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Livelihoods India Case Study Compendium 2019

Technology Solutions for Agricultural Advancement

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Sitaram Rao Livelihoods India
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Preface

Agriculture, with its allied sectors, is the largest source of livelihoods in India, with more than 50 percent of the population primarily dependent on it. In the past, Indian agriculture faced a formidable challenge to grow more food, but it faces an even greater challenge today and for the future - to grow more sustainably and inclusively. Technology has powered Indian agriculture time and again by helping overcome productivity stagnation, strengthening market linkages and enhancing farm management. However, with increasing population and demand for better quality and higher quantity of 'food, fibre and feed', the performance pressure on farms is increasing remarkably. The key challenges before Indian agriculture today include small land holdings, low productivity, infrastructure gaps, information asymmetry, climate related uncertainty, a convoluted supply chain with multiple levels and intermediaries and limited last mile delivery of services.

The emergence of farm technologies integrated with a robust information and communication technology (ICT) framework is still evolving in India, and it holds tremendous potential to both positively impact agricultural performance and enhance farmers' income. Modern agriculture could benefit from continuous improvements in digital tools and data as well as collaborations among farmers and researchers across the public and private sectors.

Therefore, it was befitting that during the current year the Sitaram Rao Livelihoods India Case Study Competition highlight cases offering technology solutions to challenges faced by Indian agriculture. Overall 37 cases were received, which were then put through a rigorous evaluation process and finally assessed by an eminent jury who shortlisted the top case studies. This Compendium brings together 8 such cases that provide evidence of technology solutions that are impacting farmers to strengthen their livelihoods through participating more effectively in value chains and earning incremental incomes.

The Jury of the Case Study Competition comprised of sector experts – Dr. Biksham Gujja; Dr. R N Ghatak; Mr. Prasanna Rao; Mr. Aileen Mukherjee and Mr. Dheeraj Mutreja.

On behalf of ACCESS, I would like to express my deepest appreciation to the Jury for volunteering their time and efforts for deliberating and collating the final list. I'm sure, critical examination and their expertise has contributed to bringing the best cases to the fore.

I would also like to thank those who have shown interest in the case study competition and submitted their cases.

I'm deeply indebted to Mr. Vikram Akula and Vaya Finserve for their invaluable support to the Case Study Competition and their efforts to perpetuate the memory of Sitaram Rao who was both his mentor and also a founding Board Member of ACCESS.

I express my gratitude to the Livelihoods India Advisory Group and our CEO, Vipin Sharma for their guidance in the conduct of the Competition. Last but not the least I would like to thank my team of Shruti, Lalitha and Aastha for facilitating the 3-stage process in a seamless manner.

I hope this compendium will be a useful resource on technology solutions for agriculture advancement and prove to be of value to the sector.

Puja Gour
Vice President
ACCESS Development Services

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Appropriating Technology for Ultra Poor Women – Smartphone Apps for Agricultural Improvement

Trickle Up Program

Introduction

Providing access to "just in time" information on crop choice, planting technique, care, harvest and marketing of produce is one of the key challenges in improving livelihood of rural ultra poor women and their households. In 2019 Trickle Up, an NGO dedicated to enhancing the economic and social inclusion of ultra poor women, completed the pilot stage of partnership with Tata Communications to address these challenges through mobile technology. To support the agricultural activities of ultra-poor households, Trickle Up developed mobile based applications which were uploaded on smartphones provided to 1000 women participating in its programs in Odisha and Jharkhand, in partnership with the Odisha Livelihood Mission (OLM) and Jharkhand State Livelihood Promotion Society (JSLPS).

This case study outlines key learnings from this project, drawing on data from internal monitoring and external evaluation. Results show that custom apps significantly facilitated adoption of improved agricultural practices and complemented the work of frontline staff in conveying training messages. This included supporting scientific cultivation practices, informed decision making around crop choice and adoption of newer farming techniques, as well as positive follow-up action enabled through access to smartphones.

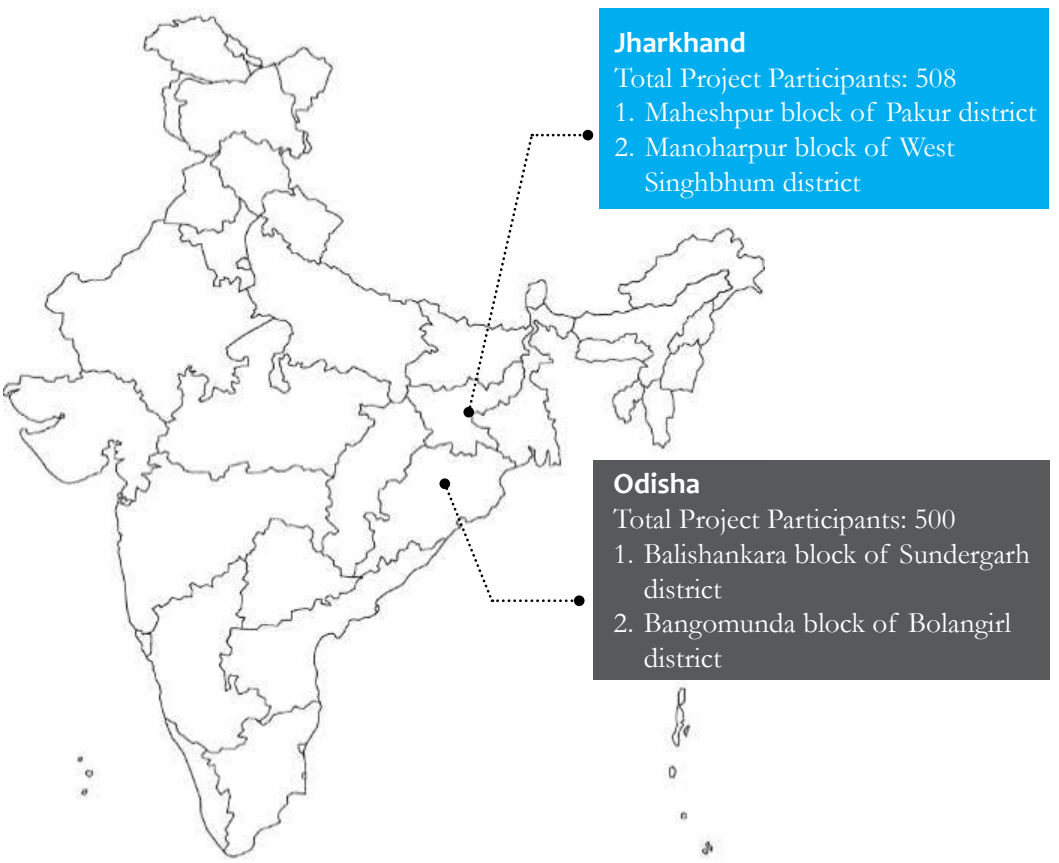
The case study explains how app design was understood and adopted by community members with no literacy and no prior experience with smartphones and how support was provided to address differing capacities. It also discusses broader issues of ownership and usage from a gender perspective. Lastly, some key considerations are addressed for scaling up, especially the comparative utility of providing individual participants with mobile devices versus shared group devices.

Project Context

Trickle Up's programs are designed to reach and benefit ultra poor women and their households. This segment of the population has very few assets and depended on sporadic and unreliable income sources. 75 percent of the project participants were primarily reliant on daily wages or migrant labour. They were often subject to multiple exclusionary factors, and left out of or are unable to fully benefit from mainstream government programs. For this reason, Trickle Up has partnered with two state agencies of the National Rural Livelihoods Mission (NRLM), from Odisha and Jharkhand, to implement and test scalable models for strengthening ultra poor households' livelihoods and effectively integrating them into NRLM and other government schemes.

The livelihood component of the project is based on the Graduation Approach, which is specifically designed for ultra poor households to create a sustainable pathway out of poverty. The elements of the program include livelihood planning and training, seed capital grants (of INR 3000) for investment in productive activities, integration into Self Help Groups (SHGs) to promote social and financial inclusion, and regular coaching by Community Resource Person (CRPs) to reinforce training messages and help participants and their households solve problems and link to services.

Since 2007, Trickle Up has been successfully using and adopting the Graduation Approach in Jharkhand, Odisha and West Bengal. The project lasts for 36 months, during which time the participants are supported to achieve a number of "graduation" criteria which indicate their ability to sustainably move out of poverty, including SHG participation, livelihoods diversification, income generation, savings, food security, and access to entitlements.



Picture 1: Pilot project implementation areas

Rationale for Technology Component

To support its programs, Trickle Up has developed "Package of Practices" (PoP) outlining the steps required to develop a portfolio of livelihood activities. These provide basic information about the required inputs and steps for growing a range of crops and managing livestock rearing activities, using pictures and fairly simple text that can be understood by front line workers. However, despite intensive training and follow-up by coaches, monitoring of the program indicated that one of the main reasons for poor outcomes was lack of full adherence to the PoP. Problems included using inappropriate quantities or types of inputs, errors in timing of transplanting, and problems with disease control such as inadequate spacing of plants.

The large majority of program participants were primarily reliant on daily labour and had little experience in cultivation of their crops, particularly higher value crops like vegetables. Furthermore, given limited education and literacy levels, most participants struggled with training sessions and were not able to effectively record information for future use. For this reason, use of the "just in time" training method that can provide information when needed, has obvious advantages. Graduation program field staff (coaches) visit on a weekly or biweekly basis, but even this creates potential gaps that can result in lowered productivity if a critical step has been missed or a problem emerges.

Most participants also tend to be reliant on field staff for support with calculations required for the planning and management of their activities. The provision of timely accessible information to support agricultural activities was amplified as Trickle Up's programs moved from a model in which the front line coaches were relatively well educated, to one in which they came from the target communities, as part of scaling within government livelihood programs.

ICT Component and PoP Application

The technology component of the project was three fold:

1. Provision of a smartphone for the ultra poor women program participants and training in its use and care;
2. The development of a custom "Package of Practices" application to support cultivation, including management of associated basic finance;
3. Access to other apps,text and voice based information to support livelihood development and linkage to entitlements.

To support planning, the PoP apps provide step-by-step instructions and automated calculations of the quantity and type of inputs required for preparing and planting nursery beds, ploughing, preparing growing beds and transplanting seedlings, weeding, fertilizing, pest control and other required care. Once commenced, an automated calendar provides reminders for each step in the cultivation process.

Picture 2: Sample screenshots

A series of visual cues, largely consisting of photos and voiceovers provide detailed guidance, and participants can check off each step as they complete it. The app enables participants to enter expenses related to each step, amount of produce harvested, income received from sales and amount consumed, thereby creating an assessment of overall profits and helping suggest future investment decisions.

Instructions were first developed for cultivating chili peppers, tomatoes, brinjal, bitter gourd, and green beans, followed by lady fingers, spinach, potatoes, onions, eggplant, long beans, pumpkin, mushrooms and green pumpkin. The choice of vegetables was updated by the staff depending on their seasonality and popularity, PoPs for more crops are now under development. The app was developed iteratively, with new crops and functions added over time, based on monitoring of use and user feedback.

Effectiveness of the PoP Apps

Usage of the PoP App was high - eighteen months into the program, 80 percent of participants were using the PoP app to support cultivation. It was also being appreciated by both participants and field staff. As per an evaluation by KPMG, 77 percent of the participants reported that the use of the PoP application has improved the agricultural yield and livelihood conditions, and almost all said that they planned to continue using the phones to support their livelihoods.

As anticipated, the apps facilitated "just in time" information, and the participants articulated the value of this. This is what Kuntala (Balisankara, Odisha) told the evaluators,

> *'Last year, I bought one kilogram of seeds and with the help of the PoP, I could produce 250 kg of onions from it. Imagine the kind of profit I was able to make! The regular trainings are also very helpful, but what happens with the PoP is that it is like a regular reference. Now that I know how to use my phone, I can refer to PoP whenever and wherever I am stuck. I do not have to wait for anyone to come and help me solve my problem. Being a single parent, this is extremely time saving for me.'*

Participants also claimed that the detailed instructions and step by step processes embedded in the PoP helped them bring in discipline to their cultivation practices. Subodhini (Pakur, Jharkhand) explained,

> *'Earlier we used to sow the seeds anyhow. Most of the crops either died from disease or pest infestation or because they were sown too close together and could not grow properly. It seemed like we would always remain poor…. With the help of the PoP, I now know details like how much distance I should keep between seeds and how to save them from pests. Naturally the quality of the produce has improved drastically. Even if one plant gets infected, the others don't get infected by it because of the distance we now maintain. We eat well now.'*

Having this information in a non-written form was noted by Subodhini and many other participants as one of the big advantages,

> *'None of us are so educated, and most of us are not comfortable with Hindi or any other language. The PoP app speaks our language. That makes it much easier for all of us to follow instructions.'*

Field staff also reinforced the importance of both the PoP app and simply having access to communication technology, in bringing about these changes. As noted by Snehalata, a Smart Sakhi, in Pakur, Jharkhand,

> *'When I started teaching the women how to use the PoP application for disciplined farming, it helped them produce better from the same piece of land, where they were unable to make any profit earlier. Being able to see how to take the measurements and follow the instructions in such detail every time they need it, and being able to reach out to me whenever they need help, has been the biggest advantage for them.'*

Furthermore, the field staff and managers used the information entered by participants on the steps they had taken in the PoP and produced calculations to determine which participants needed more support.

Participants and field staff reported that they particularly valued PoP app support for new cultivation techniques, and this sometimes provided a comparative advantage. For example, Bhagyabati, in Odisha, used the PoP app to switch to organic fertilizer and pesticides (the app promoted organic agriculture, as per OLM guidelines), enabling her to reduce costs and attract customers. Her training also enabled her to educate her customers on the benefits of organic agriculture.

Participants also reported that they were able to make more informed decisions on the crop choice. The addition of the modules on financial management were particularly beneficial in this regard. Prior to the project, most participants with some agricultural land primarily cultivated paddy and maize – high investment crops with long cycles. The PoP app helped reinforce the value of replacing or diversifying into shorter cycle vegetable crops with

higher market value. Participants' ability to record input costs and income supported this shift by providing a record of performance.

The PoP app helped empower women in family decision-making. In some households, men supported women's leadership when shown electronic evidence of increased profit.

Addressing Literacy and Numeracy Constraints

Literacy rates among the ultra poor women tend to be low, two thirds of Trickle Up's participants in Jharkhand lacked functional literacy. This situation presents both opportunities and challenges: mobile technology offers a particularly important opportunity to meet the information needs of people who are not able to access or record written information, however, illiteracy also limits their ability to fully take advantage of technology.

The challenge, therefore, was to design an app and training module that would be useful for people without literacy, still enabling extra functionality for those with some literacy, or with literate support networks. Design features were added to help low literacy users such as making key information image with instructional visual cues and step-by-step voice over. Recordings of program participants were used to make language and dialect intelligible and familiar, with content recorded in Hindi, Bengali, Oriya, Ho, Santhal and English (for staff review). Videos were initially integrated into the content, but later abandoned due to their data size. The next stage of development will involve animation to visually demonstrate PoP steps without the heavy storage demands of video.

The apps were also designed to mirror existing usage by people with limited literacy and numeracy who understand money, but never learned to add and subtract on paper. For example, the money manager part of the app helped people to count and record income and expenditure by enabling users to swipe images of different denominations of rupee notes. This proved to be extremely useful for women who had never previously had a means to record transactions and calculate overall profitability.

Electronic images of the sticks used by farmers to measure land were used for calculating land size. Together with images of different types of land, this facilitated calculations of required inputs and expected profit for each type of crop.

Despite these features, the women still needed to be able to make sense of the information provided through the apps, including in numerical form. Participants were provided with training to recognize simple numbers, but their ability to internalize these messages varied widely. Locally recruited resource people were crucial in providing support, as discussed below. The apps also included some text for support staff and participants with emerging literacy, all accompanied by voice-overs.

Furthermore, a number of apps were added to the phones that did require literacy, particularly apps to link to government services. For example, 43 percent women linked

their mobile phone numbers to their bank accounts. This enabled them to receive text message notifications from their banks, and so even though most could not read them, they knew when to seek help from a staff member or other trusted literate acquaintance. While literacy was clearly an impediment to engagement, the women were generally able to still benefit from text-based applications and information.

Designing for First Time Smartphone Users

The project had to address the lack of participants' prior experience with smartphones (only 2 percent had previously even had access to an analogue phone). Despite initial apprehension by some participants towards even holding the phones, engagement and enthusiasm proved high. Shortly after an initial training, many women were using the phones to take and share photos, and were exploring other applications. Within 6 months, all participants were using the phones to make calls and 82 percent were able to take photos or videos.

Nevertheless, there were significant differences in the uptake and capacity. Many participants who were slower to learn drew support from family members, especially children. However, peer support among quick learners in the SHGs was more effective and reliable. This was institutionalized 8 months into the program with "Smart Sakhis", many of whom were recruited from among the participant women who had demonstrated success with the phones and apps to help others. Smart Sakhis were almost all literate and committed to supporting a group of 25 peers in exchange for a modest stipend of INR 1500 per month.

They were provided training and mentoring from the field staff and effectively complemented, and sometimes replaced, the work of CRPs. Most Smart Sakhis took great pride in their work and developed significant leadership skills, including basic livelihoods development coaching. Their basic literacy and access to, and comfort with the phones enabled them to participate in online PoP training and easily communicate with technical staff through messaging apps. This made them effective field coaches who were able to support participants in decisions about crop choice and cultivation. They also provided important regular feedback on the PoP app, enabling iterative improvements in design. Towards the end of the project some Smart Sakhis articulated aspirations to train for professional coaching roles in new project sites.

One of the main predictors of success was age: there was a significant negative correlation between the age of users and the ability to understand basic concepts and effectively use the PoP app. Two percent of women who received smartphones and training were found not to be using them, even after provision of support, and expressed little interest in doing so. These were women over the age of 45, and their phones were reallocated to younger participants. The Smart Sakhi model also helped support such older women, but one of the key learnings was that the program is more effective with women aged 18-35. In the next

stage of the project, older women who meet the selection criteria (of being ultra poor) will still be integrated, but the technology component will be mediated through the support of youth within their households.

