Geodata and ICT Solutions for Inclusive Finance and Food Security

Innovative developments– An overview

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npm platform for inclusive finance

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Preface

Recent developments in technological applications offer opportunities to increase outreach of financial services to rural areas and for smallholder farmers. Early evidence suggests that these applications offer great promise to produce a higher and more stable crop supply of increased quality and improve market access. By this, the risk profile of smallholder farmers reduces which is an important stimulus for financial institutions to provide financial services. At the same time, technology reduces costs and allows for further outreach in rural areas and better services to their client base.

As more than 2 billion people depend on smallholder farmers for their livelihoods and 70% of the global food supply comes from smallholder farmers, it is evident that they have a major role to play in feeding the growing world population. As climate change affects the yields of smallholder farmers, there is a need for climate smart agriculture and technological applications that help to adapt to and mitigate the effects. Technological developments also provide a great opportunity for young people in emerging economies. Innovations create jobs and also make agriculture attractive for the young generation.

For the Dutch government, food security is one of the 3 pillars of its foreign aid, trade and investments agenda. The Dutch Ministry of Foreign Affairs committed EUR 60 million for the development of technological applications based on satellite data for the purpose of agriculture under the Geodata for Agriculture and Water programme (G4AW). The Netherlands Space Office (NSO) implements this programme. This publication is based on a desk study of more than 200 cases of technology applications in rural finance, including the G4AW projects. It provides valuable lessons learned, suggestions and recommendations for the way forward. The interactive map with all cases analyzed can be viewed on the NpM website: www.inclusivefinanceplatform.nl/home.

NpM, Platform for Inclusive Finance (NpM) supports its members in achieving the Sustainable Development Goals (SDGs). NpM does this through 4 focus areas: 1. be the Dutch inclusive finance knowledge hub 2. be the linking pin 3. be the voice of the sector 4. cooperation with the Dutch Ministry of Foreign Affairs.

It is important that from the start of the development of trajectories described above, multi stakeholder partnerships are established, including the financial sector. Even though for the start-up phase seed capital and subsidies are required, working towards a clear business case is key. If a farmer grows its business, through the use of the applications, finance is needed: investment capital, working capital, payment services, insurance, etc. Together with Rabobank and NSO we have started a trajectory to realize financial inclusion for food security.
NpM hopes that this publication will be useful and inspiring. We would be grateful if you provide us with your remarks, ideas or suggestions; we welcome your responses.

Josien Sluijs
Director

Executive summary

In light of a growing demand for food, smallholder farmers are crucial in supplying the world with sufficient food. Besides access to finance, smallholder farmers need more and better information for their farming decisions. This could improve agricultural production and market access, ultimately increasing their incomes and food security. The innovations we see today have a huge potential to improve agriculture and access to finance. Geo-data and information and communication technologies (ICTs) such as geographic information systems, drones, and cloud computing are now being used to boost smallholder's production and their income. This paper presents an overview of the possibilities and challenges of using geo-data and ICTs to improve agricultural production and access to finance for smallholder farmers.
Currently, a fast growth of the use of technologies is noticed in:

1. Applications to improve *agricultural production* through the use of geo-data, weather stations, drones, etc. These applications compile data which focus on improving farmers' use of inputs, planting date, crop calendar and market options.
2. *Data collection and combination tools* that provide relevant information for improved planning at macro level; but also to provide useful business information on *markets and prices* that is shared with farmers and businesses in agro-value chains, and;
3. *Rural financial inclusion* through digital payments systems, use of mobile banking, and micro-insurance. These developments positively affect both the cost-effectiveness and growth in outreach of financial services.

While these applications are very promising for improving agricultural production and growth in outreach of financial services; there are still few cases that combine the two aspects. The paper argues that such a combination would be able to trigger the much needed growth in agro-finance. An inquiry into the lessons learned identified several areas that are relevant for speeding up developments that benefit smallholder farmers and the financial institutions that serve them:

1. A good *policy and regulatory environment* is needed to streamline actors and interventions. The change in ICT developments is so fast, making it difficult for regulations to keep up. Issues such as legalities of payments, privacy rights and data ownership need to be guided by clear regulations to ensure transparency and proper implementation.
2. Design *appropriate information packages* for farmers. Early evidence indicates that effective use of digital information to farmers works better in combination with face to face contacts. Also interactive systems which actively involve smallholder farmers show higher uptake.
3. Financial institutions, especially those operational in rural areas, need *guidance and support* to enter into the digital highway. They face bottlenecks in terms of staff capacity, and barriers to invest, but also simple digital illiteracy to take up innovations.
4. New technology needs *high upfront development costs*. While companies now take up these challenges, the current business case serving smallholder farmers is not yet evident. Farmers might be reluctant to pay, especially when services are not addressing their needs (point 2). High risk and long term capital investments are needed that also consider the positive effects on farmer productivity, long term food security and climate change in their cost benefit analysis.

Way forward

From this paper, it becomes clear that innovative partnerships are required. This is especially shown in the Geo for Agriculture and Water (G4AW) programme. New players entering the field and organizations that develop new services outside their traditional area of work also bring about innovations, such as telecom companies providing input loans. To catalyse the development of technologies that focus on improving agriculture and finance, even more collaboration, knowledge sharing and testing is needed. Joint efforts of all stakeholders involved will be crucial in achieving this.

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1. Introduction

In light of a growing demand for food, smallholder farmers are crucial in supplying the world with sufficient food. In order to achieve this much needed growth, access to affordable and appropriate finance is key for smallholder farmers. On the other side, financial institutions see agriculture lending as risky and costly and do not easily lend to smallholder farmers. A study commissioned by NpM[1] showed that lack of understanding of agriculture at the financial institution's level leads to overestimation of the risks and costs involved. At the same time new technologies and Information and Communication Technologies (ICTs) are now being used to boost production. ICT information systems are able to address knowledge gaps at farmer level. New ICT solutions in banking assist to reach out to remote rural areas and new groups of smallholders. Through ICT applications in banking, costs of financial service delivery have reduced while outreach has improved. How can these developments in agriculture on the one hand, and finance on the other, be combined to improve finance for smallholders to the required levels?

Currently, a fast growth of the use of technologies is noticed in:

1. Applications to improve *agricultural production* through the use of GEO- data, weather stations, drones, etc. These applications compile data which are used for farmer information, agricultural extension and education and focus on improving farmers' use of inputs, planting date and crop calendar and market options.
2. *Data collection and combination tools* that provide relevant development information, such as household surveys, and population data; but also business information on markets and prices that is shared with farmers and businesses in agro-value chains.
3. *Agricultural insurance* has seen fast growth recently in using weather and soil data combined with other crop information to offer innovative insurance products.
4. *Rural financial inclusion* through digital payments systems, use of mobile phones and hand held devices for the delivery of financial services. These mostly focus on increased cost-effectiveness and outreach of services.

Potentially, new ICT applications offer great opportunities for smallholder farmers to improve their productivity, farm risk management, access to markets, and finance. The applications can assist in improving yields and thus in ensuring higher food production and income for small-holder farmers. Through increased productivity and marketability of their produce and the reduced risk of losses, the risk profile of smallholder farmers is reduced significantly, and could trigger financial institutions to increase lending to them. Developments in the ICT sector, especially the rise of digital financial services, have greatly increased financial inclusion, also in rural areas. Mostly, these services are used for savings and doing payments. Although there is a big difference in the use of digital services across continents, financial institutions can now reach out to areas and groups of rural poor they could not reach before.

Currently, the use of new technologies in agriculture and the digital developments in finance have only occasionally been linked. We believe however, that the combination of developments in agricultural technology and digital finance could greatly improve access to finance for smallholder farmers. Farming systems could be improved, leading to improved food security and higher incomes for smallholder farmers. For financial institutions, it would become easier to keep records of farmers' performance, better understand farming, and bring down transaction and monitoring costs. Consequently, this could greatly improve their lending products for smallholder farmers.

[1] Finance for Smallholders - Opportunities for risk management by linking financial institutions and producer organisations (2015)

Based on the available literature, this paper presents an insight into the current technology developments in the field of agriculture and agricultural and rural finance. Chapter 2 provides an overview of the use of technology in agricultural extension and agro-finance. It gives insights into products and services, both already in use or still in development, that are aimed at improving agricultural production and market access, and a short overview of the possibilities in digital finance. From there we explore the potential for the use in rural and agro-finance and the users of the services in chapter 3. Chapter 4 provides an insight into the suppliers of the services. There is ample documentation available on Digital Financial Services (DFS), but not much has been written on ICTs that are specifically aimed at improving access to finance for smallholder farmers and their organizations. At the end of this paper, in chapter 5, we present the lessons learned and provide recommendations for donors, investors and other stakeholders. This paper is meant as an input to the discussion on ICT for smallholder finance; it is not meant as an exhaustive overview of all experiences, nor is it meant as a scientific research paper. To give a first impression of the possibilities of geo-data and ICT to improve food security and access to finance, see the case below:

Case 1

Turning geo-data on coca plantations into a coffee monitoring tool: Caravela Coffee

In Colombia, half a million people directly depend on coffee, which is the country's most important export product, and during the harvesting season, another half a million people are added as day laborers. In the early 2000s, the Colombian coffee exporter VIRMAX was struggling to find good quality coffee. After finding out coffee producers were being paid the same price regardless of the quality, VIRMAX developed a "relationship coffee program". The program uses a model that maintains long-term relationships between smallholder producer organizations (POs) and importers and roasters abroad, based on high quality and premium prices. Unique about the model is that each link has insight into the costs and revenues of every other link, creating a high level of transparency.

Between 2005 and 2015, 3,500 Colombian farmers in 12 cooperatives have been able to improve the quality of their coffee. Rabobank Foundation started financing the first cooperatives in 2003, and expanded its financing to more cooperatives step by step. With the feedback and support from Virmax, the farmers and their cooperatives could improve the quality of the coffee, leading to a higher price for their produce. VIRMAX's origin model was replicated and introduced in Ecuador, El Salvador, Guatemala and Nicaragua. It has export partners in, Honduras, Mexico and Peru, as well as import operations in Australia, Europe and North America.

As of 2015, the company changed its name into Caravela Coffee and started a pilot project last year to start studying the impact that weather and geography have on cup quality, combined with improved social and agronomic data from the farmers they work with. The project is still in the pilot phase, making it too early to draw conclusions. However, the company is investigating the relation between geo –and weather data (in particular rainfall patterns varying per valley, area and micro-climate) on the cup profile.

