eTransform Africa: Agriculture Sector Study

Sector Assessment and Opportunities for ICT

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Executive Summary

The strategic transformation of the agricultural industry in Africa through the application of Information and Communication Technology (ICT), forms part of a bigger study commissioned by eTransform Africa, a partnership between the World Bank and the African Development Bank (ADB), supported by the African Union (AU). The objective the study is to produce a new flagship report on how ICT’s have the potential to change fundamental business models in the key agriculture sectors.

This report is divided into six chapters and follows a practice-oriented, case study approach. As Africa is a continent consisting mainly of developing countries, an effort has been made to ensure that examples and best practices cited are from developing nations. The project description found in chapter 1 states the objectives and coverage of the study while the introduction sets the scene for the study.

Introduction

Food security is highlighted as one of the main concerns relating to the survival of individuals, families and ultimately nations on the planet, emphasizing the need to strengthen of the agriculture sector. While agriculture is the largest economic sector in most African countries and remains the best opportunity for economic growth and poverty alleviation on the continent, it is identified as having been in decline over the past 40 years\(^5\). Poor farmers have largely remained poor with 73% of the people living in rural areas subsisting on less than a dollar a day.

Typical problems experienced on the African continent that have an impact on most industries, including agriculture, are: under-investment in rural areas, inadequate access to markets and unfair market conditions, inadequate access to advanced technologies, weak infrastructure, high production and transport costs, conflicts, HIV/AIDS, natural disasters, deforestation, environmental degradation, loss of biodiversity and dependency on foreign aid. African agriculture is largely traditional and practiced by smallholders and pastoralists. Characteristics of this type of agriculture are that it is predominantly rain-fed, has low-yielding production, and lacks access to critical information, market facilitation, and financial intermediation services.

ICT can play a significant role in addressing these challenges and play a key role in economic development and growth as it can bridge the critical knowledge gap between stakeholders. However, poor accessibility to sufficient infrastructure affects the use and adoption of ICT in agriculture in Africa. Mobile technology, on the other hand, is increasingly being adopted as the technology of choice for delivery of ICT services and solutions.

The report identifies four main stakeholder groups as users of ICT in agriculture:

- Businesses: businesses, associations, other organizations
- Farmers: individuals; organized and informal associations
- Researchers: researchers; educators; trainers
- Government: Ministry of Agriculture; departments; parastatals
The report also identifies the farming life cycle as a three-stage process that will be used throughout the report to identify the applicability and use of ICT in each stage. The stages are:

- Pre-cultivation: including crop selection, land selection, calendar definition, access to credit, etc.
- Crop cultivation and harvesting: including land preparation and sowing, input management, water management and fertilization, pest management, etc.
- Post-harvest: including marketing, transportation, packaging, food processing, etc.

The introduction is followed by the landscape analysis chapter providing an overview of global best practices.

**Landscape Analysis**

This chapter starts off by giving brief descriptions of some recent success stories of ICT use in agriculture, followed by a discussion on general global trends adopted. In the overview of the trends, sample case studies from developing countries are provided to depict the trends in further detail.

**Trends**

*A common platform for agriculture stakeholders*

A single, integrated information system for all stakeholders has many advantages. It minimizes the duplication of data and ensures consistency, improves integrity of the data, and addresses a variety of requirements. Although often quite complex, the system can be customised to ensure that the user experience of the system as relatively simple. Cost and time spend on maintenance is relatively low and the amount of user training required can be reduced. A good example of such a system is DrumNet, which is discussed in detail in the chapter labelled African Scan.

*Multi-stakeholder eAgriculture knowledge sharing in Africa*

Multi-stakeholder research partnerships (also referred to as the participatory knowledge quadrangle of farmers, extension professionals, educators and scientists) have many benefits as they emphasize relevance in research, can reduce the time required to complete research, and improve the efficiency and effectiveness of the research process. The following applications of ICT in agricultural knowledge sharing are identified and their value is explained:

- ICTs for multi-dimensional decision making
- ICT infrastructure to connect the knowledge quadrangle of farmers, extension professionals, educators and scientists
- Entities/individuals lacking fast and affordable internet access
- Multi-channel information delivery
- ICTs for spatial analysis and targeting of programmes
- ICTs for better risk management
- ICTs and financial services for the farmer
- ICTs and information gaps
- eEducation
- Virtual aggregation of small stakeholders
The role of mobile technology in eAgriculture

Mobile phones, GPS systems, barcode scanners, RFID readers and smart card readers technology can be used to read and capture data and to store data. However, further components, such as the internet, communication networks and regulatory systems (to provide data security and standard systems for codes), are essential to complement the input and output devices.

Two cases are used to illustrate the role of mobile technology in eAgriculture. First an overview of the mAgri Programme is provided. This programme is only at the point of requesting proposals and therefore the overview is limited to an explanation of the purpose of the fund and the programme, and the expected results it expects to achieve through the provisioning of high-quality agricultural information services through mobile channels. The criteria for eligibility for funding via this programme are listed and information on operations, technology and developers are briefly mentioned.

The second example describes a well-established service that has been operating in Ghana since 2005 extensively using mobile technology. The Esoko Ghana Commodity Index (EGCI) is a rural communication platform that publishes a cash market price index composed of data on physical commodities. The index is published weekly and tracks prices at wholesale and retail levels. Esoko seeks to improve incomes by building healthy markets. Any individual, business or producer group can set up Esoko to better manage marketing, distribution and procurement networks. Currently Esoko is active in ten countries throughout Africa with different partnership agreements which include public sector agricultural projects, Esoko country franchises and licensed partners. Esoko provides a complementary partner support programme, which focuses on capacity building and financial sustainability, with an emphasis on market data enumeration and business development services.

Traceability

Traceability is described as the recording of information so that an item moving through a global supply chain can be tracked from its origin along the value chain. In the agriculture sector, traceability is the forward and backward tracking of animals and food by paper or electronic means. Animal traceability, therefore, refers to the ability to follow an animal or group of animals during all stages of life – i.e. from birth to death. As noted in this section, there is an increased emphasis on the traceability of agricultural production particularly in the markets of the developed world, due to an increasing consumer demand for quality and food safety.

The remote tracking solutions among the coffee growers of Costa Rica and Mexico are a successful implementation of a tracking solution in a developing nation. The Coopetarrazú’s processing plant uses leading-edge technologies for coffee drying, hulling, sorting and shipping, it also tracks hundreds of thousands of coffee purchases from its members during the harvest and ensures that purchases meet certification criteria to ensure premium prices. The way the system operates and the technologies used in its operations are explained. The system’s successes include a 2,600-member base and $16 million-a-year operation.

Traceability in livestock farming is also the focus of one of the Deep Dive case studies, so these two cases provide two different views of traceability.
Agriculture insurance

Agricultural insurance is a special line of property insurance applied to agricultural entities. In recognition of the specialized nature of this type of insurance, insurance companies operating in the market either have dedicated agribusiness units or outsource the underwriting to agencies that specialise in it. Agricultural insurance is not limited to crop insurance, it also applies to livestock, bloodstock, forestry, aquaculture, and greenhouses. Crop insurance has long been used in developed countries to deal with weather uncertainties, but its availability in Africa, particularly to smallholder farmers, has been extremely limited. Agricultural insurance is particularly important in Africa today as the extreme weather patterns generated by climate change are introducing increasing volatility to food production and food prices.

Areas where ICT’s can play an important role in the agricultural insurance process:

- to facilitate access to information and services to stakeholders;
- to provide advance information about weather and market price situation;
- to provide better services and facilitate speedy claim servicing;
- to monitor and track premium repayment;
- to ensure a better interface between the insurer and the insured, particularly for field-based transactions;
- to bring improvements and change through the use of complaints and feedback;
- to use developed databases and analysis of collected information to develop specialised and affordable rural insurance products

ICT in Agriculture/Rural Development: Community Information Centres in Bhutan

The Bhutan example is provided in order to illustrate how general community centres can be used to provide remote populations with information and communication options. In response to the challenge of providing services to Bhutan’s scattered population who live in mountainous, forested terrain, which has made wired Internet and telephone connectivity prohibitively expensive for operators and end users, Community Information Centres (CIC) were established. Their objective was to provide sustainable, commercially viable ICT services in rural areas. The state provides the equipment, and an individual from the local community is employed to promote and maintain those services. Services available at the CICs include basic and advanced computer training, non-Internet-based games, Internet, telephone facilities, government information and forms, and lamination and scanning facilities.

Broadband connectivity brings high-end services closer to the rural population and helps reduce poverty. As a result, the travelling time and cost for villagers/farmers is reduced while employment opportunities are generated for rural people. The CICs not only serve as a one-stop-shop for accessing information but also as an ICT training centre for rural people.

While the Landscape Analysis highlighted the various global best practices and sample cases the following chapter, the Africa Scan, provides a closer look at proven success stories of the African continent.

Africa Scan

The Africa Scan provides an overview of selected applications of ICT solutions in Africa. This chapter summarises nine case studies and identifies reasons for their success and potential to be scaled up. In
addition to the case studies, an overview of agricultural research in Africa is provided, identifying the challenges faced and suggest recommendation for the adoption of ICT in research. Finally this section provides an overview the eAgricultural plan developed for Mauritius that is expected to act as the blue print for the adoption and use of ICT in the national agricultural sector of Mauritius.

The following case studies were reviewed¹ and are reflected in this section:

- Using ICT to bring together multiple stakeholders in the Kenyan agriculture sector – DrumNet
- Zambia’s National Farmer Union develops SMS based services
- Sissili Vala Kori- farmers use ICT to share new production, processing and marketing skills in Burkina Faso
- Mango traceability system links Malian smallholders and exporters to global consumers
- Index-based agriculture insurance on agricultural inputs in Kenya – Kilimo Salama
- Using ICT to improve forest governance in Liberia – LiberFor
- Mobile technology as a “Game Changer” in South Africa: MXit
- Mobile technologies used by GSMA as an initiative to alleviate food security related problems
- Seeing is believing – unlocking precision agriculture in West African smallholder communities with very high-resolution imagery

Sample reasons for success identified in these studies follow:

- Real economic value was added either because of savings resulting from the use of ICT or an increase in revenue or profitability.
- The language and medium used to communicate with the farmers were important contributing factors in the farmers’ response to the programme.
- Good conceptualisation and execution was achieved by including multiple-stakeholders in win-win partnerships.
- Trust was built with stockists, support centre operators and even the Government by using local champions as facilitators. This is an essential element for success in any project.
- The projects were often augmented by bundling many services together with the basic or original facilities to make them truly comprehensive.
- A government-recognised body used to implement a project provides the initiative with added credibility.
- Where mobile phone reception and signal coverage issues were problematic, local alternate media uses have emerged that circumvent this problem.
- Additional faith and trust in the system are created when a solution is developed locally.
- Other community members find it particularly useful if other farmers are directly involved in training and can demonstrate a solution.
- In instances where farmers were able to identify personally with a technology solution they were more inclined to adopt it and continue to use it.

¹ Detailed case studies are included in the main body of the report of DrumNet and the Zambian case and summaries of the others but the detailed descriptions of the others are provided as annexures to the report.
In areas of low literacy and low ICT penetration rates, use of an appropriate medium was instrumental to the success of the venture.

It is important to establish a long term interest and commitment amongst all those involved.

In the precision farming case study, the adoption of satellite technology resulted in lower operational costs and increased yield.

In the chapter labelled Deep Dive Case Studies, following the African Scan, detailed descriptions of two case studies are provided. These cases were selected in conjunction with the eTransform partnership to ensure that country case studies were not duplicated in different reports and to ensure that as deep an understanding of as many African countries as possible is obtained.

**Deep Dive Case Studies**

In this in-depth overview on the role that increased use of ICT could have on key aspects of the agricultural sector, two major opportunities were identified. Improved traceability of livestock and products and increased efficiency of irrigation of crops were found to be key areas for a rapid increase in agricultural production.

*ICT as a potential tool for increased traceability of livestock*

Livestock production is the most widespread and generally practiced agricultural activity on the African continent. The intensified use of ICT in improving the efficiency of livestock and meat production in selected African countries could positively affect all parts of the continent. Should it furthermore be found that significant increases in production are possible at affordable cost and are relatively easy to duplicate in areas with diverse natural landscapes, the potential for general increased wealth creation could be enormous.

The results of the in-depth investigation in Namibia revealed the following:

- The traceability systems employed by the commercial farming community and its downstream role players have unlocked wealth along the entire value chain;
- The experience gained by the commercial livestock sector can serve as a valuable platform to roll out traceability systems in under-developed rural areas where livestock production is heavily relied on to sustain the people;
- New, streamlined traceability systems which have recently been developed allow the inclusion of a wider spectrum of functions so that many additional services can be rendered;
- The co-ordinated extention of comprehensive systems of traceability can improve the lives of multitudes of poor people and the long-term sustainability of the entire livestock industry. This has the potential to positively affect the economy of the country at large;
- The capital and operational costs involved in the roll-out of such a comprehensive traceability program are relatively low compared to the large benefits which can accrue to the livestock industry, the respective role players in the value chain as well as the government of the country;
- An enabling environment should be created by the government and all other interested parties to ensure maximum efficiency of an advanced traceability system;
• Should international organisations involved in the provision of aid funding wish to make a contribution of note to Namibia, consideration should be given to concentrating their funding efforts on the provision and maintenance of a comprehensive traceability system;
• The traceability systems that are discussed in detail in the main part of this document can be rolled out in many other African countries where they can be expected to bring about the same wealth creation, but an enabling environment must first be created;
• Investment in the intensified use of ICT can offer more advantages than investment in possibly any other interventions to be considered.

The potential for the intensified utilisation of ICT in increased irrigation efficiency
It has been demonstrated in many areas of the globe that using good irrigation techniques can increase the efficiency and profitability of crop production as much as a hundredfold. Efficient irrigation practices provide a consistent moisture supply to crops, water deficiencies can be overcome during periods of drought, more than one crop cycle per year can be achieved and the effective use of all production resources can be dramatically improved. The pressure on the diminishing water resources can also be alleviated and, as a result, more land can be put under irrigation. The increased utilisation of ICT could have a positive effect on irrigation efficiency.

The in-depth investigation in Egypt indicated the following:

• The existing ICT systems employed by some of the commercial farming community in the large-scale irrigated farming operations studied have increased the efficiency of water use and generated larger profits;
• The experience gained by the large and small-scale commercial irrigation sector can serve as a valuable platform for even more comprehensive ICT systems. Many more agrarian communities in Egypt can be reached and this will contribute towards the improvement of living standards;
• The intensified use of ICT can offer government organisations opportunities to diversify their services to all communities involved with irrigation farming;
• The capital and operational costs involved in the roll-out of a range of ICT-based functions are relatively low compared to the large benefits which can be expected;
• The enabling environment which the government and all other interested parties create to ensure efficient use of irrigation water, can serve as an example to other countries;
• International aid organisations could make a serious contribution to Egypt by focussing their funding efforts on the intensification of ICT-based irrigation systems;
• The systems can also be rolled out in many other African countries and can be expected to bring about the same magnitude of wealth creation, provided that an enabling environment can be created;
• Investment in the intensification of the use of ICT for the improvement of crop production under irrigation, can offer more advantages than investment in most other.

Recommendations

The aim of the recommendations is to assist policy-makers and regulators to:

• Gain some insight in the benefits of ICT led interventions in their respective countries or regions;
• Implement interventions that would have a tangible outcome;
• Develop multi-country cooperation and best practices; and to
• Prioritize certain interventions that would be most beneficial for the country’s specific agricultural requirements.

Recommendations to policy-makers and regulators:
Recommendation 1 – Create partnerships with the relevant stakeholders;
Recommendation 2 – Set up an Agricultural Hub
Recommendation 3 – Regulatory implementation to govern specific opportunities;
Recommendation 4 – Adoption of livestock traceability systems at a national level in African countries;
Recommendation 5 – Empowering women in agriculture;
Recommendation 6 – Implementing irrigation solutions in Africa;
Recommendation 7 – An integrated e-Agriculture plan for the country;

Recommendations to the donor community:
Recommendation 8 - Developing self-sustaining funding solutions;
Recommendation 9 – Focus on community ownership;
Recommendation 10 – Make eAgriculture technology robust and accessible;
Recommendation 11 – Capacity building;
Recommendation 12 – Country agriculture strategy map.

Concluding remarks
Having the support of government is seen as a very important factor in eAgriculture projects and the inclusion of private sector partners and donors is also extremely important. The establishment of an Agriculture Hub was proposed as a very specific way of strengthening these relationships and allowing for them to be productive. However, full and sustained commitment from all the partners, including those “on the ground” is required.

Creating a sense of community ownership is important. Various communities exist and commercial farmers are one important community, smallholders another, and some communities are diverse with members from across the value chain.

Overreliance on any one partner, supplier or technology is unwise, particularly in the case of technology and a multiple approach, with alternate forms of media is required so that, once operational, the project does not collapse if one technology is unavailable even for a short time.

A sense of urgency is necessary to get any large project off the ground but this must go together with proper planning including financial planning and getting any necessary legislation or regulations in place, as well as a full assessment of many aspects of the current situation. Planning for ICT infrastructure, end user training, design and implementation of systems, on-going maintenance and support are all required. However, it is not only the technological issues that will need attention in eAgriculture, change management plays an important role in the introduction of ICT solutions in order to ensure sustained use.
Livestock tracking and traceability in Namibia

The Namibian Livestock Identification and Traceability System (NamLITS), established in 2005, consists of a central computerised database with an extensive network linking workstations at most Directorate of Veterinary Services (DVS) offices to the database in Windhoek. The implementation was very structured and covered the system design, legislative framework, governance, operational responsibilities, stakeholder management and outreach, implementation timetable and resources required as well as monitoring and evaluation, research and development. The ultimate goal was to enable access to lucrative livestock markets for the pastoral community by means of a proactive traceability system that supports the eradication, control and risk management of specifically Foot and Mouth Disease, Contagious Bovine Pleuro-pneumonia and Bovine Brucellosis. The current database allows DVS to control and monitor animal movements through the issuance of movement permits and notification of movements. This enables DVS to trace-back a diseased or suspected animal through animal registration and recording of animal movements between establishments.

A second phase of NamLITS, for implementation in the Northern Communal Areas (NCAs), began in June 2010 and is to be completed in October 2012. The current NamLITS database and network infrastructure is to be utilised but the database and network infrastructure will be enhancemented.

Official identification is done by means of animal identification devices as required by international standards. Official cattle ear tags in the NamLITS NCA are supplied by the Ministry of Agriculture, Water and Forestry (MAWF) through the DVS. Eligible cattle are tagged as part of a specific campaign and further tagging takes place during annual vaccination campaigns or community visit-based surveillance activities. In cases where handling facilities are in disrepair, mobile crush pens are used. All cattle are required to be identified by a primary and secondary ear tag by the age of six months.

Both a radio frequency identification (RFID) for automated data input and a visual plastic ear tag that supports remote pastoral production where there is limited or no technological support are used. Both tags have the same unique number. Suppliers of cattle ear tags must be able to demonstrate that the ear tags or RFID readers they offer are aligned with international guidelines. The management of the inventory of ear tags through the NamLITS database ensures accountability for all ear tags supplied. Experience gained in Meatco’s Ekwatho Scheme in Namibia demonstrated the benefits of using RFID enabling technology in terms of the speed and accuracy of capturing data which was a deficiency in the early paper-based NamLITS system. As a backup system, branding of animals will continue.

Currently, the NamLITS database interfaces with abattoir and auctioneering information systems, the Stock Brands Register and the Central Ear Tag ID allocation system. The NamLITS system will link registered establishments where animals are kept with identification data. This will enable officials to have access to reliable information in the event of disease outbreaks and to trace back the origin of a diseased animal as well as possible contact with other animals. The NamLITS NCA is going to introduce additional interfaces with other databases which will ensure that the database becomes a good source of standardised static data on establishments, keepers and herd and flock identification codes by using the same fundamental epidemiological information regarding livestock, establishments, keepers and animal events.
Irrigation and ICT in Egypt

Egypt depends almost exclusively on the Nile River for its water supply. Of this, 85% is used for irrigation. Three separate aspects of the use of technology in agriculture, and particularly for managing irrigation, are discussed in the case study.

Part 1

Demand for water is growing while the options for increasing supply are limited. To respond, the Ministry of Water Resources and Irrigation (MWRI) in Egypt has been implementing an Integrated Water Resource Management (IWRM) Action Plan. Its key strategy is to improve demand management. In collaboration with the World Bank, the German aid agency, KfW, and the government of the Netherlands, Egypt has developed the Integrated Irrigation Infrastructure Management Project (IIIMP). IIIMP is an important measure of the IWRM action plan. It is being implemented on 500,000 acres (feddans) in the Nile Delta covering the command of two main canals, Mahmoudia and Mit Yazid. The project aims at improving the management of irrigation and drainage and increasing the efficiency of irrigated agriculture water use and services. The main interventions of the project are improving irrigation and drainage systems and the water management institutional structure. The strength of the approach is that its engineering and institutional innovations complement and reinforce each other. Involving farmers in the management of the pumping and water control systems means that water gets to the right field at the right time, thus boosting crop yields and farmers’ incomes (38). The first phase of the project has resulted in crop yield increases of 20%. Estimates are that drainage accounted for 15-25% of this increase. A further benefit was the re-use of drainage water.

Technical development has been accompanied by the use of modern technology. Management information systems and databases have been developed and wide area networks to link the five sectors of Egyptian Public Authority for Drainage Projects (EPADP) with headquarters, have been established to facilitate data exchange, follow up on work progress and support decision makers.

Part 2

Magrabi Farms in the Nobaria area, north of Cairo, is almost 80 km from Alexandria. This area was a green-fields operation and has been developed from actual desert to the 8,500 acres that are now fully irrigated and underpin an export-oriented agribusiness. Magrabi exports produce to 38 countries.

Magrabi is an ideal example of the development of a full-scale economically sustainable unit that has used technology in order to reach its current status. They are completely independent in terms of being able to conduct all the functionalities required for good soil, water and multi-cropping management. There are fully equipped laboratories on the farm that form part of an integrated quality control programme and the whole complex has a fully-integrated, reticulated irrigation system which is managed by an irrigation engineer. All water passes through filters and all bypass water is tested for purity as fertigation is a normal practice. Efficiency of water usage is continuously monitored. An on-site weather station for temperature monitoring and evaporation pans to determine moisture loss are used to facilitate the correct irrigation scheduling in conjunction with tensiometers.
Irrigation and ICT in Egypt (continued)

Part 3

An institution-based information system, Virtual Extension Research Communication Network (VERCON), an FAO-designed Internet-based network, was established in 2000 in order to improve information-sharing between research and extension staff in Egypt. VERCON was merged with the Rural Development Communication Network (RADCON) in 2004 to serve a stakeholder community beyond government services and to include other public and private information service producers and the media. The four main categories of stakeholders are the farmers, extension services, researchers and statistical information providers. The main objective of the system was to develop a network which could improve extension services to farmers, in particular resource-poor farmers, in order to increase food production and thus income by means of improved capacity of the extension agents. The extension agents are represented by the Central Administration for Agricultural Extension Services (CAAES) and the Agricultural Directorate (AD) at governorate level.

Due to the success of VERCON, the RADCON project has taken the project to a broader scale, by expanding the network with diversified content and a wider range of stakeholders, including farmers’ organisations, youth centres, universities, NGOs and the private sector, where a more participatory methodology was used by integrating Internet-based technology with local and community media to establish an interactive information system based on two main interlinked components of an online agricultural and rural development information and communication system and a wide network of focal groups and village facilitators, in seven governorates of Egypt.

RADCON now links service providers, research and extension services as well as the private and public sectors to the farmer at 50 different centres. It is in fact an innovative rural communication system, as extensive use is made of trained village facilitators who work with farmers in order to link rural communities and enable participation in the generating, developing and sharing of knowledge. Gender equality is recognised and at least one man and one woman per village are trained as facilitators (women make up 53% of the agricultural labour force in Egypt and it is vital that they be taken into consideration).
1. Project Description

Deloitte Consulting has been selected by eTransform Africa, a partnership between the World Bank (WB) and the African Development Bank (ADB), with the support of the African Union (AU) to produce a new flagship report on how information and communication technologies (ICTs), have the potential to change fundamental business models in the key African sectors.

Deloitte was selected to conduct a study that relates to the strategic application of ICTs in Africa with specific emphasis on the agricultural sector.

eTransform Africa intends to raise awareness and stimulate action among various stakeholders including African governments, development practitioners and private sector participants on how the use of certain ICTs can generate new opportunities in certain sectors with concomitant development of realistic implementation frames and sustainability measures.