A gradualist and sequential approach to training was also deemed important. The training commenced with the basics of smartphone use and care. Initially the project staff, who feared that phones would be damaged or sold off before their value was apparent, debated whether participants should be allowed to keep the phones immediately after the first training. However, it was determined that the benefits of rising confidence in use outweighed these risks. After the initial training, the participants had 3-4 months to learn basic functions and build their confidence and comfort before receiving training on the PoP app. Their use of the PoP app was then supported by coaches, and later Smart Sakhis. Given the sequential nature of the PoP apps themselves, they also had time to get used to negotiating each step as needed. Eighteen months after receiving their phones, 87 percent of the participants could use the smartphones and the PoP application easily (and 85 percent could help others). At this point, trainings started to focus on helping the participants to use the internet and increase their access to more complex applications such as YouTube to search for information relevant to their livelihoods.

Smartphone Usage to Support Agricultural Development Beyond the PoP App

Participants were also encouraged to use their phones to contact field staff. Most participants did this, and reported that greater and quicker access to field staff was a major advantage. Participants also used their phones to take pictures of their crops and send them to coaches for advice.

Field staff used the questions and concerns shared by the participants through messages and photos to assess their training needs and to schedule and prioritize visits. Early in the project, tobacco caterpillars attacked the tomato crops in Bangamunda block in Odisha. Participants risked catastrophic losses on leased land. Affected participants immediately alerted their CRPs by smartphone. The CRPs sent photos of the damaged crops to a group chat of their peers, including OLM staff, to seek advice. Experts quickly identified the correct organic pesticide, and using the electronic network, greatly minimized crop loss. The availability of the phones in the hands of participants greatly speeded up the identification of and solution to the problem, and averted a disaster. Push notifications used by staff to share information from block officers were delivered by text, but in the next stage audio and video links will also be shared.

Participants were supported to register their mobile numbers with government departments such as Jharkhand's Department of Horticulture, which sent them mobile alerts on the availability of varieties of seed that the department was distributing in weekly markets. In Odisha, 77 percent of participants received grants of INR 1000 each to develop nutrition gardens, through linkage to an online scheme. Expanded connectivity also afforded greater

access to government services and support by enabling participants and field staff to obtain crucial information about who was or was not receiving entitlements. It enabled them to make direct contact with relevant authorities, without expensive and time consuming travel, when schemes were not implemented as mandated.

Lastly, participants used their phones to reduce costs and improve marketing, including calling wholesalers to get market prices, and arranging for goods for sale or purchase and delivery. This reduced their own need to travel, saving time and money. They also used the weather forecasting app, Kishan Suvidha.

Addressing Connectivity and Electricity Supply Limitations

Trickle Up's programs generally target remote communities where ultra poverty tends to be concentrated and connectivity is often limited. This creates challenges for large data use activities such as application updates. Smart Sakhis and field staff addressed this by identifying high connectivity locations to perform batch updates for all participant phones in their area. This was effective in the pilot, but poses problems for scaling. In the second stage, Trickle Up is partnering with mobile network providers to expand connectivity and provide pro-poor data and voice calling plans.

Electricity supply also proved to be a challenge. Seventy percent of the households did not have their own electricity connection, making phone charging uncertain, particularly during peak seasons when the grid was only intermittently available. The project had planned for solar chargers for those without an adequate electricity supply. However, these were not enough, as the reliability of the grid had been underestimated. The staff responded by mapping electricity needs to create solar charging hubs in locations with acute electricity supply problems. In the next phase of the project, solar chargers will be distributed to program participants in a ratio of 1:2. Participants will be encouraged to build enterprises to provide for the charging needs of the increasingly connected communities.

Hardware and Maintenance Issues

Phone damage and malfunction is inevitable. During the project, 70 phones had to be replaced, suggesting the need for more durable hardware with the ability to withstand the fluctuating electricity supply, high temperatures, and difficult conditions that characterize remote villages. Late in the project, the participants were willing and able to pay for repairs, so Smart Sakhis supported repair drives to bring nearby repairers to villages at fair prices. In the next phase, Trickle Up plans to expand the training of future participants or their family members to repair and maintain mobile phones and create local mobile repair hubs that can contribute to household livelihoods, while meeting the growing mobile needs of their communities.

Smartphone Ownership, Usage and Potential Negative Effects

In addition to direct project related livelihoods benefits, participants were pleased by the way their phones connected them to their near ones in distant villages. Many also reported having increased self- confidence simply from possessing phones which is currently a status symbol in their villages. Such improvements in social standing, integration, and social belonging are important objectives when working with ultra poor households. There was even evidence that the provision of smartphones was a significant motivator for many ultra poor women, who due to their socio-economic status often require significant encouragement to join. This was explained by a CRP who became a Smart Sakhi after the introduction of the phones,

> *'After I was chosen as Community Resource Person, one of my first tasks was to get the participants in my village to form a Self Help Group. But the participants were extremely apprehensive. They were scared that if they took loans and were unable to repay it, they might even end up getting jailed! It took us a lot of time to convince them to join Self Help Groups, and regular meetings to start happening. When I was chosen as a Smart Sakhi, the situation became much better. None of us had ever even dreamt of owning a mobile phone, let alone smartphones that operate on touch! The feeling of owning a smartphone completely changed the attitude of the project participants. Not only did they become more regular to the meetings, but they were happier to do so, knowing that they needed to be consistent to keep being a part of the program.'*

However, as with all changes that can affect social dynamics, the provision of smartphones and training did lead to some backlash. In fact, in one village, the participants' husbands initially barred them from collecting the phones. Eventually, after the project staff was able to convince them of the benefits to their households, they agreed to the plan, but it required significant engagement and counselling through household level visits. Based on a survey of 400 participants, majority of the women (approximately 60 percent) did manage to maintain primary control over the phones, with the rest still maintaining access. But this needed to be reinforced through frequent coaching visits, and still up to 20 husbands restricted their wives' usage and some took away the phones when they migrated.

This survey suggests that participants were using the smartphones regularly and for a multitude of reasons. On an average the participants were using the PoP app for 15 minutes a day. They also reported spending approximately three hours on entertainment and media. The latter included watching the news and videos to help them with their livelihood activities (the breakdown of this time use was not sufficiently disaggregated in the evaluation). The latter result is of concern, given the addictive nature of online content such as games, especially for new users, while noting the limited entertainment options that exist in remote communities. The participants' stated appreciation of the phones as an entertainment device.

Furthermore, 70 percent reported buying extra data to support their phone usage beyond the basic plan needed for the PoP and other supported apps, which indicates the value they place on it. However, this should not necessarily be seen as positive if it is displacing other important expenditures. It will be important to study this issue in more depth in the next phase, including acquiring more details on how the phones are used by other household members and for what purposes.

Exploring Alternate Models for Cost-effectiveness

Considerable costs are incurred to provide one phone per household at scale (approximately INR 6000 per phone plus INR 500 for SIM cards and screen guards). Therefore, it is important to consider the cost-effectiveness of this model compared to providing a smaller number of phones to be shared among a group of participants (in a SHG) or to be used primarily by field staff (such as Smart Sakhis) to support participants. This latter model was already partly explored, by default, during the pilot project period. After the first iteration of the apps were developed, Trickle Up uploaded them on the phones of the CRP working with ultra poor women in other locations. The CRPs were trained by using a function that can project images from phones on the walls to support training of small groups. Given coaches already had been provided with smartphones to support their monitoring activities, no additional costs were incurred.

Furthermore, towards the end of the program, the Smart Sakhis trained 2500 additional women from their communities on cultivation techniques using the PoP application. The Smart Sakhis, who were not agricultural experts, had themselves been trained through use of the PoP app. While passing on information to other women, they referred to the apps and also passed the phones around, so that small groups of women interested in the same crops could see the images and hear the voice overs. Some participants also showed their neighbors and relatives how to use the PoP app and lent their phones so they could also use them to start new crops.

However, this model also has significant limitations compared with each participant having direct access to the apps and smartphones. Apart from not having access to instructions for crop development at the exact time when each step needs to be taken, it also meant that the data entry by participants is complicated. Monitoring systems used by field staff can address this to an extent, but this reduces active participation and ownership of the data collection process by program participants themselves, which are important skills to develop. This can also require coaches to spend more time entering the data rather than spending time supporting and analysing it in collaboration with the participants. The app could be adjusted to be used in a group setting to enable women enter data under their own profile when they have access to a shared phone, however, the staff assumes that unavailability of the phones at their convenience would limit its usage. As smartphone ownership spreads, this issue may become less important, as the apps can be uploaded on the households' own phones. However, even with rapid expansion, phone ownership among ultra poor households remains low, and some type of subsidy is likely to be required

for the foreseeable future. Therefore, in the second stage of the project Trickle Up plans to assess the cost-effectiveness of different models in which phones with the custom apps are provided to each participant, provided to small groups of participants, or are just provided to community-based field staff.

Conclusions and Way Forward

The pilot project demonstrated that smartphones with custom apps have significant potential for enhancing the effectiveness of programs that promote agricultural productivity among ultra poor women, even when, or particularly when, they have low levels of literacy and technological experience. The PoP apps complement and support the work of front line staff by assisting them in training and mentoring women in livelihood development, providing truly just-in-time information, enhancing discipline related to cultivation, facilitating troubleshooting and contributing to informed decision-making about crop choice. This support appears to be of particular value when the frontline staff themselves are from the target communities, and hence also have limited education levels.

The pilot demonstrated the importance of continually using feedback from staff and participants to refine the app to make it more user friendly and reflect their content needs, and also to adopt implementation mechanisms to meet the varying capacities and learning speeds of participants. There was also significant value in using the provision of smartphones to link to other digital services that support agricultural and general livelihood development, as well as simply enabling voice connectivity to the staff and others. However, it is also important to monitor usage of new technology and experiment with varying models for cost-effectiveness. In partnership with Tata Communications, Trickle Up will further explore these factors in the second phase of the program, incorporating 1000 new participants in Odisha and Jharkhand, plus exploring expansion to Bihar.

Farm Related Services via Mobile Phones in India - A Case of Micro-warehousing for Farmers in Bihar

Prageetha G Raju

Introduction

Agriculture continues to be at the centre of Indian economy. Though it is the primary source of livelihood for almost 58 percent of Indian population, it is plagued by several issues. To elaborate - erratic monsoon, availability of quality inputs, pest outbreaks, inadequate farm equipment, lack of access to fair priced credit and marketing challenges due to multiple intermediaries are some of the challenges facing the Indian farmer.

Notable among the various challenges is, the lack of adequate warehousing services and facilities. For instance, 260 Million Metric Tonnes (MMT) of food grains per annum are produced in India, but, the total storage capacity is mere 115 MMT. The State and Central Warehousing Corporations together account for 85 MMT of warehousing capacity while the private sector provides another 30 MMT. Small and marginal farmer seldom use these facilities, they sell off their surplus immediately and often at distressing prices due to lack of storage facilities.

Ergos, a Bengaluru based start-up provided the idea of micro-warehousing in 2017 through a mobile app, and its experiment with the maize farmers of Bihar was successful wherein the farmers were able to sell at a price that is 20-30 percent higher a few months ahead of harvest. The app lists out the stock held by farmers in warehouses and real-time market price of grains. The farmer can set his price because he is certain of his stock in the warehouse, and is also aware of market trends. Once the farmer stocks grains, Ergos grades the stock and enters details on the app. The farmer can store grains in good condition and sell his stock when he gets his desired price.

The present case is about micro warehousing through a mobile app operationalized by Ergos, and the arduous efforts by them to create an impact amongst maize farmers in Bihar.

Maize Economy in Bihar

Maize is the third most important food grain crop and is cultivated in over 8.12-million-hectare area with an annual production of 19.77 million tonnes and an average productivity of 2435 kg/ha (Maize Atlas of India, 2009 and Langade *et. al.* 2013). Bihar is one of the traditional maize-growing states in India.

As per the Directorate of Statistics and Evaluation, up to the year 2015, the total yield[1] was around 4000 kg/ha and since 2016, the total yield has gone up to 5335 kg/ha. In India, maize is grown in all the seasons i.e., *kharif, rabi* and summer but nearly 90 percent of the production is from *kharif* season and is rain dependent. According to State Agriculture Department officials, nearly 65 percent of total maize in Bihar is grown in Seemanchal and Koshi region.

Maize is an important cereal crop which provides food, feed, fodder and serves as a source of basic raw material for a number of industrial products *viz*., starch, protein, oil, food sweeteners, alcoholic beverages, cosmetics, bio-fuel etc. Not only is it a source of nutrition for humans and livestock as animal feed but also widely used as industrial raw material. Increased industrial demand for maize comes primarily from the starch and milling industry which in turn caters to textiles, paper, glue, alcohol, confectionery, food processing, pharmaceutical industry etc. While the area under cultivation, maize production and yield have increased between 1977 to 2007, there are only 8-10 maize processing units in Bihar. They are mainly into milling of flour and production of poultry feed.

Maize Farmers - Problems and Concerns

A survey with a few maize farmers and traders was conducted using observation and semi-structured interviews to understand their problems and challenges. The key problems that emerged were as follows:

- No Storage Facility: Lack of storage facility prevents farmers from benefitting from high prices of maize in off-season.
- No Minimum Support Price: MSP procurement of maize in the state is almost non-existent which forces the farmers to sell off their produce in open markets at low prices, going as low as INR 500 per quintal.
- Poor Institutional Support: After the scrapping of the Agricultural Produce Market Committees (APMC) Act, no additional institutional support was developed by the state.
- Poor credit delivery system: Informal credit delivery system plays a very important role in meeting the credit needs of the maize cultivators and even processors. Local wholesalers/traders provide credit support to maize farmers for meeting their consumption and production needs and hence farmers are obliged to sell maize to them. The survey showed maize farmers of Khagaria district take an average loan of INR 6000-8000 per acre from the traders/moneylenders to meet their working capital requirement. The informal credit has exorbitant interest rate ranging from 5 - 10 percent per month.
- Disorganized distribution system: Maize sector is highly unorganized with many intermediaries; farmers depend on the local village aggregator/trader who plays a chief

1 The total yield is the summation of *kharif* maize, *rabi* maize, and summer maize

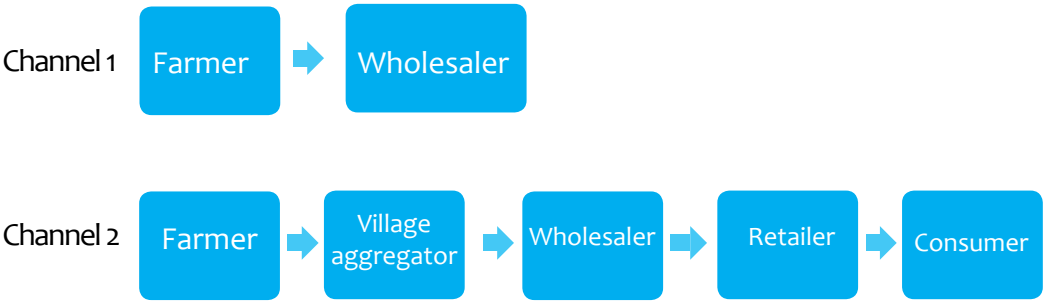


Figure1: Marketing channels in maize

role in procurement and marketing of the produce. Broadly, two marketing channels in maize were observed.

- High Price Fluctuation: It is observed that lack of MSP also gives a free hand to traders and businessmen to decide the price.

The Ergos Model

Ergos, founded in 2012 by Kishore Jha and Praveen Kumar offers solution to farmers through micro-warehousing and collateral management facility. Ergos has connected farmers with buyers for sale of their produce. They also plan for the input requirement and forecast the produce arrival.

Brajesh Mandal, a marginal farmer of Purnea district grows maize twice a year. Even when he had a bumper harvest he received low price for his maize as he did not have any place to stock his grains. In his words, *'Export companies are making a fortune from our maize that they purchase from us at the cheapest of prices. We work hard, put in hard efforts to produce maize, but we hardly get right returns. Maize farmers are exploited by everyone. What can we do?'*

A micro-warehouse is a low-cost format that operates at the village level and helps the enterprise to directly connect with the farmers. Ergos offers a chain of efficient and hygienic warehousing facilities within a range of three to four kilometres from the farmers' locations while also helping them in better price discovery. Ergos also connects the farmers to financial service providers that help them with the working capital at reasonable rates of interest. Ergos uses a mobile phone app, to list out the stock held by farmers in warehouses and share the real-time market price of grains. The farmer can set his price because he is certain of his stock in the warehouse, and is also aware of market trends. Once the farmer stocks grains, Ergos grades the stock and enters the details on the app. This app has helped make farming a viable business for these farmers and minimize the exploitation by traders. The mobile app provides 24/7 access to farmers to sell, transact, or hold the produce. Farmers can track market movements and sell when they realize better prices. Village Champ (VC) is a one-point contact for them to assist on the transaction.

Ergos runs a network of micro-warehouse called "farmer offices" that work in tandem with the retail partners of Ergos to build capacities of smallholder farmers, and to expand the existing user base. Ergos signs agreements on use basis with several smallholder farmers who store their agricultural produce in the warehouse. Once farmers deposit stock in the warehouses, Ergos checks the quality and quantity of the items and issues a warehouse receipt to the farmers certifying the weight, grade, and quality. This receipt serves as a document to obtain credit or loan from a financial institution. Ergos is also able to negotiate better prices on behalf of the farmers, based on this data.

The micro warehouse network arrangement ensures optimum capacity utilization of the warehouse, low wastage, and higher price realization for the farmers.

Another unique concept by Ergos is farmers' portfolio management, wherein its software application captures basic information about all associated farmers. The software captures information related to various business transactions between each farmer and Ergos. The enterprise also provides several value added services including grading, cleaning, sorting, and packaging to its members. It trains farmers on various aspects of financial transactions, contracts and markets. It generates general awareness among smallholder farmers regarding the importance of storage solutions through videos, road shows, and midnight cafes. Ergos uses technology such as advanced Enterprise Resource Planning (ERP) software and other web applications. *Ergoslive*, is a unique portal linked to its ERP core database. The application runs on all browsers and can be accessed by users even remotely. It has developed a mobile app for farmers, end users, and internal staff to ensure minimum turnaround time on any service request, and to make the operations easy and transparent.

How does Ergos Identify Warehouses?

