CHERUVU: SUSTAINABLE AGRICULTURE IN INDIA

Master's Project with the School for Environment and Sustainability at the University of Michigan

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1. ABSTRACT

With rapid deployment of reliable mobile data networks and rising smartphone adoption, there is a growing opportunity for digital delivery of agricultural extension services in rural India. This project worked with a company called Cheruvu which began as a provider of soil testing services in Telangana India. Cheruvu has developed a mobile application to convey the results and recommendations based on farmers' soil tests. Through surveys and interviews with some Cheruvu's customers, this project will give advice to Cheruvu about their next steps.

Results show that the farming information is shared primarily through pre-existing social networks and that it is difficult to introduce other forms of information sharing. The greatest demand for information is related to emergent issues that occurred over the farming season such as pests or disease. The local fertilizer shops dominate as providers of both information and solutions for these emergent issues. According to the interviewees, the biggest barrier for adoption of smartphone applications was lack of education and access to smartphones by the farmers in the household.

Our findings suggest that Cheruvu should continue to provide farmers with a paper form to ensure that farmers receive their advice. Cheruvu can also increase adoption at the village level by working with local influencers and offering solutions to problems as they arise during the cropping season.

2. INTRODUCTION

2.1 - CLIENT DESCRIPTION

Cheruvu's mission is to help smallholder farmers in India increase their yield and income, starting with those in Telangana. When farmers have access to more information, their yields increase by 33-66%. Research suggests that agricultural guidance works, but traditional agriculture extension does not reach everyone when they need it for a variety of local reasons (Vittal 2004). Cotton farmers' yields and income vary widely within Telangana state, which suggests there is great potential to bring those at the lower end of the range to the higher end.

One of the most important things farmers are lacking is nutrient management information. Cheruvu helps to close this information gap by testing soils in the fields of farmers and providing nutrient management advice based on soil test results that can be seen through a smartphone app. Because smartphones are quickly becoming standard in Indian villages and Cheruvu sees this as an opportunity to reach people in a new way. Cheruvu believes this solution can provide farmers with a more reliable tool for agriculture production and help bring their product more consistently to market.

2.2 - PROJECT OVERVIEW

The objective of this project is to find key issues facing cotton farmers in Telangana and provide recommendations that help increase adoption and utilization of Cheruvu's app. This latter objective requires answers to three sets of questions:

- *Determine Customer Needs*: Help Cheruvu define their customers' needs. Which services do customers value most? Is there anything else they can provide? What is the best way for them to deliver their service?
- *Assess Competitive Landscape*: Investigate players in the market, especially those who have a similar vision to Chevuru. What are possibilities for future services? What services do competitors provide that attract farmers? What can Cheruvu learn from them? Are there ways to work together to help the outcomes of smallholding farmers?
- *Improve Farming Operations*: Find ways to improve farming operations. Are there other problems that Cheruvu could help solve via their digital platform? What are other best practices for Cheruvu to help smallholding farmers?

2.3 - OVERVIEW OF COTTON FARMING IN INDIA

India is the world's second largest producer and third largest exporter of cotton. However, yields per acre remain low: the USDA reports that India has an average yield per hectare of 494kg, far lower than the leader Australia at 2,449kg, or even economically and geographically similar Pakistan at 575kg (FAO, 2020). Part of the reason for low yields are weather and infrastructure bottlenecks, but another reason is the limited utilization of relevant knowledge about yield increases among small holding farmers. Indeed, there are large variations in yields across farmers within the same region, even between farmers who have all adopted Bt cotton, the primary type of cotton farmed in India (Gruere 2010).

Bt Cotton was first introduced to Indian farmers in 2002 and resulted in large yield increases. There are concerns for small holding farmers because Bt cotton seeds are sold at a high price, and are relatively unproductive after one year of growth, creating a cycle of reliance on large agricultural companies. One of the major cotton growing states in India, Maharastra, banned the sale and distribution of Bt cotton from 2012-2013 after concerns of low quality seeds and a rash of farmer suicides (India Times 2012). Some argued that the link between the seeds and the suicides is indirect, with poor farmer information and implementation of the seeds to blame rather than the seeds themselves (Gruere 2011); others find a more direct link of the high prices of Bt cotton seeds causing indebtedness, a primary driver of farmer suicide (Desmond, 2016).

