6 Reducing Transaction Costs in Contract Farming Arrangements: the Case of Farmforce

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6.1 Introduction

Smallholder farmers produce less on a hectare of land compared to professional farmers under comparable conditions. Too many farmers don't even produce enough to work themselves out of poverty. A combination of lack of technology, know-how and access to markets, together with ill-informed agricultural policies is typically seen as holding back the 525 million smallholders worldwide (IFC 2013). Although some seem to perceive smallholders as an anachronism there is no massive move out of rural areas and out of agriculture imminent (Collier and Dercon 2014). Rather, smallholder farmers can be expected to play an important role in producing the agricultural crops required to meet the duplication in demand as the world's population reaches 9.1 billion by 2050 (IFC 2013).

Improving smallholder farmer agriculture has experienced renewed attention by development agencies and policy makers. Reaching the huge number of smallholder farmers working in remote rural areas often is the single biggest problem. This 'last mile' to the farmers' gate – or rather the 'first mile' of the food value chain – is where many well-intended projects fail. Mobile technology is increasingly seen as a major opportunity to bridge this gap (World Bank 2016). Optimistic calculations expect additional income of US$220bn until 2020 for smallholder farmers from mobile technology services, mainly improved access to financial services, access to agricultural information, improved data visibility for supply chain efficiency, and enhanced access to markets (Vodafone, 2011).

6.2 Contract Farming

In this chapter, we focus on contract farming as one approach to support smallholder agriculture to discuss the above-mentioned 'first mile' challenge and how to address it effectively. Contract farming can be an effective institution for helping small farmers raise their productivity and orient their production toward more remunerative commodities and markets. Yet, contract farming cannot serve as a broad-based strategy for rural development; it only makes economic sense for certain commodities in certain markets. Contract farming is most frequently used in the production of high-value crops for domestic formal markets and for export (Minot, 2007).

Contract farming can be defined as an agreement between farmers and processing and/or marketing firms for the production and supply of agricultural products under forward agreements. The agreement frequently predetermines the prices. Further, the arrangement involves the purchaser in providing a degree of production support through, for example, the supply of inputs (which *de facto* is a production credit) and the provision of technical advice. In sum, the basis of contract farming arrangements is: (i) a commitment on the part of the farmer to provide a specific commodity in quantities and at quality standards determined by the purchaser; and (ii) a commitment on the part of the company to support the farmer's production and to purchase the commodity (Eaton and Shepherd, 2001).

A broad range of contract farming models exist (for a discussion of the basic arrangements, see GIZ 2008). According to Eaton and Shepherd (2001), the intensity of the contractual arrangement varies according to the depth and complexity of the provisions in each of the following three areas:

- Market provision: the grower and buyer agree to terms and conditions for the future sale and purchase of a crop or livestock product.
- Resource provision: in conjunction with the marketing arrangements the buyer agrees to supply selected inputs, including on occasion land preparation and technical advice.
- Management specifications: the grower agrees to follow recommended production methods, inputs regimes, and cultivation and harvesting specifications.

Empirical studies consistently support the positive contribution of contract farming to production and supply chain efficiency. A recent systematic literature review of 11 studies on the impact of contract farming on productivity, and 12 studies on the effects of contract farming on farming income revealed that almost all the selected studies of the latter category argue that farmers on contract farming schemes experienced some increase in their income (Bellemare, 2012; Wang *et al.*, 2014; Nguen *et al.*, 2015).

However, participation in contract farming *per se* is not a guarantee for increasing farmer income. It is well recognized that contractual design factors are important determinants of the welfare impacts of the participation in the contract (Abebe *et al.*, 2013; Fullbrook, 2014).

Several factors of the contract design and execution seem to be particularly relevant. First, the contract design introduces a selection effect for participation: in contracts where inputs or interlinked services are not provided by the contractor as in-kind production credit, credit lines from banks or microfinance institutions (MFI) play a significant role in alleviating liquidity constraints that characterize smallholder systems. Households that have access to credit are more likely to invest in order to meet the buyer's quality requirements, which can earn them premium prices. Second, the distribution of the production and marketing risks between the farmer and the buyer has a significant bearing on whether the contract results in higher farmer income; this includes terms of the contract but also access to information to all parties involved (Mwambi *et al.*, 2016). Third, experience at the operational level shows that the quality of the business information system in place (be it analogue or digital) has a major bearing on the success of a contract farming scheme (GIZ 2008).

