a domain of high performance computing for a long time. However Big Data analytics when utilized can add significant additional value by providing insights into annual changes and predicting future trends based on current and past data points. Also as the cost of doing some of this analysis declines with Big Data analytics technology solutions, the granularity of the data could be increased by looking at a regional or local level effectively.

Crop disease and pest management is a significant concern in agriculture. Being able to correlate weather patterns, existing or past disease patterns and optimal use of pest management solutions such as pesticides is a fertile area for intersection of Big Data technology and effective agriculture. Coupled with sensors or a network of sensors in modernized agriculture can result in optimum ways to manage crop diseases. Furthermore as Big Data technology solutions can deal well with unstructured data, they can be used as an economical way to create large databases of information on and pattern recognition of crop diseases.


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Supply and demand variation is a major concern in most of the large and emerging countries in Asia and the Pacific that frequently leads to price variation of edible commodities. Connected infrastructure across a country with information on the supply situation and demand requirements can allow for optimization of commodity cost or reduce wastage in the case of perishable goods. Since Big Data technology solutions are capable of handling unstructured data, the data sources can be as simple as SMS messages from mobile devices that proliferate in most Asian economies. Beyond in-country use, commodity-demand analytics at a global scale can be utilized by governments to drive optimization of the crops grown and value of the commodities exported.

As Big Data technologies and agriculture evolve, there are definitely many opportunities for both to intersect. As with many current and past technologies, Big Data-oriented technology solutions could help to enrich and transform our lives.

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Transformative power of mobile broadband for agriculture

Irene Ng, Adam Wills, Victoria Clause , The GSM Association (GSMA)

The mobile market in Asia

In 2012, the global mobile market grew strongly to nearly 7 billion connections and is expected to continue to grow over the next five years, with a forecasted annual growth of 7.6 percent. In the Asia-Pacific region, emerging markets are the major engines of mobile growth. The region generated 57 percent of all new connections between 2008 and 2012 to stand at 3.3 billion currently and is projected to grow at 7 percent per annum between 2012 and 2017, adding 1.4 billion new connections.

The growth in mobile internet connections continues to be exponential. Global mobile broadband connections are expected to reach 1.5 billion by the end of 2012, representing 23 percent of total global connections. In five years, mobile broadband connections will represent half the global connections market, which by the end of 2017 will stand at over 4 billion. Asia features prominently in this growth trajectory.

Figure 16. Global mobile market

Figure 17. The rise of mobile broadband

The availability of spectrum remains a key regulatory issue, in order to ensure the continuous growth of the mobile sector. However, operators and governments in the region are driving the development of the mobile broadband market through innovative service offerings, creative partnership models and supportive government policy frameworks.

The transformation that is occurring in the mobile ecosystem, in terms of both the level of innovation and the new applications being introduced, means this is a very exciting period for both mobile operators and consumers.

Transformative power of mobile broadband

Mobile technologies are opening new means of communication for people who previously had little to no access to affordable communication channels. With their relatively low physical infrastructure requirements, mobile-based services can reach remote areas ina more cost-effective fashion than other Information Communication Technologies (ICTs).

Today, four out of five mobile connections are made in the developing world, representing potentially 1.8 billion new connections over the next five years. Mobile technology is a catalyst for development, especially for populations residing in rural and remote areas where access is a challenge. In Asia, governments, NGOs and other regional stakeholders are active in the development of mobile services and applications with potential for social impact such as mGovernment, mEducation, mHealth and mAgriculture. These mobile-based solutions can increase agricultural productivity, improve literacy and skills and address information asymmetry in society. The GSMA Asia team is working closely with the International Telecommunication Union (ITU) and other partners to encourage access and uptake of mobile broadband services, especially in areas where commercial incentives are insufficient for mobile operators to launch the full range of services.

Agricultural service opportunities in Asia

A Value Added Service (VAS) is a non-core service of a mobile operator and can be used to refer to all services beyond standard voice calls. In the telecommunication industry, Agricultural VAS form part of the rural VAS portfolio for mobile network operators and VAS providers. They are supplied either in-house by the mobile network operators (MNOs) themselves, or by a third party VAS provider. Traditionally such services spur the subscriber to use their phone more and allow mobile operators to achieve a higher average revenue per user (ARPU), helping to attract the currently 'unconnected' people in the region.[12] Agricultural VAS are targeted at those working in the agriculture sector in rural locations. These services provide the opportunity to deliver information-based services to smallholder farmers that can have a positive impact on their livelihoods (for example access to extension advice via mobile can help boost crop yields). As many countries in Asia have increasing rural mobile penetration and a high percentage of their workforce in agriculture, then there is a strong opportunity for agricultural VAS solutions in the region.

