WATERWATCH PROJECTS

Digital Farming in Kenya

Opportunities & Challanges for Dutch ICT companies in agriculture in Kenya

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Abbreviations

AgTech	Agricultural Technology companies
AI	Artificial Intelligence
CSA	Climate Smart Agriculture
EKN	Embassy of the Kingdom of the Netherlands
EO	Earth Observation
ESA	European Space Agency
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Statistical division of the FAO
FinTech	Financial Technology Companies
G4IFF	Geodata for Inclusive Finance and Food
GoK	Government of Kenya
ICT	Information and Communications Technology
ISRIC	International Soil Reference and Information Centre
GAP	Good Agricultural Practice
G4AW	Geodata for Agriculture and Water
KALRO	Kenya Agricultural & Livestock Research Organization
KCAA	Kenya Civil Aviation Authority
KNBS	Kenya National Bureau of Statistics
ML	Machine Learning
NGO	Non-Governmental Organization
NSO	Netherlands Space Office
PME	Planning, Monitoring & Evaluation
PPP	Public Private Partnership
RVO.nl	Rijksdienst voor Ondernemend Nederland
WB	World Bank
WUR	Wageningen University & Research

Glossary

Agribusiness	The entire chain of businesses in agriculture, from input providers, productions companies, farm machinery, off takers, traders, processing companies, marketing and retailers.
Algorithm	Un unambiguous specification of how to solve a class of problems. Algorithms can perform calculation, data processing, and automated reasoning tasks.
Artificial Intelligence	The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.
Big Data	Big data refers to data sets that are too large or complex for traditional data-processing application software to adequately deal with.
Block Chain Technology	A time-stamped series of immutable record of data that is managed by cluster of computers not owned by any single entity. Each of these blocks of data (i.e. block) are secured and bound to each other using cryptographic principles (i.e. chain)
Climate Smart Agriculture	Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions.
Drone	Also called an Unmanned Aerial Vehicle (UAV) is a flying robot that can be remotely controlled or fly autonomously through software-controlled flight plans in their embedded systems, working in conjunction with onboard sensors and GPS.
Earth Observation	Earth observation (EO) is the gathering of information about the physical, chemical, and biological systems of the planet via remote-sensing technologies, supplemented by Earth-surveying techniques, which encompasses the collection, analysis, and presentation of data
Extreme Weather	Extreme weather includes unexpected, unusual, unpredictable, or unseasonal weather; weather at the extremes of the historical distribution–the range that has been seen in the past.
Geodata	Geodata is information about geographic locations that is stored in a format that can be used with a geographic information system (GIS). It is also called geospatial data and information.
High Resolution Data	Satellite data with high resolution are defined by spatial resolution of about tens of meters.
Machine Learning	The scientific study of algorithms and statistical models that computer systems use to effectively perform a specific task without using explicit instructions, relying on patters and inference instead.
Very High-Resolution Data	Satellite data with very high resolution are defined by a spatial resolution at about 1 m.

Executive Summary

'Providing food security for all, now and in the future', in Kenya is a national goal which is embedded in the constitution of Kenya, in its Vision2030 plans and in the Big 4 Agenda for the coming years. Agriculture is an important driver of the national economy of Kenya and contributes 26% directly and 25% indirectly of the GDP annually. It provides livelihoods to millions of people and the sector holds the key to Kenya's socio-economic transformation.

Existing challenges such as poor agricultural practices, low quality inputs and lack of access to knowledge, credits and markets are exacerbated by new challenges such as climate change, changing pest & disease patterns and changing demographics. Traditional ways to close yield gaps by applying more fertilizers and pesticides and to teach farmers how to apply good agricultural practices are not sufficient. A transformation in agriculture is needed in which data that can lead to better and more timely and actionable knowledge will play a major role.

Digitalization, the use of mobile technology and social media is reshaping the landscape in many sectors such as finance, logistics, energy, security and urban planning. The use of Artificial Intelligence and Machine Learning makes it possible to recognize trends and carry out predictive analysis. Agriculture is the least digitized sector in the world. The influence of weather, soil, the way crops react to these conditions and small production plots makes it difficult to develop digital solutions. Data used to understand and improve agricultural practices is static, heterogenous and not timely which makes it difficult for farmers to apply it and improve their agricultural practices.

In the past decade Earth Observation (EO) data or geo-data is more and more applied in agriculture. In combination with weather- and soil-data geodata can be used in crop suitability, crop monitoring, crop activity timing, water productivity, yield forecasting and mapping risks related to water management, deforestation, pest & disease as well as credit and insurance applications.

EO data is dynamic, homogenous and can be used at different spatial and temporal resolutions. EO data from drones give users the advantage of control over the data that is required at a very high resolution. Satellite data has the advantage of repeated coverage of large areas and most of the High-Resolution Satellite data is open data. Drones are not used much in Kenya as the costs are quite high and the use of drones is restricted in Kenya.

A key question is how this knowledge can be shared in an easy and user-friendly way with the 8.6 million farmers in Kenya, of which 81% are smallholder farmers who have less than 1.21 ha of land. With a mobile penetration of over 90%, Kenya is a frontrunner in the uptake of mobile technology in Africa. Feature phones and smartphones are entering the world of farmers in Kenya also.

The average age of farmers in Kenya is 60 years. However, this indicates the age of title deed holders. Smallholder farming is family farming and younger members of the farm family are more familiar in the use of mobile technology. Nevertheless, there is a legitimate concern whether farmers are able to adopt mobile technology in agriculture in Kenya.

Farmers are risk-averse and rather stick to traditional ways of farming. Young people in rural areas in Kenya that have the opportunity, and often the skills decide to proof their luck in urban areas to find scarce blue- and white-collar jobs. The ones that are left on the farm are often less educated and skilled.

During the study many have observed that the introduction of data and mobile technology in agriculture may convince young people to stay and make efforts to increase yields on the land of their parents. The Kenyan government is recognizing the potential in the use of data and ICT-technologies in agriculture. It is host of the Africa Regional Data Cube and there are important initiatives taken at the moment such as the creation of a data platform for climate smart agriculture and the weather observatory.

In the past years a number of Dutch, Kenyan and foreign ICT-companies in agriculture (ICT-Agri) and initiatives have been developed in Kenya. A number of applications and services that have been developed have proven their value in Kenyan agriculture.

Many of these initiatives have been developed in Public Private Partnership with support from programs such as the 'Geodata for Agriculture and Water (G4AW)' program of the Dutch government. The lessons learned in these initiatives are similar: the need for a good market entry, a business approach involving other parties in the value chain and integration of different AgTech and FinTech services providing one service to clients.

Dutch ICT-Agri companies are well positioned to take a leading role in the further development of ICT-Agri solutions in Kenya. The combination of profound agricultural knowledge with geodata-technology makes them quite unique. Yet many Dutch ICT-Agri companies have

difficulties to enter the Kenyan market as they lack the specific knowledge of value chains and a local network of partners with access to large numbers of farmers. Dutch companies with a presence in Kenya are clearly in an advanced position.

In the past few years important lessons have been drawn on what works and what does not work. It is clear that the timing for innovations in agriculture in Kenya is there. For Dutch ICT-Agri companies to become successful and gain a good position, it is necessary to make a shift from supply-driven and publicly funded programs to more demand-driven and commercial services which can be applied at scale.

This shift entails that the needs of the clients becomes central in the solution offered by the company, bundling different services such as weather, Agricultural Advice and financial products in one integrated service.

Smallholder farmers are in most cases not the clients who pay for services. Other stakeholders – input providers, off takers, IT providers, however, are willing and able to pay for services provided it adds value for them as well.

Developing a sound and sustainable business model requires solutions to have a clear added value and requires solutions to be scalable to reach sufficient users to be able to cover development costs.

This means that ICT-Agri companies must either link with AgriBusiness that have a strong install base of users or build in solutions for the registration and engagement of farmers.

Dutch ICT-Agri companies can look for partners with a 'value-chain' approach who are interested in developing an 'eco-system' of information solutions addressing the needs of multiple actors in the value chain.

Cooperation with other Dutch and Kenyan companies is essential as there is not one company who is able to provide the full range of information solutions and applications needed for such a value-chain broad approach.

In particular Dutch ICT-Agri companies may want to seek cooperation with young Kenyan entrepreneurs and young farmer networks which have better chances to succeed as the adoptability of young people of ICT technologies is high.

Introduction

1

ICT for Agriculture

The use of Information and Communications Technology (ICT), in agriculture is widely regarded as an important factor that can disrupt and change the sector to make it more climate smart and to help feeding the world in the next decades. The use of relevant and actionable data forms the basis of ICT solutions in agriculture. Data can come from sensors, drones, and satellites, from farmers and from agribusinesses and often a combination of different data is used. ICT solutions can be web-based or making use of mobile phone – either smartphones or feature phones – and through the use of radio and television.

Agriculture is an essential sector to the economy of Kenya and holds a big potential for feeding its population, income and employment as well as export opportunities. Given the relatively low quality, low yield and the challenges for farmers related to climate change, farmers and Agribusiness could benefit from more accurate and timely information.

Knowledge and information are major drivers for development and smart Information and Communications Technology (ICT-) solutions could significantly impact levels of productivity in the agricultural sector in Kenya. However, despite the number of ICT related initiatives, it seems difficult to connect information services to local farmers. Challenges as local needs, local context and capacity of information uptake are seen.

There is an urgent need to identify possible Dutch technological innovations, which could be implemented to bridge this information gap in Kenya. In order to give Dutch innovators more insight into how the Kenyan market can be reached, an analysis of the challenges that have been encountered so far is required as well as a mechanism for more cooperation between initiatives and actors. This will support existing and new initiatives in the process of extracting proof of concept to actually entering the market.

'70% of the production needed to meet the growing global demand is going to come from technology.' (World Agriculture towards 2015 / 2030, rapport FAO 2008)

Objectives of the study and methodology

The Netherlands Embassy in Nairobi (EKN) and RVO.nl commissioned a team of three – Boniface Akuku from KALRO, Gerbren Haaksma and Harry Derksen from Waterwatch Projects - to carry out a study to gain more insight into the approach that is needed to make ICT initiatives successful in Kenyan agriculture.

The study has the following aims:

1) An analysis of Dutch ICT-initiatives and ICT-businesses in agriculture operating in Kenya;
2) Identification of the needs and gaps of the Kenyan agriculture sector in the area of ICT and the resulting business opportunities;
3) Identification of Dutch ICT initiatives in agriculture who could address these gaps;
4) An assessment of the business environment for Dutch ICT for Agriculture companies in Kenya as well as the current view of the Kenyan government on Data and ICT-technologies;
5) Lessons learned from Dutch ICT for Agriculture companies working in Kenya
6) Recommendations for the Netherlands Embassy in Nairobi and RVO.nl how to support Dutch ICT for Agriculture companies

The following methodology has been applied to collect data from both primary and secondary sources:

Desk research - a comprehensive literature review was done based on a wide range of contemporary reports and other documents related to the topic of ICT and Agriculture in developing countries, Africa and Kenya.

Focus group study – On December 10th, 2018 the team organized a session for key stakeholders in the ICT for agriculture sector in Kenya. Making use of the World Café methodology over 70 participants provided value information on questions around; the status and readiness of ICT in agriculture in Kenya, the potential of ICT to improve the agriculture market, strategies for a successful route to market, strategies to develop a successful eco-system, the role of education and skills development, and the role of government. The day ended with an interactive plenary discussion.

Interviews – The team performed a total of 37 interviews with companies and organizations. A distinction was made between Dutch ICT for agriculture companies which operate in Kenya, companies in the Netherlands that are interested to provide services in Kenya and ICT for agriculture companies with either a Kenyan or non-Dutch background.

Structure of the report

In chapter 2 an introduction is given of the use of data and ICT in agriculture. The use of geodata, sensor- and drone technology in agriculture is – worldwide - relatively new and in recent years big advancements have been made. The chapter provides an overview of the developments and the potential this holds for farmers, for Agribusiness, for financial institutions and for governments and international NGO's.

In chapter 3 we provide an overview and an analysis of the current situation with regard to agriculture in Kenya. The report shows the current challenges and gaps in agriculture in Kenya, how ICT is being used at present in agriculture, what the policy of the Kenyan government is vis-à-vis ICT in agriculture and which role Dutch ICT for agriculture companies are playing.

Chapter 4 provides the key findings of the study identifying how Dutch ICT for agriculture companies are filling the gaps in the Kenyan agricultural sector, what lessons they draw from their experience in operating in Kenya, in which business environment they operate and what their opportunities are in successful operating in the Kenyan agricultural sector.

In the final chapter 5 we provide a set of recommendations for Dutch ICT for agriculture companies to successfully operate in Kenya as well as recommendations for the Dutch Embassy in Nairobi how these companies can be supported and accelerate their success.

2

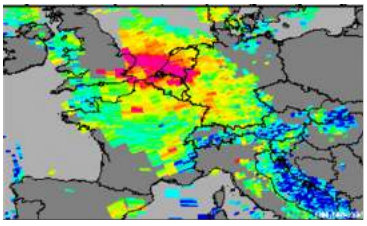
ICT and data

ICT refers to technology providing access to information through the use of mobile phones and internet. The introduction of mobile phone has started a revolution in the way of communication. While in the year 2000 only 5% of the world population had access to a mobile phone, this increased in 2018 to 55%[1].

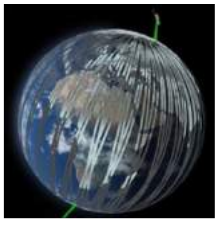
In recent years Artificial Intelligence (AI) and Machine Learning (ML) have been introduced. AI refers to "the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages."[2] With AI enormous amounts of data can be sorted and analyzed to find patterns and trends, learn from these historical trends and then predict future outcomes.
Machine Learning is a type of AI that allows computer programs to adjust when exposed to new data and learn. In many ICT applications AI is being integrated to automate and improve applications and to reach more efficiency and accuracy. Geodata or geospatial data refers to data obtained through Earth Observation either through drones or through satellites. Drones give users the advantage of control over the data that is required. Satellite data gives the advantage of repeated coverage of large areas including remote areas where it is difficult to obtain data in a conventional way. Satellite data also gives an advantage of going back in time (up to 25 years) to discover trends such as the influence of climate change on land, water, forests, crops and yields.

Most of the high-resolution satellite data is open data and free of charge. However, processing the data to bring it to information which can be used in services and applications is not free and has to be paid for. Very high-resolution data (1 meter) is costly. This overview shows the main characteristics (of the use of) satellite data and drone data.

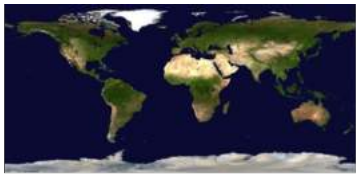
Some advantages of using satellite data



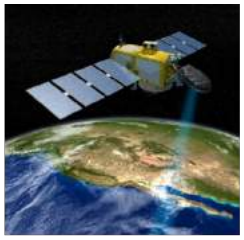
Large regions



Global coverage



Global access



Homogeneous data

[1] *Figures: Internet World Stats*

[2] *Definition: Oxford Dictionary*

Table 1: Characteristics of satellite data and drone data

Characteristic	***Satellite Data***		***Drone data***
	High-Resolution	***Very High-Resolution***	
Resolution	Coarser resolution	High Resolution	Highest resolution
Scaling	Large scale	Medium scale	Low scale
Weather	Problematic in case of serious cloud cover	Problematic in case of serious cloud cover	Under the clouds
Automation	Can be automated as a service	Can be automated as a service	Needs ground operation
Costs	Cheap or open data	Costly data	Costly operation
Temporal Resolution	Time series easy	Time series more difficult	Time series more difficult
Historic data	Able to look back in time	Able to look back in time	No archive

Apart from data acquired from data from satellites and drones, there is also data from sensors, from soil analysis, from local weather stations and data from farmers themselves.