"Ergos only engages with those warehouses which are scientifically constructed and plans are approved by NABARD, Warehousing Development and Regulatory Authority (WDRA), or State Agriculture Department," says the founder, Kishore Jha. The following steps are followed to rope in warehouses and farmers:

- The team conducts a thorough due diligence of the warehouse and creates a survey report covering titleship of warehouse, location, approach road, flood history, height from the ground, distance from police station and fire station, theft history, number of gates, security arrangements, physical condition of the warehouse structure, and number of pillars, among others.
- It finalizes the terms and conditions of long term lease of no less than five years with the landlords and executes the agreement.
- Ergos then obtains notary declaration from the owners, and registers the agreement in local Registrar office.
- The farmers set up account with Ergos, upon submission of KYC documents such as ration card, PAN card, Aadhaar card, driving license, bank passbook, voter card etc.

- Originals are verified by an Ergos executive.
- After the document verification, Ergos creates UID (Unique Identification Number) for the farmer in SAP.

Services, Costs and Revenues of Ergos

Ergos charges a lower rate as they are a social enterprise focused on smallholder farmers. They charge USD 0.09 to USD 0.18 per quintal per month as against USD 0.25 to USD 0.27 charged by others.

Ergos facilitates loans at 10-10.5 percent as it has access to the collateral stored in its warehouses. In collaboration with NCDEX e-market Limited (NeML), they provide electronic warehouse receipts (e-WHR) that farmers can use as a collateral with banks to access credit. Through this platform, it connects the rural warehouses to national market that helps discover better prices for farmers.

Some of the major costs incurred by the enterprise include warehouse rent, relationship managers' salaries, operations fee, and insurance fee. The major revenue streams of the enterprise include warehousing services and advance advisory and processing fee.

Table 1: Costs incurred by Ergos per annum

S. No.	Cost per annum (USD)	Warehouse Capacity (Metric Tonnes)
1	3,000 to 3,750	200
2	4,500 to 6,000	500
3	7,500 to 9,000	2000

Challenges and Lessons

The journey of Ergos wasn't easy. Initially, storage solutions by private sector organization did not receive a ready acceptance from the farmers. Convincing and persuading farmers through road shows, videos, etc. took more than six months. After this, Ergos faced several other challenges relating to marketing, finances and distribution. For instance, there were serious problems in managing operating cash flow, especially for small-size warehouses. The marketing and distribution challenges were related to customer engagement, awareness and trust building, and the need for behavior change amongst the smallholder farmers to adopt warehousing practices. Human resource challenges included difficulty in attracting, training, and retaining suitable talent, as the business concept itself is new, and people with desired skill-sets are rarely available.

Outcomes and Impact

Ergos has disrupted the conventional warehousing model by providing doorstep access to warehousing services to farmers. The company leverages a strong technology platform to ensure services to farmers almost akin to a "grain bank". The company's operations are currently based in the state of Bihar.

Ergos was able to negotiate better prices on behalf of the farmers, based on ERP data. The micro-warehouse network helped Ergos accomplish business development as well as transaction execution. *'Ergos is able to achieve higher turnover with limited capital. It has also achieved greater price efficiency in certain crops such as maize, wheat, and paddy, as these are the major crops cultivated in the region,'* says Kishor Jha. Initially, the team set up the warehouse facility with the help of National Collateral Management Service Limited (NCML), which helped Ergos to understand warehousing and credit access, and also provided access to finance to enrolled smallholder farmers. The farmers who are at the core of the value chain, are slowly realizing the benefits and the convenience that follows e-negotiable warehouse receipts (eNWRs), especially with regard to access to easy finance.

The success of Ergos has been a result of a partnered effort between NERL and Svakarma Finance to help farmers in India avail easy access to credit facilities, which is the beginning for many more farmers to come on board the Repository Platform. As on October 2019, nearly 7000 farmers out of 19913 registered on the platform in Samastipur, Begusarai, Darbhanga, KJhagaria, and Muzzaffarpur districts of Bihar are reaping benefits of a smart decision taken last season. Instead of selling their produce cheap, or immediately after harvesting, they warehoused yields and waited for grain prices to appreciate in the off-season.

Ergos charges INR 7-12 per quintal (per month) as warehousing-cum-market linkages charges. The post-sale payment (to farmers) is made within four to seven days into the bank account of the farmers. For immediate cash requirement, the farmer can use the warehouse receipt to borrow (70-75 percent loan-to-value) from banks and Non-Banking Financial Company (NBFCs) such as Samunnati, IDBI and SBI, in this case.

Ergos' model tends to address the following -

1. Enables farmers to warehouse their produce and thus avoid distress sales during harvest season at low prices.
2. Set up digital warehouses at the village level
3. Help farmers reduce wastage by quality warehousing.
4. Help farmers tide over their immediate liquidity/ financing needs by working with NBFCs/ Banks to extend loans to farmers against the security of their warehoused produce on one click.
5. One Tap-Connect farmers to market enabling them sell their produce in the off-season, at prices which are nearly 25-30 percent higher.

Impact

Ergos began with four warehouses (with 800 MMT storage capacity) in 2013 and has grown to include over 42 digital warehouses (aggregating over 20000 MMT).

The impact can be inferred from the satisfaction of the farmers as well as the rising demand for micro digital warehousing services of the company. Since the entire

intervention is geared towards participation of small and marginal farmers (S&M), an attempt was made to examine the pattern of participation vis-à-vis medium and large farmers (M&L) and changes in the same over time.

Since Samastipur is the oldest district where Ergos started their intervention, the trends are more visible here as compared to the other two where work was initiated only in 2016. In 2015-16, maximum number of registrations and participations were from farmers in the S&M category. However, there was a significant shift in both registration and participation by 2017-18, when the total registered S&M farmers at 3593 are outnumbered by the total medium and large (M&L) farmers at 4388. However, the company seems to have made a conscious effort to give preference to S&M farmers as reflected in the actual usage figures where S&M stands at 787 (57.8 percent) as compared to 576 (42.3 percent) for M&L in the year 2017-18. A similar ratio is to be seen in the other two districts where the S&M farmers account for 69.5 percent in Begusrai and 72.2 percent in Muzaffarpur of actual usage. The good news is that landlords are beginning to buy in to the model and building larger warehouses for Ergos.

In summary, the following impacts have been created through the Ergos Model of warehousing using mobile app:

- Economic impact achieved: Increased volume of sales, increased yield, increased market access, increased access to credit, reduced transaction cost, reduced production cost, and received higher product prices
- Environmental impact achieved: Increased efficiency in agro chemical use, increased access to agricultural information services in real time
- Social impact achieved: Increased women's participation, increased youth participation, improved social capital, increased economic mobility, enhanced social inclusion, improved social equity, enhanced social well being
- Technical impact: Increased technology adoption, improved information dissemination, increased labor demand, increased the need for agricultural extension agents, better support for extension agents

Dvara E-Registry – Leveraging Technology to Enhance Credit and Insurance Delivery to Small and Marginal Farmers in Odisha

Sanjay Mansabdar

Dvara E-Registry – Leveraging Technology to Revitalize Farmer Livelihoods

Dvara E-Registry, a start-up and new initiative promoted by the Chennai-headquartered financial conglomerate Dvara Trust, aims to help channel financial products to rural India using an intelligent blend of macro and micro alternative and traditional data to bridge the information asymmetries between clients and providers. By harnessing a variety of technologies like mobile and GIS and the power of Machine Learning, Dvara E-Registry aspires to enable the rural under-banked to participate seamlessly in the mainstream financial marketplaces and facilitates customisation of banking and insurance products.

Dvara Trust (formerly known as IFMR Trust) was set up in 2008. Dvara Trust's mission is to ensure that every individual and enterprise has complete access to financial services. The Trust invests in and supports commercial efforts that advance this mission and works towards bringing about systemic change that impacts millions of low-income households in rural and urban India.

Dvara Trust's portfolio companies include –

- Northern Arc Capital (Formerly known as IFMR Capital), a Non-Banking Finance Company that provides access to debt for under-banked individuals and businesses in India. Through a combination of capital, products and partnerships, it has created a platform that connects over a hundred non-bank financial institutions to mainstream debt investors.
- Dvara KGFS is building and supporting local, geographically focused community financial services institutions called Kshetriya Gramin Financial Services (KGFS). Each branch serves the local population focusing on a limited geography, offering a suite of financial products to remote rural households. Dvara KGFS has successfully completed 10 years of successful operations in India with extensive work done in Ganjam and Khurda Districts of Orissa, besides states such as Tamil Nadu and Uttarakhand.
- Dvara Solutions designs and offers technology solutions for financial institutions and enables them to deliver high-quality financial services in a convenient, flexible, reliable and continuous manner. Through its flagship product Perdix, it helps automate end-to-end process of a financial institution through modules such as the customer management system, loan management system, audit management system, business intelligence system and learning management system.

- Dvara Money is a digital platform that facilitates the distribution of financial products by leveraging technology and deep customer insights to deliver focused and suitable solutions to its customers.

Dvara E-Registry, aiming to improve access to agricultural credit and crop insurance and offering timely advice to farmers, has embarked on a programme in Odisha to use technology as an enabler to address the challenges farmers face. Dvara E-Registry's flagship initiative, launched in June 2019, is its mobile application 'Doordrishti' (loosely translated as far-sighted) in the Keonjhar and Jajpur districts of Odisha. The case-model under study is being implemented in a pilot in partnership with the Government of Odisha, Dvara KGFS, Dvara E-Registry, International Food Policy Research Institute (IFPRI) and Precision Agriculture for Development (PAD) in two districts of Orissa in 2019 *Kharif* season. Dvara E-Registry's partners contribute significantly to the building of the data platform in the areas of research and development, data collection, data analysis, and the provision of real-time tech-enabled advisory and financial products including credit and insurance to farmers.

The choice of Odisha to launch the Dvara E-Registry pilot was underpinned by

- The challenges faced by the state's agricultural sector are more acute than in the rest of India
- The state government's initiatives to bolster the farm sector through a slew of policies including crediting direct benefit transfers to the farmers' bank accounts, thereby promoting financial inclusion, and
- The expertise Dvara E-Registry's management possesses in the state's agrarian sector

What Ails Agriculture in Odisha?

Spanning an area of 1.55 lakh sq. kms, Odisha lies in the tropical zone along the eastern seaboard of India. It is the ninth largest state in India by area and the eleventh largest state by population. Notably, the state also has the third largest population of Scheduled Tribes in India[1].

Odisha's diverse topography encompasses plateaus, rolling uplands, deep-broad valleys, and coastal plains. The coastal plains are fertile, well irrigated, densely populated and constitute the State's agricultural hubs – Cuttack, Sambalpur, Balasore, Koraput, Dhenkanal, Ganjam, Kalahandi and Keonjhar.[2, 3]

Odisha's climate is tropical, characterized by high temperature and humidity, medium to high rainfall and short and mild winters. The normal rainfall of the State is 1451.2 mm.[4] Even though the quantum of rainfall is quite high, its distribution during the monsoon period is highly uneven and erratic, making the state vulnerable to floods, cyclones and other vagaries of nature.

1 "ST & SC Development, Minorities & Backward Classes Welfare Department:: Government of Odisha" - www.stscodisha.gov.in.
2 Odisha Economic Survey 2017-18
3 (Geography of Odisha, n.d.)
4 https://agriodisha.nic.in/content/pdf/STATUS_AGRICULTURE_IN_ODISHA_inf_30032015.pdf

Odisha's economy is primarily agrarian in nature with 61.8 percent of the working population, the highest among Indian states, engaged in agriculture activities.[5] Though the share of agriculture in Gross State Domestic Product (GSDP) has declined to 20 percent from a peak of 60 percent in the 1960s, the share of the population dependent on the sector continues to be high.[6]

Not withstanding Odisha's favourable agroclimatic conditions, the agricultural sector faces several challenges that stymies the state's economic development. Highly fragmented land holdings and informal land tenancy in conjunction with scarce availability of formal and cost-effective credit, insurance and advisory services have led to:

- Odisha's agricultural productivity lagging India's none too stellar productivity. The state's per hectare production of rice at 1.4 MTs is 22.0 percent lower than the all-India average of 1.8 MTs.
- The state's large farming population languishing in poverty. The percentage of rural poor in the total State's population at 48.01 percent, this is the highest in India.[7] The proportion of people living below the poverty line in 2004–2005 was 57.15 percent in Odisha, which was more than twice the all India average of 26.10 percent. Supportive government policies contributed to significant reduction of population below the poverty line by 2,455 basis points to 32.6 percent. These policies include natural disaster management initiatives, the KALIA scheme to boost farmer incomes, improvement of the public healthcare system, Mission Shakti to empower women and high and improving rural connectivity.

The Twin Banes of Odisha's Agriculture

Highly Fragmented Land Holdings

The onset and proliferation of mechanisation in agriculture reduced the per unit costs of large farm holdings and endowed large farmers with competitive advantages. Large farmers access and leverage irrigation, machinery, technology intensive farming methods, credit and insurance more easily than most small farmers. The later continue to rely on monsoons and ground water, labour intensive agricultural practices, informal, scarce and expensive credit and at best, minimal insurance. Small and marginal farmers are thus more vulnerable to health, labour market, pests, productivity and weather- related risks.

The average size of a farm holding in Odisha at 1.6 hectares is much smaller than the average size of farms in other Indian states.[8] By 2010-11, the State had 46.47 lakh operational holdings of which an overwhelming 91.8 percent were marginal and small holdings while a mere 8.0 percent were semi- medium and medium, and less than 1.0 percent were large holdings.

5 (List of states with Population, Sex Ratio and Literacy Census 2011, n.d.)
6 Odisha Economic Survey 2017-18
7 Tripathy, K. K., and Sudhir K. Jain. "A study of microfinance as an innovative credit delivery mechanism in rural India." IUP Journal of Agricultural Economics 8.3 (2011): 38.
8 Odisha Economic Survey 2017-18

Informal Land Tenancy

Leasing farmland is quite common in rural India and the practice of tenant farming is getting more entrenched in Odisha as in the rest of India. According to the 70th Round of the NSSO Report, the number of tenanted holdings in Odisha increased by 16.9 percent between 2003 to 2013; the growth rate across India was 10.4 percent[9]. Most of the tenant farming in India is completely informal. Tenant farmers have no proof of tenancy making it difficult for bankers and insurance providers to source reliable information such as land and crop records. The absence of robust information and inability to monitor the progress of a crop through a sowing season renders it difficult for tenant farmers to access farm credit, insurance and advisory services.

Impact on Odisha's Small and Marginal Farmers

- Highly fragmented land holdings and informal tenant farming practices have resulted in the low penetration of banking and insurance services and high indebtedness among the small and marginal farmers in Odisha.

- Low Financial Penetration: Even after the introduction of Kisan Credit Cards, tenant farmers received barely 3 percent of the total farm credit.[10] According to the Odisha Economic Survey 2017-18, crop loans disbursed by the Government of Odisha to farmers almost trebled over a seven-year period to INR 15531 crores in 2016-17 from INR 5449 crores in 2010-11.

- Land owners, despite having (mostly informally) leased out their agricultural lands and not participating in the cultivation process, avail a significant quantum of crop loans. Tenant farmers, at best, have minimal access to formal cost-effective credit and rely on money lenders who charge usurious interest rates.

- Tenant farmers with no documentary evidence also became ineligible for receiving crop insurance.[11] Crop insurance claim settlements in Odisha face hurdles with most claims being disputed or inordinately delayed. This delay primarily stems from lack of verified information about the crop grown, the timeline of crop growth and lack of proof to establish the cause for crop failure. 'The Wire' obtained RTI data indicates that during the 2018 *kharif* season in Odisha, of the aggregate claims estimate of INR 565 crores, the approved claims amounted only to INR 237 crores (an abysmal approval rate of 42 percent).[12] Of the approved claims, those pending as a percentage of the approved claims amount to 95 percent. This is a major cause for concern as farmers are left with no capital for the subsequent crop cycles. Only about 4.5 percent of rural households in Odisha have made any financial investment of sorts when compared to states like Punjab where at least 20 percent of households are covered.[13] Tenant farmers account for about 85 percent of farmer suicides in Odisha.[14]

9 https://www.thehindubusinessline.com/opinion/tenant-farmers-being-left-high-and-dry/article26081913.ece
11 70th Round of NSSO Survey Report
11 https://www.thehindubusinessline.com/opinion/tenant-farmers-being-left-high-and-dry/article26081913.ece
12 NABARD Rural Financial Inclusion Survey 2016-17
13 https://thewire.in/agriculture/pmfby-crop-insurance-claims-unpaid
14 http://www.im4change.org/docs/Small-Farmers-Suicide-in-Odisha.pdf

- High Indebtedness: An average Odisha farmer is often identified by the unfortunate tag of 'perennial debtor'. The quality of living of an average farmer in Odisha is worse than that of farmers in the rest of the country due to their low earning power, exploitative private (informal) credit mechanisms, high personal indebtedness to meet social and consumption needs, and climate-change induced calamities.

Other Pertinent Issues

In research work titled 'Impact Assessment of BGREI Programme on productivity and income of rice growers in Odisha' authored by Behera and Kumar, major constraints facing agriculture in Odisha were recorded as - lack of extension and supervisory guidance, lack of on-time input supply, lack of focused research and extension, lack of proper marketing facilities and transportation of produce and delay in payment of the produce sold by the farmers in *mandis*.

Other pertinent issues are extensively covered in news and social media platforms, and in the field of agriculture research include the lack of timely interventions in the agricultural sector in areas of credit delivery during crisis, timely guidance before and after calamities, guidance in terms of availing financial services like credit, insurance, interventions in building technologically viable irrigation methods and scaling them.

Enter Dvara E-Registry – Technological Solutions to Address Gaps in Agricultural Services Delivery

Dvara E-Registry is focused on the delivery of agricultural services, which comprises financial and advisory services to small and marginal farmers, in order to achieve the twin goals of improving their quality of living and raising the state's agricultural productivity.

As in September 2019, pilots of Dvara E-Registry's pioneering model of agricultural service delivery are being conducted in Keonjhar and Jajpur districts of Odisha. The service delivery model is based on an 'activity-based lending' premise, using 'picture-based oversight' and monitoring of crop phenology using a smartphone based near-surface remote sensing approach as a suitable tool to enhance financial services penetration and to provide timely advice to farmers. The methodology was the outcome of extensive feasibility studies[15, 16] carried out by IFPRI. IFPRI is Dvara E- Registry's partner specializing in agricultural research and development.