2. Context and types of services

2.1. Introduction

Currently, there are approximately 500 million smallholder farmers in the world, and more than 2 billion people depend on them for their livelihoods[2]. Ending hunger, achieving food security and promoting sustainable agriculture are part of the Sustainable Development Goals (SDGs)[3]. Demand for food has increased and predictions show that it will increase further. Even today, a large number of people live in food-insecurity and hunger. With the global population expected to grow to 9 billion by 2050, the agricultural sector needs to grow substantially. This requires food production to grow and become more efficient. The majority of the farmers worldwide are smallholders and their efforts are urgently required to ensure food security for all. Inevitably, improving access to finance will be crucial in achieving and maintaining production levels needed for worldwide food security. It is estimated that the total demand for financing smallholder financing is around $450 billion. Currently, the credit supply offered by formal financial institutions to farmers and value chain actors is projected to grow with 7% annually. By 2020, assuming that demand of smallholder farmers would remain constant; this would mean that only 20% of the total demand would be served[4].

Furthermore, the effect of climate change on agriculture is becoming noticeable: 'Climate change affects agriculture through higher temperature, elevated carbon dioxide concentrations, precipitation changes, and an increase in weeds, pests and diseases'[5]. In order to ensure sustainable long term food production, climate smart agriculture needs to be applied. Recent technological developments can assist in increasing agricultural production, adapting and mitigating the effects of climate change and further expand financial inclusion. Below we highlight the most important areas of ICT development for smallholders:

1. improving agricultural production;
2. facilitating market access, and;
3. improving access to financial services.

While ICTs related to improve agricultural production and market access have not been used for increasing access to finance on a large scale, these agro-technologies can reduce the risks and costs of financing smallholder farmers. Lower risks and costs for financial institutions can therefore have a positive effect on smallholder farmer's access to finance. However, this is still an underdeveloped area. The figure below presents a simple conceptual framework symbolizing the role and use of geo-data and ICTs to impact smallholder farmers and financial institutions.

[2] CGAP (2014 & 2016)

[3] For the list of the SDGs, see http://bit.ly/1IqICxS.

[4] Dalberg, Citi Foundation & Skoll Foundation (2012)

[5] FAO (2015) and 'Geo for Agriculture and Water (G4AW) report (2016)

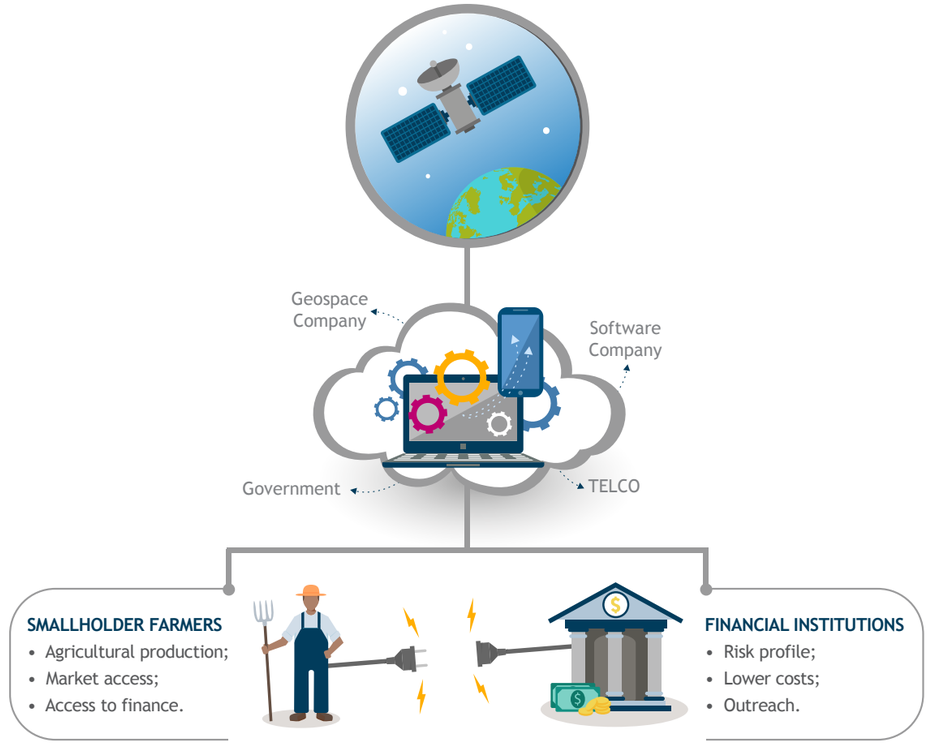


Figure 1 – Conceptual framework to use geo-data and ICTs for smallholder farmers and financial institutions[6]

2.2. ICT for Improving Agricultural Production

New technologies are already applied to boost agricultural production. Geospatial information, such as mapping tools and satellite information[7] are becoming more accessible and easy to use through the internet and mobile phones. Satellite images have improved in quality and have become cheaper or are available for free. Combining geographical information with climate and socio-economic data opens up possibilities for making accurate crop yield predictions, estimating the effects of climate change on farmers productivity or selecting the most suitable crop for certain areas.

Geographical Information Systems (GIS), Global Positioning Systems (GPS), and satellite imaging to assess soil and crop conditions, are applied to specify the availability and suitability of arable land, fertilizer and water usage, to estimate crop revenue and to spot diseases. Drones can do this at an even more detailed level. SMS text messages are used to inform farmers on disease and pest control. Information dissemination technologies such as mobile phones, but also radio, are used to distribute information to improve production to smallholder farmers.

ICTs focusing on improving agricultural production are aimed at helping smallholder farmers boost their productivity, crop yields and income from agriculture, and thus create greater food security and reduce risks of lending to farmers. Applications that focus on agricultural production can incorporate short-term and long-term productivity improvement, thus minimizing the negative effects of crisis events and improving farmer's risk management, as the sample below shows.

[6] For a more detailed overview of the G4AW framework, see the annex

[7] Such as Microsoft Earth or Google Maps.

Short-term productivity information services are readily available services that consist for example of weather forecasts for certain areas. These services are aimed at alerting farmers for any upcoming events that could immediately influence their crop productivity. This information is frequently pushed out by the information provider to its subscribers in a standardized manner. Crisis management information services provide farmers with advice on how to prevent losses. These ICT solutions combine meteorological and other data and provide value added services (VAS) such as crop advisories, pest warnings, flood warnings and seasonal forecasts.

Case 2

MUIIS, Market-led, User-owned, 'ICT for agriculture'-enabled Information Service in Uganda: an integrated package (G4AW project)

There are a lot of initiatives to improve the lives of smallholder farmers, but there are not many examples of integration of different kind of services that are provided to farmers as a package. The Technical Centre for Agricultural and Rural Cooperation (CTA), a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU), based in the Netherlands, leads a consortium that provides advice on sowing and planting, pest and diseases, fertilizer application, water use and drought warning, and index-based insurance to smallholder farmers in Uganda. Partners are NGOs, such as the Alliance for a green revolution in Africa (AGRA) and Mercy Corps, tech companies, such as aWhere (USA), EARS and eLEAF, both from the Netherlands. The business owner is a farmers' organization, the Eastern Africa Farmers Federation (EAFF).

Food producers receive the services through text and voice messages and can also access a web portal. After a free trial period of three months, the services have to be paid for. This can be done by the food producers themselves, but also by organizations that deliver services to food producers, the so-called aggregators. The goal is to reach 350,000 farmers in three years. Currently 18,200 food producers have been informed about the services and their benefits; actual use is yet to start. The services focus on maize, soy bean and sesame farmers. The MUISS initiative received ample coverage in Ugandan and Dutch media, including a radio interview and a news item on Dutch national television.

Long-term productivity information services focus on aspects that take longer to learn and requires farmers' engagement and training. These services could address issues such as fertilizer usage on a particular piece of land, marked through GIS information; or information on appropriate use of pesticides. Experience shows that such information needs to be combined with face-to-face training or support from local extension agents, since it often consists of a mix of information on how to improve agricultural systems. The long term effects of these services are realized only after a few months or even years, since typically multiple crop cycles are required.

Data storage capacity and exchange

the great increase in data storage capacity and improved ability to access data in remote areas has stimulated scientists, governments and development organizations to create numerous datasets that contain geographically referenced data on population, poverty levels, transportation and other variables. The information is based on geographical information systems and other datasets, and can in principle be accessed through computers, laptops and mobile devices using web-based tools. Sharing knowledge and exchanging data have opened up opportunities for stakeholders such as governments, agricultural research institutes and development organizations, to get more involved in agricultural research, planning and forecasting. Big Data analytics tools make it possible to build models that analyze large amounts of data and predict yields based on use of chemicals, soil types, and location of a farmers' land. Although still primarily available in the more advanced countries, these developments have great potential for developing countries. The costs of storing data have dropped dramatically and are therefore accessible to a larger number of organizations. Cloud computing provides ways to access numerous shared computing resources through the internet including tools, applications and other data sources. Benefits of these technologies range from more accurately and effectively targeting agricultural development programs to more accurate management advice at the farm level. Also many governments and other organizations such as the World Bank, FAO and CGAP are making their data more publicly available. There are also private companies such as Gro Intelligence that deliver macro-intelligence insights for policy development and decision makers.

Real time data collection at local level is now possible

farmers themselves can also provide data on crop diseases for instance and send notifications to a data service provider in case they notice disease symptoms. Smallholder farmers have assisted collecting data by sending SMS text messages with agricultural information on pest and disease incidence and crop yields without having to conduct expensive and time consuming surveys by researchers[8]. The data is sent to a network, which can be accessed by researchers, and analyzed. After analysis, the appropriate advice can be provided to these farmers how to cope with the diseases and prevent them in the future. Machine learning is becoming more and more integrated into the agricultural sector too. These technologies have a built-in ability to adapt, learn and get better over time. For instance, it allows a system to use and combine historic information with real-time information, along with the information from the farmers' experience. The Internet of Things (IoT) development will further boost the interconnectivity of devices (other than computers and smartphones). It is already possible to remotely monitor sensors, harvesting and irrigation equipment, use artificial intelligence tools, and combine this with third party information services. All this can greatly improve decision making.

Case 3

Rain for Africa (R4A): extension services combined with feedback on weather data from smallholders in South Africa (G4AW project)

Provision of information to farmers is very much on the agenda, but receiving feedback from farmers is equally important. For a successful application of satellite information, complementary data has to be gathered on the ground, especially if the aim is to provide localised and relevant information to smallholder farmers. South Africa has recognised the need for better local weather information to improve advisory services on sowing and planting, pest and diseases, and fertiliser application. The Agricultural Research Council leads a partnership, in which also the South African Weather Services and the Dutch companies eLeaf, Hydrologic & Hydrologic Research, Mobile Water Management, Weather Impact and WineJob participate, supported by the Dutch meteorological institute KNMI and Dutch regional water board Drents Overijsselse Delta. Farmers get advice in exchange for readings of small weather stations handed out by the project. This helps making weather forecasts more accurate at the local level and enables the provision of better advice, based on historical and actual data.