Adherence to voluntary sustainability standards (VSS) is a second mechanism through which smallholder farmers can get access to formal markets and – at least in some instances – benefit from a premium for their produce. VSS are private governance initiatives to shape global supply chains with the aim to facilitate more socially and environmentally responsible behaviour (Gereffi *et al.*, 2001). VSS vary in scope, i.e. the extent to which they emphasize labour conditions; economic productivity and environmental issues in requirements, i.e. how demanding and strict the rules are defined; and in enforcement, i.e. the design of the conformity assessment from self-declaration to third-party attestation. Voluntary sustainability standards have grown rapidly in number and importance in global commodity markets over the past decade. The average annual growth rate of standard-compliant production across all commodity sectors in 2012 was 41%, significantly outpacing the annual average growth of 2% in the corresponding conventional commodity markets. Sustainability standards have penetrated several mainstream commodity markets. For example, standard-compliant coffee reached a 40% market share of global production in 2012 (up from 15% in 2008), cocoa moved from 3 to 22%, palm oil from 2 to 15%, and tea from 6 to 12% in the same period (Potts *et al.*, 2014).

The industry sponsored Global Partnership for Good Agricultural Practice (GLOBALG.A.P.) standard is an example of a voluntary certification scheme that is increasingly defining market access for smallholders in developing countries. Founded in 1997, the GLOBALG.A.P. is a private initiative operating in the food and agriculture sector across 110 countries. GLOBALG.A.P. has become the *de facto* standard for horticulture exports to Europe and the USA. A study into pineapple farming in two pineapple growing districts in Ghana found that 70% of GLOBALG.A.P. certified pineapple farmers have access to formal markets (processors and exporters) compared to 30.3% of non-certified farmers. Regarding the economic performance, GLOBALG.A.P. certified pineapple farmers obtained 2.4 times more net average income than non-certified pineapple growers. This is primarily the result of a 33.5% higher productivity of certified farmers while the average sales prices across all sales channels was only 5% higher for certified pineapple farmers (Kuwornu and Mustapha, 2013).

6.3 Voluntary Certification Schemes

Often, contract farming and compliance with certification schemes are mutually dependent: for farmers, VSS are a means to access markets. Kariuki (2014) found that successful transition to GLOBALG.A.P. certification depends on training, the farm asset base, and organized production. On the other side, the lack of money to pay for certification and audit are constraints hindering complying with GLOBALG.A.P. standards. For a third of the certified farmers, raising money to pay for external audits and the proper keeping and storage of past records are difficult; two thirds struggle with keeping the rules and procedures consistent. For farmers, food safety requirements, the quality demanded, and social and environmental standards are often as much an entry barrier to formal markets as they are an opportunity to earn a stable income (Mumo, 2012; Okello, 2015).

For processors, retailers and exporters (collectively called 'aggregators' in this article) sourcing from smallholder farmers, VSS are a means to standardize quality and to communicate the level of quality provided downstream the value chain to business partners and consumers.

Yet, deploying the harmonizing and tools of certification schemes only adds to the fact that sourcing from smallholder farmers is an operational headache. Be it horticulture, fruits and vegetables, flowers, rice, soybeans, potatoes, cocoa, cotton or any other produce that is suitable for contract farming arrangements: the requirements for consistent quality, predictable quantity and traceability translate into high transaction costs, i.e. the cost for the facilitation (identifying and assessing farmers), conclusion (contract negotiation and design) and execution (distribution of inputs, technical assistance to farmers, management and logistics) of the contract as the cost incurred for the control of the quality produced and adaptation of the contract farming arrangement. As a result, aggregators often work with far fewer farmers than might be possible and prefer to rely on highly mechanized captive farms where few local farmers find seasonal jobs as labourers, e.g. for harvesting (Bijman, 2008). The high transaction cost involved in contract farming puts limits to a model that also has a positive effect on farmer welfare and productivity (Bellemare, 2012; Wang *et al.*, 2014; Nguen *et al.*, 2015).

6.4 Mobile Technology to Manage Contract Farming Arrangements

Against this background, Farmforce was created as a mobile-phone-based Software-as-a-Service (SaaS) business management system that makes the farm–firm interaction more effective and efficient. The theory of change informing the development of Farmforce is that the reduction of transaction cost in the form of: (a) improved efficiency of farmer identification, coordination and interaction; (b) comprehensive and real-time availability of management information; (c) improved agronomy; (d) reduced cost of monitoring standard compliance and standard audit; and (e) simplified downstream value chain coordination will make contract farming more effective and efficient, and hence a more attractive production option for aggregators compared to producing in captive farms. In turn, this will lead aggregators to involve more farmers in contract farming arrangements though which they get access to formal markets and earn more income. The theory of change holds under the condition that the envisaged technology solution is: (a) scalable; (b) applicable across different value chains; and (c) affordable for the end user of the software solution.

The role of technology in the theory of change is very clear: to enable the reduction of transaction cost as specified in (a)–(e) on p. 56 and again (a)–(c) above.

