The Potential of Artificial Intelligence to Support Smallholder Farmers and Agricultural Enterprises

Self-Employed Women's Association (SEWA)

Final Report

May 10, 2019

Dear SEWA Team,

The following is the final report prepared by the Columbia SIPA Workshop Team pertaining to the Project Terms of Reference and agreed upon scope.

Best regards,

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Table of Contents

Table of Figures

1. Executive Summary

Throughout the course of this project, the School of International and Public Affairs (SIPA) Team has sought to identify technologies/services that can be implemented by SEWA to improve its women farmer members' resilience to climate change and allow them to more sustainably manage their farms and agricultural enterprises. As requested by the client, the SIPA Team's research and findings has focused primary attention on technologies and services that would be responsive to its members' most pressing resilience needs and challenges.

Based on desk research, January and March 2019 field visits and interviews, and engagement with SEWA's Agriculture and ICT teams, the SIPA Team understands timely, predictive weather and price information to be a foremost need for SEWA farmers in order to boost resilience and improve decision-making. Building on findings concerning these priority needs, SEWA and SEWA member farmer capacities and constraints, and potential technology solutions, the SIPA Team has devised recommendations for SEWA which are subdivided into four categories of possible actions to be taken, addressing recommendations for both the short and the medium/long term as follows: defining of solutions, planning for implementation, implementing technologies/services, and enabling of implementation. (Figure 3 in Section 7.1 of the report provides a summary of recommendations, by category.)

Defining of solutions

In order to address SEWA farmer members' and SEWA's internal needs, it will be important to select which of the technologies/services outlined and assessed within this final report SEWA desires to implement. In doing so, the SIPA Team recommends that SEWA consider, as a first step, existing technologies/services which can be leveraged through partnerships with local organizations. Partnerships with well-established local organizations, such as Precision Agriculture for Development (PAD), RML AgTech, or other organizations cited in Section 6.2, who understand the precise needs of SEWA farmers, as well as the challenges faced both by SEWA as an organization and SEWA farmers members, will facilitate a rapid roll-out of services and effective targeting of needs.

Evaluate and select technologies using a detailed checklist:
In order to select the most appropriate technologies and technology partnerships, and confirm potential partner capabilities/compatibility, the SIPA team recommends that SEWA adopt a detailed checklist approach, covering key weather and price forecasting indicators, capacities/standards for accuracy, frequency, multi-channel collection and dissemination of information (SMS, voice, digital information boards, digital tablets) and two-way information flow, and compatibility with/ease of integration with SEWA's existing platform. (Figures 4 and 5

in Section 7.1 of the report provide details on recommended evaluation criteria for both weather and price forecasting.)

Leverage local and international partnerships, while building in-house capacity:
In the short/medium term, the SIPA Team recommends that SEWA leverage local partnerships to address immediate needs, while exploring possibilities to accomplish more and more tasks largely in-house. Of critical importance, since the implementation of sophisticated artificial intelligence services, such as remote-sensing and drone technologies for precision agriculture, depend heavily on extensive data from farmers for refining machine learning algorithms' accuracy, SEWA will need to grow a data collection and management system with the capacity to accomplish this. In addition to providing forecasting services to members, a partnership with a local organization such as PAD, or others detailed in this final report, can facilitate the process of establishing basic enhancements in internal capabilities, such as a data collection process through which information is updated at least once annually and a database management system that can be integrated with MMS and allows full access to SEWA.

Planning for implementation

Upon selecting the desired technologies/services, the SIPA Team recommends that the SEWA Agriculture and ICT teams work collaboratively to build a detailed technology roadmap. This roadmap should confirm and enumerate SEWA's institutional priorities, and consider any prerequisites to implementing more advanced technologies. (Figures 6, 7 and 8 in Section 7.1 of the report provide details on the recommended roadmap framework, and a hypothetical example of how it might be applied.)

Implementing technologies/services

In the medium and long-term:
Generating awareness amongst farmers in order to familiarize them with a given technology will be critical to implementing any given technology/service. As such, the SIPA Team recommends that SEWA conduct pilots prior to full roll-out of chosen technologies/services. Testimonies from SEWA administration and farmer members reveal the necessity of establishing farmers' trust in a given program to ensure uptake. The SIPA Team also recommends that District Level Leaders and Aagewans be fully trained on any new technology/service, and that they be kept apprised of all plans for implementation.

In the near term:
Actions that can be immediately implemented include leveraging the Gujarat state-run Agriculture Technology Management Agency's two-way communication system, by disseminating their toll-free number to farmers through Aagewans and District Level Leaders. The SIPA Team also

recommends that these local SEWA leaders actively disseminate and ensure farmers register both SEWA and Krishi Vigyan Kendra agricultural extension centers (KVK) service phone numbers, to make certain farmers recognize the caller ID. Finally, in light of findings that the KVK and SEWA SMS advisory services provide highly similar information to farmers, it is recommended that SEWA consider re-evaluating its existing SMS system and explore the possibility of working collaboratively with KVK to continue this activity and potentially free up some SEWA staff time/resources that might be redirected towards other near-term resilience boosting priorities, including the requisite aforementioned partnership for data management.

Enabling of implementation

The SIPA Team recommends that SEWA consider several steps (elaborated in Section 7.1) to enable implementation of the chosen resilience initiative, including modestly growing internal capacity, leveraging the tech-savvy younger generation, funding and/or research partnerships with select international organizations, providing farmers with a regularly updated list of government initiatives, and establishing an ongoing data collection, monitoring and evaluation system.

2. Introduction

The Self-Employed Women's Association (SEWA), an internationally-recognized member-based organization, has been at the forefront of the movement to advocate improved working conditions and income generating opportunities for poor women in the informal sector since its establishment in 1972 (Sahy, De Luca, and Joshi 2015, 137). SEWA provides a suite of services to its members who are engaged in trades such as construction, artisanship, farming, home-based work and street vending, to strengthen their technical capabilities, market linkages and social security (SEWA 2009).

SEWA launched an agriculture campaign in 1995, to accelerate its work to improve the livelihoods of the over 500,000 small, marginal and frequently landless women farmers who form its agriculture program member base. For over two decades, SEWA has combined its expertise in organizing members into income-generating entities with its growing in-house information and communications technology (ICT) capabilities, to facilitate the implementation of numerous initiatives along the agricultural value chain, including provision of quality inputs at affordable prices, procurement of produce at fair prices and extension services such as training programs and soil testing (SEWA 2012).

SEWA recognizes that increasing variability and extremes in weather conditions pose numerous threats to members' livelihoods, such as increased input costs, pest and disease damage, and more erratic water supply, with implications for crop yield quantity and quality, revenues, and the perception of the viability of farming as a source of income among youth. SEWA is interested in exploring ways of harnessing artificial intelligence, mobile phones and drone technologies to make available affordable solutions to its members.

In November 2018, SEWA requested the assistance of a team of graduate student consultants at the School of International and Public Affairs, Columbia University, to help SEWA ascertain the feasibility and appropriateness of such technologies in building its farmer members' resilience to climate change, focusing priority attention on their most pressing needs. To this end, the SIPA Team explored the possibility of leveraging weather and price forecasting technologies to enable farmers to make suitable decisions pre- and post-harvest. The SIPA Team's final report presents the team's insights from primary and secondary research, and provides immediate and longer-term recommendations for promising technology service solutions, as well as for planning and enabling implementation.

3. Background

3.1. Challenges facing smallholder farmers in India

In the 1950s and 60s India was swept up in the Green Revolution, marking a transition from traditional agriculture, and the introduction of high-yielding seed varieties and other new technologies and practices to dramatically increase food production. Since then, although the incidence of famine and malnutrition has fallen, many of these new products and practices have failed to significantly improve the livelihoods of India's millions of rural agricultural workers. Moreover, the fertilizers and pesticides that became widely available in the 1950s and 60s have progressively degraded Indian ecosystems through groundwater contamination and loss of biodiversity (Nieuwkoop 2018).

Today, an estimated 80% of India's farmers remain smallholders (Rapsomanikis 2015, 5), many of whom still face barriers with respect to accessing essential goods and services, information, and markets. For women smallholders, the challenges are compounded by social and legal conventions that can preclude their ability to take independent business decisions to benefit their farms and agricultural enterprises. Meanwhile, environmental degradation continues to negatively impact incomes and food security, and increasingly dramatic climate variations and changes further threaten vulnerable farmers. Some of the most critical issues and challenges facing smallholders in India generally, and women smallholders in Gujarat, in particular, are outlined by category below.

Productive Resources

Land is the primary productive asset for any agricultural enterprise, but not all plots are equal in their ability to generate revenue. Decades of poor crop-rotation, over-application of inputs, and other substandard practices have done tremendous damage to the soil quality of many smallholder farms in India. Soil rehabilitation and other agro-ecological improvements can be expensive. As such, farmers facing declining productivity can become trapped in a cycle whereby reduced income perpetuates substandard practices, which then further degrade the soil. In addition to the land itself, most farmers lack access to agricultural machinery that could significantly improve their labour efficiency. Finally, smallholder farmers often lack proper storage facilities for their crops. This introduces the risk of some portion of the harvest spoiling before it reaches the market and also limits farmers' agency in deciding when to sell. Prices often fluctuate on a seasonal basis, so reserving a part of the harvest to sell at a later point in time can allow a farmer to significantly increase their total (Legault 2017).

Information Services

Timely and accurate information on all aspects of farm management is critical to sustainable and successful agricultural enterprises. Two of the most fundamental pieces of information for smallholders are market prices and weather information, which will be examined in more detail

below and in the body of the final report. Increasing climate volatility in agriculture has made timely information and updates in these areas even more essential.

India is currently experiencing an explosion of agricultural technology startups, seeking to provide more precise data and information to and from farmers, and to connect farmers with various actors throughout the agricultural value chain through mobile platforms. New digital extension services, which offer everything from general recommendations to individually tailored advice, aim to simultaneously reduce risk and increase productivity for their clients. However, for the time being, many farmers remain unaware of these services, or lack the resources or the requisite familiarity with technology, to fully realize their benefits.

Through substantially augmented yields, Green Revolution showed that smallholders are willing and able to update their farming practices to increase productivity, and the proliferation of mobile technology has tremendous potential to correct information asymmetries. But new technologies are often slow to make their way to rural areas, and conventional agricultural extension services have struggled to reach much of India's remote farming population. Moreover, in their current form, most digital platforms have greater compatibility with smartphones. According to a 2018 study conducted by Cotton Connect in two states in India, including Gujarat, while 56% of farmers use smartphones, only 10% of them are women. Thus, at present, a large segment of the farming community is reached via SMS and calling services that are compatible with feature phones.

Financial Services

Smallholder farming is an industry in which year-round work is rewarded with a few, infrequent intervals of income, usually following harvest time. As such, farmers must budget for needs months in advance, and are vulnerable to unexpected costs that might arise during the offseason. Moreover, this irregular income schedule can preclude a farmer's ability to invest in higher quality inputs or other agricultural upgrades even when the return on investment is favorable. Microfinance agencies seek to bridge this gap but often lack effective mechanisms to assess credit worthiness; this uncertainty is then passed on to farmers in the form of frequently untenable interest rates (Kannan and Panneerselvam 2013).

The difficulties of running a small enterprise without affordable financing are further compounded by a lack of affordable insurance. Smallholder farming is a high-risk, low-profit venture, making conventional insurance schemes either unprofitable for the insurance company or unaffordable for the farmer. Index insurance schemes show some promise as a solution to certain types of climate-related losses but may not offer the level of compensation required by farmers experiencing poor harvests (CGIAR 2013b).

Climate Resilience

A typical smallholder farmer operates a single contiguous plot of land, often with just one or two crops. The inability to diversify creates enormous vulnerability to climate shocks, including drought, flooding, wind damage, pests, and diseases. Any one of these events can decimate a farmer's yearly income, making risk management a key skill for smallholder enterprises to succeed. Affordable insurance is an essential part of any risk management strategy, but the pressures of smallholder farming also mandate more proactive measures. Climate shocks are increasing in frequency and severity; this will require that farmers dedicate more of their income towards climate-resistant crop varieties and other inputs(Self Employed Women's Association 2017).

Inclusive Value Chains

Market access is another critical challenge for smallholders. These farmers generally work in remote areas and produce in small quantities; when they cannot directly sell their produce in the market, they are frequently forced to deal with middlemen who have little incentive to offer fair prices. Even in situations of perfect information symmetry, smallholders can be exploited by the monopsony power of unscrupulous buyers, and their bargaining power may be further limited by lack of information about current prices. Conversely, many large buyers may choose not to deal with smallholders at all, because of the inherent difficulties of quality assurance and administering transactions with a multitude of individual sellers. Finally, smallholders often lack the resources to obtain lucrative certifications that might boost the value of their produce in international markets(Self Employed Women's Association 2017).