The extension services of ARC interact directly with the farmers, but text messages, apps and a web portal are also used. Advice is free for smallholder farmers, but large farmers pay. The aim is to reach 125,000 farmers in three years; currently a pilot with grape farmers is being carried out. Tests show that grape farmers can save 10 – 20% pesticides spraying costs, because of the improved information. The more efficient use of inputs generates cost savings and higher yields, which lead to a higher income and food security. Moreover, it also lowers smallholder farmer's risk profile which could improve their access to financial services. Technical development has advanced well and contacts are established with potential partners. There is considerable interest in the R4A-concept, both nationally and internationally. The initiative is not only a test case for receiving and processing citizens' (farmers') observations, but also for a public-private partnership for smallholder farmers.

2.3. ICT for Facilitating Market Access

Improved access to markets for farmers will enhance farmers income and reduce their risk profile for lenders. Facilitating market access is another area where ICT services play an important role for smallholder farmers. *Price information services* are the most commonly known digital services on market access. Most of these services provide information on current market prices for agricultural crops. The information is usually pushed out by the providers in a standardized manner and provided through mobile phones, radio, TV and websites. The improved price information increases transparency and can assist farmers in choosing the best place to sell the produce. This can increase farmers' negotiating power vis à vis potential sellers. *Virtual Trading Floors (VTFs)* are market places where buyers and sellers connect over an electronic network. This limits the need for physical contact between buyers and sellers and can save travel costs and time. Virtual Trading Floors connect buyers and sellers directly to one another on the spot market of a certain agricultural product. Both the seller's and buyer's needs are then matched by providing both parties with a set of options in order to conduct the transaction. Such trading floors increase connectivity in the market, but physical attention to good quality and quantity of produce will still be required at farm and buyers level.

Commodity Exchanges not only provide a spot market, but have enough information to estimate future commodity prices and can provide risk management services for both buyers and sellers that mitigate the risk of future price fluctuations[9]. Commodity exchanges are generally more complex and capital-intensive than Virtual Trading Floors and require large volumes to make the investment profitable.

A special type of Market facilitation through ICT is when it is used in the context of a structured value chain. *Downstream and Upstream ICT solutions* include ICTs that directly assist value chain actors, such as input suppliers, cooperatives, large buyers, exporters, processors and transport companies to manage their businesses more efficiently. Examples include temperature and moisture monitoring systems for products stored in warehouses that avoid spoilage, tracking trucks that move the produce from the cooperative or producer organizations to the processor using satellite information, payment systems that are linked to equipment for testing the quality and content of products, databases of input suppliers for farmer customer management and traceability systems that can track the produce through the entire value chain from the start to the end[10]. *Holistic ICT services*, often found in the context of a structured value chain, combine pricing information services with additional services such as weather and disease information and information to improve agricultural practices. The service packages of these providers can include linking farmers to actors involved in logistics, transportation, processing and storage and sometimes even offer access to financial services, thus covering services to a whole range of chain actors.

Case 4

Improving productivity and market access for smallholders in India: Ekgaon Technologies

Ekgaon Technologies in India is a social enterprise that has improved the lives of over one million households over the past 13 years. By joining the "One Village One World Network", smallholders can start using Ekgaon's OneFarm service, which is aimed boosting agricultural productivity and reducing cultivation costs. For Rs. 150 per cropping season, OneFarm provides customized information on soil and nutrient management, crop and weather conditions, disease alerts and market prices. It has developed an algorithm for each crop, using variability parameters of land, soil, bio-climate and crop type. The information is delivered mainly through SMS in the local language as well through outbound calls to the farmer's phone at fixed intervals. Farmers can also send their feedback through SMS or by using Interactive Voice Response, making Ekgaon able to continuously improve its services.

Currently, Ekgaon is delivering services to 20,000 farmers across 465 villages in Tamil Nadu, Madhya Pradesh and Chhattisgarh. In 2015 it has conducted an impact survey including over 10,000 farmers. The survey showed that average production per farmer increased from 12.05 quintal per acre to 24.91 quintal per acre. In the same year, the company also launched Ekgaon.com, an online platform that sells the farmers' produce at equitable prices. Within one year, the platform has attracted 5,000 customers, of whom 50% are repeat customers. Over 50 products are sold, including rice, millet, spices, sugar, tea, etc. As a result of these two services, farmers' income have increased on overage with Rs 8,500 per month, an increase of roughly 67%. Ekgaon is now also working on entering the retail markets, building relationships with bulk buyers and improving farmers' access to insurance. Next to retaining the existing network of farmers, the company has ambitious plans to reach 25 million households by 2020 and to generate Rs 1 billion in revenues.

[9] For instance by using forward contracts and derivatives

[10] FAO (2013) & World Bank & African Development Bank (ADB) (2012)

2.4. ICT for improving access to financial services

The recent mushrooming of digital services offers great opportunities to improve finance for smallholders. In general, digital financial services are developed to ease financial transactions and have the potential to reach out to the poor in the remote rural areas where the financial service providers were not able to reach before. The commonly used types of ICT based financial services include money transfers and payments, savings, loan disbursement and repayment facilities. By providing low-cost, convenient, secure, and flexible payment and savings services to the rural poor, financial services providers can extend their outreach. The use of mobile phones in emerging markets presents MFIs with the opportunity to improve their service to current customers by providing ubiquitous, safe and convenient ways to disburse and repay loans; save money and check their balance. By bringing services beyond brick and mortar branches, costs will be reduced, which could potentially lower interest rates in rural areas. In short, it could assist farmers to have better access to quality and affordable financial services.

Currently, financial service providers find it difficult to reach out to smallholder farmers and they have limited understanding of this market segment. They find it difficult to collect proper data on agricultural production and to deal with seasonal cropping patterns. Even when data is available, it is often distributed among a number of stakeholders and not easily shared. Sometimes, the lack of regulation also makes it difficult to acquire the right information. However, ICTs in agriculture can help financial service providers acquire the information they need and boost their knowledge level on agriculture as well as lowering their transaction and monitoring costs. The table below presents an overview of the type of ICT services found in the different papers and information sources, spread over the different regions.

Category	Central Asia	East Asia & Pacific	MENA	South-Asia	Sub-Saharan Africa	LAC	Total
Agricultural production	1	9	3	2	17	76	**108**
Agricultural production & Financial Services		5			2	1	**8**
Agricultural production & Market Access	4	3	1		13	27	**48**
Agricultural production, financial services & market access		1				1	**2**
Financial Services				1	4	38	**43**
Market Access	3	7			8	37	**55**
Total	**8**	**25**	**4**	**3**	**44**	**180**	**264**

Table 1 – ICT solutions to improve food security and access to finance by category and region

Note: financial services in the table above only include those services that are related to agriculture.
Sources: CGAP Digital Finance Plus - Global Landscape, GSMA mAGRI Deployment Tracker, and authors' own research.
For a more detailed overview including the types of services, see table 4 in the annex

3. Users' perspectives: opportunities and challenges

The ICT developments in agriculture and finance are expanding rapidly. In order to understand the applicability for the users, it is relevant to explore the users' perspectives. The major users currently are:

1. smallholder farmers
2. government and development organizations and
3. financial service providers.

Smallholder farmers

For many years the use of geospatial information for agriculture was considered only to benefit relative large farming enterprises which could afford these service[11]. However, it has become clear that ICTs can also address the needs of smallholder farmers. Farmers use these for agricultural and market information as well as for access to finance. Recent reviews show that it is important that agricultural and marketing information services can provide relevant and timely information in a way that can immediately be absorbed and acted on by the farmer. The message should be user friendly, simple to understand, easy to subscribe to and to use, and provide possible entry points for additional information services. ICT information services can be an excellent entry point for farmers who have not previously had access to unbiased and timely information. Creative ways of information transmission are used, such as the use of voice messages and voice boxes[12] to ensure easy understanding by the farmer, although basic SMS text messages continue to be the most popular and least costly method. Still it remains a huge challenge to transform more complex information into useful information packages for farmers, MFI staff, and Producer Organizations (POs). While the situation has greatly improved in recent years and mobile phone coverage and internet use will continue to expand, many farmers still do not have access to mobile (smart) phones or face connectivity issues. Low-technology solutions, such as radio, may therefore still be good option for years to come. The challenge is to make the information relevant at the local level.

Smallholder farmers face many challenges when adopting ICTs: they are often illiterate and low skilled and have limited access to capital for investment and training. Furthermore, they are often risk adverse and they have to be convinced that any new service works and will benefit their agricultural production. Lack of proper understanding of how to use the services or tools in the most effective way makes client education and training necessary for the success of the service. Proper education and training might also take away farmers' fear to adopt new technologies and decrease (digital) illiteracy. Service providers can start to work with so called lead farmers that have strong networks and can convince other farmers. It also helps when services are built on to systems that are already in place and have gained the trust of the farmers. Building in feedback loops in the services creates greater understanding of how farmers are using them.

Other challenges include the delivery of tailored services to the end-user. The more tailored the service, the more added values it provides to smallholder farmers. However, tailored messages require detailed knowledge of that farmer or group of farmers. While services related to agricultural information and platforms are highly appreciated by farmers, these solutions offer very generic and non-interactive content, whereas farmers often desire more personalized and responsive information. Another issue for services that provide agricultural information is their profitability. Smallholder farmers might only need short-term productivity services in specific times of the year and might not be willing to pay for them year round, especially when alternative free services are available. To date, the (un)willingness of farmers to pay for specialized information services is one of the key bottlenecks to long term sustainability of the investments.

Special focus should also be given to gender. Women comprise on average 43 percent of the agricultural labor force in developing countries. Since women also play an important role in smallholder agriculture, it is crucial they are connected as well and to provide them with similar access to productive resources as men. For example, in Tanzania women appreciated the digital wallet in their mobile phone which gives them control over their own money transactions.