A project initiation meeting was held with project representatives of Deloitte Consulting, the WB, the ADB, and the AU in February 2011 in Nairobi, Kenya. Subsequently a peer review meeting was held with various stakeholders in Johannesburg, South Africa in June 2011.

1.1. Objectives of the study

The main objective of the study is to take stock of emerging uses of ICT across sectors and of good practices in Africa and in other countries, including how ICTs are changing business models in the strategic sector of agriculture. This study will look at the contribution of ICTs to this information sensitive sector that is in many respects the backbone of African economy, that is agriculture, and how local ICT infrastructure, skills and technology are being harnessed for effective data processing, storage and dissemination of information for rural development.

Other associated objectives of the study are to:

- Identify key ICT applications that have had significant impact in Africa or elsewhere;
- Identify constraints that have a negative impact on ICT adoption and scaling-up of potentially effective models;
- Commission two country case studies in Namibia and Egypt, and use them as a guide for rolling out and scaling up key applications in Africa.
- Develop a common framework for providing support in ICT for development to countries that bring together the operations of the two Bank Groups and their respective departments in relation to the findings of the in-country studies.
1.2. Coverage of the studies

The study aims to cover the following:

- Identify specific opportunities and challenges in Africa that can possibly be addressed with an increased or better use of ICT. Constraints that are hindering ICT uptake and scale-up will be examined within the context of the agricultural sector, including human capacity in IT skills and sustainable business models such as for public private partnerships (PPP).
- Undertake a quick scan of ICT applications in the sectors and identify a few applications with significant impact in Africa or elsewhere and that have the potential of being scaled up.
- Analyse and understand the barriers to the greater adoption and mainstreaming of ICTs.
- Analyse and understand the enabling factors of success, including political economy, policy, institutional, human, financial and operational factors.
2. Introduction

Food security is one of the main concerns related to the future survival of individuals and families and ultimately this impacts on nations. Strengthening the agriculture sector is a crucial aspect of addressing this challenge. Today, governments around the world are finally recognizing that future food security is more uncertain than ever and are focusing on agriculture and taking the first steps towards long-term solutions.

The 1996 World Food Summit in Rome defined food security as existing “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (1). At the time, it seemed realistic to expect to halve the number of chronically undernourished people by 2015. This goal was at the heart of the Rome Declaration on World Food Security, and formed the basis of the first of the Millennium Development Goals.

The roots of today’s food insecurity go back 30 years, when investment in agriculture started to decline. In 1979, aid to agriculture was 18% of total assistance. By 2008, it was just 4.3%. In developing countries, government investment in agriculture also fell over this period, by one third in Africa and by as much as two thirds in Asia and Latin America (2).

In many developing countries, particularly low-income countries, decreased investment was accompanied by a policy vacuum. Governments dismantled older, costly instruments that had supported agriculture, but did not replace them with new, more effective ones. When global food prices soared in the period from September 2006 to June 2008, in many cases almost doubling, it became apparent that the world was facing a new era of uncertainty. Volatility returned again to some food commodities markets in 2010.

Given the future demand for food, the importance of the agriculture sector in serving this need and the importance of ICT in the development process, the conclusion is ipso facto that ICT will play an increasingly important role in the production, marketing and distribution of food in both developing and developed countries.

In addition, the world’s population is expected to rise from 6.7 to 9.1 billion by 2050, with most of the growth in developing countries.
Increasing population sizes create more demand for food, water and land at a time when agricultural land is being increasingly used for bio-fuel production. At the same time, climate change is expected to put millions more people at risk of hunger in the coming years. Africa has one of the largest proportions of arable land available in the world and hence production potential. Therefore, many nations are looking at Africa for the production of food. Countries like China and India have already started to acquire land in various countries to plan for future food shortages.

Since 2000, world market prices for agricultural goods have been increasing and are projected to do so going forward as the need for food and the production capacity globally is misaligned. It is also projected that the per capita food consumption will increase significantly - especially in countries such as India and China.

The final conclusion is that the supply and demand for agricultural products is likely to be out of kilter in future, placing agricultural producers in a strong position to attain higher prices for their products. Everyone in the agribusiness value chain should benefit from this trend.

<table>
<thead>
<tr>
<th>Fast facts - World Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are 925 million hungry people in the world.</td>
</tr>
<tr>
<td>The world population is expected to grow from 6.7 to 9.1 billion by 2050.</td>
</tr>
<tr>
<td>Food production will need to nearly double by 2050 in developing countries.</td>
</tr>
<tr>
<td>About 40% of the world’s arable land is degraded to some degree and will be further affected by climate change.</td>
</tr>
<tr>
<td>There are 500 million small farms in developing countries, supporting around 2 billion people.</td>
</tr>
<tr>
<td>GDP growth generated by agriculture is up to four times more effective in reducing poverty than growth generated by other sectors.</td>
</tr>
<tr>
<td>Development aid to agriculture was 4.3% in 2008, compared with 18% in 1979.</td>
</tr>
<tr>
<td>Poor people spend between 50% and 80% of their income on food.</td>
</tr>
</tbody>
</table>

Table 1 Fast facts about agriculture in Africa

2.1. Agriculture in Africa

Agriculture is the largest economic sector in most African countries and remains the best opportunity for economic growth and poverty alleviation on the continent, contributing about 17% to the Gross Domestic Product (GDP) and 40% to exports, besides creating employment. The agricultural sector has been described as the engine for economic growth and improved livelihoods in Africa.
2.2. Declining trend in food production amidst rising poverty

Sadly, the sector has been in decline over the past 40 years (5), and poor farmers have largely remained poor with 73% of the people living in rural areas subsisting on less than a dollar a day. 26% of Africa’s population is malnourished (4). In fact, Africa has the highest proportion of people living in extreme poverty in the world and is the only continent where food production has been falling. Reasons include collapsed agricultural development banks, corruption, inadequate infrastructure, and poor soils and seeds.

There are problems of underinvestment in rural areas, inadequate access to markets and unfair market conditions, inadequate access to advanced technologies, weak infrastructure, high production and transport costs, conflicts, HIV/AIDS, natural disasters, deforestation, environmental degradation, loss of biodiversity and dependency on foreign aid.

2.3. The predominance of small-scale agriculture in Africa

African agriculture is largely traditional and practiced by smallholders and pastoralists. It is predominantly rain-fed and low-yielding, with farmers being trapped in a cycle of poverty and food insecurity for decades. However, agriculture remains a very important economic sector in Africa not just because its contribution to GDP and employment, but also because of the multiplier effect it has on the economy, which ranges between 1.5 to 2.7% (6).

Small-scale agriculture and the harvesting of natural resources provide livelihoods for over 70% of the African population (4). For various reasons, some of which will be discussed in more detail below, most of those smallholders concentrate on subsistence farming, with low yields and relatively low excess production volumes available for large-scale trading (4 p. 90). This has resulted in large imports into many African countries, low food security levels and limited expendable income to rural households. Although large amounts of development funds have been donated by a number of leading development agencies with the objective to stimulate agricultural production and reduce poverty, most of those attempts have unfortunately failed.

Smallholder farmers lack access to critical information, market facilitation, and financial intermediation services.

2.4. ICT in agriculture

An ICT is any device, tool, or application that permits the collection, processing, storage or exchange of data. ICT is an umbrella term that includes the use of any device from mobile phones to ATMs.

Recent increases in ICT affordability, accessibility, and adaptability have resulted in their use even within impoverished rural homesteads relying on agriculture. New, small devices (such as multifunctional mobile
Many of the information needs that could improve smallholder livelihoods can be fulfilled with the effective and easy use of ICT. This report defines eAgriculture as the use of information and communication technology (ICT), such as computers, mobile phones, satellites, applications, information systems and digital platforms, to enable, support and enhance agricultural production. In particular it facilitates the collection and exchange of data and information between various stakeholders in the agriculture sector. These include: farmers, businesses selling products into the sector, such as seeds and fertilisers and businesses enabling the sale of agricultural produce to consumers, agriculture researchers and those structures within government that are directly involved with the agriculture sector. This report identifies mAgriculture as the subset of eAgriculture where mobile devices, including but not limited to mobile telephones, are involved.

2.5. ICTs for economic development

ICT is a key resource for economic development and growth as it can bridge the critical knowledge gap between stakeholders. However, though ICTs are used widely in large-scale farms and the commercial sector, relatively little attention has been paid to deploying ICTs for small-scale farmers and the associated upstream and downstream actors. ICTs could help small-scale farmers and other associated communities in Africa address some of the issues and challenges they face and enhance communication and delivery of critical knowledge, information and services.

2.6. ICT as a means for addressing small-scale farmers’ problems

In the developing world in general, including in Africa, the main issues indicating a greater need of ICT include, though are not limited to, the following:

- **Marketing**: Small-scale farmers have little experience in marketing of their produce. ICTs represent not only a medium through which they can be taught marketing skills but could also provide new channels through which information can be accessed and disseminated.

- **Knowledge creation**: Although research, civil society, government and the private sector have developed innovative technologies and best practices to modernize small-scale agriculture, most of these do not reach the intended beneficiaries. Traditional systems have proved to be inefficient, and most institutions have inadequate processes and capacity to share and disseminate outputs widely to small-scale farmers and other actors. ICT can be used to improve this situation.
2.7. Communication infrastructure in Africa

ICT is critical in modern-day transactions, but Africa lags behind in this area. Fixed-line and mobile communications density are about 13% and 64% of the averages in other developing regions, respectively. International calls cost four times as much as those of other developing regions, while Internet dial-up service is two and a half times that of other developing regions. Overall generation capacity of electricity in Africa is 37MW (megawatt) per million people, which is only 11% of the other developing regions’ average. Power tariffs are high in Africa compared with other developing regions\(^6\).

2.8. Mobile communication technology in agriculture

![Graph](image)

Figure 1 ICT Penetration Rates in Recent Times 2000-2010\(^7\)

Mobile technologies are becoming an increasingly important way to connect rural and isolated communities. In fact the mobile phone penetration rates are outstripping those for internet users, fixed phone lines and broadband subscriptions (see Figure 1\(^7\)).
An important trend to observe is the rate of cellular subscription increase in developing countries. Figure 2 indicates that the number of mobile subscriptions have gone from approximately 250 million in 2000 to almost 4 billion in 2010 (8). The rate of penetration is astounding and has brought with it several innovations and opportunities for mobile applications.

Users can use mobile phones for various activities such as mobile banking, selling products, and to gain access to market data and commodity prices. Many other services such as health services, extension services and general information sharing are now possible via mobile devices.

The role of mobile communication technology alone has the potential to transform the rural agricultural landscape in manners that will enhance productivity, data sharing and market access. There are a number of benefits that need mentioning and these include:

- **Access.** Mobile wireless networks are expanding as technical and financial innovations widen coverage to more areas.

- **Affordability.** Prepaid connectivity and inexpensive devices, often available second hand, make mobile phones far cheaper than alternatives.

- **Appliances.** Mobile phones are constantly increasing in sophistication and ease of use. Innovations arrive through traditional trickle-down effects from expensive models but have also been directed at the less expensive phones.
• **Applications.** Applications and services using mobile phones range from simple text messaging services to increasingly advanced software applications that provide both livelihood improvements and real-time public services. In the agricultural sector these include price information, market links, extension and support and distribution, logistics and traceability (9).

Through this expansion process, formerly costly technologies quickly become everyday tools for the man in the street. Additional opportunities for more frequent and reliable information sharing will open as technological advances lead to additional convergence between mobile phones and the Internet, GPS, laptops, software, and other ICTs.

### 2.9. Information and services exchange among stakeholder groups

Four main groups of stakeholders in the agriculture sector have been identified each of which includes several different subgroups. These are:

- Businesses including: associations; and other organisations.
- Farmers including: individuals, organised and unorganised associations.
- Researchers including: educators; and Trainers.
- Governments including: Ministry of Agriculture; Departments; and Parastatals.

Table 2 shows the type of information and services that different groups of stakeholders exchange with one another. This information exchange can be facilitated using ICT.

<table>
<thead>
<tr>
<th>Businesses (B)</th>
<th>Farmers (F)</th>
<th>Researchers (R)</th>
<th>Government (G)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(B)</strong></td>
<td><strong>B2B</strong></td>
<td><strong>B2F</strong></td>
<td><strong>B2G</strong></td>
</tr>
<tr>
<td></td>
<td>B2F</td>
<td>B2R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demand, market trends, possibilities of new products, quality requirements;</td>
<td>Employment-related information;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevailing products prices;</td>
<td>Facilitating internships and training for skills development;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Virtual markets that link producers and consumers.</td>
<td>Forecasting skills requirements and skills availability.</td>
<td></td>
</tr>
<tr>
<td>Businesses (B)</td>
<td>Farmers (F)</td>
<td>Researchers (R)</td>
<td>Government (G)</td>
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<td>---------------</td>
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</tr>
<tr>
<td><strong>(F)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• F2B</td>
<td>• F2F</td>
<td>• F2R</td>
<td>• F2G</td>
</tr>
<tr>
<td>• Crop forecast estimates from the fields;</td>
<td>• Crop forecast and yield data for import/export forecasting;</td>
<td>• Crop forecast and yield data for import/export forecasting;</td>
<td>• Crop forecast and yield data for import/export forecasting;</td>
</tr>
<tr>
<td>• Extension requirements, e.g. loans, insurance, fertilizers and subsidies.</td>
<td>• Skilling and re-skilling requirements of farmers;</td>
<td>• Advocacy regarding what government should supply.</td>
<td>• Advocacy regarding what government should supply.</td>
</tr>
<tr>
<td><strong>(R)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• R2B</td>
<td>• R2F</td>
<td>• R2R</td>
<td>• R2G</td>
</tr>
<tr>
<td>• Research findings and important new research areas;</td>
<td>• Information on problems encountered during stages of the cropping cycle and how to solve those problems;</td>
<td>• International trends and practices assist government to re-define policy elements;</td>
<td>• International trends and practices assist government to re-define policy elements;</td>
</tr>
<tr>
<td>• Product and market information informed decision making.</td>
<td>• Market intelligence to inform farmers' decision making;</td>
<td>• Sharing market intelligence and scientific research to facilitate sector development policy decisions.</td>
<td>• Sharing market intelligence and scientific research to facilitate sector development policy decisions.</td>
</tr>
<tr>
<td></td>
<td>• R2F</td>
<td>• R2R</td>
<td></td>
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<td></td>
<td>• R2R</td>
<td>• R2G</td>
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</tr>
<tr>
<td></td>
<td>• R2G</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• New varieties, fertilizers, soil-treatment and pre and post-harvest technologies;</td>
<td>• Interaction between farmers and researchers;</td>
<td>• Interaction between farmers and researchers;</td>
</tr>
<tr>
<td></td>
<td>• Interaction between farmers and researchers;</td>
<td>• ICT-based educational.</td>
<td>• ICT-based educational.</td>
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<td></td>
<td>• ICT-based educational.</td>
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</tbody>
</table>
Table 2: Mutual Information and Services Requirement among Stakeholder Groups

<table>
<thead>
<tr>
<th></th>
<th>Businesses (B)</th>
<th>Farmers (F)</th>
<th>Researchers (R)</th>
<th>Government (G)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(G)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G2B</strong></td>
<td>Information and applications for licenses, subsidies, tax breaks and incentives in establishing new markets and products;</td>
<td>Schemes, subsidies, loan processing, insurance and other extension services;</td>
<td>Schemes and subsidies for research promotion and priority areas for research;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advocacy;</td>
<td>Early warnings and weather forecasts.</td>
<td>Data for researchers and links between researchers and other stakeholders;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Schemes and subsidies;</td>
<td>Facilitation of links with appropriate ministries and departments in other countries.</td>
<td>Single-window one-stop-shops to all services.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E-services offered for better implementation of schemes, plans and strategies.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G2F</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Schemes and subsidies for research promotion and priority areas for research;</td>
<td></td>
</tr>
<tr>
<td><strong>G2R</strong></td>
<td></td>
<td></td>
<td>Data for researchers and links between researchers and other stakeholders;</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Single-window one-stop-shops to all services.</td>
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<tr>
<td><strong>G2G</strong></td>
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</tbody>
</table>

2.10. ICT in the farming cycle

From a farmer's perspective, the cropping cycle typically goes through three stages:

- **Pre-cultivation**, including crop selection, land selection, calendar definition, access to credit, etc.
- **Crop cultivation and harvesting**, including land preparation and sowing, input management, water management and fertilization, pest management, etc.
- **Post-harvest**, including marketing, transportation, packaging, food processing, etc.
Figure 3 Information and Services Requirements for Different Stages of Crop Lifecycle

Figure 3 is a snapshot of possible ICT solutions that could be used for each of these stages.

2.11. Conclusion

The agriculture sector plays an extremely important role in the world economy but its importance in terms of food security is even more important as it relates to the future survival of people and nations. Strengthening the agriculture sector is, therefore, of universal interest. It is arguably the oldest economic sector in existence.

Information and communication technologies by contrast make up the newest economic sector and the technologies are developing at a rate not experienced with any previous form of technology. This ever-changing set of tools, coupled with the decreasing price of ICT, has had an impact on almost every aspect of life for a high percentage of the world’s population. Mobile phones in particular are rapidly becoming accepted as essential even for people who live in remote, traditional areas and own very little.
Africa is by no means a homogeneous set of countries and even though the agriculture sector as a whole has general common interests the specific contexts where ICT is used will have a major effect on how it should be introduced and for what purpose. This report examines how the two fields of interest, namely agriculture and ICT, can be brought together in various ways in Africa and what aspects of context need to be taken into account. The ICTs of the 21st century have already been seen to have great potential to address many of the communication, information and even social needs of a wide variety of stakeholders in the agriculture sector, but have predominantly been implemented in the more established economies and the commercial farming component of the African agriculture sector.

Having provided background information regarding the current conditions in Africa in terms of the challenges that face agriculture and the diffusion of ICT, in the chapters that follow, this report sets out to learn valuable lessons from cases where the use of ICT in agriculture has been successful. Relevant information in this regard has been sought from existing programmes and projects in a variety of countries and contexts. Information regarding best practice but also challenges, constraints and barriers will be presented not only relating to small scale farming and cases where community members collaborate in ICT for agriculture initiatives, but also where the technology has been introduced in commercial farming. The intention is to develop guidelines on designing appropriate and sustainable ICT components for agriculture sector projects and on evaluating the impact of these interventions.
3. Landscape Analysis

3.1. Introduction

eAgriculture is a fairly new phenomenon but already has had some notable successes resulting in significant improvements in the agricultural value chain and benefitting various stakeholders. Its value cannot be contested as it includes the application of ICT in obtaining market price information, minimizing the impact of price volatility on farmers of smallholdings, assisting various stakeholders to make informed decisions and generally improving food production as is essential to combat the growing global economic and food crisis.

This chapter starts off by giving brief descriptions of some recent success stories of ICT use in agriculture. After that more general categories are presented in which some trends are noted without giving specific examples. Finally somewhat more detailed sample case studies from developing countries are included, focusing on areas that have a significant impact on the agricultural process. As this study relates to Africa and mobile technology has been highlighted as a specific means to provide access to ICT solutions, two examples of the use of mobile technology (mAgriculture) are specifically included in this chapter as the first two of the longer descriptions. These are: Initiative by GSMA to use mobile technologies and Agricultural Commodity Exchange Index - Esoko. Traceability is studied by looking at the case “Remote tracking solutions among the coffee growers of Costa Rica and Mexico”. Agriculture insurance is discussed and a detailed description of one case, Kilimo Salama, is given in Annexure A, section 8.3). Community Information Centres in Bhutan are described.
### 3.2. Selected success stories from ICT in the agriculture sector

In this section we touch upon some recent success stories of ICT use in agriculture. Table 3 describes a few success stories categorised according to the type of ICT application in them \(^{(9)}\). Some of these are covered in greater detail in the following section.

<table>
<thead>
<tr>
<th>Use to which ICT has been put</th>
<th>Objective</th>
<th>Case Studies/ Success Stories</th>
</tr>
</thead>
</table>
| Access To Market Information | To help farmers find out about market prices. This helps them make decisions regarding when to harvest, how to negotiate with intermediaries, and so on. Often combined with other information such as weather forecasts. | • Esoko (various countries in sub-Saharan Africa)  
• e-Choupal and Reuters Market Light (India)  
• Manobi (Senegal)  
• Infotrade (Uganda)  
• Zambian National Farmers Union MIS (Zambia) |
| Distribution and Supply Chain Management and Traceability | To increase efficiency and predictability, reduce spoilage, and more. To record movements along the value chain, respond to quality standard requirements, and help large buyers track, manage, pay, and reward small producers. | • Application across dairy sector (Kenya)  
• Dunavant Cotton (Zambia)  
• Infosys system for horticulture (India)  
• EJAB (Bangladesh)  
• SourceTrace (Costa Rica, Mexico) |
| Farm Extension Services, Access to Sector Experience, Research, and Other Resource Information | Using ICT to deliver better farm extension services (utilisation of best agriculture practices, research, weather, climate and more). | • Grameen AppLab Community Knowledge Workers (Uganda)  
• Farmer Voice Radio Project (Kenya)  
• IFFCO/Kassan Sanchar (India)  
• Radio (Mali and many others in Africa) |
| Commodity Exchanges/ Warehouse Receipt Systems | To provide transparency in price discovery and to facilitate better prices and efficiencies between buyers and sellers. It avoids moving crops themselves, reducing spoilage, transportation, and transaction costs. Exercises temporal and spatial arbitrage. | • Ethiopia Commodity Exchange (ECX)  
• Uganda Commodity Exchange (warehouse receipt system)  
• Zambian Commodity Exchange (ZAMACE)  
• SAFEX (South Africa) |

Table 3 Selected Success Stories from ICT in Agriculture across the World \(^{(9)}\).
3.3. A common platform for agriculture stakeholders

As noted in Chapter 2, there are a number of different role players in the agriculture sector and they participate at different times in the value chain and crop life cycle. These include: farmers, businesses selling products into the sector, such as seeds and fertilisers, and businesses enabling the sale of agricultural produce to consumers, agriculture researchers and those structures within government that are directly involved with the agriculture sector. The stakeholders and their activities and associated information requirements were shown in Table 2 of Chapter 2 (Mutual Information and Services Requirement among Stakeholder Groups) and Figure 3 of Chapter 2 (Information and Services Requirements for Different Stages of Crop Lifecycle).

It is advantageous if a single, integrated information system can be used for all the stakeholders and drawing from a single repository of shared data as this ensures that the data is not duplicated in various separate systems and will be consistent. Such systems will, therefore, be multifunctional and address a variety of requirements but the interface between system and individual user can be customized to his or her particular needs. That is, those functions, reports and even data sets that an individual user does not need can be hidden so that each user interacts with a relatively simple system. The fact that a single version of the data is maintained improves its integrity but also reduces costs related to maintaining it. The use of such a common platform also means that individual users do not need to learn how to use different systems when they need different types of information. DrumNet is a good example of such a system but the detail discussion on this case is only given in Annexure A.

3.4. Multi-stakeholder eAgriculture knowledge sharing in Africa

Research is generally defined as searching for information that can be used to build new knowledge. In this section a more practice-oriented definition will be used to encompass activities where a researcher can assist or form partnerships with others involved in agricultural practice in order to find information or to analyse data further in order to make it immediately useful, to allow well-informed decision making and to reveal patterns and relationships in the data that could not be found without the use of ICT, software and fast and accurate processing. The various types of knowledge sharing noted below under Technology are widely available worldwide and no specific programmes or projects will be referred to.

Information and communication technologies, including the Internet, are directly relevant to all stakeholders in the agriculture sector as they allow everyone to access research reports and publications and partner with formal, scientific researchers. Multi-stakeholder research partnerships (also referred to as the participatory knowledge quadrangle of farmers, extension professionals, educators and scientists) have many benefits as they emphasize relevance in research, can reduce the time required to complete research, and improve the efficiency and effectiveness of the research process.
A. ICTs for multi-dimensional decision making

ICTs, such as decision-support systems and geographical information systems, can be utilised by researchers who are supporting farmers’ decision making as these tools can amplify results, accelerate the process and improve precision. Since multi-dimensional decision making, which integrates water, nutrient, pest and disease management and weather forecasting information, can be quite challenging, a software (ICT) tool that assists the end user is valuable.