Activity-based Lending

Dvara E-Registry's agricultural service delivery model establishes a farmer-land parcel association from the very beginning of a crop cycle right to the end, thereby sourcing

15 Ceballos, Francisco; Kramer, Berber; and Robles, Miguel. 2019. The feasibility of Picture-Based Insurance (PBI): Smartphone pictures for affordable crop insurance. Development Engineering 4: 100042. https://doi.org/10.1016/j.deveng.2019.100042

16 Hufkens, Koen; Melaas, Eli K.; Mann, Michael L.; Foster, Timothy; Ceballos, Francisco; Robles, Miguel; and Kramer, Berber. 2019. Monitoring crop phenology using a smartphone based near-surface remote sensing approach. Agricultural and Forest Meteorology 265(February 2019): 327-337. https://doi.org/10.1016/j.agrformet.2018.11.002

details about the crops grown by farmers and their health, by receiving, storing and monitoring a weekly record of the crop during the entire period of the crop cycle. The continuous availability of farmer-land parcel wise crop growth and crop health information will enable Dvara E-Registry and its partners to provide tailor-made guidance to farmers on use of customized inputs, weather and market information, potential pest attacks and other disease outbreaks and prevention, and expected yield and harvest time.

This reliable farmer-land parcel association coupled with weekly information dissemination will help address the following challenges

- Absence of verified documentation to establish farmer-land parcel associations
- Scarce availability of cost-effective credit from the formal sector resulting in farmers borrowing from local money lenders at exorbitant interest rates
- Risk of agricultural loans being diverted for consumption purposes
- The formal sector's inability to disburse loans in a timely manner
- Low insurance penetration
- Inability of farmers of all categories (small, marginal, large and tenant) to access timely advice and information on weather, agricultural commodity prices, government schemes etc.

The agricultural service delivery model, underpinned by advanced algorithms and technologies like artificial intelligence, machine learning, remote sensing and satellite imagery, generates ground-level insights to address the said issues.

Farmers possessing smartphones is a prerequisite for the agricultural service delivery model, which is based on entry-level data sourcing and collection, to be successful. Dvara E-Registry conducted a research poll, which established that 25 percent of the farmers owned smartphones and that almost all farmers had access to smartphones through their friends and family. Hence a smartphone based data collection technique was deemed appropriate as the model required only timely sourcing of information like images of crops and ownership of a smartphone wasn't required.

Picture-based Oversight

Dvara E-Registry created a mobile application called 'Doordrishti' which is in Odia language, features an onboard voice (in Odia) and image-based guidance. It was designed to be largely asynchronous to account for poor data connectivity. The app's user interface is simple, and farmers are able to easily enter the data and upload the information as required.

Each farmer was asked to input the following two types of data/information:

- One-time basic data required at the time of onboarding of the farmer: The basic details of the farmer like name and address along with KYC documents are collected through the app. The farmer was also asked to provide the survey / Khata number

of the land he/she was cultivating. Farmers were asked to download 'Doordrishti' on their smartphones and capture and upload 5 images of their land-parcels through the app. 'Doordrishti' has the capability to map the metadata or co- ordinates of the land parcels whose images are captured through the app. This one-time data provision enables Dvara E-Registry to validate an individual farmer's operational holding. The app is tamper-proof and uploads farm parcel images, associated coordinates, and time stamps in a cloud storage. Additionally, every digitized land parcel is checked against the existing database of land parcels to ensure that the same land parcel cannot be claimed by many farmers. This information is captured well in advance of the crop cultivation season to help partner institutions decide on seamless ways to provide suitable financial and advisory products to Dvara E-Registry's farmer partners.

- Recurring Information Through the Tenure of the Loan: Once a loan is sanctioned and the initial sowing is completed, Dvara E-Registry trains farmer-partners to capture and share 5 images of the field/crops through 'Doordrishti' on a weekly basis. These repeat data-sets are collected and shared with partner institutions and are used to record and monitor:
    - Real-time crop cycle stage
    - Crop health
    - Customized inputs to be provided to the said farmer
    - Remedial measures in case of crop damage
    - Farmers' commitment as demonstrated by their punctuality in transmitting images.

This method is used to establish activity by a specific farmer on a specific land parcel, without the need for documentation. Tenant farmers, who comprise a significant proportion of farmers in Odisha and in India, may thus easily access financial and advisory services.

'Doordrishti' at Work

The captured metadata such as latitude, longitude and timestamps are juxtaposed with remote-sensing technology generated high-resolution satellite images to identify the exact land parcel and cropping area. The repeat data sets consisting of images' metadata like timestamps, longitude and latitude of the same piece of land serve to reconfirm the farmers' activities. This primary confirmation is done every time when farmer-partners transmit images to ensure that the same farmer-land parcel association was being referenced, thereby strengthening the farmer-land parcel association.

The agricultural service delivery model combines image processing intelligence and satellite data to identify the crop, crop stage, crop health, expected yield and predict the harvesting time. Machine Learning is adopted to identify and study the above said information in a dynamic real-time format. The information allows for several specific product

enhancements and serves as real time-data to provide much needed timely advisory for farmers, and as a real-time document for land and crop verification.

The product enhancements supported by the agricultural service delivery model include:

- Milestone-based lending: The milestones are specific stages achieved in crop growth that is identified by farmer-partner transmitted images and satellite data
- Insurance cover: The fool-proof farmer-land parcel mapping Doordrishti provides and the recurring images sent by farmer-partners enable them secure appropriate insurance coverage
- Pricing of insurance policies: The recurring data helps predict land parcel specific crop yield that reduces insurance basis risk substantially in insurance programs like the PMFBY
- Insurance claims: The time series of images transmitted by farmer-partners and satellites serve as evidence of damage and enable insurance companies to accurately calculate damages and claims if the crop were to fail prior to harvest.

Dvara E-Registry shares customized farmer information to its partner - PAD, a Government of Odisha accredited agency, which in turn provides customized advice to farmer-partners. This advice is based on the verified images that farmer-partners send.

Outcomes of Adopting Doordrishti

With the adoption of Doordrishti, Dvara E-Registry aims to enable the actual cultivators of land i.e., tenant-farmers to avail of formal, cost-effective crop loans, the appropriate insurance cover for the lands they till and the crops they sow, and professional and customised advice based on the images farmer- partners upload.

Dvara E-Registry, as a part of its pilot launched in June 2019, has surveyed 1,871 farmers and has identified credit worthy 147 farmers, of whom 7 have availed crop loans by the end of August 2019.

Table 1 delineates the process of crop loan disbursement, starting from farmer surveys and culminating in crop loan disbursements.

Table 1: Status Update of Dvara E-Registry's Pilot (as on August 31 2019)*

Branch	Districts	Farmers surveyed	Shortlisted for credit advice	Credit appraisal completed	Farmers eligible for credit	Doordrishti installed & land digitalised	Loan disbursement completed
Keonjhar	Keonjhar	584	426	49	35	24	0
Mangalpur	Jajpur	655	336	99	55	34	4
Panikoil	Jajpur	632	222	90	57	29	3
Total		**1871**	**984**	**238**	**147**	**87**	**7**

**Figures represent number of farmers*
Source: Dvara E-Registry Pilot Records

With this soft launch, Dvara E-Registry targets running the pilot for three years, covering potentially six crop cycles. Paddy growing farmers are the target group in the pilot; the company proposes to extend its service to cultivators of other crops on a best-effort basis. Dvara E-Registry has shortlisted for credit advice close to 1,000 farmers in the first crop cycle and aims to expand its coverage to over 25,000 farmers by the sixth crop cycle by making its data and technology platform widely available to participating financial institutions.

Takeaways

Agriculture, in general and especially in India, is a complex industry. A vast landscape with varying topography and climactic conditions necessitate the adoption of customised cultivation methods for different crops and in different regions in India. Inadequate investments in agriculture, predominantly monsoon dependent irrigation systems, highly fragmented land holdings, prevalence of tenant farming and low access to financial and advisory services have resulted in most tenant farmers languishing below the poverty line. Dvara E-Registry believes that the use of cost-effective technology including mobile apps in local languages, satellite imaging, artificial intelligence, and machine learning will help improving agricultural productivity in India and the quality of living of the nation's small and marginal farmers. Public-private partnerships in which the central, state and local governments, research institutes and think tanks, financial service providers, technology and telecom companies, farmers and intermediaries that link all stakeholders need to work in tandem to achieve the ambitious goals of revitalising Indian agriculture and boosting farmer incomes.

Dvara E-Registry's pilot in Odisha demonstrates how multiple agencies may function cohesively to improve the lives of farmer-partners and has potential to ameliorate agricultural productivity. The company aims to scale its model across other districts in Odisha and across the rest of India to achieve similar outcomes.

AGRIBUDDY - CONNECTING THE NEXT BILLION
Case Study of the Red Chilli Project, Khammam Telangana

Raj Kancham

Introduction

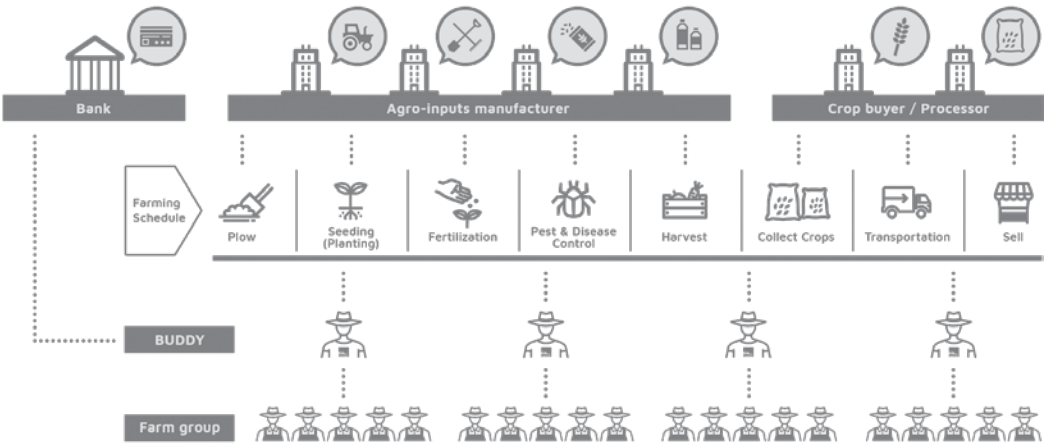
AGRIBUDDY aims to make agriculture a sustainable business for farmers. The objective is to transform agriculture and make it remunerative for every stakeholder in the agricultural industry globally.

Picture 1: The AGRIBUDDY model

The AGRIBUDDY platform helps farmers in getting the highest productivity and efficiency from their farms. The platform aims to "connect the next billion" to educate and sustain the next generation of farmers. The platform provides a variety of knowledge and tools, from information on crop care to market intelligence and updates on the latest agriculture technologies. Additionally, AGRIBUDDY also provides its own credit scoring function to improve access to finance for purchasing agricultural resources.

AGRIBUDDY partners with farmers, service providers and agri input suppliers to provide complete extension services required by farmers for their crop production. The AGRIBUDDY team works closely with farmers on providing quality services and coordinates with other players in the value chain for providing crop advisory, agri inputs and market access for fetching a fair price for farmer's produce. The BUDDY (rural entrepreneurs) integrates communities of farmers by collecting and recording individual farmer data such as land area, crop data, yields, infrastructure availability, weather patterns etc., and facilitates good and services to farmers, by being a conduit for expert inputs such as latest in agronomy, soil testing, fertilizers, seeds, best time for planting, market information, harvest and market connects.

The AGRIBUDDY platform also enables aggregation of agri commodity outputs for domestic and export bulk buyers. The platform can track availability in real time, execute tighter quality control and coordinate logistics for higher cost-efficiency across disparate regions and multiple locations. AGRIBUDDY also functions as a monitoring platform for contract farming companies.



Picture 2: The AGRIBUDDY technology platform

AGRIBUDDY in India

AGRIBUDDY was founded by Kengo Kitaura and is now managed by a diverse and skilled team from Japan, Cambodia, India, Hong Kong and Vietnam. Agribuddy India Pvt Limited is registered in Gurgaon, Haryana and has started operations in the state of Andhra Pradesh and Telangana. Its India business is led by Raj Kancham and Naho Shigeta. AGRIBUDDY has offices in Guntur, Andhra Pradesh, Bangalore, Karnataka and Gurgaon, Haryana. Primary operations are run out of Bangalore and Guntur offices.

Nature of Problem

Market research conducted by AGRIBUDDY revealed the following issues and challenges confronted by farmers:

- Non-availability of credit from formal financial institutions was a major issue that the farmers were facing. As a result, they were forced to borrow money from money lenders and middle men at a very high rate of interest going upto 24-36 Percent per annum.
- Middlemen were hedging crops at very low prices for providing unsecured loans to farmers
- Farmers depended on local input providers for agronomy advice. The input providers had vested interest in offloading their inventory. As a result, farmers did not get desired results from the inputs that they were purchasing
- Not following modern agricultural practices increased the cost of cultivation for famers
- Over usage of agricultural inputs led to unhealthy low grade produce
- Farmers did not receive timely and sound agronomic recommendations because of weak extension systems

- Farmers were not getting the correct price for the produce and were paying higher commission charges to middle men
- The farmers did not receive timely payment for their crops. At times the buyer did not even return to pay for the farmers's produce causing huge losses to farmers.

The Red Chilli Project was designed to address the above problems and bring in transparency in the entire farming ecosystem.

The Red Chilli Project

The AGRIBUDDY Red Chilli project is a transformational project, that will for the first time bring a transparent, end to end value chain to small and marginal framers encompassing a range of goods and services such as soil testing, provision of agri inputs, quality agronomy advice, on-ground monitoring of crops, financial assistance, and market access for better price for the produce.

Selection of farmers was based on their progressiveness, willingness to adopt scientific package of practices, good credit history and openness to take instructions from AGRIBUDDY on ground representatives.

This project is located in Khammam district of Telangana state.

Acres Under Cultivation	Number of Farmers	Average Farm Size (in acres)	Number of Villages	Loan Amount required (INR)
649	292	2.22	52	44,046,649

Project Finance

Partnering with Samunnati Financial Intermediation & Services Pvt. Ltd. as the crop loan provider, AGRIBUDDY processed loan applications for 292 farmers using its platform and physical collection of documents for fulfilling KYC requirements of the financial institution as per RBI guidelines. Since AGRIBUDDY had automation in place, they were able to complete the loan application process within 2 weeks for all farmers across 52 villages. Samunnati sanctioned a collective crop loan of INR 5 Crores for this group of farmers.

Crop Insurance

Partnering with Weather Risk Management Services Private Limited (WRMS), AGRIBUDDY enabled farm level crop insurance for farmers, covering pest attack and weather risks. This insurance was underwritten by HDFC ERGO.

Since AGRIBUDDY had the loan application automation in place, insurance forms were pre-populated, and the farmers were only required to sign on the form. This reduced the time required for filling of farmer details into insurance forms.

WRMS installed weather stations in every project village, giving near real time weather updates of the farms, which is helpful in analytics and to substantiate insurance claims.

The maintenance of weather stations is assigned to BUDDYs which creates an income source for them.

Agro Inputs Supply Chain

Partnering with BigHaat.com, an online platform, AGRIBUDDY has negotiated and aggregated input supplies for on time delivery, aligned with the planting schedule. BigHaat being an online platform, it becomes easy for AGRIBUDDY to put in farmer orders and plan supplies online in a timely fashion.

This arrangement largely reduces time, human errors and supports ease of communication. BigHaat ensures the agri inputs are delivered in each village and collected by the farmers on time. All records are maintained both digitally and physically with the farmers in a farm book which records input supplied and applied in the fields.

Partnering with Professor Jayashankar, Telangana State Agricultural University and Red Chilli Research station, Khammam, AGRIBUDDY with their multi-year domain experience, have developed a detailed package of practice required to grow Red Chilli in a scientific way. The field staff of AGRIBUDDY have been trained on this package of practice, and further conduct farmer training in each village to ensure the package of practices are followed as per the guidelines provided.

AGRIBUDDY leverage a combination of tech and non-tech methods to measure progress. To start with, they have issued farm book for all the farmers enrolled under this project. Their field staff captures data of input delivery and application during the previous crop cycle. For farmers "seeing is believing." So data in the farm book gives them confidence while AGRIBUDDY staff captures the same on the mobile app for backend analytics and processing.

The AGRIBUDDY team along with the BUDDYS monitor the field by meeting the farmers and provide them with agronomy advice on a weekly basis. Apart from on-ground agronomy support, AGRIBUDDY also send in automated planting schedule, tips, alerts and symptoms to look out for via SMS in vernacular language.

Any emergency situation is quickly addressed using platforms like WhatsApp and Telegram where the farmer or AGRIBUDDY staff can record videos and send them to AGRIBUDDY agronomy team for expert advice. This real time communication using video and audio has helped arrest pest attacks at village level.

Tracking using both the ground staff and technology enabled systems has got the farmers efficiency in resource usage and protected the crops from overuse of pesticides and fertilizers.

Market Connect

AGRIBUDDY has signed a contract with farmers to buy back their crops from the farms managed using AGRIBUDDY's package of practice. When the harvest is ready, AGRIBUDDY sends the day's market price over SMS to member farmers. If any farmer agrees to sell their produce, AGRIBUDDY collects the crop, grades and sorts them at the farm itself and makes digital payment into his bank account that was recorded during the registration process.

The farmer stands to gain by selling his produce to AGRIBUDDY as they do not charge any commission, which is paid to middle men (typically 5 percent). AGRIBUDDY deducts the loan amount and repays the Crop Loan provider the outstanding, paying the balance to farmer instantly at the farm gate using UPI/ IMPS payment methods.

Building Circular Economy Models for Recycling Black and Grey Water for Food Security

Pooja Gupta and Dhiraj Santdasani

Introduction and Background

Economic development of a region where agriculture is the mainstay of livelihoods of majority population, encompasses two crucial aspects- inclusive growth and poverty reduction. If the agriculture sector fares well, both these vital aspects strengthen, resulting in sustained economic development for the region. The state of Tamil Nadu has always performed well ahead of other states with a stellar record production of 10.1 million tons of food grains in the year 2011-12 and, highest productivity of sugarcane and other important crops such as oilseeds and maize. Unfortunately, the growth rate in agriculture over the last decade has taken a dip because of rainfall deficit and limited or non-availability of sufficient water for irrigation.

Irregular rainfall over time has resulted in substandard production of standing crops dependent on rain-fed conditions. There is a need for renewed innovative methods to meet the ever-increasing requirement of food, in view of the limited scope for expanding cultivation under irrigation.