ICT and the Agricultural Sector

The use of ICT in agriculture is not new. In many countries radio was used to communicate important messages to farmers. The introduction of Internet, mobile technology and social media has in many sectors meant a transformation in the way information is being used and communicated. The agriculture sector however has been lagging behind. According to a report of McKinsey, agriculture is the least digitized sector in the world[3].

There are good reasons why digitalization in agriculture is going much slower than in sectors such as finance or logistics. One reason is that digitalization needs data and to obtain objective data in agriculture on crop growing is not easy. Data on crop growth is coming from sensors, drones, satellites and from farmers themselves. The interpretation of this data and to bring this data to information as to why crop growth is different in one field compared to another field or from one growing season to the other, is difficult and needs to be established per crop. With some crops this is difficult to establish as there is not an easy correlation between what we measure and crop growth. E.g. monitoring potato growth is not easy as drones and satellites can only measure what is above the ground while of course it is the growth of potatoes underground that counts.

A second problem is that current databases are static, heterogenous and difficult to access. Agricultural databases that are dynamic (near real time data) and homogenous have only recently start to develop.

[3] *"Which Industries are the Most Digital (and Why)?" – Prashant Gandhi, Somesh Khanna and Sree Ramaswamy of McKinsey Global Institute in Harvard Business Review, April 2016.*

A third problem lies in the validation of ICT solutions in agriculture. Once the factors such as temperature, soil, water and radiation are established that influence crop growth and one understand how these influence crop growth and crop yield, one can start to develop solutions. However, these solutions need validation over a number of growing seasons and therefore it takes time to develop these solutions.

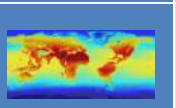
A fourth problem occurs in the complexity of agricultural value chains. Every crop has its own specific value chain with various actors and various interests. An ICT-solution may solve one problem in the value chain but if other problems remain unsolved, the ICT solution may have little or no impact and farmers will ignore it. E.g. if an early alert is given to farmers that his crops may be infected with a particular disease and an advice is given to the farmer for treatment, but he is unable to buy the particular pesticide as it is too expansive or not available on the market, this solution will be of no use.

Finally, ICT solutions are not always easily adopted by farmers, certainly not in the development phase when ICT solutions are not yet working in an optimal way.

The potential impact of ICT in agriculture is however unmistakable. Farmers are often considered to be the primary links in the agricultural value chain, sometimes also referred to as 'first mile'. As farmers live in rural areas and dispersed, it is difficult to reach them. In many countries costly systems of extension workers are used to 'educate' farmers about Good Agricultural Practices (GAP). With the introduction of Internet and mobile technology this is changing rapidly.

This impacts farmers and the industry in different ways. First of all, farmers with a mobile phone now have access to the outside world, weather forecasts, market prices and other information that is of interest to them. Secondly, it is also possible now to communicate with farmers in an interactive way. They can not only receive information but also give information back for instance e.g. on what they are growing, on pest and diseases, on land and water issues. Increasingly farmers will become important sources of information necessary to take decisions on meta-levels. And thirdly it becomes possible to make agricultural value chains fully transparent, which in turn is a precondition to make value chains sustainable.

Drivers to apply data in agriculture:

	*Feed the World*	Realization that in 2050 the world needs to produce 70% more food to feed the world
	*Biodiversity*	Better informed decisions will help to harmonize food production within its natural environment.
	*Climate Change*	Changing weather patterns makes data about crop suitability, crop calendaring essential
	*Yield Gap*	Closing the gap between potential and actual yield and increase land- and water productivity
	*Traceability*	Informing consumers where their food was produced and under which circumstances
	*Sustainable Sourcing*	Safeguarding future sourcing due to customer demands and changing climate patterns
	*Mobile Technology*	Makes it possible to connect farmers to the agricultural supply chain

To many in the agricultural sector it is now clear that the growth of the agricultural sector in the past 50 years cannot be continued by using more land, more pesticides or more fertilizers. The use of data will play an essential role in a more resilient, more efficient, more sustainable and fairer AgriFood system.

Most databases in agriculture contain static and heterogeneous data, often difficult to access or compare. In 2015, the Dutch Ministry of Foreign Affairs supported the establishment of the Water Productivity Open-Access Portal (WaPOR) database for Africa and the Near East, run by the FAO[4] and developed by a consortium of Dutch and Belgium partners. This database is the first continental database of its kind containing dynamic and homogenous data at 250m, 100m and 30m resolutions with data going back to the year 2009.

Though this is a major step forward, there is still a lack of use cases, which can show (potential) users and clients the benefits of the use of such a database.

[4] See: *https://wapor.apps.fao.org/home/1*

Data and Services applied in agriculture

Though most satellite data is open data, these data cannot be used directly but must be processed and 'translated' into information, knowledge and finally application.

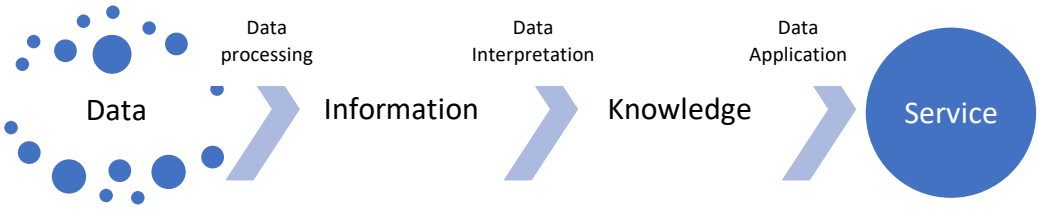


Figure 1: From data to service

Earth Observation (EO) data can be used in agriculture at different levels and by different actors. We can find hidden trends; create new insights and we can visualize these. The interaction and interchange of data at these different levels can help to transform agriculture to become more productive and sustainable. As lessons drawn from various ICT-Agri projects show, the use of EO Data is not a panacea or a 'quick fix' in solving all current problems in agriculture. It can however make an important contribution in addressing these challenges.

Earth observation data can be used at different levels:

Farmer	Agri-Business	Government	Research	Technical Assistance
• Increase yields • lower costs • reduction of losses • Increase income	• Make supply-chains more effective • increase quality • sustain sourcing • traceability	• Tools for policy development • set conditions for sustainable agriculture • promote economic growth	• Analysis and research • Study effects of agriculture on climate change and biodiversity • Recommend Good Agricultural Practices	• Increase quality of extension services • Reach more farmers

Figure 2: Application of EO-data at different levels

ICT-services to farmers

Influencing the growth process of crops to increase quantity and quality is an important, and perhaps even the primary, goal of applying data and IT in agriculture. However, for many farmers access to the market, to finance and to inputs is of equal importance.

There are considerable variations in production levels of crops as can be seen here

Yields in tons/ha	The Netherlands			Kenya		
	2015	2016	2017	2015	2016	2017
Potatoes	43	42	46	15	9	8
Maize	11	10	13	2	1	2
Onions	47	44	52	15	15	15

Table 2: Figures FAOSTAT

These figures give an indication of the 'yield gap'[5] and the potential yield of crops possible in Kenya. The yield gap is the difference between the potential yield and the actual yield. Analysis of conditions crucial for crop growth explain why there is a yield gap and take measures to improve the yield. Farmers are interested in closing the yield gap, improving the quality of their products and in the pricing of their products. To do this, they need to know what issues limit their yield such as lack of nutrients and water or disturb their yield such as Pest & Diseases, why they limit the yield and how they can improve their yield.

Measuring the optimal conditions for crops to grow is key. What can be measured and what data can be gathered by using earth observation or other data differs from crop to crop. Also, the accuracy of data differs from crop to crop. Some data show a clear and direct relation with biomass and yield while other data are only an indication of the crop growth. Ground data are therefore often important to validate geodata.

To understand the yield gap and provide advice to farmers requires profound knowledge of the growth process of the crop and the way in which crops are grown (e.g. shade trees, irrigated or non-irrigated crops) which may differ from country to country. The advice to farmers also depends on the means the farmer has in his/her country and the availability of inputs (seeds, fertilizers, pesticides). It does not make sense to advice farmers on the use of certain quality seeds if these are not available on the local market or too expensive for the farmer.
In the past number of years, a number of different ICT-services have been developed by Dutch and other ICT-Agri

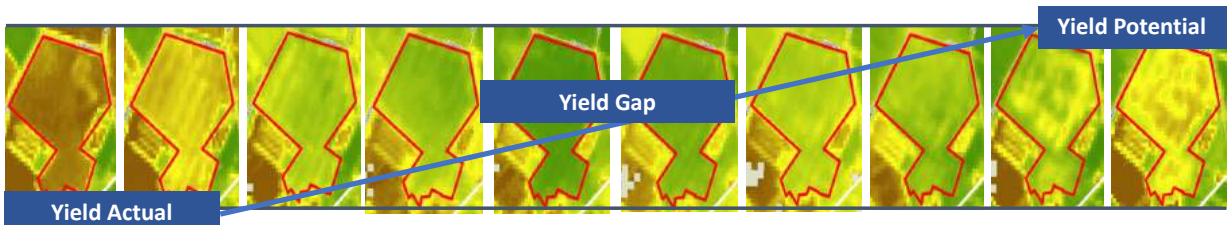


Figure 3: Yield Gap

[5] See: *http://www.yieldgap.org*

companies to address the challenges in agriculture which help to close the yield gap. The services in table 2 present the currently available ICT-services offered by ICT-Agri companies. The development of these services is still ongoing, and it may be expected that in the near future new technologies will be used such as Artificial Intelligence and Machine Learning to make these services more accurate and insightful. It is also important to mention that some services e.g. on Pest & Disease have been developed for particular crops and still needs to be developed to include all (varieties of) crops. Some services can be used as stand-alone services but often these are used in combination, a.o. with services on soil analysis.

Table 3: ICT-services for farmers based on different data-inputs

Service	**Aim**	**Data needed**
Weather Forecast	9x9 km precise, used in combination with other services	Satellite weather data preferably in combination with ground station data to develop prediction models
Crop Selector	Advice to farmers what best to grow on their land	Soil data, Weather data, previous crops, market/pricing data
Crop Monitoring & Calendaring	Advice to farmers when to do what - Good Agricultural Practice	Weather data + Satellite Data + Ground Truthing Data within Good Agricultural Practice of specific crop
Fertilizer Planner	Advice on which fertilizer for which crops to optimize yield	soil data, crop-variety data, market data (available seeds or tubers)
Pest & Disease Alert	Prevention and Combating P&D, minimalize use of pesticides and costs	Weather Data, Crop Monitoring data, crop disease algorithms, image recognition
Salinity Advice	Reduce salinity and/or advice on salinity-resistant crops	Satellite data in combination with in-situ data
Extreme Weather Risk	Early warning on drought, floods and advice on mitigating measures	Weather prediction models
Water Usage & Irrigation	More Crop per Drop	Water productivity + satellite data + GAP
AgriCoach	Advice to farmers on Good Agricultural Practices	Instruction pictures + videos
Mobile Learning	Expand the learning opportunities available to rural communities	Course related information, discussion forums and assessments.
Market Information	Advice farmers on current market prices and availability of inputs	Market information

With the right knowledge, the right data, the right advice and the right inputs, the farmer can close or minimize the yield gap and produce more crop on the same land and with less inputs resulting in higher income and more sustainable way of farming.

ICT-services to Agribusinesses

Different companies in the agriculture supply chain have an interest in information services based on geodata and data from farmers:

Interests	Input Suppliers	Credit & Finance	Farmers	Traders	Food Processors	Retailers	Consumers
Problems	Purchasing capacity farmers	Agri = Risks	Climate Change Information gap Soil Nutrients	Unstable quality & yields	Sustainable sourcing	Critical consumers	Food Quality
Solutions	Supply Planner Crop Disease Alert	Risk-monitoring Credit Scoring	Grower Apps What–When-How	Yield Prediction Optimize planning	Certification	Traceability	Tracer App
Impact	Higher quality input	Increase loan portfolio	Higher yield & income – higher efficiency of resources	Sustainable sourcing & supply	Sustainable supply of quality products	Reducing risk factors	Increased Trust

Figure 4: Information needs in the value chain

Input suppliers Suppliers of seeds, fertilizers, and pesticides, have an interest in knowing what the farmer needs and when he needs the inputs. They also like to know the performance of their input, trends of yields and quality, drought-resistance and pest & disease patterns.

Off takers Traders and food processors are interested to have yield predictions, quality of the produce, the timing of harvesting.

Logistic Companies Companies specializing in transport of inputs and products to off takers as well as cold storage facilities have an interest in crop selection and planning, crop calendaring data, yield prediction, planning of harvesting.

Table 4: Possible ICT-services to Agribusiness

Service	Aim	Data needed
Crop Classification	Mapping which crops grow where and with which yields	Optical data in combination with ground data
Crop Suitability mapping	Mapping which areas are best suited for particular crops	Data of climate, soil, water availability and crop characteristics
Crop Certification	Increase the sustainability and transparency of agricultural supply chains	Biomass production, Quality indices of crops and soil, Crop water usage, Deforestation, Land classification
Water Risk mapping	Determine the water-risks involved in growing crops	Data of climate, soil, water availability and crop characteristics
Deforestation Mapping	Determining where and when deforestation is taking place	Optical and/or radar data
Plantation age – tree health	Farm Development Plans, sustainable sourcing	Historical analysis of land use data
Plantation Productivity	Plantation development plans	Comparing greenness indicators (NDVI or LAI) to productivity of neighboring plantations
Logistical needs assessment	Provide transport and storage of inputs and crops at the right moment and place	Crop selection data, fertilizer advice, P&D advice, Crop Calendaring, Yield forecasts.
Environmental Risk Mapping	Mapping risks such as erosion and water usage in relation to land use and infrastructure	Elevation data, land cover data, soil data, weather data
Yield Monitoring & Forecasting	Estimating yields for pricing and food processing capacity; spatial and temporal comparison of fields	Satellite data for biomass calculation
Market Access	Promote linkages between producers and other parties in the value chain	Collecting & Analyzing information about buying & selling

FinTech Services in Agriculture

FinTech services relate to financial services in this case directly related to agriculture. There is a mutual interest between farmers on the one hand who require credits to pay for inputs and/or insure themselves against unwanted crop failure, and banks, microcredit institutions and insurance companies on the other hand to reduce the risks and invest in agriculture.

70% of the 11 million clients of the Equity bank in Kenya are farmers; yet only 4% of the credit portfolio of the bank goes to agriculture (source Equity Bank), an indication of this catch 22 situation farmers and banks find themselves in: farmers need inputs (and thus credits) to improve their farming and performance while banks are reluctant to provide credits before of poor performance.

Data and services on farm performance can help to map and mitigate the risks of farming, follow and increase the performance of farmers and raise the creditworthiness of farmers.

Table 5: Possible ICT-services for Financial institutes:

Service	Aim	Data needed
Credit scoring instrument	Assessment of farmer credit risk based on potential yield and earnings and how risks can be mitigated.	Credit history, farmer profile and data, farm development plan, Crop Monitoring data, Yield estimates, Input & Credit needs
Index-based insurance	Provision of a safety net in case of crop failure	Soil moisture, precipitation, drought, evapotranspiration, extreme weather, plot identification, yield estimation
Block Chain Technology	Traceability in agricultural supply chains validating transactions	Data about yield, quality and field or origin. Transaction payments
Saving- and credit schemes for farmers	Providing (smallholder) farmers to save earning, make transactions.	Database with personal data of farmers.

Management systems for agriculture

Management systems are becoming increasingly important to support agri-businesses in their day-to-day management of the supply chain.