[11] G4AW (2016)

[12] Interactive Voice Response (IVR) technology proves to be very effective for illiterate and less tech-savvy farmers

However, it is recognized that there are still many obstacles for women to having equal access to responsibilities and revenues from agriculture and other resources. A proper understanding of the gender perspective is essential to get them involved in using ICT services. A first attempt to understand the use of digital information by women was explored in a study undertaken by Dalberg.[13]

Case 5

GEOBIS, Geodata based information services for small farmers in Bangladesh: commercial interest and poverty reduction go hand-in-hand (G4AW project)

Lal Teer Seed Limited is the largest seed company in Bangladesh. In partnership with the Interdisciplinary Centre for Food Security at Bangladesh Agricultural University, mPower, Multisourcing Ltd., Unnayan Onneshan (all from Bangladesh), and Alterra and NEO (both from the Netherlands), Lal Teer adds satellite-based information services to its portfolio. The services consist of advice on seed variety and quantity, seed bed preparation and land preparation, sowing and transplanting (timing, skills), irrigation and application of fertilisers and agro-chemicals (timing, quantity, type) and weather information. Smallholder farmers that are clients of Lal Teer receive the service. The aim is to reach 600,000 farmers (all the clients of Lal Teer). Currently, 400 farmers are taking part in a first test and a second pilot is planned. The services benefit from Lal Teer's extension network that ensures close contact with the farmers. Other transmission channels used are text messages, apps and a web portal.

Although there is a good presence on the ground and a history of cooperation with the target group, the project still has to overcome a number of problems. The small plot sizes pose a challenge for the utilisation of satellite imagery and the cost-effective and reliable collection of data from individual farmers is difficult, as is obtaining reliable weather data. The coverage of the mobile network in some areas is very weak and the technical and commercial requirements from mobile phone operators (there is cooperation with all five mobile operators in Bangladesh) are difficult to comply with. Another obstacle encountered is the inability of farmers to read in Latin script (although they use help from acquaintances to decipher messages). The willingness to pay for services and a differentiation of fees are being investigated. If the cost of delivering the services can be brought down, the outlook for Lal Teer and its clients is very positive: both customer loyalty and production can be increased, while using less input.

Government agencies and development programs

As mentioned, government and development agencies have invested in new technologies to develop large databases and other services. Governments can hire external parties to create such systems or employ in-house expertise to develop the systems and services internally. The usage and development of data systems and geo-information for governments and development programs is still in its infant stages. However, more accurate geo-information combined with other ICTs could be used by governments to better understand agricultural production cycles, better target their development programs or more effectively respond to drought or flood affected areas in the country. Until now, the available data are not yet used in long term policy and development planning.

Donors and investors have played an important role to stimulate and boost the development and adoption of ICTs in agriculture. They have funded large projects aimed at collecting large volumes of data on the environment, soil and water conditions. It is important to make the raw data useable and modify it in such a way that researchers or companies can develop tools, instruments and products, which they can use to provide advice to smallholder farmers. This is still work in progress. Although space and meteorological data are becoming more openly available, their usage to enhance smallholder farmer's food and nutrition security is not guided by clear policies.

[13] See: GSMA (2015)

This is because it takes specialist skills and knowledge to apply this data in a relevant and reliable manner. Some private companies such as Gro Intelligence and the African Soil Information Service (AfSIS) are offering services to transform data into useable insights for government and development programs. In several of the G4AW projects; government agencies are an important partner. Not only governments, but also Mobile Network Operators (MNOs) and donors (both multilateral and bilateral donors) have to work together to build the infrastructure. An example is the Indian ID-system (Aadhaar) from the Unique Identification Authority of India (UIDAI). After receiving an ID, people are now formally existing (and part of the national database) and can build a credit history. This opens up possibilities for further financial inclusion and more advanced (agricultural) financial products related to agriculture. Significant investments in the telecommunications sector might spur mobile payment systems developments and connectivity rates.

Case 6

High-value soil information: Africa Soil Information Service (AfSIS)

Each planting season, smallholders have to decide what type and how much fertilizer to apply to their crops. There is a lot of uncertainty about how the crops will respond, and even the risk that farmers will make a loss when they sell their crops after the harvest. Testing the soil beforehand and knowing how plants will respond can play an important role in reducing this risk. But the high cost and lack of access to testing services have been major bottlenecks for farmers in developing countries. Governments, the private sector and NGOs also lack the right information on what types and combinations of inputs to supply to smallholders and where. Existing soil maps do not provide up-to-date information on specific soil properties that are required to make the right decisions. The Africa Soil Information System (AfSIS), funded by the Bill & Melinda Gates Foundation, is developing digital soil maps for Sub-Saharan Africa based on soil spectroscopy and digital soil-mapping technology. Not only remote sensing imagery is used, but the information is also being crowdsourced from ground observations.

AfSIS can also provide a baseline to monitor changes, develop global standards and methodologies and improve soil and land management in Africa. In the future, crop responses to inputs will be calibrated directly to spectral tests. Linking this with decision models can tell farmers what the likelihood is of a given level of response of their crops to the inputs used. Optimal use of inputs can save on input costs, while increasing yields, ultimately leading to improved food security and higher incomes for smallholder farmers.

For the private sector and development organizations, it would be much easier and cheaper to monitor soil conditions at field levels. For financial institutions, cost and time savings in soil samples can lower transaction and monitoring costs. Knowing the crop response to inputs in combination with the soil information can also lower a farmer's risk profile, making him/her more eligible to get a loan.

Thirdly, governments can now afford to analyze large numbers of geo-referenced samples, with sufficient sample density per unit area to map soil properties in 3D. Satellite imagery and unmanned aerial vehicles (UAVs) make it now possible to create high resolution and low cost soil property maps, with which decision models can be improved in order to better target interventions in agriculture. To give an indication of the cost and time savings: a soil sample can now be scanned in just 30 seconds and the resulting "fingerprint" can be used to predict a number of soil properties. This costs only $ 1 as opposed to at least $ 100 when conventional soil testing methods are used. The project area includes around 17,5 million km2 of Sub-Saharan Africa, an area covering more than 90% of Africa's human population living in 40 countries. AfSIS ground surveys will provide around 9,600 new soil profiles observations consisting of more than 38,000 individual soil samples.

Financial Service Providers (FSPs)

The use of ICT based payment systems has greatly taken off in the urban areas in developing countries and is now spreading into rural areas as well. ICT based financial services have often been driven by mobile network operators and to a lesser extent by large banks. In many cases the financial service providers can be seen as users of systems developed by digital service providers (DSPs). According to an analysis by Dalberg[14], high tech banks, mobile network operators and niche non- bank financial institutions have digitalized most functions already, while commercial banks and innovative Microfinance Institutions (MFIs) are still in the process of digitalizing their lending functions and maintain parallel legacy systems in place. Traditional MFIs have made less progress on digitalization. Of those MFIs that have successfully leveraged mobile banking, the majority is located in urban or semi- urban markets where the mobile service is widely used.

While MFIs are distinguished for their expertise in knowing clients' needs, they are not well-known for their success with large innovative technology projects. Evidence indicates that mobile money services could help MFIs to improve operational efficiency, reduce costs, and better serve their existing customer base, including the rural areas. Few MFIs however have the resources to invest in vast mobile banking programs and reach the required scale to make the investment financially sound. In rural areas, payment and money transactions are much less frequent than in urban areas and often they fluctuate with the seasons, thus making income flows for ICT and financial service providers unstable. MFIs and banks use ICT for marketing, enrollment, lending to more remote and/or higher risk farmers, reducing credit risk, and achieving higher credit penetration. Still, in the context of developing countries, the relevance of face to face interactions remains high and thus innovative credit providers have integrated digital technology with other services in the lending chain, especially when reaching out to farmers[15].

For smaller MFIs, barriers include high upfront costs, lack of internal capacities, limited knowledge on digital service providers, limited internal capacities, resistance to change[16], and regulatory barriers[17]. Besides technical expertise, companies often lack knowledge and understanding of the digital landscape and cannot easily assess the quality of the digital service providers. The changes require high level change management and the need for this is not always recognized. There are also challenges in integrating ICT in financial service providers. The costs are high and the business case is not yet proven, especially in rural areas. High implementation costs and additional costs of staff training can be a huge obstacle, particularly for smaller MFIs. Digital illiteracy of end customers is challenging, especially when providing financial services through mobile phones. Understanding their clients, developing flexible loan products (especially loan terms and repayment conditions), looking at total household cash flow, hiring specialized credit officers and staff, adapting credit analysis to agriculture, investing in proper MIS, and optimizing customer service, can prove very helpful in helping smallholder farmers increase their production and incomes, as is shown in case 7[18].

[14] See Figure 2 in the annex, from The MasterCard Foundation et. al. (2016)

[15] For a more details, see Figure 2 in the annex

[16] Especially to higher levels of transparency

[17] The MasterCard Foundation et. al. (2016)

[18] CGAP (2016) & IFC (2014)

Case 7

Combining advisory and microfinance services: CommonSense project Ethiopia (G4AW project)

The CommonSense project in Ethiopia intends to reach 200,000 smallholder farmers (through unions, cooperatives and MFIs) in the sesame sector in four regions in the country. Earth observations and geographic data will be used to strengthen the value chains, improve livelihoods and food security. The Partnership is being led by the DLO Foundation, and consists of Achmea Foundation and Ethiopian partners APPOSIT (IT platform & business development and also the business owner) and Exotalent (user needs assessment, pilots and capacity building). Remote sensing services and weather information are provided by Airbus Defence and Space Netherlands and Weather Impact. Several MFIs offer financial services, including Busaa Gonofaa, Harbu and SFPI, which are supported by ICCO Terrafina Microfinance.

The data will be used to offer a range of services to different end-users. Localized weather data, crop monitoring and yield forecasting, crop suitability advice, and information on market prices are provided to smallholder farmers. The information can be accessed through SMS, apps and a web portal and enables smallholder farmers to make better informed decisions. This will help boost agricultural production and improve farm risk management, which will lead to increased food security. Additionally, MFI's improved risk assessment and loan portfolio monitoring will lower monitoring and transaction costs, which improves smallholder farmer's access to financial services. Next to smallholders and MFIs, unions, cooperatives, out-grower organizations and the Ethiopian government are targeted end-users.

Since this requires a serious investment by the financial institution, only those institutions that are committed to agro-finance will make this jump. Launching a poorly defined service and hurried implementation will not contribute to the success. If the service functions poorly, farmers will easily lose trust.

However, there are many positive aspects of digitalization: it can assist in timely disbursing loans before the agricultural season and increase the internal ability to detect fraud and inefficiencies. The impact of digital payment systems on farmers appears to be positive due to savings in travel costs and time and a reduction of risks related to carrying money on the way. However, very few financial institutions have started adding value by linking to other types of digital information coming from weather stations, GIS and other data.