However, before calling a software company to get on the task, it is worth considering prior experience with mobile technology projects that attempt to improve smallholder farmer productivity in one way or another. Many development agencies have ventured into this area with mixed success. An in-depth stocktaking of mobile applications for agriculture as well as the experiences gained with the technology has produced a number of relevant insights that help to avoid the most common pitfalls of ICT4D projects (Brugger, 2011):

- First, *avoid a narrow focus*. Mobile technology projects often emanate from particular projects with the aim to solve one specific issue. Scaling to other topics or to more users is put aside until the initial challenge is solved and the pilot works. Also, mobile technology projects are often project managers' or organizations' pet projects. As a consequence, technology and design choices are made that most likely will impede efficient scaling up.

- Second, *develop a business case*. In almost all cases reviewed, the financial business was driven by donors or by research and reliant on donor funding. No one had a clear concept as of how to move from pilot to scale. The lack of a working revenue model puts the sustainability of any mobile technology offer into question. This also holds for solutions that build on open-source software; even in this case a business model is needed to cover ongoing operational and maintenance cost (Schireson and Thakker, 2016).
- Third, *be aware of the technology adoption curve*. It points to the chasm between early adopters of technology and the majority of the intended end users (Rogers, 1983; Moore, 2014). Most often, reports about pilot deployments of mobile technology for smallholder farmers are enthusiastic and conclude with a positive outlook for scaling up. Yet, it turns out that farmers don't use the mobile technology solutions at scale beyond the pilot group. The reason behind this is that early adopters tend to be over-represented in pilot groups which are not representative of the large majority of the envisaged end-users. Early adopters are more open to technology and more willing to try out new ways of doing things. More recent research has confirmed the difference between pilot groups buying into mobile technology solutions and the majority of farmers staying away from technology.

The lessons illustrate the need to think about scaling-up as well as about a sustainable business model early on, since this will directly influence the concept and architecture of the software. In order to avoid the pitfalls identified, the Farmforce strategy is based on the following business model.

6.4.1 The Farmforce business model

Although the motivation and goal behind Farm-force is to provide more farmers access to formal markets through outgrower arrangements, the software is not designed to be used by small-holder farmers. Rather, Farmforce is built for those actors in the value chain who have a direct economic interest in reducing transaction costs involved in contract farming arrangements. Typically, this is the aggregator, be it a processor, exporter, cooperative, a nucleus farm or similar. This economic interest of the aggregator translates into the willingness to pay for a technology solution (provided it meets their expectations), and – equally important – it is the best guarantee that the software is properly introduced and used by the field officers (mobile application) and office staff (web application). Moreover, aggregators often have enterprise resource planning (ERP) systems or other downstream software in use; integrating with them allows to build gapless traceability from the smallholder's farm to the consumer's fork.

In such a business model, smallholder farmers will indirectly benefit from reduced transaction costs in two ways: first, they can get higher prices for their products and, second, more farmers can be involved in outgrower schemes due to gains in efficiency.

Serving hundreds of contract farming clients in developing countries with the same software is only possible when the solution is able to work: (a) across a large number of different value chains; (b) different certification schemes; and (c) different organizational set-ups. As a consequence, Farmforce cannot be a bespoke application or a solution that is tailor-made for one particular contract farming arrangement, one particular client (irrespective of how big the client is), or one value chain. Rather, it must be a product that serves hundreds or thousands of customers, similar to Salesforce that serves customer relationship management (CRM) requirements for many different businesses.

The strategic decision to take a product approach instead of a consulting approach has far-reaching consequences for the architecture of the solution. It determines how to select and design features to be implemented and how to respond to customer requests (Cagan, 2008). The core challenge of a product approach – and main difference to a bespoke solution – is that it requires finding generic ways to implement features to any given problem. The example of documenting compliance with certification standards (VSS) well illustrates this point: the permanently changing and growing landscape of VSS and the fact that most of the VSS keep changing their criteria make it impossible to build all voluntary sustainability standards into Farmforce with reasonable effort; it would be an endless maintenance hassle (*see*, for example, www.standardsmap.org for an overview). Moreover, many contract farming systems have multiple certifications with sometimes significant overlap in the criteria. The generic solution to the problem is the identification of the basic structure of VSS. It turns that any VSS is always a combination of: (a) documentation of some sort of production-related activity along the growing cycle; and (b) assessment of social or environmental or organizational conditions at the level of a farm, a field or a farmer organization that are specific to a given VSS. Analytically, an assessment is a survey whereby each survey question is ranked against some sort of criteria and the sum of the ranked questions translates into a results statement that follows a more or less differentiated pass/fail logic. Hence, building the capability to document growing activities and carrying out assessments linked to fields, farms, farmers or farmer groups allows capture of the information required for any VSS or combination of VSS and adaptation to any changes that inevitably will occur. The assessment logic can further be used for the assessment of a farm-er's eligibility to join a scheme or to establish whether he/she qualifies for a loan.