Figure 18. Number of mobile broadband connections

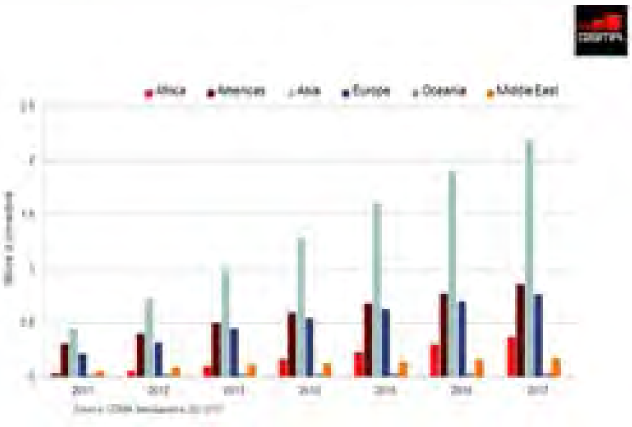
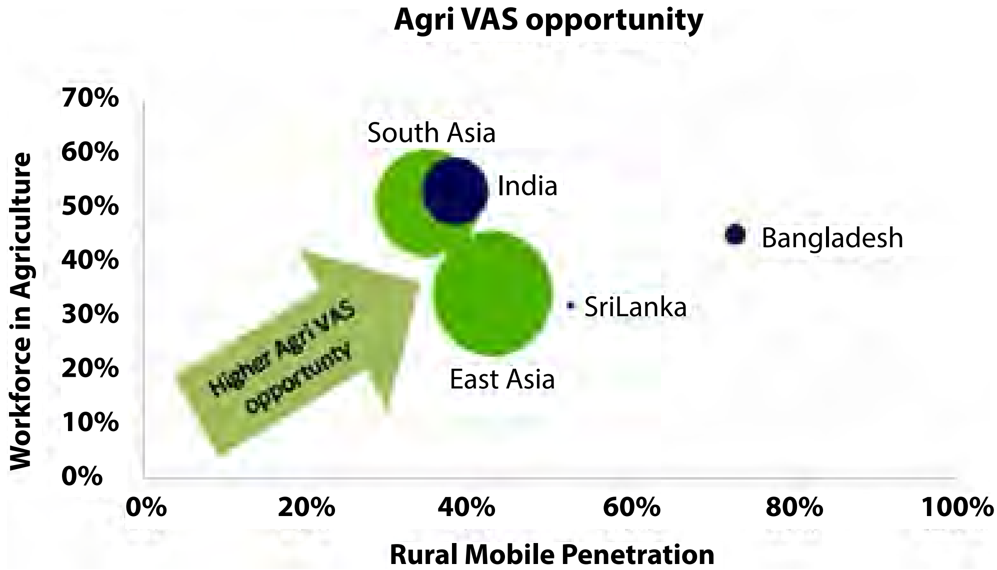


Figure 19. Mobile broadband growth 2012-2017

12 A recent GSMA survey found that future mobile subscriber growth will be driven by demand among currently 'unconnected' populations in developing countries, particularly those in rural areas, which research estimates to be 1.8 billion people throughout the next five years. More info at http://www.gsma.com/newsroom/gsma-announces-new-global-research-that-highlights-significant-growth-opportunity-for-the-mobile-industry

Figure 20. Agricultural VAS opportunity in Asia



Sources : GSMA, USAID, Dialog, TRAI.

In addition to such agricultural VAS, which are aimed at smallholder farmers as end users, it is helpful to define a different set of solutions for 'connected agriculture' that are aimed at solving problems higher up the agricultural value chain (typically being B2B offerings). Next we assess the opportunity that increasing mobile data connections in Asia represent for both kinds of mobile-enabled agricultural solutions.

The story on the ground: Agricultural VAS mobile technology and the established infrastructure and marketing power of mobile operators, has brought a new opportunity for two-way information flow between farmers and service providers. Examples from Asia show that providing information and advice to smallholder farmers, and giving them the option to speak to an agricultural expert using their mobile phone, is proving to be a popular means of information exchange.

1. Mobile operator Bangalink in Bangladesh has a service called Jigyasha 7676 – a helpline where farmers can call and speak to an agriculture expert about farming-related queries. In 2012 the helpline received 140,000 calls a month, or an average of 4,667 calls per day.