Agricultural ministries, cooperatives, food processors, exporters, aggregators of agricultural commodities and agro-dealers and agro-vets all benefit from a system to manage large numbers of out growers, stock and customers. These systems facilitate the flow of information between parties and provide valuable data about business activities, production features and production records, and monitor compliance with quality, environmental, and other standards.

In addition, standardization of data opens up the opportunity to integrate third-party systems and software for services in finance, communication, weather information and much more. Allowing business owners to analyse customer information, facilitating the activity of buying or selling of products and predict future developments.

Last mile distribution channels in agriculture

One of the key challenges in the development of ICT for Agri solutions is how information is delivered to the end user in such a way that it is both efficient (price friendly) and effective. Often information is shared through human contact (by extension officers, or lead farmers) which is effective, but also high in cost.

The use of traditional media such as radio and newspapers to reach farmers can be efficient but is often too general to be very effective. The same applies for early ICT solutions which have made it possible to communicate directly to the end user

through text or voice messages, but with a limited amount of information and little control on real action.
The more recent ICT developments of smartphone (or tablet) based applications allow to share a lot more information in different formats (text, audio, video) and expand the learning opportunities available to rural communities through course related information, discussion forums and assessments.

Applications can be used to register farmers and link them to a GPS based location. Online communities share information and enable participation in policy dialogues and discussions. Extension and advisory services are transformed by providing access to full sets of good practice and information about markets and prices to strengthen farmers' position in their day-to-day trading. As a result of more in-depth analytics of user behavior is possible.

As a result, alternative models for last mile distributions may be needed, that combine the best of both worlds by connecting the physical (which have a high level of trust) and the digital. Involvement of youth in such systems may be a key to success when cultural aspects of society are taken into account.

Policy setting services in agriculture

National and local governments, farmer boards and councils, local and international NGO's have an interest in developing policies, setting rules and conditions, and monitor progress in trying to develop the agricultural sector while at the same time preserving the environment, water resources and biodiversity. Setting agricultural policies starts by studying historical data and the ability to recognize and forecast trends in agriculture. Reliable agricultural data are often missing or not accessible. Using satellite data have many advantages such as the availability of historic data (often 10 to 25 years back), the objectivity of data, covering all areas including remote areas, regular monitoring of areas and crops. This results in higher credibility of data, well-informed policy making and decisions and better monitoring & evaluation.

Table 6: Possible ICT-services for Government bodies and INGO's

Service	**Aim**	**Data needed**
Land Administration	Registration of title deeds to land	Aerial photographs + GPS
Land Coverage mapping	Monitoring land use and deforestation Prevent environmental damage and erosion	Optical Data in combination with ground data
Water Management	Mapping and monitoring of water points, water quality, water productivity and irrigation schemes	Land cover data, water productivity data, elevation, soil data, geomorphology
Salinity advice	Reduce salinity and/or advice on salinity-resistant crops	Salinity mapping based on in-situ data + geodata
Extreme weather risks	Flooding and Drought risk forecast and early warning	Weather data analysis

Early warning systems on flooding, droughts, extreme weather, locusts	Mitigating policies and measures	Weather forecasts, seasonal forecasts, precipitation monitoring, SPI data
Environmental Assessment	Mapping risks such as erosion and water usage in relation to land use and infrastructure	Elevation data, land cover data, soil data, weather data.
Disaster monitoring	Determine the agricultural damage and provide disaster relief	Land cover mapping (before-after), aerial photographs
Climate change	Scenario planning of the effects of climate change on agriculture	Analysis of weather data, water abstraction,
Conflict prevention and resolution	Prevention and solution on land- and water related resources, e.g. between pastoralists and farmers	Dependent on situation all of the above data can be used.

The above-mentioned services are not complete. Services become cheaper if they are applied at larger areas and for more customers. At the same time services need to be based on the specific needs of users. A balance is needed between application at scale and tailor-made advice.

Traditional approaches for Planning, Monitoring & Evaluation (PME) by governments and NGO's are usually time-intensive and costly and are sensitive for manipulation. Collection of reliable data about outputs, outcomes and impact is often complicated.
With satellite data it is possible to objectively measure for instance the effects of irrigation schemes or land management programs on water (-productivity) and (de)forestation. As historic satellite data of areas are available over the past 10 to 20 years, it is possible to make comparisons before, during and after programs have been carried out to establish the impact of such programs.

The market for ICT-services for Agriculture

The market for ICT services in agriculture is relatively young. Many small Ag-Tech companies and initiatives are blossoming. Despite their enthusiasm about the potential use of their application or service, they discover that entry to the market is difficult. This has a number of reasons.

Many users, and certainly smallholder farmers are not aware of the potential use of such applications. Companies need to invest in 'evangelism' of their products. A complication is that their services still need to be tested and validated (over more than one growing season) and the risk of failure of concepts and 1st trials is

there. Tech-companies offering services are not always aware of the specific needs of farmers or have insufficient knowledge of agriculture. Aligning the needs of users with the technical possibilities is therefore key. Many farmers do not simply trust new services as sometimes they have bad experiences with companies. Many agriculture value chains are complex and a service focusing on only one problem often has a limited value.

The development of the market of ICT-services for agriculture is different for farmers in Western countries and in Southern countries and different for medium-sized and big farmers and smallholder farmers. The bigger farmers are willing and able to invest and pay for services while smallholder farmers are unable or unwilling to pay for such services. The ability to reach large numbers of smallholder farmers with a relevant service and with a sound business model is decisive.

If one looks at the development of the market for ICT-services and applications for agriculture, roughly three different phases can be distinguished:

Phase 1 – Early Stage

In any product market combination, companies who choose for a 'product-development' strategy within an existing market, have to convince their clients of the benefits of their new product. Companies wishing to expand their market and choose for a 'market-development' strategy, have to convince new clients of the benefits of their existing products. Most Ag-Tech companies have however a double challenge: they have to develop a new product and they have to develop a new market and attract new clients. This is a risky strategy as it requires resources and time to be able to do this.

Figure 5: Ansoff Matrix

There is a striking difference between the development of the Ag-Tech market in the US and in Europe. While in the US venture capitalists recognize the potential of Ag-Tech and invest in young and promising companies, this is hardly the case in Europe where governments, the European Union and ESA support Ag-Tech companies with blended finance of subsidies and own capital investment often in Public-Private-Partnerships (PPP). The capital provided by either investors and/or public bodies, gives young Ag-Tech companies the opportunity to further develop their services and test them with their first clients.

This difference between American and European ICT for Agriculture companies can also be found in Kenya where American based companies work with considerable investment funds while European companies work on a mostly grant-based project-base.

Phase 2 - Commercialization

Slowly now, major AgriFood companies are beginning to work with Ag-Tech services and data. AgriFood companies working with large farmers see the benefits of the use of big data to optimize the supply chain.

For AgriFood companies and traders working in supply chains such as cocoa and coffee which is grown mostly by smallholder farmers, an important driver is to make their sourcing more sustainable and minimalize the effects on the environment for instance on deforestation or on the use of scarce water resources.

This can only work if they are able to work directly with smallholder farmers and capacitate them to work in a more sustainable way and improve their yield, income and living conditions. Almost all major AgriFood companies in the world such as Nestle, Unilever, Olam, Mars and Cargill have sustainability plans and departments. Increasingly they also start geodata-based services for their farmers using the technology developed by small Ag-Tech companies.

Phase 3 – Maturity

The market moves from 'single services for single users' to integrated data platforms using data from different sources for a variety of clients. The combination of these different data and applications and the use of machine learning and AI becomes then a strong driver in the market. Data companies such as Google, Microsoft and SAP are starting to develop such platforms.

The use of data in agriculture has a huge potential and will require in 5 to 10 years data platforms and information services that can handle large amounts of data which can be easily integrated in the regular services they offer.

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 complex, the system can be customized 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.

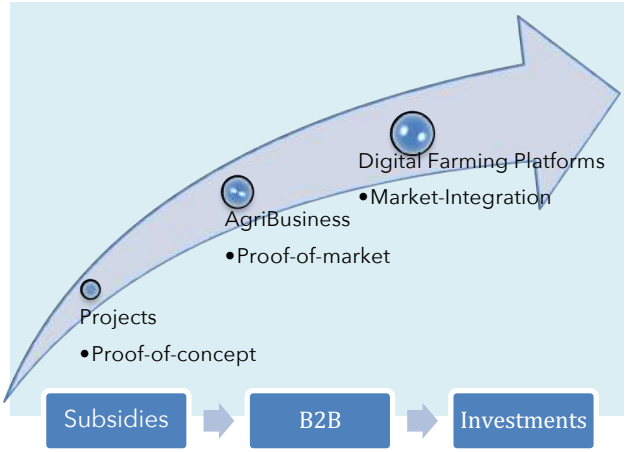


Figure 6: Ag-Tech market development

Dutch ICT-Agri companies

The Netherlands counts about 60 companies in the area of space technology.[6] Their activities range from building satellites (ISIS, Cosine), providing a platform for data (Nelen & Schuurmans) to delivering processed data (eLEAF, Satelligence). The sectors in which they are active range from Energy, Climate & Environment, Water & Delta, Mobility, Security, Weather and Agro & Food. 16 companies are member of NEVASCO, a platform that links geo-information providers to clients in four selected markets including Agro & Food.[7]

From the 60 Dutch Space Technology companies, about 12 companies focus on Agro & Food and Water. Their products and services are in the field of water management and water quality, crop monitoring with PiMapping technology (eLEAF), with radar technology (Satelligence), with passive radar technology (VanderSat), weather models (Weather Impact) and integration of data in business solutions (Waterwatch).

Most companies are SME's with less than 50 employees. Many Dutch ICT-Agri companies are dependent on public funding either directly through tenders from institutes like ESA, EU (Horizon 2020), FAO, Netherlands Space Office, the Bill & Melinda Gates Foundation or indirectly through orders from other companies or NGO's who work with public funding.

Financing ICT-Agri companies

Most ICT-Agri companies face difficulties in financing their operations. Their products are not yet fully developed, they cannot yet prove that their products are working and the market for such products is simply not yet existing. Within Europe the majority of start-ups in the field of space technology are established in the UK and the Netherlands, followed by Germany, Italy and France. The distribution of investments in start-ups however show a different picture for the Netherlands. The investment climate for space companies is very favorable in the UK, Ireland and Finland while the Netherlands is clearly lagging behind.[8] Why the investment climate in the Netherlands is less favorable than in other countries is not known. Dutch ICT-Agri companies presently developing high quality products find it difficult may to compete with other European, American, Indian or Chinese companies who with sufficient investment capital can develop similar solutions and conquer the market.

[6] See: *https://www.nlspace.nl/en/spacedirectory/*
[7] See: *https://nevasco-group.nl*
[8] *'Space Venture Europe 2018' – Entrepreneurship and Private Investment in the European Space Sector. Report 67 of the European Space Policy Institute – February 2019.*

Data and the Sustainable Development Goals

In September 2015, world leaders adopted the Sustainable Development Goals (SDGs) and committed to 17 goals to eradicate poverty, promote peace and equality, fuel inclusive growth, and protect the environment.

The SDGs present a historic opportunity for businesses to engage more deeply as a strong and positive influence on society. As an engine of economic growth and employment and a source of technology and innovation, business has a critical role to play and a self-interest in contributing to delivering the SDGs. First and foremost, business cannot succeed in societies that fail and therefore has a vested interest in stable and prosperous societies.

By developing a better understanding and proactively addressing the SDGs, companies will be able to better manage their risks, anticipate consumers' demand, secure access to needed resources, differentiate themselves from competitors, and strengthen their supply chains. In essence, the SDGs can help to connect business strategies with global priorities.

Companies can use the SDGs as an overarching framework to shape, steer, communicate and report on their strategies, goals and activities, allowing them to capitalize on a range of benefits such as identifying future business opportunities; enhancing the value of corporate sustainability; strengthening stakeholder relations and keeping pace with policy developments; stabilizing societies and markets; and using a common language and shared purpose with stakeholders.

The Netherlands is strongly engaged in translating the SDGs' ambitions and words into business action underpinned by business solutions: business-led ventures that are impactful, scalable, measurable, replicable, and going beyond business as usual. A tangible example of a solution is inclusive business, a term coined by the WBCSD in 2005 referring to ventures that go beyond philanthropy by integrating low-income communities into companies' value chains as customers, suppliers, retailers, and distributors. Inclusiveness is part of the Dutch vision for collaboration between private sector, governments, NGOs and the Research institutes.

How EO-solutions in agriculture contribute to the SDG's- an overview

	Sustainable Development Goal	Contribution of EO-solutions
	End poverty in all its forms everywhere	EO-solutions will enable farmers to increase their yield and income and decrease crop loss and the costs of inputs.
	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Smart farming solutions on crop selection, crop monitoring, access to markets and credits as well as risk management tools and early warning systems on extreme weather.
	Ensure healthy lives and promote well-being for all at all ages	Providing the right knowledge at the right moment can help farmers to reduce chemical fertilizers and pesticides.
	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	AgriCoach applications can reach farmers directly and will educate farmers and others in agribusiness to apply Good Agricultural Practices.
	Achieve gender equality and empower all women and girls	Mobile technology provides women direct access to essential information and empowers them to take their own decisions.
	Ensure availability and sustainable management of water and sanitation for all	Water productivity, land- and crop suitability maps to make optimal use of scarce water resources in agriculture. Mapping impact of agriculture on the water situation.
	Ensure access to affordable, reliable, sustainable and modern energy for all	Mapping sustainable sources of energy for use in agriculture.
	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Smart farming solutions increases the income of farmers and providing more and better jobs for all, in particular young people.
	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	EO data are essential inputs for the creation of Big Data networks for agriculture which facilitate EO solutions and predictive analysis in agriculture.

	Sustainable Development Goal	Contribution of EO-solutions
	Reduce inequality within and among countries	Smart farming solutions using EO data provides farmers near real time information which strengthen their position in the agricultural value chain.
	Make cities and human settlements inclusive, safe, resilient and sustainable	Smart farming solutions can give opportunities for people in rural areas for a decent living and prevent young people to migrate to overcrowded cities.
	Ensure sustainable consumption and production patterns	Smart farming solutions based on Good Agricultural Practices encourage producers to farm in a sustainable manner and makes values chains transparent.
	Take urgent action to combat climate change and its impacts	Smart farming solutions as part of a circular economy in which agriculture becomes an asset to a sustainable planet.
	Conserve and sustainably use the oceans, seas and marine resources for sustainable development	Ecosystem mapping and monitoring of salinity of land.
	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Smart farming solutions increase the yield per ha and take away the need to cut forests to add land for agriculture. Deforestation mapping, land- and water management mapping using EO data help to protect biodiversity and forests.
	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Smart farming solutions help to create opportunities for farmers for a decent income and prevent migration. Early warning systems on drought and disaster mapping help to take the right measures.
	Strengthen the means of implementation and revitalize the global partnership for sustainable development	Reliable and near real time data form the basis of (predictive) analytical models which can be used by all partners in sustainable development.

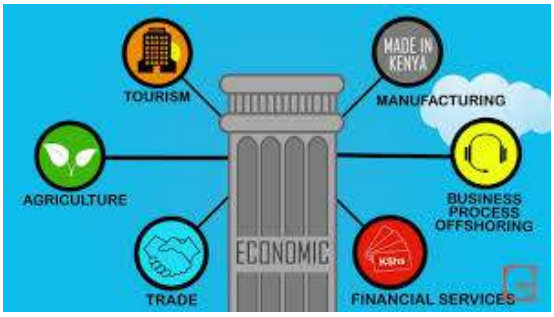
Importance of the Kenyan agriculture sector

Agriculture is an important driver of the national economy and contributes 26% directly and 25% indirectly of the GDP annually. The sector accounts for 65% of Kenya's total exports and about 75% of industrial raw materials. In addition, it provides livelihoods to millions of people and has a high employment multiplier effect of approximately 18% of Kenya's formal and more than 70% of informal employment in the rural areas being in the agricultural sector (GoK, 2013). The sector undoubtedly holds the key to Kenya's socio-economic transformation, food security and poverty alleviation.