The product approach allows management of the full range of outgrower arrangements and offering Farmforce under the Software-as-a-

Service (SaaS) concept are key preconditions for a successful scaling-up. Therefore, the set of functionalities built into Farmforce were identified based on a thorough analysis of the organizational contract farming particularities and in close cooperation with projects that display the most complex organizational arrangements.

In order to meet the requirements of aggregators, who are Farmforce's primary user group, development of the software was conducted in close collaboration with Kenya Horticulture Exporters Ltd, a horticulture exporter in Kenya with longstanding experience with contracting smallholder farmers located in the Laikipia area. We have deliberately selected french beans production for export to the European Union (EU) as a primary test case. This is because the combination of a perishable crop produced in short cycles of six to ten weeks combined with the EU's highly regulated and strict food safety certification requirements, and strict minimum residual limits (MRL) for chemicals, represents the most complex and challenging case in managing smallholder contract farming. Over a period of two years, the partner company's chief agrono-mist participated in the requirements design while a team of field officers tested the application under real-world conditions. It was important to understand the various complex processes and requirements the envisioned management software should be able to handle. Accordingly, the requirements were translated into generic solution concepts and checked against a diverse set of other contract farming arrangements.

Technically, Farmforce was created following the agile development methodology: new features were regularly deployed in a number of test sites in order to make sure that the software architecture was flexible enough to allow the deployment of Farmforce across the whole range of agriculture contract farming arrangements. Further, it generated a constant stream of user feedback that greatly helped to optimize usability and process flows.

6.4.2 Farmforce concept and features

Conceptually, the core of the Farmforce architecture builds the *'virtual farm'*. This means that Farmforce models each participating farm in some detail: while incorporating the farmer's personal details and his or her affiliation with farmer groups are a no-brainer, Farmforce models each field a farmer tills (including information on ownership status) with a GPS point or – alternatively – with the geo-coordinates of each corner of the field based on which Farm-force automatically calculates the field seize. This static information about a farm's core productive assets builds the basis to model the farming activities. On any given field, Farmforce models each individual growing cycle including all activities performed from land preparation to sowing, weeding, fertilizing, transplanting, applying fertilizer or whatever activity needs to be recorded. The definition of an 'activity' is fully configurable including information on who performs the activity, recommended dosage, waiting periods, cost per unit of input (e.g. seeds, fertilizers, chemicals) and the amount of input effectively used. To make Farmforce easy to use in the field, all meta-information on inputs and activities is defined on the Farmforce web- application by the office staff so that field staff can select entries from drop-down menus and all relevant processing happens automatically.

Along the growing cycle, field officers can record yield forecasts in Farmforce at relevant growth stages (e.g. germination, flowering or podding); the number and definition of growth stages are fully configurable. Following standard agricultural practice, yield forecast is expressed as a percentage of the full harvest potential under optimal conditions (e.g. a 90% germination rate or a 75% flowering rate). Since the information on optimal productivity is deposited as meta-data of the seed information, Farmforce calculates the harvest amount to be expected using the field size information and the information about the crop's performance at time t_1 and updates the information after the next yield forecast at time t_2, etc. As proof of the field officer's assessment he/she can add a picture of the field to the forecast and complement this information with the expected harvest date in case this deviates from the standard harvest date (calculated as sowing date plus days to maturity taken from the seed meta-information).

At the end of each growing cycle, harvesting information can be added for one full harvest or for several partial harvest rounds together with information on quantity, quality harvested, and the price paid to the farmer. To improve accuracy and transparency, an electronic scale can be connected to the mobile Farmforce device via Bluetooth and the reading of the scale is automatically entered into Farmforce. A mobile printer, also connected via Bluetooth, can print receipts at the farm-gate to be handed out to the farmer. To enable traceability Farmforce creates a unique code for each harvest batch which can also be printed out on the spot. Alternatively, Farmforce scans pre-produced QR codes or bar-codes (which are more robust that just a piece of printed paper) using the mobile phone's camera. Each harvest batch can be tracked as it moves down the value chain, even as one or more larger consignment(s) and also if later split into smaller units again.