Internal challenges can also be observed. Financial service providers might be reluctant to share their data with digital service providers because they consider it too sensitive to their own business. A real partnership needs to be established between the financial service provider and the digital service provider with both benefitting from the business case. Since pioneering is costly, this could also involve sharing the initial investment costs. Good and continuous communication between financial service providers and digital service providers can effectively overcome this issue. The financial and digital service provider are in this venture together, while they are also in a business relationship. In such a partnership, the final ownership of the application can be a trade-off as well.

From an investor's point of view, it is necessary to assess and identify the risks related to agricultural finance. Making sure these risks can be handled and showing that agriculture can be a sustainable and profitable activity, which is in line with the organizations' social mission, might incentivize MFIs and other financial institutions to enter into the agricultural lending market, thereby attracting investments from foreign investors as well. With the new developments in agri-technology, digital tools can also make it easier for financial institutions to assess smallholder famers prior to the lending decision. Getting the right information on farmers' personal finances and farming output, combined with agricultural information could not only reduce transportation costs, loan assessment costs and recovery costs, but also costs related to loan monitoring and credit risk. The ability to integrate agriculture related data into the loan analysis and monitoring

will improve the credit analysis and the tuning of the loan cycle to farmer's needs. Receiving information on input prices, soil fertility and the (local) climate, can increase loan officers' understanding of the dynamics of agriculture and lower the perceived risk.

Case 8

Using GPS in Financing Cocoa Farmers in Ghana: Opportunity Bank

Opportunity Ghana started financing cocoa farmers in the Ashanti and Brong Ahafo regions under the Cocoa Livelihoods Program (CLP) and Millennium Village Program (MVP). Prior to the start, Opportunity developed a detailed cocoa crop profile and began registering farmers and completing household profiles. To determine whether farmers are economically and commercially viable, it uses two innovative technologies: GPS for land mapping and a Customer Relationship Management (CRM) tool for the household profiling.

After the initial screening process, the loan officer maps the farmer's land using a GPS hand-held device which determines the location and exact land area available for farming, the position of the house, altitude and access to water/irrigation. Information on up to three crops being grown by the farmer and the land size of each crop is collected, which can be used to accurately determine the appropriate amount of inputs required by the farmer. The data is then also provided to extension service providers to facilitate cooperation with another important supporter of the value chain. ***The loan officer then researches each potential crop to understand the direct and indirect costs of production, and assess the expected yield, demand and market value.***

All the information is fed into the CRM tool which enables the loan officer to determine whether the farmer is able to feed their household and run a business. Each farmer is offered a total farm plan, including a range of financial services and a three-acre package worth around US$ 300 per plot which contains fertilizer, pesticides, and protective clothing. With the help of the mapping tool, subsequent loan clients received inputs based upon the actual acreage of their farm plots to maximize production and household income. ***Additionally, all loan clients received training, credit life insurance, and access to savings.***

Farmers' spending on inputs was reduced significantly, thereby improving their repayment capacity, making them more eligible to get a loan. For Opportunity Ghana, yields can be more accurately estimated and a more tailored package of financial services can be offered. Ultimately this reduces the risks and costs associated with agricultural lending and expands Opportunity's client base.
Combining financial resources with instruments to hedge risks and training on best practices made farmers able to maximize their output and profits, and achieve greater sustainability. At the end of 2011, Opportunity had disbursed 3,572 loans to cocoa farmers with an average loan size of US$ 552. Repayment rates reached 100% for the MVP group, and 99,4% for the CLP group.

There have also been remarkable developments in creating data-based lending models. These models base their risk analysis on the assessment of large numbers of similar clients in a particular portfolio who have already received the loan. Key to this is to get the data from the field and local branches digitalized and ready for analysis. However, such models require existing agro-portfolios and these are not yet commonly found in rural based financial institutions. Several companies have developed alternative lending models using the data collected from other sources19. Such models have already been implemented by Grameen Foundation, Gro Ventures, Farm Drive, EFL, Lenddo and Arifu. These models look at agricultural product specificities at the start of the loan cycle, see the case 9.

Case 9

Alternative credit scoring: Lenddo & FarmDrive

Lenddo is a technology company that uses non-traditional data to compute people's credit scores. The company started in 2011, with the aim to improve financial inclusion in developing countries. It uses advanced machine learning to build predictive algorithms that are able to collect, analyze and process huge amounts of data. By analyzing social media activity, network, consumer's and browsing behavior, geolocation and other mobile phone data, Lenddo is able to analyze these digital footprints, verify identities and assess a person's creditworthiness and risk. The algorithm translates all the information into a LenddoScore, which proves to be a powerful predictor of a person's character and willingness to pay. The score ranges from 1 to 1000, with higher scores meaning a lower propensity to default.

Since social data are much more widely available, this might be a very interesting solution to the lack of financial records for farmers, and for young farmers in particular. Younger people tend to be more familiar with social media and (smart) phones, which could speed up the process of having access to affordable and suitable financial services. For financial service providers, Lenddo can help extend credit to consumers and SMEs, reducing risks, increasing portfolio size, improve customer service and verify borrowers.

After starting its activities in the Philippines, Lenddo is now active in 20 countries worldwide, on boards 200,000 applicants a month and has received several awards for being an innovative and influential FinTech company.

FarmDrive is another example of using alternative credit scoring to improve financial inclusion, particularly for smallholder farmers. Its algorithm aggregates several sources of alternative data, namely environmental data (market data, crop portfolio, soil health, pests), social data (social interactions, FarmDrive app usage) and individual data (demographic, geographic, plot size, production, income). The environmental data come from big external datasets, while the social and individual data comes from the farmer's usage of FarmDrive's own mobile phone application. The algorithm generates credit profiles and tailor-made loan products for farmers based on the nature of their farming activities. Financial institutions are offered decision tools that enables them to develop small-scale agricultural loan products combined with weather-index insurance.

It appears that significant value of digitalization is mostly found in increasing outreach to remote areas and less in cost reduction advantages, according to information from financial service providers. According to the study by Dalberg, portfolio growth is the key driver behind the investments in digital services from financial services providers. This growth is realized through three pathways: 1) increasing field officers productivity 2) acting as a distribution channel for other digital devices and 3) by bringing in new client segments in the market. A more detailed overview of the potential use of digital tools along the value chain can be found in the annex.

Agricultural Insurance

In order to raise agricultural production, timely, affordable, and suitable financial services that are tailored to the needs of smallholder farmers should be developed. Payments services and agricultural loans (both for working capital and equipment investments) are two of them, but smallholder farmers also need financial services that mitigate the risk of losing (part of) their harvest. A specific financial product that benefits from the information link with geo-data is agricultural insurance. The unpredictability of rainfall patterns is something that can have a large impact on farmer's crop yields. Climate change will make these rainfall patterns even more unpredictable. A drought resulting in a bad harvest leads to lower or no savings that can

[19] Examples include alternative lending models that use psychometric and behavioral characteristics or data from social media, but there are also examples of services using geographical, climate and value chain data in order to assess a borrower's lending capacity.

be invested into next year's planting, which ultimately puts the farmer into a vicious cycle of poverty. This, in combination with smallholder's inadequate access to financial services to save or to borrow, makes it even more difficult to overcome weather related shocks.

One way to overcome the risks of adverse weather shocks is through insurance. Most of the insurance products are indemnity based: the company insures the farmer against crop losses or damage. Although this type of insurance helps farmers overcome losses from any type of damage, the insurance is very costly, especially for rain fed agriculture. Several index-based micro-insurance schemes have been developed that cover farmer's inputs in the event of drought or excessive rainfall. Local weather stations measure the amount of rainfall and other climate conditions and automatically send the information to a centralized database. Actual rainfall levels are then compared to "trigger levels": the amount needed for normal plant growth of a certain crop. When the actual rainfall level exceeds the trigger level (too much or too little rain), payouts are calculated and sent to the farmers, usually to their mobile money account. Currently, some insurance products are being adapted to include more features and flexibility. Now, not only seeds, but also other inputs and harvest outputs can be insured.

Case 10

GIACIS, Geodata for Innovative Agricultural Credit Insurance Schemes (Ethiopia): Public-Private Partnerships for index insurance (G4AW project)

The Faculty ITC of the University of Twente has developed a satellite-based information system that can be used for agricultural index insurance, with no or limited need for field inspections. The business owners are the Ethiopian insurance companies Kifiya Financial Technology and Oromia Insurance Company. Other partners are the Agricultural Transformation Agency – ATA (Ethiopia), the National Meteorology Agency of Ethiopia and Swiss Re, a Swiss re-insurance company. A pilot for 2,000 farmers has delivered such promising first results that the Ethiopian government stepped in to expand the scheme, with the aim to reach 1.6 million farmers in three years (the consortium keeps the rights to provide the service in the open market as well).

Farmers receive information through text messages, (financial) apps, email, face-to-face contact with insurance agents and can access a web portal. Food producers pay for the insurance, with a subsidy provided by government. The government also provides credit to make it possible for the food producers to pay the insurance premium after the harvest. A problem with re-insurance of the service was solved (with government backing). Bundling with other financial services is planned but the limited outreach of financial institutions to rural areas is still an issue (only 14.5% of Ethiopian households can benefit from these types of service, mostly in urban areas). Correct identification of farmers' plots also poses a challenge, but the general outlook of the initiative is very promising.

4. Digital Service Providers: who are they?

Apart from looking at the user, it is important to understand what digital service providers can offer. To understand the relevance of digital service providers to smallholder finance, we have clustered them according to their function in the information chain.

Data category	Potential sources	Providers	
Geo	• Satellite • Drones • GPS • GIS • Weather stations • Research Institutes	• Telephone Farmers • MbeguaChoice • Planet Labs • Digital Globe • Aware • Acre Africa • Getchee • IPRS • The Climate Corporation • CI Agriculture	• Geotraceability • SatImagingCorp • eLEAF • WaterWatch B.V. • Resilience Atlas • Cropio • Geosys • Trimble (Greenseeker) • InVenture • Novus Agro • Milan Innovincy
Value chain / market	• Input supplier • TA providers • Buyers/traders • Cooperatives/Producer Organizations • Aggregators • Value Chain Support services	• Agricultural Loan Evaluation System • AgriLife • Hurudza • MFarm • Zevan Ltd.	• Kaa (smart agriculture solutions) • ThingWorx • Scanntech • Gro Ventures • FarmDrive

Table 2 – Digital service providers that use geo-data and value chain/market data for their services

Source: The Intiative for Smallholder Finance (2012) and authors' own research

It is important to make a distinction between the different DSPs to understand what they are doing and how the end-users benefit from their services. End-users can not only be smallholder farmers, but can also be banks, MFIs, and NGOs. It is important to note that the government can both be a provider and a user of digital services. For the purpose of this paper, a useful categorization is:

Data acquisition and collection: firstly, there are the actors who acquire and collect large amounts of data. Especially those providers that collect geo-data through satellites, drones or other instruments tend to be either high-tech companies involved in the space industry, (inter) national space agencies or meteorological services. They use different technologies and provide the required data on soil and weather conditions, crop health, and so on.