The Kenya Vision 2030 policy identifies agriculture as a key sector through which annual economic growth rates of 10% can be achieved (GoK, 2010). However, there is need to transform Kenya's agriculture from largely subsistence activities that have been heavily dependent on rainfall, poorly mechanized and marked by low productivity and value addition into 'an innovative, commercially-oriented, internationally competitive and modern agricultural sector' (GoK, 2010).

Additionally, agriculture supplies numerous sectors with raw materials and generates foreign exchange. The sector employs over 40% of the total population and over 70% of the rural population[9]. Key foreign exchange earners include tea, fresh flowers, fruits and vegetables among others. To achieve this, transforming smallholder agriculture players from subsistence to an innovative, commercially oriented, and modern agricultural sector is critical. In this regard, the vision of the Kenyan Government has set a target of 7% annual economic growth for the sector.

To strategically realize these targets, a number activities have been set for implementation and includes: (i) transforming key institutions in agriculture and livestock to promote growth; (ii) increasing agricultural performance and



productivity; (iii) review and recommend amendments of land-use policies to promote better utilization; (iv) modernizing agricultural practices; (v) digitizing the development of agricultural value chains, and; (vi) improving market access. Similarly, support promotion of value addition and identifies aspects relevant to the creation of social equity and wealth creation opportunities.

[9] Kenya at a Glance – see http://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/

Kenyan Farmer Profile

The Kenyan "agricultural sector transformation and growth strategy 2019 – 2029" describes that Kenya has 8.6M Farmers which represent 4.5 million farming households, with 350,000 formal jobs in the sector[10]. Kenya's farms are small, and for the most part are getting smaller which is a major agricultural development concern.

According to FAO's Smallholder data portrait[11] 81% of farmers in Kenya are smallholder farms (less than 1.21 ha) and 854.400 (10%) are medium farmers and large farmers/Agribusiness. The smallest 20% of farms generate 57% of their income from farm activities. Areas of high or medium potential for agriculture occupy about 17% of Kenya's land and support about 80% of its population.

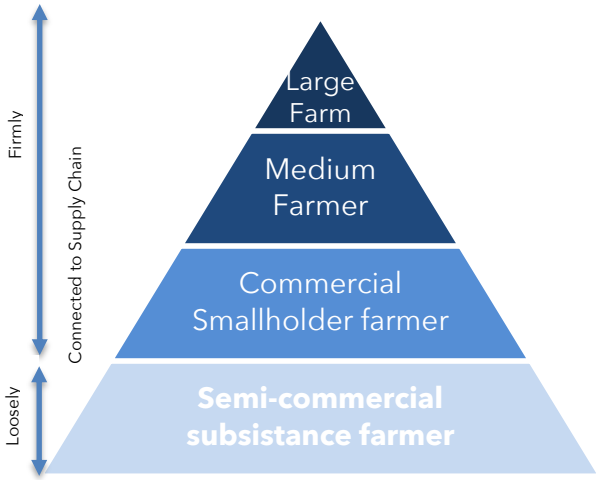


Table 6: Farmer Segmentation Profile Africa

About 83% of land is located in Arid and

Semi-Arid area – low potential. The rural population is exceedingly concentrated: about 20% of Kenya's arable land contains 74% of its population.

The figures provided below are based on figures for the whole of sub-Saharan Africa and therefore only an indication of the farmer segmentation profile in Kenya.

Segment Size	Land	Access to Tech	Access to Finance
3% 3%	>10 ha 5-10 ha	full	yes
12%	2-5 ha	plus	sometimes
20%	1-2 ha	basic	sometimes
62%	**<1 ha**	**no**	**no**

The average age of farmers in Kenya is 60 years[12]. This figure however represents the formal ownership of farmers who hold the title deeds to their land. Farming, and specially smallholder farming in Kenya is family farming involving children and sometimes grandchildren. A recent study

[10] http://www.kilimo.go.ke/wp-content/uploads/2019/01/ASTGS-Full-Version.pdf

[11] See: http://www.fao.org/family-farming/ data-sources/dataportrait/farm-size/en/

[12] See: https://agra.org/over-40-above-average/

by GeoPoll[13] from Kenya using a sample of 972 farmers out of a panel of 18.000 farmers showed that only 54% of the respondents own the land they farm on. Farmers leasing land or landowners having others farming their land (in Kenya called telephone farmers) is quite common.

Many farmers use mobile phones to get access to market prices, market inputs, weather and other information that can help to solve problems they are facing. Mobile phones are disrupting the agricultural value chain. Where in the past, farmers were vulnerable to exploitation by traders, they now hold a much better position.

Of the respondents in the GeoPoll study, 53% of the farmers use a smartphone and 47% a feature phone with SMS or access to basic Internet. The feature they use most are mobile lending and mobile banking followed by farming apps.

Though these figures are based on a relatively small sample, they do indicate the changing trend in the use of mobile phone technology by farmers in Kenya. The consequences of climate change in particular make farmers look for information that can help them to mitigate the risks.

Major challenges facing the agriculture sector in Kenya

The agricultural sector in Kenya is confronted with a number of – interrelated – challenges.

One main critical question is how to increase agricultural productivity and competiveness in the wake of small and declining farm sizes and lack of access to market? How can these farmers be reached to improve their yield, income and access to the market? They farm on average 0,5 ha of land and lack knowledge, quality inputs and the credit to buy these and are confronted with the consequences of climate change.

There is a need for farmers to diversify their operations. There is a gender asymmetry in access to services, knowledge and credits.

[13] The Digital Farmer: A Study of Kenya's Agricultural Sector - GeoPoll

There is an ongoing conversion of agricultural land to other competing land uses. As Kenya's population is fast growing, agricultural land is increasingly used for housing and for industry. Weak enforcement of land use regulations leading to cultivation on steep slopes and encroachment into forests resulting in catchment degradation and soil erosion in some counties.

A serious question is how young people in rural areas can be convinced to continue with farming. It should be noted that in the context of Kenya in most cases one should speak of farmer families – grandparents, parents, children – who are in one way or the other involved in farming. However, for many young people in rural areas, agriculture does not offer at present the prospects they are looking for. Those that have the opportunity, prefer to look for white- or blue-collar jobs in cities. The once that are left on the farm are often less educated and skilled. However, this is the generation that will have to take care of (food) production in the future.

It is therefore imperative to enhance youth inclusion in Kenya's agricultural development and tap the immense potential of ICT as an enabler to spur the sector's efficiency along the value chains. The active and notable involvement of youths in technological revolution is being witnessed in Kenya and across the globe provides evidence of this desired change. This has also been recognized by the Kenyan Government and other organizations resulting in new strategies to support the development of ICT for Agri skills among government extension workers, farmers and youths.

Climate change exacerbates agricultural risks, with serious implications for agriculture, food security and the wider economy. The Center for Global Development ranks Kenya 13th out of 233 countries for "direct risks" arising from "extreme weather" and 71st of 233 for "overall vulnerability" to climate change - after adjusting for coping ability.

Severe droughts that occurred in 1991/92, 1995/96, 1998/2000, 2004/2005, and 2008-11 caused precipitous crop losses, killed livestock, led to spikes in food prices, increased food insecurity and malnutrition among the poor. Producers in mixed crop/livestock systems used to anticipate major droughts once every 10 years, but droughts now arrive every 3–4 years. Climate change also leads to changing Pest & Disease patterns.

Increasing population pressure pushes farmers into dryer, more marginal areas where they are more vulnerable to drought and the unpredictability of weather.

Despite the efforts of the Government of Kenya to promote irrigation and while farmers know they are too dependent on rain, most of them do not have the means to invest in irrigation systems. Smaller plots of land and continues cultivation without sufficient crop rotation lead to soil nutrient deterioration and environmental degradation.

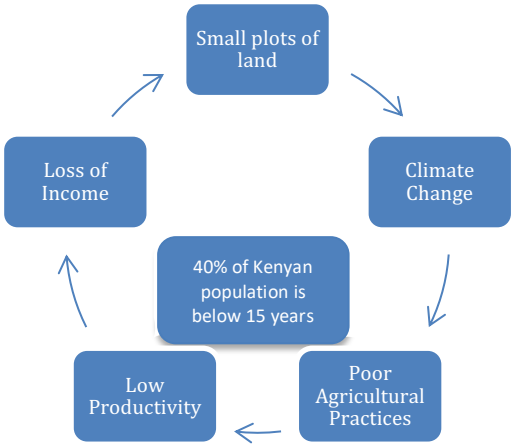


Figure 7: Vicious circle of poverty in rural areas

Poverty, climate change and population pressure form the ingredients for a vicious circle which makes it difficult for most people to escape. Limited access to extension services and inadequate access to advanced knowledge and technologies as well as credits lead to poor agricultural practices.

It is therefore not surprising that most agricultural value chains in Kenya are neither effective nor efficient. This leads to high production and transportation costs and post-harvest losses. This can partly be attributed to a weak infrastructure. But a lack of alignment in the agricultural value chain however is causing the main gaps in the supplies of inputs and a mismatch between market needs and agricultural supplies.

The interrelated problems in most agricultural value chains in Kenya can only be addressed properly in an integrated and coordinated approach.

The access to financial services remains a constraint on the agricultural sector in Kenya, loans or investments are hard to come by. Both public and private investment in the sector remain behind. Current investment by the government stand at 2.3% of GDP and the interest rate cap on bank loans which was introduced end of 2016 has had a negative effect on the amount of loans being distributed, this has hit the agricultural sector first. For young people it is even more difficult to get a loan the land, which can be put as collateral, land belongs to the parents.

The use of ICT-solutions in Kenya

In sub-Saharan Africa there are 420 million unique mobile subscribers, and this is expected to increase by 2020 to more than 500 million.[14] Smartphone connections are rapidly growing and are expected to double in 2020 to nearly 200 million.

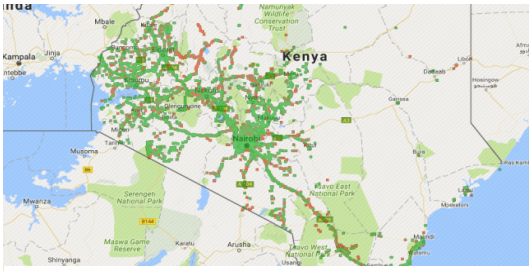


Figure 8: Mobile network coverage Kenya

[14] *Jumia – Kenya Mobile White Paper 2018*

The adaptation of smartphones is largely driven by the improving affordability and the uptake of Internet services.

The overall state of ICT Infrastructure penetration in Kenya is good and includes Base Transmitter Stations for Mobile Networks often loosely called Transmission Towers, Fiber Optic cables, Fixed Broadband, International Internet landing stations. The speed of current mobile network connection in Kenya is estimated at 13.7 megabits per second. Kenya has been ranked 28th globally with an average internet speed of 10.7 mbps. The figure below illustrates mobile network coverage in Kenya.

The Communications Authority of Kenya's 2018 – 2019 data indicates that the number of active mobile subscriptions in Kenya stood at 46.6 million as at September 2018.

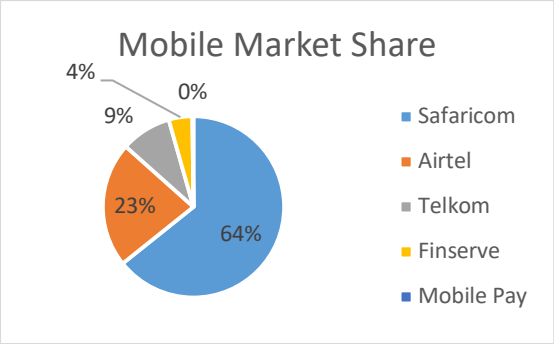


Figure 9 : Mobile Network Operators Market share

The growth of internet connectivity in Kenya has been on the upward growth over time.

Year	Users	Population	Penetration
2000	200,000	30,339,770	0.7 %
2008	3,000,000	37,953,838	7.9 %
2009	3,359,600	39,002,772	8.6 %
2015	31,985,048	45,925,301	69.6 %
2017	43,329,434	48,466,928	89.4 %

Table 7: Internet growth coverage in Kenya – Source ITU and CAK

According to data from Kenya National Bureau of Statistics household survey report, 8.4% of the adult population has access to computer[15]. The use of computers increases with age but is at its peak between 20-24 years then gradually decline.

As a result of smartphone adaptation, Internet connectivity is growing in Kenya. Though games, social media, news and music are popular downloads, increasingly mobile payment systems (M-Pesa), credit provider apps (Tala, BranchLoan) and transport apps (Uber, Taxify, Little Cab) are popular. Mobile applications in other sectors such as health care (medAfrica) are being introduced. With 17 million accounts in Kenya, M-Pesa, introduced in 2010 by Vodafone and Safaricom in Kenya, is one of the most successful mobile payment services in the world.

[15] *https://ca.go.ke/wp-content/uploads/2018/12/Sector-Statistics-Report-Q1-2018-2019.pdf*

The use of ICT-solutions in agriculture in Kenya

A study by Mercy Corps, 2016, among farmers in Kenya shows that *"While the number of basic phones owned is still increasing, smart phones take over from feature phones and presumably become more widespread"*[16]. This is supported by a growing network coverage with a 3G population coverage of 85% and 4G penetration of 25% in 2017[17]. Making Kenya the leader in Internet penetration in Africa with total Internet penetration of 86 percent in 2017"[18]

Young farmers are most likely to own smart phones in Kenya[19], Young farmers (age 15 -34) now account for 32 percent of the farmer population and this number will increase drastically in the coming years. The digital transformation of the agricultural sector provides entry points to engage young farmers who seek access to key information such as market prices, record keeping, pest and disease control, farming practices and technologies and communication with other farmers.[20] Woman play an important role in the Kenyan agricultural sector, 75% of Kenya's women work in the sector. For half of this group it is the men that own the farm[21]. As in many developing countries women in Kenya face a triple divide of digital, rural, and gender inequality[22]

The rapid developments in the ICT field in Kenya have enabled integration of different parts of the agricultural value chain. Incidentally, ICT has become a fixture of interest for researchers, practitioners and policy makers in Kenya over the past decade. Furthermore, use of ICTs in agricultural sector continues to be a key area of interest for development today being reflected in initiatives such as the Agri-Fin Mobile program, the Africa Regional Data Cube and the agricultural observatory platform.

Within agriculture sector in Kenya, the use of ICTs continues to be a key area of interest for research and practice such as in data analysis, development of agricultural knowledge content and information. These efforts translate to ease of access, sharing and utilization of agricultural information and knowledge. Consequently, increasing agricultural production and therefore better health as well as a reduction in poverty for smallholder famers. This further works towards attaining the sustainable development goals through economic empowerment. Some of the ICT tools, which have applied in agricultural sector

[16] http://mercycorpsafa.org/wp-content/uploads/2017/02/AFA_Second_SecondBenchmarkStudy_Kenya.pdf

[17] *https://www.safaricom.co.ke/images/Downloads/Resources_Downloads/Safaricom_2017_Annual_Report.pdf*

[18] *https://www.jumia.co.ke/mobile-report/*

[19] *http://mercycorpsafa.org/wp-content/uploads/2017/02/AFA_Second_SecondBenchmarkStudy_Kenya.pdf*

20 *file:///C:/Users/Gebruiker/Desktop/Commentaar%20ICT AgroKeya/230118_afa-youth-final-vF-compressed.pdf*

[21] *http://www.kilimo.go.ke/wp-content/uploads/2019/01/ASTGS-Full-Version.pdf*

22 *http://documents.worldbank.org/curated/en/522141499680975973/ICT-in-agriculture-connecting-smallholders-to-knowledge-networks-and-institutions*

in Kenya, include the development of web portals, mobile-based applications, and application of big data analytics. These systems have capabilities of helping farmers to access simplified and personally designed information to apply in farming practices.