Land Titles

Though women represent the majority of India's agricultural workforce, they are still a small minority of landowners. Government extension services and welfare schemes for smallholders are often targeted exclusively at land owners. Also, land ownership is often a precondition for microfinance services. Thus, gender discrepancies in land ownership translate to gender discrepancies in income.

In addition to increasing income, land ownership can empower women in other ways, such as by boosting their status in their communities and even within their own homes. The Indian government has tried to remedy the problem of gender inequalities in land ownership through legislation that assures women's land inheritance is equal to that of their male relatives. However, enforcement of these policies has been lax and traditional inheritance schemes still predominate in many rural areas (Oxfam 2013).

3.2. SEWA's role serving women smallholder farmers

SEWA was founded as a trade union in 1972 to address the needs of women working in the textile industry in Gujarat state, employing holistic, Gandhian collective action techniques to promote full-employment and self-reliance. Building on its successes with textile workers, SEWA quickly grew to serve women working in a range of different informal sectors of the economy, including agriculture. Today, SEWA has a membership of approximately 1.9 million women workers across 14 states and also works in other South Asian countries.

In recent decades, SEWA has sought to adapt its methods to address new challenges stemming from climate change and globalization. These efforts have included expanding the reach of microfinance services, health initiatives, vocational training, renewable energy technologies, and smartphone applications to promote financial literacy. SEWA's openness to innovation has allowed it to remain relevant even as the economic landscape of India is continuously reshaped.

Climate change poses myriad threats to SEWA members working in the agricultural sector in particular. Most of these women are dependent on incomes from smallholder plots, which they farm without the benefit of modern agriculture technology or mechanization. Their farms rely largely on monsoon rains, so irregular weather patterns can have devastating effects on their financial situations. These threats will only grow as climate variability increases. Changing conditions also necessitate that farmers invest more heavily in inputs like fertilizer, pesticide, and more resilient seed varieties to achieve the same yield as before.

SEWA has adopted several strategies to address these problems (Self Employed Women's Association 2017):

Seed Banks
SEWA has earmarked 220 acres, spread across thousands of micro-plots, where members can store seed crops from year to year. Preserving seeds from previous harvests reduces the input cost during the following planting season.

Vermi-compost
SEWA has trained women in 620 villages to produce and apply organic fertilizer produced from organic waste. In some areas, vermi-composting has become an income generating activity for women who sell the fertilizer at local markets.

Tools and Equipment Libraries
SEWA has organized the creation of seven "libraries," where farmers can check out expensive agricultural equipment, such as tractors and thrashers. Many women are accustomed to paying substantial fees to larger farmers to rent their equipment. The library method minimizes costs,

allowing members to access the machinery when and where they need it, and to collectively invest resources saved in their own farms.

Rural Distribution Network (RUDI)
Many SEWA farmers suffer from lack of market access and unfair pricing. SEWA has sought to address both of these problems through an integrated supply chain approach. RUDI purchases agricultural products from SEWA farmers, at a preset price, and then produces packages of those products to be sold at an affordable price in rural areas. In addition to bridging inefficiencies in both supply and demand for agricultural goods, RUDI creates income for the women employed as food processors, packagers, and salespeople.

Rainfall Insurance
SEWA has partnered with several insurance agencies to provide an insurance scheme for its members indexed to rainfall. Payouts are determined by the extremity of rainfall patterns during a given season rather than individual damages, which allows insurers to calculate risk much more precisely and offer insurance at an affordable rate.

Advisory Services
SEWA provides advisory services that diagnose and respond to specific problems reported by its members. They also provide information on weather, market prices, and government services through pre-recorded voice messages.

Solar Pumps
SEWA facilitates the installation of solar pumps which use solar panels to power an electric water pump. They rely on a drip system that minimizes water waste. In addition to mitigating the impact of droughts, these pumps eliminate the need to purchase expensive fuels required for conventional pumps and generate revenue in the form of water sales.

SEWA continues to seek out sustainable solutions to climate challenges to ensure the continued self-reliance of its farmer members.

3.3. Weather and Price Forecasting

In the high-risk world of smallholder farming, weather and crop prices are primary sources of uncertainty; nearly every business decision that a farmer makes involves a calculation along at least one of these two dimensions. Timely, accurate information can be invaluable, and has been rendered even more critical by climate change, as weather patterns become less predictable and introduce more variability into agricultural markets. Insurance policies and climate resistant inputs can mitigate the impacts of a potential loss but do little to address the uncertainty itself. Predictive

modelling seeks to address the problem more directly, by providing farmers with reliable information with which to make decisions about farm operations.

Weather Forecasts

Although weather forecasts are widely available in India, the scope of these predications is usually limited to cities and larger towns. Many smallholder farms are far enough from the nearest city center that these weather forecasts are of little or no use to them. Working without weather forecasts can be costly for a number of reasons. Most fertilizers, pesticides, and similar products need several days without rain to take effect. These products often constitute a considerable investment, so seeing them washed away the day after application can be devastating. Lack of information on coming rainfall also makes it harder for farmers to plan irrigation and conserve water. Additionally, without accurate forecasts, it is more difficult for farmers to allocate their own labour, including to adjust their planting date to best capture the benefits of the rainy seasons.

Accuracy and accessibility are key obstacles in the path of actionable weather information for India's smallholder farmers. In rural areas, generating accurate weather forecasts can necessitate the installation of a weather station. Moreover, even in areas where reasonably accurate weather forecasts are available, many farmers struggle to interpret them due to lack of familiarity with technical terminology and low literacy. Thus, the ideal weather information service generates accurate predictions but also involves a system of communication to make these predictions accessible to the target demographic (CGIAR 2013a).

Price Information Services

Market prices are a major determinant of smallholders' incomes, and farmers frequently need to make decisions based on their assumptions about current and future market conditions. Access to market information in the form of spot prices (current prices) can enable farmers to bargain more effectively and plan their finances in the short term. Access to information on future prices can empower farmers to take strategic decisions to maximize profits in the longer-run. Knowledge of future prices might allow a farmer to choose when to harvest, when to bring produce to market, or even which crop to plant in a given season. Future prices will likely grow in importance as climate change introduces increasing volatility to agricultural markets.

There are several services that provide spot prices through lower-technology solutions, like market enumerators (people paid to attend markets and report prices in real time) or national economic data. Future prices present much higher technological obstacles, because they usually require machine learning algorithms and massive datasets including market data, satellite imagery, and climate indicators. Consequently, future prices are more commonly predicted at the national or international level, which is less useful for smallholders who need to know what the price will be at their local market. Moreover, the technology required to generate accurate future prices can make these services cost-prohibitive for smallholders.

4. Scope and Goals

The SIPA Team supported SEWA to investigate and map the feasibility of AI, drone, and other technologies to boost SEWA farmer members' resilience to climate change and enable them to more sustainably manage their farms and agricultural enterprises.

Increasing climate variability magnifies the uncertainty faced by smallholder farmers. Uncertainty can prove incredibly costly in environments where insurance and information are not readily available. Predictive technologies have the potential to reduce uncertainty, thereby empowering farmers to make more informed decisions in managing their farms. As such, a core focus of this project was to explore and assess feasible technologies and services to facilitate access to predictive weather and price information for SEWA farmers. Because the implementation of such technologies requires that SEWA have effective data infrastructure in place, the SIPA Team also focused on technologies to streamline the collection, management, and analysis of data, and to facilitate timely dissemination of information to SEWA farmer members.

In addition to these primary goals, having assessed the needs of SEWA farmer members, the SIPA Team also explored additional technologies and other applications that have potential in terms of addressing the broader range of priority SEWA farmer needs.

Based on findings from desk and field research, including regular discussion with SEWA throughout the first quarter of 2019, interviews with external organizations leveraging relevant technologies, insights from the January and March 2019 field visits, and SIPA Team expertise, the SIPA Team has prepared this final report outlining methodology, desk and field research findings, and locally appropriate and feasible recommendations for SEWA.

Table 1. Objective targets reached throughout the project

✓	Assess SEWA farmer and agricultural enterprise owners' most pressing needs in terms of climate resilience and successful and sustainable farm management
✓	Assess technologies and methods with the potential to improve SEWA's data infrastructure
✓	Assess technologies and methods to improve SEWA's climate information service collection and timely dissemination to farmers
✓	Assess technologies and methods capable of facilitating the collection and dissemination of market price information for SEWA farmers
✓	Assess technologies and methods to address SEWA farmer broader needs in ways that are locally appropriate and feasible
✓	Provide recommendations of feasible technologies and methods to improve SEWA's advisory services relevant to data infrastructure
✓	Provide recommendations of feasible technologies and methods to improve SEWA's collection and dissemination of climate information to farmers
✓	Provide recommendations of feasible technologies and methods to improve SEWA's collection and dissemination of price information to farmers

5. Methodology and Stakeholders

5.1. Methodology

The SIPA Team conducted the accompanying study in three distinct phases: 1) preliminary desk and field research, 2) continued desk and field research and hypothesis testing, and 3) synthesis, analysis, and deliverable preparation.

Phase 1: Preliminary Desk and Field Research

To gain a preliminary understanding of SEWA as an organization, its smallholder farmers' needs, the environment in which SEWA operates, and possible solutions to challenges faced by SEWA and its farmers, the SIPA Team conducted an initial 2 months of desk research. During this time, the team made use of available online materials as well as internal documentation provided by SEWA staff, met weekly with SEWA leadership, ICT, and Agriculture teams, and engaged with external organizations both in India and elsewhere to explore technologies and services being leveraged to address challenges similar to those faced by SEWA farmer members.

To complement preliminary desk research findings, in January 2019, two members of the SIPA Team did an initial field visit during which they met with SEWA leadership and staff, and visited the districts of Kheda, Sabarkantha, Mehasana, and Surendranagar to engage with SEWA farmer members, District Level Leaders, and Aagewans.

Figure 1. January field trip activities

Kheda district	Sabarkantha district	Mehasana district	Surendranagar district	SEWA office
•Discussion with solar pump owner, Pij village •Meeting with district president and SEWA leaders (aagewans/master trainers) •Meeting with SEWA Bank staff	•Discussion with district association •Discussion with solar pump owner •Discussion with manager, seed and fertiliser store •Meeting with district association president	•Discussion with farmer members •Discussion with SEWA leaders (aagewans/master trainers) •Meeting with SEWA district association president •Meeting with KVK staff	•Discussion with farmer members •Discussion with SEWA leaders (aagewans/master trainers) •Meeting with SEWA district association president	•Meeting with ICT team •Meeting with Coordinator, Agriculture campaign •Meeting with Head, SEWA

Phase 2: Continued Desk & Field Research and Hypothesis Testing

In Phase 2, the SIPA Team leveraged insights from Phase 1 and sought to gain a more granular understanding of SEWA farmer challenges, and to brainstorm feasible and contextually appropriate solutions related to predictive technologies with potential to boost SEWA farmer

members' resilience to climate change, enabling them to more sustainably manage their farms and agricultural enterprises.

In March 2019, the SIPA Team conducted the second field visit during which the team engaged with SEWA leadership, ICT, and Agriculture teams, visited the districts of Sabarkantha, Mahasana, and Surendranagar to meet with farmer members, District Level Leaders, and Aagewans, and met with partnering organization Krishi Vigyan Kendra (KVK), and other external organizations on the ground, including Precision Agriculture for Development (PAD), and RML AgTech.

Figure 2. March field trip activities

Sabarkantha district	Mehasana district	Surendranagar district	SEWA office
• Discussion with farmer members • Discussion with SEWA leaders (aagewans/master trainers) • Meeting with SEWA district association president	• Discussion with district association • Meeting with IT in-charge • Meeting with KVK staff	• Discussion with salt farmers • Discussion with manager, tools and equipment libraries • Meeting with SEWA district president	• Meeting with ICT team • Meeting with Coordinator, Agriculture campaign

Phase 3: Synthesis, Analysis and Deliverable Preparation

During the final phase of this study, the SIPA Team synthesized field findings for analysis and prepared draft findings and recommendations for discussion with SEWA staff. Based on feedback from SEWA, and further analysis by SIPA Team members, the SIPA Team prepared the final report for distribution to SEWA and Columbia University.

5.2. Stakeholders

The following is a list of relevant stakeholders with whom the SIPA team engaged during the January and March 2019 field visits, and/or held conference calls with throughout the course of the research conducted in January-April, 2019.

- *SEWA ICT team:* SEWA's ICT team is in charge of all initiatives implemented by SEWA that have any technological component, such as the member management system, savings application mBachat, and the RUDI application RUDI Sandesha Vyavhar.
- *SEWA Agriculture team:* The agriculture team at SEWA is involved in implementing SEWA's agriculture campaign across Gujarat.