While the 'virtual farm' provides all relevant information about an individual farmer participating in a contract farming scheme, aggregators are as much interested in understanding the overall performance of a particular crop that farmers are growing collectively. For example, assume an exporter who has to honour a contract to supply 120 tons of French beans. To produce this amount, the exporter has contracted 500 farmers and he needs aggregated information across the 500 farmers' growing activities; browsing through the records of 500 farmers is cumbersome and still does not provide the information required. For this reason, Farmforce has introduced a second pillar in its architecture, which is the *'planting campaign'*. This feature allows linkages between an unlimited number of fields into one planting campaign. (i.e. the production of 120 tons of French beans to be supplied to client *x* at time *y* taking our example above). Farmforce handles all fields linked to a planting campaign as one big field by aggregating the information of the underlying individual fields such as yield forecast or harvest information. A 'planting campaign' lasts for one growing cycle only and any field can be part of a different planting campaign during the next growing cycle.

These two core concepts – *virtual farm* and *planting campaign* – of the Farmforce architecture are the backbone to track the flow of goods, information and money (*see* Fig. 6.1).

Flow of goods

Monitoring the flow of the agricultural produce using traceability codes allows an uninterrupted chain of custody from the field to the fork. However, there are often additional goods that need to be tracked, as well such as inputs or seeds in order to guarantee and document its proper use and disposal (e.g. for chemical inputs or to make sure that that valuable items do not disappear are being misused). To this end, Farmforce includes an inventory app that allows the management of decentralized warehouses fully integrated with the functions of the virtual farm discussed above. For example, inputs used for growing activities can be automatically deducted from the warehouse stock; information on disposal of the remaining balance can be entered as well providing a full audit trail. Such a real-time overview over stock levels in decentralized warehouses and the tracking of agricultural produce and other goods simplifies logistics planning and minimizes capital outlay.

Flow of information

In addition to the information captured along the growing cycle and downstream of the value chain, the survey and assessment module discussed above allows capture of any additional information that might be required. On top of that, a separate module facilitates the management of farmer training activities including support for the monitoring and evaluation of training effectiveness. Information is not only relevant for managing contract farming, but also for other partners involved, mainly but not limited to auditors of VSS schemes and downstream processors or buyers of agricultural produce. Since those players in the value chain typically have their own IT systems in place, Farmforce offers standardized application programming interfaces (APIs) in order to seam-lessly integrate with existing systems.

Flow of money

Farmforce accounts for the fact that contract farming always includes some sort of pre-financing by providing an accounts module to track all items provided as pre-financing in cash or in-kind, as well as all repayments either in cash or in-kind at harvest or at any other point in time. This financial information is also accessible by the individual farmer by sending a text message to his Farmforce account to query the balance and latest transactions.

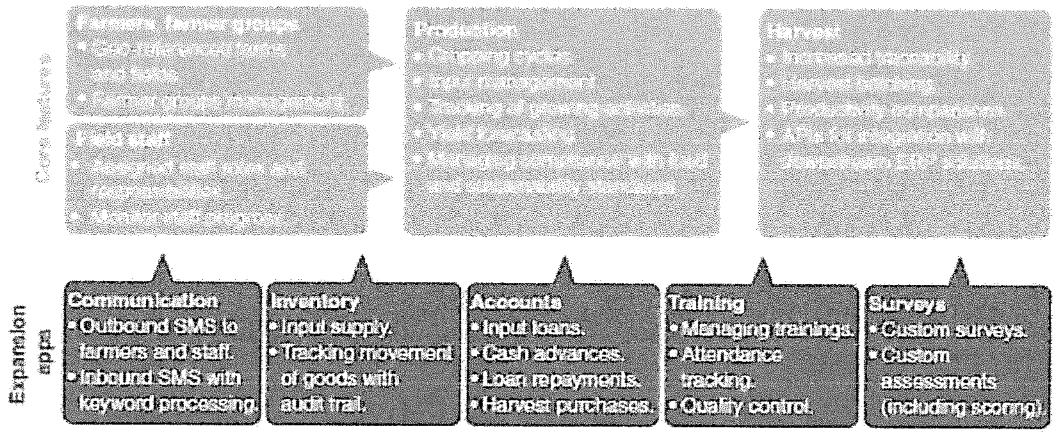

Fig. 6.1. Farmforce features.

6.4.3 Digital management

Farmforce generates all necessary data for steering the complex interfaces between farmers and farmer groups, field officers and famers, farm supply and off-take and to facilitate the corresponding business decision-making and management of daily operations. The key agent feeding information into the system is the field officer using the mobile application. Farmforce translates this into management information relevant for decision making in several ways: for example, combining the data collected due to the application of chemicals, the meta-information stored in the backend results in an internal control system that allows detection of irregularities such as the non-observation of application rules or waiting periods in real-time (*see* Fig. 6.2)

The management has not only an interest in production related information but also in monitoring and managing its field-staff in an efficient and effective way. To this end Farmforce provides views, not only on each farmer, but also on each field officer working in a scheme. Practitioners in development projects are aware that this level of transparency regarding field officers' performance can result in increased efficiency and effectiveness of their work provided that the management takes the opportunity to actively promote its staff performance. From agricultural and development perspectives, the data collected over consecutive growing cycles provide a rich source to observe changes in productivity over time as well as each farmer's profitability and relate this to any parameter related to production. Unsurprisingly, the capacity of Farmforce to track growing practice in detail also attracts users from research who are interested in studying crop management systems in developing countries.