The World Bank Survey Report indicates that there are limited products and services being provided by the existing platforms in Kenya. Also, it is evidenced that the platforms do not have effective mechanisms with which to track their users. A summary of ICT services in agriculture in Kenya:

Type of service	*(%)*
Early warning	80
Climate predictions	78
Weather Forecasts	55
Agro-weather advisories	70
Government policies	45
Insurance derivations	45
Climate projections	30
Transport safety advisories	30
Airspace forecasting	21
Others	14

Table 8: World Bank Group Field Survey Report Number 103186-Ke (2016)

The majority of the data in agriculture in Kenya is collected manually which is an expensive undertaking and is not sustainable.

Type of data used in CSA services	**%**
Manually collected data	59
Automatically collected data	7
Data collected from remote sensing	34

Table 9: World Bank Group Field Survey Report Number 103186-Ke (2016)

Also, very little data in the management ecosystem is automated. These findings re-enforce the need for a big data platform.

The application of Earth Observation data in combination of ground data can help to address the challenges of the agricultural sector in Kenya. Technically speaking many applications are possible already and in the coming years this will increase even further.

However, lessons from G4AW programs running in East Africa[23] and similar programs make clear that the application of data and applications in Agriculture in Kenya is still in its infant stages.

Technology is of course important but the main challenge for ICT-agri companies in Kenya is the adaptation by farmers, particularly smallholder farmers and by other actors in the agriculture value chain.

[23] *From Early Stage to Scale, Sustaining results of the G4AW Program - G4AW Regional Workshop Nairobi, 17-18 May 2018*

The reasons why technology is not easy adopted are multifold:

Registration of farmers

The threshold for a business model in ICT services for smallholder farmers in Africa and Asia is around 100.000 smallholder farmers. This threshold is used by the G4AW program and is needed to be able to cover the costs of the service. For any paid service an ICT-Agri company needs to have access to an active network of farmers. Though farmers are organized in cooperatives, in crop-specific networks (e.g. the National Potato Council of Kenya) or in data-networks of traders or food processors, these networks are often not or poorly digitized and the loyalty of farmers to such networks is often not very strong. ICT-Agri services can be successful once they can link with companies or organizations which have a network of farmers and have built up a relationship of trust.

Readiness to pay

Many farmers are not prepared to pay for information services. Existing ICT applications are offered for "free" as part of a mobile phone subscription, paid by companies on the basis of a loyalty business model, or paid by governments or NGO's as part of development programs. This makes it difficult to convince farmers to subscribe and pay for such services. Another reason why farmers are not prepared to pay is when they do not see the cost-benefit of the application. Experience also in G4AW programs show that Agribusiness (e.g. input providers, off takers) are interested in paying for 'their farmers'.

Business approach

Many ICT-Agri companies are supply-driven, trusting on the quality and added value of their services without a sufficient understanding on the needs of the users. It is important to understand what users need, offer them tailor-made services and convince them what will be the added value of these services.

Integration of Services

A major problem in this emerging market of ICT-Agri services is that many small companies offer single services using single sets of data. Users – farmers and agribusiness - however demand integrated services in agriculture (weather, soil, drought predictions, pest & disease, crop monitoring etc) and/or integrated with Fintech services (credits, insurance, mobile payment) or Agribusiness services (pricing, yield predictions, seed/fertilizer planning, etc).

Market readiness

Many ICT-Agri services and applications have been recently developed without much evidence (yet) about added value and impact. Testing and validation of ICT-Agri services usually require at least 3 growing

seasons and many customers demand to see proof that applications are really working, preferably in their country and with the crops they grow.

Value chain approach

Problems relating to low quality and quality yields are often the result of a combination of factors such as changing weather patterns, low quality seeds, bad agricultural practices (e.g. no crop rotation), poor infrastructure, little knowledge at farm level, no access to credits. Solving one problem (e.g. advice to farmers on the use of quality seeds) without addressing other problems (e.g. access to credit to buy quality seeds) has little value. An approach involving the main actors in a particular value chain, using multiple sets of data and providing various services has much higher chances of success.

Governmental and business climate on data and ICT in Kenya

Comparative to most other sub-Saharan African countries, Kenya is a relatively stable country with a good business climate, educational level and entrepreneurship. It has a good agribusiness education. Dutch ICT-Agri companies have to get acquainted though with the different culture and way of doing business. Kenya is ranked 61 among 190 economies in the 'ease-of-doing-business index', according to the latest World Bank annual ratings[24]. The rank of Kenya improved to 61 in 2018 from 80 in 2017. In sub-Saharan Africa it takes the 3rd place after Mauritius ranked 20 and Rwanda ranked 29.

Kenya has put in place a national ICT policy which is spearheaded by ministry of ICT. The process of developing the policy involved different stakeholders including private sector. The main actors and their roles are listed in table 10. The Kenya ICT policy is a critical pillar in national development and is an enabler to businesses in Kenya.

Kenya's ICT policy recognizes their citizen as an ICT literate as the foundation to economic growth, poverty eradication and academic excellence at levels. Academic institutions from primary, secondary schools to higher learning institutions in Kenya offer ICT and related studies. The Government has also embraced e-learning in schools and higher learning institutions to enhance ICT skills in the country.

ICTs are to drive the Big 4 Agenda for Kenya: manufacturing, food security, universal healthcare and affordable housing, identified by President Uhuru Kenyatta as top priority areas for the next five years. Emerging technologies including artificial intelligence, big data,

[24] *http://www.doingbusiness.org/en/rankings*

machine learning, computing power, storage capacity, cloud computing and distributed ledgers (blockchain) are now being used and expected to improve people's lives[25].

Kenya is ranked one of the most innovative countries in Africa and one of the many countries in the African region seeking to become a data/ICT hub. In line with this development Kenya is developing a Privacy & Data Protection Policy following the European Union-General Data Protection Regulation[26].

The Ministry of Agriculture of Kenya recognizes the need to pay more attention to agriculture and wants agriculture to be a compulsory subject in both primary and secondary schools. At the same time the number of students which apply for studies that relate to agriculture are in decline. ICT is seen as one of the ways to involve and enthusiast youth for agriculture. Supporting organizations recognize the need for skills development at all levels, from secondary school to vocational training[27].

Drones have the potential to be used in precision agriculture and in livestock monitoring. In March 2018, the Kenya Civil Aviation Authority (KCAA) published

regulations for the commercial use of drones. The regulations under which a farmer can use a drone are quite scrupulous as operators need to be medically fit, are licensed operators, have police clearance and need an insurance cover. It is believed that regulations are strict because of fear that drones are used by terrorist groups like al-Shabaab to carry out attacks. Because of the high costs and the strict regulation, it is expected that drones will have limited application in agriculture in Kenya.

At the High Level Conference on Data Revolution, held in Addis Ababa, Ethiopia in 2015, a decision was taken to create an African Open Data Network (AODN). Kenya has taken this agenda forward and taken a number of actions and steps in this direction. Some of the actions includes:

1. Mobilization and advocacy on open data as a common agenda informed by Africa's Agenda 2063 and other normative continental frameworks
2. Development of several open data platforms for shared learning and peer networking
3. Increased sharing of data and other knowledge e products and services from data
4. Catalyzing open data research.
5. The development of Kenya Open Data Initiative (KODI).

Various open data initiatives have been started to promote efforts at ending poverty, ending hunger, reducing inequality and delivering inclusive prosperity for all through knowledge driven initiatives. Similarly, a number of global networks of Open Data have good presence in Kenya mainly focusing on training to help researchers and academics to align their open data efforts

[25] *https://ca.go.ke/icts-to-drive-the-big-4-agenda-for-kenya/*

[26] https://ca.go.ke/document/ibm-rfc-data-protection-bill-policy-2018-moict-ca-final-submissions/

[27] *https://4-hkenya.com*

with global practices. The goal is to advance the creation of locally driven and sustainable Open Data ecosystems within their organizations and research/learning programs. These programs have increased collaboration and research activities. However, there is a need for data driven evidence that can authoritatively inform policies and practices in agriculture in Kenya.

Most of the higher learning institutions in Kenya have integrated ICT in a number of courses in the country. Furthermore, there is a proliferation of new and emerging courses in ICT for instance in courses such as, data science, data journalism among others are recently being offered in Kenya

Existing data management platforms In Kenya do not have sufficient capabilities to provide for the rapidly growing demand for intelligent data products and services as well as discovery of knowledge from agricultural datasets. While adequate agricultural datasets exist, there is need for tools and solutions to undertake deep analysis and to turn data into insight using big data techniques and strategies. Similarly, the findings indicate that there are limited platforms that can meet the aggregate need for real time predictive data analytics from agricultural datasets.

Towards this end, the Kenya Agricultural and Livestock Research organization (KALRO) with the support of World Bank is setting up a Big Data Infrastructure in Kenya. The infrastructure will include high performing computing, capacity building and analytics solutions. The investment is expected to spur growth in agricultural production in Kenya as well as address a host challenges facing agricultural especially climate change.

Big Data Platform for Climate Smart Agriculture

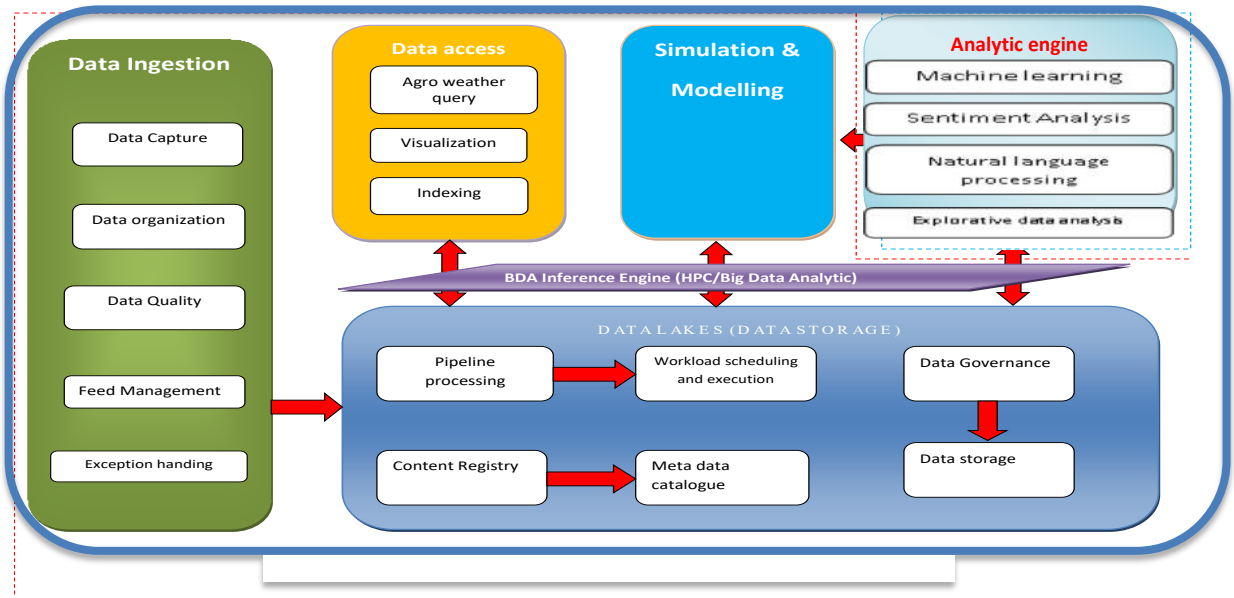


Figure 9: Big Data Platform for Agriculture

Dutch ICT-Agri companies in Kenya

The Netherlands has a strong and diverse economic relationship with Kenya. Today the Netherlands is the second export destination for Kenyan goods. Dutch companies are important investors in the horticultural sector but also in other areas of the economy. Support programs for Kenya by the Dutch government focus on areas such as Food Security and Agriculture, Water, Trade and Investment Security and Rule of Law.

The Netherlands has a rich tradition in agriculture. The agronomic models of many crops developed by Wageningen University & Research (WUR) serve as the scientific models used in many parts of the world.

The Netherlands is also a frontrunner in the use of Space Technology (Delft University of Technology). The Netherlands hosts the European Space Agency (ESA) and through the Netherlands Space Office (NSO) space technology is being promoted in different sectors including agriculture. Many of the Dutch companies working with Earth Observation data in agriculture find their origin in either Delft or Wageningen or in the combination. The technologies developed by these companies compete with the best available at present in the world. Many of the Dutch ICT-Agri companies are partner in the Geodata for Agriculture and Water (G4AW) program, which improves food security by using satellite data. The G4AW program is commissioned by the Dutch Ministry of Foreign Affairs and executed by the NSO.

G4AW
GEODATA FOR AGRICULTURE AND WATER

With ICT becoming more important in today's society and the Netherlands being a global leader in ICT development for agriculture, it is no surprise that a number of initiatives have developed in Kenya that focus on ICT in agriculture and that are closely linked to the Netherlands. For an important part this is stimulated by Dutch and international seed capital to support the development of these initiatives such as the G4AW program of the Dutch government, the UK Space Agency program on agriculture, the Bill & Melinda Gates Foundation program, World Bank and others.

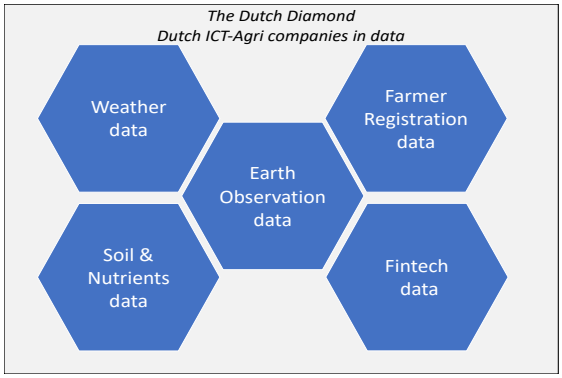


Figure 10. Dutch ICT Agri fields of competence

In Kenya there are at present 13 Dutch companies and organizations active on ICT and Data in agriculture and another 4

to 6 companies who are interested in becoming active.
These companies are active in different fields and most offer complementary services needed to offer a complete package to clients. A complete list of Dutch ICT-Agri companies and organizations is included in the annex.

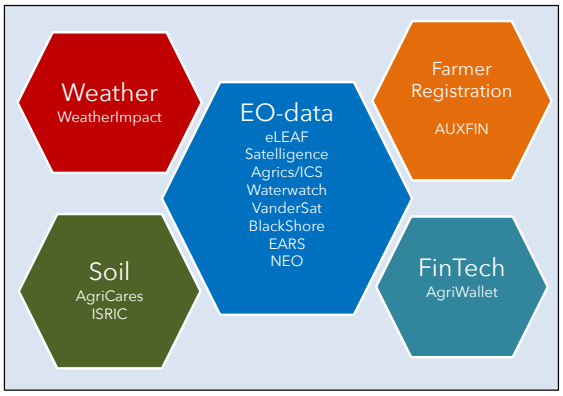


Figure 11. Dutch companies offering different services in Geodata and Fintech

For this study we have looked at a number of companies in Kenya that focus on ICT and Agriculture and are driven by Dutch entrepreneurs or with a strong link to the Netherlands. What we see is a diverse field of players at different stages of development, from start-up, to growth or even expansion and all with different needs when it comes to access to finance as well as partnerships and/or clients. Some companies such as eProd-solutions, AgriCares, Dodore, Waterwatch and Agrics/ICS have local presence in Kenya and therefore can much easier connect with Kenyan counterparts and clients For the majority of Dutch ICT-Agri companies who do not specifically focus on Kenya, this is not feasible.

