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.

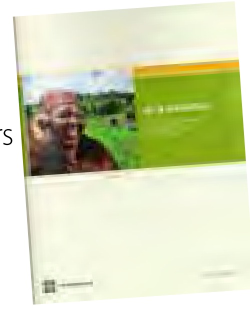
Figure 10 : Conceptual model of VERCON

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.

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

A

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.


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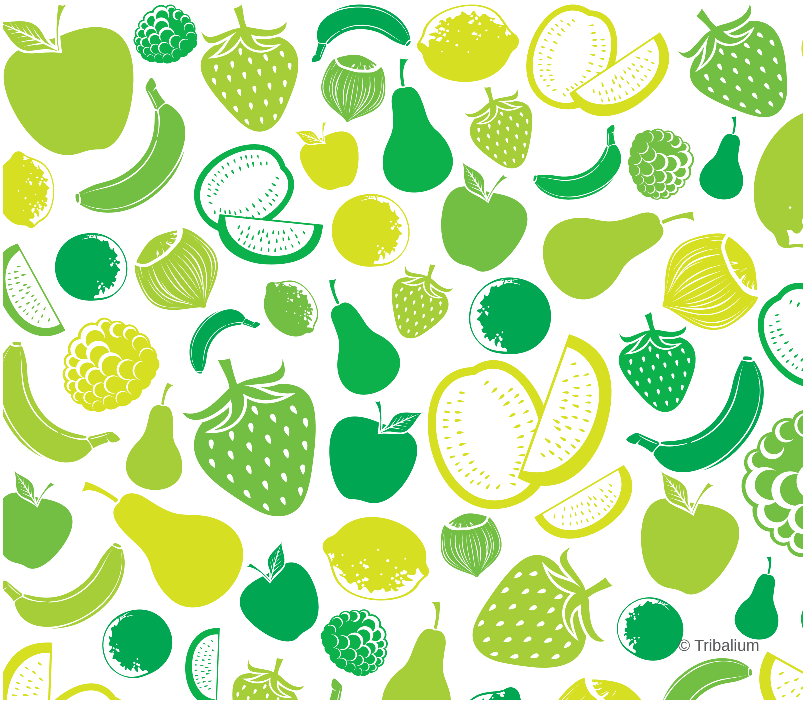
The development of ICT in agricultural information service

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.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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.


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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

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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.

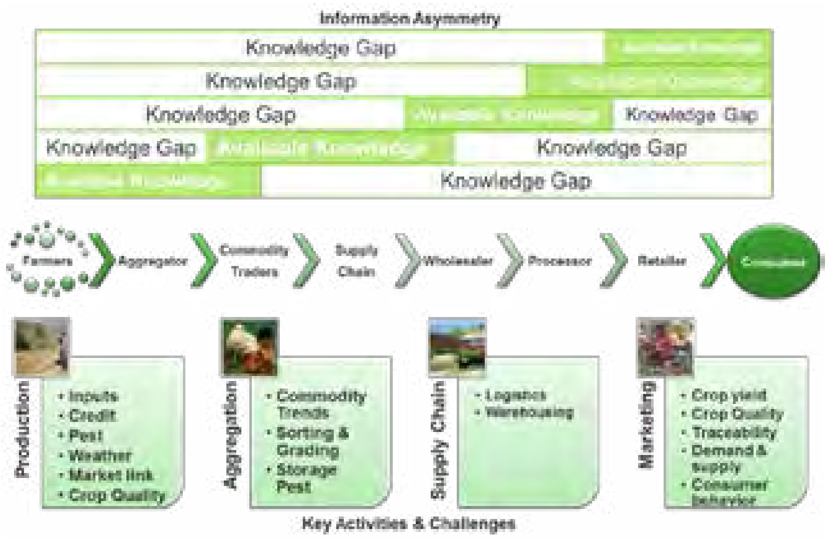
However, using mobile phones, even smallholder farmers can easily increase their circle of communication without being physically moving out of their farms. In a 2011 study by the Institute of Human Development (IHD) India, it was observed that using mobile phones, the farmers in the states of Punjab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

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.