6.5 Preliminary Results

Introduced in 2013, Farmforce is used in over 35 projects, managing around 150,000 farmers in 22 countries from Central America and the Caribbean to Western, Eastern and Southern Africa, and Asia, and a diverse range of 24 agricultural products as of early 2017 (Box 6.1). Since its commercial launch in 2013, Farmforce was successfully deployed not only in horticulture but also in other contract farming arrangements as diverse as cassava, coffee or cut-flower production. This fact proves the ability of Farm-force to cover very different contract farming arrangements with distinct documentation and certification requirements.

Both users and crops managed vary considerably which is according to the assumptions that have informed the development of Farmforce and is recognized as a strategy to professionalize smallholder farming (IFC, 2013; Kshetri, 2016; Protopop and Shanoyan, 2016).

For example, Doreo Partners, an impact investment firm in Nigeria, signed up to Farm-force in 2013 for its Babban Gona operations. At that time, Kola Masha, the social entrepreneur behind the venture, was running a maize intensification program with 2000 farmers spread over a total area of 1500 hectares in Northern Nigeria increasing their productivity by providing inputs and techn,ical advice, and buying their outputs. Kola subscribed to Farmforce to manage his operations and to be able to realize his ambitious growth plans which increased the number of farmers to over 12,000 by 2014 and is planned to reach 50,000 in 2020 (Storrs, 2014).

Similarly, Farmforce is used to manage the operations of Wilmar Agro Ltd, a small enterprise in Thika, Kenya, bringing to international markets Rainforest Alliance certified summer flowers produced exclusively by small and medium growers, with a view to improving their livelihoods (Atkins, 2013). Another enterprise using Farmforce and working with over 1500 smallholder farmers linked to a nucleus farm is Fair-Fruit in Guatemala, owned by the Dutch impact investment company Durabilis.

Certified with FairTrade and GLOBALG.A.P. the primary market for their vegetables and fruits are the US market. With the introduction of the Food Safety Modernization Act requirements for documenting compliance with food safety standards have significantly increased driving demand for Farmforce in the Central American region.