Dutch ICT-Agri companies use a variety of different strategies to cope with the immature market for ICT in agri. They focus on 'low hanging fruits' such as the flower sector which is quite organized and understand the benefits. They develop the market by providing training to organizations and by prototyping products in an agile – start small, fail fast – way. And by using grants and instruments such as the SBIR instrument from RVO.nl.

For companies with a presence in Kenya it is easier to explore and develop the market as is demonstrated in the CROPMON project. But overall it is difficult as most Dutch ICT-Agri companies are small and dependent on project-based grant money, often also on the basis of co-funding which means these companies have little or no resources to explore for instance the market in Kenya.

Two examples how it can be different are aWhere from the US and Cropin from India who have been able to develop themselves because they have received major investments (Cropin for instance received a grant of 8 million dollars from the Gates Foundation). With the exception of Vandersat whose primary customers are insurance and reinsurance companies and who managed to attract investors, Dutch ICT-Agri companies have not been able (yet) to attract investors.

For companies with no presence in Kenya it is even more difficult. They mention that a lack of concrete business opportunities prevents them from becoming active in Kenya. Or rather: they are not aware of such opportunities. Vice-versa this is true as well: Kenyan entrepreneurs and businesses are not – fully at least – aware of the technologies and services offered by Dutch ICT-Agri companies.

Dutch ICT-Agri companies also mention lack of knowledge of the Kenyan market

and the landscape of local partners as crucial elements. They regard market studies, matchmaking facilities and business integration efforts as the most important ways to let the technologies meet the demands.

It is however difficult to match high potential Dutch technologies with Kenyan entrepreneurs as a business integrator or matchmaker is missing at the moment.

The case of Cropmon

CROPMON is a Dutch-Kenyan consortium (SoilCares, NEO, Weather Impact, Cereal Growers Association, Coffee Management Services, Equity Group Foundation, Springg, Sugar Research Institute), which produces a weekly SMS service providing crop growth monitoring, weather forecasting and farm management advice to maize, coffee, sugarcane, grass and wheat-farmers in the southwestern part of Kenya. CROPMON is funded under the G4AW program of the Netherlands Space Office (NSO)

CROPMON is reaching at present 65.000 farmers and will eventually offer commercial services to 150.000 farmers in Kenya.

The success of the project can be attributed to:
1) a good combination of Dutch technology partners with strong local distribution partners;
2) a strong business drive; and
3) using a fast learning curve of developing, testing, learning and adaptation.

Business opportunities and business models

Most Dutch ICT-Agri companies work on a B2B basis, providing services to other companies, telephone companies, banks, farmer boards, governmental institutes and NGO's against a lumpsum or a subscription fee. These services are being used by these business partners either directly for their own activities or being offered to farmers with whom they are related.

The commercial basis to deliver ICT services in agriculture is important as reliance on public funding makes the further development and investment in ICT in agriculture vulnerable. It is important to not only focus on the direct B2B opportunities for ICT-Agri companies in Kenya, but also on the further innovation and development of sound business models to end users.

Which business model can be applied best depends very much on the size of farmers, their information needs, their ability and willingness to work with new techniques and their ability to pay for the services. In general, larger farmers have

more opportunities to pay for these services than smallholder farmers. But the information needs of large farmers also are different. Usually they already are quite knowledgeable about using new farming techniques and their information needs are then very specific. Large farmers are also able to pay for services.

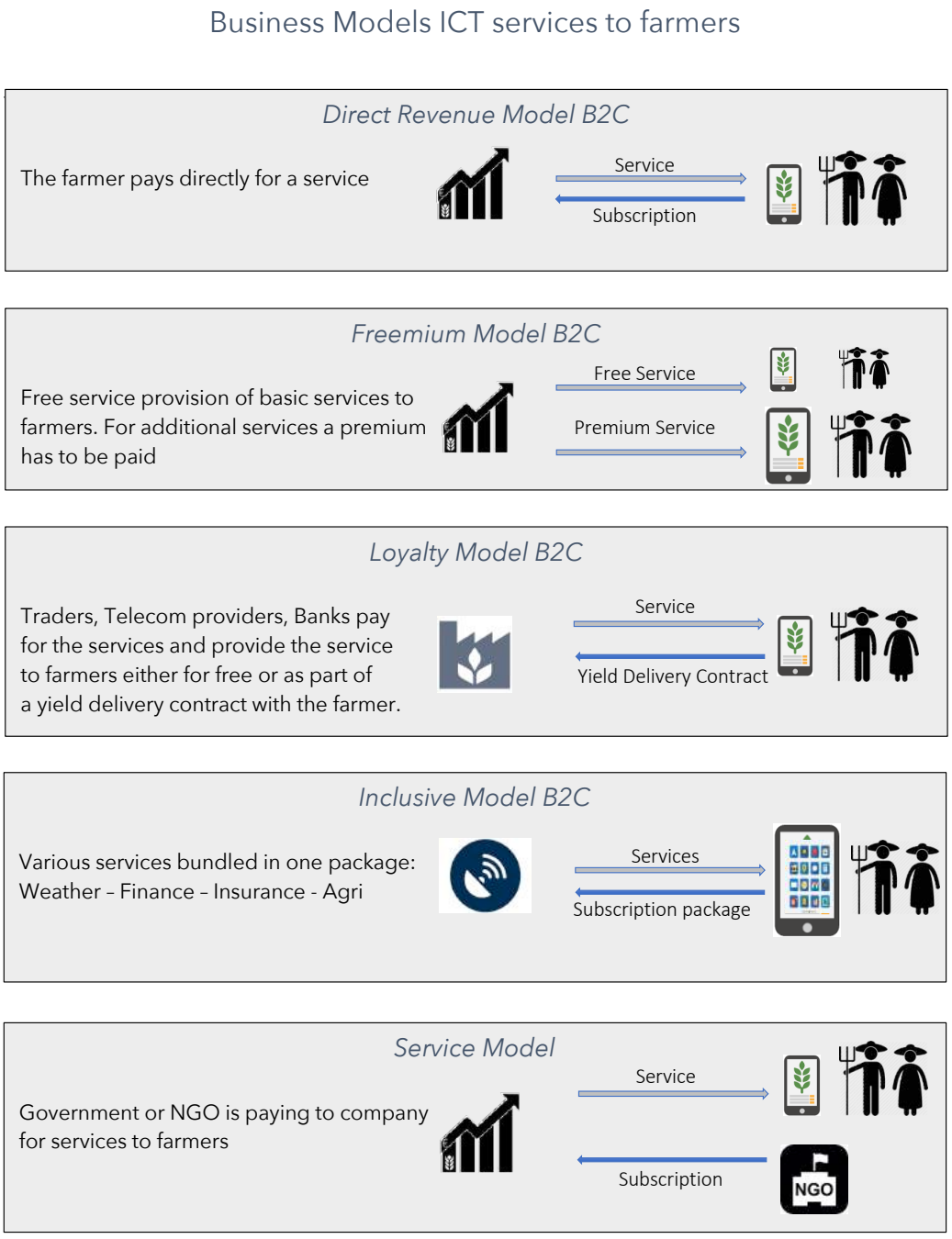


Figure 12. Business Models in ICT-Agri Services

Challenges and opportunities in Kenyan agriculture

The agricultural sector in Africa is in need of transformation. At the recent High-Level Forum Africa-Europe in December 2018 in Vienna, Austria, a recommendation was made to start a knowledge, innovation and networking initiative for transformation of agriculture and rural areas[28]. Such a transformation is needed in Kenya as well. Existing challenges such as poor agricultural practices, low quality inputs and lack of access to knowledge, credits and markets are exacerbated by new challenges such as climate change and changing Pest & Disease patterns. Traditional ways to close yield gaps by applying more fertilizers and pesticides and to reach farmers and teach them how to deal with these new challenges are not sufficient.

The rapid uptake of mobile technology in Kenya such as mobile payments systems, are an indication how technology can be disruptive and reach millions of people. Of course, the adoption of such technology is going faster in urban than in rural areas and young people are embracing ICT applications much faster than the generation of their parents. Uptake of ICT technology in the rural agricultural sector by a generation of aging Kenyan farmers is a challenge. The use of ICT technologies in agriculture in Kenya however also offers good opportunities to convince a young generation of farmers in Kenya to make a living in farming.

Various and diverse Kenyan parties in agriculture begin to recognize the potential of using ICT and data and so the demand is increasing. The timing for involvement for Dutch ICT-Agri companies in Kenya is there.

ICT and data can be applied at all levels and with all stakeholders in agriculture in Kenya: Farmers, Agribusiness, Researchers, NGOs and Government. Within each group further market segmentations can be made. What makes involvement sometimes complicated is that each value chain has its own characteristics and its own landscape of stakeholders and within each value chain different sets of data are required. These complexities require ICT-services in agriculture to be value chain-specific and tailor-made.
The Kenyan government is recognizing the potential in the use of data and ICT-technologies in general as well as in agriculture. The hosting in Kenya of the

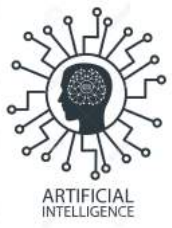
[28] *High-Level Forum Africa-Europe 2018, Vienna, Austria, 18 December 2018 : Towards an Africa Europe partnership for sustainable development and jobs in rural Africa - Priority Areas for Action and Key Recommendations of the Task Force Rural Africa.*

Africa Regional Data Cube and the recent initiative of the Ministry of Agriculture to create a Data Platform for Climate SMART Agriculture in Kenya are testimonies to this. These developments offer great opportunities for (Dutch) ICT-agri companies to deliver services.

Potential use of ICT for Agribusinesses

The services that have been developed in recent years in Europe, the US, Africa and Asia in the field of Data and ICT in agriculture show that with better and timely information it is possible to take the right decisions at the right moment to increase yields and water productivity, to make better use of inputs, to limit crop losses and post-harvest losses. In chapter 2 a number of different services for different stakeholders in the agricultural value chain are mentioned that show this potential. This is only the first step.

With the introduction of Artificial Intelligence (AI) and Machine Learning (ML), a next generation of services will be developed that will help to feed the world in the next decades in a way that nurtures people and planet. Given the frontrunners position of Kenya in sub-Saharan Africa in the use of ICT, the expectation is justified that the use of ICT in agriculture will be booming in Kenya in the next 5 years. The timing to invest in ICT in agriculture in Kenya with the aim of building a good position is now.



Companies investing in ICT in agriculture have to take into account the limitations and challenges in the use of ICT in agriculture in Kenya in a number of areas.

The need for customer segmentation

Some ICT-Agri Companies have succeeded in developing products that are successful and slowly start to enter the market. Most of them have the support and network of a major other company such as Safaricom. Some ICT-Agri companies however do not have sufficient knowledge about the value chains they intend to serve and operate on inadequate assumptions. A simple differentiation between big farmers and smallholder farmers is not enough as within the groups of smallholder farmers there are large differences. For instance, between more business-oriented farmers eager to try new technologies and more elderly subsistence farmers who don't see such opportunities easily.

Development of services takes time

Developing new products for actors in agriculture require time, resources and to a certain extent the 'space to fail'. To develop a new service, profound knowledge about the crop and the possibilities to measure crop growth is required. Validating a new service will need the feedback of users, at least over 2 or 3 growing seasons. New ICT-Agri companies, who have to demonstrate their service towards their investors or donors, often lack this time and the resources to do this. They cannot afford to fail. This runs the risk that services or applications are brought to the market too soon and are being ignored by farmers or other users.

Farmer engagement is key

Most companies have high hopes but discover that farmers are not signing up to their services. The ability to reach large number of farmers is decisive. Registration of farmers in cooperatives or networks is often poor and expectations about the uptake by farmers of new ICT-technology is not always based on reality.

Farmers who have little time and cannot follow the technological developments will not easily trust companies that claim to have the solution to their problems. This is exacerbated by the fact that many farmers are aging and less able to adopt new (ICT-) technologies.

The involvement, knowledge of farming and feedback of farmers is crucial. Some ICT-Agri companies therefore have adopted a strategy of working with groups of farmers or with key-farmers. They test their products with them and once ready, roll out the products. NGOs that work with farmers such as SNV, Hivos and Solidaridad have already done a pre-selection of groups that are well organized and can be a valuable partner.

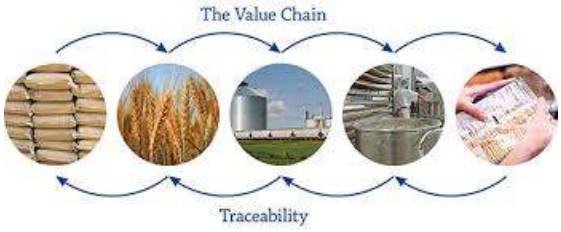
Sound business models

It is essential therefore that a company invests in a good entry point to the farmers as it takes time, guidance and trust of farmers to adapt to new technologies. Business models need to be realistic and based on the lessons learned in similar enterprises. For ICT-Agri companies to be successful they have to be able to reach smallholder farmers in big numbers, at least over 50.000 farmers. Only then it is possible to develop an affordable service. This 'economy-of-scale' requires ICT-Agri companies to have access to such large number of farmers and engage them in their services.

A value chain broad approach

Donors often put priority on the improvement of the position of smallholder farmers while they are not always the early adopters of new techniques. While this is understandable a single focus on smallholder farmers runs the risk of denying the complexities of the value chains they are working in and may not automatically lead to an improvement of their position and income.

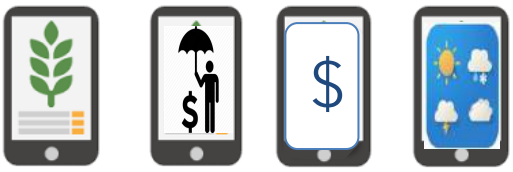
The involvement of input providers, banks and other credit providers, off-takers, food processors and other stakeholders in the value chain and addressing their information needs will make the entire value chain stronger, more efficient and will increase the entire value and income for farmers. This does not (yet) take place.



Integration of services

The development of the ICT-Agri market in Kenya can be best described by an approach of 'let 1.000 flowers blossom'.

Many initiatives have started up in recent years many of them focus on a single service for a single customer. The result is that many different apps have been developed, some very different while others have similar features.



For customers it is difficult to distinguish the value of one app to the other app. As customers need a variety of different services – both FinTech and AgTech – they are almost obliged to sign up with a number of different services. As one customer exclaimed: "Don't throw more apps to us!".

An Agricultural Data Base

Data-driven systems are dependent on the availability, quality and relevance of data. Standardization of data (-systems) with near-real-time data will help developers of ICT-services in agriculture to bring relevant applications to the market and it will help to integrate different services.

The government of Kenya recognizes the need for such an independent, high quality data platform. Recently the World Bank Group together with the Ministry of Agriculture, Livestock Fisheries and Irrigation (MoALFI) and Korea-World Bank Partnership Facility started The One Million Farmer Initiative. This initiative aims to develop a digital platform that will bring together different disruptive technology innovators to offer an end-to-end platform solution to farmers.

Opportunities for Dutch ICT-Agri companies in Kenya

Dutch ICT-Agri companies have a lot of opportunities to do business in Kenya if they are able to find the right partners and prepared to invest in building up their network. Still they face a double challenge in doing business in Kenya. They have to develop new products and they have to develop a new market. The proof-of-concept of ICT services in Agriculture requires a lot of testing with every crop needing its own specific data-points and services and multiple growing seasons to test and validate and convince potential users of the benefits. Public funding programs (such as G4AW) gives ICT-Agri initiatives the opportunity to develop these services further, test them with groups of farmers and users and prepare for entry to the market.

Programs such as the G4AW program have been a good learning exercise for ICT-Agri companies. During the G4AW-

workshop in May 2018 in Nairobi[29] important lessons were drawn. In a market that has only recently started it is logic that mistakes are made. Most ICT-Agri companies are aware of their shortcomings.