2. In China, the world's largest mobile operator, China Mobile, runs an information service called '12582'. More than 50 million farmers have made use of the service over six years. It provides farmers with access to information and advice about agricultural weather patterns, market prices and trading facilities, farming techniques and working opportunities in cities via the call centre (also expert helpline), SMS, MMS, WAP and WEB.[13]

3. One of the biggest challenges facing agricultural VAS providers is aggregating, customizing and developing high quality information for the mobile channel that is valuable and trustworthy for farmers. There is a large cost associated with developing agricultural content in this context and this can be reduced as different content providers – including agricultural research bodies and governments – work together to make the information available in the correct formats.

13 SMS stands for 'short messaging service'; MMS for 'multimedia messaging service', WAP for 'wireless application protocol', and WEB for 'mobile web'.

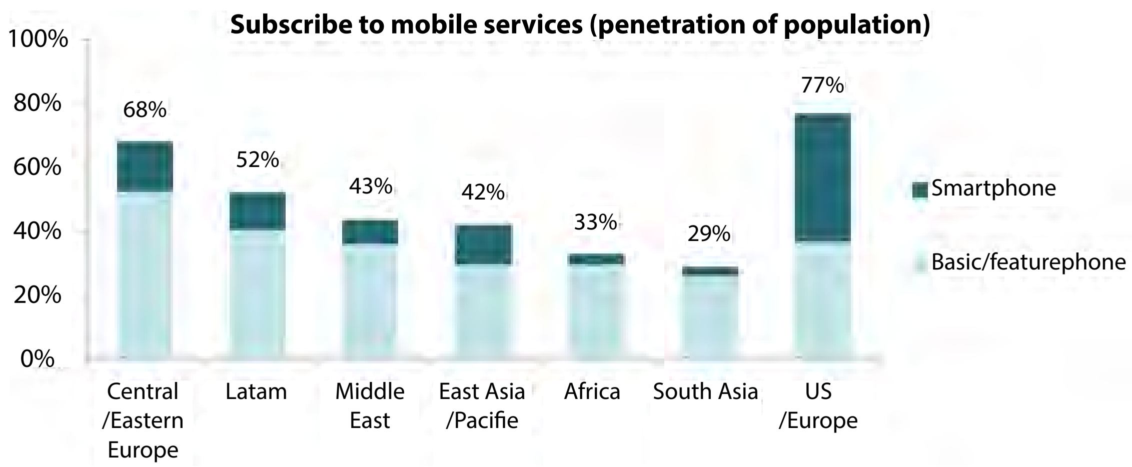
Enabling factors for agricultural VAS: mobile data

To harness the increasing mobile data availability in the developing world, at least three factors should be strongly considered for agricultural VAS:

1. **Mobile data coverage is least accessible for agricultural customers:** Smallholder farmers live in rural areas with low population densities which are generally the least economically viable for MNOs to cover. While 2G coverage is prevalent (even in rural areas) and can be used for mobile data provided capacity is not stretched, 3G is much less widespread. This means that as more people begin to use data, 3G will be required to service demand, and the coverage for this in rural areas is likely to lag behind that in cities.

2. **Data-enabled devices are less accessible to agricultural customers:** Even though smart phone penetration is rising, the vast majority of handsets in developing regions are feature phones.[14]

Figure 21. Subscribers to mobile services (population penetration), 2012 estimate



Source: GSMA-MDI estimates based on GSMA Wireless Intelligence, Strategy Analytics.

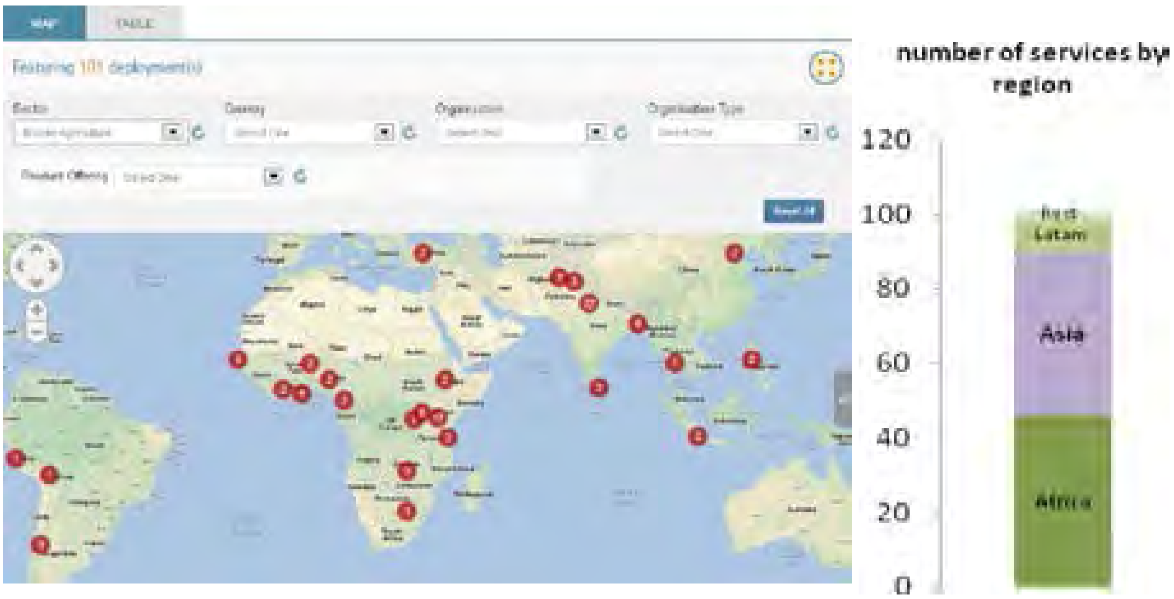
In the case of agricultural customers in low-income segments, this skew toward low-end handsets will be even more prevalent.