- *District presidents:* These SEWA members have been elected district association presidents and oversee all activities in the region.
- *SEWA leaders:* SEWA leaders refers to those members who have been elected or appointed by SEWA for various purposes, as representatives of clusters of farmers (*Aagewans*), RUDI saleswomen (RUDIbens), master trainers or district association members.
- *Farmer members:* These include SEWA members whose primary trade is agriculture.
- *Krishi Vigyan Kendra (KVK) staff:* KVK agricultural extension centers have been established by the Indian Council for Agricultural Research and its affiliated district- level institutions. They provide agricultural support and partner with organizations such as SEWA to share information and execute activities. KVK services include: provision of advisory services, technical trainings to farmers, training programs for agricultural extension workers, demonstrations for farmers, and on farm testing (OFT) of new agricultural practices (Jose 2016).

6. Findings

Findings related to the scope of this project are subdivided into two sections; findings from field visits conducted in January and March of 2019, and findings from desk research, interviews and engagement with SEWA staff throughout Quarter 1 of 2019.

6.1. Field Visit Findings

6.1.1. Weather Forecasting

During the March 2019 field visit, the SIPA team gained insights relating to: 1) existing channels of information dissemination for current and future climate conditions 2) whether farmers who report receiving this information make use of it in their farming decisions, and 3) smallholder farmers' views on weather advisory services and means of improving such services.

- *Smallholder farmers report receiving information about regular weather forecasts via mass media and information about extreme weather occurrences via SMS messages.*

  In each of the three districts visited during the March 2019 field visit, farmers report having regular access to daily weather updates through television, and note that this information pertains to weather forecasts for the coming 24 hours. They add, however, that working large portions of the day in the fields and tending to household needs does not allow time for regularly checking these updates on television.

  - *The KVK offers district-level weather forecast services but the uptake is limited.* SEWA leaders in Sabarkantha district recall, and KVK staff confirm, that the KVK provides weather updates specifically in the case of extreme weather events through their free of charge advisory services disseminated via SMS messages to farmers' mobile phones. This includes information on expected rainfall, wind speed, and any precautions to be taken to protect livestock and crops from damage.

    The KVK receives district-level information from four agriculture universities in Gujarat, which collect weather data through weather stations installed on the university premises, and disseminate this information through email and on their website in the form of weekly weather bulletins. However, farmers do not recall receiving weather updates via SMS. A few farmers with smartphones in Sabarkantha district report occasionally accessing weather updates online or through WhatsApp, but note they do not find the information to be accurate.

KVK's method of onboarding subscribers appears to be a limiting factor for the uptake of KVK services among farmer members. As shared by the KVK staff, farmers are typically registered for KVK services at their self-organized training events. As reported by KVK staff, approximately 3,000 farmers are trained in each district on an annual basis. Thus, the large proportion of farmers who do not attend trainings are not provided with the opportunity to register for these services. Additionally, farmers report losing access to these updates upon changing their mobile numbers.

- *Farmers note the usefulness of weather forecasts at various stages of the production cycle.*

  - *Sowing stage*
    Farmers in Surendranagar note that receiving information on predicted monsoon season rainfall volume could inform their decisions to grow water-intensive crops such as cotton versus relatively less thirsty crops such as castor, or vice versa.

  - *Application of inputs*
    Farmers rely largely on past farming experiences to determine appropriate application of pesticides or fertilizers. However, they add that rainfall predictions still prove useful to avoid fertilizer/pesticide wastage. SEWA leaders in Surendranagar have been trained to make decisions regarding irrigation based on weather indicators such as temperature and expected rainfall.

  - *At the harvest stage*
    Farmers report that receiving information on extreme weather events a few days in advance of the harvest stage could allow them to temporarily store recently harvested crops to prevent damage. They add, however, that storing grains remains a challenge, as they do not have adequate space in their houses to store large quantities of produce, and there are no village-level storage facilities available to them. Additionally, some commonly grown crops such as maize and wheat cannot be stored for long periods of time.

    Farmers also note having been unable to protect unharvested crops during a spell of unseasonal rain that had occurred a few days prior to the March 2019 field visit. They therefore share apprehension regarding the usefulness of receiving such weather information between the sowing and harvesting stages when precautionary measures for extreme weather events cannot be taken.

- *Smallholder farmers would like to receive accurate information on weather forecast at least once a week, with some districts requesting information every day or every two days.*

Due to the volatile nature of weather conditions, some farmers would like to receive information at least once a week. SEWA leaders in Surendranagar also note that a weather bulletin covering a full production cycle or season would prove useful, as it could heavily inform cropping decisions.

- *Farmers state that they prefer to receive this information primarily via SMS (text and/or voice), and that SMS and radio are two frequently leveraged channels at present.*

- *Though there is variability in response between SEWA leaders and farmer members regarding the price farmers are willing to pay for predictive weather information, most suggest they would be willing to pay up to 50 rupees per year.*

  SEWA leaders note that they believe farmers would be open to paying for weather advisory services if their accuracy and benefits were to be demonstrated beforehand. As such, they state that it would be necessary to roll-out a pilot project, entailing provision of free of charge service prior to initiating a fee. Based on SEWA's past experience providing paid services to farmers, some leaders suggest farmers would be willing to pay up to INR 50 (USD 0.72) per year, or INR 15 (USD 0.22) per season (Federal Reserve 2019).

6.1.2. Price Forecasting

During the March 2019 field visit, the SIPA team gained insights relating to 1) mediums through which farmers receive price information 2) whether this information informs decision-making regarding chosen crops to cultivate and 3) which communication channels would be most effective in disseminating price information.

- *Smallholder farmers primarily receive information about current prices on the day of the sale or during the days preceding the sale.*
  - *The majority of farmers do not have access to future price information.*

    Most farmers note that they sell their produce directly to traders in the market who set crop price based on samples provided by farmers, leaving farmers with limited bargaining power. Farmers do not appear to have access to future prices. Rather, they attempt to estimate future prices based on the number of farmers growing a certain crop and anticipated market saturation.

- *Farmers share that they would be able to modify their decisions regarding which crops to cultivate each season, if they received reliable information about future prices prior to the sowing season (reliability i.e. the price remaining stable until the selling date).*

Farmers add that having access to price information at different stages of a crop's cycle would also be useful. However, farmers across all districts express hesitation in relying on future prices due to their volatile nature. Additionally, Aagewans in Mehsana stress that farmers need information regarding the crop's selling price at least one month before the date of sale.

- *Farmers would like to receive information about future prices via information boards (highly desired by most older generation farmers) and via SMS (text and/or call).*
  - *Many farmers share a tendency to dismiss voice calls as they do not recognize the sources' number and believe it to be spam.*

  Farmers share their desire to receive price information through publicly displayed boards outside of dairy cooperatives or village offices. Aagewans add that this communication method allows farmers who cannot read or who don't know how to interpret the information to ask for immediate assistance. Farmers also express interest in receiving price information via SMS, sharing that this would allow them to review the information whenever they require. For farmers who cannot read, voice SMS are preferable to text messages.

- *Although there is some variability in responses regarding farmers preferred time to receive future price information, the majority prefer to receive this information at least at the start of every season.*

  Across all districts, farmers state that future price information before each season is vital in deciding which crops to cultivate. In Sabarkantha, Aagewans as well as farmers express the need to receive future price information on a daily basis.

- *Most farmers appear willing to pay up to 50 rupees per year to receive this information.*

  Farmers in Sabarkantha state they are willing to pay INR 100 (USD 1.45) per year to receive weekly messages regarding price information. In Mehsana, they are willing to pay up to INR 50 (USD 0.72) per year for price forecasting services (Federal Reserve 2019). In Surendranagar, farmers state that their husbands control household finances, and that they are therefore unable to assess how much they could pay to receive price information.

6.2. Desk Research Findings

The SIPA team has conducted a review of existing organizations leveraging weather and price information services to support smallholder farmers.

6.2.1. Existing Technologies/Services

Presented below is an overview of select technologies/services related to weather and/or price forecasting being implemented by organizations to boost resilience for smallholder farmers by enabling them to make better cropping and business decisions. The following is not intended to be an exhaustive list but rather to provide an overview of organizations leveraging technologies/services that have the potential to address SEWA's needs.

The organizations included in this section have been selected based on the following criteria:

1. The use of ICT to provide agriculture services;
2. The use of predictive technologies such as remote sensing and satellite imagery to provide predictive weather or price information;
3. Partnerships with organizations operating at SEWA's scale.

I. Precision Agriculture for Development (PAD) (India)

PAD provides farmers with a bundle of advisory services including weather forecasts, weather alerts, pest or disease alerts, as well as guidance on input utilization throughout the crop cycle. PAD does not provide price forecasting information. They use a call center model to collect information from farmers. This data is processed and analyzed to deliver farmer-specific advisory services. Further, farmers can contact PAD through their two-way communication system to pose inquiries and will receive a response within 24 hours of posting their query. PAD partners with research institutions such as IRRI (International Rice Research Institute), CIMMYT (International Maize and Wheat Improvement Center), KVK, and agricultural universities to conduct mobile soil analyses, gain real-time weather forecasts, and receive other technical information related to farming practices. PAD's mobile phone-based advisory model includes a two-way communication system through which PAD (in partnership with Awaaz De) disseminates useful information to farmers. Farmer-specific information is disseminated in the form of voice messages, which can be repeatedly listened to by farmers.

- *Target Customer Base:* Smallholder farmers in India, Kenya, Pakistan, and Ethiopia.
- *Scale:* PAD has reached over 491,000 smallholder farmers in the aforementioned countries through their mobile phone advisory services.
- *Impact:* Based on impact evaluations conducted in 2017 with 1200 farmers using PAD's services in the state of Gujarat, on average, PAD services lead to an increase in farmers' individual net income by $100 per year (approximately INR 7,000), 8.6% increase in cotton yields, and 28% increase in cumin yields.
- *Partnerships:* IFFCO-Kisan (mobile phone advisory service offered in partnership with a Telco), Government of Odisha's Department of Agriculture and Farmers' Empowerment, Coffee Board of India

- *Technology requirements*: PAD's current model requires basic feature phones. However, they are also launching a smartphone application which aims to simplify storing and accessing information as farmers will be able to access all messages (voice and text) through a single application platform.
- *Price information:* PAD offers its services free of charge to farmers, but will be shifting to a subscription model in the next 3-5 years and will charge an annual fee of less than $10 per farmer (less than ~ INR 700).
- *Technology/Service advantages:*
    - The model includes a two-way communication system.
    - The service is currently free.
    - Advisory services are comprehensive, including weather forecasts, weather alerts, pest or disease alerts, and guidance on input utilization throughout the crop cycle.
    - Advisory services are farmer-specific.
    - Data collection occurs through a call center model.
    - PAD has expressed interest in collaborating with SEWA.
- *Potential challenges:* PAD relies on external funding as they do not currently charge farmers for their services.

II. RML AgTech Pvt.Ltd ("RML") (India)

RML leverages its farmer database to assist farmers obtain price information. With access to information about the number of farmers growing a given crop in each district, RML gauges the price at which farmers can sell their crop. RML connects farmers with vendors and agribusinesses through a market information and intelligence tool. Farmer-specific pricing information is disseminated to farmers via SMS.

- *Target customer base:* Mid-sized farmers with an average of 15 hectares, and access to mobile phones.
- *Scale:* RML has reached over 1.7 million farmers in 50,000 villages across 18 states in India.
- *Impact:* According to a study conducted with the World Bank in 2011, on average, RML users experience an 8% increase in price realization.
- *Technology Requirements:* Farmers require a basic feature phone to receive text messages.
- *Price Information:* Based on the service package selected, the price for farmers ranges from $22/year (INR 1540) to $75/year (INR 5,250)
- *Technology/Service advantages:*
    - Service provides farmers with an estimate for selling prices for various crops
    - Service helps connect farmers to vendors and agri-businesses
- *Potential challenges:*
    - RML works with mid-sized farmers

- Cost to farmers is somewhat high

III. National Commodity & Derivatives Exchange Ltd (NCDEX) (India)

NCDEX is an online commodity exchange platform incorporated in India in 2003, which permits market actors to trade a wide range of commodities including agricultural products such as cereals, pulses, plantation products, spices etc. (Srinivas, Raghunathan, and Shukla 2017). Farming organizations can enroll in this platform, through which farmer members can engage in contractual price agreements with buyers, thus 'locking' the price and reducing farmers' vulnerability to future price shocks. The platform has proven successful for a number of organizations' farmer members. For example, a farmer producer company supported by grassroots NGO Samaj Pragati Sahayog used NCDEX to hedge 400 tons of soybean at INR 4500 ($65) per quintal, and avoided losses of nearly INR 40 lakh ($57,600) in spite of prices in the local market having dropped by more than 30% (Livemint n.d.).