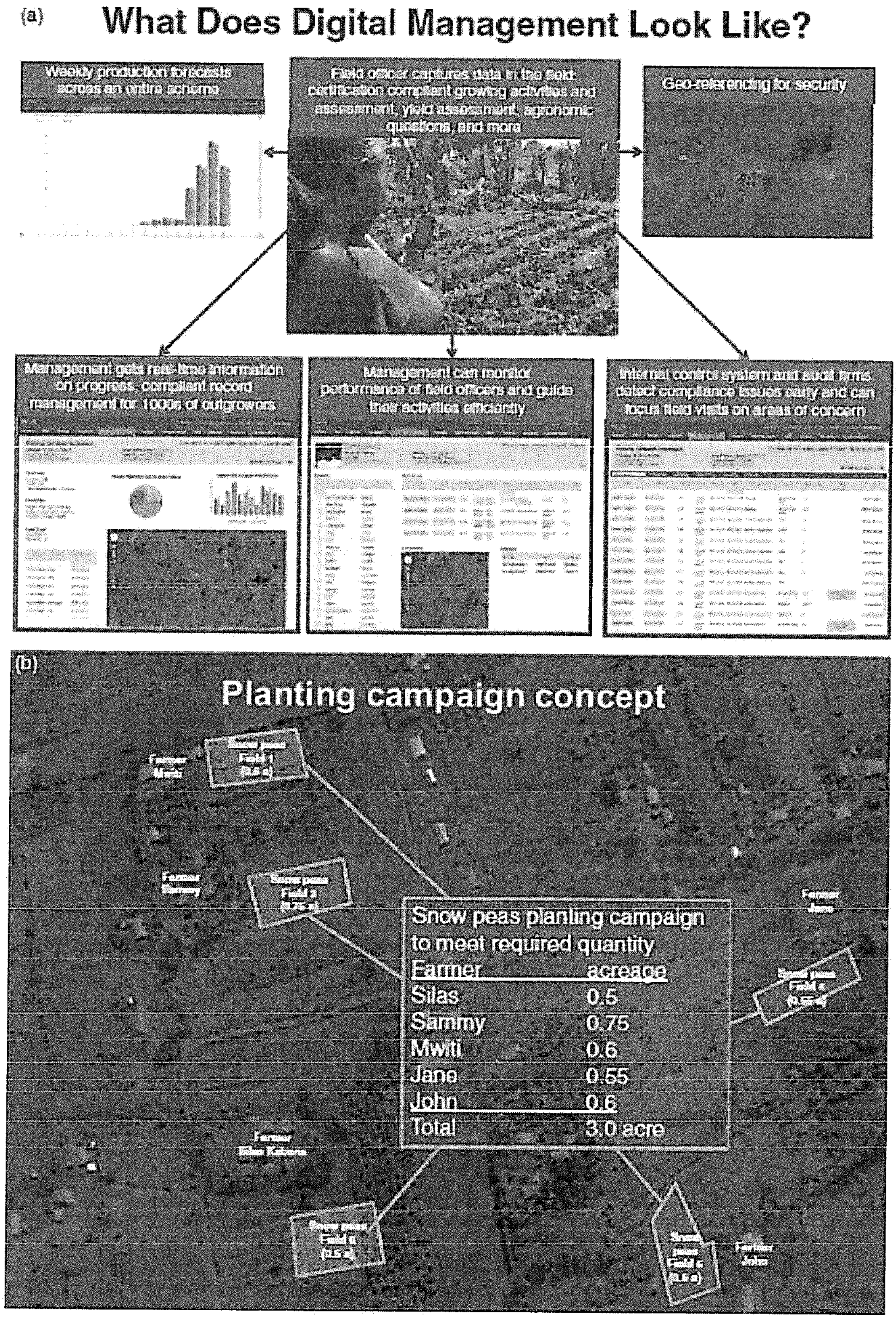

Fig. 6.2. Near real-time management information: (a) digital management; (b)

planting campaign concept.

Box 6.1. Countries with Farmforce deployments (January 2017).

Africa: Cote d'Ivoire, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda, Zambia

Asia: Bangladesh, India, Thailand, Vietnam, Singapore, Turkey, Indonesia

Latin America: Guatemala, Haiti, Honduras, Nicaragua, Peru

Crops managed using Farmforce: Baby corn, cassava, cereal, coffee, corn seed, French beans, garden flowers, groundnuts, maize, mangos, oregano, passion fruit, peanuts, peas, pepper, potatoes, rice, snow peas, soy, spice, sugarsnaps, tea, vanilla, vegetables.

A different – and growing – category of Farmforce users are big multinational companies such as Kellogg's, Tesco or McCormick who want to expand their engagement with small-holder farmers, often as part of their corporate responsibility strategy and sustainability commitments. McCormick, for example, started to use Farmforce as a means to facilitate procurement of sustainably grown oregano, black pepper and red pepper from smallholder farmers. Starting in 2016, the US-based company rolled out the system to about 500 farmers in Ivory Coast, 600 in India, 800 in Madagascar and 1200 in Turkey in the context of McCormick's participation in the Sustainable Spices Initiative. A wider rollout of Farmforce was slated for 2017, according to the company (McCormick, 2016).

Finally, development organizations started to use Farmforce as well. For example, the Clinton Foundation's Development Initiative (CDI) active in Rwanda, Malawi and Tanzania started to deploy Farmforce in 2014 to collect agronomic data from demonstration plots and small-holder farmers. Farmforce enables field officers to collect detailed information about growing and harvest activities, administer custom surveys, and facilitate market transactions. The insights enable the CDI to improve its programs and services. To this end, CDI tracks the output of their programs such as recording the number of trainings held, the amount of crops produced, or attendance at our community field days. Then, they analyze how this output has had an impact on people's lives measuring increases in productivity and profitability, access to markets and services (Clerkin, 2015; Kshetri, 2015).

To date, no systematic impact evaluation of the use of Farmforce has been conducted. However, anecdotal evidence documented by Farmforce users seems to confirm that Farm-force can reduce transaction cost in a number of ways:

- *Improved compliance and agricultural management:* one company notes that the time required for audit preparation went down from 15 to 3 days, pesticide detection went down by 53% and the rejection rate decreased from 10 to 2% following the deployment of Farmforce. Another company even reports zero MRL failure since Farmforce was deployed. In some instances, yield forecast accuracy has doubled which is particularly important given the market commitments of the aggregators.
- *Improved traceability:* farmer level traceability has become reliable according to many Farmforce users. In some instances, this has not only positive effects for downstream market integration but also increases internal efficiency and transparency. In one case – and people familiar with agriculture projects will not be surprised – ghost famers and famers that are not active any more were detected and could be eliminated leading to a reduction of 40% of farmers that are listed.
- *More effective use of field officers' time*: the mobile-technology-based data recording system has allowed field officers to spend 20 minutes more per visit to provide technical assistance to farmers – this time was

used for manual report writing before and now contributes to increase farmers' know-how and productivity. Another Farmforce user reports that field staff effort has reduced by 30% and the real-time management enabled field staff to better meet defined key performance indicators (KPIs).