During the workshop organized in December 2018 in Nairobi, participants indicated they are now ready to make the next step: cooperation and integration of services in agriculture, weather, payments, credit and insurance.

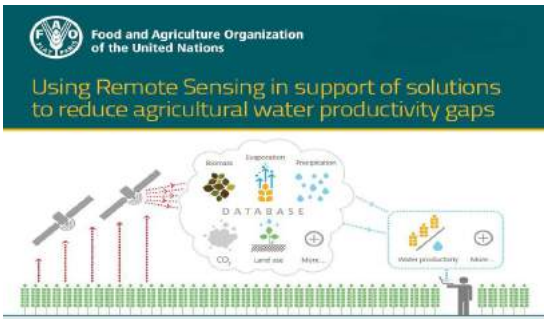
From a technical point of view, Dutch ICT-Agri companies are well positioned to take a leading role in the further development of ICT-Agri services. They combine profound knowledge of 'Good Agricultural Practices' (often with a basis at Wageningen University) with state-of-the-art techniques in Geodata. The technologies they are using can meet or are even ahead of companies from other countries.

At the same time, it should be noted that developments in ICT in Agriculture are going fast now. Within the coming 5 years the landscape will be changed entirely and the timing for Dutch ICT-Agri companies to act and to invest in Kenya is now.

Success criteria for Dutch ICT-Agri companies

From the interviews and from the lessons in the G4AW programs the conditions are clear for a company to become successful:

1. An excellent product and service with a clear added value.
2. Ability and willingness to cooperate with other business partners to deliver integrated services that match the specific needs of the customer.
3. Knowledge of the specific value chain and its actors and a clear idea what value a service can add.
4. Clear business approach and business owners to develop a service and take it to scale.
5. A strong learning curve to develop, assess, fail, adapt the service into a viable and marketable product.



The use of EO-data and databases requires an infrastructure where data are made actionable for all parties in agriculture. An example of where this infrastructure is missing at this moment is the Dutch Government funded FAO WAPOR database[30] containing crucial water productivity data (with historic data since 2009) and which is operational since 2017 but which so far is hardly used as not many potential users know of its existence or don't have the capacity or knowledge to apply these data.

[29] *'From Early Stage to Scale – Sustaining results of the G4AW Program' - G4AW East Africa Regional Workshop Nairobi, 17th and 18th May 2018.*

[30] *See: https://wapor.apps.fao.org/home/1*

Dutch support to ICT-Agri initiatives

The challenge for Dutch ICT-Agri companies is to find good business opportunities. They are quite dependent on programs such as G4AW, SBIR and other related co-funding programs from the Dutch government to become active in Kenya. Most Dutch funded programs on agriculture, water and climate so far do not have a focus or interest in using new data and ICT technologies in agriculture. There is much to win if more efforts are undertaken for integrating this in existing and new programs that are focused on agriculture and water in Kenya by or through the Dutch Government. Dutch ICT-Agri companies can add much value to these programs.

Dutch ICT-Agri companies active in Kenya (or interested to become active) use a variety of EO-data.

As Kenya has a relatively high cloud cover, companies using radar technology (in combination with satellite imagery) have an advantage. Drone-technologies are not commonly used in Kenya and strictly regulated. For bigger farmers in Kenya it could be helpful; for most smallholder farmers, drone-technology is too advanced and too expansive.

Dutch ICT-Agri companies offer very specific services of high value but which will be very difficult to market as stand-alone services. The weather models from a company like Weather Impact, the PiMapping of eLEAF, the FinTech solutions from AgriWallet, the soil analysis model of AgriCares or the Grower Apps developed by AUXFIN and Waterwatch are all examples of innovative Dutch technology. They have the potential to become different surfaces of a diamond if used and integrated well.

Building a network and partnerships between Dutch companies and with Kenyan counterparts, takes time and often local presence. Most Dutch ICT-Agri companies do not have the time or the resources to open a local presence and build up partnerships. Many of them depend on 'business-by-coincidence', waiting for a chance to become involved in a project and start from there. New strategies are needed to shape Dutch diamonds.

For the Dutch government, Kenya is a country in between Aid and Trade which poses a paradox for ICT-Agri companies. Aid programs require a focus on the poorest while Trade requires a focus on

the market. The processes in Aid Programs - tender procedures, conditions and criteria – are different and do not always match with the entrepreneurial culture required to do successful business. Programs such as G4AW are essential as they give companies the opportunity to develop their products and test them with customers and farmers. However, it can also give the wrong incentive as one company interviewed explained: "We have G4AW or SBIR or another program and let us try to find a good project to participate in the tender".

The Dutch government makes use of Public-Private Partnerships models (PPP's) which are meant to make the transition from Aid to Trade. The different interests of NGO's, governments and business partners within such consortia make them sometimes slow and companies interviewed complained about the lack of efficiency and entrepreneurial spirit within such consortia.

Dutch ICT-Agri companies who are still small lack the expertise and the time to deal with complex tender procedures. They find it difficult to compete with bigger companies and organizations. An exception is made about the SBIR-instrument[31] used by RVO.nl which most ICT-Agri companies find relevant and easily accessible.

[31] *SBIR Innovatie in opdracht – see https://www.rvo.nl/subsidies-regelingen/sbir*

5 Recommendations
From Early Stage to Maturity

All parties from companies, NGO's, financial institutions and government agree that the readiness and the timing for innovations in the Kenyan agriculture is there. In the past years and thanks to programs such as G4AW, SBIR and HortIMPACT important lessons have been learned about what works and what does not work. This does not mean that the market for ICT-Agri can now continue on its own. It will still take time for the market to develop and reach its mature state.

Recommendations for Dutch ICT-Agri Companies

An important step that Dutch and Kenyan companies that are developing ICT applications for agriculture can make is to make a shift in their strategy and approach:

From	To
Supply Driven	Demand Driven
Stand-alone services	Bundled services
Single customers	Value-chain approach
Project Approach	Business Approach
Donor Driven	Commercial Customers
Public Funding	Investments

Figure 13: Approach of ICT-Agri companies

This shift entails that the needs of the clients becomes central in the solution offered by the company. The clients are the farmers, the input providers, off takers and others in the agricultural value chain.

Bundling of different services – weather, AgTech, FinTech – stand a much higher chance for take-up and use than single services. Offering 'one-stop-shop' - solutions require Dutch and Kenyan companies to seek cooperation.

Many ICT-Agri companies are focused on offering services to (smallholder) farmers. In most cases however these are not the clients who pay for the services. For instance, off takers that have an interest in a steady supply of good quality products are likely to benefit from the services developed by ICT-Agri companies. Finding clients who are willing and able to pay for services is key.

There are several requirements for ICT-Agri solutions to be profitable. First of all, these solutions need to be relevant and actionable: the service must lead to a higher quality and produce and safe on costs. Secondly, the solution must be scalable to reach sufficient users to be able to cover development costs, become profitable and as a result become sustainable.

This means that ICT-Agri companies must find a solution for the registration and engagement of the primary users of the solutions, the smallholder farmers. Service providers can either link with parties (off takers, IT-companies) that already have a strong install base of users

or develop with them a solution how to create this.

One further step can be made by taking up a 'value-chain' approach with several potential clients which are willing to pay for services. These may include input providers, off takers, IT-companies, financial institutions, insurance companies and county governments. Such an approach requires from ICT-Agri companies that they have a certain level of insight and knowledge on the value chains, the actors in these value chains, the interests and needs of these actors, and the potential impact of solutions offered by the company.

It is then that an 'eco-system' of solutions for each actor in the value chain can be developed with each solution being able to interact with the needs and solutions of others in the value chain. In this way companies are able to create value for individual actors in the value chain as well as a strong added value for the value chain as a whole.

This approach will make value chains more productive, more effective and efficient and more transparent and will cut out actors such as middle men with little added value. This will result in a higher income for all actors in the value chain, not least the smallholder farmers.

It will be difficult however for ICT-Agri companies whose main competence is on data and tech-solutions, to analyze these value chains and develop a set of comprehensive solutions.

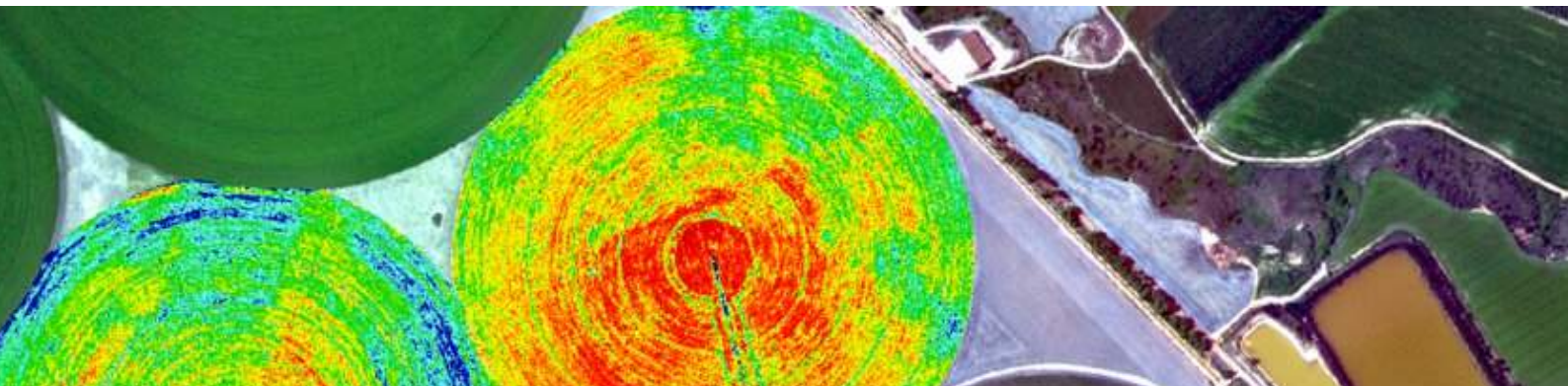
Dutch ICT-Agri companies are therefore advised to seek cooperation with companies or parties that take the role of system-integrator by bringing together different parties in a value-chain based approach.

For Dutch ICT-Agri companies it is essential to seek such system-integrators and/or partner with strong Kenyan companies. Ideally these companies have:

- A good knowledge and network in the sector and/or value chain in which they are active.
- A strong drive for innovation.
- The financial capacity to invest and build the business case.
- A willingness to cooperate.

As this market is still for a large part uncharted territory, it is important for companies to seek cooperation and seek alliances with other parties that have an interest in developing the agricultural sector in Kenya.

In particular companies may want to seek cooperation with young entrepreneurs and young farmer networks which have better chances to succeed as the adoptability of young people of ICT technologies is high.



Summary of Dutch ICT-Agri companies active in Kenya

Agrics: https://www.ics.nl/en/home/ and http://agrics.org

Agrics is formed by the ICS Foundation has a focus on a) economic growth for farmers, and b) empowering farmer families. The agricultural part takes place through local companies. ICS has formed a company – ICS BV – which in turn has formed a Kenyan company: AGRICS. ICS BV is the holding company for all socioeconomic activities of ICS in East Africa.

AgriVijana: www.vijanareloaded.com/agrivijana

AgriVijana works on selling services to farmer trough youth groups. AgriVijana trains youth groups to use certain technologies, at this moment soil testing. In the AgriVijana business model farmers pay through MPesa for the services of which the youth group receives a fee. Besides soil testing AgriVijana is looking to expand to other services, but also encourages the youth groups themselves to pick up new business opportunities. The youth groups function as a last mile distributor and can submit information from any company. The youth groups are able to market in their own area and it is the aim of AgriVijana is build a network across a lot of regions.

AgriWallet: www.agriwallet.org

AgriWallet facilitates the financial flow between the farmer and the market, between the farmer and the agrovets/dealers and between the agrovets/dealers and their suppliers. AgriWallet also allows farmers to lend extra money. AgriWallet finances different actors in the value chain. From smallholder farmers, to actors that buy the produce from smallholder farmers (buyers, markets) and merchants that sell products to smallholder farmers. This finance is provided in in the form of tokens. Customers can borrow tokens which they can spend only for a specific goal, which is buying from one of these three parties. Market parties loan tokens which they can only use to pay farmers, farmers loan tokens which they can only use to buy from agrovets and agrovest loan tokens which they can only use to buy from the input suppliers. In addition, AgriWallet gives the smallholder farmer the possibility to safe.

AgroCares: https://www.agrocares.com/en/

AgroCares technology is a key enabler to measure real-time data on nutrients. AgroCares supports farmers to take decisions based on both broader and more specific insights. Value chain participants are given new opportunities to create value and mitigate risks by making data available. Applications are key to its services. In combination with the in-house developed monitoring tools, the apps provide the world's farming community with on-the-spot, fast, integrable and reliable data and customizable farm management recommendations.

Dasuda: http://dasuda.nl

Dasuda is the Alliance for Sustainable Urban Development in Africa. Dasuda is a specialist in sustainable urban planning. Its role is on spatial planning and bringing together public and private parties in the planning process. ICT plays an important role in the process as the law in Kenya states that planning has to take place using GIS. In most cases agriculture is part of the process as urban planning also involves rural areas.

eLEAF: https://eleaf.com/

eLEAFprovides satellite-based applications and data to optimize crop production and water management. The products offer solutions in Agriculture and Water Management. Our products are used by public sector (e.g. water authorities), private sector (commercial agri-businesses) and global institutions (e.g. FAO, World Bank).

E-prod: www.eprod-solutions.com

E-prod provides a tool to companies in the agri-business sector to manage their supply chain. This can be small cooperatives, food processors, exporters and aggregators of agricultural commodities. Services vary from contract farming to fully traceable system, quality-based payment and flexible payment systems, mobile and online banking, communication, reporting, production features to monitor feed activities and production record data and a stock module that includes the middle man who is buying. It is a very complete and comprehensive tool to manage a large number of out growers. Before implementing this tool with its customers e-prod assess the company and provides advise on a implementation strategy which is followed by a training program over a long period of time to assure the company really takes up the system in a way that makes sense to them.

FutureWater – ThirdEye: https://www.futurewater.eu/projects/third-eye/

The ThirdEye project supports farmers in Mozambique and Kenya with their decision making in farm and crop management by setting up a network of flying sensors operators. This innovation is a major transformation in farmers' decision making regarding the application of limited resources such as water, seeds, fertilizer and labor. Instead of relying on common-sense management, farmers are now able to take decisions based on facts, resulting in an increase in water productivity. Since 2018, the ThirdEye service is implemented in Kenya.

MTela: www.mtela.com

MTela aims to help small agro dealers/retailers for agro inputs to run the shop more efficient by allowing them to manage their sales, prices and stocks 100% on the phone. MTela replaces the cash register system with a system over the phone. There are different functionalities such as image product recognition, a search option with knowledge about the product and how use it and for what. In the future MTela aims to open up the actual stock available to people who are looking for certain products. As a result, farmers have insight whether the Is the product that they are looking for is available in the shops in their area. This "find my product" will become available through an API that can be run on other applications.

NEO: https://www.neo.nl

NEO is a world leader in the monitoring and the detection of changed objects using earth observation technologies. The complex process to secure and update information from (satellite) imagery has been mastered in SignalEyes, NEO's certified work process. NEO serves customers by monitoring crop parcels, forests, nature reserves, but also assets as buildings, roads, other infrastructure and pipelines, canals, trees, etc. in order to secure and update management (geo-)information. NEO's information helps customers to plan and to reduce costs, increase safety, prevent errors, to comply with regulations and to manage our environment better.

Rabobank Foundation: https://www.rabobank.com/en/about-rabobank/in-society/rabobank-foundation/index.html

Standing stronger together. That's the strength of a cooperative. It is also the idea behind the Rabobank Foundation, the bank's social fund. Investing in people's self-sufficiency is our most important task. Not only in our own country, but far beyond it. People who work hard to be economically self-sufficient and build an independent life deserve our support. Not only our financial support, but also the support of our expertise and our network.

