THE FUTURE OF THE WESTERN CAPE AGRICULTURAL SECTOR IN THE CONTEXT OF THE 4TH INDUSTRIAL REVOLUTION

Review: Information and Communication Technology (ICT)

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USB
University of Stellenbosch Business School

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1. What is the ICT?

Introduction

Information and Communications Technology (ICT) refers to the connection of telecommunications (telephone lines and wireless signals), computers as well as software, middleware, storage, and audio-visual systems, which enable network users to access, store, transmit, and manipulate information. ICT infrastructure components include hardware, software, networking, wireless, computer systems, Internet access, mailing systems, servers, videoconferencing equipment etc. along with the human capacity that manages and operates the ICT infrastructure. Thus, the scope of ICT is vast with myriad components involved in the capture, transmission, storage and analysis of information. This review will focus on ICT as it relates to big data and geo data specifically.

2. Why is ICT important now?

Our ability to capture, communicate, store and analyse information has rapidly increased in recent years. The underlying driver behind this increase is best described by the Food and Agriculture Organisation FAO of the United Nations in their description of the phenomenon known as convergence: "Convergence refers to the erosion of boundaries among previously separate services, networks and business models in the ICT. Convergence (as the name implies) blurs the distinctions between the domains of Internet service providers, television media companies, fixed-line telecommunication companies and operators of mobile telephony networks. Convergence has far-ranging implications for ICT service providers and users. It changes business models, expands markets, increases the range of services and applications available to users, and alters market structure and dynamics. The fundamental technology drivers for convergence have been the digitization of communication and the falling costs of computing power and memory.

Both factors have increased a network's capacity to carry information while bandwidth remains fixed. Consequently, the capacities of telephone, cable TV and wireless networks have grown steadily. The growing use of Internet protocol (IP)-based packet-switched data transmission has made it possible for different devices and applications to use any one of several networks, and for previously separate networks to interconnect. Together, these factors have facilitated the growth of multimedia or mixed media communication. This has reduced costs and eased the design and deployment of multimedia access devices, and has thus led to a proliferation of increasingly inexpensive digital devices. For example, personal computer or mobile telephones can now receive and transmit different types of media and services because of enhanced processing power and memory capacity.

From a user's perspective, device convergence has two main aspects. First, users can access content in different formats (audio, data, location data, pictures, maps, text) and with different dynamic properties, produced by different authors, on the same device. Second, users can take advantage of different options (radio, GSM, Wi-Fi, Bluetooth, satellite) for accessing that content."[1]

The potential of convergence in agricultural and rural development has yet to be fully assessed, but as the importance of being connected in order to create analysable data vital to the business-of-tomorrow increases, this potential will rapidly start to be realised. It is easy to see the benefits of convergence in the context of agriculture and big data, when we think of IoT sensors capturing images, sounds, locations, temperatures etc. digitalising those inputs and transmitting them using optical fibre, 3G networks, low range bluetooth, satellite etc.

3. What are the applications of IoT today?

The State of Connectivity

One of the biggest deterrents to widescale technology adoption in agriculture is the lack of ICT infrastructure available in outlying areas. All network providers, be they fibre-to-the-home (FTTH) providers or mobile network operators (MNO), perform their return on investment(ROI) calculations by assessing population density before placing infrastructure in a geographic location. Population density drives volume when it comes to network usage and thus is the key component in revenue. However, more extensive coverage is also extremely important to many customers particularly when they are travelling, and thus MNOs compete for customers by having better coverage than competitors. A US based example of this competition can be seen here: https://www.youtube.com/watch?v=IMz3jatsanE.

The figure below shows Vodacom's current coverage for 3G and LTE in the Western Cape respectively. Vodacom has the most comprehensive coverage of South African MNOs and thus their coverage map shows the current scale of possibility when it comes to mobile connectivity in the region excluding satellite connectivity.