- *Target customer base:* Farmer producer organizations, aggregators, exporters
- *Scale:* Over 150 farmer producer organizations are registered with NCDEX
- *Impact:* 15-25% net price realization reported by farmers; 3% savings as a result of direct market access
- *Service Advantages:*
  - Multi-channel dissemination of price information - Kisan Call Centres, price ticker boards in wholesale markets, warehouses, television channels such as DD Kisan, and newspapers
  - NCDEX's accredited warehouses serve as storage units for farmers' produce, and check points for food safety standards and grading
  - Subsidized membership for government-registered farmer producer organizations
  - NCDEX provides training in post-harvest management, cleaning, storage and price risk mitigation through regulated market platforms.
- *Potential Challenges:*
  - Limited number of warehouses for storage
  - Heavy reliance on web-based platforms, requiring proficiency in technology among users

IV. Harvesting (USA, India)

Harvesting uses artificial intelligence to enable greater efficiency in service provision along the agriculture value chain. Its Agri Intelligence Engine utilizes remote sensing data alongside a range of traditional and alternative data points to assess a farmer's creditworthiness. This includes continuous monitoring of weather data, soil moisture, changes in vegetation/crop cover and providing an early warning system for repayment risk. Harvesting has worked with microfinance

institutions in East and West Africa, Latin America and Southeast Asia, and more recently, with an input company in India.

- *Target Customer Base:* Smallholder farmers and service providers in the agriculture sector including microfinance institutions and input companies.
- *Technology Requirements:* Harvesting has launched a mobile application that loan officers can use to collect preliminary farmer-related data. A critical data point is the farm boundary, which, once collected, allows users of the Harvesting platform to remotely monitor farmers' croplands.
- *Price information:* Harvesting currently charges its microfinance partners $3-6 per farmer per loan, but report customizing its service fees on a case-by-case basis.
- *Technology/Service Advantages:*
  - Technology allows for gathering of farm-level information including vegetation pattern, field size, weather forecast and predicted crop yield. The organization is open to discussion about leveraging their services for dissemination of information outside of their current scope.
  - Their service generates profiles for each farmer which are regularly updated using weather and remote sensing data.
- *Potential challenges:*
  - Limited experience in facilitating communication between farmers and implementation agency
  - Currently, the platform does not allow users to download raw data to conduct their own analysis, thereby necessitating Harvesting's continued support.

V. The Weather Company - IBM (USA, India)

The Watson Decision Platform for Agriculture is a B2B (business-to-business) solution through which agriculture input and output companies gain access to local farm information enabling them to offer relevant advisory services to farmers. The platform creates an Electronic Field Record (EFR) for each farm. The EFR contains information on farm-level weather data (historical data, as well as 15-day forecasts and seasonal trends), soil data (moisture, fertility), farming practices (harvesting dates, pesticide/fertilizer application rates, harvest outputs), and visual imagery from satellites and drones. The platform uses AI and machine learning to analyze the EFR data and automatically generate guidance to improve decision-making.

- *Target Customer Base:* Farmers, commodity traders, insurance providers, lenders, governments (i.e. government programs targeting smallholder farmers).
- *Technology Requirements:* The company's clients have in-house subject matter expertise to synthesize agriculture data provided by IBM/The Weather Company and translate it

into advisory services for farmer members or farmer producer organizations with whom they work.

- *Price information:* Information not available.
- *Technology/Service advantages:* Service provides access to farm-level information
- *Potential challenges:* Burden of processing weather information lies with partner organizations.

VI. Farmerline (Ghana)

Farmerline works with smallholder farmers in 12 countries to provide a multitude of services for related to value digitization and extension. They have experience providing farmers with spot prices and two-day weather forecasts in the format of pre-recorded voice-messages. Farmers access these services by dialing a toll-free number provided through a partnership with local telecom companies. Farmerline has experience building partnerships with telecommunication companies through the value proposition that increasing farmers' incomes will enable them to purchase more phone credit.

- *Target customer base:* Smallholder farmers and small agribusinesses
- *Technology requirements:* Farmerline does not operate its own AI technology but instead relies on partners to conduct analysis and acts as an "information middle-man". Thus, they do not have any specific technology requirements, but whatever organizations they rely on to provide pricing and weather forecasting information might still require certain types of data from SEWA's farmer members.
  - *Price Information:* Farmerline has experience providing spot prices but not price forecasts. Their information comes from outside sources so they might be able to partner with another organization that specializes in price prediction and convey that information to farmers.
  - *Technology/Service advantages:* Farmerline has experience partnering with telecom companies to provide no-cost information solutions to farmers. This model removes a considerable financial burden from the farmers.
  - *Potential Challenges:* Farmerline does not currently operate in India so they would likely need to build a new set of institutional relationships in order to fully operationalize their model in the Indian context. Additionally, they do not provide AI analyses of farmer data so SEWA would likely need to seek out other partnerships to fill that technology gap.

6.2.2. Agriculture and Technology Programs

As SEWA has shared an interest in exploring the feasibility of partnerships with multilateral organizations, the SEWA team has also reviewed initiatives for consideration which are relevant to the accompanying recommendations.

I. United Nations Food And Agriculture Organization (FAO)

- *ICT Platform (Digital Green Model)*

  The FAO India has initiated a pilot project in the Deogarh district of Odisha to promote proper nutrition practices among local farmers. The pilot project leverages an ICT platform (Digital Green Model) to communicate messages including nutrition-sensitive agricultural practices with vulnerable women (Food and Agriculture Organization of the United Nations 2018).

- *The Strategic Pilot on Adaptation to Climate Change (SPACC) Project*

  The Strategic Pilot on Adaptation to Climate Change (SPACC) Project focuses on development and implementation of climate adaptation pilots in order to address observed and projected climate variability. The FAO is implementing the pilot project with 9 NGOs throughout India, with the aim to establish climate resilient, locally relevant, and pragmatic approaches to climate adaptation in groundwater-based agriculture systems (Das, Priya, and Kenmore 2015).

- *Strengthening Agricultural Market Information Systems Globally and in Selected Countries (Bangladesh, India and Nigeria) Using Innovative Methods and Digital Technology*

  The FAO has launched this program with the aim of increasing access to agricultural market information systems globally, and has selected India as one of the target countries in which to pilot innovative methods and digital technology projects. The FAO aims to improve data reliability, timeliness and frequency of receipt through capacity-building activities in national institutions, as well as by developing and piloting new methodologies (Food and Agriculture Organization Office of Evaluation 2017).

II. International Fund for Agricultural Development (IFAD)

- *The Weather Risk Management Facility (WRMF)*

  The Weather Risk Management Facility (WRMF) is a partnership between IFAD and the World Food Program (WFP), established in 2008. The partnership supports initiatives that aim to reduce smallholder farmers' vulnerability to weather and other agricultural production risks in order to encourage investment in agricultural production and contribute to food security. The WRMF accomplishes this through research, technical assistance, capacity building, and implementation of innovative risk management solutions such as agricultural index insurance (IFAD n.d.). Since 2011, WRMF has been working on the "Improving Agricultural Risk Management in Sub-Saharan Africa: Remote Sensing for Index Insurance" project. Crop-

specific insurance products have been developed and leveraged for maize, wheat, rice, beans and cotton in Benin, Burkina Faso, Kenya, Mali, Rwanda and Tanzania. According to IFAD, data is a key challenge to farmers and is thus the focus of the project. Although insurers are the primary end-users, the WRMF initiative has also brought together a wide range of stakeholders including farmers associations, data-providing agencies, agriculture credit agencies, and input providers who help design and implement the agricultural insurance products and programs.

- *Scaling Up Renewable Energy Based Agricultural Technologies for Empowering Smallholder Farming Families in India*

  A primary objective of this project is to bridge the gap between lab research and the needs of farmers by using existing platforms of farmers organizations. The project will span a period of 5 years beginning in April 2019. The Indian Council of Agricultural Research (ICAR) will serve as lead implementing agency for the project, and will be supported by a committee comprised of the KVK, NGOs, Farmers' Organizations and IFAD financed projects. The project intends to focus on smallholder farmers' needs and their demand for new technologies in areas such as production, harvest, post-harvest, storage & processing and agricultural residue management (IFAD 2018).

III. World Economic Forum

- *Innovation with a Purpose and the New Vision for Agriculture (NVA)*

  In 2017, the World Economic Forum initiated "Innovation with a Purpose"; a project focused on the role of technology innovations in addressing food systems challenges. The program has identified 12 technology applications that illustrate the potential of emerging opportunities in food systems. These include improving consumer nutrition, increasing supply chain efficiency and transparency, and boosting farmer productivity and profitability (World Economic Forum 2018). In its first stage of development, the program will focus on connecting innovators with food systems leaders, filling information gaps, and forging partnerships by connecting local innovators and agriculture practitioners (World Economic Forum n.d.).

  The New Vision for Agriculture (NVA) is another initiative the World Economic Forum is implementing in Africa, Asia and Latin America. The New Vision for Agriculture (NVA) initiative has set up an India Business Council to provide private sector championship and strategic guidance to expand partnership efforts in the country. Thus far, the NVA has initiated and supported public private partnership platforms in the states of Maharashtra, Karnataka

and Andhra Pradesh. Other states have expressed interest in initiating similar platforms as a model for implementation.

IV. Consultative Group on International Agricultural Research (CGIAR)'s Climate Change, Agriculture, and Food Security (CCAFS) program

- *Decision Support Tool for Scaling Out Climate-smart Agriculture in South Asia*

  In 2017 CCAF/CGIAR introduced this project which leverages models, data and other tools for crop yield monitoring, prioritization of Climate-Smart Agriculture and strengthening/development ICT-based toolkits for targeted delivery of weather forecasting information and Climate-Smart Agricultural knowledge to stakeholders (CGIAR 2017). Their partners include The Borlaug Institute for South Asia (BISA), Indian Council of Agricultural Research (ICAR), Village Development Committees (VDCs) and local farmers groups.

V. USAID

- *Using Digital Tools to Expand Access to Agriculture Insurance*

  Research illustrates that insurance can be a valuable tool to increase households' resilience to climate shocks. As such, as part of a broader effort to promote resilience in rural communities, USAID has launched a guide for leveraging digital tools such as mobile phones to increase access to agricultural insurance (Tran 2018). USAID aims to develop an inclusive insurance market that meets the needs of smallholder farmer households and enterprises at all income levels. USAID has identified mobile network operators, credit suppliers such as banks, credit unions, microfinance institutions and input suppliers, as well as member organizations like farmers associations and village savings groups, as key value chain actors relevant to this initiative.

7. Recommendations

This section details recommendations covering all proposed phases of an agriculture technology initiative, from defining of solutions to implementation, and provides immediate "Next Steps" SEWA can take.

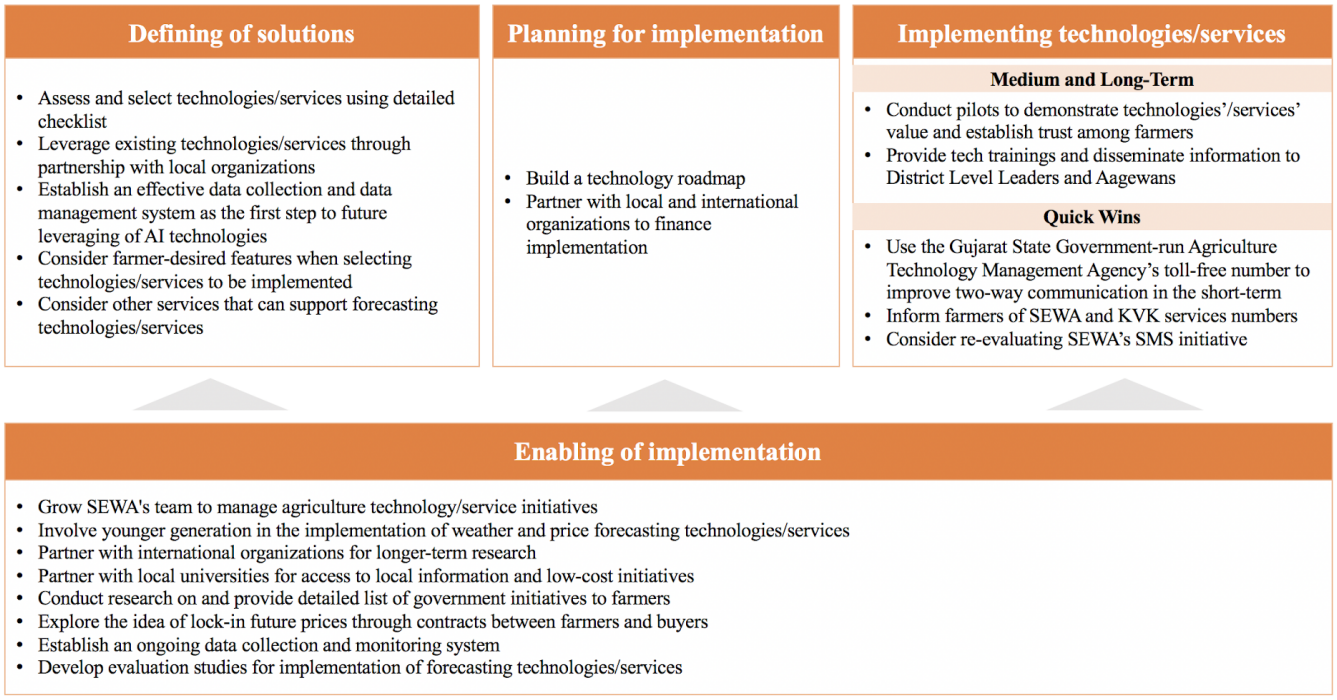
7.1. General Recommendations

The recommendations outlined below are based on the aforementioned findings from desk and field research and are subdivided into four categories:

1) *Defining of solutions,* providing guidelines for selecting the most appropriate technologies to address SEWA farmers' and organization's internal needs;
2) *Planning for implementation*, containing proposed steps for implementation of appropriate technologies/services, including possible partnerships with local and international organizations;
3) *Implementing technologies/services*, suggesting relevant strategies to execute implementation. This section includes "*Quick Win"* initiatives which require relatively low organizational, cost and time input, but have potential to be highly impactful for farmers. These propositions vary in execution time, ranging from the very short-term to the medium and long-term, the latter of which are anticipated to have the highest value for farmers but, due to their complexity, will require more effort and time to be planned and executed;
4) *Enabling of implementation,* describing initiatives and resources that can support / enable the implementation rollout.