3. **Existing agricultural VAS services use basic technology:** Currently, the services that have a potential for scale and impact are those with basic functionality, meaning higher usability and lower cost. These solutions are already deployed across developing regions (including Asia), and utilize basic delivery technologies – text-based channels such as SMS, unstructured service delivery data (USSD) or voice-based channels such as on-board diagnostics (OBD), interactive voice response (IVR) and helplines – all of which are ubiquitously applicable to all handsets.

14 That is, there is some way to access the mobile Web.

GSMA tracked mAgri deployments

Figure 22. GSMA-tracked mAgri deployments



Source: GSMA-MDI.

Implications for agricultural VAS

Growing mobile data coverage in Asia undoubtedly presents opportunities for agricultural VAS, although this is still a latent opportunity for rural smallholder customers as they live in areas with the lowest network coverage, limited access to affordable data-enabled devices and where existing examples of scalable agricultural VAS initiatives use basic delivery technology (designed for low-end handsets and GSM networks). For those interested in developing new agricultural VAS solutions, design should focus on basic, low cost functionality (building on proof points from existing services), with the ability to add additional layers of multimedia format for Internet-based channels as the availability and ownership of devices that support this increases. This will give VAS providers the chance to build on existing service design tailored for basic low-cost models, with high potential for improving such services with mobile data offerings when these become viable. It is also vital to stress that these are primarily information-based content services; while the mobile acts as the delivery channel for such services, VAS providers must partner with content providers who are able to deliver high-quality, relevant and customized content to smallholders.

At the same time if the providers of face-to-face extension and advisory services for farmers (whether government-owned or private) have capacity to introduce data-enabled mobile handsets for their network of agents, there is scope for developing applications and media-rich content for these intermediaries in order to support the extension services. One of the examples of this intermediary-based model has been pioneered by the Community Knowledge Worker (CKW) programme in Uganda, but could be applied more widely and across regions. Some of the media-rich content to support face-to-face agricultural training in Asia is already available (for example training videos developed by Digital Green) but will have to be customized for small-screen handsets. As access to smart phones is only one bottleneck to data-rich agricultural VAS at scale, the success of such intermediary-centred-models will still be dependent on the extent of coverage that supports mobile data access.

Connected agriculture

The growth of mobile data brings broader opportunities for agricultural development than those covered above under agricultural VAS. Current examples of mAgri solutions using mobile data tend to be B2B products that are designed to create efficiencies and overcome problems in the agricultural supply chain. These types of mAgri services can improve the flow of data and efficiencies of transactions within a value chain.

1. **Farmforce** is a cloud-based mobile platform to manage outgrower schemes with smallholder farmers in developing countries. The platform manages crop production and compliance with food and sustainability standards, simplifies audits and provides real-time traceability from the farmer's field. Farmforce supports all aspects related to outgrower management such as loans to outgrowers, produce purchases, management of warehouses, SMS communication and monitoring of farmer training.[15]

2. **Machine-to-machin (M2M)** solutions such as Telit[16] (developed by mobile operator Telefonica) use M2M technology to transform farms into smart farms. Farmers can monitor their crops and greenhouses using a wide range of connected sensors that measure different data such as wind speed, temperature, pressure, humidity etc.