Vodacom 3G Coverage Vodacom LTE Coverage

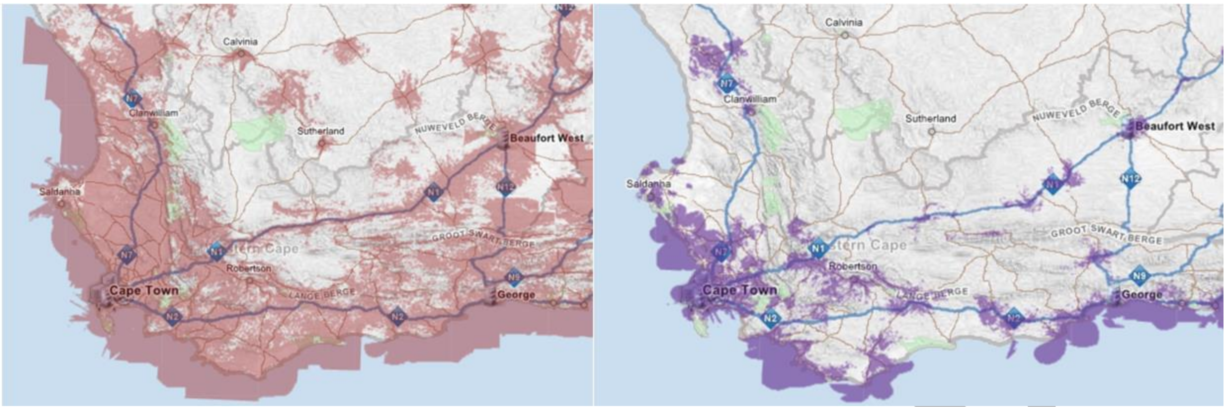

Figure 1: Vodacom Coverage Map. Source: Vodacom

When reviewing the ICT requirements for big geo data sets, the main constraint imposed by the lack of comprehensive LTE in the Western Cape, is on video and high resolution image transfer, particularly in real time. The user experience of transmitting video or images via smart phone or Internet Protocol (IP) cameras is poor. Many of the use cases illustrated in other papers in this study, (IoT for example) are limited by a lack of bit rate transfer on the existing 3G (or worse) coverage in agricultural lands. For example, a drone recording high resolution images or video of crops or patrolling for security purposes, cannot transmit that data back to decision makers or store data in the cloud due to current network constraints. These constraints need to be reduced through updated ICT but the change is atypically slow for a number of factors discussed below.

Data creation has exploded as the increasing penetration of smartphones drives data-heavy interactions on mobile networks. The increased stress on networks is compounded in developing nations and particularly in agricultural areas for three reasons: Firstly, users are starting with at a low base with lower traffic data per user prior to smartphone adoption. Secondly, fixed internet access is much less common in these regions putting more emphasis on mobile broadband. Third, lower affluence levels lead to price sensitivity, compelling customers to exploit flat rates and prepaid pricing, thus pushing the boundaries of MNO fair usage policies.[2]

In other words, better connectivity and rapidly improving technology in the hands of users will erode profitability of MNOs. With reduced willingness to pay high prices for connectivity coupled with intense competition, MNOs revenue is under constant pressure. Other innovations such as voice over internet protocol (VOIP) and the total movement towards packet switching on LTE networks have also resulted in a reduction in margin for MNOs. Reduction in profitability means reduction in expenditure on infrastructure, particularly in low density areas. Thus, until MNOs address these issues, 3G may well be the standard in the Western Cape for the foreseeable future.

GeoData in Agriculture

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

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

We discuss the capture of big data more extensively in our IoT report and the analysis of that data in our AI and Machine Learning report. From an ICT infrastructure perspective, many of the key data components required to perform meaningful big data analytics are small in size and can thus be transmitted via the existing 3G connectivity that covers the majority of the province. For example, temperature readings, soil readings, water readings etc. can be transmitted as very small character strings over the slowest of networks. Indeed, in developing countries (such as Bangladesh and remote areas in India) where smaller independent farmers experience very poor connectivity, the trend has been to transmit data using existing ICT infrastructure, rather than waiting for more powerful networks to solve the problem. A great example of this is FAO's Avian Flu prevention system, where health workers submitted medical data from farms via sms. This resulted in an 87% reduction in Avian Flu outbreaks.[3]

Conversations on big data so often centre around networks and sensors, as these devices become more numerous. However, in agricultural areas where limited to no internet connectivity exist, the power of the crowd should not be discounted as a data source. A billion people worldwide sending information via text message is a powerful source of data. The key to building meaningful data sets will come from managing the transition from traditional circuit switching to packet switching through innovative hybrids of data capture and transmission.

4. What is the Future of ICT for Big Data?

LPWA

Low-power wide-area networks (LPWA) are a key enabler for the Internet of Things (IoT), but familiar options such as Bluetooth, ZigBee, Wi-Fi, or cellular, lack an acceptable combination of extended range and battery life. To address this, new sub-GHz specifications are being offered. LPWA are intended for wireless battery operated Things in a regional, national or global network. There are a number of positives for IoT with LPWA. Firstly, the protocols governing the transmission of information have been built in order to maximise the usage of the network for IoT devices. Secondly, and most importantly, the low power nature of LPWA means that fewer base stations are required per graphical region and less power is needed for the sensor to transmit data back to the network hubs. This results in lower costs for setting up an internet connected farm. Low range frequencies also allow for connection with underground sensors, which is ideal for agricultural application.