B. ICT infrastructure to connect the knowledge quadrangle of farmers, extension professionals, educators and scientists

As noted previously, there must be vastly improved access to ICT in Africa to reach the unreached. Increased investments in communications and knowledge infrastructure are required to enable access to the Internet, libraries and information centres for the participatory knowledge quadrangle of farmers, extension professionals, educators and scientists. Such investments will provide them with access to the resources of currently available databases and other information. Collaborative research, including what research needs to be undertaken, the collection of data in the field, access to and application of the results can be facilitated using technology. An example is the four international research centres making up the Consultative Group for International Agricultural Research who actively sought participation from governments, funders, extension officers, researchers and the private sector \(^{(11)}\). Web-based tools can be used to facilitate research collaboration and to make data and information accessible to all interested parties \(^{(11)}\).

C. Entities/individuals lacking fast and affordable internet access

Institutions and individuals lacking fast and affordable access to the Internet can make use of CD-based information sets such as the Essential Electronic Agricultural Library \(^{(10)}\). The Essential Electronic Agricultural Library (TEEAL) is a full-text and searchable database of articles from 200 high-quality research journals in agriculture and related sciences spanning several years. TEEAL has been improving access at institutions with limited Internet time and/or financial resources. It is a searchable, offline, digital library which contains mainly agriculturally focused reference journals updated annually and delivered on the 1TB hard drive by Cornell University’s Mann Library. This non-profit digital library includes some of the most prestigious full-text agriculture journals that leading publishers have gifted to TEEAL users (see www.teeal.org).

D. Multi-channel information delivery

Several international service providers have developed online databases on agricultural technologies based on geographical or local conditions. To be effective in the African context, a diversity of channel and communication tools with a strong people focus should be introduced.
E. ICTs for spatial analysis and targeting of programmes

Spatial information allows analysts to view the distribution of income and other types of data across a country as a map in order to target areas for action, understand demographic trends, and monitor progress. Spatial information collected by satellite or airborne remote sensing can be used to understand the capability of the land to support economic activity and water use efficiency. This information can help ensure that natural resources are used efficiently and sustainably.

ICTs for better risk management

New technologies are being developed that provide more accurate and timely estimation of risk. Spatial information about fire, rainfall, wind, and salinity may help countries identify and estimate risk more accurately.

F. ICTs and financial services for the farmer

ICTs in universal access to financial services should not merely be limited to the access, but take into account the process and the end usage. ICT can be used for land records, future price discovery, market intelligence, and agricultural database management, e-banking, mobile-based payment, etc. New delivery technologies like ATM, digital cash, mobile banking, etc., can make microfinance reach until the last mile.

G. ICTs and information gaps

Farmers have little information on the kinds of crops they should grow, how they should grow the crops, what planning they need to do with respect to their area and soil conditions, and what the market dynamics are, etc. Other gaps include the credit gap, productivity gap, marketing gap, price realisation gap, and infrastructure gap, etc. Barring the infrastructure gap, all the above-mentioned gaps can be dealt with to an extent by using ICTs. It has been found that in developing countries information that is obtained from, or applies specifically to the local environment is valued much more than information about more distant happenings. Attention needs to be given to local information needs and conditions and this means that information provision can be costly and difficult to scale up.

H. eEducation

There is significant web-based distance education and video conferencing available that is relevant to stakeholders in the agriculture sector and which can complement and supplement courses given in African universities and vocational colleges.

I. Virtual aggregation of small stakeholders

Virtual aggregation of small stakeholders (producers) across multiple geographies, to get the power of scale, is possible through the use of ICT. Real-time multicasting, customisation of information, and
personalisation of content on the basis of knowledge of who is logging in and who is participating, can be done through ICTs.

3.5. The role of mobile technology in eAgriculture

The most prominent form of mobile technology, namely mobile phones, and its penetration in Africa was discussed in the previous chapter. It is important to note, however, that this is not the only form of mobile technology that is of interest to agriculture. Numerous other devices with more specific purposes exist, such as smart cards and RFID tags used to store data and as scanners used to read and capture particular forms of data (barcode scanners, RFID readers and smart card readers). GPS systems have a specific purpose relating to pinpointing geographical location. Other components are essential to complement the input and output devices and these include the Internet, communication networks and regulatory systems to provide data security, standard systems for codes.

According to the Mobile Applications for Agriculture and Rural Development report commissioned by the World Bank, “The largest number of mobile applications for agricultural and rural development (m-ARD apps) involve improving supply chain integration and likely have the greatest impact on agricultural and rural development.” (9 p. 14)

Initiative by GSMA to use mobile technologies

History and funding

The GSMA, (11) the body that represents the interests of mobile operators world-wide, recently announced the launch of the mFarmer Initiative Fund, supported by a grant from the Bill and Melinda Gates Foundation. Through the mFarmer Initiative Fund, the GSMA Development Fund’s mAgri Programme will accelerate the provision of high-quality agricultural information services through mobile channels, and by 2013 the initiative aims to provide two million farmers in developing countries with an invaluable and transformative business resource. The GSMA Development Fund accelerates economic, environmental and social evolution through mobile technology. Within the Development Fund, the mAgri programme exists to catalyse the deployment of mobile solutions benefiting the agriculture sector.

Eligible projects can qualify for funding on successful demonstration of the following criteria:

- The project will directly result in significantly increased access to affordable agricultural information and advisory services by smallholder farmers who are living on under US$2 per day;
- The agricultural information and advisory services will provide information and advice of sufficient relevance, range and quality to be of utility to smallholder farmers;
- The project will involve a commercial business model for the provision of agricultural information and advisory services that will be sustainable after the period of grant funding;
- The project will demonstrate how it will provide equitable access to female smallholder farmers.
Purpose

The mFarmer Initiative Fund is designed to:

- Stimulate the development of mobile phone-enabled agriculture information and advisory services that are commercially sustainable;
- Build services that impact farmers' income and productivity;
- Reduce the barriers for operators to launch and improve mFarmer Services;
- Test and prove models for delivering agricultural information services via mobile phones;
- Promote a culture of knowledge sharing in the mFarmer ecosystem.

Operation

The mFarmer Initiative Fund will support projects implemented in South Asia (India) and sub-Saharan Africa (Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Nigeria, Rwanda, Tanzania, Uganda and Zambia). Whilst these are the target countries for disbursements, the mFarmer initiative has the wider scope of sharing learnings with the mFarmer ecosystem. Disbursement decisions will be made on a competitive, deadline-driven basis by an independent assessment panel. Grant recipients will have access to relevant agricultural information via an on-line database. Technical assistance will be provided to support the design and implementation of projects.

Technology

The fund will encourage mobile communications service providers, in partnership with other public and private sector agriculture organisations, to use mobile communications to provide information and advisory services to smallholder farmers in developing countries.

Projects eligible for funding must include the use of the mobile communications channel as a significant element of its delivery model.

Developers

To date, the focus has been on engagement with mobile operators and their partners to prove the market opportunity of agricultural extension services through mobiles to smallholder farmers and to understand which business models are most suitable.

Projects eligible for funding must involve a mobile communications service provider in partnership or consortium with one or more organisations that are using, or planning to use, mobile communications to provide agricultural information and advice to poor smallholder farmers.
Agricultural Commodity Exchange Index - Esoko in Ghana

Purpose

Ghana has launched an agricultural commodity index that tracks the prices of selected agricultural products across the country. The Esoko Ghana Commodity Index (EGCI) is a rural communication platform that publishes a cash market price index composed of data on physical commodities. The index, which is published weekly, tracks prices at wholesale and retail levels.

Esoko seeks to improve incomes by building healthy markets. Any individual, business or producer group can set up Esoko to better manage their marketing, distribution and procurement networks. Currently Esoko is active in ten countries throughout Africa with different partnership agreements which include public sector agricultural projects, Esoko country franchises and licensed partners. Esoko provides a complementary partner support programme which is focused on capacity building and financial sustainability, with an emphasis on market data enumeration and business development services.

Results demonstrate that farmers are able to improve revenues by negotiating better prices, or selecting more favourable markets for their produce. Traders can procure product more quickly and at better prices for everyone.

Operation

Esoko enables consumers to request services by texting through short messaging service (SMS) codes.

There are four key services provided by the platform. Donovan\(^{(14)}\) describes these as follows:

- **“Live market feeds: real-time SMS alerts on market prices and offers that are automatically delivered to subscribers. Users can submit offers into the system directly using SMS.”**
- **Direct SMS marketing: businesses can target specific groups of users and target procurement or extension messages to reduce their travel and communication costs.**
- **Scout polling: enterprises can set up automatic SMS polling for field activities to track inventories, crop activities, etc. to monitor and report on crop cycles and yields.**
- **Online profiling and marketing: any user or business gets a customizable web space that can advertise their goods and services. This space can be updated using Esoko’s mobile-to-web content management service”**\(^{(14}\text{ p. 59})\).

In the absence of a proper warehouse receipt system and a regulatory framework that would support the operation of a commodity exchange in Ghana, the system has established a network of enumeration agents stationed in market centres. These agents feed Esoko with critical data like prices, offers and industry profiles. Markets were selected based on their regional location and strategic importance.
Technology

The updates for farmers and traders are delivered by SMS. Recognizing the explosive growth of cellular services in Africa, Esoko makes use of both web and mobile devices to push and pull market information from the field.

History and awards

Esoko originated as TradeNet in 2005 as a private initiative and has partnered with USAID’s MISTOWA programme in West Africa and CIAT’s FoodNet programme in Uganda. Esoko was recognised by the United Nations as a World Summit Awards 2009 Winner for its work in creating unique content.

Developers

Esoko has a team of 20 technology developers located in Ghana who developed the software.

3.6. Traceability

The studies that follow have one particular feature in common, namely traceability. The International Organization for Standardization (ISO) defines traceability as the ability to trace the history, application or location of what is under consideration. In other words, traceability means the recording of information so that an item moving through a global supply chain can be tracked from its origin or source along the value chain. In the agriculture sector traceability is the forward and backward tracking of animals and food by paper or electronic means. Animal traceability, therefore, refers to the ability to follow an animal or group of animals during all stages of life – i.e. from birth to death. The EU General Food Law, Article 18 Regulation (EC) No 178/2002, defines traceability as “the ability to track food, feed, food-producing animal or substance intended to be, or expected to be used for these products at all of the stages of production, processing, and distribution” (12).

One reason for the increased emphasis on the traceability of agricultural production is that there is an increasing consumer demand for quality and food safety. As a result, exporters want to be able to trace production back to the specific farm from which it came in order to ensure quality and safe production and handling procedures. Although traceability is required so as to be able to respond to quality standard requirements it also helps large buyers track, manage, pay, and reward small producers.

Agricultural goods destined for international markets need to meet certification requirements guaranteeing the quality and identifying the source of the product. GLOBALGAP is a private sector body that sets voluntary standards for certification of agricultural products. All goods are checked for quality and exporters have to provide details of all who handled the product through the supply chain, from the farmer to the exporter and include transporters, traders and warehouses.
Remote tracking solutions among the coffee growers of Costa Rica and Mexico

Purpose

Coopetarrazú’s processing plant uses leading-edge technologies for coffee drying, hulling, sorting and shipping. Coopetarrazú’s operations go beyond processing, however. It must track hundreds of thousands of coffee purchases from its members during the harvest and ensure that purchases meet certification criteria (including CAFÉ Practices, Organic, Fair Trade, Rainforest Alliance) to fetch premium prices. For a technology solution that could meet these complex and divergent requirements, Coopetarrazú has operationalized source tracking solutions.

Operation

Traceability module

This powerful, flexible agricultural traceability solution allows the tracking of any agricultural value chain from the farm gate to the pack house via mobile phones, point-of-sale devices and other wireless units. Automating administrative tasks and data entry, the traceability module offers cooperatives significant time and cost savings.

Data from the traceability module provides up-to-the-minute visibility into a cooperative’s productivity, including crop quality issues in the field and yield rate, productivity and product characteristics by farm. Web-based reporting capabilities, accessible anywhere in the world, include real-time statistics by geographical area, crop quality, producer and farm. Coffee producers, for example, can trace variables such as ripeness, green, mixed, conventional or organic beans. The module also ensures complete financial transparency, provides visibility and reporting for all stakeholders and employs smart cards (optional) for security, accounting transparency and convenience.

Certification module

The certification module has a mission-critical role, reducing the time and costs of collecting farm-level data and generating reports for certifiers/verifiers who can access the information on their own websites. The consolidated customisable certification schema is configured to the internal agricultural monitoring processes of agricultural commodity firms, and covers major certifications such as Starbucks CAFÉ Practices, Organic, Fair Trade and Rainforest Alliance. The module includes digital documentation and necessary e-forms. Data are captured at the farm level, automating and streamlining complex data entry once performed at an agricultural commodity company’s offices, providing substantial cost savings.
Agricultural processing module

This processing module helps coffee companies by capturing key indicators and values needed to support marketing and sales negotiation processes, letting the coffee processor monitor the drying process remotely from anywhere in the world allowing the cooperative to detect and immediately correct operational or temperature problems during the drying process, and tracking all coffee lots processed by the dryers from the reception of the coffee to the cupping room and storage places.

Technology

The solution provider is also working with Coopetarrazú on incentive/loyalty programmes and smart cards to increase membership, retain present members and increase coffee deliveries within the co-op. They are currently developing a customised, web-based dashboard to provide visibility and analytics on metrics that are important to the co-op.

Mobile devices as well as GPS’s, RFID’s and barcode readers are used to capture and collect traceability data at the farm level. Data is transmitted through any available network to the central offices of the agricultural cooperative. Web-based reporting capabilities include real-time statistics.

History and awards

The farmer-owned enterprise has become a 2,600-member, $16 million-a-year operation \cite{13}.

The buying station module is reducing data error rates and data entry and analysis costs, while improving information analysis. Workers have become more productive and require less training and monitoring. The agricultural industrial module is improving real-time monitoring/analysis of Coopetarrazú’s mechanical drying process.
3.7. Agricultural insurance

In general, insurance is a form of risk management used to hedge against a contingent loss. The conventional definition is the equitable transfer of a risk of loss from one entity to another in exchange for a premium or a guaranteed and quantifiable small loss to prevent a large and possibly devastating loss.

Agricultural insurance is a special line of property insurance applied to agricultural firms. In recognition of the specialised nature of this type of insurance, insurance companies operating in the market either have dedicated agribusiness units or outsource the underwriting to agencies that specialise in it. Agricultural insurance is not limited to crop insurance, it also applies to livestock, bloodstock, forestry, aquaculture, and greenhouses.

Agricultural insurance in Africa

Crop insurance has long been used in developed countries to deal with weather uncertainties, but its availability in Africa, particularly to smallholder farmers, has been extremely limited. Agricultural insurance is particularly important in Africa today as the extreme weather patterns generated by climate change are introducing increasing volatility to food production and food prices.

In the ‘South African Insurance Industry Forecast to 2013’ by RNCOS Industry Research Solutions, 70% of the current African insurance market is said to be in South Africa (14). The figures demonstrate the potential of the insurance market on the continent. The industry however faces major challenges, according to the African Insurance Organisation, including underdeveloped insurance organisations, a weak insurance regulatory environment, need for expertise in the sector, and lack of ICT infrastructure (15).

Despite the challenges, micro-insurance or insurance for low-income people is drawing attention. The MicroInsurance Centre estimates only 4% of Africans and less than 1% of poor Africans are covered by micro-insurance (15). Major insurance companies like AIG, Zurich, and Swiss Re have entered the market. AIG was the first major player to enter micro-insurance in Africa, partnering a local microfinance institution in Uganda in the 1990s. This increasing interest will naturally lead to opportunities for the ICT industry. For example, the International Livestock Research Institute (ILRI) has developed satellite technology to assess weather conditions, such as drought patterns, which could lead to livestock deaths (19). This technology will help insurance agencies to calculate risk.

Examples of ICT-enabled agricultural insurance are: Kilimo Salama (which is discussed in detail in Annexure A, section 8.3); Mongolia has an Index-Based Livestock Insurance (IBLI); Mexico has small farmer mutual crop and livestock insurance through the “Fondos de Aseguramiento” (Self Insurance Funds, SIFs) programme; Agrinsure Botswana is a joint venture effort between South Africa’s Farmers Technical Insurance Services Company (FTISC) and Alexander Forbes Botswana and is the first to offer agricultural insurance products in Botswana covering both livestock and crops. The crop insurance programme being run in India is the largest in the world. The Agriculture Insurance Company of India Ltd (AIC) has tailored its programmes to the specific requirements of its targeted stakeholders and uses the latest techniques like remote sensing to estimate crop yield.
Challenges for ICT in agricultural insurance

Challenges in providing agricultural insurance include the following:

- There is generally a very low level of awareness and education among those for whom this insurance is targeted;
- Being remote areas, documents required for certification like age-proofs, death certificates and the like are often not readily available and it takes time for these to be obtained;
- Common insurance products which work in urban areas are often not completely suitable for rural areas. Significant product customisation is required for pricing, payment options and simplicity;
- A change in mind set is required to be brought about from “willingness to pay” for services obtained to “willingness to charge” approach for eventualities that could happen;
- More often than not, with no direct access and poor banking infrastructure, premium routing is often found to be a bottleneck;
- Unless some minimum volumes are acquired remuneration of expenses for distribution and servicing is generally very high owing to factors of remoteness.

Role of ICT in insurance

ICTs could be used at least in the following ways:

- to facilitate access to information and services to stakeholders;
- to provide advance information about weather and market price situation;
- to provide better services and facilitate speedy claim servicing;
- to monitor and track premium repayment;
- to ensure better interface between the insurer and the insured, particularly field based transactions;
- to bring improvements and change through the use of complaints & feedback;
- to use developed databases and analysis of collected information to develop specialised and affordable rural insurance products.
3.8. ICT in agriculture/rural development: community information centres in Bhutan

Background

Bhutan is located in the Eastern Himalayas, a small land-locked country with a mountainous terrain, and has an economy that is based on agriculture and forestry, which provide the livelihood for more than 60% of the population. Agriculture consists largely of subsistence farming and animal husbandry. Population below poverty line is 23.2% and the literacy rate in Bhutan is 59.5% \(^{(17)}\). Internet usage in Bhutan has seen significant increase with about 13.6 % now having internet access \(^{(18)}\). Bhutan’s fixed line penetration stands at 12.2% in urban settings and a mere 4.9% in rural areas \(^{(19)}\).

Challenges in connecting communities

Bhutan’s mountainous, forested terrain has made wired Internet and telephone connectivity prohibitively expensive for operators and end users. Some villages are so remote that only locals can understand the market conditions \(^{(20)}\). Bhutan’s national media (particularly its newspapers) are weak, and rural service users are likely to have higher levels of trust in local business managers. The settlement of people in the high mountainous region is scattered and population is sparsely distributed. Repair and maintenance of remote infrastructure/stations is difficult too. Unstable commercial electric power supply in rural and isolated areas adds to the high deployment costs. There is also a shortage of technology knowhow and skilled personnel.

Community Information Centres

Bhutan’s Department of Information Technology (DIT) has established a series of Community Information Centres (CICs) to provide sustainable, commercially viable ICT services in rural areas. DIT provides the equipment, and the local community provides an individual who is employed to promote and maintain those services. Services available at the CICs include basic and advanced computer training, non-Internet-based games, digital reproduction, Internet, telephone facilities, government information and forms, and lamination and scanning.

Hub and spoke network

The Government of Bhutan plans to provide a hub-and-spoke network, enabling it to overcome difficulties with placing infrastructure in mountainous and remote terrain. It seeks to provide a network of broadband connection through fibre-optic cables from the capital and out to the 20 districts (dzongkhag) and village groups (gewog). The connection from districts to village groups and on to the villages will be provided by wireless technologies such as GSM. These “spokes” lead to the CICs \(^{(15),(20)}\).
**Benefits to rural development/agriculture**

Broadband connectivity brings high-end services closer to the rural population and helps in reducing poverty. The travelling time and cost for villagers/farmers is reduced even as employment opportunity is generated for rural people. The CICs serve as one stop shop for accessing information and also serve as vehicles for training rural people on ICT.

**Scaling up plans for ICT**

- CICs can be equipped to provide telemedicine, distance education, news distribution, government services, and business opportunities
- The usage of ICT will benefit rural population, as land/forest/crop related information is integrated in one-stop-service. The features of online services should be upgraded to be available on basic mobile phones that are cheaply available in market.
- To run the ICT equipment in remote locations, a major challenge will be the availability of electricity. More emphasis could be given to solar power solutions.
- Focus could be shifted on setting up of more and more VSAT stations in remote locations.
- However, central intervention will be necessary to subsidize the high costs of accessing some rural areas, which is crucial if telecommunications are to reach the population at large. The partnership between local players and government strikes a favourable balance.

**Reasons for success**

- A key factor enabling the development of CICs is that they receive strong government support and are government led, though self-regulating. As long as local managers produce a profit and offer the services detailed in the government guidelines, they are free to operate their CICs as they see fit.
- The affordability cost for ICT in Bhutan has fallen by 75.4 % (18). This made ICT services affordable to a significant segment of the population.
- CICs provide all basic services required by citizens. For rural/illiterate population, helpers assist in operating the systems. Almost all the locations at Gewogs (block level) have been connected.
3.9. Conclusion

Sharing information among farmers is not a new practice. In the developed nations where connectivity is readily available and relatively cheap, the use of communications technologies to share best practices, market information, business efficiencies, climatology information and other related information has become the norm. With the growing adoption of social media and other open information sources in these countries, this is even more the case than before.

For developing nations, where connectivity is often not as widely available and is expensive in comparison to that of their developed counterparts, innovative approaches and measures designed to overcome these challenges are key.

The cases described in this section had many features in common. They were largely intended to assist smallholder farmers, the provided many services including those mentioned in Table 4, Chapter 4, namely, access to market information; distribution and supply chain management including traceability; farm extension services, access to sector experience, research, and other resource information and commodity exchanges/warehouse receipt systems. Hence it might be useful to refer back to that table to find references other similar projects and programmes not discussed here if more examples are needed.

Many of the same features will also be seen to be present in the cases which will be discussed in greater detail in the next chapter, the Africa Scan. Specific success factors and risks have not been identified in this chapter but will be noted in the subsequent discussions. Technologies that became evident as frequently used are mobile phones and web-based services.
4. African Scan

In this chapter we present only a short summary of the different case studies that reflect the use of ICT in Agriculture (eAgriculture) and allied domains like rural development. These are discussed in much great detail in Annexure A.

In the selection of the case studies and the content of this chapter the following were considered: (a) ensuring all important aspects that have a bearing on information, services and knowledge provision to stakeholders are covered; and (b) representation of prominent examples from where important lessons could be learned, specifically focusing on areas where these experiences are either replicated or comparable circumstances arise in other contexts, are included. Figure 6 has been used as the basis for the selection of case studies.

4.1. Framework used for selection of case studies

Coverage of the ICT in the Agriculture landscape can be conceptualised as comprising (a) all functional aspects of Agriculture, for example, forestry and the like), and (b) all support aspects that help the realisation of the functions.

Figure 3 in Chapter 2 referred to the cropping cycle (or farming cycle) and the functional aspect could be further broken down into different stages as follows:

- Pre-cultivation, including crop selection, land selection, calendar definition, credit, etc.
- Crop cultivation and harvesting, including land preparation and sowing, input management, water and fertilization, pest management, etc.
- Post-harvest, including marketing, transportation, packaging, food processing, etc.
Support aspects for ICT in agriculture would, similarly, consist of the following areas:

- Policy, encompassing policy pronouncements and strategies;
- Access, including availability of ICT infrastructure and channels/devices of communication;
- Content, comprising production of information and services over appropriate ICT platforms;
- Capability, reflecting capacity with which to avail information and services.

Figure 6 illustrates this framework in totality. Further, case studies have been chosen in such a way that each of the seven different categories are covered, with at least one case study that is representative of the situation.
Figure 6 Coverage of Case Studies for Africa Scan
Table 4 provides a concise summary of the case studies analysed. Two extracted cases are dealt with below.

4.2. Using ICT to bring together multiple stakeholders in the Kenyan agriculture sector – DrumNet

DrumNet, a project of Pride Africa, offers support services to smallholder farmers in Kenya by providing access to information, financial services, and markets. It addresses the need for access to markets using information technology, efficient business processes, and economies of scale. Launched in 2002, it combines information, commodity transaction services, and financial linkages into a single business service model that provides access to markets, market information, and credit for the rural poor to support sustainable agriculture and rural development.