ICT for Value added services: next up in the information chain are the organizations that add value to the data collected. Here the transformation step takes place. Many companies exist that feed the images and data into their servers, process and analyze it and build a product that would suit the needs of the end-user. More and more services and products are now being developed by (social) enterprises that aim to make a profit and a positive impact. Software companies also play an important role in making the ICT work for the value added services. Enterprises that build mobile, web –and desktop applications enable users to access market and price information, weather updates and so on. These service providers also develop management information systems for MFIs. It could therefore also be interesting for companies that build these systems for financial institutions and MFIs to integrate agricultural data and price information services in their systems.

Case 11

Eyes in the sky: using drones to monitor crops in Rwanda

The US Agency for International Development (USAID) is partnering with Agrilift, Milan Innovincy's Rwandan subsidiary, to pilot its crop monitoring technology using drone technology. The pilot is to reach 2,000 potato farmers affiliated with 20 potato cooperatives in the Imbaraga Cooperative Federation located in the Northern provinces. The drone will take overhead images of the growing crops at specific intervals. These images will be analyzed with an open-source computer model of plant growth, specifically designed for potato farms. The drone is not only able to identify the optimal maturity for potato plants, but can also identify nutrient deficiencies and diseases.

With the new drone technology, farmers, farmers associations and cooperatives now have access to more detailed information and can greatly improve their farming practices. It will provide information on soil conditions as well as which seeds and (amounts of) fertilizers to apply. Moreover, it can also be used to determine the best times to harvest the crops and enables farmers to quickly take corrective measures if necessary. According to Agrilift, drone technology can potentially reduce the costs of constant crop monitoring and post-harvest losses. Increasing yields brings positive effects to the whole value chain and can also benefit the entire Rwanda economy. Not only farmers, processors, traders, and input dealers, but also financial service providers and the government can benefit from the new technology.

The first drone test flights where conducted in the Musanze district during the September-January planting season starting in 2015. Currently, 242 plots of farmland under four cooperatives have been registered for the drone technology. Both farmers and government officials very much welcomed the drone technology, affirming that it would make it a lot easier to cultivate their land with improved scientific knowledge.

Source: www.newtimes.co.rw/section/article/2016-12-08/206076

Product distribution: thirdly, when the data is transformed into usable information for farmers or other users, it needs to be distributed timely, correctly and at low-cost. Telecommunications technology has achieved this at an incredible speed, making mobile phones the preferred choice to deliver these services to smallholder farmers in the future. Telecommunication companies and mobile network operators not only provide reliable and low-cost mobile payments services, but are also required for the short and long-term information services to work, become economically viable and reach scale by addressing farmers and farmer groups. Examples include Safaricom, Zoona, EcoNet, etc. However, in some instances, mobile phones might not yet be the best distribution channel. In many cases, radio and television are still the most effective ways to reach farmers.

Linking geo-data and ICTs to financial services

Table 2 has presented a short list of digital service providers that either use geo-data and/or data on value chains/markets to improve smallholder farmers' agricultural production and markets access. However, as mentioned in the first chapter, there are not that many examples that actually do create the link with financial services. Table 3 presents several examples where financial service providers explicitly use geo-data and data on value chains/markets to improve smallholder farmers' access to finance. As becomes clear, many examples include insurance products, and not so much financial services for working capital or equipment.

Financial Service Provider	Financial product	GEO	Value chain
Opportunity International	Insurance & Loans	GPS	Market prices
FESA Microinsurance	Insurance	Satellite	
Kilimo Salama	Insurance	Weather stations	
Juhudi Kilimo	Asset financing & insurance		
NUCAFE	Weather insurance	Weather stations	
EcoFarmer	Weather insurance	Mobile telephony base stations	
ACRE	Weather insurance	Weather stations	
Ekgaon Technologies	Mobile phone based financial services		Market platform
Umati Capital	Factoring & Reverse Factoring		
FarmDrive	Access to loans	Satellite	

Table 3 – list of financial services providers that use geo-data and ICTs

Digital Service Providers and their challenges

Digital Service Providers also face challenges that affect the provision of their service. They are also constrained by the less developed mobile ecosystem in rural areas and the regulatory environment, which includes the lack of clarity on intellectual property rights and privacy regulation for financial service providers. An adequate (ICT) infrastructure is absolutely necessary for the success of ICT services in a country.

Furthermore, a market with many subsidized services (such as agricultural helpdesks and call-centers) might challenge the business case for private digital service providers. Many services are still pilots subsidized by the government or multilateral institutions. Large up-front investments and unexpected costs can seriously hamper the development of digital services. Private sector players tend to step in at some point and can improve sustainability and outreach once a critical mass has been achieved.

Despite many challenges, two factors are expected to speed up the provision of digital services: lower costs of delivery and improved sustainability of the provider. Data collection may be expensive for short-term productivity services, but the delivery of such services has become much easier and less expensive with mobile phones. Simple software can be embedded in the phone or downloaded, although many providers choose the even easier and less costly route of providing text messages. Most short-term productivity services are leveraged on existing infrastructure, such as radio stations or mobile phone networks. As these service providers have already covered the major costs in their businesses' fixed costs, any additional service essentially entails added value with relatively low additional costs.

5. Business Models and Public-Private Partnerships

A good partnership is key for the service or project to succeed. In the G4AW facility, some new and unexpected partnerships emerged with the involvement of smallholder farmers' organizations, financial institutions, insurance companies, governments, input suppliers, traders, mobile phone companies, research institutes and technical companies. When these partnerships work well, the business case has a much higher chance to succeed.

In most cases, developing new ICT applications requires strong and intensive partnerships between different types of actors from both the public and private sector. Many of the innovative partnerships supported by the G4AW facility were able to build business models that show promising results of becoming a sustainable business case for smallholder farmers. Initially, new ICT services have been developed by the public sector or by development partners. They attracted attention from the private sector once their potential to be profitable became clear. For agriculture, the public sector still remains the largest investor to provide information services. These programs struggle to be sustainable or scale up because of limited public funding and a lack of business approach in the design.

The entrepreneurial nature of digital service providers has created new partnerships and attracted new forms of investments. Mobile network operators have invested in providing large text packages at a lower cost, collecting (insurance) premiums, providing payments services and extending their networks into rural areas[20]. Processors, input suppliers and exporters are also investing in ICT in order to serve their clients better and reduce bottlenecks in the value chain. Business incubators can be used to identify investors and business partners that can help to further develop enterprises that provide agricultural services more efficiently to smallholder farmers. Knowledge brokering, in which a private company provides (agricultural) information for a fee (such as price, crop, market and weather information), offers ways for farmers to benefit from information sharing[21].

In most of these public private partnerships the business owner should be clearly defined. The business owner needs to ensure continuity and should be functioning as the driver of the case. It can be a company, government organization, NGO, or farmer organization. The business owner should have a clear stake in the outcome within a given project time frame, and have a vision for the period after the project has ended, but also other partners should play their role well, related to the core business of their organization. The business owner is the linking pin for upscaling of the project in the country or beyond. However, ownership and the license to operate are difficult issues, especially in the case of a collaboration between a financial service provider and digital service provider who both want to make a business case. Ownership of both the data and the ICT application then becomes an issue.

- **Freemium model:** free service provision of basic services to smallholder farmers. A number of other clients pay for the service.
- **Loyalty model:** free service provision avoid clients switching to a competitor. Also called "direct revenue" Business to Business (B2B) in case of a seed or nutrient supplier or "indirect benefit" in case of a mobile phone operator.
- **Direct revenue Business to Consumer (B2C):** the smallholder farmer pays directly for the service.
- Inclusive model: paid service provision bundled into package e.g. insurance coupled to credit.
- **Service model:** client is paying a (subsidized) fee for service provision. The subsidy can come from government or from another (farmers') organization.

The service model and the inclusive model are the two most often adopted models in the current projects.

Box 1 – Different types of business models in G4AW facility[22]

[20] Accenture & Vodafone (2011) & World Bank (2011)

[21] FAO (2013) & World Bank (2011)

[22] Internal evaluation G4AW (2016)

6. Flexibility in business functions

New technologies in agriculture and finance have changed the agriculture extension and financial landscape both in the developed and the developing world. Digital financial services, especially those involving mobile phones, have been able to offer low-cost, efficient and reliable financial services, making the financial sector more inclusive and also benefitting smallholder farmers. However, the speed at which existing technologies change and new ones are developed offer both opportunities and challenges for traditional financial institutions. People can already make payments without using a financial institution. And what if people are allowed to borrow from actors other than a financial institution, and at a lower interest rate? Currently, telecom providers and supply chain companies also engage in financial transactions, such as lending, with simple and fast procedures.

Tech-giants in the developed world are also entering new markets, which also includes the financial services industry. Big companies, backed by tremendous amounts of capital and the latest technologies,, are getting involved in financial services provision either directly or indirectly. Alibaba for example has already set up deposits and savings initiatives and other e-Commerce players have also developed their own lending platforms, such as Amazon (2012) and PayPal (2013). It will take some time but these developments will also reach the developing world and even the remote rural areas. Currently, it is technically possible for a farmer to order inputs for the next growing season online from an e-Commerce platform, taking credit from the company and paying it back after harvest. The increased level of connectivity and decreasing costs in rural areas, combined with the expected increase in smart phones will speed up this process.

An interesting development, still quite small but growing at an incredible pace, is peer-2-peer lending and crowdfunding, which is a form of peer-2-peer lending. Private investors and individuals that seek both profit and social impact are more and more willing to lend to likeminded entrepreneurs or businesses[23]. Platforms such as Kiva, Crowdo and CreditEase might potentially provide another source of funding for borrowers and become another competitor in the financial services industry.

7. Lessons learned

Recent developments in technology for agriculture and finance have seen a huge growth and can potentially have significant impact on smallholder farmers' productivity and income. While these developments area still in the early stages of exploration, we can distinguish several important lessons learned:

1. Good policy and regulatory environment

The speed of the technological evolution offers both opportunities and challenges, not only in the financial services industry but also for regulators. It is therefore crucial for regulators to create the necessary controls, transparency and stability in the business and financial system, whilst providing sufficient room for innovation that is beneficial for both the industry and its clients.