LPWA can achieve a 15 km range at power consumption levels low enough to enable 10-year battery life. Further, the availability of an off-the-shelf development kit lets designers quickly bring up a complete LoRaWAN network application with minimal effort. Lower frequency transmissions typically translate to lower data rates, but IoT applications rarely present significant throughput requirements. Additionally, lower data rates bring another advantage in the form of reduced error rates, thereby decreasing the sensitivity requirements of the receiver.[4]

The three big contenders are NB-IoT, LoRaWAN and Sigfox – all three have pro's and cons, but all three aim to do essentially the same thing: to achieve long battery life in the devices that use them to communicate – by reducing the energy that is used to transmit and receive data, to provide connectivity that is relatively cheap, and to offer potentially large geographical coverage.

Vodacom and MTN are both rolling out NB-IOT in 2017 and across Africa from 2018, and Telkom – via Fastnet – is looking to rollout LoRaWAN. Remgro subsidiary Dark Fibre Africa has decided to join in. DFA will be launching Sigfox (called SqwidNet) in 2017, with big ambitions for national coverage by 2018.

LPWA will be a massive enabler for IoT in South Africa. What's more, farmers need not wait for MNOs to roll out to their regions as setting up LPWA is possible and relatively inexpensive, particularly if done as a cooperative. The characteristics of LPWA make it ideal for collecting geo data on a massive scale from connected sensors, thus solving current ICT issues encountered during IoT rollouts.

Ubiquitous Internet

Companies like Facebook, Google and SpaceX believe that access to internet connectivity should be a basic human right, easily accessible anywhere in the world. All three of those tech giants have spoken about projects to achieve this goal. Facebook has rolled out Facebook Zero in collaboration with local MNO to provide free access to a basic version of Facebook for free. Cell C and Vodacom have championed the cause locally. Access to free networking will have its own positive ramifications, particularly for rural farmers who desperately need to learn best practice in farming with limited wealth and connectivity. Facebook Zero could potentially be used both the capture data from farmers, and send the results of data analysis from large organisations back to the farmer.

From a connectivity perspective, Google, SpaceX and Facebook are of interest. Elon Musk has said that he would like to launch a constellation of low earth orbit satellites that would provide LTE-speed internet to the entire planet. Last year, SpaceX applied for permission to launch 4 425[5] satellites to service the globe. Google's Loon project aims to achieve the same goal by providing internet via balloon. The Loon project is being tested in Puerto Rico at the time of writing. Facebook's Aquila project is aiming to achieve the same goal with massive solar powered drones to circle the earth.

Such infrastructure would revolutionise the farming industry by providing a massive leap forward in data transmission. Real time access to cloud computing, in particular image recognition and video analytics, is not possible in remote agricultural regions via 3G networks or worse. If these companies succeed in being the network providers to the planet, the disruption for many industries and incumbents would be significant. At present, these projects are not feasible due to the sheer cost to roll out so much infrastructure. Elon Musk has received scorn for his plans as being overly ambitious. However, if recent history has taught us anything, it is that this type of world-changing innovation is deceptively fast, and any industry would be remiss to write-off the possibility of ubiquitous internet access in the recent future.

Figure 2: Google Loon Balloon
Source: https://onelucian.com/2017/03/28/four-google-loon-balloons-spotted-east-of-st-lucia/.

5. ICT Application Life Cycle

ICT as an application has an infinite lifecycle. Whether it be copper cables, fibre optic cables or satellites and drones, humans will always require connectivity and will seek to perfect ICT until such times as massive quantities of data can be moved anywhere in the world in real time.

6. Business Eco-System View

As mentioned above, all of the big network providers are rolling out solutions for LPWA networks. If these networks are slow to arrive in farming communities then farmers can buy affordable LPWA antennae themselves as the technology continues to drop in price. The amount of companies entering the ICT ecosystem is expanding every year, with new network providers such as Rain, attempting to disrupt the market. Vula Telematix has secured a deal to do smart metering for the Drakenstein (Paarl) municipality in the Western Cape and is running several pilots around the country through partners, including a precision agriculture project, a refuse management system and a livestock tracking system. As new competitors seek to dominate the market or carve out niche connectivity offerings, businesses and consumers benefit as it becomes easier and easier to connect.

7. Benefits and Risks

The benefits of ICT are obvious. Increased connectivity allows us to move information more quickly which allows us to communicate, analyze and optimise all aspects of professional and personal life. There are minor risks of increased infrastructure such as security cameras recording all of our movements in applications such as smart cities. These risks do not apply to the agricultural community in the Western Cape and we see increased infrastructure and connectivity as beneficial to the region.

8. Potential Economic, Social, Ecological and Political Developments and Impacts

ICT could potentially have a negative social and ecological effect, which in turn could pose an economic and political threat to the Western Cape. The impact is difficult to measure but tourism could be affected in certain regions. If the ability to travel to areas with no connectivity is a positive factor for tourists deciding where to go on vacation, then a remote tourist area where there was previously no connectivity (thus making the area attractive to such tourists) could potentially lose favour with clients. However, this could also impact the region positively as foreign tourists are more comfortable travelling in areas with connectivity. Further user testing on this threat would need to be conducted to classify it as serious or not.

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