The framework below provides a summary of these primary recommendations.

Figure 3. Summary of recommendations



7.1.1. Defining of solutions

- **Assess and select technologies/services using detailed checklist:** In order to select the most appropriate forecasting technologies to be implemented, it is recommended that SEWA adopt a detailed checklist approach, comprised of six main features as outlined below. These features were identified based on desk research, analysis, and group discussions conducted throughout the project. Technologies should be evaluated jointly by SEWA's Agriculture and ICT teams.

Figure 4. Checklist for assessment of weather forecasting technologies

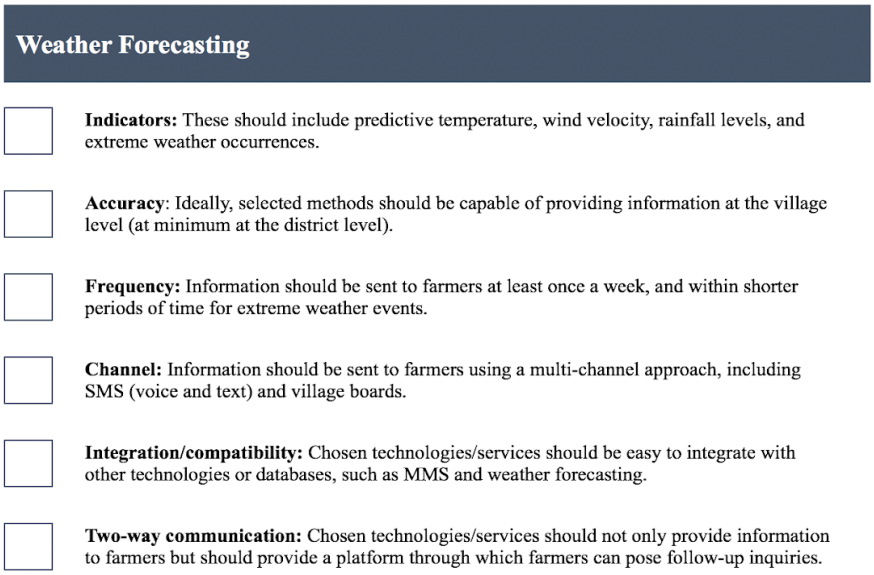
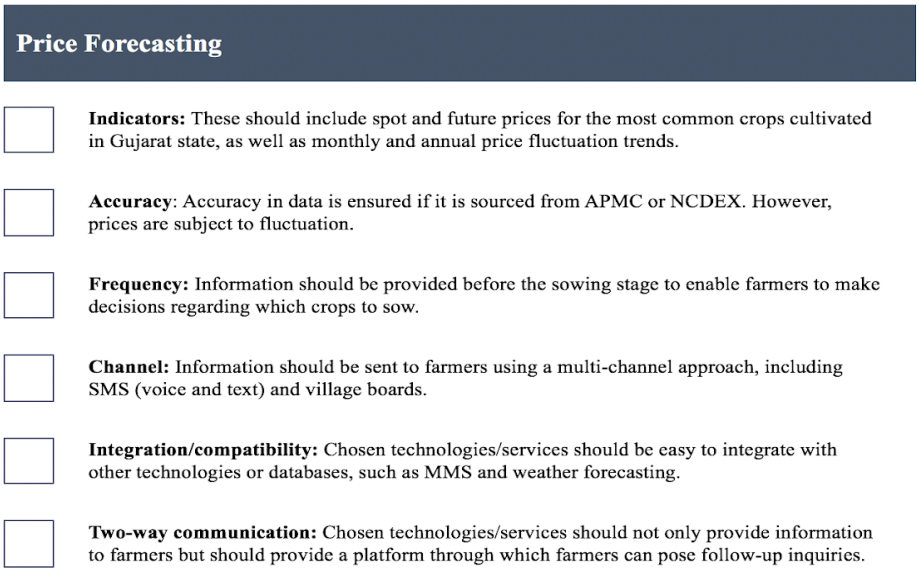


Figure 5. Checklist for assessment of price forecasting technologies



The SIPA Team recommends that SEWA utilize this checklist to evaluate and consider the technologies/ services offered by organizations such as PAD, RML AgTech, Harvesting, and/or IBM, discussed above. This will enable SEWA's ICT and Agriculture teams to begin to build a tailored technology roadmap, a critical step that is explained in the *Planning for Implementation* section.

In addition to obtaining the basic information contained in these checklists, it is also recommended that SEWA consider the following when assessing potential technologies/services:

- **Leverage existing technologies/services through partnership with local organizations:** There are a considerable number of technologies and services already being implemented in India that can address SEWA members' forecasting needs. SEWA would benefit from partnering with local organizations that understand the local context and challenges, and are successfully implementing initiatives in the weather and price forecasting spaces. SEWA should leverage local expertise by seeking to partner with these organizations who can respond quickly to SEWA's needs and facilitate execution.

- **Establish an effective data collection and data management system as the first step to future leveraging of AI technologies:** The implementation of more advanced/sophisticated Artificial Intelligence technologies rely heavily on having an organized database containing farmer information such as currently cultivated crops, farm location and size and personal contact information (e.g. contact numbers). Without this information, AI applications including remote sensing systems and drone technologies, cannot generate accurate predictions or effectively target farmer needs at a local level. Therefore, in addition to exploring partnerships for weather and price forecasting technologies, it is recommended that SEWA seek to partner with organizations such as PAD to support the establishing of 1) a data collection process through which information is updated at least once a year and 2) a database management system that can be integrated with SEWA's MMS system and allows full access to SEWA.

- **Consider farmer-desired features when selecting technologies/services to be implemented:** Insights from field and desk research reveal the need for a diversity of communication channel mediums (SMS, information boards, radio) and for facilitating the connection between farmers and buyers. These insights, detailed in Section 6.2, should be taken into consideration when defining weather and price forecasting technologies/services to be implemented:

  - **Multi-channel communication:** Field visit findings reveal that smallholder farmers obtain weather and price information through multiple channels and value this diversity. As such, the chosen weather and price forecasting technologies/services should allow SEWA to disseminate information through multiple channels, including SMS (voice and text) and digital boards throughout villages. If chosen predictive technologies/services do not have this capability,

SEWA can leverage additional partners to fulfill this multi-channel communication need such as local radio stations or telecommunication companies.

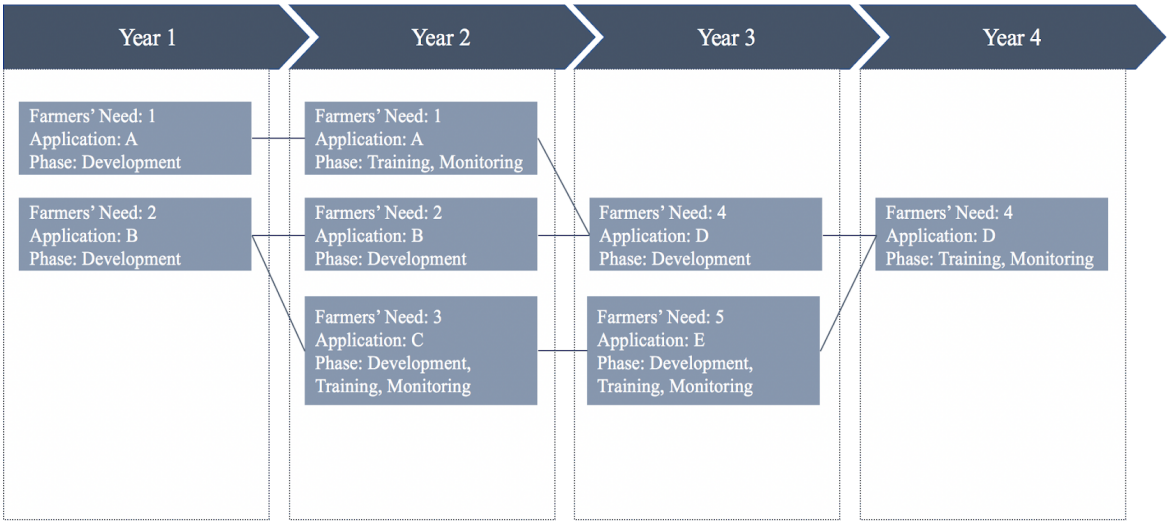
- **Trading platform connecting farmers and buyers:** The SIPA team also recommends that SEWA explore the possibility of establishing trading platforms that connect farmers and buyers to facilitate commercial transactions. This will be a longer-term objective (outlined below in "Enabling of implementation") as platforms of this kind will require basic farm and price information, and established trust between farmers, buyers, and SEWA.

- **Consider other services that can support forecasting technologies/services:** Technologies such as digital boards can facilitate weather and price forecasting as they are an effective means of communicating information at the local level. Similarly, use of digital tablets by Aagewans and District Level Leaders has potential to increase the ease, accuracy, and speed of data collection throughout the various stages of a project rollout. Additionally, other applications can help address needs related to irrigation systems and pest control. A list of technologies and implementing organizations identified during the desk research phase is provided in the Appendix.

7.1.2. Planning for implementation

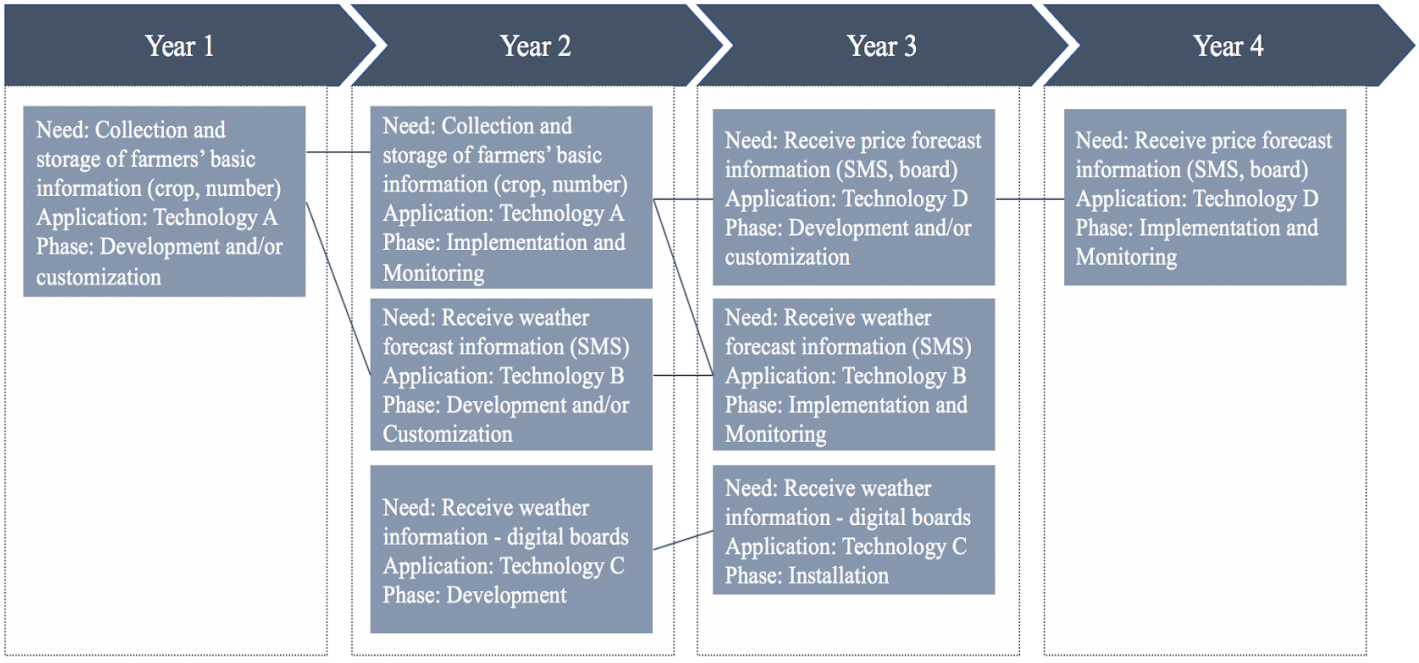
- **Build a technology roadmap:** Once SEWA has selected the desired data management, weather, and price forecasting technologies to be implemented, it is recommended that a technology roadmap be established to map the chosen technologies'/services' various applications along with the need they address, in order to visually illustrate how such a plan might be developed and rolled out over a determined period of time. This kind of map can also show how chosen technologies/services are interconnected and depend on one other, especially in terms of technical requirements. The following framework is an example of such a roadmap:

Figure 6. Framework of technology roadmap



This roadmap can only be constructed after SEWA has finalized its selection of the most appropriate technologies/services to meet its needs, at which point further technical expertise such as that of SEWA's ICT team will be required. A hypothetical example of what such a future roadmap might consist of is provided below, based on initial insights from the SIPA Team's review of organizations mentioned in Section 6.2.