Background

Though the impressive growth in Kenya’s horticultural sector has undoubtedly contributed to increased rural incomes and reduced rural poverty, exports remained a small fraction of the overall horticultural sector. Until recently over 90% of all fruit and vegetable production was for domestic use. While over 90% of smallholder farmers in all but the arid regions of Kenya produce horticultural products, fewer than 2% did so directly for export (21).

![The DrumNet Process](image)
DrumNet as a solution

DrumNet tries to overcome the lack of information flows by directly linking commercial banks, smallholder farmers, and retail providers of farm inputs through a cashless microcredit program. DrumNet encourages production of export oriented crops even as it ensures that farmers meet the quality standards. DrumNet members, organized into co-guaranteed solidarity groups, are able to access required farm inputs (seeds, fertilizers, pesticides, etc) at local participating stockists (input suppliers) through an established line of credit using their DrumNet transaction card.

DrumNet operation

The stockists, trained in basic DrumNet record keeping, submit receipts to DrumNet and are paid in two-week cycles from a credit account maintained by DrumNet. DrumNet clients are required to sell their produce to DrumNet at harvest time. DrumNet organizes the pick-up of the produce and deducts principal and interest payments from farmer net returns, as well as a 15% commission (21). Immediately following a successful transaction, data is entered into DrumNet systems, and a set of bank account transfers are triggered to pay the participating farmers, agents, and (if necessary) transporters. In case the value of the produce does not cover the loan repayment, DrumNet enforces a group guarantee by subtracting the required amount from a group of peers. Later, generally at monthly intervals, funds from the buyer are transferred into DrumNet accounts to complete the transaction.

The DrumNet platform also links large-scale buyers, farmers, transporters, and field agents through an integrated marketing and payment system. Before farmers plant crops, DrumNet negotiates contractual arrangements between buyers and farmers, and at harvest time coordinates produce aggregation, grading, and transportation through agreements with local field agents and transporters. Market data and transaction details are made available to participating farmers.

A win-win arrangement for all participating stakeholders

The integration of the two processes of pre and post-harvest operations contributes to both risk and cost reduction and is the real value of DrumNet.

- Farmers reduce transaction costs by accessing both credit and markets through their interactions with DrumNet, paying off loans with their farm produce proceeds.
- Large-scale buyers are also freed from the requirement of managing cumbersome transaction intensive credit programs to ensure reliable supplies of produce. Instead they write a single check to DrumNet every month, thereby reducing costs.
- Stockists can access new customers without the requirement of selling products on short-term credit.
- Banks and financial institutions are able to tap into a currently inaccessible market for savings and credit while avoiding high transaction costs. The process creates an enabling environment for agricultural finance in several ways.
  - Banks are assured at the time of lending that farmers have a market for their produce and the means to adequately serve that market which indicates a healthy revenue stream.
- Banks minimize the problem of loan diversion by offering in-kind credit to farmers for inputs and directly paying certified (and monitored) input retailers after distribution of the inputs.
- Cashless payment through bank transfers reduces strategic default, since farmers cannot obtain revenue until their outstanding loans are fully repaid.

Figure 8 brings out the impact of DrumNet to the smallholder farmer in terms of increased returns from 65% of his total output to nearly 86%, an increase of over 32% (22).

Facilitation by the government

The Ministry of Agriculture organizes farmers into self-help groups (SHG). Government extension agents have set up “Field Farmers’ Schools” that provide technical assistance in certain crops chosen by the members of the newly created SHG. This method consists of a demonstration plot which is visited several times a month over the course of the cropping season. The program, however, does not provide credit in the form of inputs nor marketing contacts. In this sense, the government work and DrumNet can be seen as complementary.

Additionally, DrumNet staff participates in NGO meetings organized by the local government whereby the government learns about the involvement of the different NGOs and the targeted export crops. This
enables government extension agents to later focus their efforts in creating SHGs whose members are interested in DrumNet crops.

**ICT in DrumNet’s operations**

The contractual agreement mentioned earlier allows producers to access credit and purchase farming inputs from certified input retailers. This involves in-kind loans and a cashless payment procedure. Instead of providing farmers with cash, financial institutions pay the input retailer directly after notification of input collection. DrumNet tracks and facilitates the entire process through the use of complementary manual and short message service (SMS) based systems.

![DrumNet as an ICT-enabled collaboration platform](image-url)

**Figure 9 DrumNet as an ICT-Enabled Collaboration Platform**

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DrumNet facilitates the information flow up and down the supply chain during the crop cycle, predominantly via the use of SMS. Large-scale buyers are informed about what was planted, so they can estimate production and plan accordingly. The buyer is also able to monitor crop progress and pass on important extension information to growers. Input retailers are updated on which products to stock at what time and producers are informed of collection dates and locations long before harvest. In the end, all players benefit from DrumNet’s timeliness, transparency and oversight. At harvest time, contracted produce is aggregated and graded at designated collection points, then sold to the buyer.

DrumNet facilitates and tracks payment following a successful buyer-seller transaction, ensuring credit are repaid to the bank and payment to producers are both secure and accurate. DrumNet’s IT system provides the internal controls to track and report on compliance throughout the process. It also retains data for the establishment of user and credit ratings.

Figure 9 brings out the ICT-enabled collaborative platform pictorially \(^{(23)}\).
DrumNet support centres

To facilitate information dissemination, DrumNet has set up support centres – simple, stand-alone facilities catering to clients who require financial, market, and technical information in order to make more profitable transactions. Each support centre is equipped with a computer with a dial-up connection to the Internet and a mobile phone (GSM) to link up with the central hub in Nairobi, which acts as the main server/database and provides an access centre for the storage and retrieval of information.

Each support centre is managed by an agent, usually a member of the local community, who collects and disseminates information, assists in forming farmer groups, and arranges buy and sell deals. The centres have been designed to keep start-up and operating costs low and allow the agents to reach rural areas typically untouched by such services. In addition, by working collaboratively with organisations that provide up-to-date information on comparative market prices throughout the region, DrumNet offers information on leading production methods for the more profitable crops. It works with farmers through established learning organisations such as self-help groups, cooperatives, and Farmers Field Schools to maximise the peer-to-peer dissemination of this information (24).

DrumNet charges a modest fee for its brokerage, administrative and transactional services.

Challenges and opportunities

Financing farmers is difficult in Africa. They tend to be geographically dispersed, resource poor, and under-educated, all of which amplify costs and risks involved with lending. Plus unpredictable weather patterns, long crop cycles, irregular market access, and volatile or high farm input costs, make the proposition even more unappealing to financial institutions. Consequently, agricultural lending constitutes less than 1% of the commercial lending taking place on the continent (5).

The DrumNet Project employs proven microfinance principals and a supply-chain approach to promote agricultural lending. The targeted use of ICTs across the platform makes the process efficient, cost-effective, and practical in the African context.

Challenges DrumNet has encountered during implementation include the following:

- For the endeavour to function properly, each supply-chain partner must comply with an established set of procedures and rules. Once one actor fails to comply because he or she does not find value in the arrangement, the overall value of the supply-chain approach is lost. DrumNet has, however, experienced its share of noncompliance. Farmers have opted to side-sell produce outside buyer agreements to attain quick cash or evade loan obligations. Buyers have at times failed to honor contract terms, and input retailers have engaged in dishonest practices as well. Even banks have strayed from the program by delaying payments and introducing unexpected fees to farmers.
- Farmers’ inability to attain sufficient crop yields has also negatively affected the project and its overall service package. Poor yields have often resulted from poor weather conditions. Kenya has experienced several years of irregular and insufficient rain, especially in the eastern portion of the country. Consequently, many farmers have produced only small or extremely stunted harvests.
Soil conditions in Kenya have also diminished farmers’ productivity. Population pressures, intensified agricultural activities, and low fertilizer use, have led to many Kenyan farmers exhausting their soils. With such soil conditions, even the best agronomic practices result in disappointing yields, low returns on farm investments and consequently further soil degradation from season to season. The use of poor seed varieties has exacerbated the problem.

Lessons learned

DrumNet has learned lessons from its past experiences and has identified the following products and services that can be bundled with or added as supplements to the supply chain:

- **Performance Rating**: By devising a performance rating system integrated into DrumNet processes to allow good and bad performers to be identified, incentives would be created for better partner behaviour and commitment and distinguishing especially competent, reliable actors over time. Simple credit ratings could also serve as helpful indicators for banks as they assess potential borrowers’ creditworthiness.

- **Crop Insurance**: A dedicated crop insurance product that insures farmers’ inputs against natural events would reduce weather risks inherent in agricultural financing, win further buy-in from farmers, and fill a crucial gap in this bundled, supply-chain approach. The product could be directly tied to input sales or incorporated into production contracts. Farmers would receive not only a guaranteed purchase price, but also guaranteed reimbursement or replacement of inputs.

- **Soil Analysis**: A soil analysis service would provide farmers with recommendations on restoring fertility to their soils and, accordingly, improve land productivity. A fertilizer matching component—matching the right fertilizers to a farmer’s particular soil composition—would make it even more effective. The analysis could be offered by input retailers, thereby generating greater trust between farmers, retailers, and DrumNet.

- **Payment Systems**: Payment systems like M-PESA, ZAP, and MobiCash can increase timeliness of transactions between supply-chain partners and move cash points closer to rural-based farmers. These payment solutions, together with the increasing number of bank products available in the market, will reduce hassles farmers now face when receiving payment.

Scaling up plans for DrumNet

DrumNet is also commercializing its operations through the formation of a private company in Kenya. The following could be envisaged to scale up DrumNet to other locations:

- **Expansion through a chain of franchisee kiosks**: Info-kiosks could be embedded into existing banks, savings and credit societies, and agricultural associations, and possibly even operated as independent franchises could be tried to reduce the last mile distance to farmers.

- **Drumnet as a one-stop platform for farmers**: Products and services to be bundled together with the core purpose of the project as mentioned above, being incorporated into the DrumNet platform to make it a fully integrated One-Stop Platform for farmers in the region.
• Making the ICT platform user friendly and operable by the farmers: DrumNet’s existing ICT system should be a more robust and expandable system that is accessible to rural-based partners. The system should be modular in structure, so users with different requirements can select and use different components. The system itself should be user-friendly and must approximate to the way users already conduct business.

• Adoption of common standards: Commonly accepted standards for communication, financing, information, and exchange must be applied across the DrumNet supply chain to further improve its scalability.

• Removing the lock-in of the farmers to the DrumNet supply chain: As the DrumNet scales up the real value will be created if the lock-in of the farmers to sale points offered by the platform is removed. With greater accessibility, DrumNet should offer farmers a platform by which they will be able to see for themselves the competitive positioning of their products in the market and then sell their produce to the buyer offering the best price. This will not only make the platform more transparent but also convince farmers of its fairness, which in turn will go a long way in scaling it up.

4.3. Zambia’s National Farmer Union develops SMS-Based service

Background

Zambia is a landlocked country with an economy at the lower end of the sub-Saharan African spectrum and is highly dependent on the agriculture and copper industries. There are high levels of deprivation and poor infrastructure, especially in rural areas. Literacy is high (between 85% and 90% of the adult population).

Zambia has had an increase in telephone ownership and use since the advent of mobile phones; the mobile coverage covers the entire country. The fixed telephone network, however, is extremely limited, confined to the main urban centres, the Copperbelt and the rail links between them.

As in much of Africa, most of Zambia’s agriculture is with smallholders. Lack of access to reliable and up-to-date market price information is a serious problem for them, without which they are vulnerable to unscrupulous traders offering prices at below-market rates. They are also reluctant to diversify into different cash crops for fear of not finding a

How it Works

Farmers simply send an SMS message containing the first four letters of the commodity name to 4455. Within seconds, they receive a text message with the best prices by buyer using abbreviated buyers’ codes. After selecting the best buyer, farmers can send a second SMS message with the abbreviated buyer’s code. A text message is sent back with the contact name and phone number of the buyer, the full name and address of the company and simple directions for reaching both. Farmers are then able to phone the contact and start trading. Each SMS message costs approximately US$0.15. The system is also supported by a website, for those who have Internet access.
profitable market for their output (26).

The Zambia National Farmers Union (ZNFU) aims to promote and protect interests of members as farmers, individuals corporation/companies and other organisations involved in farming in order to achieve sustainable economic and social development.

**The SMS-based information service**

The Zambia National Farmers Union (ZNFU) operates an SMS-based information service that provides details of commodity prices and is aimed at smallholders who have access to a mobile phone. Farmers who have produce for sale can find out the best price and the best buyer they are likely to get for their produce in their district and beyond. This saves them from transporters and agents who would offer farmers lower prices.

The service allows smallholder farmers to compare current prices in their district, province or nationwide and to make the best decision on where to sell their output, thus giving them commercial power that they did not have previously. It spurs competition among traders and processors, who keep a close eye on the website to see how their competitors’ prices are moving. So far, over 1,000 hits per week have been recorded on the system. It is estimated that more than 15% of SMS messages directly lead to farmers selling their outputs, and over 130 traders update their prices on the system weekly (26). Prices are updated each day, and more comprehensive information is also available via a website.

To make information available to farmers without mobile phones and in areas lacking network coverage, ZNFU trains at least one farmer in every district to act as a contact farmer who would then publish the commodity price and trader information that they get either via SMS or from the website and give it to extension officers. Extension officers weekly display the prices and details of interested traders on posters in local information centres (27).

**An e-Transport system**

The ZNFU has also launched an eTransport system, a web-based interactive information system which allows transport users to publicise availability of loads or cargo to a known destination and at preferred times of delivery to transporters. The system allows registered transporters to inform transport users the availability of trucks on various routes (28).

**Scaling it up**

- The SMS-based information system could be applied to the sale/purchase of any commodity or service. The system has been tried with seeds and veterinary service. Consolidation could also happen when integration is effected between these different platforms trading in different commodities and services. With infrastructure being shared, transaction related prices could come down further.
- The programme could be taken beyond the boundaries of Zambia. The cross-border SMS-exchange will help further spur competition and better returns for Zambian farmers.
Beyond commodity prices, through easy-to-use mobile applications farmers can be served with market trends for different crops that would help them diversify further into other commodities and services. More service providers could be brought into the fraternity to link research-seekers and research-providers just as well as the other matchmaking services are being provided.

**Reasons for success**

Reasons for success could be summarised as follows

- The service provides real economic value by providing information to those who need it most. This translates to additional earnings and savings of immediate economic benefit to farmers.
- The system capitalizes on the high literacy rate in Zambia by communicating to farmers in a medium and language that they are well-equipped to understand.
- Being a government-recognised body gives added credibility to ZNFU. Farmers do not just take important decisions but also share personal details into the database. They are confident that privacy issues will be respected by the ZNFU.
- The e-Transport system helps farmers arrange for transport of their produce after sale. This ties in with the current programme and makes for added adoption rates.
- Where access to technology is a problem, use of alternative media, such as printed notices, are also used and resolve the problem. Hence, although with a bit of delay, the same objectives are realised.
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<th>Case Study</th>
<th>Brief Description</th>
<th>Scaling Up Plans and Potential</th>
<th>Reasons for Success</th>
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<tr>
<td>Using ICT to bring together multiple stakeholders in the Kenyan agriculture sector – DrumNet</td>
<td>DrumNet offers support services to smallholder farmers in Kenya by providing access to information, financial services, and markets using ICT, efficient business processes, and economies of scale. It combines information, commodity transaction services, and financial linkages into a single business service model that provides access to markets, market information, and credit for the rural poor to support sustainable agriculture and rural development.</td>
<td>• Info-kiosks could be embedded into existing banks, savings and credit societies, and agricultural associations, and possibly even operated as independent franchises. This could reduce the “last mile” distance to farmers. • Products and services to be bundled together should be incorporated into the DrumNet platform to make it a fully integrated One-Stop platform for farmers in the region. • DrumNet’s existing IT system should be more robust and expandable and be accessible to rural partners. • Commonly accepted standards for communication, financing, information, and exchange must be applied across the DrumNet supply chain to further improve its scalability. • DrumNet should offer farmers a platform by means of which they will be able to see for themselves the competitive positioning of their products in the market and then sell their produce to the buyer offering the best price.</td>
<td>• Provides real economic value to farmers translating to additional earnings and savings. • System talks to farmers in a medium and language they are well-equipped to understand. • Using the right channels and devices with which to communicate with the partners. • Using existing networks and infrastructure, particularly distribution facilities of stockists • Good conceptualisation and execution on the ground of multiple-stakeholders in win-win partnerships. • Trust is built with stockists, support centre operators and even the government using local champions as facilitators. • Augmented by bundling many other services together with the basic loan payment facilities to make it truly comprehensive. • Implementation is localized. Local champions invest time and effort and that added to trust.</td>
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<td>Zambia’s National Farmer Union develops SMS-based service</td>
<td>An SMS-based information service provides details of commodity prices and is aimed at smallholders who have access to mobile phones. Farmers who have produce for sale can find out the best price and the best buyer they are likely to get for their produce in</td>
<td>• The system is quite generic in nature and could be applied to the sale/purchase of any commodity or service. It has already been tried with seeds and veterinary service. • Consolidation could happen when integration is effected between different platforms trading in different commodities and services. • Could be scaled up if it is taken beyond Zambia. • Easy-to-use mobile applications can provide</td>
<td>• Provides real economic value to farmers translating into additional earnings and savings. • System talks to farmers using a medium and language they are well-equipped to understand. • ZNFU is a government-recognised body and this gives the services added credibility. • The e-Transport system helps farmers to arrange for transport of their produce after sale. • Where mobile phone reception and signal</td>
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<td>Sissili Vala Kori-farmers use ICTs to share new production, processing and marketing skills in Burkina Faso</td>
<td>More FEPPASI owned/managed centres are needed given the economic conditions of the majority of people.</td>
<td>Dogged determination and clear vision ensured that promoters had the necessary staying power.</td>
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<td>Mobile as a platform can serve as a good medium for operations to be scaled up.</td>
<td>Faith in the endeavour was high as it was completely locally developed.</td>
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<td>Streaming technologies can also be tried.</td>
<td>All relevant stakeholders were involved, including local ICT companies, research entities and even the government.</td>
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<td>Include real-time online sale of commodities, advisory networks connecting all stakeholders active in the region and so forth.</td>
<td>Use of right medium of communication in the local language in an area where both connectivity and literacy was low.</td>
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<td>Self-generating sources of revenue have started being explored.</td>
<td>Use of images.</td>
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<td>Increased publicity and awareness may be required as a pre-requisite before this idea is adopted in other similar countries.</td>
<td>Successful demonstrations by fellow farmers were a powerful incentive.</td>
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<td>Training ensured that agriculture was passed on before ICT.</td>
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<td>Mango traceability system links Malian smallholders and exporters to global consumers</td>
<td>Could now be taken to the next level by adding other activities and a wider group of stakeholders including credit agencies, extension providers and the like.</td>
<td>Operations were personalised; farmers could easily associate themselves with it. Growers’ photographs were taken and incorporated into the traceability platform.</td>
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<td>Needs to move to the next level where the Fruiléma platform could extend advisory and marketing services, matchmaking facilities, training etc.</td>
<td>Involvement of the farmers themselves right from the conceptualisation to commissioning.</td>
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<td>Unique first mover advantage: a Malian label can be created for crops including mango and facilitate market recognition in target export markets.</td>
<td>Real and significant economic returns to the farmer.</td>
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<td>Integration could be effected with payment</td>
<td>In an area of low literacy and low ICT penetration rates, usage of the right medium was instrumental to the success of the venture.</td>
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<td>Training of growers on mango growing was</td>
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| Index-based agricultural insurance on agricultural inputs in Kenya- Kilimo Salama | This is an index-based insurance product that covers farmers' inputs in the event of drought or excessive rainfall is a means for farmers to avoid risks associated with rainfall variability that directly affects their livelihoods. | • Win-win partnership like those in Kenya are evident elsewhere too.  
• More products can be brought into the ambit of the scheme.  
• Output-based agricultural insurance can be covered too.  
• Microfinance institutions can require farmers approaching banks for a loan to take out agricultural insurance policies.  
• As more payment gateways emerge, competition could be introduced which could further reduce the costs to the farmer. | • Farmers initially had to pay small amounts; then they scaled up.  
• Using existing networks and infrastructure, particularly distribution facilities.  
• Good conceptualisation and execution on the ground.  
• Trust enabled by visibly objective measurements that are automated and tamper-proof. Further reinforced by using local champions through stockists.  
• Existing payment gateway, M-PESA, is used  
• Augmented by marketing services over radio, seen as being the right choice.  
• Excellent outreach to its target farmers by training, convincing farmers about insurance, and ensuring readily available helpline.  
• Implementation is localized. Local champions contribute the effort that added trust.  
• Long-term interest and conviction.  
• Insurance bundled with agricultural inputs that farmers bought anyway. Perception that the financial impact of this on farmers was small. |
| Using ICT to improve forest governance in Liberia- LiberFor | LiberFor is a public-private partnership developed in 2007 to implement a tracking system for the forest product supply chain that extends from the stump to the point of export. It | • Legal and regulatory provisions are not comprehensive yet and processes are not standardised. Running LiberFor in parallel with these incongruities may be counterproductive and may defeat the very purpose behind putting it in the first place.  
• Capacity building of staff and users must necessarily accompany construction and implementation of these systems. Also, systems need to be user-friendly if real gains have to be achieved.  
• The system built has to be completely handed over with a comprehensive knowledge transfer taking |
Case Study | Brief Description | Scaling Up Plans and Potential | Reasons for Success
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Mobile Technology as a “Game Changer” in South Africa: MXit | MXit is a popular communication tool used for exchanging information and networking. The most frequent uses of the tool are announcements, exchange of information and communication of assessment results. Text messaging (SMS) and chats are the most commonly used communication feature used by students. | Integrating this application with Meteorological Department and Marketing Agencies for sending information as alerts on-demand basis will be useful. The information base could be broadened by including researchers, agricultural extension service providers and the like. Chat application will be useful since it can take place in real time. Other local languages should also be incorporated in the service for dissemination of information. Steps could be taken by the government to lower prices of handheld devices. Functional enhancements to be supported by basic phones. The agriculture sector can use it to educate farmers about crop production techniques. Researchers can participate in building a knowledge database, which can be made usable for farmers. | Most of the mobile applications available are supported by high-end mobiles, which are costlier. MXit is supported by even the most basic mobiles, which are cheaper. Students, and prospective farmers, could easily afford cheap mobiles. Some of the farmers are only making use of partial functionality of the application. They are using it for selling their farm equipment, tractors, etc. The application already has government support which has helped it in no small measure.