Introduction to the Region Where the Innovation has Taken Place

The Nilgiris district in the state of Tamil Nadu in India is home to several indigenous communities, flora and fauna whose livelihood interaction is shaped by the water flow landscape. Nilgiris has a population of 7.35 lakhs with over 40 percent of total working population associated directly or indirectly with agriculture making it the principal source for livelihood in the region (Census 2011). Nilgiris is known for cultivating exotic vegetables such as carrots, beans, broccoli, Chinese cabbage, beetroot, garlic, strawberries etc.

As the state of Tamil Nadu faces frequent dry weather spells affecting tea plantations, horticulture and vegetable cultivation, farmers are in dire need of access to water and bringing moisture content back to soil. Hydro-electricity power generation also requires water in large quantity.

Natural sources of water such as ground water have been exploited inequitably and without considering the sustainability across the state. Scarcity of natural sources of water and increase in demand for water has meant exorbitant increase in price of water for irrigation purpose.

WASTE

WASTE, a Netherlands based organization in partnership with the Rural Development Organization (RDO Trust), Nilgiris has developed a model for producing high quality co-compost from waste water and faecal sludge for cultivation of exotic vegetables by women farmers in the district. In order to enable target consumers to buy the co-compost, WASTE has implemented **The Diamond Model** that provides tools for private financing alongside potential market linking strategies in addition to generating quality co-compost and providing access to treated grey water. The innovation has received monetary award and support from Securing Water for Food (SWFF). The aim of the innovation is to establish a local circular economy model in sanitation for agriculture that is scalable and enables women agri-entrepreneurs to have better quality of crops with market quality co- compost application and extend crop season to advance green growth in the Nilgiris. The cultivation of crops is essentially an interplay of inputs such as seeds, fertilisers, pesticides, water and credit which determine the production and productivity. It becomes pragmatic to utilise inputs more efficiently and diversify cultivation to more sustainable and higher value crops.

Inadequate treatment and disposal of solid and liquid waste leads to a massive waste management challenge within the area disrupting the ecological balance of the area. The innovation directly caters to this gigantic issue by converting waste water and faecal sludge into co-compost, therefore, addressing the waste treatment and disposal needs for the authorities. As part of innovation, two resource recovery parks were built nearer to villages, thereby making transportation of co-compost easy and cheap. This whole process of production of co-compost has huge potential of creating jobs, smoothening waste management, increasing agriculture productivity and reducing water stress in agriculture sector.

The Rural Development Organization (RDO Trust)

RDO Trust was founded in 1980 by the renowned social activist, Mr. N. K. Perumal. RDO trust is a non- profit, non-partisan and secular volunteer organization (VO) committed to work for the upliftment of indigenous communities of the Nilgiris. Since its inception, RDO trust has been instrumental in building capacities of rural communities across technological, social, educational and cultural development. Their exemplary work in skilling, training and empowering village level communities have garnered them trust and respect from communities, government and other stakeholders.

Given their incredible work and stellar reputation among the farming community, RDO Trust was evidently the first choice of WASTE for a local implementing partner. They have been working with rural women since years and wanted to invest in training them with newer farming technologies and practices. The target beneficiaries for this project are women agri-entrepreneurs in Self Help Groups (SHG) grouped into Farmer Producer Companies. The project is supported by 13 partners including Canara Bank, National Horticulture Board of India and Bremen Overseas Research and Development Association

(BORDA). The innovation was implemented for the first time in 2017 and has been in operation for two years now.

The case measures the impact of the recent innovation by WASTE in the water stress regions and explores the possibilities which navigates issues related to soil fertility, gender disparities, climate change, income changes, water management, irrigation practices and technologies and market dynamics of the region.

Achieving Efficiency in Resource Use

The intervention is a solution to multidisciplinary problems pertaining to the environmental pollution and agricultural crisis in the Nilgiris. It is known that faecal sludge and grey water possess high value of nutrients which are required for quality crop production. While chemical fertilizers are deteriorating the soil quality, soil improving actions have become must for sustainable farming. Although this calls for leveraging the nutrients available in the waste streams, it is important to recognize the bacterial contamination and high load of pathogens in these streams and arrange for its sufficient treatment for recycling.

Co-compost produced using faecal sludge and treated wastewater has the capacity to improve the ever-worsening soil conditions. Farmers in pursuit of higher production and profits try to use more chemical fertilizers that can yield short term benefits. However, it needs to be understood that chemicals not only affect the health of the consumers but also severely affect the soil productivity in the next seed sowing cycles resulting in lesser production in every next cycle. To stop the menace of this vicious cycle in future, there was an immediate need to incorporate highly organic resources.

Water management can be essentially looked upon into two major parts a) Resource availability and b) Resource management.

While availability of water concerns with the quantum of fresh water available for different applications, water resource management focusses on water supply and demand management followed by wastewater treatment and recycling. Although, all the sectors are important and contribute towards water security, the innovation presented here essentially focuses on treatment and recycling of the water as part of a strategy to address the water scarcity in the region. The prime reason for this particular focus is that the community as a root level stakeholder has limited intervention to make for water availability planning and water supply management. Whereas, recycling and wastewater management initiatives involves the local community and gives them ownership for water management resulting in benefits for them.

The Diamond Model

The model produces nutrient rich co-compost to be used as a soil conditioner for cultivation of exotic vegetables by women farmers in the district. The model focuses on

four key areas for successful implementation of the program and to achieve sustainability in the agriculture sector -

- Farmers raising the demands
- Women SHG members involved with Farmers' Producer Company and managing the supply of co-compost
- Agri-marketing companies for managing finances
- Government authorities for implementation of the project focusing on treatment of faecal sludge and grey water.

Technical innovations within the model involves recycling of greywater and using treated water for irrigation in critical period of lower rainfall and dry seasons. The other innovation is focused on recycling of faecal sludge contained within the on-site sanitation systems of the region. With the presence of private emptying operators and government vacuum trucks, these containment systems are emptied regularly and the faecal sludge is transported for treatment to produce co-compost at the end. The co-compost unit is operated by women in cooperation with town panchayats by mixing faecal sludge and organic solid waste. Women farmers who procure the co-compost are members of the Women Farmers Producer Companies and Groups.

The innovation presented here answers both the agriculture challenges prescribed in the discussion, water scarcity and soil productivity in one single attempt. It not only addresses both the major challenges, it also solves the menace of solid and liquid waste management in the region for the authorities which is a win-win situation for all stakeholders. Additionally, the model also incorporated market linkages for continuous business for farmers cultivating exotic vegetables and has enabled mobilization of private finances to overcome economic challenges for the stakeholders involved.

Technology Details

The intervention has two major technical applications in the project – a) greywater recycling at local level and b) Faecal sludge recycling with organic solid waste using co-composting methods. Figure 1 explains the faecal sludge recycling and the treatment process flow.

Earlier, faecal sludge used to be collected and dumped at either open grounds at distant locations or into the nearest water bodies resulting into heavy contamination of the freshwater resources. Whereas, the intervention here collects the faecal sludge from the private vacuum truck operators, transports it to the treatment site and feeds into the system.

Vertical wetlands: The unit essentially acts as a solid liquid separation system where the faecal sludge is first fed upon its advent at the treatment plant. The wetland is constructed

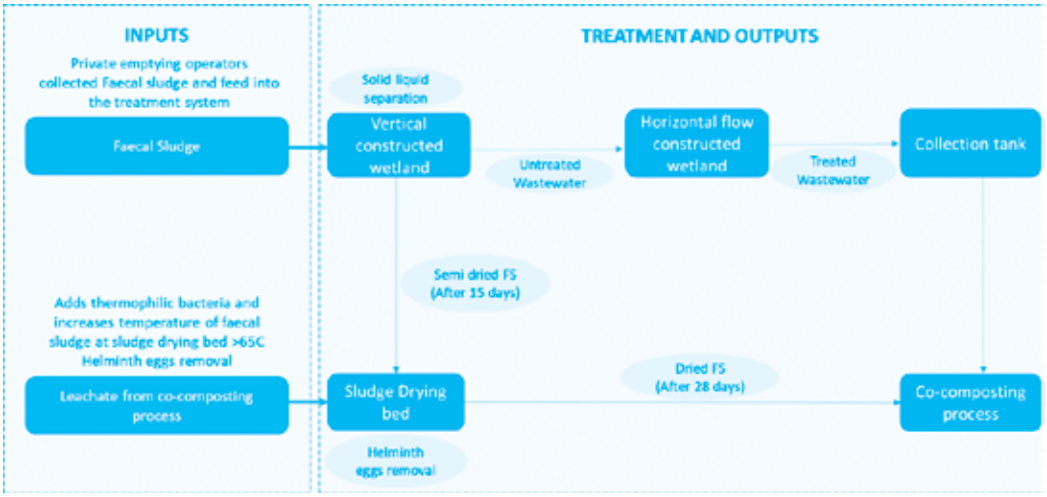


Figure 1: Treatment processes

using gravel and sand as filter media and native marsh plants to enable evapotranspiration for efficient dewatering. Heavy organic contents in the partially digested and fresh sludge, treatment system with only conventional sludge drying beds would not be able to achieve the output standards prescribed the pollution control board. Percolation of the liquid through filter media assures dewatering while plants root system maintains the permeability of the media and permits continuous addition of the faecal sludge.

The outputs are separated into two streams untreated water which is further treated and collected in a tank and dried faecal sludge which is conveyed to the sludge drying beds for further drying and co-composting is processed.

Horizontal wetlands: These units are designed to treat the liquid fraction of faecal sludge separated at the vertical wetlands. The unit is sealed at the bottom and sand-gravel matrix is used as filter media along with wetland plants like Phragmites or Typha. Several processes take place using bacteria and fungi to treat the waste water. The system treats the waste water and transports it to the collection tank from where it is conveyed to the composting area to be mixed with the composting heap or can be directly used in irrigation.

Sludge drying beds: Solid fraction of faecal sludge coming from the vertical wetlands is diverted to the sludge drying beds before conveyed for co-composting. The drying beds are essentially designed to further remove the water from the faecal sludge. One of the most important pollution standards is Helminth egg removal from the faecal sludge before putting it to any reuse. Sludge drying beds are fed by the leachate produced at the composting heap which raises the temperature at the drying bed to attain about 65°C. This adds thermophilic bacteria to the beds and removes the helminth eggs from the sludge.

Co-composting: Composting process uses two separate feedstocks as part of the treatment and to produce nutrient rich compost. The quality of compost depends upon the content

Table 1.Resource Recovery Parks

Particulars	Units	Ketti	Adigarahatty
Vertical constructed wetlands			
Chambers	number	3	4
Treatment capacity per chamber	litres/day	8500	11000
Total treatment capacity	kL/day	25.5	44
Dimension	L*B*H	10.5*4*1	16*4.5*1
Area requirement	M^2	42	75
Horizontal constructed wetlands			
Chambers	number	1	1
Dimensions	L*B*H	4.5*2.5*1	4.5*3*1
Area requirement	M^2	11.25	13.5

of carbon and nitrogen in the mix. Apart from C: N ratio other factors like temperature, moisture content, size of particle and aeration. Ideal recommendation for C: N ratio in the compost should be in range of 25- 40:1 (Richard,1998). Ideal ratio for faecal sludge to solid waste is 1:2 to 1:3 for dewatered sludge and about 1:5 to 1:10 for liquid sludge (Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph. and Zurbrügg, C., 2014). The compost is used by the farmers as a soil conditioner for growing vegetables.

Key Challenges in Implementation

- As co-composting is dependent on the continuous availability of two feedstocks, faecal sludge and organic solid waste, it is important that the quantum of these feedstocks is managed proactively to run the plants as designed. As only the organic fraction of the solid waste can be utilised for composting process, waste segregation needs to be carried out precisely.
- The efficiency of the treatment processes and quality of co-compost produced highly depend on the ratio of the mixture of faecal sludge and solid waste. Therefore, regular emptying of the containment structures of the on-site sanitation systems needs to be followed for ensuring the availability of required faecal sludge for composting.
- Availability of grey water: Settlements that are located scattered from each other and do not have operational conveyance infrastructure for grey water faces difficulty in implementing the innovation. Scattered habitations would need bigger network of conveyance infrastructure and would also generate lesser greywater which would not suffix the farming requirement in the area. This ultimately leads to technical and economical unsustainability in implementing the innovation.
- Market fluctuations: Although the farmers have leveraged the opportunity of water availability in dry seasons through greywater recycling and have been able to produce more crops than before, market fluctuations have often resulted into losses for the farmers. While the compost is only 1 rupee costlier than the conventional fertilizer sold by the cooperative society, farmers are not discouraged to use this innovation. However, for buyers buying in ample amount, the differences can also add into the losses and hence mitigating the market problems assumes importance sooner or later.

- Cost of compost: The farmers producer company currently sells the compost at 5 rupees per kg excluding the cost of transportation. Although farmers have been benefitted by the innovation tremendously and want to continue using the same, a group of farmers have demanded for 50 percent cost reduction in the price of compost. While this seems difficult at first place as it involves significant treatment, laboratory tests and constant quality monitoring incurring a lot of cost for the authorities, there exists certain scope for subsidy or funds through corporate social responsibility that needs to be explored.

Impact

The impact is measured by carrying out ground level surveys with farmers.The survey involved 50 farmers who were selected to produce a representative sample of the entire region.Various impacts measured are presented in detail below.

Agriculture Activities

Table 2 shows the number of crops cultivated before and after using innovation by the respondents. It is evident from the table that substantial diversification is the outcome of the innovation. Farmers have observed better yield in terms of size, colour, skin and taste of the vegetables. Carrot, the golden crop of the Nilgiris, has performed well with 14 percent increase in the production after using innovation. Beetroot saw an increase of 12 percent in production whereas garlic and potato only saw an increase of 2 percent. Other crops such as beans, cabbage, radish, cauliflower, broccoli, zucchini also witnessed an increase in the production. Crops like flowers, strawberries, fenugreek and capsicum were introduced which were not produced before the access to innovation.

Water Security Benefits

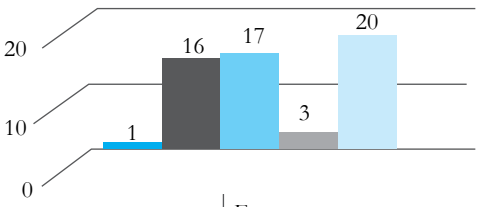
It was becoming a common practice amongst farmers to only cultivate 1/3 or 1/5 of their land due to paucity of water in this area. With the introduction of recycled grey

Table 2 Diversification in crops as a result of using innovation

	Carrot	Radish	Beetroot	Garlic	Peas	Beans	Potato	Cabbage
Number of crops grown before Innovation	35	2	13	12	1	4	19	4
Number of crops grown after Innovation	42	4	19	13	1	10	8	5

	Cauliflower	Broccoli	Zucchini	Flowers	Strawberry	Capsicum	Fenugreek
Number of crops grown before Innovation	1	3	1	0	0	0	0
Number of crops grown after Innovation	2	6	3	1	1	1	1

water, although limited, has allowed them to cultivate a part of additional land. Figure 2 below showcases 32 percent (16 out of 50) farmers could cultivate additional land unlike before and about 34 percent farmers were able to provide more irrigation than before. From a water scarce place to a situation where farmers could achieve more cultivation and irrigation itself signifies the value and benefits that the innovation has brought in the region.



		Freq.
	Can't say it's too early	1
	Could cultivate additional land	16
	Could provide more irrigation than before	17
	Could cultivate fodder and support dairy cattle	3
	Not using	20

Figure 2: Result of using recycled water

Soil Productivity Benefits

As shown in figure 3 below, 68 percent (34 out of 50) farmers declared that they have witnessed the reduction in the quantity of water used for irrigation purposes, citing the co-compost has increased the moisture retention in the soil making it viable to use less water which is an extreme benefit considering Nilgiris is witnessing the highest recorded dry season in the last decade.

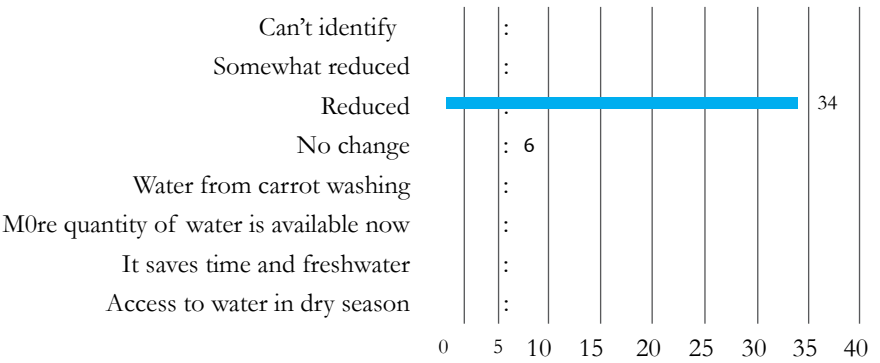


Figure 3: Water usage pattern

Crop Yield

As detailed in figure 4, 68 percent (34 out of 50) farmers saw their yields increase over the period the innovation was active in Nilgiris. All of those who observed increase in the crop yield felt that there was better quality and improved survival rates of their crops. 28 percent (14 out of 50) farmers reported to observe a substantial increase in the yield with 4 percent (2 out of 50) farmers reported to not using the innovation.

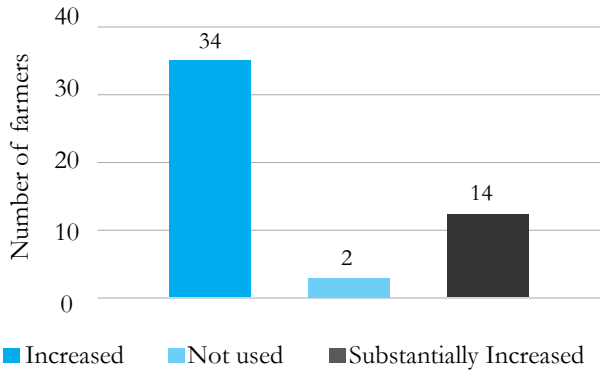


Figure 4 Change in crop yield

Crop survival rate

The survey concluded that farmers observed moisture retention in the soil, and using co-compost automatically reduced the usage of fertilizers ultimately enhancing the survival rate of the crops.