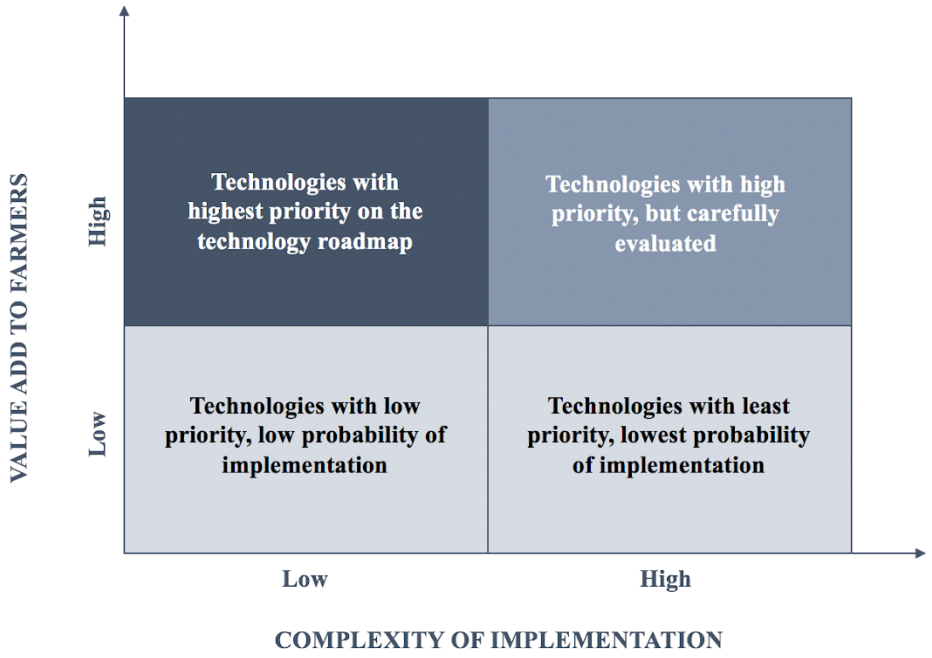
Figure 7. Hypothetical example of technology roadmap



The recommended steps to build this roadmap are the following:

- After completing the checklist for each chosen technology/service, it is recommended that SEWA seek to understand 1) the technology's/ service's value add to farmers and 2) the complexity of implementation of each chosen technology/service. An example of this value-complexity matrix evaluation is illustrated below.

Figure 8. Value-complexity matrix



This evaluation might be conducted collaboratively between SEWA's Agriculture team, which can shed light on farmers' perspectives, and SEWA's ICT team, capable of evaluating the complexity of implementation from the technical perspective.

- Identify the linkages between the technologies - if Application C (Figure 7) requires a database that will be developed as part of Application B, respecting this order is critical. A SEWA-specific example of this is the prerequisite data management system discussed in the previous section. Without basic information from farmers, sophisticated AI technologies cannot be developed. This evaluation should be done by the ICT team, with information gathered from the organizations providing such technologies/services.

Finally, while building the roadmap for the weather and price forecasting technologies/services, the SIPA Team recommends that SEWA consider the following:

- At the start of implementation, in addition to the data management system previously mentioned, it would be interesting to prioritize available technologies/services that

provide information on weather forecasts and spot prices at the district level. Although this information can lack the ideal level of accuracy desired by farmers, these technologies/services will lay the foundations for implementation of more sophisticated applications moving forward.

- In the subsequent years of implementation, SEWA should consider the development of customized weather and price forecast solutions if required. Such solutions can include i) a more precise weather forecast technology/service, providing localized, village level information through advanced weather stations or satellite technologies and ii) a model to predict future prices, like the one developed by the Government of Karnataka in partnership with Microsoft.[1] Local organizations with proven expertise can be interesting partners with whom to develop such technologies while SEWA continues to focus on its core areas of expertise.

- **Partner with local and international organizations to finance implementation:** Some local organizations, such as PAD, offer competitive prices for forecasting technologies which align with smallholder farmers' willingness to pay for weather and price forecasting services (maximum of INP 50 per season / year) [USD 0.72]. This would be an ideal solution to fund ongoing programmatic costs and, given SEWA's large farmer members base, such prices may be negotiable. One-time costs such as development and customization of new technologies/services and initial trainings, could potentially be funded through partnerships with international organizations, such as the FAO, IFAD or CGIAR, all of whom have launched initiatives related to weather and price forecasting in the agricultural technology space to increase farmers' resilience to climate change (details provided in Section 6.2).

7.1.3. Implementing technologies/services

7.1.3.1. Medium and Long-Term

- **Conduct pilots to demonstrate technologies'/services' value and establish trust among farmers:** From group discussions with farmers, it appears the adoption of new technologies/services relies heavily on farmers observing evidence of successful results. Therefore, SEWA should first implement each chosen strategy through a pilot in order to demonstrate effectiveness and follow this by a roll-out to other districts within Gujarat. Ideally, the pilot should include 4-5 districts with different characteristics and challenges so

[1] Through this partnership established in 2017, plans are underway for the Government of Karnataka to benefit from Microsoft's multivariate agricultural commodity price forecasting model which would allow them to predict both the arrival of future commodities and their corresponding prices.

SEWA and the organization providing/facilitating the technology/service can adjust certain features for the roll-out and maximize the program's applicability to all SEWA districts. For each pilot, it is recommended that SEWA establish a determined time frame with phases of identified activities to be executed as well as a simple set of metrics allowing SEWA to evaluate the pilot's progress and success.

- **Provide technology trainings and disseminate information to District Level Leaders and Aagewans:** Both District Level Leaders and Aagewans are crucial in the successful implementation of weather and price forecasting technologies/services. It is recommended that SEWA train these groups both on the new technologies/services being implemented and in general training practices in order to enhance their training abilities. Such training might include strategies to explain the benefits of given technologies/services to farmers and stress the importance of repeated follow-up and monitoring to understand if solutions are being appropriately leveraged and are having the intended results. Therefore, during monthly meetings SEWA should ensure to:

    - Inform members of SEWA's plans to implement technologies moving forward;
    - Train them on the new technologies being implemented;
    - Train them on how to train farmers on the use of such technologies;
    - Train them on receiving and reporting on feedback regarding the use and success of such technologies.

- **Establish protocol for regular dissemination of information from District Level Leaders and Aagewans to Farmer:** Due the importance of generating awareness amongst farmer members in order to ensure uptake of new projects and solutions, farmers members should be kept apprised of all planned and ongoing activities and technologies to improve farming practices.

7.1.3.2. Quick Wins

- **Use the Gujarat State Government-run Agriculture Technology Management Agency (ATMA)'s toll-free number to improve two-way communication in the short-term:** One of the services provided by ATMA is a toll-free number that farmers can call to receive additional information or pose agriculture-related questions. Because a two-way communication platform is a priority for SEWA farmers and this service is already provided by ATMA at no cost, SEWA can disseminate this number to farmers through Aagewans as an immediate strategy to allow for two-way communication.

- **Inform farmers of SEWA and KVK services phone numbers:** Farmers in more than one district share that they frequently ignore voice messages as they do not recognize the incoming

number and assume the call to be spam. Therefore, although SEWA and KVK both provide relevant advisory services and have a communication channel in place, farmers often do not receive this information simply because SEWA's and KVK's numbers are not registered/recognized. As a short-term strategy to mitigate this problem, District Level Leaders and Aagewans can share these numbers with farmers and instruct them to register the number in their phones.

- **Consider re-evaluating SEWA's SMS initiative:** KVK and SEWA appear to provide similar advisory services to farmers - SMS messages are sent every one or two weeks with similar content related to crop cultivation and weather information. However, SEWA reaches a much smaller number of farmers than KVK. Therefore, it is recommended that SEWA consider re-evaluating its SMS initiative; if the content and frequency of messages are indeed equivalent, SEWA could opt to work collaboratively with KVK to increase the number of recipients of their messages. This would also allow SEWA staff to save on costs/resources associated with the SMS initiative, and focus attention/resources on developing partnerships for the data management, weather and price forecasting technologies/services mentioned above. *[Note: the SIPA team was unable to gather sufficient information on the Awaaz De service, so cannot provide a more specific recommendation.]*

7.1.4. Enabling of implementation

- **Grow SEWA's team to manage agriculture technology/service initiatives:** Establishing a data management system that can support the implementation of initiatives to boost resilience, including the provision of timely, responsive weather and price forecasting technologies/services, will require close, frequent communication with partner organizations and close internal coordination, especially between the Agriculture and ICT teams. As teams must continue to focus heavily on other important initiatives, including day-to-day activities, it could be very beneficial for SEWA to bring on at least one new member dedicated to coordinating the implementation of chosen technologies/services. It is recommended that new team members work closely with the Agriculture and ICT teams, as well as with SEWA leadership, Aagewans, and District Level Leaders, and arrange frequent meetings to discuss projects, report the roll-out status, define next steps for each phase, and receive feedback.

- **Involve younger generation in the implementation of weather and price forecasting technologies/services:** Farmer members lament that the younger generation is more and more disinterested in agriculture, viewing it as an unstable activity with marginal returns. SEWA can leverage new weather and price technologies/solutions to re-engage the younger generation in agriculture. These technology-based initiatives would not only encourage their participation but could also enhance program results, as young people are more familiar with smartphones and other technologies and could support their families to improve the learning

curve. SEWA might establish monthly meetings with younger members and younger family members, and partner with international organizations to provide specific trainings.

- **Partner with international organizations for longer-term research:** Initiatives developed by international organizations such as FAO, IFAD and CGIAR can take the form of continued funding to support research or ongoing provision of information related to the latest agriculture technologies/services, which can inform SEWA's future weather and price forecasting initiatives.

- **Partner with local universities for access to local information and low-cost initiatives:** Initiatives like the ones run by KVK, primarily predictive weather advisory and information services through SMS messages, can support the implementation of data management systems and forecasting technologies/services. In addition, other initiatives such as on and off-campus trainings, demonstrations of specific technologies/services and on-farm trials (example: vermicompost unit) can add value to farmers' agricultural initiatives in ways outside of weather and price forecasting. SEWA staff can build a list of initiatives being developed by KVK and other local universities in Gujarat and keep regular communication with identified liaisons at such institutions in order to update this list.

- **Conduct research on and provide detailed list of government initiatives to farmers:** Many Aagewans and smallholder farmers cited government schemes supporting agriculture activities. SEWA staff can compile and regularly update a list of the most relevant schemes being offered to improve quality of advisory services. This information can be disseminated through the aforementioned multi-channel approach. Additionally, initiatives such as that being developed with the Government of Karnataka in partnership with Microsoft might be further explored as they have potential to provide insights related to price forecasting technologies/services and future pilots.

- **Explore the idea of lock-in future prices through contracts between farmers and buyers:** Farmers can mitigate risks associated with future crop price volatility by establishing contractual agreements with prospective buyers to fix rates published by NCDEX and ensure access to favorable prices at the time of sale. This can help address the concern expressed by farmers across districts regarding the unreliability of futures prices (NCDEX n.d.).

  SEWA might consider implementing a pilot project wherein it registers a fixed number of its members on the NCDEX trading platform. Through this electronic platform, farmers can enter into futures contracts for selected crops at the stipulated contract price (Times Now News 2018). Alternatively, the organization could explore facilitating commodity options that guarantee a minimum price at which farmers are able to sell their produce, thereby protecting them from prices dropping unexpectedly, but also allowing them to sell at higher prices in

case of an increase in price. In doing so, they can capitalize on the higher prices and reduce vulnerability to market prices post-harvest.

- **Establish an ongoing data collection and monitoring system:** Keeping track of basic information, such as the number of members trained, number of farmers receiving information through a specific channel, number of members contacting advisory services and progress of trainings (in terms of number of participants and quality of trainings) are important metrics to track the progress of a given initiative, as well as to inform future decisions about pilots and training initiatives. Therefore, it is recommended that SEWA establish an ongoing process of data collection, monitoring system, and sharing of monitoring results with District Level Leaders and Aagewans (through monthly meetings). If it would be useful to SEWA, developing a cost-effective, feasible data collection and monitoring system could inform the Terms of Reference of a future Columbia SIPA capstone project.