3. **Nanoganesh** provides an irrigation management system enabling farmers to remotely control pump solutions. This system, while incorporating M2M technology, only requires a basic GSM network.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15 See full case study at https://mobiledevelopmentintelligence.com/insight#!MDI_Case_Study_-Farmforce

16 For more information see http://www.gsma.com/mobilefordevelopment/programmes/magri/tracker

Implications for connected agriculture

mAgri solutions that rely on data are still relatively new and therefore there are fewer examples of successful deployments to learn from. There are opportunities for data-enabled products and services that offer either efficiencies along the supply chain or remote monitoring. Agribusinesses that have access to mobile data and the capital required to develop these more complex and expensive services are the likely beneficiaries until rural connectivity increases and smart phone prices fall to a point where smallholder farmers can buy them. The most successful products are likely to be those designed in response to real needs along the agricultural value chain, with this being helped by service providers and developers recognizing successful examples already out there and building on them.

Conclusions

- For both kinds of mobile agricultural solutions discussed – agricultural VAS for end-users and 'connected' value-chain solutions – it is recommended that new services employ best practice, and build on the examples of existing services wherever possible.
- It is important to recognize that as 3G coverage increases, and with it mobile data availability, different opportunities are likely to arise for agricultural VAS and connected agriculture solutions.
- For agricultural VAS, it is important to design for scale and a variety of channels. At present mobile data is more of a latent opportunity for agricultural VAS solutions, but product design should factor in the data-based channels able to store and disseminate multimedia content that are likely to become more widely used over the next two to three years.
- For connected agriculture, data may be more immediately applicable to B2B offerings that aim at customers higher up the agricultural value chain.
- Mobile is merely a channel, and when thinking about information content services to smallholders, governments and agricultural research organizations have a vital role to play in providing quality content. Forming such content-technology partnerships between these institutions and VAS providers is vital for the success of many agricultural solutions.

Country-wide agro-ICT infrastructure and stakeholder cooperation for the benefit of farmers in cluding smallholders

Walter H. Mayer, PROGIS Software GmbH

Based on the use of precise ortho-images such as those available from Microsoft Bing™ Maps, GIS-based agro-ICT of PROGIS, data from agrosensor technology and rural area management consulting services, the AGRO-ICT-Backbone® concept was developed. It provides not only the necessary information technology (IT) tools but is also a holistic model to establish an agro-infrastructure throughout a whole country for fostering better agricultural development. It contains:

- The production of a high resolution 30 cm ortho-image for the whole country as a base for further planning and control with an update frequency of three to four years.

- The setup or if available, as in Europe, the upgrade of existing land parcel information (LPIS) systems) – or a cultivation register and/or a rural open street map (OSM), based on ortho-images and PROGIS GIS software WinGIS®.

- The implementation of a sophisticated farm management information system (FMIS) which also supports farm advisory (extension) services and serves the ministry for regional or country-wide statistical needs.

- The installation and integration of a logistic system including mobile solutions to support farmers and their chain partners in the industry, for in-time delivery needs for seeds, fertilizer, harvest and so forth or for traceability needs.

- The installation of agrosensor networks, consisting of agroweather stations and soil sensors for decision support and guidance.

- Value-added services for needs like precision and virtual farming, land consolidation, environmental management, carbon calculation, risk management, following the 2013 Common Agricultural Policy (CAP) requirements etc. including consulting if merited. A special training concept enables users to develop their own on-top applications for solving local needs.

- Apps for mobile phone solutions for Windows phone with Bing maps, (but also iPhone with Google maps, or Android with Google maps), such as:
  - GIS apps for field identification;
  - access to the logistic system for automated order processing;
  - access to farm management tools for sending and receiving cultivation-specific orders (including precision farming maps via advisors);
  - access to the software developer component for personal and local GIS-based developments.

- Capacity building, including education and training models, enables local experts to be ready for a rollout.

- The intelligent business model enables the owner of the ICT infrastructure (public, private or private-private partnership) to generate return on investments (ROI) by supporting stakeholders such as banks, insurance companies, large farms, large forest enterprises, chain partners like the food-industry, suppliers of farm equipment, agrochemicals and other agroresources as well as international investors.

Beneficiaries are farmers and forest holders, also smallholder enterprises, groups of farmers, cooperatives, advisory/extension services, other service providers, affiliated industries, ministries, banks and insurance companies, researchers, rural populations and the public in general.