Mobile technologies used by GSMA as an initiative to to alleviate food security related | The GSMA, the body that represents the interests of mobile operators world-wide, recently announced the launch of the mFarmer Initiative Fund, supported by a grant from the Bill and Melinda Gates | Innovative idea strongly based on win-win aspects of any collaborative venture. Not only does the GSM association gain through it by increasing penetration, thereby increasing revenues to its operators, but it also helps its corporate social responsibility cause. The criteria of eligibility for proposals is well- | The initiative is still under implementation. As such, it may be premature to highlight it as an implementation success. However, as an initiative, this does represent an unprecedented effort in Africa and qualifies for replication in other contexts, particularly by donors along the lines of...
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| problems   | Foundation, to encourage mobile communications service providers, in partnership with other public and private sector agriculture organisations, to use mobile communications to provide information and advisory services to smallholder farmers in developing countries living on under US$2 per day. | defined, tied to objectives of the initiative and targeted;  
- The criteria recognise that projects have to outlive the donor support period; accordingly, including self-generating sources of revenue forms an integral part of the project eligibility criteria. | an example given in the case study. |
| Seeing Is Believing – unlocking precision agriculture in West African smallholder communities with very high-resolution imagery | The approach of “Seeing Is Believing” is to showcase potential uses of VHRI in community level agricultural development and to specifically demonstrate the value of VHRI to help scale up a few productivity enhancement technologies in six sites in Burkina Faso, Ghana, Mali and Niger. |  
- Potential as a tool for a range of decision support, (agro-forestry, water harvesting, and fertility management). However, evaluation remains exploratory and needs to be deepened in a pilot follow up as part of the scaling up phase.  
- Farmers spatially skilled and can quickly assimilate contents of VHRI derived map products. VHRI can harness, rescue and upscale key grass-root expertise by providing a modern and standardized conduit for local knowledge.  
- Freezing “current” (and possibly erroneous) land tenure into paper maps is likely to be the biggest challenge in a context of population growth and changing land ownership. Need to accelerate democratization and roll out of GIS/GPS-enabled mobile phones that can carry dynamic community-to-farm scale maps. |  
- Satellite can record how soil reflects light by colour. Condition of the fully-grown plants can then give an idea of the quality of the soil.  
- VHRI gives an accurate picture of relative fertility across the landscape, rather than just the results from a few sample points.  
- This method of analysis is cheaper than visiting every individual farmer’s field and sending a comprehensive set of soil samples to the laboratory.  
- Farmers could improve distribution of fertilizer throughout their fields and plan which crops should go in which areas. SIBWA team worked with the farmers to determine the area of each field. Farmers could use this to calculate precise amounts of seeds, pesticides and fertilizers.  
- Small and fragmented fields, and fields with an |
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| Agricultural research in Africa and the potential of ICT usage | The case study describes the status of agriculture research in Africa, challenges faced and recommendations for the adoption of ICT in research. | • Clipping trees and their shadows out of individual fields was successfully adapted for automatic tree density estimation. Additional work required for automatic crown delineation is being pursued with potential linkages to voluntary carbon markets.  
• VHRI shows potential for accelerated knowledge confrontation and co-learning by a diversity of stakeholders which needs to be showcased and deepened. | awkward shape, are difficult to work with a tractor or even animal traction. It is a simple process to determine that from the image before the community invests in any new equipment.  
• Farmers use this method to encourage water infiltration and reduce soil erosion. From the satellite imagery, farmers can monitor whether they are following the contour lines accurately and efficiently. |
| | | • ICTs can help improve precision of farmers’ decision making such as integrated water, nutrient, pest and disease management and weather forecasting information.  
• Increased investments in ICT infrastructure are required to enable access to the Internet, libraries and information centres for the participatory knowledge quadrangle of farmers, extension professionals, educators and scientists.  
• Institutions lacking fast and affordable access to the Internet can make full use of CD-based information sets such as the Essential Electronic Agricultural Library. Web-based distance education and video conferencing can complement and supplement courses.  
• A diversity of channel and communication tools with a strong people focus should be introduced.  
• Spatial information allows analysts to view distribution of income across a country as a grid in order to target areas for action, understand demographic trends, and monitor progress.  
• Spatial information on fire, rainfall, and salinity can help countries estimate risk more accurately.  
• ICT can be used for land records, future price discovery, market intelligence, and agricultural database management, e-banking, mobile-based payment, etc. Unconventional technologies like ATM, digital cash, mobile banking, etc., can make microfinance reach until the last mile. Farmers have little information on the kinds of crops they should grow, how they should grow them, market dynamics, etc. Other gaps include the credit gap, productivity gap, marketing gap, price realisation gap, and infrastructure gap, etc.  
• Real-time multicasting, customisation of information, and personalisation of content on the basis of knowledge of who is logging in and who is participating, can be done through ICTs. |
Case Study | Brief Description | Scaling Up Plans and Potential | Reasons for Success
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Mauritius | One-agriculture is the national eAgriculture Plan for Mauritius, a blueprint for the adoption and use of ICT in the agriculture sector in Mauritius. Objectives included bringing about cost-reduction, sectoral efficiencies and better customer service delivery. | ● Insufficient collaboration among entities within single Agriculture Ministry qualifies for a replication of this idea.  
● Customer facing processes and back-office processes are not standardised and are inherently inefficient. The plan is a vehicle to remove incongruities, and re-design processes to make them more efficient and standardised.  
● Smallholder farms are inherently uneconomical; the plan recommends consolidation at the level of farms to bring about economies of scale and scope.  
● Services not geared for customer convenience. Single-window services, one stop shops and mobile as a service delivery device among measures are recommended and can be tried elsewhere after suitably tailoring the concept.  
● The national plan serves as an umbrella plan under which all initiatives fall. The plan brings all stakeholders together and guarantees a minimal budgetary allocation.  
● The plan is still under implementation with the implementation vendors yet to be selected. As such, it may be premature to highlight any specific solution as an implementation success. However, as a plan, this does represent an unprecedented effort in Africa and qualifies for replication in other countries. | Table 4 Summary of the Potential for Scaling Up and Reasons for Success among Case Studies covered

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eTransform Africa: Agriculture Sector Study: Sector Assessment and opportunities for ICT

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5. Deep Dive Case Studies

5.1. Introduction

In the preceding part of this investigation documented evidence was provided to confirm the potential wealth creation by the introduction of various forms of ICT into areas where development is needed. As a consequence of the generally accepted experience that the increased utilisation of ICT holds promise for the improvement of agricultural production on various fronts, the authors were tasked to conduct in-depth investigations on the potential role which intensified utilisation of ICT could have on the improvement of certain key agricultural sectors. In the forthcoming portion of this report a detailed description is provided of the nature of the investigations, the characteristics and usage of the ICT, its significance for the agricultural production processes, challenges encountered, the role of the respective interested parties and governing institutions to create enabling environments and an outline of the road ahead to further improve efficiency of agricultural production.

Choice of focal disciplines in agricultural production

The significant positive contributions which the implementation of intensified inputs of ICT can have on increased agricultural production are manifest, as discussed earlier in this document. The discussion above, however, dealt with generalised issues and it was decided that two in-depth case studies would be conducted in order to critically examine the real impact of the intensified use of ICT in different theatres of agricultural production on the African continent. After a number of production sectors were considered, it became clear that two areas presented themselves with the best potential for increased production by the intensified use of ICT. The two major opportunities which were identified as key areas for a rapid increase in agricultural production were improved traceability of livestock and products derived from that sector as well as increased efficiency of irrigation of crops. In both those areas it has already been proven in many parts of the world that the intensified use of ICT can bring about marked positive changes.

ICT as a potential tool for increased traceability of livestock

Livestock production comprises the most widespread and generally practiced agricultural activity on the African continent. Should the intensified use of ICT be able to assist in increasing the efficiency of livestock and meat production in selected African countries, the resultant effects could reverberate across all parts of the continent. Should it furthermore be found that the achievement of significant increases in production be possible at affordable cost and be relatively easy to duplicate in areas with diverse natural landscapes, the potential for general increased wealth creation could be enormous.

Based on many observations made by a multitude of observers in the recent past, indications had already been obtained that the improvement of traceability of livestock held the potential to result in a positive large-scale unlocking of the production potential of livestock and have an observable improvement in the well-being of large numbers of people on the African continent. It was therefore decided that priority should be given to that area where ICT could have the most dramatic effect on livestock production, namely on improved traceability of livestock and that it should be targeted as the subject of an in-depth case study.
The potential for the intensified utilisation of ICT in increased irrigation efficiency

It has been demonstrated in many areas of the globe that by utilising efficient irrigation techniques, the efficiency and profitability of crop production can be increased as much as hundredfold. With efficient irrigation practices moisture supply to crops can be made more consistent, water deficiencies can be overcome during periods of drought, more than one crop cycle per year can be achieved and the efficiency of the use of all production resources can be dramatically increased. The pressure on the diminishing water resources can also be alleviated and more crop production could be put under irrigation.

If it could therefore be demonstrated that by the increased utilisation of ICT, the positive effects of irrigation on crop production can be significantly increased, then an important tool in the achievement of enhanced wealth creation can be identified. That improved efficiency of irrigation application would then have the potential to provide a valuable tool for countless subsistence and small as well as large-scale farmers to escape from the stranglehold of low crop yields and marginal profits. It could consequently enable them to enter into the main stream of commercial production and wealth creation.

Selection of target countries for the conduct of in-depth case studies

Namibia as the choice of a target geographical area for an in-depth study of intensified ICT usage for the improvement of traceability

When various countries were considered as hosts for the in-depth case study on the utilisation of intensified ICT for improved traceability, the choice fell on Namibia. In that country the commercial farming sector had already proved that by utilising intensified ICT techniques, traceability of animals and animal products could be enhanced and large benefits could be enjoyed by a chain of role players in terms of higher export prices and a wider range of markets for their meat.

Other countries where ICT is also already being used to increase traceability of livestock are South Africa and Botswana. It was nonetheless decided to select Namibia in view of its potential for increased meat exports and its increasing success rate with traceability practice, while the potential for meat exports from South Africa are limited due to upward spiralling of demand and Botswana is currently encountering serious challenges with its handling of its traceability program. In the in-depth case study conducted in Namibia the potential to narrow the large gap existing between the standard of livestock production and income derived from meat marketing of the commercial and tribal farming communities could also come under close scrutiny.

Egypt as the choice of a target area for the in-depth study of intensified usage of ICT for the improvement of crop irrigation practice:

As a result of the arid climate all crop production in Egypt has to be conducted under irrigation with water from the Nile and boreholes. It would therefore be informative to observe the manner in which intensified usage of ICT is being employed to boost crop yields and profitability. It is a well-known fact that large-scale new irrigation schemes are being implemented in that country and that much progress is being made in maximising profits from crop production. In the planned in-depth case study a picture would also be formed of the probable road map to be followed by traditional peasant farmers to attain the same enviable results as their large-scale commercial counterparts.
Method employed in the investigations

In both countries the investigations would assume intensive investigations in the form of site visits by Deloitte task teams, discussions with all role players involved in crop production and marketing, organisations supplying and operating ICT and people involved in the creation of an enabling environment. The status of the practices would be recorded, past experiences considered and the ambience of the operation of ICT in close relationship with crop irrigation and community development would be reviewed.

Summary of results obtained

Employment of traceability systems to improve the profitability of the production of livestock and downstream products

The results of the in-depth investigation in Namibia revealed the following:

- The existing traceability systems employed by the commercial farming community and its downstream role players have proven to be extremely valuable in unlocking wealth along the entire value chain;
- The experience gained by the commercial livestock sector can serve as a valuable platform to roll out traceability systems in under-developed rural areas where great reliance is placed on livestock production to sustain the people from those areas;
- New streamlined traceability systems which have recently been developed in South Africa offer even more advantages for the inclusion of a wider spectrum of functions with the prospect of the involvement of a host of additional services to be rendered;
- The co-ordinated intensification of a comprehensive system of traceability, together with other functions provided by the same system, can serve to touch the lives of multitudes of poor people in addition to the improvement of the long-term sustainability of the entire livestock industry. This has the potential to positively affect the economy of the country at large;
- The capital and operational costs involved in the roll-out of such a comprehensive traceability program are relatively low, compared to the large benefits which can accrue to the livestock industry, the respective role players in the value chain as well as the government of the country;
- An enabling environment should be created by the government and all other interested parties with the objective to ensure maximum efficiency of the operation of an advanced traceability system;
- Should international organisations involved in the provision of aid funding wish to make a contribution of note to the country, consideration should be given to concentrate their funding efforts on the provision and maintenance of a comprehensive traceability system;
- The traceability systems as discussed below in this document can also be rolled out in many other African countries where it can be expected to bring about the same magnitude of wealth creation, if an enabling environment can be created;
- Investment in the intensification of the use of ICT can offer more advantages than investment in possibly any other interventions to be considered.
Intensification of ICT employment in irrigation farming in Egypt

The results of the in-depth investigation in Egypt indicated the following:

- The existing ICT systems employed by some portions of the commercial farming community, as represented by the large-scale irrigated farming operation involved in the investigation, have proven to be extremely valuable in increasing the efficiency of water use and generation of larger profits;
- The experience gained by the large and small-scale commercial irrigation sector can serve as a valuable platform for the employment of even more comprehensive ICT systems. This can be employed to reach many more elements of the agrarian communities of Egypt and can make a valuable contribution towards the improvement of living standards over a wide spectrum of social activities;
- The intensified employment of ICT can also offer valuable tools for the government organisations to diversify their services to all communities involved with irrigation farming;
- The capital and operational costs involved in the roll-out of a range of ICT-based functions are relatively low, compared to the large benefits which can be expected by the irrigation farming industry, the respective role players in the value chain as well as the government of the country;
- The enabling environment which is being created by the government and all other interested parties with the objective to ensure increased efficiency of the use of irrigation water, can serve as an example to be followed by other countries where development is regarded as important;
- Should international organisations involved in the provision of aid funding wish to make a serious contribution to the country, consideration should be given to the focussing of their funding efforts on the intensification of ICT-based systems for the improvement of the fortunes of a multitude of rural people;
- The systems as discussed below in this document for increasing the efficiency of irrigation agriculture in Egypt, can also be rolled out in many other African countries where it can be expected to bring about the same magnitude of increased wealth creation, if an enabling environment can be created;
- Investment in the intensification of the use of ICT for the improvement of crop production under irrigation, can offer more advantages than investment in most other interventions to be considered.

It can be concluded that the exercise to embark on an in-depth investigation of the effects of the employment of ICT in agricultural production, has yielded results which were even more positive than previously expected. The implications for the use of ICT-based intervention programs, such as those demonstrated by the findings of this present report, elsewhere on the African continent are significant and should be taken note of by organisations which are serious about accelerated development in Africa.
5.2. Traceability

Livestock tracking and traceability in Namibia

*Introduction*

Animal traceability refers to the ability to follow an animal or group of animals during all stages of their life – i.e. from birth to death \( ^{(29)} \). Under the Codex Alimentarius, traceability is the forward and backward tracking of animals and food by paper or electronic means. The International Organization for Standardization (ISO) defines traceability as the ability to trace the history, application or location of what is under consideration or a series of recorded identifications.

In order to gain access to international trade, animal traceability and the traceability of products of animal origin should have the capability to be linked to achieve traceability throughout the animal production and food chain taking into account relevant OIE and Codex Alimentarius standards.

It is ironic that there although is an estimated total number of 241 million head of cattle in Africa, only a few countries such as Botswana, Namibia and South Africa are actually in a position to comply with international standards for export. Even though the livestock sector is one of the most important agricultural contributors to GDP in Africa (one-third of agricultural GDP in Ethiopia, half in Kenya, two thirds in Sudan and 80-90% in Djibouti and Somalia \( ^{(30)} \)), it is plagued by inefficiencies. Furthermore, Africa is unable to capitalise on growing export markets due to the inability to increase productivity through changing production systems, reduced cost, and controlling endemic and zoonotic diseases. Lack of certification and traceability as required by international markets has long been a major stumbling block which has prohibited the export of livestock products.

The use of tracking and traceability systems may be one of the most important initiatives that a government can institute in order to unlock the latent potential of the national livestock herd and to create a vibrant industry which generates much-needed foreign exchange. In order to be successful it is required that a multitude of factors be taken into account and that clear roles and responsibilities be defined for each of the respective key players in the industry.

When properly done, tracking and traceability systems have many more benefits to offer than the obvious as it basically requires the whole industry and government, with all its relevant departments, to work together. This in actual fact creates cohesion in the industry where no one player is more or less important than the other. Independent of the actual traceability system that may be chosen, government is required to create an enabling environment in which the system can operate. Traceability systems can also be utilised as a basis from which the efficiency of the national herd can be improved as current ICTs are capable of including management functionalities which can be used as part of extension services for groups or individuals.
It is important to take note of the fact that the requirements of a traceability system may vary between the different role players in the industry. Given this fact, it needs to be stressed that government plays a crucial role in the creation of an environment which is conducive to the successful operation of traceability systems as they are required to establish a legal framework for the implementation and enforcement of animal identification and animal traceability in the country. Government on its own is however not the only determinant of the successful operation of such a system. All relevant role players are required to be involved in the planning, implementation and operation of a system as and when their expertise and skill is needed. One of the most significant issues in the establishment of a traceability system is the fact that the livestock industry in Africa is deeply rural-based with a high mobility, as animals are frequently moved as to find the best pastures. Connectivity in deep rural areas is, as a rule, very poor and reliance needs to be placed on mobile equipment that is rugged and reliable. A well-developed network of trained staff (private/public) is also required in order to operate the system as the literacy levels of rural people especially with regard to ICTs are low.

A clear understanding by all role players is also required as to the driving forces and advantages behind any traceability programme such as serving as a deterrent against stock theft, improved farm management practices, early prevention, control and isolation of animal diseases, proof of ownership in subsidy payment schemes, performance recording and trade opportunities in terms of the export of animal products to markets for higher prices subject to certification and thus eliminating trade barriers.

The systems available for the traceability, identification and ownership of livestock are numerous and range from the original ear notching and traditional hot-iron branding to retinal scans and DNA profiles.

The most common systems used for identification in Africa are hot branding and ear notching where no formal traceability system is in existence.

In a presentation on animal identification and traceability (30) (Table 5) a comparison was made on the suitability of the available ways in which traceability could be established. From a practical point of view, radio frequency identification (RFID) technology and electronic ear tags, visual ear tags, bolus (ceramic coated transponder inserted into the rumen of an animal) and branding, or a combination of the items mentioned, seem to be the logical solutions for pastoral Africa. It needs to be kept in mind that the future use of branding may be banned due to pressure from international animal humane societies. At the moment it is still allowed.

It needs to be noted that in an analyses done in Botswana, the use of bolus as the only identifier was not deemed as successful when compared to a bolus with a visual ear tag (31). A transponder (electronic ear tag) is applied in the left ear of an animal prior to leaving the herd of origin. The most common ID is the small doughnut-shaped ear tag partly concealed inside the ear of an animal. The RFID electronic reader activates and transfers the data contained on the transponder in the ear tag to a data interrogator. The device, which must comply with the specifications of ISO 11785, may either be handheld or permanently mounted in an alleyway. It should also include wedge software, failing which it should be acquired separately as “stand-alone” wedge software. Mounted systems are normally used in feedlots and handheld readers are used when mobility is required in rural areas. A data accumulator is used to capture data from the reader. It can be any device (wire or wireless) such as a laptop or handheld computer which is capable of interfacing and accepting data from the electronic reader. Data are then transferred to software/web-based analysis and storage systems that can be linked and interfaced with herd or health management software.
<table>
<thead>
<tr>
<th>System</th>
<th>Species and breeds</th>
<th>Animal welfare</th>
<th>Cost of devices</th>
<th>Expertise required</th>
<th>Lifespan retention</th>
<th>Read in ability</th>
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<td>Low</td>
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<td>High</td>
<td>Long</td>
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</tr>
</tbody>
</table>

Table 5 Traceability systems and components analysis (30)
The injection of electronic transponders, imaging and DNA sampling is not done in Africa as a rule and if used it is for the exclusive use of stud-breeding facilities or endangered wildlife species.

Countries that are currently examining or using traceability systems are amongst others Tanzania, Kenya, Ethiopia, Botswana and Namibia, which can be seen as the most successful to date. The Namibian system which has been running successfully since 2005 utilises RFID ear tags, visual ear tags and branding as the means of identification of animals.

Interventions in Tanzania, Kenya and Ethiopia can be recommended as they are well suited for the replication of traceability systems.

**Challenges to replication of traceability systems**

Challenges in Africa which acts as inhibitors to the replication of traceability are:

- Border wars which are specifically fought over grazing rights;
- Pastoral production systems that necessitate the movement of large numbers of livestock to available grazing;
- Underdeveloped national and local markets;
- Regulated markets with price fixing;
- Poor infrastructure of which fencing, roads, handling and watering facilities are the most important;
- Low per capita meat consumption levels;
- High taxes on animal movement for marketing purposes;
- Lack of market information;
- Insufficient trader credit;
- Lack of government support in terms of legislation and enforcement of legislation and lack of or insufficient veterinary and extension services.

Cattle rustling has also become a commercial venture and traceability may be one of the solutions to this ever-increasing problem. Statistics indicate that between 1996 and 2002, Kenya lost more than 300,000 livestock with an estimated value of USD 37.5 million due to rustling. Issues that have been cited as reasons for failure in the implementation of traceability systems are:

- Human and capital limitations;
- System costs which are often underestimated;
- Lack of information on available technologies, guidelines and coordination among different industry role players;
- Farmer illiteracy;
- Perceived intrusion by systems which are not deemed confidential.

The above is by no means a disqualification but rather a list of issues that needs to be addressed in order to successfully replicate traceability systems. The positive factor is that several countries with significant cattle populations have already expressed interest in setting up traceability and tracking systems. These countries with estimated herd size are Tanzania (est. 17,800,000), Ethiopia (est. 38,500,000) and Kenya (est. 12,000,000). These three countries constitute roughly 28% of the total African cattle numbers. Kenya
has recently completed a study into the implementation of a traceability system which could generate an annual estimated 400,000 metric tons of meat exports from the country (32).

**Opportunities and success factors governing replication of traceability systems**

Several factors act as enablers for the use of traceability systems in Africa. Prerequisites for success that were apparent during the study were the following:

- Political stability of the regime and commitment towards improvement of agriculture in general;
- Availability of land tenure;
- Enforceability of current legislation;
- Presence and use of agricultural research institutes;
- Presence of a basic veterinary as well as agricultural extension service for implementation, monitoring and training purposes (this includes para-veterinarians as part of community-based animal health workers);
- Network of rural government offices represented in livestock production areas;
- Presence of livestock producer organisations indicating a degree of coordination in the industry;
- Free market system or minimal government intervention to capitalise on improved product pricing’
- Proper communication channels between government departments and the private sector;
- Presence of export incentives in order to stimulate the development of value chains and encourage FDI.

<table>
<thead>
<tr>
<th>Northern Africa</th>
<th>Cattle numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>1,560,000</td>
</tr>
<tr>
<td>Egypt</td>
<td>4,500,000</td>
</tr>
<tr>
<td>Libyan Arab</td>
<td>130,000</td>
</tr>
<tr>
<td>Morocco</td>
<td>2,728,800</td>
</tr>
<tr>
<td>Sudan</td>
<td>38,325,000</td>
</tr>
<tr>
<td>Tunisia</td>
<td>750,000</td>
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</table>

<table>
<thead>
<tr>
<th>Western Africa</th>
<th>Cattle numbers</th>
</tr>
</thead>
<tbody>
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<td>Benin</td>
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</tr>
<tr>
<td>Burkina Faso</td>
<td>8,010,160</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Gambia</td>
<td>330,000</td>
</tr>
<tr>
<td>Ghana</td>
<td>1,385,000</td>
</tr>
<tr>
<td>Guinea</td>
<td>3,400,000</td>
</tr>
<tr>
<td>Guinea-Bassau</td>
<td>530,000</td>
</tr>
<tr>
<td>Liberia</td>
<td>36,000</td>
</tr>
<tr>
<td>Mali</td>
<td>7,700,000</td>
</tr>
<tr>
<td>Mauritania</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Niger</td>
<td>2,260,000</td>
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<tr>
<td>Nigeria</td>
<td>15,200,000</td>
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</table>

<table>
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<tr>
<th>Middle Africa</th>
<th>Cattle numbers</th>
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</thead>
<tbody>
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<td>Angola</td>
<td>4,150,000</td>
</tr>
<tr>
<td>Cameroon</td>
<td>6,000,000</td>
</tr>
<tr>
<td>Central African Republic</td>
<td>3,423,000</td>
</tr>
<tr>
<td>Chad</td>
<td>6,540,000</td>
</tr>
<tr>
<td>Congo</td>
<td>115,000</td>
</tr>
<tr>
<td>DRC</td>
<td>756,940</td>
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<tr>
<td>Equatorial Guinea</td>
<td>5,050</td>
</tr>
<tr>
<td>Gabon</td>
<td>35,000</td>
</tr>
<tr>
<td>São Tomé and Principe</td>
<td>4,600</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Eastern Africa</th>
<th>Cattle numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burundi</td>
<td>325,000</td>
</tr>
<tr>
<td>Comores</td>
<td>45,000</td>
</tr>
<tr>
<td>Djibouti</td>
<td>297,000</td>
</tr>
<tr>
<td>Eritrea</td>
<td>1,950,000</td>
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<tr>
<td>Ethiopia</td>
<td>38,500,000</td>
</tr>
<tr>
<td>Kenya</td>
<td>12,000,000</td>
</tr>
<tr>
<td>Madagascar</td>
<td>10,500,000</td>
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<tr>
<td>Malawi</td>
<td>750,000</td>
</tr>
<tr>
<td>Mozambique</td>
<td>1,320,000</td>
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</table>
Table 6 Cattle Numbers by Country

<table>
<thead>
<tr>
<th>Country</th>
<th>Cattle Numbers</th>
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<tbody>
<tr>
<td>Senegal</td>
<td>3,070,000</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>400,000</td>
</tr>
<tr>
<td>Togo</td>
<td>280,000</td>
</tr>
<tr>
<td>Cape Verde</td>
<td>23,000</td>
</tr>
<tr>
<td><strong>Eastern Africa</strong></td>
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</tr>
<tr>
<td>Tanzania</td>
<td>17,800,000</td>
</tr>
<tr>
<td>Zambia</td>
<td>2,600,000</td>
</tr>
<tr>
<td>Namibia</td>
<td>3,133,887</td>
</tr>
<tr>
<td>Total cattle</td>
<td>121,317,960</td>
</tr>
<tr>
<td><strong>Grand total</strong></td>
<td>241,026,448</td>
</tr>
<tr>
<td><strong>Southern Africa</strong></td>
<td></td>
</tr>
<tr>
<td>Botswana</td>
<td>3,100,000</td>
</tr>
<tr>
<td>Lesotho</td>
<td>540,000</td>
</tr>
<tr>
<td>Namibia</td>
<td>3,133,887</td>
</tr>
<tr>
<td>South Africa</td>
<td>13,764,000</td>
</tr>
<tr>
<td>Total cattle</td>
<td>119,708,488</td>
</tr>
</tbody>
</table>

The significant presence of livestock farming improves social and economic conditions by means of interventions. African cattle numbers are indicated in Table 6, which serves as a preliminary source of possible investment opportunities. It is interesting to note that 20% of the countries constitute 70% of the cattle volume and that none of them currently has a national operational tracking and traceability system.