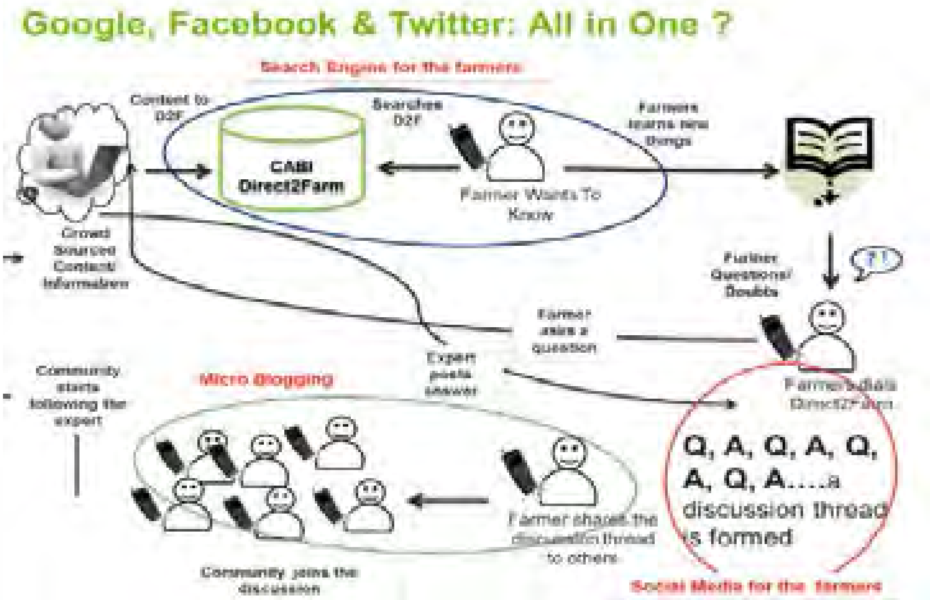
Case studies of CABI's work in empowering farmers through mobile based interventions:

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.

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.

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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.

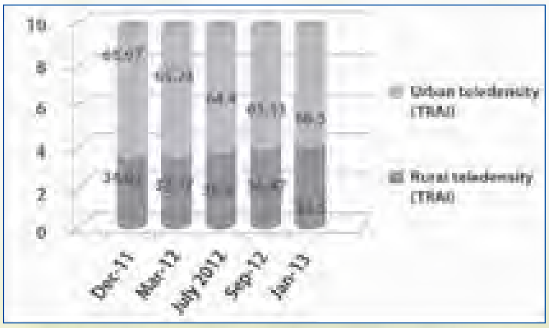
Mobile usage – statistics and growth pattern

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.

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

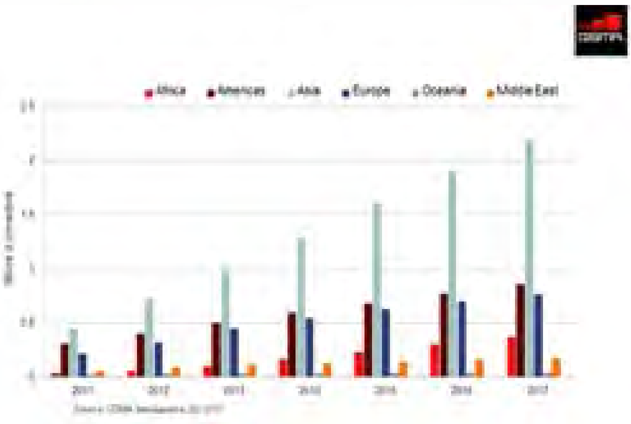
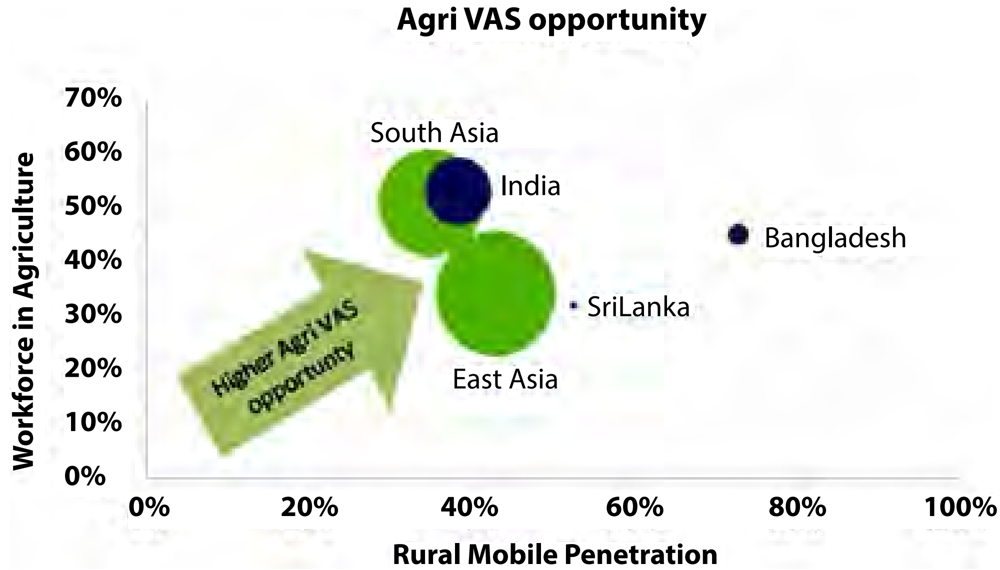