Increase in Income

Figure 5 below shows, 30 percent (15 out of 50) farmers reported to have somewhat increase in the income, owing to reduction in water labour, quantity of water used, and better quality of yield produced but also to the farmers' own productivity, price variations, and varying weather conditions. Out of 50 interviews, 14 farmers reported to have a significant increase in the income. 5 declared to observe very significant income change and 4 were not able to determine change in the income, while 1 farmer hoped for a better income in the next cycle.

Women Empowerment and Livelihood

Women were more enthusiastic about the innovation as they were provided with knowledge and techniques of farming through innovator's outreach program making them technically strong. The innovation enables women to become agri-entrepreneurs by selling co-compost to farmers. This led to ownership of farming practices and a shift of decision making amongst women.

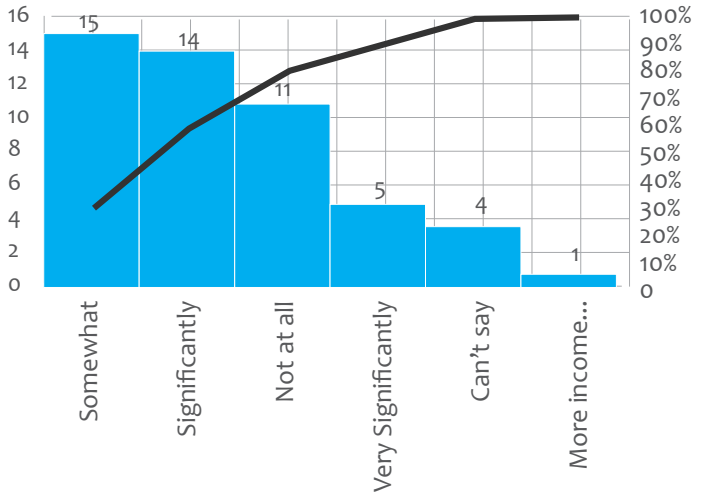


Figure 5: Increase in income

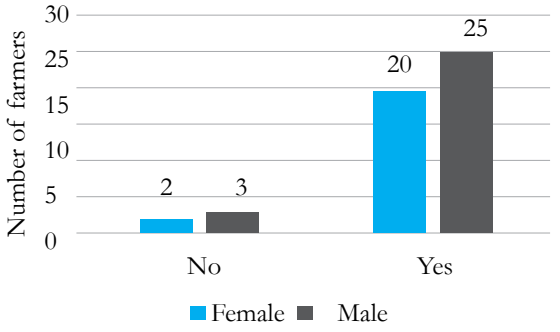


Figure 6: Desirability for compost: Gender view

Community Benefits and Livelihood

The impact and benefits of WASTE's innovation can be noted confidently for farmers across all regions. Although, benefits on community is difficult to measure but, one can observe tangible community cohesion as a result of innovation. The grey water unit installed in some of the villages has allowed small groups of farmers to use the water cyclically which brought community level sharing and adeptness to resources judiciously. For instance, farmers reported that quality of grey water is so good that it looks like filtered water. Additionally, this cyclic process is community driven which is also enabling them to take ownership of general cleanliness in the village. Good quality yield after using co-compost has led to building of confidence amongst farmers. A farmer stated

'I plan to use co-compost for tea farming as well now seeing better quality yield from neighbor farmers. This will help me improve my family income and give better education to my children'

As a result, it was observed that farmers exhibited a lot of trust in the innovation and started to treat it as a tool for community engagement. The youth in the region were also attracted towards agriculture, witnessing the positive changes. They now see farming as a sustainable profession, which otherwise was difficult to sustain in the past years because of acute dry season and climate change.

Conclusion

The intervention has made the community water literate and has created a sense of ownership within themselves for water management which has **promoted efficiency in resource use.**

The innovation primarily takes into account the concern of limited and expensive resources, such as water, seeds, compost, manure, labour, fertilizers and petrol, and figure out a sustainable, scalable and actionable route map to produce high quality co-compost from waste water and faecal sludge. The case provides insights on various parameters which may become essential to understand the future scope.

- Cost of co-compost should be reviewed, as it is important to monitor the market competition and operational cost to produce co-compost and how it can be reduced to meet farmer's request of lesser price.
- A service centre for farmers can be developed and maintained which disseminates the cognizance of new technologies, new and sustainable brands of inputs and scalable methods of sustainable farming to the farmers. Such centre would specifically be useful for women farmers who generally hesitate in learning new technologies or largely do not have access or voice to learn new processes. The centre can also enable capacity building of farmers teaching them a balanced application of fertilizers.
- Most of the farmers requested for more quantity of treated grey water. This depends upon the topography of the villages and also the contributing number of households. There seems to have flexibility in terms of designing and costing grey water unit. This insight may be explored further.
- Access to treated greywater in farms had become indispensable to them as they had to reduce the consumption of fresh water for irrigation to divert its use as drinking water in state of scarcity. Similarly, any region having high depletion of the freshwater sources or seems to reach that soon in the future, should adopt this model to make the best use of available resources. As the model involves multiple stakeholders having a shared goal, implementation of model has become easy and highly impactful.

- When it comes to food security, organic carbon content in soil is essential. Co-compost helps in retaining the carbon and sync it in the soil.
- The innovation had an impact over water usage, crops, yields and farmers' income. In order to build it further, the capacities of farmer producing companies need to be strengthened which would eliminate middle men. An EMI or a quarterly system for agri-inputs can be facilitated. Market has a huge cultural aspect towards pricing of a crop. Farmers purely rely on agents because they do not want to undergo any stress or risk, hence willingly loose a massive chunk of profits.

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Fasal - Setting Indian Farms on Auto-pilot Mode

Soumya Kushwaha

It was the calm evening of August 20, 2019 when Ananda Verma, the CEO of Fasal sat in his office with Shailendra Tiwari, the co-founder. It was one of the frequent sessions they held to discuss the future course of action amidst changing business dynamics. They were reflecting on the purpose of setting up Fasal, the successes and challenges before Fasal in the previous one-and-a-half years and the milestones it achieved so far, after being founded in January 2018. Having successfully created positive impacts in the lives of tens of Indian farmers, they felt it was now time to gear up for future challenges and ride over the tide to reach out to millions more.

28 year old Ananda Verma hails from a farming family in Azamgarh near Varanasi. Growing up, he has seen his father suffer because of crop loss due to weather related uncertainties and lack of information. "And this problem is not only with my father, but every farmer faces the same issue because of lack of data points to make a decision," Verma shares.

After graduating from IIIT Bangalore, and working in the IT software industry for over five years, Ananda realised that he had a solution to this problem of guesswork through the use of tech advancement in Internet of Things (IoT) and Machine Learning (ML). This fusion of agriculture and technology and a belief that precision farming and Artificial Intelligence (AI) can bring second Green Revolution in India led him to start Fasal with his co-founder Shailendra Tiwari. The official name of the company is Wolkus Technology Solutions Pvt Ltd. based out of Bangalore, Karnataka. The company has a motto to 'Give Back To The Society'.

Traditional Farming Practices in India

Farming has been one of the oldest economic activities in India. There are numerous farming methods being practiced in different regions of the country that have evolved over the years owing to changing climatic and socio-cultural conditions. However, they have failed to catch the pace of changing requirements of time as the farmers continue to follow non-scientific, traditional methods of cultivation.

In India, farming has traditionally relied on intuitions and insights of the farmers having generations of experience. However, due to the uncertainties caused by environmental degradation and climate change, even die-hard sons-of-soil today need help. The problem, *inter alia*, lies in the fact that the farming methods deployed by Indian farmers are far from optimal. Seeds are randomly strewn across the field without giving due consideration to

how many plants should grow in a given piece of land. The irrigation system is not robust and agriculture depends largely on monsoon. Farmers lack knowledge on optimal quantity of fertilizers and pesticides to be used on a given hectare of land. Excessive use of such chemicals robs the soil of its natural nutrients, thereby compromising the soil's productivity.

Advanced nations such as the US, reap seven times the yield from the same size of land as compared to India through deploying precise, scientific farming techniques. Therefore, there is an urgent need to take action and avoid a scenario where despite having enough land and advanced technology available, Indian agriculture becomes untenable.

Possible Alternatives to Solve Agriculture Problems

Ananda was convinced that technology could solve the problems faced by farmers in India, particularly due to unavailability of reliable and accurate information. He was determined to level the field by eliminating information asymmetry. His aim was to provide farmers with all the necessary information and empower them to make right and timely decisions. The two choices he had were using 'Drones and Satellite' or 'AI and IoT Solution'.

Deploying any solution using drones and satellites is a challenge in India given the small size of landholding with farmers. Moreover, farmers are skeptical of believing in and adopting recommendations given to them through insights drawn from satellite-collected information. They tend to be more open to relying on information coming from something that stands in their farms and tells them exactly what to do. Additionally, the commercial and operational feasibility of such a solution has not yet been proven. It is a complicated and intensive solution, where even the data and insights cannot be delivered in real-time. Although these challenges are not insurmountable, it would take at least 2-3 years before they are conquered.

AI and IOT solutions on the other hand provide crucial information to farmers that helps them optimise water, fertilizers, and pesticides uniformly in their fields by targeting only specific areas, or even individual plants as per the requirement. This provides the following benefits:

- Increased crop productivity
- Reduced use of water, fertilizer, and pesticides, which in turn helps in keeping food prices down
- Controlled impact on natural ecosystems
- Less contamination of rivers and groundwater through farm chemicals
- Improved safety of worker

In addition, robotic technologies enable reliable monitoring and management of the quality of natural resources, such as air and water. It gives producers greater control over the production, processing, distribution and storage of produce. This results in:

- Higher efficiencies and lower prices
- Safer growing conditions and safer food to consume
- Controlled environmental and ecological impact

Different types of sensors are being deployed in the earth and from the air (Pictorial representation in Annexure 2). For example, a multispectral sensor captures data that will enable farmers to better predict the irrigation and nitrogen requirements of crops. Similarly, in-field water sensors can help pinpoint the best times and rates for site-specific areas irrigation.

It assists not only in production but also in distribution. For example, tech-enabled cold storage chains, which are controlled using smart devices help in preventing post-harvest storage losses. Automated grading and sorting of crops using robotics also helps in reducing efforts and wastage in the supply chain.

Quite often, farmers can be hesitant to try out and invest in such technologies due to lack of clarity on ROI. Infrastructure issues such as power supply and internet connectivity in remotely located farms can be a great challenge in building connected farms or deploying IoT solutions. Last mile logistics, to get farm products into the hands of farmers, is still a big challenge. They often need to rely on cash-based traditional distribution channels that are not nimble enough.

Ananda's Choice- IoT Solution with Fasal

To address the problems plaguing Indian agriculture, particularly those stemming from poor and inefficient decisions on the farmer's part on which crops to sow, how much to grow, how much fertilizer to use, what prices to expect etc., Ananda launched Fasal. Fasal is an AI powered IoT platform, which eliminates guesswork and manual methods adopted by most farmers. It does so by providing them with data and analytics to grow and reap better.

The target audience/ clients for Fasal are farmers who are progressive and willing to adopt new technology in their fields to improve their yields and income. Various institutional farmers such as Grover Zampa Vineyards, Chawda Bhag and Lohan Krishi Farm among others, are also their customers.

During his interactions with farmers, Ananda observed that there is often poor utilization of important resources by farmers. Fasal guides them to make optimal use of water and electricity resulting in significant input cost savings. Sample information in this regard, provided by Fasal to the farmers is exhibited at Annexure 1. Disease infestation of crops is one of the biggest pain points of the farmers. With Fasal, farmers are enabled to become better doctors of their crops through accurate threat assessment of plant diseases. Thus, farmers can approach the problem through prevention instead of reaction.

Their business model includes a nominal monthly subscription fee. There is no upfront charge or deposit. It's a pay-as-you-go model. "It has worked pretty well for us to penetrate the Indian agriculture market which is very price sensitive," Ananda informs. For large scale and institutional farmers, they also offer to sell their IoT device for an upfront installation charge and bill less subscription fee on software usage.

Recently, Fasal has received acceleration support form Zeroth, which is Asia's first AI and Machine Learning (ML) accelerator. Fasal has also successfully raised $120K from them with the aim of enhancing their AI capabilities. Besides, Fasal is also collaborating with the UC-Berkley Andhra Pradesh Smart Village Initiative. It is a collaborative initiative between Govt. of Andhra Pradesh and the University of California Berkeley. Fasal has completed its first installation under the smart village initiative in Kuppam, Andhra Pradesh.

Impact Created by Fasal

The Fasal Smart Agriculture Basic Solution kit enables monitoring of environmental parameters in agriculture fields, vineyards, greenhouses or golf courses. Specialized sensors for detecting soil moisture and temperature, humidity, leaf wetness and atmospheric pressure are installed to control the amount of sugar in grapes that enhances wine quality. The sensors also gauge micro-climate conditions that are more useful to the farmers than weather forecasts in maximizing the crop yield.

The two levels of depth of the soil moisture sensor help in reducing water wastage through selective irrigation in dry zones. On the other hand, controlling humidity and temperature levels in hay, straw, etc. help prevent contamination by fungal and other microbial attacks.

Fasal has created its own AI based weather forecast system Fasal μClimate. This is because the company believes that the costs of depending on weather forecast as seen from weather apps can be huge for a farmer. Imagine the consequences for a farmer who sprays his farm in the morning going by the 'clear weather' prediction, but it actually rains in the evening. All the spray and his money along with it, will get drained in the rain. Not only this, but changes in the weather greatly affect growth rate of the potential crop yield, the disease pressure, the irrigation and fertilizers scheduling. Not only plantation, but also the demand and supply for the yield depends heavily on weather conditions. Directly and indirectly, weather is one of the major reasons for crop loss. Even the United States have sustained over 90 weather related disasters in the 30 years in which overall damages to agriculture have exceeded 1 billion dollar. That is why Fasal has built its own micro-climate model for weather forecast. Fasal's micro-climate forecasts are tailored to specific farm location and performed at a point scale, instead of a kilometer-wide spatial scale. In essence, as Fasal collects more data, the AI based micro-climate forecasting algorithm incorporates real-time in-field information and relates it with the publicly available weather forecasts, so that farmers get real-time, actionable information relevant to day-to-day operations in their specific farm fields.

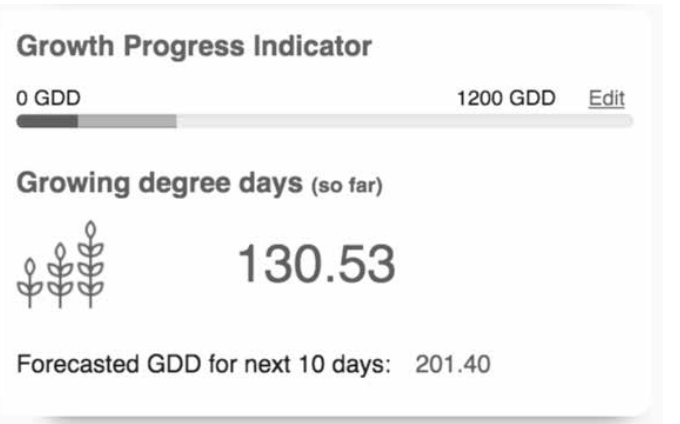
Another interesting offering by Fasal is the Fasal GPI (Growth Progress Indicator), which is built on top of Growing Degree Day (GDD)[1], calculating accumulated GDDs, based not only on real-time farm data but also with the power of Fasal μClimate, it makes GDD prediction for next 10 days. This helps the farmer plan their week well in advance. A sample of GPI can be seen in Picture 1.

Compared to companies in the Western part of the world, Fasal is at a competitive advantage because India is much more cost-efficient. Furthermore, Fasal team believes that their farming background has enabled them to reach out to farmers in a more empathetic way, which will continue to be an advantage going forward as well. They are currently in traction stage and actively looking for more partners to collaborate with them and help them in taking their offering to farmers. They also plan to onboard more agro-based companies as customers in this year.

'We were running six pilots across the three states of Karnataka, Madhya Pradesh, and Chhattisgarh. We started our paid subscription model in February and have three paying subscriptions today. We have also pre-booked three more for next month, and planning 10-20 more selective customers for the next three months,' Verma reveals.

To summarise, Fasal provides following the benefits to its customers:

- Costs savings through judicious usage of resources such as water, energy, fertilizers, and pesticides
- Prevention of product losses by preparing for precise weather conditions
- Automation of the daily farming routines that help farmers focus more on critical farming tasks
- Real-time monitoring and alarm notifications about the field and crop conditions to help farmers make early adjustments to reach the optimal growth conditions
- Insights, future predictions and analytics to help farmers make more data driven scientific decisions and eliminate guesswork



Picture 1: Sample GPI

1. GDD means measuring plant growth by daily heat accumulation. It is a more reliable method than calendar days to predict crop and insect development. Differing threshold temperatures and beginning accumulation dates are used to determine accumulated heat units for different crops.

The company has fared well in the face of challenges. *'One of our biggest challenges was managing the operations. We are operating in three different states and installing devices on the farm at remote locations. It is a huge challenge to make farmers understand the technology,'* says Ananda. To solve this problem, Fasal has distribution partners and have also appointed their product engineers to manage operations. *'From the technology point of view, we make sure we have less operational overhead,'* he adds.

The company also faces challenges in acquiring customers. Talking on this Ananda says, '*We work in smart agriculture and it is a challenge to acquire customers. Farmers do not want technology. They want solutions to help them save costs and increase production. Traditionally, farming has been about guesswork and it will take time to shift to data-driven techniques. But yes, despite all the challenges we are making it happen, because we understand the whole ecosystem. We sit with farmers and try to understand the real problems that they are facing, which technology like IoT can solve. Rather than building technology for them, we are building solutions for farmers' pressing problems.'*

With agri-tech startups buying investors' interest, Fasal is looking at an interesting opportunity. As per BIS Research, the global market size for precision agriculture is going to grow over $6.34 billion by 2022 at an estimated Compound Annual Growth Rate (CAGR) of 13.09 percent from 2015 to 2022.