**Namibian Livestock Identification and Traceability System (NamLITS) for the Northern Communal Areas (NCA)**

**Background**

Prior to the establishment of a livestock identification and traceability system in Namibia, they were reliant on traditional paper-based recording and visual identification such as ear tags (plastic and metal) as well as branding. The establishment of an electronic system not only added value in terms of time saved but improved the accuracy of recording of data and a total new understanding of the livestock breeders of the necessity of the system.

As an indication of the success, cattle marketed by Namibia in 2010 boosted the economy by N$630 million. Beef production is in fact the backbone of the local agricultural sector and Agribank Chief Executive Officer, Leonard Lipumbu, released figures demonstrating the importance of the livestock industry in Namibia in July 2011:

- 85% of all suitable agricultural land is under livestock production;
- Beef production constitutes 87% of agricultural revenue;
- Cattle numbers are estimated at 2.5 million of which 71% are found in communal areas;
- Additional to cattle marketed, 900,000 head of small stock was exported on the hoof to South Africa;
- 150,000 weaners exported to South Africa originated from communal areas south of the veterinary cordon fence.
The Namibian case study is an approach to the requirements of establishing a workable traceability system as well as the different national and international role players required to initiate and operate the system.

The implementation of the Namibian Livestock Identification and Traceability System for the Northern Communal Areas of Namibia is an excellent example of a workable and practical traceability programme for replication into Africa for the purposes of economic and social improvement. Deloitte wishes to thank Dr Alexander Toto of the Directorate of Veterinary Services of the Namibian Ministry of Agriculture, Water and Forestry for his personal contribution to this study, without which information this study would not have been possible. The case study is an abbreviation of his comprehensive implementation plan.

In the case study, a very structured approach was followed in the implementation of NamLITS in five regions of Namibia, i.e. Caprivi, Kavango, Ohangwena, Oshana and Omasuté as well as the areas of Kunene and Oshikoto regions which are situated North of the Veterinary Cordon Fence (VCF).

The implementation plan covered the system design, legislative framework, governance, operational responsibilities, stakeholder management and outreach, implementation timetable and resources required as well as monitoring and evaluation, research and development. The implementation in the Northern Communal Areas was specifically designed to increase the regions’ contribution to Gross Domestic Product from livestock sales and to alleviate poverty and ensure food security. The ultimate goal was to enable access to lucrative livestock markets for the pastoral community by means of a proactive traceability system that supports the eradication, control and risk management of specifically Foot and Mouth Disease (FMD), Contagious Bovine Pleuro-pneumonia (CBPP) and Bovine Brucellosis.

The NamLITS was established in early 2005 for use in supporting the implementation of the animal identification and traceability system in the FMD free zone. The system consists of a central computerised database with an extensive network linking workstations at most Directorate of Veterinary Services (DVS) offices to the database in Windhoek.

A second phase of NamLITS for implementation in the Northern Communal Areas (NCAs) was initiated during June 2010 where the current NamLITS database and network infrastructure would be utilised. This second phase is set to be completed in October 2012. Enhancements of both the functionality and structure of the database and network infrastructure will however be required. The current database provides DVS with the capacity to control and monitor animal movements through the issuance of movement permits and notification of movements. This enables DVS to trace-back a diseased or suspected animal through animal registration and recording of animal movements between establishments.

System used in identification

Official identification of animals is done by means of animal identification devices as required by international standards, such as an electronic ear tag that comprises a radio frequency identification (RFID) for the purposes of automated data input and a visual plastic ear tag that supports a system of remote pastoral production, with limited or no technological support. All cattle are required to be identified by a primary and secondary ear tag by the age of six months. The primary identification is a Radio Frequency Identification Device (RFID) tag in the left ear and a conventional visual plastic tag in the right ear. The RFID and visual ear tags will have the same unique number and will be used in the NamLITS NCA subject to conform with standard specifications set by DVS for official cattle ear tags. Suppliers of cattle ear tags in the NamLITS NCA must be able to demonstrate that the technology solutions (ear tags...
or RFID readers) they offer are aligned with international guidelines as set out by the World Organization for Animal Health (OIE), International Committee of Animal Recording (ICAR) and the International Organization for Standardization (ISO). Official cattle ear tags in the NamLITS NCA are supplied by the Ministry of Agriculture, Water and Forestry (MAWF) through the Directorate of Veterinary Services. The management of the inventory of ear tags through the NamLITS database ensures accountability for all ear tags supplied. Eligible cattle in the NCA are tagged as part of a specific campaign after which tagging takes place during annual vaccination campaigns or community visit-based surveillance activities. In cases where handling facilities are in disrepair, mobile crush pens are used.

Experience gained in Meatco’s Ekwatho Scheme in Namibia demonstrated the benefits of using RFID enabling technology in terms of the speed and accuracy of capturing data which was a deficiency in the early NamLITS system due to transcription errors of paper-based and visual tag recording. As a backup system, branding of animals will continue.

Dr Toto states that, "the animal identification number (AIN) to be used will be a unique, 15-digit RFID number. The first three numbers (516) are the UN/ISO 3-digit country code for Namibia, followed by 12 digits that are available for the animal’s unique identifying number. The NamLITS NCA will utilize these digits to create a unique AIN within Namibia as follows: two digits representing the brand area indication symbols, for example EC (01) followed by three zeros (000) and a six-digit serial number, 123 456. A combination of the two digits representing the brand area indication symbols and a six-digit serial number forms the unique AIN. The example given above will read as 516 001 000 123 456 and will be imprinted on the both ear tags as EC 123 456. The code NAM in the logo on the visual ear tags is the ISO 3-alpha country code for Namibia. Since the area of animal identification is evolving, details on current specifications of the official ear tags to be used in the NamLITS NCA will be available from the Chief Veterinary Officer (CVO)."

The key functions of the current NamLITS database include the following:

- User access control and managing business units;
- Maintenance of the register of establishments;
- Maintenance of the register of livestock keepers;
- Monitoring use of official ear tags;
- Registration of tagged cattle;
- Maintenance of a central livestock register;
- Managing movement restrictions on establishments and keepers;
- Livestock import controls;
- Recording slaughter data including carcass traits;
- Monitoring animal movement history;
- Providing a number of key reports required by DVS and the industry;
- Providing access to the stock brands register;
- Data confidentiality with restricted access to DVS officials.

Currently, the NamLITS database interfaces with abattoir and auctioneering information systems, the Stock Brands Register and the Central Ear Tag ID allocation system. The NamLITS NCA is going to introduce additional interfaces with other databases which will ensure that the database becomes a good source of standardised static data on establishments, keepers and herd and flock identification codes by using the same fundamental epidemiological information regarding livestock, establishments, keepers and animal events.
Figure 10 Training and Extension
From an African perspective it is critical that strategies for controlling and eradicating trans-boundary animal diseases exist. Information systems are required to be very reliable, complete and cost-effective. To enhance the animal disease surveillance capabilities, common data elements and a new field data acquisition system under the NamLITS NCA have the potential to ensure that separate databases within DVS can communicate with each other. The NamLITS system will link registered establishments where animals are kept with identification data which will enable officials to have access to reliable information in the event of disease outbreaks. This is in order to trace back the origin of a diseased animal as well as possible contact with other animals.
With regard to separate databases, a further advantage can be gained should the current performance recording scheme and livestock pedigree registry adopt the animal identification and traceability system, as this would support interfacing between NamLITS, stud breeders and performance recording.

In order to support the DVS team, a technical assistance consultancy is required for a period of 12 to 18 months to strengthen capacity and assist with implementation and deliver results as addressed in the scope of work and terms of reference.

Roles and responsibilities

In Namibia a four-tiered schedule is used for the implementation and operation of the system. These tiers are:

- National government
- Industry participants
- Donor agencies / funders
- International community.

Government

Government is critical to the successful operation of the system and as such would be responsible for coordinating the system design, developing and facilitating an implementation plan, determining the infrastructure required and managing the NamLITS NCA. Communication, training, technical support and problem-solving support to the relevant players are all part of ensuring a smooth roll-out of the programme. Development of policy, review of legislation and compliance monitoring ensures that the correct legislative environment is created to implement and evaluate the system against performance standards. Maintenance of the system’s integrity, accuracy of records, and facilitation of access to the NamLITS database is an integral part of management of the system. Government through the different Ministries of Veterinary, Extension, Health and Legal Services is responsible for the following:

- Zoning of diseased and disease-free areas;
- Registration of keepers / owners as well as premises where animals are kept;
- Identification of animals / tagging;
- Animal movement control and monitoring;
- Governance and acts as competent authority;
- Legislation regarding animal identification, regulation of stock brands and stock theft;
- Act as implementation unit through Veterinary Services;
- Serve as trainer, communications channel and facilitator.

The use of regional and tribal councils assists with the dissemination of information and will also serve as an additional resource to administer the system and to assist with movement control.

Industry participants

- Meat Board of Namibia

Contribution to the design, implementation and coordination of the system. Maintain the integrity of the ear tag ordering system and assist with the development of fund arrangements. Manage contributions from livestock keepers and industry, and provide funding for technical support, research and development. Monitor market responses and review costs/benefits and regulatory impact.
Owners and keepers of livestock
Their responsibility is in terms of complying with the system requirements such as keeping livestock registers up to date, rounding up cattle and presenting them for tagging, and complying with notification requirements for animal movements and for other animal events. Understanding the NamLITS NCA, its technology and their obligations will be addressed by means of training of the owners / keepers.

Abattoirs, auctioneers and traders
These key players will not only be involved with compliance but would be required to play an active role in research, planning and review of operations and training relevant staff. Testing of their systems and assisting DVS officials with problem-solving will be an ongoing process. In order to operate the system they will also be required to purchase RFID reading equipment and accessories and to acquire computers and appropriate software. Regarding compliance they will have to supply accurate details of buyers and sellers of livestock, notify animal movements and other animal events, check cattle identification and carry out documentation checks and report non-compliance to DVS officials.

Livestock transporters
They have the same requirements as abattoirs, auctioneers and traders, except for animal movement and events reporting.

Farmer organisations
As representatives of farmers, their contribution to the system design, implementation and coordination would be crucial. Assisting with problem solving, support for communication and training activities, and reporting of non-compliance would also contribute towards a sense of ownership.

Donor agencies
The Millennium Challenge Account (MCA) Namibia Compact, providing grant funding for public investments in education, tourism and agriculture (livestock and indigenous natural products), was signed on 28 July 2008 between the Republic of Namibia and the US Government, acting through the Millennium Challenge Corporation (MCC). An amount of US$304.5 million is available for development in the target sectors, over and above current government allocations and assistance from other development partners. Under Activity 2: Livestock Support, there is the overall aim of improving livestock productivity and incomes. This investment targets key constraints to increased profitability of NCA livestock operations:

- Reduction of animal diseases and mortality through improved availability of public veterinary services;
- Introduction of a traceability system that enables herd monitoring, which is one requirement for livestock access to international markets;
- Shrinking of costs and losses incurred from farm gate-to-slaughter (i.e. in the transport, quarantine, and marketing of cattle). Remediation of constraints will directly increase value received from livestock production and increase the average off-take rate in the NCAs.

International community
Involvement of the international community in terms of organisations that regulate world trade and health (animal and human) standards is invaluable. These are the World Organization for Animal Health (OIE), International Committee of Animal Recording (ICAR), the International Organization for Standardization (ISO), the Codex Alimentarius of the Commission of the European Union (EU), World Health Organization (WHO) and the World Bank.
Communications and outreach plans

All communications media, i.e. radio, television (prime time advertising and documentaries), printed media (media releases, fact sheets, circulars to staff and stakeholders, Government Gazettes, training manuals, industry newsletters, daily newspapers and direct mailing), emails (key role players’ mailing lists), computer websites as well as field community visits, training workshops and demonstration sites, will be used as a means to convey information and updates.

Besides the extensive communication plan other key success factors in the successful implementation of the NamLITS NCA would be competent veterinary services which are staffed by extremely well-trained professionals backed up by a trained cadre of para-veterinarians and animal health workers as well as highly qualified technical personnel in the veterinary laboratories (35). A further contributor is the close cooperation that exists between Veterinary Services and other stakeholders such as the Meat Board of Namibia, Namibia Agricultural Union and other role players in the industry.

Additional benefit is derived from the following:

- A five-year experience with phase one of NamLITS where most practical problems were identified and solutions generated;
- Strong support network from organised agriculture and farmers;
- Strong back-up system in terms of the agricultural extension services in existence;
- Assessment of the bolus RFID system by Dr Toto in Botswana and the invaluable contribution that he and fellow authors are making to the government of Botswana

Traceability systems available in Southern Africa

Background

A traceability system that was developed in South Africa adds additional value to the systems described above. Value added is in terms of management functionalities over and above the normal required veterinary, health and movement control. It is a system where data may be captured manually and electronically in an offline, batch mode or real-time upload and download. To maintain the highest level of traceability, tamper-evident, non-re-usable internationally approved tagging devices are used. The business principles that are incorporated support the current and future development of the system application and provide market access to the role players (36).

Up-to-date data records and online access to various reports are required by animal health officials (private and government) and the system utilises technology in the agricultural industry ranging from sophisticated to less sophisticated operations, as well as peri-urban through to rural areas where IT functionality is often limited due to a lack of infrastructure.
Traceability in the system is based on a unique item-level serial code that is linked to a specific item for the lifetime of that item. Through identifying and tracking these items based on their unique identifier codes, regulation and control is enabled of all the functions and compliance factors associated with each. The approach to traceability of animals is focused on the entire life cycle that includes the life span of both the animals and the associated animal products.

**System**

In the development of the system it was realised that a “web-based” system was not a viable option for the environment in South Africa and Africa as cellular and Internet connectivity is restricted in the remote agricultural regions. Currently web-based operations as provided by banks, medical organisations, etc. can really only be utilised in the urban or more populated regions. A single centralised location of all information is necessary and the design of the system must replicate all data to a central database as indicated in Figure 12. This figure indicates the various components of the GMP system desktop client software represented visually on the left and the central server represented on the right.

![Figure 12 High-Level Solution Architecture of GMP System](image)

- It is possible to use the desktop client in total independence of the central web application as data are replicated back to this system whenever an Internet connection is made. The central server enables the easy dispatch of livestock between farms or organisations with a complete paper trail, inclusive of a full history of livestock health. This central server allows government agencies access to critical information in order to perform their mandated functions.

- The system is designed to be used at the handling facilities of livestock, which allows the operator to be operational at all times and with the capability to do updates to the central database at any convenient time or destination.
Simplistically stated it can be compared to a desktop application such as Microsoft Outlook where emails may be written offline to be sent later when connectivity is established.

A uniquely patented coded numbering structure is used and as such an affordable system and cost-effective tagging system was created for Africa. The system also allows for the integration of EID and RFID equipment to accommodate commercial livestock farmers.

The use of a unique patented code in association to a tamper evident, non-reusable tag enables the system to focus on traceability. The process for the generation of the ID tag, marking and issuing is illustrated in Figure 13.

![Diagram](image)

Figure 13 The Process for the Generation of the ID tag, Marking and Issuing

The process flow is as follows:

- A hardware security module generates a unique code by means of a random number generator that is FIPS 140-2 Level 3 certified and uses the same type of technology as secure banking transactions.\(^{(37)}\).
- To ensure the integrity of the codes, cryptographic techniques are used to transmit codes to the central database and the manufacturer of the tags and a single tag is made for each code. Manufactured tags are verified and activated on the central server and delivered to the distribution channel and end-user where livestock is tagged. The captured data is synchronised on the end-user’s unique profile with the central server by means of a desktop application. The desktop application software is supplied free of charge under certain terms and conditions, and
the basic requirement is access to a computer and some tags. Due to this fact, entry-level barriers to use the system are low and easy. Livestock inventory control, and farm management systems are some of the additional features that are offered and add value for the producer.

**Key product features**

- **Hierarchical reporting**
  The GMPBasic solution has been designed with a hierarchical reporting structure. Categories such as gender, species, breed, health, geographic location and different reporting levels such as national, provincial, individual user, product use, test and procedure results are possible from a traceability perspective. Any of the fields in the database can also be subjected to full inquiry.

- **Critical identification standards**
  For the purposes of the identification of high-value livestock, DNA traceability can be captured via laboratory results from a central web-managed platform.

- **Lasered two-dimensional barcodes**
  In order to enhance the automated data capture, a two-dimensional barcode which is laser marked, is used with human-readable digits on the visual ear tag. These tags can be used in conjunction with EID tags or combinations thereof. If scanning equipment is not available the visually readable numbers enable a user to enter the tag number into the system via the computer keyboard. The unique code can be linked to this number at a later stage for authentication and verification purposes.

- **Counterfeit tag codes**
  In order to guard against counterfeit codes the system identifies and flags potential counterfeit codes based on duplication, code structure deviations and other non-authentic codes.

- **Human readable component**
  The readable ear tag serves as a back-up system of identification for manual paper-based data capture.

- **Data capture**
  Updating and capturing of data is done through a client-based database via server (web application) with the central database. Registered third parties are allowed to update information on the central database based on a registered identification number and level of access for the respective third party. This enables the system to be used on national, provincial and regional level with a client’s own information accessible through direct interface with his/her personal database.

- **Registration**
  As livestock are registered, the identified units can be traced and movement requirement documentation can be generated as required for the different role players in the value chain.

- **Livestock data management functions**
  Additional livestock management functions such as health management, interventions, reproduction, and management prompts for actions to be taken are all added benefits for the producer which can improve acceptance of participating in a livestock traceability system.

- **Third-party users**
Flexibility of the system enables health officials to register as users and to upload information. Use by a third party is recorded by means of ID, date and time in order to track access to the system. This enables officials to record relevant information on behalf of producers that do not have direct access to the system.

- **Paper-based data capture templates**
  To safeguard against events such as the unavailability of computers or due to excessive costs of hardware or computer illiteracy, the system has been designed to be paper-based as well. Data can then be recorded by a third party.

- **Affordability**
  The system operates on a similar basis as cell phones on a pay as you use basis where each ear tag pays for use of the system. As ear tags are intended for use over the productive life of an animal costs are minimised. Licence fees are not applicable either and updates can be obtained by means of CD or the Internet.

**Farmer participation and buy-in**

Due to the livestock management activities that farmers are able to enter, they willingly participate on a daily basis to update the system with:

- New birth records and animal registrations;
- Regular weight recordings;
- Regular procedure or treatment records;
- Mating and breeding records;
- Pregnancy determination records;
- Movement records within their own herds (mobs / flocks etc.);
- Deaths or losses of animals;
- Early warning mechanism whereby the stock theft department could be notified, more quickly;
- Contribute to livestock statistics;
- Contribute to the national statistics of reproduction and production;
- Use more functions of the system to improve their livestock operations (multi-species);
- Grow with the additional functionalities (become more self-reliant rather than spoon-fed as with certain systems);
- Allows more public–private interactions vs purely a dominant public sector service.

**Conclusion / findings**

This case has shown that a systematic and well-planned approach is required where capacity and infrastructure is created in order to establish a backbone for the implementation of a traceability system. A due diligence study of the livestock industry in the country is needed to be undertaken should all relevant information regarding the legal system, infrastructure, capacity and resources, skills level and industry players not be available.

Creation of an enabling environment for a traceability system normally starts with government as all legal and administrative systems must be put in place to create a workable solution. This entails the creation or amendment of specific acts in the legal system that will govern a traceability system. This will include issues such as zoning of diseased areas, tagging and branding requirements, stock theft, registration requirements of specific livestock and keepers, animal health requirements, movement controls and
system governance. It is also critical that the legal system can be enforced. Research into proper policy, standard operating and administrative procedures is required and should focus on the responsibilities of all relevant role players in the industry. Hence, fact-finding missions by policy makers and regulators to the government of Namibia’s Ministry of Veterinary Services are also strongly recommended. Strong inter-departmental and industry communication on a regular basis is required.

Deregulation of markets and export incentives will incentivise role players in the system and will be conducive to FDI which is required to initialise change and improvement. A traceability system that is linked with management capabilities will contribute towards a much higher efficiency of the livestock industry and will result in demand-driven production systems which could mitigate the disastrous effects of drought on overstocked natural resources. Land tenure for agriculture is important as it enables ownership and the ability to improve infrastructure which is conducive to higher productivity of production systems.

Specific provision must be made for training all levels of staff in specific areas of expertise, namely, information technology, veterinary, laboratory, and livestock extension services. Extension officers should also be trained and experienced in livestock, pasture management and financial management. A system that can be used in areas where a shortage of qualified staff exists, is the training of para-veterinary staff who are taught to identify, treat and report diseases in specific rural areas. This system is used to great effect in Sudan where groups of staff are assigned to formally qualified veterinarians. This also serves as the first link in a communications chain between livestock producers and animal health officials. Government should allow and encourage sufficient participation of the private sector as they alone are not able to implement a broad enough scope.

In the initiation of traceability systems, private partners can serve as the ideal first phase where systems can be installed in feedlots as infrastructure already exists and the time frame of feeding is acceptable to the international health authorities’ quarantine time. The system can then be expanded to regular suppliers of such feedlots and incorporate transporters and auctioneers as a further phase. As initiators, partners will play an invaluable role in the research, planning, problem solving and review of operations and in training relevant government officials and staff. The identification system to be adopted should be made mandatory for all those who wish to engage in livestock marketing activities in the region. It must be mainstreamed in the marketing process. For instance, only pastoralists who participate in the scheme access subsidised state animal health services (38).

Back-up in terms of public-private initiatives is important, as is the use of private participants as funders and enablers. System choice is crucial – management capabilities/ functionalities, robustness/ ruggedness with a proper platform, and hardware and software are important. In the procurement of equipment, hardware and software, care should be taken in the selection of the actual operating systems. One supplier alone should not be able to dictate terms and conditions.

System design should cater for fast processing as any delays in the value chain, for example movement from pasture to abattoir, due to slow administration, will cause a loss of income. This is detrimental to the producers as they lose faith in and commitment to the system. A measure of the operational efficiency of a system is the time from when the marketing decision is made up to the point of slaughter and processing of the product. Systems currently in use is Africa are proven and even subject to international interest in terms of use. Donor funding from aid agencies and foreign investors will be necessary. Communication and outreach campaigns are crucial to success.
5.3. Irrigation and ICT in Egypt: Application and replication for social and economic benefit

Background

Egypt depends almost exclusively on the Nile River for its water supply. Of this, 85% is used for irrigation. As with the rest of the world, the country’s water demands are ever growing. For Egypt, the solution lies in making better use of the Nile’s existing flows. To do so, the most viable solution is to make the current irrigation system more efficient—while being responsive to farmers’ needs. In order to address the country’s growing water demands, Egypt has adopted innovative approaches to make better use of the Nile’s existing flows.

In collaboration with the Ministry of Water Resources and Irrigation (MWRI), the World Bank, the German aid agency, KfW, and the government of the Netherlands, Egypt has developed the Integrated Irrigation Infrastructure Management Project (IIIMP). The strength of the new approach is that its engineering and institutional innovations complement and reinforce each other. Involving farmer groupings in the management of the new pumping and water control systems means that water gets to the right field at the right time, thus boosting crop yields and farmers’ incomes (39).

Egypt needs a plan to develop its irrigation system and optimise its water sources. The plan should include an economic model that farmers can feasibly implement. A new water-use plan should also raise awareness among farmers of ways to boost the economic benefits of the project and overcome the problem of fragmentation of property ownership.