There is also a need for a conducive regulatory environment. This ranges from clear regulations on mobile payment systems and user privacy rights, to protection of ownership of systems and data. Governments should play an important role to stimulate an appropriate legal and policy framework. Clear regulations on data privacy and security are needed. Proper regulation will create an enabling environment in which other users of services including farmers and their organizations, extension services, knowledge institutes, companies and financial services providers are able to innovate and adopt new technologies. Currently, it is noticed that systems are often already developed before the legal system is ready to govern them. Technology developments go faster than the required legal developments[24].

[23] See European Microfinance Network (EMN) (2015)

[24] The MasterCard Foundation et. al. (2016)

2. Appropriate and relevant information packages for farmer.

Evidence indicates that services need to be easy to understand and user-friendly for farmers, often alongside with face to face interactions to increase impact of the messages. Standardized information that is pushed out to farmers only has a limited effect. Farmers want to be able to see the message at a glance and be able to respond to the information or ask additional questions. Such interactive applications have not yet been developed on a wider scale. It is assumed that once farmers are used to basic technologies, more advanced applications, such as for farm management, business development and access to finance, can be introduced. There is also a need for applications that are able to function off-line too, and attention should be given to applications that address the needs of women, since they make up a large proportion of the users[25]. Further research into gender sensitive methodologies for technology service provision is needed. Another important group to be addressed are the young farmers and youth in rural areas. They are often already familiar with new technologies and might be attracted to farming when modern technology is applied.

The key element to create appropriate services for farmers and their organizations is to make sure they are involved from the start. This will ensure that services are developed that are truly relevant and used by farmers. It could also help to monitor if these developments will not enlarge differences in poverty levels between farmers, whereby progressive farmers grow fast and subsistence farmers are left out completely. Active participation of farmers should also safeguard against increasingly unequal terms of trade between inputs used in agricultural production and agricultural output. Higher prices for inputs and lower prices for agricultural output would discourage farmers to use the technologies that are being developed.

3. Guidance and support to financial institutions

The use of digital systems for financial operations is a major change for emerging financial institutions, especially those that operate in rural areas. This change, combined with a focus on agro-finance, is new for these organizations and requires key improvements in the lending processes. Adopting new technologies for agro-lending asks for a double change process which calls upon strong change management capacities of rural based financial service providers. At the same time, new technologies can also accelerate the changes and increase the appetite of financial institutions to go into rural and agri-finance. Improved systems and applications can lower the cost of client outreach and loan analysis. It is observed across the board that young rural based financial service providers need guidance and support in these processes. Especially financial institutions and cooperatives that reach out to remote farms currently see high cost of training and system costs as big barriers to digitalization. Donors and investors could consider addressing these in their programs on financial inclusion.

4. Realistic and clear expectations on the business case

New technology in agriculture can greatly improve farm management and income for farmers, and financial service providers can increase their outreach which otherwise would not have been possible. The improved productivity and income for farmers through new technologies in agriculture combined with the use of technology to increase outreach could have a double positive impact on farmers. It could increase financial inclusion of the rural population. However, initial investments are high, both in terms of technology, hardware, as well as in terms of client and staff training. The early uptake and transaction volumes might be low, especially in low density rural areas. It is therefore almost inevitable that subsidies are needed at the early stages of development. According to the Rural and Agricultural Finance Learning Lab[26], the impact of financial services providers business model digitalization on small holder farmers is not yet fully understood. Long term business perspectives can provide a driving force for further development, but currently small farmers are not willing and able to pay for the services. A too strong focus on short-term financial sustainability might kill interesting innovations in an infant stage. A long term holistic perspective would make creative innovations possible. The cost benefit analysis should then also include effects on increased farmer productivity, long term food security, improved loan repayments and positive effects on climate change.

[25] Internal evaluation G4WA (2016)

[26] The MasterCard Foundation et. al. (2016)

5. Innovative partnerships

The first evaluation of the G4AW facility and other program reviews, show a remarkable diversity in partnerships between a pallet of actors. Organizations that normally would hardly be in contact with each other now work together intensively to make the partnership work. If the partnership works well, the outcome can accelerate, but if the partnership fails, the implementation staggers. Explicit attention to create and maintain effective partnerships is needed. Issues such as ownership and return on investment should be discussed properly from the onset, especially when all parties invest their time and resources. In the case of business links between financial service providers and digital service providers, the ownership issue can become problematic when financial service providers want to control and protect client data while digital service providers want to use the data to improve their product. In the G4AW facility, it appears that having partnerships with both the public and private sector involved is a successful combination, especially when parties bring in their distinct expertise.

6. New players in the field of finance

The latest developments in technology make it possible for partners and actors to provide services outside their regular scope of business. Telecommunications companies for example can engage in lending transactions and input suppliers can provide digital loans for their products. These developments will challenge the more traditionally oriented organizations such as governments and banks to find new ways and think out of the box. Financial service providers need to partner with non-traditional actors to incorporate alternative sources of data and explore what types of date are most valuable in dealing with the risks associated with agriculture. It is important to find out how the data -such as weather data, GIS, soil information, data on crop diseases- can be obtained and used to design customer centric services while reducing the high costs of continuous physical contact. Also, new risk and cost sharing structures have to be developed where providers optimize their inputs and services.

8. Way forward

The aim of this paper is to provide a first overview of the existing body of literature related to ICT developments and rural and/or agricultural finance. It has given an overview of the different types of technologies available at the moment, with some examples of projects and programs in different countries that have used ICTs with the aim of increasing agricultural productivity, access to markets, agricultural income and food security. In addition, it has briefly discussed the financial institutions' existing experience with agricultural lending and the use of new technologies in this field. It has identified success and risk factors of agricultural finance and how new technologies can contribute to address these.

It becomes clear that we are at the start of a new development that can have a great impact on agricultural production, marketing and inclusive agro-finance. This can create new opportunities for smallholder farmers, but collaboration at all levels is needed. The lessons learned already give us some ideas on the way forward. We would like to highlight the following suggestions which came from various sources:

1. Geo-data and ICTs carry a big promise for improvements in agriculture and finance worldwide but it is also clear that big investments are needed to make it work for all parties involved. Who should take up these investments and how can the risks be shared? Donors and development actors could support governments in developing appropriate legal frameworks; stimulate increasing exposure of farmers and other stakeholders to new technologies; support the innovation agenda of digital service providers and support brokering for strong partnerships. The new developments will need high risk bearing capital to allow for experiments which are not sure of success immediately. Concerted efforts are needed from governments and donors to make funding available for this.
2. The new developments go fast and impact on farmers, women and youth is not always understood, so there is a need for knowledge exchange to share successes and learn from mistakes. This requires investment in monitoring systems to assess the impact on farmers and agriculture, an assessment of the vendor landscape for digital service providers as well as stimulating the use of learning platforms.

3. Innovative collaboration between varied actors is required, sometimes outside the normal boundaries. Knowledge institutes need to work with farmer organizations, financial institutions with agro-extension services, but also with ICT research centers and so on. Such a shift will require an open mindset and a learning attitude in all organizations involved.
4. The paper has shown that geo-data and ICTs can have a positive impact on farmers' performance, but also has potential for improving agro-finance. However, there are still not many examples showing the link with agro-finance. More cases are needed and both the financial and agro-sector could try to stimulate this. The available data sets and technologies need to be adapted to stimulate easy exchange between the two fields of knowledge.
5. New technologies can also be a stimulus for younger people to enter into agriculture as a business. Currently, the average age of farmers is 50+. Youth is more familiar with new technologies and willing to use technological innovations. ICTs and digital services could make farming more interesting to them, also because it could make farming more profitable. Actively stimulating youth to adopt ICTs and involve them is needed.
6. The use of geo-data and ICTs could have a positive effect on adapting and mitigating the effects of climate change. More knowledge on this subject needs to be collected and shared.
7. Further research is required to understand the gender component of new technologies, since the impact differs for men and women. Dalberg has already conducted a study on the use of mobile payments services by women, but more such studies are needed.

Annex

Table 4 – ICT solutions to improve food security and access to finance by type and region

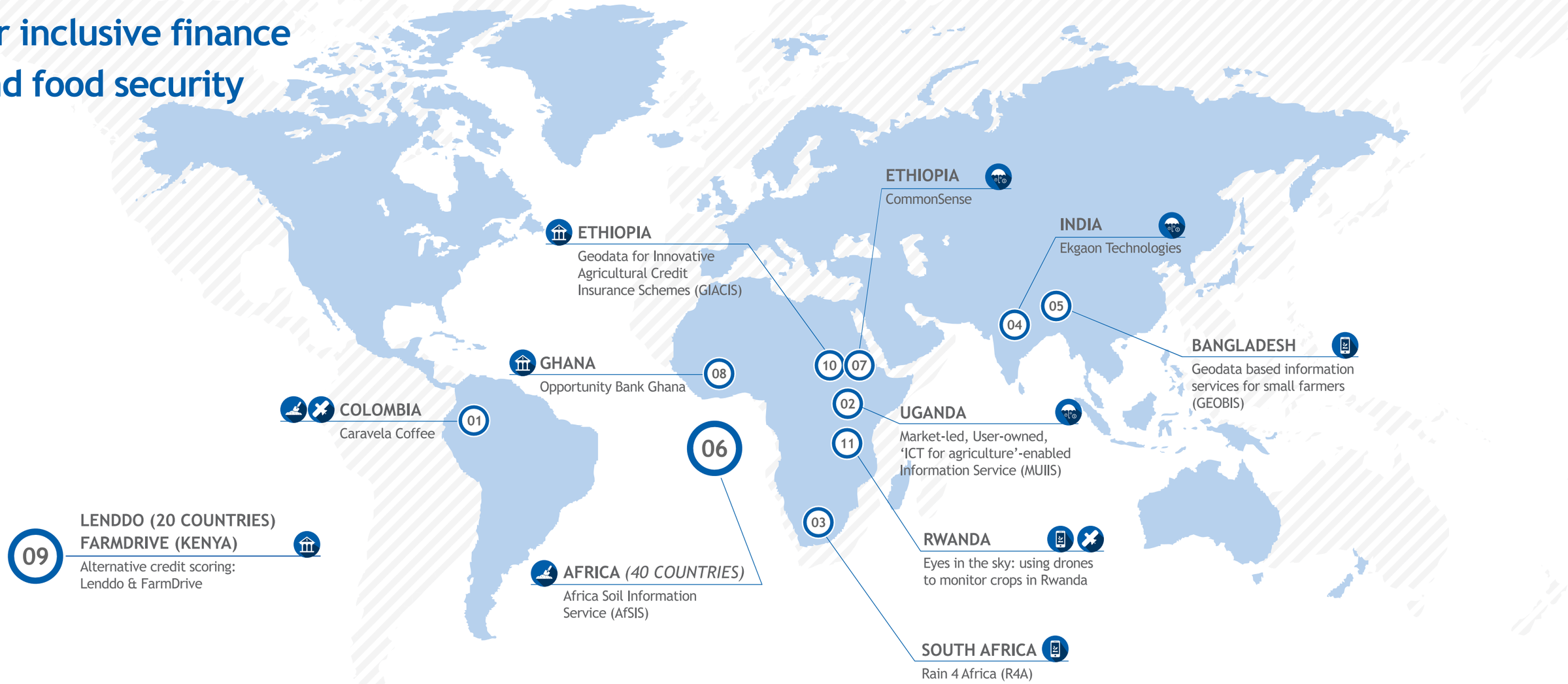
Type	Central Asia	East Asia & Pacific	MENA	South-Asia	Sub-Saharan Africa	LAC	Total
Access to inputs						2	**2**
Agricultural advice		5	1	1	14	14	**35**
Crop monitoring	1	9	1	1	2	12	**26**
Financial services				1	4	39	**44**
Holistic service	4	4	1		13	28	**50**
Information sharing		2			2	14	**18**
Price information	3	2			7	19	**31**
Soil information			1		1	40	**42**
Supply chain linkages		1				4	**5**
Traceability		2				7	**9**
Weather information					1	1	**2**
Total	**8**	**25**	**4**	**3**	**44**	**180**	**264**