Solution from PROGIS

The implementation of this agro-ICT-backbone has to be realized within a large-scale project together with a range of local partners and experts. It can be done in a public, public-private or private project and is partitioned into the following steps:

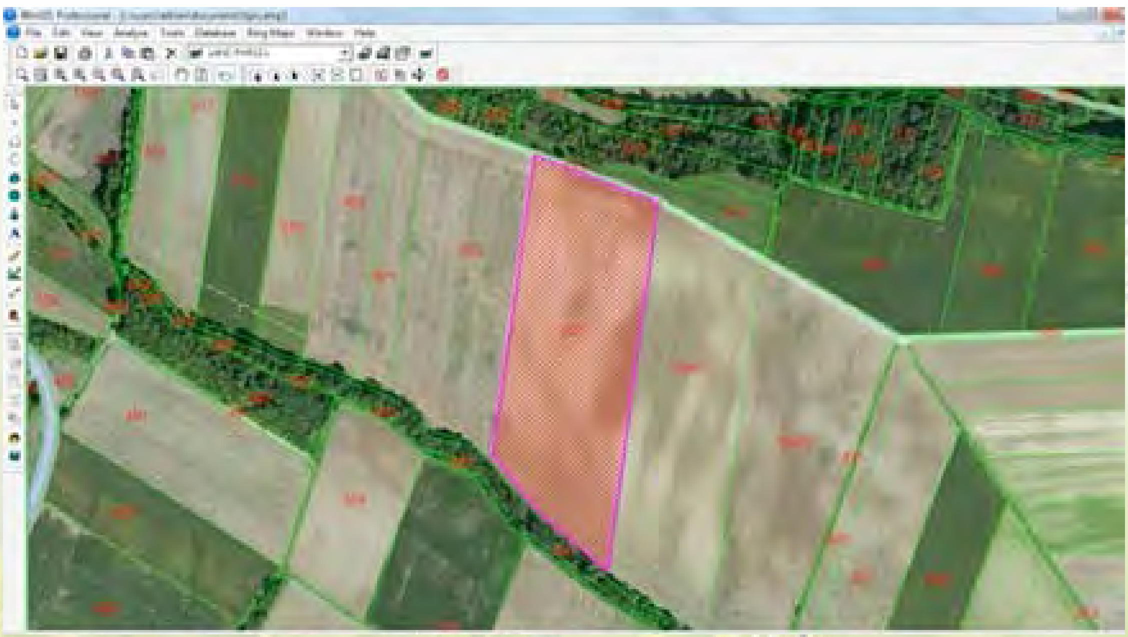
Ortho-images

Production of 30-cm ortho-images with a vertical digital surface model (DSM) of < 1.5 m resolution and a 60-cm infrared image. Examples of technical specifications of compliant ortho-images are given in the Microsoft (MS) article Global ortho: rapid, high efficiency ortho update technologies[9]

Preparation of LPIS

The first task is to implement the GIS system WinGIS® and on the basis of MS images, set up the LPIS- or cultivation register including the assignment of owners or leaseholders to individual plots and

Figure 23. LPIS polygons on an ortho-image



thereby build up a country-wide land parcel database. An OSM technology can be integrated. The LPIS systems are already implemented in most countries of the European Community (EC) and updates can be done directly by farmers or farm advisors to increase precision and lower land administration costs by data transfer to the existing LPIS/IACS system (see details later).

GIS services

GIS services for non-specialists were a primary aim of PROGIS when developing WinGIS® It is easy to learn and use GIS software on a personal computer, with extensive geographic application possibilities and facilities. Due to the ability to integrate online map data such as Microsoft Bing Maps as an 'embedded module', access to worldwide geographic data like satellite and aerial images, road maps and address databases is already part of the software package. Import and export interfaces support the most common GIS/CAD file formats like the ESRI™ shape files, the AutoCAD™ DXF, MapInfo´™ MIF and also text-based file formats like CSV or GPX for data import from, for example, GPS devices. In a few steps external spatial data can be uploaded into the user´s project.

By using the developer component, application developers can link their application with WinGIS® in order to visualize, edit and administer any data with a geographic relation. This is very relevant for realizing suggestions to implement local integrated agricultural control system (IACS) applications, to monitor GAP/CAP compliance or for supporting consultancy applications.

With the help of such a software development kit (SDK) local IT experts managing the IACS system of an EC country can easily implement an application to generate a subsidy form out of the farm management information system (FMIS) and transfer it via the Internet to the government homepage. This is thus 'one stop shop software', managed by a trained farmer or by an advisor that in parallel with the subsidy form also manages business calculation, nutrient balance, carbon balance, integrates data for other future documentation needs like food traceability, a business plan, insurance data or after 2013, CAP´s ICT needs. Not only can governments save money, but farmers will save travel and time costs from driving to a subsidy centre. Within a similar time frame, much more output can be realized on one side and if advisors are supporting farmers within a region (in all negotiations about a CAP reform new advisory concepts are asked for) much more can be achieved in all sectors where single farmers alone cannot reach the targets but in groups can accomplish them. These targets concern mainly the environment, landscapes and natural risks, but also logistics, precision farming, land consolidation missions etc. This is also something the new GAP regulations will support.