The government is investigating procedures to develop irrigation systems in the Nile valley and the Delta, especially in areas that use flood irrigation, which requires large amounts of water. Reports indicate that modern irrigation techniques can reduce water consumption by more than 20%. Attention must be paid to the advantages of making the transformation to sprinkler irrigation systems, which should enhance the quality and productivity of land and eventually increase farmers’ incomes.

In a related development, Minister of Irrigation Mohamed Nasr Eddin Allam has presented a report on his ministry’s efforts to overcome the agricultural problems that arose in March 2011 in Lower Egypt as a result of severe temperature changes, which led to an early harvest of winter crops.

In a dry climate, crop plants require water, and it must be provided by the farmer. Irrigation has been the technology underlying many of the world’s greatest civilisations.

Irrigation in Africa poses several challenges. The most common are the lack of foreign investment in projects that not only assist in the establishment of infrastructure such as water supply and pumping stations, but include the actual equipment required to irrigate and cultivate. Linked to these challenges are the use of the correct technology which makes the most efficient use of water and systems that are designed to assist the farmers in optimising production. The secret is the delivery of the right quality and quantity of water as required by the plant.
Soil type, clay percentage, mineral deposits such as lime (calcium carbonate) or salt (sodium chloride), mineral content of water, design of the irrigation system and other factors such as high evaporation of water in dry climates typify many of the management issues that need to be dealt with in an irrigation scheme. As water is used on crops, it spreads out as a thin sheet, exposed to the surface. Much of it may evaporate, making it more saline. It may dry up altogether, leaving a thin layer of salts on and in the soil. Even under normal circumstances, plants absorb moisture from the soil, leaving behind excess salts. Eventually salts build up in the surface soils until they become infertile. Over time, therefore, soils in dry irrigated areas tend to become salinized.

The only way to deal with this problem is to apply enough water so that salt is flushed off or through the soil. The flushing must remove salts from the area altogether, along with natural or artificial drainage. In well-drained areas with a dry season and a wet season, natural flushing takes place each year. But in poorly-drained areas, over-watering simply mobilizes the salt while the water table rises to ground level. Capillary action draws the saline water to the surface, where the salt dries out as a surface deposit, and the problem is made worse rather than better. Once the soil is saturated, with water up to the surface, there is no way to leach salts out of the soil, and the fertility of the region is destroyed unless major drainage channels are built to carry away the salt. Even flushing may not be a net environmental plus: flushing simply delivers salt somewhere else, perhaps to downstream users, or into groundwater supplies. Flushing also leaches away soil nutrients with the salts.

Therefore, irrigation can only be maintained on a long-term basis in the following conditions. Water is applied in such a way that salt is not allowed to build up in the soil. Usually, this means that a lot of good-quality water is applied, and that drainage is rapid and efficient. Soils need a large infusion of fertilizer, to balance the flushing that is required to keep them salt-free.

A region that can be irrigated on a long-term basis thus has:

- An abundant supply of good water;
- Well-drained soil;
- Good regional drainage;
- A supply of fertilizer for the soil.

If any of these conditions fails, the system will eventually fail. Such failures have brought down civilisations that solved the engineering and logistical problems of designing, building, and maintaining irrigation systems, but neglected the long-term effects of salinization or nutrient depletion. The major success stories for civilisations based on agricultural irrigation are Egypt and China. Technology to address the issues of water quality, quantity and management of salinity is therefore one of the key drivers of any irrigation system. This is especially relevant to Africa due to the medium to high clay content of soil, which is characterised by slow drainage ability and is thus prone to salination.
Egypt and the Nile

Ancient irrigation styles depended very much on
the physical geography and geology of the area,
and the engineering skills available. All irrigation
systems depend on taking water from natural
sources and diverting it to artificial channels or
ponds where it is applied to crops.

Egypt depends almost entirely on 55.5 billion
cubic meter per year of water from the Nile River,
as 97% of Egyptians live on just 2.5% of its area.
The prosperity of the Nile valley civilisations has
depended throughout recorded history on the
efficiency with which the central government has
organised the best use of the river water. Crops
could be stored after years of abundance, for
example, and irrigation schemes could be both built and maintained.

The Nile receives its water from the tropical highlands of Africa. The river receives no tributaries at all for
the last 1,500 km of its course across the Sahara Desert to the Mediterranean. In Egypt, far from its
sources of water, the Nile has no sudden flood-wave crests. The High Aswan Dam presently ensures
Egypt's annual water needs for irrigation and other purposes with full control of discharge. The release of
water for irrigation is adjusted throughout the year to provide all agricultural areas with sufficient water for
crop needs. Distribution canal cross-sections are designed to serve command areas according to
specified water duties. Masques (private canals) are served from distribution canals which are on a two or
three-turn rotation.

The time interval between periods when water is turned off and when it is later turned on depends on the
cropping patterns and seasonal climatic conditions. The on-days of a canal rotation are considered 24-
hour periods (starting at sundown) without any adjustments between day-time and night-time use. The
number of on-days in a turn is sometimes modified to meet farmers' requests for more irrigation water.
The water supply for any given area is monitored by observing water surface levels in delivery canals.
The water is typically delivered from 50 to 75 cm below the ground surface of the fields, so irrigators must
lift the water into the land. Delivery canals are closed for approximately one month during the winter to
permit maintenance and construction of structures. In general, the winter closure is preceded by a
general irrigation for ten days.

Farmers are not required to pay for water. Its use along the masques is determined by custom, which
usually favours the farmers at the head of the masque. Similarly, masques at the head of a distribution
channel have an advantage over those at the tail end as a farmer is free to distribute the water over his
fields by his own method. Generally, he distributes the water through a marwa (field ditch) to small
banded units called basins.
The surface of the fields may be furrowed for row crops or smoothed for basin crops. Excess surface water may be drained off into open field drains or, in some cases, back into the masque. The best environment for crop production is achieved when the plants’ root zones are kept sufficiently moist. Either inadequate or excess water in the root zone causes plant stress and reduces yields. Good irrigation management should maintain optimum root zone moisture conditions without using excessive water. Poor irrigation management wastes water, sometimes wastes plant nutrients, contributes to potentially harmful high water table conditions, and tends to waste the labour and energy required for lifting excess water to the field and from the drains. Good on-farm water management requires level fields, appropriately designed on-farm distribution systems, and knowledge of when to irrigate and how much water to apply. It also requires a dependable source of water, available when needed in a quantity which can be distributed efficiently over the farmers’ field. Consequently, there must be close communication and interaction among all farmers served by a masque and with the district irrigation engineer who regulates the water upstream from the masque intakes. The potential for achieving benefits from better water management is substantial. Approximately half the water resources available are presently required for evapotranspiration by crops. Of the remainder, most is lost from the system in the delivery process through seepage, evaporation and flow-through. Any measure which conserves water and reduces losses provides an opportunity for increased agricultural production through horizontal expansion as well as reducing drainage costs (40).

Due to the construction of many control structures, including the High Aswan Dam, radical changes have occurred in the traditional irrigation systems due to the move from basin irrigation and a single crop per year to perennial irrigation with multi-cropping per year.

Management of the delivery and drainage systems has become more difficult under conditions of year-round irrigation and changes in crop patterns. Due to the fact that the Nile is a closed irrigation system, as well as the mentioned changes, several problems have arisen that had to be surmounted. Amongst the most relevant and are:

- Salination of soils through leaching of agricultural lands and saline intrusion from the sea with associated loss of irrigable land.
- Decreased efficiency of water usage due to old technology and silting of supply channels. Field water efficiency values are typically around 50%, which implies that half of the water that is applied is lost.
- The uncontrolled dumping of industrial and domestic sewage and solid waste in the drainage system increasingly constrains the reuse of drainage water.
- Recirculation of polluted water for irrigation use which compounds the salinity of soils.
- Lack of continuous flow of water (as mentioned previously), which hampers the correct scheduling according to crop needs. This is exacerbated by extreme high temperatures and thus evapo-transpiration in the region.
• Decreasing crop yield due to drainage problems with associated financial decline in agriculture.
• The Egyptian Public Authority for Drainage Projects (EPADP) is the main public sector body responsible for monitoring and evaluation of technical aspects of drainage such as
• Decreasing crop yield due to drainage problems with associated financial decline in agriculture;
• Studying the condition of agricultural lands in Egypt and determining their need for surface and sub-surface drainage as well as determining the priorities for execution of projects;
• Collecting data and executing studies and research on the design of sub-surface drainage networks and the construction of surface drains or remodelling the existing ones and constructing the required civil works on these drains;
• Designing drainage pump stations and their power supplies and rehabilitating old sub-surface drainage networks, and prioritising rehabilitation projects;
• Preparation of contracts, technical specifications and advertising them in public tenders, and supervision of the execution of all drainage works;
• Conducting surface drain maintenance and weed control to ensure effective drainage network operation and preserving their cross-hydraulic sections according to the design;
• Maintaining sub-surface drainage networks and providing the required equipment to execute sub-surface/surface drainage networks, pump stations in addition to maintenance and weed control equipment by mechanical and biological means;
• Cooperating with the Drainage Research Institute (DRI), and the specialised institutes in the drainage field to study the problems of sub-surface drainage and find the best solutions to overcome problems in order to improve the sub-surface drainage network performance;
• Training of staff in order to equip them with skills to use the most modern equipment. Two Drainage Training Centers (DTCs) exist in Tanta and Alexandria where specialised training is given. Besides training EPADP staff, DTC provides training for private and public contractors to reinforce their capacity to execute EPADP plans. DTC offers 43 training courses in applied civil and mechanical engineering and agricultural engineering.
• Technical development has been accompanied by administrative development that coped with the age and use of the modern machinery like personal computers (PC’s) and the establishment of management information systems and information system databases in addition to establish wide area networks to link the five sectors of EPADP spread nation-wide with headquarters, to facilitate data exchange, follow up on works and support decision makers.

The first phase of the project of improving agricultural production through better drainage, where 248,000 hectares have been provided with new sub-surface drainage as well as surface drains on more than 311,000 ha, has resulted in crop yield increases of 20%. Estimates are that drainage accounted for 15 to 25% of this yield increase. A further benefit was the re-use of drainage water with a huge increase in water use efficiency according to the National Drainage Programme (NDP) 1 and NDP 2.
EPAPD’s remarkable physical progress over the years was directly related to its command and control system as they were given full executive autonomy and developed the procedures necessary to exercise it. According to plan, by 2012 the last new horizontal pipe drain will be installed. In all probability the EPADP will perform more of a regulatory role in the future with as their core function of design and construction comes to an end, and maintenance and drainage will be passed on to water boards and private contractors.

**Integrated Water Resource Management Action Plan**

Demand for water is growing while the options for increasing supply are limited. Egypt faces the challenge of improving the productivity and sustainability of water use. To respond, the Ministry of Water Resources and Irrigation (MWRI) has been implementing an Integrated Water Resource Management (IWRM) Action Plan. Its key strategy is to improve demand management.

The Integrated Irrigation Improvement and Management Project (IIIMP) is an important measure of the IWRM action plan. IIIMP is being implemented on 500,000 acres (feddans) in the Nile Delta covering the command of two main canals, Mahmoudia and Mit Yazid. The project aims at improving the management of irrigation and drainage in the project area and increasing the efficiency of irrigated agriculture water use and services. The main interventions of the project are improving irrigation and drainage systems and improving the water management institutional structure. As most farmers are smallholders – with 98% owning less than two ha of land and no new major water resources to develop – expansion of land is sought from increased use of groundwater and from intensified reuse of drainage water. At the same time, urbanisation is progressing in large cities as well as in small rural centres. This translates into additional demand for domestic and industrial water but, more importantly, into a larger pollution load and an increased need to address water quality.

Drainage development in Egypt must be viewed in this context: how to maintain the productivity of the water resource system in a situation of increased demand and environmental pressure on the resource.
The IIP included three types of improvements or innovations:

- First: Introduction of continuous flow in secondary channels to supply a constant delivery of water as it gives more flexibility in water management, in order to grow high value crops. Reliability is thus established.
- Second: Providing a single lifting point. The low-lying tertiary water systems (mesqas) were replaced by pressurised/elevated systems which has led to better water distribution equity and reduced operational cost. This was done by taking advantage of the relatively good electrical transmission and sub-transmission infrastructure in the Nile Delta and the economic efficiency, life span, and capital and running costs of the electro-pumps.
- Third: Piping tertiary canals. Earthen open tertiary canals were converted into piped canals as this allows for pressurised water delivery and reduced seepage losses, preventing discharge of solid waste and sewage into the tertiary system, and saving approximately 2% of the total command area.

Table 7 Average Incremental Yield and Incomes by Crop

The benefits derived by farmers participating in the study were both in yield and in profitability as can be seen in Table 7. Crop yield improvements ranged between 12 to 25% while improvements in income ranged between 20 and 64%.
As an extension of the above project, the World Bank is to extend a $100m loan to Egypt to support its farm-level irrigation modernisation project (FIMP). The project is being carried out as part of Egypt’s strategy of sustainable agricultural development 2030 to modernise irrigation on five million feddans (approximately 2.1 million hectares). The project aims to improve access to higher-quality water for around 140,000 small-scale farmers on 200,000 feddans (84,000ha) in the command areas of Mahmoudia, Manalifa and Meet Yazid, located in the Nile Delta area of the country. The project comprises two components. The first component supports marwa (farm-level ditches) and farm-level irrigation modernisation in the command areas noted above. In these locations, branch canal and mesqa (tertiary channels that receive water from branch canals) improvements have been carried out or are currently ongoing.

The project will build ditches, branch canals and enhance the knowledge of farmers.

It is thus apparent that commercial agriculture in Egypt compares favourably with the rest of the world. The advantages that Egypt has from an African continental perspective, is that they have vast experience in the creation of solutions with regard to problems that can and will arise under irrigated farming. The most relevant challenges in the application of irrigation where technology can assist are:

- Design of continuous flow and reticulated irrigation systems that have a high efficiency of water use;
- Determination of irrigation water quality (mineral content, residues and contaminants);
- Determination of soil mineral content with specific reference to salinity;
- Determine the exact amount of nutrients required by plants under irrigation (macro as well as micro elements);
- Irrigation scheduling and moisture content of soil and plant water usage / requirements;
- Soil mapping and topography;
- Infrared photography to indicate irrigated areas under stress.

An additional factor that is important to take note of is that the issue of self-reliance of projects or large commercial ventures is deemed to be paramount by farmers. The role of government is extremely important; they are seen as the creators of an agriculture-friendly environment by means of:

- Training of officials for extension service delivery;
- Training of irrigation and engineering specialists;
- Correct legislation for water rights;
- Investor-friendly environment to attract new entrants in agribusiness;
- Making land and resources available to young new entrepreneurs;
- Conducting research and planning new projects;
- Maintaining the main irrigation service infrastructure and ensuring the continuous supply of water in order to be able to do irrigation scheduling properly;
- Very close cooperation between all government departments that link with agriculture.
Practical ICT in Egypt – Irrigation technology

Businessmen in Egypt were invited to contribute to economic, social and agricultural reform through desert reclamation during the late 1980s. The aim was to increase arable land, provide new jobs, and plant new crops that could be exported. As a result the Maghraby family took the initiative and acquired 500 acres of land in the Nobaria area – north of Cairo – in a desert reclaimed area that is almost 80 km from Alexandria. The establishment of this area was a green-fields operation and has been developed from actual desert to the current 8,500 acres fully irrigated and export-oriented agribusiness.

Magrabi is therefore an ideal example of the development of a full-scale economically sustainable unit that used technology to its advantage in order to reach the current status. During a visit to Nobaria at Magrabi Farms it was found that they were completely independent in terms of being able to conduct all the functionalities required for good soil, water and multi-cropping management. The unit comprises 8,000 acres of irrigation inclusive of enterprises such as flowers, figs, pomegranates, citrus, mangoes, vegetables (lettuce and peppers), herbs and grapes, to name but a few.

There are also fully equipped laboratories with the capability to:

- Analyse soil and leaf samples in order to continuously monitor nutrient requirements for optimal production and cost efficiency;
- Conduct gas chromatography tests to determine the presence of pesticides and other contaminants in soil, water and fresh produce;
- Determine water and soil acidity for buffering and liming;
- Test the electro-conductivity of water (salinity);
- Grow and identify bacteria and fungi for disease identification.

The laboratory also contains an insect predator breeding centre for biological control of pests for the purposes of conducting organic farming. All of the aforementioned forms part of an integrated quality control programme, as Magrabi Farms exports produce to 38 countries.

The whole farm has a fully integrated reticulated irrigation system which is managed by an irrigation engineer. All water passes through filters and all bypass water is tested for purity as fertigation is a normal practice. Efficiency of water usage is continuously monitored. As an indication of efficiency, an average of 450 cubic metres per acre is used on the grape enterprise through correct management practices and drip irrigation.

An on-site weather station for minimum maximum temperature monitoring and evaporation pans to determine moisture loss are used to facilitate the correct irrigation scheduling in conjunction with tensiometers. A
fully automated and programmable computerised irrigation system is in place to facilitate optimal use of water.

**ICT systems and programmes**

Regarding the matter of disseminating information that is gathered by available technology, various options are available for use. In a study of the mapping and preliminary evaluation of ICT applications supporting agriculture development by PS Krishna Kumar, several available options were examined that were in use in Uganda, India and Indonesia.

The purpose of the study was to determine which medium (from the various options such as telephone, radio, SMS, Internet, etc.) would be the most effective to reach farmers with timely agricultural information to increase knowledge, and what minimum literacy skills are required by small-scale farmers in order to use ICTs.

Further questions that were required to be answered related to sharing and exchanging of agricultural information among illiterate farmers, how ICT solutions could be improved as well as how agricultural knowledge is created, captured and shared.

![Available communication systems for dissemination of information](image)

**Figure 14** Available communication systems for dissemination of information
Regarding the position in Egypt, the Central Administration for Agricultural Extension Service in the Ministry of Agriculture and Land Reclamation (MoALR) is the primary source of information and extension in Egypt with an estimated 7,421 staff members. The clientele served and targeted are small to medium-scale commercial farmers, small-scale subsistence farmers, large commercial farmers, farmers growing rice, cotton, vegetables and fruits, rural youth, rural women (nutrition, health, hygiene), women farmers, young (adult) farmers as well as landless farmers.

ICT staff number a total of 229, of which 113 are employed in print and mass media and 116 in computer-based information technology. Of these, 10% of the extension field staff have Internet access. The main use of ICT in Egypt is for the production of information bulletins and fact sheets (771,000 copies), workshop and training materials, audio-visual educational material for use by extension staff (260), extension materials and publications available online (193), TV programmes (52 per month) as well as radio programmes (16 per month).

Current training systems do not have the capacity to reach enough people and exclude state-of-the-art technologies and know-how. E-learning could be a tool to reach more people, including more women. The estimated number of Internet users in Egypt is 11,414,000 or 14.5% of the population (2008) \(^{(44)}\).
An institution-based information system, VERCON (Virtual Extension Research Communication Network), an FAO-designed Internet-based network, was established during August 2000 in order to improve information-sharing between research and extension staff. VERCON was merged with the Rural Development Communication Network (RADCON) in April 2004 which served a wider stakeholder community beyond government services to include other public and private information service producers and the media. The four main categories of stakeholders are the farmers, extension services, researchers and statistical information providers. The project also sought direct participation of all gender groups in farming in the communications network with an envisaged geographic coverage of 116 sites in 15 governorates. A current live internet link to VERCON is illustrated in the figure above.

The main objective of the system was a virtual extension and research communications network which could be utilised to improve extension services to farmers, in particular resource-poor farmers, in order to increase food production and thus income by means of improved capacity of the extension agents. The extension agents are represented by the Central Administration for Agricultural Extension Services (CAAES) and the Agricultural Directorate (AD) at governorate level. Use of the VERCON system is based on the following:
- AD: Review of problems collected from extension centre that have been reported either by farmers or staff, providing documented solutions and use of VERCON in farmer extension seminars.
- CAAES: Publishing all extension documents through its media centres and obtaining solutions to growers’ problems from specialised institutes, which have direct connectivity to VERCON, and then documenting these problems in the growers’ problems database.
- VERCON functions as a depository and database for problems, solutions and recommendations, new research findings, and the dissemination of information and training back to farmer level.

Due to the success of VERCON, the RADCON project has taken the project to a broader scale, by expanding the network with diversified content and a wider range of stakeholders, including farmers’ organisations, youth centres, universities, NGOs and the private sector, where a more participatory methodology was used by integrating Internet-based technology with local and community media to establish an interactive information system based on two main interlinked components of an online agricultural and rural development information and communication system and a wide network of focal groups and village facilitators, in seven governorates of Egypt.

At inception a comprehensive training of trainers curriculum was developed and implemented. A community media strategy supports the project ensuring that the project is known and new developments are shared within the pilot areas. A dynamic online communication system and library is now in place to support the face-to-face work of the village facilitators and extension agents in agriculture, health, nutrition, and other areas (45).

RADCON now links service providers, research and extension services as well as the private and public sectors to the farmer at 50 different centres. It is in fact an innovative rural communication system (Figure 15), as extensive use is made of trained village facilitators who work with farmers in order to link rural communities and enable participation in the generating, developing and sharing of knowledge. Gender equality is recognised and at least one man and one woman per village are trained as facilitators (women in Egypt make up 53% of the agricultural labour force and it is vital that they be taken into consideration as the share of female-headed households is increasing in Africa and as they tend to remain responsible for growing food crops and other post-harvest activities ranging from crop preservation to processing and storage). These facilitators are supported by a network of experts and mentors (both on and offline), and are not confined to agricultural extension and research alone but include those working in community development, rural enterprise, nutrition, women’s affairs etc. An additional benefit is that RADCON is supported by the FAO Research and Extension Division (NRR) and the Knowledge Exchange and Capacity Building Division (KCE) and funded by the government of Italy.

Table 8 shows the actual content of the RADCON programme in terms of the different sub-systems used for the generation and dissemination of information plus the objective that is to be achieved. The relevant responsible key organisations are identified. All the sub-systems are designed to convey information/skills improvement to levels ranging from landless farmers up to a commercial level of farming.
Table 8 Stakeholders, Objectives and Organisation

It is clear that proper planning and implementation was done in order to cater for the total spectrum of
users in agriculture. From a social improvement level all levels of the population regarding gender and
age are addressed ranging from the youth to male and female groups. The system is therefore not
confined to agriculture alone, which makes it an excellent example of what ITC can accomplish through
participatory rural communication appraisals (PRCA), for the formulation of communication strategies at
community level, to enhance the use of multimedia and new ICTs by rural people.
Conclusion / findings

Several ICT applications exist that can be used for the establishment and improvement of irrigation in Africa. Examples of technology employed for improved production and profitability are:

- **Irrisat SMS**: an irrigation water management service that uses high-level technology to deliver information to farmers. This tells them exactly how long they should run their water pump in order to replenish the water delivered to the crops by their irrigation system. The satellite input used in the Irrisat service, combined with automated weather station information, allows for regular, remote monitoring of rural areas. This system has only been used in Australia and no international tests have been conducted \(^{(46)}\).

- Led by scientists at the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), the SIBWA team provided the farmers with very high-resolution imagery (VHRI) of their land via satellite. Computer software is used to enhance the image, add extra layers of information and analyse the data that would be useful to the farmers – estimates in variations of soil fertility, land size and shape and contours which could assist with farming ventures \(^{(47)}\).

- The World Agroforestry Centre (ICRAF) is developing an irrigation master plan in Rwanda using GIS and other scientific and engineering principles. Information from across the country on soil types, topography, water resources, current land use, and socio-economic factors and data on each criterion is entered as a separate layer in a GIS application. Detailed multi-criteria analysis is done and it can accurately pinpoint areas which could be suitable for irrigation. Best practice is also advised regarding cultivation. Remote sensing is envisaged as the next step in similar projects \(^{(48)}\).

- Use of soil moisture sensors (tension-meters) is becoming more prevalent as a means to assist irrigation farmers. Not only can it regulate water flow through a connection to solenoid valves (to open and shut valves) but it can be used to indicate minimum and maximum moisture levels and log data on a data logger as a means of creating management information to do irrigation scheduling \(^{(49)}\).

- The use of neutron moisture meters is growing (portable radiation equipment capable of performing a large number of reliable soil-moisture measurements, that is almost insensitive to change in salt concentration in the soil and its readings are not upset by the concentration of fertilizer) \(^{(50)}\).

- The use of digital satellite radio receivers, wind-up radios and solar-powered transmitters in dissemination of agricultural information in deep rural areas is a new innovation. This is called RANET (Rural communications using radio and the Internet) \(^{(51)}\).