- **Develop evaluation studies for implementation of forecasting technologies/services:** Besides monitoring the implementation process, it will be crucial to understand if the forecasting technologies and advisory services are effective in increasing farmers' resilience to climate change. Impact evaluations like this are relevant for informing SEWA's decisions on future initiatives that will be responsive to the needs of SEWA members and future members. Therefore, such evaluations should be conducted for the selected technologies/services, and defined/planned before implementation begins. Local universities can support SEWA in structuring/conducting these evaluations. If it would be useful to SEWA, structuring appropriate, feasible evaluation studies could also inform the Terms of Reference of a future Columbia SIPA capstone project.

7.2. Next Steps

The immediate steps recommended in this section might assist SEWA to move forward in implementing the SIPA Team recommendations elaborated above. It should be noted that this list is not exhaustive, and that the order of the following proposed actions can be adapted to best suit SEWA's needs.

- **Initiate the assessment and selection of technologies/services, described in the *Defining of Solutions* section:** It is recommended that SEWA schedule meetings with the organizations of interest described in Section 6.2 and possibly with other organization relevant to SEWA's objectives. Through these meetings, SEWA will gather additional information with which to build the proposed technology roadmap and develop partnerships to fund its initiatives.

- **Execute Quick Wins:** SEWA can begin immediately working on the recommendations in the *Quick Wins* Section, namely 1) using the Gujarat State Government-run Agriculture Technology Management Agency's toll-free number to improve two-way communication in

the short-term and 2) informing farmers of SEWA and KVK services phone numbers and re-considering its SMS initiative. Such initiatives are considered relatively low-resource intensive and can offer immediate value to farmers from services already provided by the government and KVK, while also benefiting SEWA as an organization, freeing up staff time and attention that can be allocated to medium and long-term priorities, including initiating implementation of additional recommendations outlined in this final report.

- **Grow SEWA's team to manage agriculture technologies initiatives:** Though execution of this recommendation will depend on SEWA's internal budget, it is highly recommended that SEWA consider modestly growing its team as soon as possible. Having an individual who is dedicated to coordinating the roll-out of chosen resilience-boosting technologies/services will be extremely beneficial to effective program implementation.

8. Conclusion

The use of AI, drone, and other information technologies is playing an increasingly instrumental role in the agricultural sector. While a considerable amount of AI and digital technology is now available for farmers, a number of the technologies currently under development or already operational may not be well-suited for use by SEWA's farmer members. Therefore, the core focus of this project has been to explore and assess feasible technologies and methods that could be most effectively tailored to suit SEWA farmers' most urgent needs.

This final report has summarized the key findings by the SIPA Team to leverage weather and price forecasting technologies to boost SEWA members' resilience to climate change and market shocks. Through desk and field research and hypothesis testing, the SIPA Team has gained the following insights pertaining to future technology/services end users (demand side): 1) Farmers recognize the value of and express willingness to pay for weather and price prediction services; 2) Farmers currently receive weather and price information through a diversity of channels; 3) Farmers report that they would make use of predictive weather and price information in their farming decisions, and believe that accurate information has great potential to boost their productivity.

Regarding available technologies/services that SEWA can leverage (supply side), key findings are as follows: 1) There are a number of organizations in India providing ICT technologies related to weather and/or price forecasting with whom SEWA might partner in order to leverage these services for SEWA farmer members; 2) Organizations typically leverage predictive technologies such as remote sensing and satellite imagery to provide predictive weather or price information; 3) Organizations typically use voice-messaging and/or call-centers to disseminate information.

Figure 9. Summary of findings

Demand Side **Farmers Needs Assessment**	**Supply Side** **Technologies and Services Available**
• Farmers desire and are willing to pay for more and better price and weather information services • Farmers have already been obtaining weather and price information through multiple channels and value this diversity • Farmers believe that access to enhanced price and weather information has the potential to significantly improve their earnings	• A growing number of local and international organizations provide price and weather forecasting services • The organizations typically rely on remote weather stations and satellite imagery to generate accurate information • Voice-message or call-center models are the typical distribution channels

The SIPA Team has made numerous recommendations for SEWA moving forward. Regarding immediate next steps, the SIPA Team believes that there are three primary recommendations which can be implemented in the short term. First, it is recommended that SEWA utilize the

detailed checklist provided in this final report, to assess the possibility and suitability of partnering with organizations such as PAD, RML AgTech, Harvesting and/or IBM, including to confirm the scope, specifications and compatibility for SEWA of technologies/services offered. Second, the SIPA Team recommends that SEWA execute some or all of the proposed *Quick Win*s, including leveraging the Gujarat State Government-run Agriculture Technology Management Agency's toll-free number to improve two-way communication. Third, budget permitting, the SIPA Team recommends that SEWA modestly expand its team, bringing on someone to help support and drive implementation of SEWA's agriculture technologies resilience initiative, including helping to support and coordinate outreach and communication within SEWA, and between SEWA and outside partners, and the building of in-house resilience technology capacity.

Advanced technologies/services related to weather and price forecasting have notable potential to empower SEWA members and enable them to more sustainably manage their farms and agricultural enterprises. The findings and recommendations the SIPA Team has provided herein should not be considered exhaustive. Nevertheless, it is the SIPA Team's hope that this final report will prove a helpful framework for SEWA to begin leveraging technologies and services to support farmer members by increasing their resilience to climate change.

9. Appendix

The following a series of organization's leveraging or providing technologies/services that may be of interest to SEWA. The first group of technologies/services (Section 9.1) pertain to the primary scope of research, weather and price forecasting technologies, and further technologies/services (Section 9.2), are profiled as the SIPA Team feels that can either support recommended technologies/services or address additional farmer member needs.

9.1. Weather and price forecasting technologies

Technology/Service: Farmerline (information services, market access)
Country: Ghana

Basic information
● Organization name: Farmerline ● Organization or initiative website: https://farmerline.co/ ● Collaborating organizations: ○ Mobile networks and agricultural organizations whose content they deliver: MTN phone company; Vodafone (to lesser extent) ○ Weather stations from whom they acquire their weather info ● Organization contact: +233 24 214 1333 +233 32 202 3183 team@farmerline.co
Product description
● Key users / target audience: **Smallholder farmers** ● Problem(s) the technology / initiative addresses: ○ Lack of information for farmers ● Description of the technology / initiative: ○ Provides real time agriculture education delivered to farmer's mobiles: **weather forecasts, market prices** and GAPs; delivered via voice in local languages; information is customizable given location and stage of production ○ Provides education on global certification standards and how to apply for global certification, improve sustainability and boost productivity, and access extension services; **in-person training** for rural workers ○ Facilitates access to inputs, water, financial services through phone order ■ Primarily provides: **Market prices, weather forecasting** and agronomic tips (on their own)- also conduct workshops where they provide this information face to face (same information provided via phone when subscribed) ● Data team that gathers the info on market prices for them (enumerators) ● Sends the info to farmers via phone call (overcomes literacy concerns)- in specific dialect
Technology requirements
● Software required for the technology / initiative:

- Mergdata- is their system built by engineers in house through which they send **information to farmers** and have mapping capabilities
- Paytime- is a **platform used to make payments** for certain services however it remains relatively un-commercialized

- Hardware / infrastructure required for the technology / initiative:
  - Computers
  - Feature mobile phone- USSD *2399# - Farmers can use this to access information
    - They have one specifically for farmers, a web version, and a android version
  - Android phones- used for data collection via surveys setup on phones- designated enumerators go to the field to complete surveys
    - This system can be used for anything but for farmers they do Bio data, image of farmer, signatures, map out farm, - the information varies but is extensive
- Expertise required for the technology / initiative:
  - Basic phone literacy

Funding

- Technology price: Farmerline must pay small fee to phone companies for messaging service
  - Technology (mergdata) is built in-house, so they didn't outsource development
- Funding source: most of the funding comes from the B2B side- organizations paying them for services- farmers are charged very little (11 cedis (~$2.14) per season of 6 months for market price information) and 9 cedis (~$1.75) for weather forecasting per 6 months

Partnership

- Partners involved in the implementation of technology / initiative:
  - Partner 1: Private weather stations throughout the country- ex: Tamo= an organization with whom they worked to set up some weather station
  - Partner 2: Ghana meteorological agency
- Partners' roles and responsibilities:
  - Partner 1: Assisted in setting up some weather stations at time of set up
  - Partner 2: Provides additional meteorological information

Technology/Service: GroIntelligence (GroAPI; Gro Analytics; Gro App Web)
Country: US, Kenya

Basic information
● Organization name: GroIntelligence ● Organization or initiative website: https://gro-intelligence.com ● Organization contact: No direct contact, (718) 935-0100 or contact form
Product description
● Key users / target audience: Corporations working in: finance, agriculture, food and beverage, or consulting. Gro-Intelligence aims to increase value "across the value-chain" ● Problem(s) the technology / initiative addresses: ○ Lack of centralized agricultural data sources ○ Power imbalances in global agriculture markets ● Description of the technology / initiative: ○ Massive **agricultural datasets** (8,000,000 distinct data series totalling trillions of individual observations) drawn from **satellite imagery, weather forecasts,** government and industry reports, and farmer reports ○ **Proprietary machine learning algorithms** provides predictions on global market trends ○ Dashboards and infographics summarizing agricultural statistics
Technology requirements
● Hardware / infrastructure required for the technology / initiative: Computer; smartphone ● Software: Gro Analytics; Gro API; Gro Web App

Technology/Service: MFarm (market pricing; market access)
Country: Kenya

Basic information
● Organization name: Mfarm ● Organization or initiative website: http://mfarm.co.ke/ ● Organization contact: Jamila Abass (CEO)- no contact info but info@mfarm.co.ke +254 707 933 993
Product description
● Key users / target audience: Kenyan Farmers ● Problem(s) the technology / initiative addresses: ○ Lack of information regarding market prices ○ Dependence on middle men-imposed pricing and buyers ○ Low production → hassle to buyers purchasing from multiple farmers ○ Little leverage to negotiate input prices ● Description of the technology / initiative: ○ Digitally provides farmers with up-to-date **market prices** and connects farmers with buyers (retailers & food suppliers) via their application or SMS. Farmers text "20255" to receive information on the retail price of their products (includes daily info for 42 crops sold in 5 markets) ○ Digital group selling tool- Assists Farmers producing in low volume from whom buyers do not want to purchase (cost of transport for low volume etc.) → Farmers text the system which crop they would like to sell and platform assists in collectivizing ○ Digital group buying tool- Provides farmers with the ability to collectivize in order to be able to negotiate input costs (e.g. fertilizer)
Technology requirements
● Hardware / infrastructure required for the technology / initiative: ○ Cellphones ● Expertise required for the technology / initiative: ○ Basic cellphone literacy ○ Basic literacy (including numeric)
Implementation
● Main challenges during implementation: ○ Behavioral change (getting farmers to trust the services)

Technology/Service: Sokopepe (SOKO+/FARMIS)
Country: Kenya

Basic information
● Organization name: Sokopepe (Swahili for 'virtual market') ● Organization or initiative website: https://sokopepe.co.ke/
Product description
● Key users / target audience: Diverse stakeholders in the agricultural sector ● Problem(s) the technology / initiative addresses: ○ Insufficient information for stakeholders throughout agricultural value chains ○ Poor linkages between small scale farmers and buyers ● Description of the technology / initiative: ○ **Farm Records Management Information System** (FARMIS) is a farm management and diagnostic tool that **aggregates farm information** records and aims to identify productivity trends and profitability of different farm enterprises to **facilitate evidence-based decision making** for agri VC stakeholders (risk assessment, insurance, extension and access to finance) ■ Includes reports (yield, disaggregated by crop, identification of profitable lines etc.), **market reports** (farm gate price, lorry price and others for comparative analysis) and profit and loss accounts, which can be used as evidence for decision-making. ○ SOKO+ is a digital commodity trading and information system; links smallholder farmers to buyers; provides **commodity prices** from major markets around area of operation; e-extension services; lists of various technical and logistical support providers