Figure 19. Mobile broadband growth 2012-2017

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'.

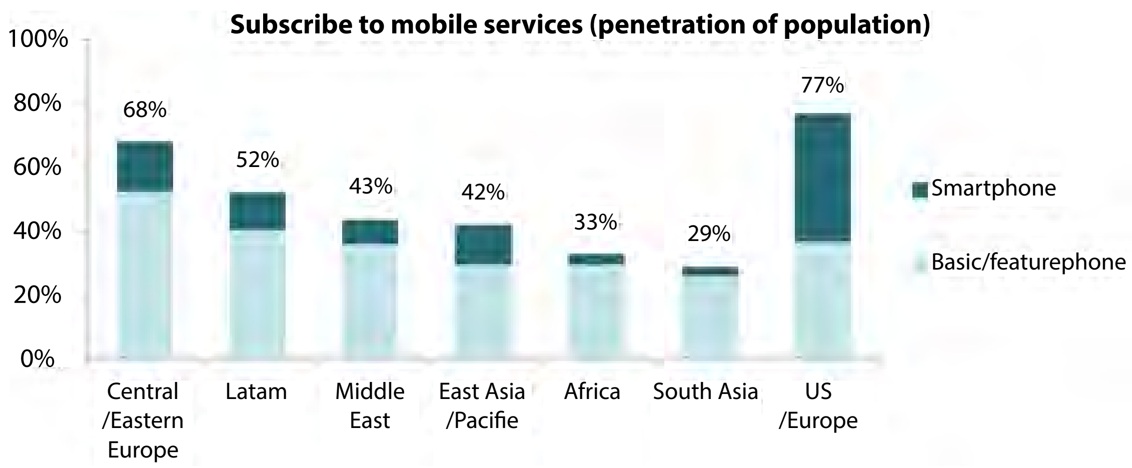
Enabling factors for agricultural VAS: mobile data

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.

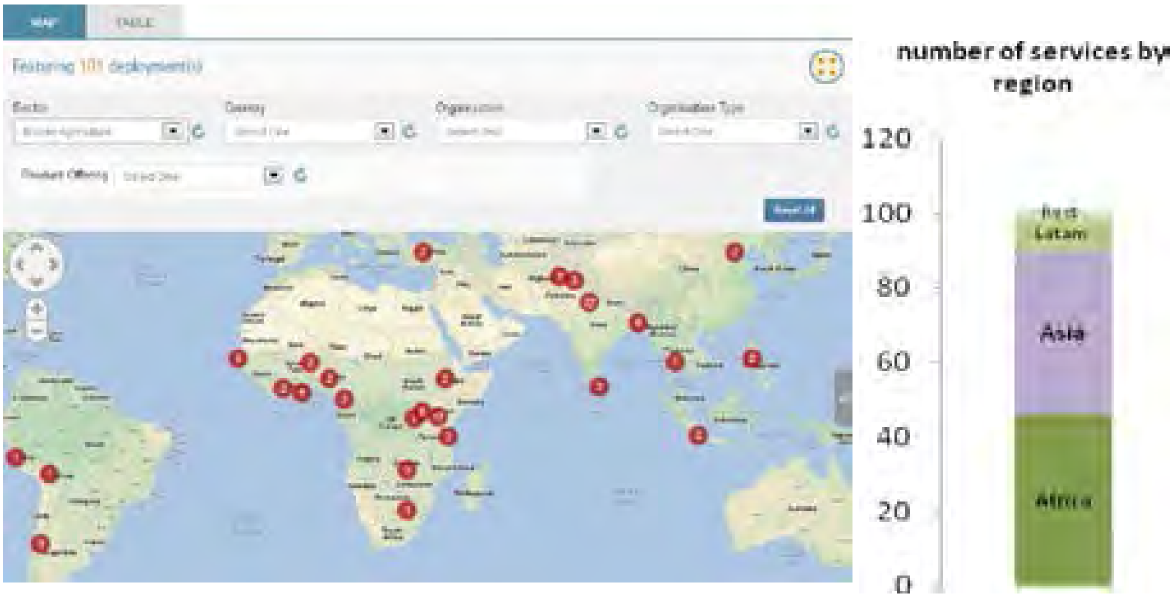
In the case of agricultural customers in low-income segments, this skew toward low-end handsets will be even more prevalent.