Satelligence: https://satelligence.com

Satelligence has extensive experience in remote sensing, natural resource management, GIS, computer vision and machine learning. Satelligence specializes in providing highly detailed, semi-automated satellite-based insights and actionable results over large areas. Satelligence delivers smart forest & commodity analytics to verify, predict and decide

Tahmo: www.tahmo.org

The core business of Tahmo is to generate ground weather data. Tahmo installs automatic weather stations mainly to fill the gaps in the market. Many areas in Africa do not have enough weather stations. Tahmo looks for ways to add more stations in those areas and make the data available to consumers/ users. To roll out Tahmo collaborates with research institutions and sells weather stations to private customers. In the future Tahmo wants to move more towards consumer products and to bank on the data that is collected. At this time Tahmo has over a hundred ten stations in Kenya (see map: https://school2school.net/map/).

Upande: www.upande.com

Upande makes data for decisions available for its customers in the field of water and agriculture. In the water sector Upande provides services for water supply companies. In agriculture the focus is mainly on the flower and logistics industry that already understand the importance of data. Upande also works with sensors and weather stations to open-up this data for end users who can benefit from this.

VanderSat: https://www.vandersat.com/

VanderSat has developed a method to improve the soil moisture data obtained from satellites bringing the resolution to 100x100 metres. It uses this a.o. for soil moisture monitoring, land service temperature monitoring and Vegetation Optical Depth. VanderSat works with big companies in Food & Agriculture as well as in insurance. VanderSat also works in programs for smallholder farmers and is involved in a number of G4AW programs.

Waterwatch: https://waterwatchcooperative.com

Waterwatch is developing a number of different services and applications that serve as cornerstones in a connected agricultural data platform: a global vegetation data base, a crop disease alert, grower apps and services for the agribusiness industry. Waterwatch is partnering with SAP and functions as a business integrator.

WeatherImpact: https://weatherimpact.com

Weather Impact is a global weather company, specialized in the risks of extreme weather and climate change. Weather Impact is active in all sectors and industries in which important decisions or business continuity is influenced by (extreme) weather but has a focus on agriculture.

Yielder: www.yielder.world

Yielder App improves the flow of information and communication between farmers, knowledge centres and other players in the agro-ecosystem. Yielder helps farmers to make better choices and make farmers better reachable for NGOs and others that want to reach out. Yielder started in 2018 with a pilot in the potato sector in Kenya and aims to roll out in other sectors in 2019.

List of Companies and persons interviewed

Nr	Company / Organization	Person Interviewed
01	ACRE Africa	Winnie Wairimu Rugano
02	Agrics / ICS	Violanda de Man
03	Agri-getter.com	Amos Tabalia
04	AgriPlace	Nico Broersen
05	Agri-Vijana, Vijana Reloaded	Lisanne de Bakker
06	AgriWallet, Dodore,	Sijmen de Hoogh
07	aWhere- AmfriTech	Frankline Agolla
08	BlackShore	Hans van 't Woud
09	Cabi	Henry Mibei
10	Dalberg Research	Jasper Grosskurth
11	Dasuda	Remco Rolvink
12	Delphy	Martine de Jong
13	eLEAF	Mechteld Andriessen
14	e-Prod	Almut van Casteren
15	FAO	Stuart Tippins
16	FinancialXS	Veerle Haagh
17	GreenWorks	Francis Hoogerwerf
18	Infobiovision	Hudson Were
19	Microsoft	Kunle Awosika
20	Ministry of Agriculture	Peter Kithuku
21	MTela	Reinder van der Meer
22	MVO Nederland	Steven Trijsburg
23	NAFIS	Aggrey Adul Ochieng
24	QPoint	Carel Jaspers
25	Rabobank Foundation	Albert Boogaard
26	RCMRD	Ken Kasera
27	Safaricom	Elizabeth Mudogo
28	Satelligence	Arjen Vrielink
29	Siaya County	Charles Ogada
30	Tahmo	Gilbert Mwangi, Frank Ohene Annor
31	Upande	Mark de Blois
32	USAID- KCDMS	Jacqueline Ndambuki
33	Vandersat	Celine Nobel
34	Waterwatch	Harry Derksen
35	WeatherImpact	Stefan Ligtenberg, Fiona van der Burgt
36	World Bank	James Muli Musinga
37	Yielder	Alexander Valeton

Financial Instruments available for Kenya

G4AW (2013 – 2017) - https://g4aw.spaceoffice.nl/nl/

The Geodata for Agriculture and Water (G4AW) Facility is a program of the Ministry of Foreign Affairs of the Kingdom of the Netherlands. The Netherlands Space Office is responsible for the implementation of this program. G4AW supports projects to improve food security in partner countries. The projects are aimed to improve sustainable food production and to increase the use efficiency of inputs like seeds, fertilizer, pesticides and water in agriculture by providing satellite information-based products and services to smallholders. Satellite data can help to generate reliable, timely and frequent information facilitating better decision making by smallholders. Partnerships between the private and public sector are the basis for developing new services.

SBIR Food Security in Sub-Saharan Africa (2018) - https://www.rvo.nl/subsidies-regelingen/sbir

Through the competition SBIR the government of the Netherlands challenges starting and established companies to help solve a social problem. SBIR mobilizes entrepreneurship and the innovative strength of companies for solving social issues. The SBIR "Food Security in Sub-Saharan Africa" challenges companies and knowledge institutes to develop new relevant solutions to tackle the problem of insufficient productivity at primary production level, insufficient productivity of agro-processing and poor value chain coordination and performance.

DHI - https://english.rvo.nl/subsidies-programmes/dhi

The DHI scheme supports Dutch enterprises (including enterprises in the overseas parts of the Kingdom of the Netherlands) who would like to invest in or execute a project in emerging markets and in developing countries. Dutch enterprises can apply for DHI from 15 January 2019. Complete applications will be judged according to the principle of 'first come first serve' and based on DHI criteria. There are two separate budgets, one for DGGF countries and one for other countries.

SDG Partnership facility - https://english.rvo.nl/subsidies-programmes/sdg-partnership-facility-sdgp

Support program for company, public institutions, NGOs or knowledge institutions that want to cooperate in a public-private partnership in order to contribute to sustainable development goals (SDGs) in developing countries. With the SDG Partnership facility (SDGP), the Ministry of Foreign Affairs, in collaboration with the Netherlands Enterprise Agency (RVO.nl) as the executor, aims to help achieve SDG 2 (ending hunger), SDG 8 (decent jobs and economic growth) and SDG 17 (partnerships for the goals) in developing countries.

HortIMPACT (2015 – 2019) - http://www.snv.org/project/hortimpact

The Kenya Market-led Horticulture Project (KMHP or HortIMPACT) is implemented by SNV (lead) Hivos, Solidaridad and Delphy and combines private sector expertise with social impact solutions to build sustainable, inclusive, climate resilient, horticulture value chains and markets Kenya that benefit small and medium-sized farmers. HortIMPACT aims to reach 50,000 SME farmers with 15 business cases that focus on promoting the inclusion of SME farmers, improving food safety and reducing post-harvest losses.

CSA-EA (2018 – 2022) - http://www.snv.org/project/climate-smart-agriculture-east-africa-csa-ea

The CSA-EA program is funded by the Netherlands Ministry of Foreign Affairs to increase the availability of climate smart foods for the growing population in Kenya, Tanzania and Uganda. The CSA-EA program is implemented by SNV (lead) in partnership with Wageningen University and Research (WUR), CGIAR's Climate Change Agriculture and Food Security Program (CCAFS), Agriterra, and in cooperation with Rabo Partnerships in Kenya, Tanzania and Uganda. The CSA-EA program aims to increase the adoption of climate smart practices and technologies amongst farmers and agro-enterprises, increase investments and business growth in climate smart value chains and create the enabling environment necessary to ensure large-scale roll out of market driven climate smart agriculture.

AgriFin - https://www.agrifinfacility.org/

AgriFin's is a special initiative to increase access to financial services for farmers and agribusinesses. The program focuses on activities that promote knowledge sharing and networking among financial institutions globally. AgriFin uses its growing global network of bankers and other FI professionals, to capture and disseminate knowledge in order to strengthen the capacity of financial institutions to serve agricultural clients.

MasterCard Foundation - https://mastercardfdn.org/

Mastercard Foundation vision is a world where everyone has the opportunity to learn and prosper. Using youth employment as an indicator of progress, our work together will help millions of Africans find a pathway out of poverty for themselves and their families. Moving forward, MasterCard Foundation aims to work in a diverse group of countries with high levels of young people living in poverty who are vulnerably employed. Within a country, we work with African governments, the private sector, educators, and other funders to improve the quality of education and vocational training so that they equip young people with the skills employers need**.**

Bill and Melinda Gates Foundation - https://www.gatesfoundation.org/

Gates Foundation focus on four strategic goals that help drive agricultural transformation and that ensure this transformation is inclusive: increase agricultural productivity for smallholder farmers; increase smallholder farmer household income; increase equitable consumption of a safe, affordable, nutritious diet year-round; and increase women's empowerment in agriculture.

DeveloPPP – https://www.developpp.de

The develoPPP.de programme was set up by the German Federal Ministry for Economic Cooperation and Development (BMZ) to foster private sector engagement in areas where business opportunities and the need for development action overlap. BMZ supports your company with innovative projects and commercial investments in developing and emerging countries that have long-term benefits for the local population.

Strategic development partnerships - https://www.developpp.de

BMZ provides greater support for projects which have the potential to achieve outstanding development benefits and may be viewed as 'strategic development partnerships'. Strategic development partnerships run in parallel to ideas competitions and can be realized at any time with DEG or GIZ as partners.

AGRA – https://agra.org/

AGRA is an alliance led by Africans with roots in farming communities across the continent. We understand that African farmers need uniquely African solutions designed to meet their specific environmental and agricultural needs so they can sustainably boost production and gain access to rapidly growing agriculture markets. AGRA identifies organizations to implement projects designed to help attain our goal: to double yields and incomes for 30 million farming households by 2020.

Feed the Future – https://www.feedthefuture.gov

Feed the Future is the U.S. Government's global hunger and food security initiative addressing the root causes of hunger and poverty.Feed the Future brings together partners from across various sectors and the U.S. Government to use each of our unique skills and insights in a targeted, coordinated way to help countries that are ripe for transformation change the way their food systems work.

Literature

Adventech Consulting (2016) How to Grow and Sustain the Digital Harvest? Deep dive into Business models of 15 ICT4Ag solution providers across Ghana, Kenya and Tanzania *https://www.raflearning.org/file/1210/download?token=sGc8nRs8*

AGRA (2018) Africa Agriculture Status Report 2018: Catalyzing Government Capacity to Drive Agricultural Transformation https://agra.org/wp-content/uploads/2018/10/AASR-2018.pdf

AgriProFocus (2018) *From Early Stage to Scale, Sustaining results of the G4AW Program - G4AW Regional Workshop Nairobi, 17-18 May 2018*

Austrian Presidency of the Council of the European Union (2018) High-Level Forum Africa-Europe 2018: Taking cooperation to the digital age. Vienna, Austria, 18 December 2018

Communication Authority of Kenya (2018) First Quarter Sector Statistics Report for the Financial Year 2018/2019 https://ca.go.ke/wp-content/uploads/2018/12/Sector-Statistics-Report-Q1-2018-2019.pdf

European Space Policy Institute: Space Venture Europe 2018 - Entrepreneurship and Private Investment in the European Space Sector. https://espi.or.at/news/new-espi-report-space-venture-europe-2018

Food and Agricultural Organization of the United Nations (2019) WaPOR The FAO portal to monitor Water Productivity through Open access of Remotely sensed derived data. https://wapor.apps.fao.org/home/1

Food and Agriculture Organization of the United Nations (2019) Family Farming Knowledge Platform http://www.fao.org/family-farming/data-sources/dataportrait/farm-size/en/

Food and Agriculture Organization of the United Nations (2017) Information and Communication Technology (ICT) in Agriculture: A Report to the G20 Agricultural Deputies http://www.fao.org/3/a-i7961e.pdf

Global Yield Gap Atlas (2019) http://www.yieldgap.org/

HCP International: Geodata for inclusive Finance and Food - G4IFF - inventory of technology. http://www.inclusivefinanceplatform.nl/documents/Documents/Publications/20180507geodata%20for%20inclusive%20finance%20and%20food%20-%20inventory%20of%20technology%20-.pdf

Internet World Stats (2019) Internet Growth Statistics: Today's road to e-Commerce and Global Trade Internet Technology Reports
https://www.internetworldstats.com/emarketing.htm

ISRIC World Soil Information (2019) Africa Soil Information Services (AfSIS)
https://www.isric.org/projects/africa-soil-information-service-afsis

JUMIA (2018) Kenya Mobile White Paper 2018: Smartphones: The gateway to a better life
https://jumia.co/nl-templates-kenya/uploads/mobile-report/Jumia_MW18_White_Paper.pdf

NEVASCO (2019) https://nevasco-group.nl/

NL Space (2019) NL Space Directory https://www.nlspace.nl/en/spacedirectory/

Mercy Corps (2016) AGRIFIN ACCELERAT|E: Second Benchmark Study of Smallholder Farmers of Kenya, 2016: Insight on Baseline Changes from 2015
http://mercycorpsafa.org/wp-content/uploads/2017/02/AFA_Second_SecondBenchmarkStudy_Kenya.pdf

Mercy Corps (2019) AFA Case Study: Digital Pathways for Youth in Agriculture
http://mercycorpsafa.org/wp-content/uploads/2018/12/230118_afa-youth-final-vF-compressed.pdf

Ministry of Agriculture, Livestock, Fisheries and Irrigation in Kenya (2019) Agricultural Sector Transformation and Growth Strategy: Towards Sustainable Agricultural Transformation and Food Security in Kenya, 2019 – 2029 http://www.kilimo.go.ke/wp-content/uploads/2019/01/ASTGS-Full-Version.pdf

Radiant Earth Foundation: Annual Report 2018 – Open Data, Positive Impact, Innovative Technologies. https://medium.com/radiant-earth-insights/radiant-earth-foundations-2018-annual-report-good-wishes-for-2019-f0945dc0b93a

Rijksdienst voor Ondernemend Nederland (2019) SBIR: Innovatie in opdracht
https://www.rvo.nl/subsidies-regelingen/sbir

Safaricom (2017) Safaricom Annual Report and Financial Statements 2017: Where we will go next
https://www.safaricom.co.ke/images/Downloads/Resources_Downloads/Safaricom_2017_Annual_Report.pdf

Space Venture Europe 2018 - European Space Policy Institute (2019) Entrepreneurship and Private Investment in the European Space Sector. ESPI Report 67
https://espi.or.at/downloads

The Digital Farmer: A study of Kenya's Agricultural Sector; A GeoPoll study of livestock

and crop farming and the effect of mobile technology on farming in modern Kenya. https://www.geopoll.com/blog/data-farming-kenya-mobile-phone/

The World Bank (2017) ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions http://documents.worldbank.org/curated/en/522141499680975973/pdf/117319-PUB-Date-6-27-2017-PUBLIC.pdf

The World Bank (2019) *Doing Business: Measuring Business Regulations* *http://www.doingbusiness.org/en/rankings*

USAID (2018) Digital Farmer Profiles: Reimagining Smallholder Agriculture https://www.usaid.gov/sites/default/files/documents/15396/Data_Driven_Agriculture_Farmer_Profile.pdf

Which Industries are the Most Digital (and Why)? Prashant Gandhi, Somesh Khanna and Sree Ramaswamy of McKinsey Global Institute (Jan, 2019) Harvard Business Review, April 2016. *https://hbr.org/2016/04/a-chart-that-shows-which-industries-are-the-most-digital-and-why*