Technology/Service: Time2Sell (price prediction API)
Country: India

Basic information
● Organization name: Our Food ● Organization or initiative website: https://www.icrisat.org/crop-price-prediction-innovation-wins-ict4d-data-jam-2/ http://www.ourfood.co.in/ ● Collaborating organizations: N/A ● Organization contact: ○ Bala Reddy V (Co-Founder and CEO, Our Food Pvt Ltd) ○ Raghu Prasad Mulukoju (CTO, Our Food Pvt Ltd) ○ Harsh Nisar (Data Scientist, IFMR LEAD) ○ Hari Prasath Sundaram (Consultant, Consulting AgriTech)
Product description
● Key users / target audience: Farmers ● Problem(s) the technology / initiative addresses: ○ High fluctuation in crop prices ○ Difficulty getting a fair price for harvest ● Description of the technology / initiative: ○ Data-based price **prediction API** which provides farmers with **information on crop prices** and aids in making decision regarding the right **time to sell crops** ○ Information is provided to farmers through a mobile application ○ Aims to create customized installment sales plans for farmers, based on their existing loans, crop quality, interests, etc. ● Time2Sell also plans to offer storage solutions to farmers who are not able to stagger crop readiness and prefer an installment sales strategy
Extra information
● http://www.ourfood.co.in/2017/05/14/our-food-time2sell-price-prediction-innovation-wins-ict4d-data-jam-hackathon/ ● http://www.icrisat.org/wp-content/uploads/2017/05/19-May-Happenings_1741.pdf

Technology / Initiative: The Weather Company (IBM)
Country: India

Basic information
● Organization name: The Weather Company ● Organization or initiative website: https://www.ibm.com/weather ● Organization contact: Himanshu Goyal, AD, Sales, The Weather Company
Product description
● Key users / target audience: Farmers, commodity traders, insurance providers, lenders, governments (i.e. government programs targeting smallholder farmers) ● Problem(s) the technology / initiative addresses: ○ Lack of access to farm-level information to enable provision of customized services ○ Lack of information around weather conditions among farmers ● Description of the technology / initiative: The **Watson Decision Platform for Agriculture** is a B2B (business-to-business) solution through which agriculture input and output companies gain **access to local farm information**, enabling them to offer relevant advisory services to farmers. ● The platform creates an **Electronic Field Record** (EFR) for each farm. The EFR contains information on **farm-level weather data** (historical data, as well as 15-day forecasts and seasonal trends), soil data (moisture, fertility), farming practices (harvesting dates, pesticide/fertilizer application rates, harvest outputs), and visual imagery from satellites and drones. The platform uses AI and machine learning to analyze the EFR data and automatically generate guidance to improve decision-making.

Technology/Service: WFP ('ALPS' / price forecasting)
Country: Senegal

Basic information
● Organization name: World Food Program ● Organization or initiative website: http://dataviz.vam.wfp.org/economic_explorer/price-forecasts-alerts ● Collaborating organizations: *Commissariat* à *la Sécurité Alimentaire; Anacim* (Implementers) ● Organization contact: Mouhamadou Ndiaye (CSA); Diaba Ba (WFP- VAM Unit)
Product description
● Key users / target audience: Smallholder farmers, Fishers, Pastoralists ● Problem(s) the technology / initiative addresses: ○ Food insecurity exacerbated by price volatility, uncertainty. ● Description of the technology / initiative: ○ Seeks to address food insecurity by **reducing uncertainty** posed by price volatility- WFP "**price forecast and alert tool**" informs partner organizations and WFP's internal operational programming related to cash, vouchers, and local procurement ○ WFP's Alert for Price Spikes (ALPS) indicator forecasts pricing and detects price spikes to inform actions ○ Collect weekly data, aggregate, and apply a formula based on the past 10-15 years of monthly aggregated prices throughout Senegal, in order to project future pricing of a given commodity (e.g. all cereals)

9.2. Other technologies

NEW TECHNOLOGY NOT FULLY DEVELOPED
Technology/Service: Team AgriBarT (collective bargaining app)
Country: India

Basic information
● Organization name: Team AgriBarT ● Organization or initiative website: https://www.icrisat.org/crop-price-prediction-innovation-wins-ict4d-data-jam/ ● Organization contact: ○ ICRISAT@cgiar.org (this initiative won 2nd place (behind Time2Sell) at the conference held by ICT4D Conference, CGIAR, awhere, Global Development Analytics Group, A-M-Z Group, Digital Globe, Esri India)- No direct contact yet available
Product description
● Key users / target audience: Smallholder farmers ● Problem(s) the technology / initiative addresses: ○ Frequently fluctuating crop prices ○ Price arbitrage by middlemen ● Description of the technology / initiative: ○ Preliminary prototype development of a group formation application that enables collective bargaining for farmers ○ Identifies farmers with similar purchase requirements, demographics, geographies and historical cropping patterns; Empowers farmers to gain benefits of bulk ordering in the shared economy

Technology/Service: AgroStar (Mobile App)
Country: India (including Gujarat)

Basic information
● Organization name: AgroStar ● Organization or initiative website: https://agrostar.in ● Collaborating organizations: Monsanto, Bayer, Honda Dow Chemical
Product description
● Key users / target audience: Indian farmers ● Problem(s) the technology / initiative addresses: ○ Lack of knowledge ○ Poor access to inputs ● Description of the technology / initiative: A mobile app that provides mobile extensions services (including personalized recommendations) and a digital market for inputs. Farmers can also receive information by sending a missed call.

Technology/Service: CropIn (SmartRisk)
Country: India

Basic information
● Organization name: CropIn ● Organization or initiative website: https://www.cropin.com/ ● Collaborating organizations: Invested Development, UKAid, Buhler, Seeders, FICCI (Federation of Indian Chambers of Commerce and Industry) ● Organization contact: ○ Krishna Kumar, Founder and CEO ○ Chittaranjan Jena, Co-founder and CTO
Product description
● Key users / target audience: agribusinesses, farm management companies, agri-insurance companies, lending institutions ● Problem(s) the technology / initiative addresses: ○ Pest/diseases ○ Output unpredictability ○ Crop risk ○ Inventory management challenges ● Description of the technology / initiative: ○ **SmartRisk** – Predictive prescriptive tool for risk monitoring, mitigation and forecasting ○ **AI and machine learning-based platform** detects cropping patterns and predicts the future of the crop, highlighting associated risks and opportunities for agri-stakeholders. ○ Supports businesses in achieving **farm-level crop detection and yield prediction** ○ SmartRisk capabilities can also establish historical performance at farm/postcode/state/country level by utilizing Connector APIs.
Technology requirements
● Indicators / metrics required by the technology / initiative: ○ Satellite monitoring ○ Weather analysis ○ Geo-referenced data (for accurate predictability and accountability) ● Softwares required for the technology / initiative: ○ Machine learning and Data storage

Technology/Service: Digital Green (support platform; data analytics; logistics service)
Country: India, Ethiopia

Basic information
● Organization name: Digital Green ● Organization or initiative website: http://www.digitalgreen.org ● Collaborating organizations: Ministries of Agriculture, USAID, Gates Foundation, awaaz.de, J-Pal, IPA ● Organization contact: Rikin Gandhi
Product description
● Key users / target audience: smallholder farmers, agricultural development practitioners ● Problem(s) the technology / initiative addresses: ○ Lack of knowledge ○ Lack of market access ○ Lack of data on training/implementation ● Description of the technology / initiative: ○ Video-based agricultural extension content ○ CoCo (connect online, connect offline) platform for collecting and analyzing data on training and uptake of new practices. ○ Loop - a logistics service that matches farmers with nearby buyers who can purchase their products. ○ Digital Green has also partnered with Awaaz De to deliver voice messages as an added component to its training programs.

Technology/Service: Ekgaon (market access; financial services)
Country: India

Basic information
● Organization name: Ekgaon ● Organization or initiative website: http://ekgaon.co.in/ekg/index.php ● Organization contact: ○ Vijay Pratap Singh Aditya (Founder and CEO) ○ Tapan S Parikh (Co-Founder)
Product description
● Key users / target audience: smallholder farmers, rural businesses, underserved rural women ● Problem(s) the technology / initiative addresses: ○ Lack of market access ○ Lack of responsive financial services for rural women and smallholder farmers ● Description of the technology / initiative: ○ Provides utility services for farmers, rural businesses, underserved rural women and the large urban migrant labor population of aspiring consumers. ○ First company to provide mobile **phone-enabled financial services** delivery platform in South Asia. ○ Market connect platform (ekgaon.com) provides 'Direct from Farm Produce', that is certified organic and naturally grown, from farms of small farmers to urban customers.

Technology/Service: Eruvaka Technologies (risk reduction diagnostic equipment)
Country: India

Basic information
● Organization name: Eruvaka Technologies ● Organization or initiative website: https://eruvaka.com/about ● Organization contact: ○ Sreeraam Ravi, Founder and MD
Product description
● Key users / target audience: Aquaculture farmers ● Problem(s) the technology / initiative addresses ○ Risk of insufficient production: Helps farmers manage risk through regular aquaculture monitoring ○ Lack of pond protection ● Description of the technology / initiative: ○ Eruvaka Technologies develops **on-farm diagnostic equipment** for aquaculture farmers to **reduce risks** and increase productivity. ○ Integrates sensors, mobile connectivity and **decision tools** to promote affordable aquaculture monitoring and automation. ○ Seeks to accelerate the use of technology in aquaculture, to help farmers more effectively monitor their ponds, reduce investments and promote sustainability.

Technology/Service: Harvesting (Agri Intelligence Engine)
Country: Uganda, Myanmar, India

Basic information
● Organization name: Harvesting ● Organization or initiative website: https://harvesting.co/ ● Organization contact: Ruchit Garg
Product description
● Key users / target audience: Farmers, lending institutions, input companies ● Problem(s) the technology / initiative addresses: ○ Lack of knowledge about land quality, hampering farmers' ability to plan/make financial decisions ○ Inability of lending institutions to ensure repayment ● Description of the technology / initiative: ○ Uses **artificial intelligence** to support microfinance institutions in providing services to farmers. ○ Agri Intelligence Engine utilizes **remote sensing data**, along with a range of traditional and alternative data points, to assess a farmer's creditworthiness. This includes continuous monitoring of farmlands, capturing changes in vegetation/crop cover and providing an early warning system for repayment risk.
Extra information
● https://www.indianweb2.com/2018/07/10/this-silicon-valley-based-startup-aims-to-solve-indian-farmers-age-old-problem-using-its-agricultural-intelligence-engine/

Technology/Service: SunCulture (RainMaker2)
Country: Kenya

Basic information
● Organization name: SunCulture ● Collaborating organizations: Shell Foundation
Product description
● Key users / target audience: Farmers ● Problem(s) the technology / initiative addresses: ○ Lack of access to water for non-agricultural uses ○ Irrigation systems run by petrol/manually that are inefficient in terms of costs and labor ● Description of the technology / initiative: ○ **RainMaker2** is a solar-powered water pump designed for off-grid households, as a replacement for diesel, electric and manual water pumps that are used for irrigation, livestock and household water supply. ○ Comes with a built-in platform, **ClimateSmart**, that uses soil sensors and internet-connected weather stations to analyze data and provide customers with **weather forecasts** and irrigation timing advice via SMS.

Technology/Service: UjuziKilimo (interactive farm advice; big data analytics)
Country: Kenya

Basic information
● Organization name/Application: UjuziKilimo ● Organization or initiative website: http://ujuzikilimo.com/sms.html ● Partners: Village Capital, Miller Center ● Organization contact: info@ujuzikilimo.com
Product description
● **Interactive SMS:** ○ Seeks to deliver **real-time information** "within 3 minutes" upon receiving soil and farm data from the Ujuzi sensor device – and thus to deliver actionable farmer-specific recommendations and advice based on soil and farm conditions. ○ Personalized weather updates, crop management and market information. ○ Allows farmers to respond, ask questions, and get feedback from UjuziKilimo experts. ○ SMS platform is subscription-based. ● **"Big Data" analytics:** Provides insights on farming trends and productivity, based on findings from data generated by the UjuziKilimo system. The organization states that it places emphasis on the importance of customer data privacy.

Technology/Service: Zenvus (Zenvus Smartfarm; zPrices)
Country: Nigeria

Basic information
● Organization name/Application: Zenvus ● Organization or initiative website: https://kalgudi.com/index.html ● Organization contact: zenvus@fasmicro.com
Product description
● **Zenus Smartfarm** is an intelligent electronics sensor which, when inserted into farm soil, collects pertinent data on humidity, temperature, pH, moisture, nutrients etc. and wirelessly transmits this data to a cloud server where advanced computational models help to make sense of what is happening on the farm. ● zPrices provides Zenvus farmers with **information on prices of products** across major cities and markets. ○ Goal is to **empower farmers** by giving them data as they make decisions on what to farm and how much to sell. ○ Zenvus is responsible for the data's integrity and seeks to use consistent metrics to "instill confidence in users". Prices are compared across cities, over weeks, days, etc., helping farmers to manage price risks and protect themselves. ○ Data is also available to organizations such as insurers, investors, and lenders.
Funding
● Technology price: Free for farmers; INR 12 ($0.17)/farmer/year for donors/NGOs; INR 50,000 ($722.77) pm for up to 25000 farmers for market linkage
Extra information
● https://www.hks.harvard.edu/sites/default/files/centers/mrcbg/working.papers/AWP_85_final.pdf ● https://hbr.org/2017/05/how-digital-technology-is-changing-farming-in-africa ● https://www.zenvus.com/

10. January and March field trips photos

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