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.

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:

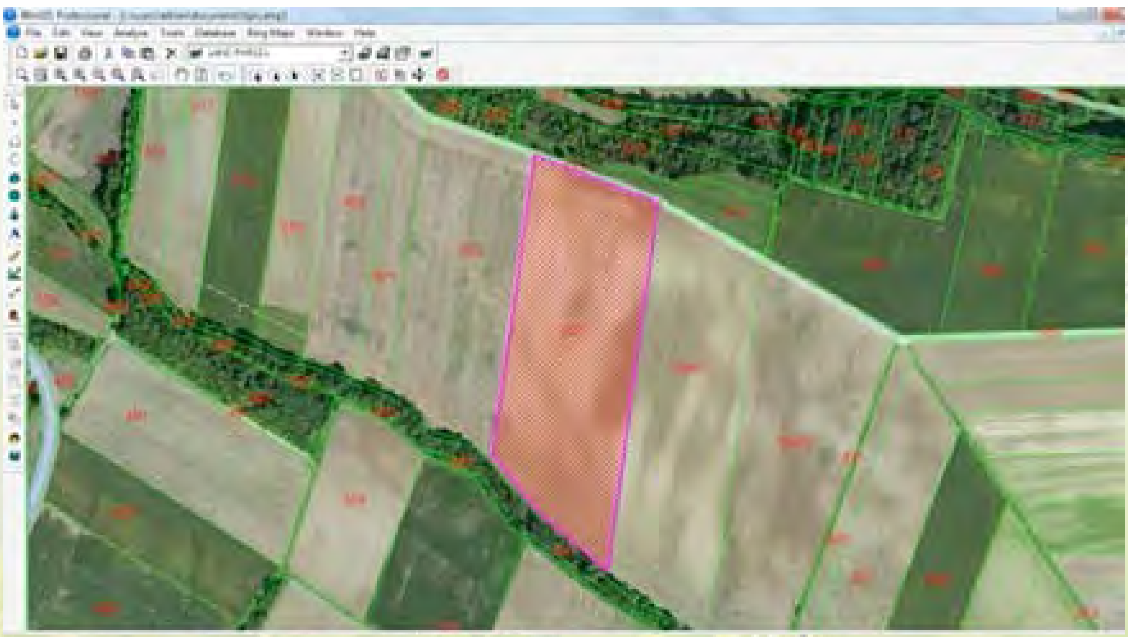
Ortho-images

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.

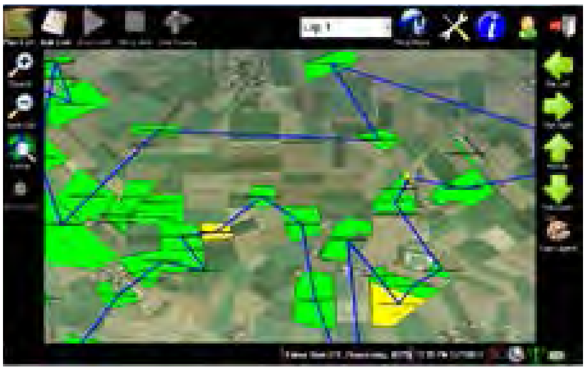
Forest management

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.

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.

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