An interesting observation can be made across Farmforce deployments that, in itself, documents the effectiveness Farmforce introduces into contract farming management: moving from paper-based to IT-based management systems tends to evoke resistance once staff realize that the transparency that comes with Farm-force exposes them to a new level of oversight and accountability. In addition, Farmforce leads to a re-think and adaptation of the way operations are managed. All users confirm the importance of the engagement of the management during the introduction phase together with support provided for field officers to learn the new technology and understand the benefits of the system as key factors to render the Farmforce deployment successful.

6.6 Conclusions and Outlook

The introduction of Farmforce has advantages for aggregators and managers of contract farming arrangements at different levels, from more accurate and near real-time management information to strengthened compliance with VSS and better traceability and downstream integration.

However, the importance of tracking information on production, compliance and finance not only has value for commercial aggregators, it has wider relevance for the farmers as well: one of the biggest challenges small farmers face when they try to access finance or interact with formal players in the value chain is that they are an unknown risk. A big part of their economic life is informal and there is basically no formal record of what they are doing. Without the ability to make a credit assessment, banks and other financiers are reluctant to lend and other buyers cannot access the reliability of those farmers either. Records collected through Farmforce can give lenders and other formal market players confidence, even in the absence of traditional credit data. With the collection and sharing of records of input purchases or in-kind production credits, compliance with standard requirements and crop yields, farmers are finally gaining an economic and financial identity against which banks, micro-finance institutions (MFIs) and other commercial players are increasingly willing to lend (Castell 2014). The 'economic identity' that Farmforce helps to establish itself is an important contribution to enable farmers' participation in formal markets beyond the initial contract farming arrangement.

Farmforce is designed as management software in the first place. However, the platform could expand in various directions to further support contract farming while sticking to its product approach. For example, the agricultural support structures built into Farmforce are robust but still relatively simple, providing:

- Active guidance to following a 'crop protocol' (i.e. the standard agricultural practice defined for a particular crop).
- An internal control mechanism for following application guidelines as described above.
- The possibility to send pictures of a disease stricken crop to an agronomist who sees the disease problem in the full context of the production.

However, agricultural support can be taken to a next level towards precision agriculture. Precision agriculture aims at site-specific crop management with the goal of optimizing returns on inputs while preserving resources (McBratney *et al.*, 2005). One such step Farmforce lends itself towards is linking the information on crops under cultivation contained in Farmforce with disease forecast models. Disease forecast models predict the likelihood of disease pressure which typically depends on the prevalence of micro-climatic conditions conducive for a disease. The relevant parameters fostering diseases are typically temperature, rainfall, humidity and leaf wetness prevailing over a certain period of time. For example, Light Blight (LB) is a frequent disease in potato cultivation and LB models have been described as early as 1975 (Krause, 1975; Fry *et al.*, 1983). Knowing how disease pressure evolves over time allows prediction of the need for fungicide sprays early on. Early protective measures help to save cost on chemicals as well as reduce crop loss. With the advent of low-cost weather stations that transmit sensor data to cloud-based computing systems the automated monitoring and calculation of disease pressure for specific locations has become widespread in high-value agriculture such as horticulture, orchards, potatoes, tomatoes or coffee among others. While this holds for developed countries, farmers in developing countries lack access to this kind of information contributing to higher input costs and lower yields. Farmforce knows exactly 'who plants what' and opens new opportunities: low-cost weather stations put in farming areas monitor microclimatic conditions, send the data to a cloud-based computer which calculates pressure for a number of diseases. This information can be extracted and sent to Farmforce. Farmforce then selects all fields that currently have crops in a field that need preventative or early treatment against the disease identified and automatically sends instructions to the farmers and/or field officers in charge.

Finally, while the anecdotal evidence on Farmforce's effectiveness is encouraging, more rigorous research is required in order to understand the impact of Farmforce. The following questions could be part of a research agenda:

- *From an economic perspective:* what happens to the savings from reduced transaction costs? Are more farmers involved in outgrower schemes or do the savings translate into higher profits for the company or even into lower export prices that benefit consumers in the Global North?

- *From an agricultural development perspective*: how does the availability of proper record keeping and real-time agriculture information affect productivity and compliance with standards?
- *From an agricultural management perspective*: how does the transparency effect introduced by mobile technology influence management culture and staff qualifications in aggregator companies?

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