Fasal's Key Accomplishments

The success of Fasal lies is the success of the various farmers it has helped so far. Deepak Taunk, a progressive vegetable farmer of Chhattisgarh reveals that with Fasal, he is able to correctly analyze the irrigation and fertilizer requirement in his farms, thus enabling cost savings. Grover Zampa, one of the largest vineyards of India, has been able to maintain required water stress level in the soil, improving the quality of yield. Mr. Bhupendra, an influential vegetable farmer has been able to save 50 percent in irrigation costs ever since he deployed Fasal's solution. He also successfully saved his bottle gourd crop through preventive spraying upon disease prediction by Fasal. Another farmer from Raipur better understands his soil suitability and grows crops accordingly without wasting valuable resources such as time and investment. Similarly, Mr. Amol Rakibe, a progressive grape farmer has successfully reduced his disease management cost by up to 50 percent, simply by using Fasal's smart farming solution. Another farmer from Chhattisgarh, Mr. Abhishek Chawda, who studied in Australia and came back to India to undertake scientific farming, expects a yield of 60 tons per acre, thanks to support from Fasal. His ambition is to undertake farming on an industrial scale and improve the current state of affairs with respect to agriculture in India. Another farmer named Kiran Patil reaped a direct monetary benefit of INR 78,250 simply by implementing Fasal's solution. Similarly, Nayan Taunk, a farmer from Raipur reaped a direct monetary benefit of INR 85,000 after subscribing to Fasal. A few case studies are presented in detail at Annexure 3.

Since its founding, Fasal has won several awards and accolades - Center of Excellence for IoT and AI (CoE IoT), NASSCOM selected Fasal for incubation. The company is one of

the three winners of Seaside Startup summit. Also, Fasal is being listed as the Great Indian Startup by Tech in Asia and Top Six Indian AgriTech Startups that are Revolutionising Agriculture.

The future prospects for Fasal appears bright, especially in the light of steps taken by the Government (Refer Annexure 4 for Government Focus on Use of Technology in Agriculture). The Ministry of Electronics and Information Technology (MeitY) recently released a draft policy related to IoT plans with the goal to create an IoT industry of $ 15 billion by 2020. India is expected to gain a 5-6 percent share in the global IoT market.

The IoT Policy has proposed the implementation via a multi-pillar approach comprising five vertical pillars - Demonstration Centers, Capacity Building & Incubation, R&D and Innovation, Incentives and Engagements and Human Resource Development and two horizontal supports - Standards and Governance structure. The CoE-IoT incubation center in Bengaluru where FASAL was incubated is one such example.

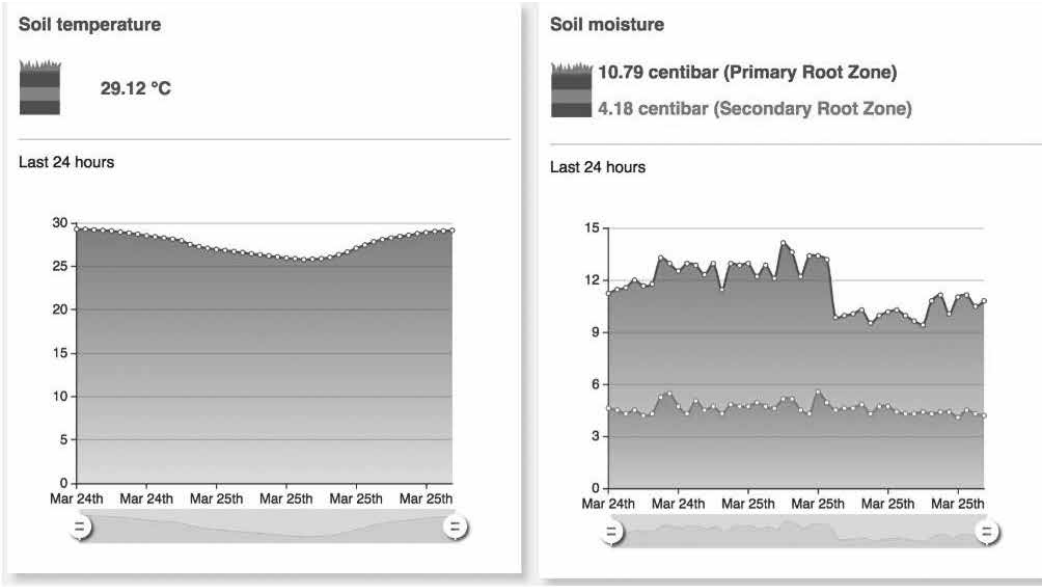
Conclusion

Ananda sees great future potential. About the agricultural ecosystem in India, Verma said, "The Indian food industry is poised for huge growth. The Indian food & grocery market is the world's sixth largest, with retail contributing 70 percent of the sales. The Indian food processing industry accounts for 32 percent of the country's total food market, one of the largest industries in India and is ranked fifth in terms of production, consumption, export and expected growth. It contributes around 8.80 and 8.39 percent of Gross Value Added (GVA) in Manufacturing and Agriculture respectively, 13 percent of India's exports and 6 percent of total industrial investment." Fasal has huge plans going ahead. "We would like to see Fasal in every farm in India in coming years and farming on auto-pilot. We are on a mission to help farmers grow more and grow better and we would like to make sure that they also sell better. A very far vision is – Fasal should be able to tell you what crop you should grow this season for a better outcome and what will be the market price once you harvest," said Verma.

However, there also remain apprehensions about the future. Bright prospects in the field has resulted in increased competition. Fasal is competing against Indian startups such as Yuktix and eXabit Systems, while the competition worldwide includes Cropx, Pycno, The Yield Technology Solutions, and more. Besides competition, there are other questions that occupy Ananda's mind as he sits down for a discussion with Tiwari. What should be ideal growth plan and timeline? How will Fasal expand its reach to more farmers, agri-institutions and companies in India? How will it grow beyond India to solve agriculture problems in other countries?

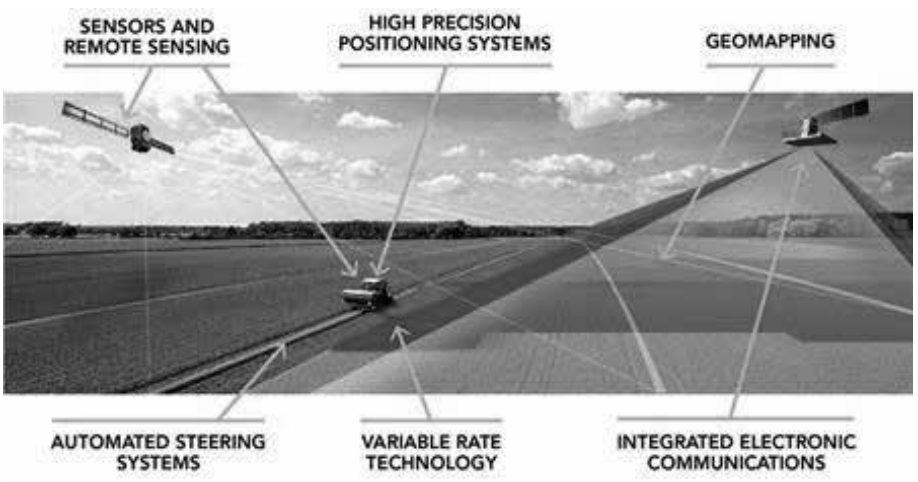
Annexures

Annexure 1: Sample Information about Soil Given by Fasal



Soil temperature and Soil moisture at Primary and Secondary root zone

Annexure 2: Precision Farming



Annexure 3: Farmers' Testimonies and Case Studies

Kiran Patil's story of success with Fasal

Fasal

Case study - ROI on Grapes

Direct monetary benefit of 78,250/- INR

Disease management: Direct saving by cutting 14 sprays of Downey and Powdery Mildew worth 47600 INR. By virtue of this, saved 14 tractor passes for spraying saving 7000 INR in fuel cost.

More Yield: Increase in yield of about half a metric ton, converting into better revenue realisation of ~ 20000 INR

Optimum data driven irrigation: About 8.5 lack litres of water saved this season from irrigation. There was a 30% decrease in irrigation frequency. Saved about 10% in fertigation cost. A cumulative saving of 3650 INR

"Saheb, Kranti hona rey"

Farmer's Name - Kiran Patil

Region - Tasgaon, Sangli ,Maharashtra

Crop - Grape

Land area ~ 1 hectare

Date of pruning - November, 2018

Mode of irrigation - Drip

Kiran Patil, a grape farmer from Tasgaon, Sangli (Maharashtra, India) used Fasal for his grape plantation for the last season starting the mid of November 2018 to April 15, 2019. And midway through this journey he concluded the experience by saying "Saheb, Kranti hona rey", which in english translates to "Sir, this is a revolution". Kiran Patil is an experienced grape farmer who has been doing grape farming since last 15 years. In his region Downey mildew and Powdery mildew are a big menace. Afraid of loosing his crop, just like all other farmers of the region, Kiran Patil also had developed the practise of spraying funcicides on any sign/ feeling of threat from the mentioned diseases. Just like other farmers of the region Kiran patil also had the practise of irrigating everyday for 1.5 hours. This time, with Fasal as his companion, he decided that he will not just follow the decade old practises but, will take decisions based on hard facts. Kiran Patil sprayed this time when the concrete data and intelligence told him to, irrigated when the crop needed water and was on preventive mode rather than reactive this entire season.
Kiran Patil has already sold his produce and is now busy encouraging other farmers to adopt Fasal.

Nayan Taunk's story of success with Fasal

Fasal

Case study - ROI on Onion

Direct monetary benefit of 85000/- INR

Disease management: Direct saving of 33,000 Rs in managing Downey mildew by precision and preventive spraying.

More Yield: Approx 1.5 Tonnes more yield per acre than other farmers in the same region. A total of 12 tonnes more. 42000 Rs from the yield.

Optimum data driven irrigation: maintained at 20 Cb cutoff. Saved ~ 10K in fertilisers by checking leeching.

"My onion was the best in quality in the whole region"

Farmer's Name - Nayan Taunk

Region - Raipur ,Chhattisgarh

Crop - Onion

Land area - 10 acres

Date of sowing - December, 2017

Mode of irrigation - Drip

Nayan Taunk, a vegetable farmer in Raipur (Chhattisgarh, India) used fasal's services for his onion plantation. And he sums up the whole journey by saying, "My onion was of the best qualtiy in the whole region". Equipped with data and actionable recommendations this year, he is waitng for the next season to grow onions more profitably using Fasal. Downey mildew and purple blotch, are two major problems in his region with onion. Donwey mildew is only identifiable when the leaves start to turn yellow and the damage in terms of yield loss has already happened. This time, Fasal sent him alerts on 3 instances that Downey spore generation has already happened and advised him to do take prevetive sprays. Nayan sprayed a combination of M-45+Blue copper, preventive spray, which costs 500 Rs per acre, instead of reactive sprays, which cost 1500-1600 Rs per acre. The Downey mildew passed the whole season without any damage to the crop with only 3 preventive sprays. His farmer friends who grew Onion and suffered from Downey lost ~1.5 Tonnes per acres, but Nayan did not. Owing to proper irrigation and precise disease and input management the quality of Produce was superior and was sold in the first flush itself.

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Partnership in Climate Services for Resilient Agriculture in India

Shahida Bano

USAID, an agency of the United States federal government works towards combating global hunger, poverty and malnutrition, through various collaborations across the world. In India, USAID has come up with a unique partnership with Skymet Weather Services called Partnership in Climate Services for Resilient Agriculture (PCSRA) in India to help digitalize the archaic methods still employed by the Indian farmer and develop new risk mitigation products. The duration of the project is 4 years (October 2015-September 2019) and it has benefited more than 80,000 farmers spread across 31 districts in 9 states.

India is prone to various kinds of hydro-meteorological and geological hazards, especially droughts, earthquakes, floods, tsunamis, cyclones and landslides. These hazards threaten millions of lives and can cause large-scale loss-to people, infrastructure and the economy. Every year, unpredictable or irregular weather events cause unprecedented losses of capital and produce, which, in turn, set off a ripple effect culminating in inflation in food prices and in extreme cases, farmer suicides. 610 deaths have been reported in Maharashtra alone between January and March this year. Accurate weather predictions at the right time can go a long way in mitigating, if not in eradicating this crisis.

India is a study of dizzying contrasts. It's hard to imagine that the country credited with launching the highest number of satellites in a single mission is also the country with almost 31 million homes with no electricity. This perplexing gap is the startling reality of our country. The disconnect between technological progress and technological impact needs to be bridged in order to metamorphose from a 'developing' to a 'developed country'.

Increasingly accurate weather forecasts will not facilitate agriculture if the right information does not reach the right person at the right time. And this is what sets the PCSRA project apart. With its grassroots approach, it aims to take all its specific and detailed weather predictions and insurance information to every disadvantaged farmer, and this is precisely what digitalization is all about- making the maximum impact on the maximum number of people.

The PCSRA project is helping farmers and vulnerable agricultural communities in rural areas cope with climate variability and make informed decisions by providing them with hyper-local weather information. To realize this goal, 675 Automated Weather Stations (AWS) have been installed to generate real time weather and crop monitoring data to

extrapolate weather parameters in the near term. Besides weather information, real-time weather based customised crop advisory is also made available to the farmers. This permits the Indian farmer to make time-sensitive decisions regarding the varieties of crops, irrigation, pesticides, fertilizers and the like. A unique aspect of the project is its concept of 'community of practice' which organises farmers' meets where discussions are held for the adoption of the best practices for agriculture to be more productive and effective. In the community of practice, various stakeholders like district agriculture officials, agricultural research institutions, banks, farmer organisations and NGOs are brought together. This project also deals with an often ignored aspect of risk-management in agriculture - agri-insurance. It facilitates insurance through the Government of India's flagship program- the Pradhan Mantri Fasal Bima Yojna. This benefits the farmer to cope with climate induced shocks.

Since, the beginning of project till the third quarter of the fourth year of the project (i.e. during 1st October 2015 to 30 June 2019), 80,423 farmers have been registered under the project. The state-wise registration of farmers is reflected in Table 1.

Table 1: State-wise registration of farmers under PCSRA (as on 30 June 2019)

State	Total Farmers Registered
Andhra Pradesh	5835
Bihar	10819
Gujarat	10662
Haryana	7638
Madhya Pradesh	11951
Odisha	7783
Punjab	6767
Rajasthan	13136
Telangana	5832
Total	**80423**

Each of the registered farmer under this project is geo-tagged. Skymet has developed mobile application known as 'Skygreen', which was introduced for farmer's registration and activity monitoring on the field. The app also captures the farmers' geo-coordinates, which helps in service customisation and better service delivery.

SkyMitra is an android mobile app developed by Skymet Weather under this program to help the farmers by providing relevant weather and agro advisory information quickly. The app provides weather forecast for 7 days and 15 days. Accurate weather forecast not only helps farmers to protect themselves against the natural factors. They can also benefit significantly if they are aware of the actions they can take to leverage good weather patterns.

Under the project intervention, Skymet gives access to regular and reliable weather information to the small, medium and marginal farmers in all 31 geographies under the project. Shorter real-time meteorological information such as daily forecast further helps to determine timing of various activities such as sowing, weeding, spraying and harvesting.

The project relies heavily on Information and Communication Technologies (ICT) to deliver weather-induced risk management solutions. Skymet collects and processes 6 high resolution satellite data to run Numerical Weather Prediction (NWP) algorithms on computers. It then assimilates data generated through AWS and generates weather forecasts and agro advisories. The farmers are registered through an android based app and receive the weather forecasts and agro advisories on the mobiles of registered farmers. Real-

Picture 1: SkyMitra app

time daily weather data, 7 days' and 15 days' forecast are helping farmers make practical decisions that save their time and money or protect them from weather related damages.

Accurate and detailed weather forecasts are irrelevant to farmers if they do not reach the farmer in the remotest locations or are not understood by those with little to no literacy skills. Besides the SkyMitra app and WhatsApp groups, information is also promulgated through other mediums. A majority of Indian farmers do not have a smart phone. Weather information including weather forecasts and weather alerts are sent to them through SMSs in 6 regional languages, twice in a week. Weather Display Boards are placed in high visibility locations to reach out to farmers who do not have access to mobile phones. The display boards are updated periodically. Through Voice Broadcast Services (VBS), the weather information is disseminated to the registered farmers in six regional languages in the form of voice messages. There is a lack of platform for the Indian farmers to voice their queries and gain access to precise and detailed answers to those queries. This is addressed through a toll-free number where one can dial the pin code number of their district to hear district specific weather information.

The Skymet-USAID partnership also seeks to address the gender disparity in agriculture by directly engaging with them. Due to socio-cultural barriers, it is often difficult to enroll women farmers. Although the share of female farmers is just 10 percent of the total enrollments, it is three times more when compared to the total farmers registered since the inception of the project. To encourage participation of women farmers, the project team conducts separate meetings for women and organises meetings at a time which is more convenient for them. In their experience, meetings held in the evenings have witnessed a higher turnout as women farmers who are engaged in house work or field work during the day are able participate in these meetings and discussions.

Smart Agriculture to Enhance Rural Livelihoods and Adapt Climate Resilience Practices

CropIn

Climate-Smart Agriculture: A Need to Build Resilience to Mitigate Climate Change Risks

Climate change has a potential impact the soil health through physical, chemical and biological properties of soil. The factors affecting soil health are soil organic matter, and uneven shifts in carbon and nitrogen ratio (C:N). Higher temperature will accelerate the decomposition of organic matter, resulting in release of CO_2 to atmosphere. The resultant decrease in C:N will lower the soil temperature that is suitable for growing crops. The dry soil conditions suppress the growth of roots and organic matter decomposition and result in soil erosion. Due to unfavorable climatic conditions, the occurrence of pest infestations and plant diseases are higher in tropical regions.

To respond to the unprecedented challenges posed by climate change, there is a dire need to become **climate-smart** and enhance agricultural productivity through a sustainable model. Climate-Smart Agriculture (CSA) is a holistic approach to address food security, increase agricultural productivity, improve the adaptive capacity to climate change, while also uplifting the rural-poor above the poverty line.

The Sustainable Livelihoods and Adaptation to Climate Change (SLACC) Project

The SLACC project was initiated by the Ministry of Rural Development (MoRD) and supported by the World Bank. As the Ag-tech partner to the project, CropIn implemented the pilot project in Madhya Pradesh and Bihar, in partnership with National Rural Livelihoods Project (NRLP) and supported by the respective State Rural Livelihood Missions (SRLMs).

The aim of this project is to eradicate rural poverty, improve food security and increase the household income of rural poor through sustainable livelihood enhancement and improved access to financial and selected public services.