Implementation of Farm Management Information Service (FMIS)

When the European Union (EU) launched the CAP reform to increase food quality and safety for the welfare of its citizens, PROGIS developed DokuPlant™ on top of the GIS software tools for farmers and advisors to manage the many needs which this new legislation brought along. This integrates expert databases (all agricultural data and cultivation recommendations sustainably supported by local experts) and a perpetual calendar and documentation tool, and facilitates planning, calculation, control and traceability. With this, extension officers/advisors are able to aggregate the data from fields, farms or a whole region and to prepare them for a ministry or other public authority for statistical use or for projects.

Figure 24. Farm management: where-what-when expert data

The following information is generated from every field and can be accumulated countrywide:

- Activity management
- Crop rotation
- Cost calculation
- Nutrient balance and carbon balance
- All input/resource needs
- Harvest estimations

PC-GIS, real time management and the expert data base are integrated. The mapping of plots/fields is supported and a perpetual calendar enables the display of any performed activity: what–when–where (**Figure 24**). The integrated database is filled with agro-expert data, generated in close cooperation with local agroforest-environmental scientists/experts and contains (example: agro-Germany) 2 500 agromachine data (KTBL, costs, time), data on thousands of mineral and organic-fertilizers, 850 herbicides with contents, crops including varieties and 400 plants with average yield and seed needs. The complete working process for a year with all activities and relevant data is predefined for all crops and enables planning with one click: Where (plot in the map) do I plan what (select crop from the expert data bank). This database is consequently also a knowledge base and allows know-how transfer from scientists to the base, the farmers and foresters daily and sustainably. After planning, the data entry can be done manually or automatically.

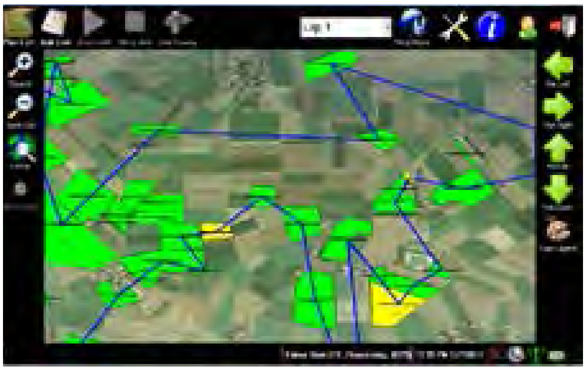
Forest management

ForestOffice is FMIS for forest enterprises. It deals with sustainable forestry planning, forest facilities, forest management and forest logistics; the expert database contains local growth tables of different trees. Both agricultural and forest expert data have to be modified by local experts working within a 'farmer/forester-advisor-expert' business model.

Logistic services

The protection of the environment and of natural resources is on everyone's lips today. Within agriculture sector group management, activity-based planning and sharing of production facilities contributes to reaching these targets. PROGIS developed a smart logistic solution to solve these needs. The base data are the accumulated information from the a.m. FMIS from which farmers, foresters and the industry devise their planning. Process and time optimization answering queries like: "where to deliver what?" or "where to pick up what and when?" (**Figure 25**) and how to come to a location (with the help of the rural OSM) supports all process-related partners.

Figure 25. Logistics – "where to do what"



The system leads to optimization of daily and seasonal routing, accurate information of harvest status, GPS position data visualization, online two-way communication (GPRS/UMTS) between central and mobile terminals and order processing. The system consists of a central station and a number of mobile units (mobGIS). It handles crops for food/feed or biomass production, liquid manure deposits, forest harvesting or any other logistic task. Up to 30 percent cost reductions or even more can be achieved. Environmental pollution is far smaller than with conventional methods and due to the recordings ongoing improvements may occur.

Agrosensor networks

Sustainable cultivation and protection of soils depends considerably on the application of fertilizers, pesticides and water. Agrosensor stations help to take decisions and to optimize rates. A network of agroclimate sensors – one station for every microclimate – and soil moisture sensors are needed. Based on the data and a tool set, experts can provide farmers with tailor made recommendations (such as forecasts for weather situations), and also obtain protocols of the climate situation of the past and the related impact for the future; for example, mass reproduction of a fungus or a beetle with an SMS-induced decision – "start spraying" for example.

The expert models, such as those based on meteorological conditions collected during the last four weeks, which fungi or beetle will tend to outbreak, have to be adjusted or developed and fine-tuned by local phytopathology experts.

With the soil moisture sensors, which are also available in different depths, all necessary data for irrigation can be collected and used to support an automatic controlled irrigation system.