- Construction of project-specific weather stations which sole purpose is to service each development project within its own micro climate is planned. This alleviates the necessity of high-cost communication systems and provides site-specific data which is more relevant. Project-specific weather stations also typically involve a digital console that provides readouts of the data being collected. These consoles may interface to a personal computer where data can be displayed, stored, and uploaded to websites or data ingestion/distribution systems.
Further important factors are that the DSCs in Egypt are a source of support and training for other countries in the African and Arab regions. Current technology that has been used for a number of years in Egypt with great success will still be deemed as “new” from an African perspective. The situation in Egypt is a practical example where government has successfully instituted change by means of the upgrading of infrastructure through the use of modern irrigation principles, proper training of officials in the required fields of expertise and direct control of improvement projects and research (Egypt is also one of the few nations able to convert project plans into reality).

Proper administrative systems and operating procedures were created to ensure proper control in the improvement projects. A system of fair and equitable distribution of water has also been instituted and gradual handover of control to water users has been implemented. The actual use and implementation of technology has been initiated by the commercial sector.

- **The successful use of ICTs**: The VERCON and RADCON systems that are utilised in Egypt are a striking example of the ability to supply basic as well as advanced information and technical assistance through a participatory communications model. According to the study the success of the RADCON project can be summarised as follows:

- **Early and continuous** involvement of all relevant role players in any environment is required to gain acceptance of new technology and specifically a participatory communication approach. A community accepted principle will be easier to implement, more efficient and effective, and thus have a greater chance of achieving goals and objectives.

- **Continuous and timely interaction of all role players in the network in order to update and sustain motivation levels**: An open information and communication network allows for timely interaction among project stakeholders. A key requirement for effective interaction, as well as for realising the potential benefits that such a network offers, is the continuous engagement and motivation of all stakeholders, and being aware that keeping stakeholders motivated and engaged during the whole project cycle requires considerable effort.

- **Community-based system**: A community-based information and communication network allows community members to be both information users and generators. This increases the effectiveness of the project, raises the self-esteem and sense of ownership of the rural stakeholders, creates new community-specific knowledge and exponentially increases the amount of information flowing through the network.

- **Bridging the ICT gap**: Appointing community facilitators is an effective and efficient way of reducing ICT illiteracy in rural communities. The facilitators encourage the communities to identify their information and communication needs, and then help them to address those needs through the use of ICTs.

- **Project management unit independence**: The independence of the project management unit (in RADCON’s case, the ICD Unit) provides the basis for bringing a variety of stakeholders into the project and ensures objectivity and unbiased solutions to the challenges faced during the implementation of the project.
- **Demand-driven project**: A demand-driven project is likely to result in the efficient and effective use of project resources. Through the use of PRCA tools and the establishment of an open information and communication network in which all the stakeholders are both information users and information generators, RADCON was able to remain focused on the information and communication needs of the stakeholders.

- **Engaging local leaders**: The formal and informal engagement of local community leaders in the early stages of a project can accelerate its acceptance and use by the community. From the outset of the RADCON project, the management and implementation team worked closely with local leaders, engaged them in decisions related to establishing the RADCON centres and identifying the community facilitators, and kept them informed about project implementation and progress in their respective communities.
6. Recommendations

6.1. Challenges and opportunities

Africa in the minds of many stakeholders globally is an uncertain continent. There are many perceptions – right and wrong that drive behaviour and attitudes in ICT and agriculture.

Some of the challenges experienced in Africa include:

- The lack of ICT and physical infrastructure to use as the backbone for further development;
- The lack in numeracy and literacy skills across the continent and by implication the lack of knowledge economies across the continent;
- Inconsistent production volumes and the erratic quality of products;
- The limited use of irrigation;
- The lack of participation in the downstream value chain of agricultural based products;
- Decreasing profitability of primary production;
- Limited trading and tradability of livestock and livestock products;
- Inefficient and corrupt practices by authorities;
- Poor research and research facilities;
- Security of tenure challenges; and
- Relatively poor safety and security.

By the same token there are several opportunities on the continent – that if managed correctly – could yield strong positive results for various institutions. Some of these are mentioned below:

- Increased commercialisation of livestock farming;
- Major irrigation opportunities across the continent;
- The introduction of biotechnologically modified crops;
- Aquaculture opportunities;
- The syndication of natural and other resources to improve production efficiencies;
- Mechanisation of crop production; and
- Precision farming via ICT.

In the following section we will deal with specific recommendations to try and deal with some of the opportunities cited.
6.2. ICT from an agriculture sector perspective

Usage of ICT in the agriculture sector can enable the following broad objectives:

**Sector Development**

Sector development means enabling better sectoral growth and development by identifying new products, locating different markets, and generally empowering policy planners to make better decisions. In particular the following possibilities exist:

- *Expansion of markets and activities* by facilitating expansion of activities in the same markets, or access to new markets, new ideas and methodologies, niche markets, etc.
- *Harnessing knowledge management* by access to information on international best practices through virtual communities and online forums.

**Sector Management**

Sector management means performing activities better by improving efficiency and effectiveness through the use of information systems. Among other things, this would include:

- *Re-engineering internal processes*, or streamlining operations making for clear work allocation which would then lead to gains in efficiency and productivity.
- *Knowledge management systems*, or invoking better information management and sharing between stakeholders in the sector.
- *Multi-channel service delivery* or extending services anywhere, anytime and anyhow through portals, mobile phones, postal systems, and telephones for user convenience.

**Inter-Sectoral Collaboration**

Collaboration within and across sectors can be used to advantage by stakeholders to bring about better synergies. The following can take place:

- *Discussion forums* or using web-based and other ICT-enabled discussion forums to facilitate collaborative networking between participants.
- *Advocacy and advisory*, or using networking to facilitate advisory and advocacy by sector participants and attract attention of policy planners.
6.3. Recommendations to policy-makers and regulators

Purpose of the recommendations

The previous chapter dealt with the detail regarding the intensified ICT usage in livestock traceability, as well as the use of ICT in crop irrigation practices.

The aim of the recommendations is to assist policy-makers and regulators to:

- Gain some insight in the benefits of ICT led interventions in their respective countries or regions;
- Implement interventions that would have a tangible outcome;
- Develop multi-country cooperation and best practices; and to
- Prioritize certain interventions that would be most beneficial for the country’s specific agricultural requirements.

Recommendation 1 – Create partnerships with the relevant stakeholders

*Why:* In many African countries, synergies are not exploited optimally as there is a general disconnect between the different parties in the agricultural value chain.

*What:* Forums need to be set up to encourage dialogue and interaction. Specific partnerships should be identified in these forums and then be built between stakeholders for specific eAgriculture projects. These forums will promote knowledge related to use of ICT in agriculture. The role of these partnerships will go beyond advisory committees. As initiators, partners can play an invaluable role in the research, planning, problem solving and review of operations and in training relevant government officials and staff in the use of ICT in agriculture. Partnerships should have specific targeted eAgriculture outcomes.

*Who:* Agriculture sector regulators may facilitate partnerships but Agricultural Hubs (see recommendation 2 below) would be central in the formation of partnership.

*With whom:* Key decision makers from stakeholders’ groups together with decision maker’s in government would play an important role as co-facilitators. Private sector participation as well as inputs from rural communities and their specific needs are required.

*Operation:* The forum should meet formally twice a year to really add value across the spectrum. An example of a national stakeholder forum is the one in Kenya which guides the Kenya Agricultural Information Network (KAINet) together with a board of trustees and a network management committee. Also in Kenya, the SMS e-Service is a communication and information sharing forum between citizens, Ministry of State and Registration of Persons, Public Sector Reform and Performance Contracting (PSR&PC) and the Directorate of e-Government. This forum is more a way in which citizens can access services and less one in which they participate in decision making. A third example is eBrain, a non-profit, membership-based organisation that promotes ICTs for development in Zambia. Its main objective is to develop a common knowledge-sharing community on the use of ICT to foster social and economic development.
Recommendation 2 – Set up an Agricultural Hub

**Why:** Leadership, communication and creative thinking are required in eAgriculture projects that will have a wide-ranging impact on the sector.

**What:** An Agricultural Hub, as a purpose-built management and support structure, would enable communication between private sector and government and would facilitate eAgriculture projects. Such an Agricultural Hub would drive agricultural diversification, mega projects including eAgriculture projects, and initiate and coordinate opportunities in the agricultural sector. The eAgriculture projects would in turn serve nations through commercialization, diversification and job creation. Since the Hub would not have bureaucratic processes and not be subject to all the bureaucratic processes within Government, it could act swiftly, for example, to meet investor needs. It would exist to drive the strategic agenda of the state and would be designed to be nimble and quick acting.

**Who:** Policy makers and regulators facilitate the initial creation of the Agricultural Hub.

**With whom:** Further operation of the Agricultural Hub would require the participation of a fully representative group of leaders and would report to the Ministry of Agriculture but would not be subject to all the processes within government.

**Operation:** This would be a permanently staffed and active operation.

Recommendation 3 – Regulatory implementation to govern specific opportunities

**Why:** Different types of agriculture programmes require different types of support and authoritative structure as well as access to resources.

**What:** Legislation and regulation relevant to eAgriculture

a) Legislation and regulations relating to ICT’s must be revisited, to ensure that, amongst other concerns, information security is protected, the cost of communications infrastructure (broadband) is reduced and ICT infrastructure is accessible even from deeply rural areas.

b) Some programmes, such as national irrigation schemes and traceability programmes, may require new, strong legislation and regulation. All legal provisions must be defined fully.

eAgriculture programmes will depend on reliable and affordable ICT infrastructure. In addition, specific national eAgriculture programmes, for example, the creation of an enabling environment for a traceability system, normally start with government, as all legal and administrative systems must be put in place timeously to create a workable solution. The success of mobile money applications in Kenya and the Philippines have been found to have depended on legislation and regulation (9) as well as both the cases reported in Chapter 5 of this report (traceability system in Namibia and irrigation system in Egypt) and the lessons learned there are crucial to most other applications of ICT.

**Who:** National legislative bodies are the primary actors in this case.

**With whom:** Ministries of Agriculture and Ministries of Communications are responsible for putting forward the legislation and regulations for final ratification by the relevant authorities.
Operation: These laws and regulations need to be in place before the programmes that depend on them can go into operation. Drawing up the regulations so that they can be enforced and do not have unintended consequences is essential and will require time and attention.

Recommendation 4 – Adoption of traceability systems at a national level in African countries

Why: There is an increasing consumer demand for quality and food safety. As a result, exporters want to be able to trace production back to the specific farm from which it came in order to ensure quality and safe production and handling procedures. Although traceability is required so as to be able to respond to quality standard requirements it also helps large buyers track, manage, pay, and reward small producers. Traceability systems have been identified as having the potential to result in an observable improvement in the well-being of large numbers of people on the African continent.

Governments and the agriculture sector can create export markets for their producers when traceability systems are implemented correctly.

What: The traceability systems that are used should address full traceability, from first contact to market destination, since systems that do not cover the whole lifecycle create gaps in traceability, which may be detrimental to the industry and the consumer.

Who: At national level the primary initiator would be the national Department of Agriculture. However, private initiatives supported by government are also recommended.

With whom: International health authorities, national legislators, national Department of Agriculture including agricultural advisors, farmers, suppliers and other stakeholders throughout the value chain will all need to be consulted. Strong inter-departmental and industry communication on a regular basis is required. Kenya, Morocco and Mali have traceability systems in place for the export of fresh produce and olive oil\(^{(12)}\). South Africa, Namibia and Botswana have traceability programmes in place for the export of beef\(^{(12)}\). It is essential that these countries ensure that they ensure that legislation and regulations are enforced and will also apply to other agricultural products. For example, Kenya is currently putting livestock traceability systems in place\(^{(58)}\).

Many developing countries lag in developing and implementing food safety and traceability standards which means they may be missing an export opportunity\(^{(12)}\). Interventions in Tanzania, Kenya and Ethiopia can be recommended as they are well suited for the replication of live stock traceability systems. Sudan has very large herds of cattle which are reputed to be disease free and already exports beef to Egypt\(^{(57)}\). It is also reasonably close to Europe but cannot expand its exports to Europe without the ICT infrastructure, legislation and regulatory provisions in place.

Operation: Adoption could be incremental, that is, be introduced in phases: private partners should serve as the first phase; the system can then be expanded to regular suppliers of feedlots and incorporate transporters and auctioneers as a further phase.

Recommendation 5 – Empowering women in agriculture

Why: In Africa women perform 65% of all the activities within the agricultural sector. Women not only often have little access to finance for agriculture, they are also time poor (have almost no free time to devote to their own interests or to rest) and are physically at a disadvantage.
Women in rural communities and particularly those moving from subsistence farming to small-scale farming in the commercial sector can benefit greatly from the use of ICT without there being specific features focussed on the sex of the recipient. The proper use of ICT in agriculture can assist the user to save time, which would be enormously useful to women. Cutting down avoidable travel can save physical effort by reducing walking to bus stops carrying produce for sale. eAgriculture solutions that offer end-to-end delivery of service including payment are best for this group.

**What:** a) Mobile telephony can be used for sending and saving money and this enables rural woman to have some sort of autonomy over their finances. b) The multiple responsibilities that women have in caring for families as well as farming can be addressed by including health, nutrition and educational advice in the content provided by the eAgriculture information systems.

**Who:** General government support is required but needs to go beyond lip service to active monitoring of all eAgriculture programmes to assess the degree to which they contribute to this goal.

**With whom:** Developers of eAgriculture information systems and applications need to be approached to collaborate in achieving this goal.

**Operation:** More specifically, governments need to incentivise cell phone companies to further invest in expanding money transfer services offering with a specific focus on rural communities. Content providers need to provide appropriate health, nutrition and educational advice to be placed on various eAgriculture information systems.

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**Recommendation 6 – Implementing irrigation solutions in Africa**

**Why:** Reports indicate that modern irrigation techniques can reduce water consumption by more than 20%. ICT can schedule sprinkler irrigation systems and enhance the quality and productivity of land and eventually increase farmers’ incomes.

**What:** Use of the correct technology makes the most efficient use of water and systems that are designed to assist the farmers in optimising production. The secret is the delivery of the right quality and quantity of water as required by the plant.

**Who:** In the case of Egypt, the actual use and implementation of technology was apparently initiated by the commercial sector. However, again learning from the Nile irrigation project in Egypt, government has apparently subsequently partnered with the commercial sector and in so doing has successfully instituted change by means of the upgrading of infrastructure through the use of modern irrigation principles, proper training of officials in the required fields of expertise and direct control of improvement projects and research.

**With whom:** Since current technology that has been used for a number of years in Egypt with great success will still be deemed as “new” from an African perspective, consulting with and learning from experts and those with extensive experience in ICT.

**Operation:** Examples of irrigation related ICT’s implemented are:

- Use of soil moisture sensors as a means of collecting data for an irrigation water management service that use high-level technology to do irrigation scheduling.
- An irrigation master plan using GIS can accurately pinpoint areas which could be suitable for irrigation. Best practice is also advised regarding cultivation.
- The use of digital satellite radio receivers, wind-up radios and solar-powered transmitters in dissemination of agricultural information in deep rural areas.
- The construction of project-specific weather stations provides site-specific data which is highly relevant at regional and district level.

**Recommendation 7 – An integrated e-Agriculture plan for each country**

*Why:* This would help, not just in involving all stakeholders, bringing about economies of scale particularly in resource-constrained economies and increasing stakeholder ownership, but also make sure there is the appropriate level of political and executive commitment to eAgriculture followed by a commensurate budgetary allocation. The plan should bring all stakeholders together and guarantee a minimum budgetary allocation.

*What:* A comprehensive, integrated, long-term Agriculture Plan, within which an e-Agriculture plan would fall, should be developed for each country. The eAgriculture plan would facilitate the overall design of a single technology framework into which new ICT hardware and software components, addressing different eAgriculture functionality and features could slot. Although the design and implementation would be modular and a phased approach would be adopted, the system would at all times appear to be a single system with a single interface. Single-window services and one-stop-shops are a natural result from such a plan. Mobile technologies as service delivery devices are recommended. The case study on Mauritius, in Annexure A, serves as an example.

*Who:* Agricultural policy makers and regulators are responsible for the overall Agriculture Plan. The eAgriculture plan would require input from experts on eAgriculture functionality and features, ICT hardware and software.

*With whom:* Such plans should emerge from upstream national ICT or sectoral or country level developmental strategies.

*Operation:* Although a formal eAgriculture plan is proposed this would be a living document and would need to be revised regularly (possibly annually) as new technologies and ideas surface.

### 6.4. Recommendations to the donor community

**Recommendation 8 - Developing self-sustaining funding solutions**

*Why:* eAgriculture ventures, particularly those taken up by communities, must be sustainable beyond their initial funding periods. It is necessary that projects be based on strong business models and that revenue-earning options are explored that the community members themselves can benefit from.

Furthermore, school leavers or even those with higher qualifications frequently leave rural communities and move to urban areas in order to find work, and these potential community leaders then usually never return to live at the family home on a permanent basis. There are, however, a small number of jobs related to eAgriculture that local people could fill and this would address the rural brain drain to some small extent.
**What:** More often than not, given the added convenience and the indirect saving it engenders, farmers are willing to pay for the extra services they get. Paid services could be one way of earning revenue. This money could be used to pay a small number of people to do specific essential tasks as part of the routine operation of the programme. Examples of the tasks are collecting relevant information from various sources and updating content on web sites. This cycle of revenue generation and returning some of it back into the community is an example of a self-sustaining funding solution.

**Who:** Donors should publish the fact that a description of viable plans for ultimately making a project self-funding is one of their funding application, evaluation criteria.

**With whom:** During the implementation and subsequent routine operation of the system, local schools could be asked to propose candidates to fill internship positions. Those interns who prove capable could fill more permanent positions.

**Operation:** Applications for funding should be evaluated using the probability of the project becoming self-sustaining as a major factor.

**Recommendation 9 – Focus on community ownership**

**Why:** A well-established sense of community ownership of community-based eAgriculture projects assists them to survive after donors move on to new projects and reduces long-term dependency on an external champion.

**What:** Enable the community to become actively involved in, and ultimately take full ownership and responsibility for the project by including them early in decision making regarding the project and increasingly hand over leadership and operation of the project to community members.

**Who:** Programme designers and implementers

**With whom:** Product developers, local authorities and local communities.

**Operation:**

- Local authorities: Community owned projects are often resource-scarce. Adopt approaches that make adequate use of the existing infrastructure.
- Local community: Have extensive local involvement in all aspects of the projects that directly touch the lives of communities. Locally relevant content is key to increasing chances of success and the involvement of local champions increases the trust factor that communities need to have before they involve themselves in endeavours of this nature.
• Product developers: a) During product development pay attention to details, for example, easy user-friendly ways for the community itself to take on data entry, as often projects fail owing to poor or out-of-date information. b) Personalized services is an approach by which the involvement of the end users of the system could be further augmented.

**Recommendation 10 – Make eAgriculture technology robust and accessible**

*Why:* Systems are only valuable if they are used but this can only occur in eAgriculture projects if the end users have access to the necessary technology. eAgriculture systems that are difficult to use, require access to expensive or unavailable technology, are unreliable or cannot be run off-line when necessary will probably eventually be abandoned.

*What:* Backup and disaster recovery plans as well as alternate work processes that can easily be linked into the primary system, need to be implemented so that systems are useable even if there is an interruption in electricity supply, mobile phone access or some other failure of the technology. The system must be robust and accessible.

*Who:* Initial donor financial support is needed for community centres housing technology and maintenance support for eAgriculture technology until the number of users reaches a critical mass.

*With whom:* Systems designers and developers need to design for system access through commonly available technology devices and also design for alternative communication options in order to include the largest possible number of end users.

*Operation:*

• Exploit fully the possibility of the mobile device as an excellent option for services delivery: In the vast majority of Africa's places and people, fixed line penetration and Internet penetration is low while mobile penetration rates are going up. Mobile phones are therefore excellent vehicles for information and services delivery. Further, voice instead of text, is often a better option to bridge literacy gaps, a common problem found in most African examples.
• Have options built into the project to cater to the requirements of unconnected people and places: Solutions offered also need to take into account possibilities for unconnected people and places. Not all places are covered by networks (even mobiles) and not everyone can afford to have an ICT device. Solutions offered should be inclusive in their scope and must have alternatives built into them to cater the specific requirements of these unconnected entities.
• Multi-purpose telecentres as important centres for learning, listening and stimulating ideas: Telecentres serve as more than places of Internet or ICT access; Use them as centres of learning, listening and ideating. A multi-purpose (as against a limited purpose) telecentre is likely to have more footfalls.

**Recommendation 11 – Capacity building**

*Why:* Rural communities urgently need opportunities for learning numeracy and literacy, basic farming skills and business management skills. Making these education opportunities accessible to women as well as men, complements the request for policy makers and regulators in Recommendation 5 above.
What: Teachers need opportunities to improve their own knowledge and to have access to top quality teaching aids and material as is available on the web. There is a good possibility of piggy-backing educational use onto any eAgricultural programme. However, funding to provide an Internet connection that can be used jointly by teachers and eAgriculture initiatives and for other incidental purposes only serves a purpose if the service can be maintained and the equipment can be secured.

Who: Donors and funders of existing eAgriculture programmes are requested to broaden the service they provide to include fairly general access to the Internet by teachers.

With whom: Teachers who teach basic farming skills, basic education and business management skills.

Operation: Complete reliance on eEducation is not recommended in farming communities made up primarily of smallholders or subsistence farmers but the Internet can be a very valuable resource for the teachers who provide classroom tuition. Donors and funders are urged to ask for such an educational use component to be made a funding eligibility requirement for all projects.

Teaching computer literacy and more advanced skills was deliberately not included in the list of skills requirements given above as ICT should be seen as a tool for achieving other goals rather than as a goal in itself. It is expected that some computer skills will be picked up by the teachers along the way, but the secondary requirement of capacity building to extend these basic ICT skills in order to increase the teachers’ productivity and life options must also be recognised.

Recommendation 12 – Country agriculture strategy map

Why: Country agriculture strategy maps serve the purpose of encouraging environmentally responsible farming as well as commercially astute practices.

What: Country specific agriculture strategy maps using a variety of ICT tools, but primarily imaging tools such as GIS and satellite technologies.

Who: Donors, such as the World Bank, are urged to assist in developing the eAgriculture plan recommended to policy makers and regulators in Recommendation 7 above by providing access to the necessary technology and international experts required for developing country specific agriculture strategy maps.

With whom: Experts on eAgriculture functionality and features, ICT hardware and software working on the individual countries’ eAgriculture plans.

Operation: A wide variety of maps can be obtained including:

- Satellite imagery for mapping of region, district & selected sites from GPS coordinates obtained previously;
- Regional drainage and water systems – to determine impacts on the ecological systems and implement water management plans;
- Topographical / topo-cadastral mapping – from rectification & ground “truthing” of satellite imagery;
- Slope, contour and watercourse mapping – natural drainage mapping for water management and erosion control;
- Protected flora & fauna species mapping – remedial actions plans if necessary;

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- Soil survey, profiles and sample analyses;
- Soil classification and soil type mapping;
- Interpretation of soil type mapping and soil sample results;
- Land use planning models including siting of fencing, dams, fields, plantations, paddocks, waterways, roads, infrastructure, housing, etc.
- Very high-resolution imagery (VHRI) of land via satellite. Computer software is used to enhance the image estimates in variations of soil fertility, land size and shape and contours which could assist with farming ventures.

6.5. Conclusion

Having the support of government is seen as a very important factor in eAgriculture projects and the inclusion of private sector partners and donors is also extremely important. The establishment of an Agriculture Hub was proposed as a very specific way of strengthening these relationships and allowing for them to be productive. However, full and sustained commitment from all the partners, including those “on the ground” is required.

Creating a sense of community ownership is important. Various communities exist and commercial farmers are one important community, smallholders another, and some communities are diverse with members from across the value chain.

Overreliance on any one partner, supplier or technology is unwise, particularly in the case of technology and a multiple approach, with alternate forms of media is required so that, once operational, the project does not collapse if one technology is unavailable even for a short time.

A sense of urgency is necessary to get any large project off the ground but this must go together with proper planning including financial planning and getting any necessary legislation or regulations in place, as well as a full assessment of many aspects of the current situation. Planning for ICT infrastructure, end user training, design and implementation of systems, on-going maintenance and support are all required. However, it is not only the technological issues that will need attention in eAgriculture, change management plays an important role in the introduction of ICT solutions in order to ensure sustained use.
7. Endnotes


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