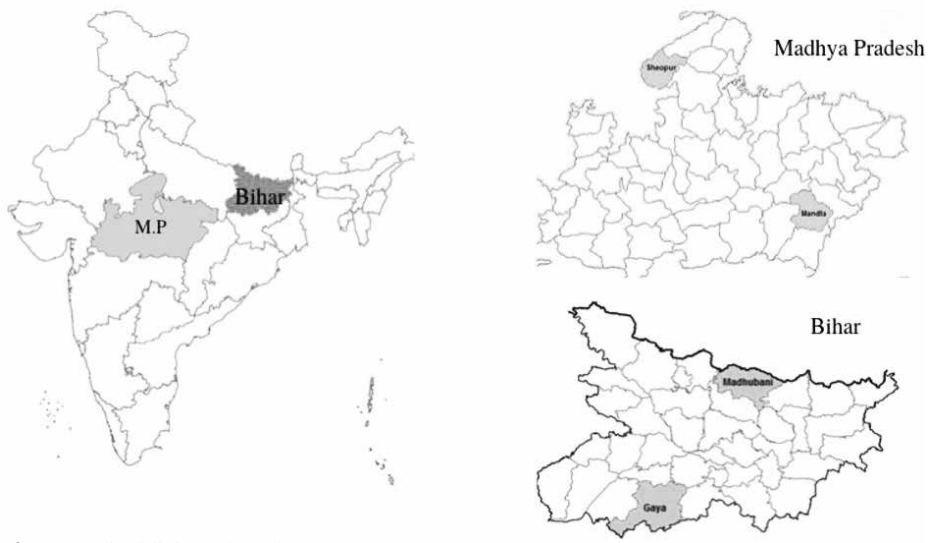
The objective of the SLACC project is to improve the ability of farmers to cope with climate uncertainty. Weather-based Agro Advisory Services (WBAAS) module provided by CropIn for short-term weather forecasts are intended to help farming households schedule their farm operations better, thereby minimizing loss or costs or both.

Longer-term weather forecasts are intended to help farmers make better varietal or crop choices and make appropriate arrangements to decrease the impact of climate change or even put in place adaptation mechanisms. However, not every farmer is equipped with the knowledge (or has access to) to make appropriate choices.

Therefore, instead of simply providing weather forecasts, the farmers are given weather based agro-advisories that inform them of likely impact of weather on crop, and also the steps that they need to take in order to tide over the situation. Improved capacity to learn and deal with unexpected, changing and adverse weather conditions are expected to gradually improve farmer resilience to weather variability and hence prepare them for climate change in the longer-term.

Selection of Project Locations

Before the start of the project, an environmental assessment was carried out to assess the vulnerability of various states to climate change. Through this assessment, Bihar and Madhya Pradesh were identified as the most flood-prone and drought-prone regions amongst other states in the country.



Picture 1: SLACC Project Area

Socio – economic Profile of Targeted Population

Madhya Pradesh (M.P.) is a highly populous state having a total population of 72.3 million1[1]. 80 percent of the population is rural, who are highly dependent on climate-sensitive sectors for their livelihood, viz. agriculture, forestry, and fishery. The rate of incidence of poverty is high in M.P with more than 40 percent of the population falling below the poverty line. M.P. has the highest concentration of tribal population in India. 71 percent of M.P's population is dependent on agriculture for a living. Out of 45 districts

1 Census of India, 2011

in M.P, 14 are categorized as having very high vulnerability to climate change and 16 are categorised as having high vulnerability to sensitivity, exposure and adaptive capacity.

Bihar is another highly populated state in India. 42 percent of Bihar's population lives under poverty. Nearly 90 percent of the population depends on agriculture based livelihoods. Livelihoods in rural Bihar are characterized by high dependency on agriculture, predominance of landless labourers and high levels of seasonal migration.

The major crops cultivated in M.P. are rice, maize, millets, pulses, wheat and mustard for both *Kharif* and *Rabi* season. In Bihar, rice, maize, sorghum, pigeon pea and soybean are the commonly grown Kharif crops. Gram, wheat, and vegetables are the *Rabi* season crops.

Every year due to erratic weather conditions, 10 to 40 percent of the crop is reported lost in Bihar and M.P. The severity of crop loss emphasizes a need for local community-based interventions to reduce vulnerabilities to climate-induced losses.

Key Stakeholders in SLACC

The key stakeholders in this project are National Rural Livelihood Mission (NRLM) and SRLMs of Bihar and M.P., including Young Professionals, Village Resource Professionals (VRPs) and Community Resource Professionals (CRPs) who work with farmer communities.

The target population of SLACC project are the rural-poor supported by the NRLM including, self-help groups and their federations, farmer interest groups/ producer groups such as farmer association, livestock rearers' groups etc. and their collectives such as Producer Companies.

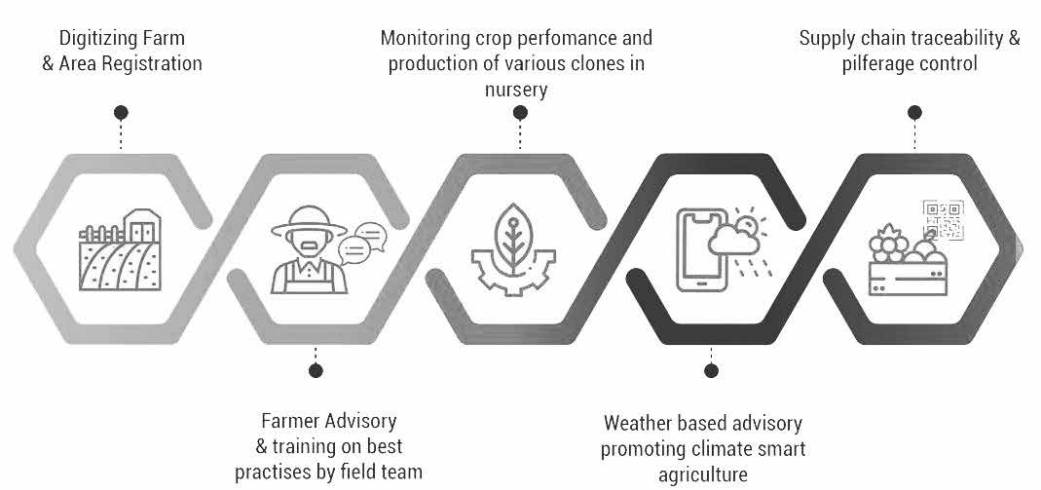
These community institutions of rural-poor, majority of whom depend directly on climate-sensitive sectors such as agriculture, animal husbandry, and aquaculture have limited adaptive capacity. The project specifically focuses on uplifting tribal, and small to marginal farmers belonging to disadvantaged social groups, including women farmers.

Role of CropIn

In 2017, CropIn was roped in as an Ag-tech partner to support the World Bank funded SLACC initiative to mitigate risks associated with climate change and enhance the rural livelihoods. In this endeavor, CropIn collaborated with a weather forecast provider to develop a Weather-based Agro Advisory Services (WBAAS) for Climate Change.

The innovative technology of CropIn has been instrumental in enhancing the adaptive capacity of farmers to climate change. The Model is depicted in the Picture 2.

CropIn's Climate-Smart Advisory module is enabled on both web and mobile-based platform to transmit WBAAS to farmers. The system is capable of electronically receiving



Cropin's Sustainability Model

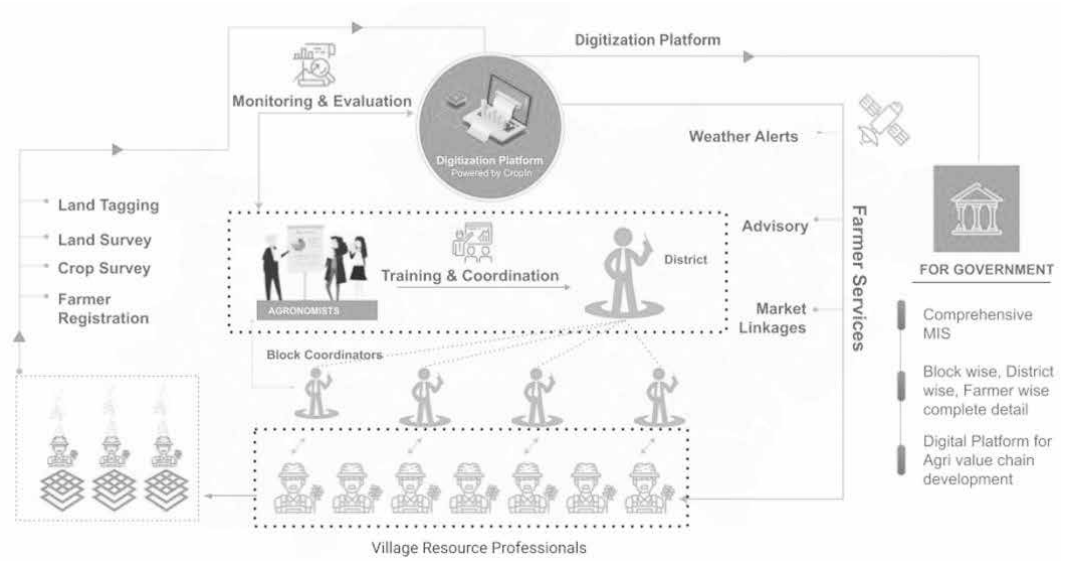
Picture 2: CropIn's Sustainability Model

and using data generated such as weather forecasts and farming advisories. CropIn adopted a systematic process for collecting and uploading data to the SmartFarm ICT Platform, which involves a regular, periodic and pre-decided visit schedule for VRPs, for each participating farm and for each crop.

CropIn has developed custom-forms and formats for collecting data on crop including pest and disease calendar for selection of critical period for each crop. It also schedules when the data must be collected, timing and technique of pictorial data (photographs of the crop) collection that shows crop growth, pest and disease attack, etc.

CropIn provides the following types of advisories to farmers through SMS:

- Weather Based Advisory and Weather alerts to SLACC farmers in local language
- Package of Practices (PoPs) to farmers for sustainable crop production
- Agronomic advisories to prevent and control the pest and diseases
- Nutrient, soil and water management practices for every crop stage to ensure high crop yield
- Livestock Management



Picture 3: CropIn Digital Platform for SLACC

Project Timelines

SLACC is a 3 years project conducted in three different phases based on the crop seasons - *Kharif*, and *Rabi*. The project started in March 2017. After witnessing a favourable impact in terms of crop yield, and adoption rate, the World Bank has extended the project to another year i.e till 2019.

Key Challenges in Implementation

During the implementation of the project, CropIn confronted major challenges in terms of technology adoption by the rural communities as they lacked awareness on technology and its application in farming to mitigate climate change risks. Understanding the socio-economic profiles and the literacy levels of farmers in the project areas, CropIn took an initiative to conduct training on how to use the application exclusively meant for VRPs / CRPs and Young Professionals.

The VRPs, CRPs, and Young Professionals are the farmers who are moderately equipped with agriculture literacy and work with farmers on the farm fields. These trained farmers, in turn, educate other farmers on the right usage of climate-smart advisories, PoPs and other chemical applications. Furthermore, considering the language barrier and low literacy rate, CropIn provides the SmartFarm application in the local language.

Exclusive trainings of field executives on usage of CropIn's technology and building local capacity of rural community is carried out for:

- Web and mobile applications data capturing process such as on how to register a farmer plot, crop varieties, different crop stages, raise alerts, use and act on advisories

- How to monitor and close activities including raising and resolving alerts
- How to capture, harvest and archive data
- How to utilize PoP advisories for better farm management

Monitoring and Evaluation of Project Activity

Adoption Survey to Measure the Adoption Rate of Farmer Advisories

CropIn conducted advisory adoption survey to measure the impact of WBAAS on farmers. The purpose of this survey was to identify whether the advisories are being utilised and implemented at the farmer's end.

The results of the Adoption Survey revealed that there was a dramatic change in the behavior of the the participating community towards the adoption of climate-smart practices.

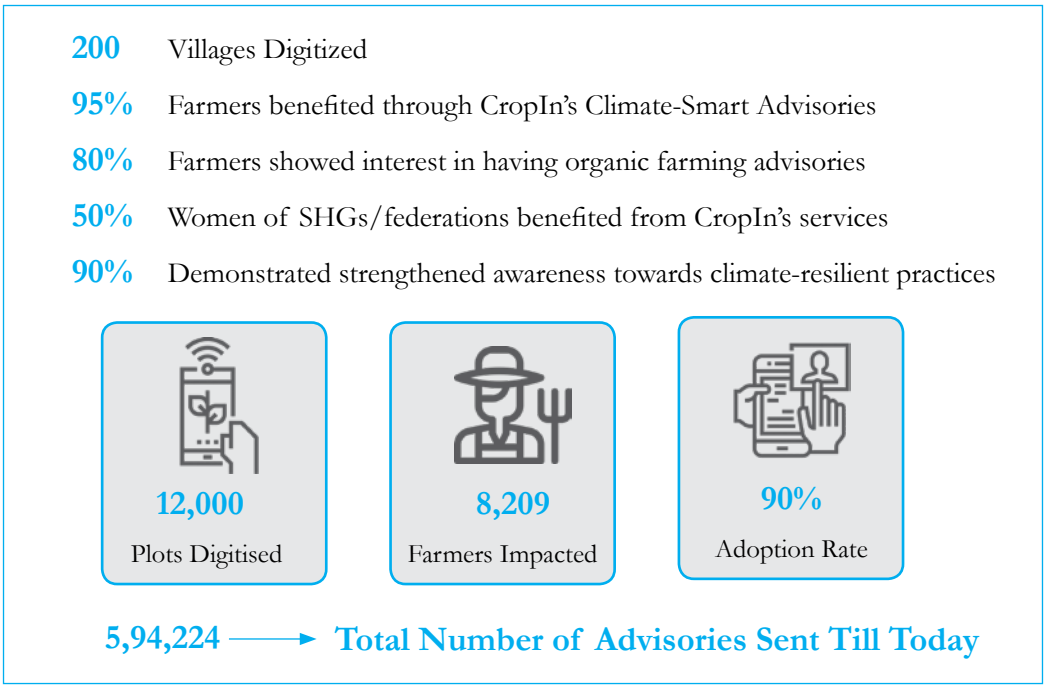
The key outcomes of the survey are as follows:

- 200 community institutions implemented climate adaptation measures
- 92.3 percent respondents considered weather-based advisories as a game changer in terms of effective cultivation.
- 95 percent farmers considered advisory and alerts on pest/diseases as beneficial
- 81 percent farmers showed interest in having organic based plant protection advisories

There was a huge uptake of CropIn's technology and high-level farmer engagement with optimum agricultural productivity. Each Village Resource Person (VRP) covers about 40 farmers and spends about 10-15 days per month on SLACC work. In this way, CropIn strengthens the capacity of rural communities by responding to their vulnerabilities and risks to climate-induced losses.

Third-party Evaluation

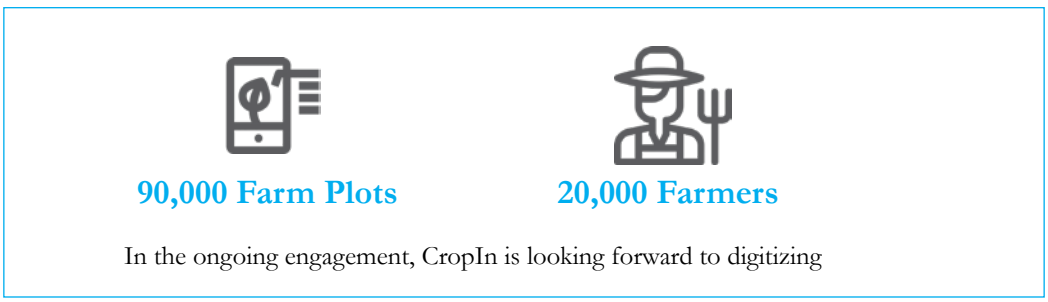
The World Bank conducted an independent survey and evaluation of the project through a third- party to measure the impact created through SLACC pilot. It aimed to assess the impact of the program, including the effectiveness of program design, relevance, sustainability of results, and impact of the SLACC intervention on the target community. The agency carried out monitoring and evaluation in three phases - baseline, mid-term and end term - for Mandla, Sheopur, Madhubani and Gaya districts.



Picture 4: Illustration of Independent Audit Results from Third Party Evaluation

Looking Ahead

Ushering technology transformation in agriculture is critical to fight climate change and ensure food security. Since its inception stage, WBAAS services has gone through a significant learning phase. The lessons learnt have been integrated in the next phase of implementation to achieve sustainable impact. CropIn continues to address the farmers' issues through the WBAAS intervention accompanied by remote sensing, Artificial Intelligence (AI) & Machine Learning (ML) capabilities.



Picture 5: CropIn's Future Plans

A Proud Patron of JEEViKA

Kanti Devi, a farmer from Barachatti, is proudly using the services of CropIn since Kharif 2017. Kanti says, "The advisories which I receive on a regular basis for seed treatment, sowing, irrigation and harvesting have helped me tackle various problems and keep an eye on my crops, without having to frequently visit my farms." She adds that the recent services on livestock advisory has been phenomenal. She now understands various symptoms of diseases and deficiencies because of the advisories received on her phone.

Based on the current activities, feedback and increase in farmers adoption rate, CropIn proposes to extend the services to other regions of M.P and Bihar as follows:

- Cropin will apply satellite-based weather data to disease and pest alert incidences
- As subject matter expertise is hard to find in villages, CropIn plans to test out automation of forecast-based advisories through built-in AI and ML algorithms which will rely less on SMS
- The advisories will not only be sent based-on weather but also other allied services such as sowing window prediction, crop health monitoring through remote sensing, and yield estimation
- Promoting organic based nutrient and crop protection management and introduction of Good Agricultural Practices (GAP)
- Enhancing visibility of messages by effectively installing blackboard in community places of every village where the VRPs will write down the advisory on Package of Practice (PoP) for the major crop of that village

Dedicated to Late Sitaram Rao, mentor and guru of Indian microfinance and livelihoods movement, the Case Study Competition aims at bringing together the collective intellect of the sector and assimilating innovative solutions, breakthroughs, good experiences and best practices that help in learning from diverse sector experience and impact poverty reduction. The Competition was instituted as a pioneering initiative by ACCESS in 2009 to identify and collate models and practices that have significantly contributed to livelihoods promotion of the poor in India.

The theme for Sitaram Rao Livelihoods India Case Study Competition 2019 was **Technology Solutions for Agricultural Advancement**. The Compendium covers cases from across the country that provide evidence of technology solutions that are impacting farmers to strengthen their livelihoods, participate more effectively in value chains and earn incremental incomes.