Figure 26. Agro-sensor network

Mobile phone solutions

A range of apps has been developed for 'mobile agriculture' to support farm and land management via mobile phones and to develop on its own supportive GIS-based apps. It is already possible to digitize, edit and delete polygons, to record GPS positions, to cluster them and to send all recorded positions and digitized polygons via e-mail and import the data into the WinGIS® software for further processing. Also the access to DokuPlant and Logistics is a great advantage for advisors to communicate with their clients and advise them on field-related activities via mobile phone and thereby bridge local distances.

Organizational components

New business models

In the same way that ICT has supported many other sectors throughout the last decades, ICT is able to support agriculture, but enabling structures and a new form of cooperation are needed. Farmers will also be able to support the new requirements of the CAP reform, but they need better support, assisted by new advisory structures focusing on farmers' needs and not only other stakeholder needs. The farmer is the integrative factor within the food/feed, bioenergy or even environmental or natural risk chain-management and he/she has to be supported. Then all other chain members will also benefit from the ICT structure.

Figure 27. Apps for Windows phone

New business models are necessary – and available – that take care of the leverage effect due to integration of technologies and cooperation of structures. Less group egoism in agroforestry chain management is essential.

A prerequisite to start such an agrosolution is a local infrastructure comprising local hardware, communication technologies and the whole appropriate personnel organizational structures. It contains both the hardware and software for aggregating data at the ministry level, the countrywide structure for LPIS and a farm advisory system (FAS), mobile solutions and the communication layout. Access to ortho-images and weather data supporting all farmers' needs is a must in the future. Making data available like Finland´s Cadaster department did recently is vital, with private ortho-image suppliers like MS-BING being ideal options for future cooperation.

Beneficiaries who are the stakeholders in such a concept are described next and for all of them the ICT backbone can provide valuable services. For these services much return on investment (ROI) money can be acquired due to the benefits delivered by the ICT, but it always remains a political decision regarding to what extent the ministry will support the achieved benefits or how much beneficiaries for the use of this ICT backbone will have to pay. (On –request ROI calculations for single sectors can be done.)

The business models may be different – public, private or public-private. A model is imaginable, where public (Ministry of Agriculture) and private (banks, insurance, and investors) share the investment and set up a common structure to support the different beneficiaries with information against a fee.

Beneficiaries

A crucial effect of this agricultural ICT backbone concept is that data will be generated displaying the whole current situation and for planning the future situation of agriculture and forestry in a country. At a certain point after implementation, the empirical knowledge derived from the storage of the history together with latest R&D leads to further actions. Many stakeholders are interested in these data and need them for their daily work. With an appropriate model for data sharing, this can bring benefits for several businesses. It can be taken for granted that chain partners will be ready to pay to get access to this information. The model in detail has to be worked out together with local structures and representatives from different stakeholders, based on a trust centre concept that respects the ownership of information.

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A public-private run ICT infrastructure consisting of new ortho-images for the country covering GIS and IT solutions for rural area management in connection with land management and extension services, agriculture management and logistics can be used by different governmental organizations and also by private structures. They can support:

- The Ministry of Agriculture's needs for organizing subsidies;
- The ministry responsible for landscape changes or for the cadaster and ground tax;
- Consultants in their advisory work;
- Food chain partners for traceability and for the documentation of production,
- Logistic service experts to do the right actions at the right field to find the right roads to the field and be there at the right time as well as deliver goods to the food industry 'just in time';
- Agrocontrol organization for subsidies;
- Bankers to draw up a business plan for financing farmers/forest holders and obtain output from the LPIS including a calculation of the growth period (costs and expected return);
- Insurance companies to make the appropriate policies for the relevant crops and fields because an output can also be obtained from an LPIS system that informs on which farmers have which crops and how many hectares can be grown, including a map.
- Ecology experts and natural risk managers for the appraisal of the risks related to field or ecological coherences;
- Medical experts to judge the influence of a farm activities on the public at large;
- And last but not least, support farmers by giving them tools for economic calculations.

NOTE :

1. ICT In Agriculture, World Bank e-Source book, 2011
2. Nagayets, O. 2005. Small farms: current status and key trends
3. Tuning in: Radio on mobile in Jharkhand. Photo: Sarita Brara, The Hindu, April 8, 2013 (photo & news article)
4. ICTs, Enterprises and Poverty Alleviation, UNCTAD, 2010
5. Balwant Singh Mehta, Working Paper 29, Capturing the Gains 2013
6. Balwant Singh Mehta, Working Paper 29, Capturing the Gains 2013
7. International Telecom Union, 2013
8. Text and image sourced from: Angela Crandall, Albert Otieno, Leonida Mutuku, Jessica Colaço, Mobile Phone Usage at the Kenyan Base of the Pyramid, 2012










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