Note: financial services include loans, insurance, factoring and reverse factoring and asset financing, but all related to agriculture. The same holds for payments.

Sources: CGAP Digital Finance Plus - Global Landscape, GSMA mAGRI Deployment Tracker, authors' own research

CASE OVERVIEW

Geodata and ICT solutions for inclusive finance and food security



WEATHER INFORMATION services usually provide information on climate or localized weather forecasts, including warnings on disease infestation or extreme weather events.

ACCESS TO INPUTS
Usualy these ICTs consist of a digital ecosystem that facilitate smallholder farmers' access to inputs, such as in-kind fertilizer or seeds subsidies using evouchers.

SOIL INFORMATION services provide soil testing, analytics and soil mapping. This provides detailed information on soil types and conditions and can help to make decisions on crop suitability and improve the efficient use of inputs.

FINANCIAL SERVICES only include those services that use ICTs and are related to agriculture. Financial services include payments, loans (working capital and equipment), insurance, factoring and reverse factoring.

HOLISTIC SERVICES contain a combination of services; usually these services include price information, weather information, agricultural advice, supply chain linkages, etc.

PRICE INFORMATION services are aimed at providing smallholder farmers, but also traders and processors with accurate and actual market information for specific crops, markets, regions or countries. Usually price information is delivered using mobile phones or computers.

TRACEABILITY SERVICES are aimed at tracking smallholder farmers' produce through the value chain or tracking livestock with a tracking device that provides analytics about an animal's health.

AGRICULTURAL ADVICE
Smallholder farmers receive useful advice on agricultural practices which is tailored to their specific needs. It can contain advices on sowing and planting, pest and diseases, fertilizer application, water use, drought warning, etc.

SUPPLY CHAIN LINKAGES often come in the form of an (online) trading platform enabling farmers and traders to interact and make transactions, without physically having to go to a market place, thereby strengthening value chains.

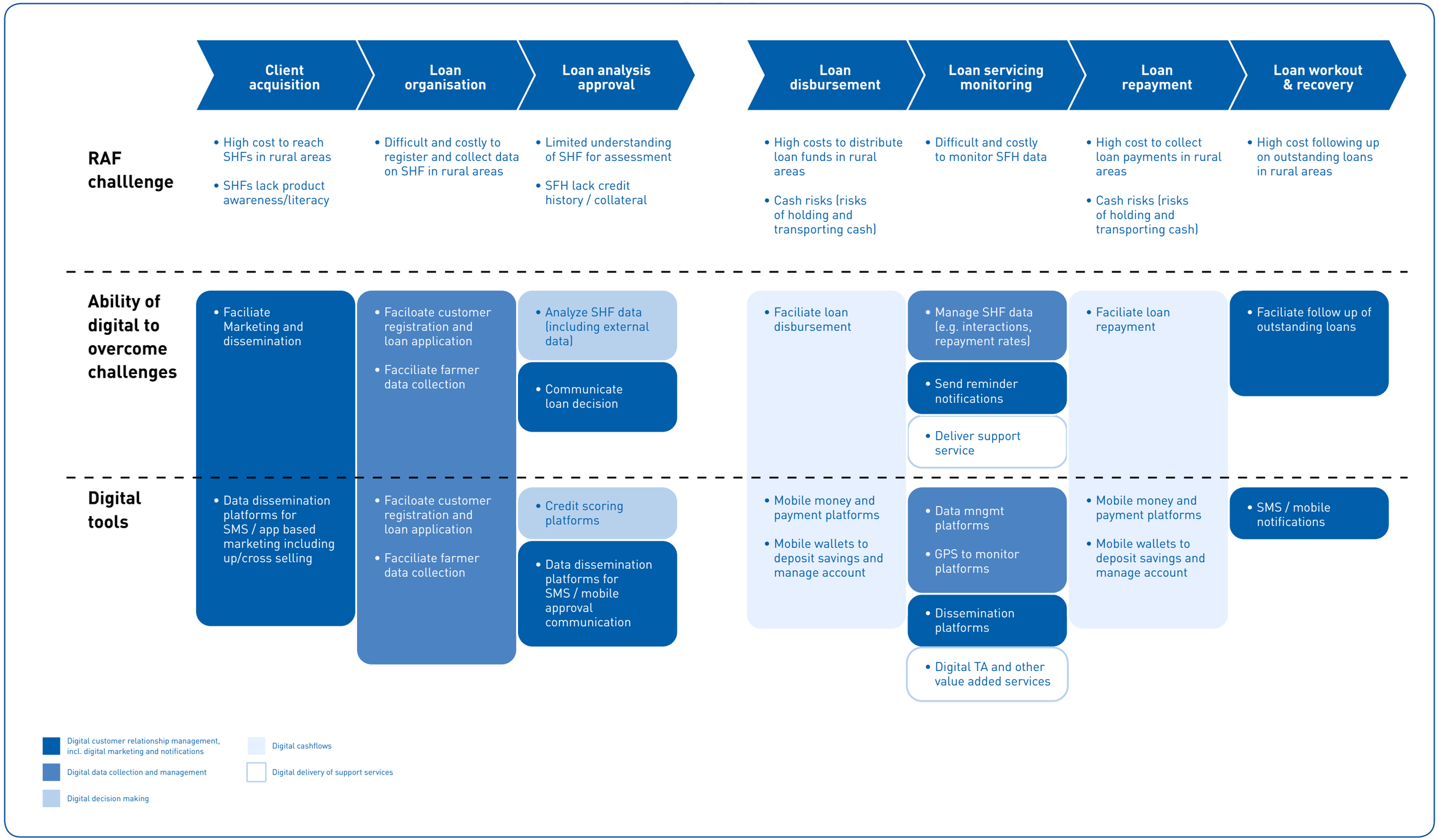
CROP MONITORING is used to track crop development and health. This can be used to develop improved crop forecasting (models), inform smallholder farmers, governments, NGOs and financial institutions about expected crop yields and corrective actions to ensure sufficient crop growth. Satellites and drones are often used to monitor crops.

INFORMATION SHARING services are aimed to bring together smallholder farmers or other value chain actors, so they can interact with each other, share information, experiences and best (agricultural) practices. Often these services are offered through online platforms, but SMS, USSD and WhatsApp are also used to disseminate information.

To access more than 250 ICT/Geodata cases go to *www.inclusivefinanceplatform.nl*

Annex

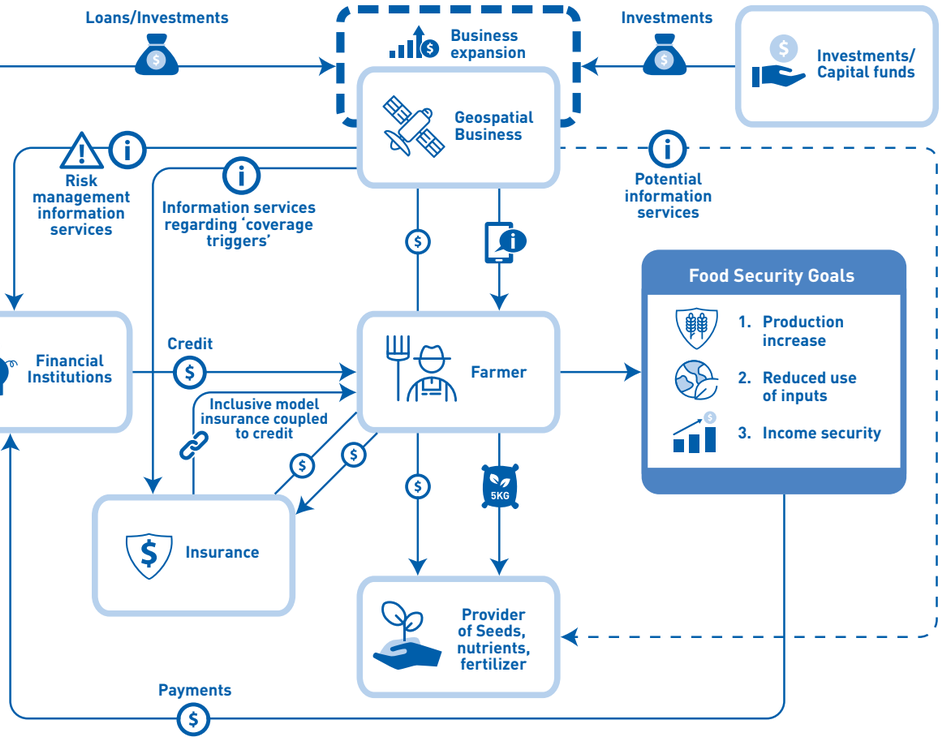
Figure 2 – Potential uses for digital tools along the lending value chain



Source: Dalberg, in The MasterCard Foundation et. al. (2016)

Annex

Figure 3 – Conceptual framework G4AW facility



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