Despite Bt cotton reducing the need for pesticides, cotton still represents the highest pesticide use in India due to the high susceptibility of cotton to pests and disease. In cotton farms that do not use pesticides there can be losses of up to 82% (Oerke 2006). Studies show that there was a sustained reduction in

pesticide use among Indian cotton farmers using Bt cotton of up to 50% when compared to non Bt plots, including among smaller farms such as those Cheruvu works with (Krishna 2011). This lowered the input costs for farmers and improved their health because the pesticides used to prevent bollworms are among the most toxic (Kouser, 2011). These effects of these toxic pesticides include reduced reproductive performance and skin and eye disorders (Rupa 1991). Kouser estimated that by 2008 Bt cotton had helped avoid up to 2.4 million cases of pesticide poisoning in India per year.

In 2005 the FAO reported approximately 6% of fertilizer used in India is applied to cotton, the third largest percentage after rice and wheat (FAO 2005). The majority of farmers in India apply inorganic fertilizers rather than organic fertilizers (Bagal 2018). As of 2012 India was one of the highest users of fertilizer for cotton in the world, at 116.8 kg per hectare (FAO 2005). With the high proportion of citizens relying on agriculture in India, and fertilizer being one of the most expensive inputs, the Indian government works to ensure that the price of fertilizer is fair across the country. The Department of Fertilizer works to set prices, recommend vendors, and deal with farmers' grievances against fertilizer shops (Dept. of Fert., 2020) ; urea, a key nitrogen fertilizer, is kept under particularly tight control, with a maximum price enforced across the country (Economic Times of India 2019), while other fertilizers generally received a national subsidy rate rather than a maximum price.

India has 17% of the world population while it only has 4% of the freshwater resources (Dhawan 2017). Scholars predict that maintaining sufficient water for agriculture will become increasingly difficult. Given the ever increasing demand of water for urbanization and industrialization, Kumar (2003) expressed concerns regarding water resource allocation for agriculture; other issues such as groundwater depletion and water logging add to the challenge. In the state of Telangana, farmers have become increasingly concerned by the severe inaccessibility of irrigation resources (Vakulabharanam 2004). According to Mahesh (2016), 200,000 acres of total 1,060,000 acres (18.87%) of arable land in Telangana receives irrigation support. Furthermore, groundwater irrigation needs substantial private capital, adding to the financial pressure of farmers (Vakulabharanam 2004).

Infrastructure is directly linked to agricultural productivity as well as access to financial institutions (Binswanger 1993); the level of infrastructure tends to be tied directly to each individual state in India's level of agricultural production (Bhatia 1999). Roads tend to allow greater access to inputs, which lower costs and allows for spending on other inputs, improving yield (Zhang 2004). Another aspect of infrastructure is the amount of and access to agriculture scientists and agriculture extension workers which have significant effects on the development and usage of modern farming equipment and knowledge, and in turn affecting agricultural productivity (Bhatia 1999).

There is also a strong link between infrastructure and access to financial institutions (Binswanger 1993). Access to financial products such as loans, crop finance, and agricultural insurance, is one of the major issues for smallholders' inclusion in sustainable supply chains (Fayet & Vermeulen 2014). Small holding farmers often lack the funds to buy necessary inputs which may result in suboptimal yields. Farmers are then forced to turn to loans for support. The high dependence on creditors result in continuous and tied credit (G. Parthasarathy and Shameem 1998).

3. LITERATURE REVIEW

3.1 - SOIL TESTING

Soil testing is crucial in order to determine the optimal amount and types of fertilizers to use (Mohan 2018). The Indian Government's Soil Health Card (SHCs) scheme facilitates soil testing and delivers recommendations to farmers (Soil Health Card 2020). To date they have conducted over 50 million soil samples and distributed soil health cards to almost half that number. They have achieved results from reduced fertilizer usage which reduces input costs, and increased yields by as much as 40% (Soil health Card, 2020). Rego et al. (2007) showed similar results across a variety of crops when conducting experiments in Andhra Pradesh. Soil testing has proved effective for cotton farmers in Pakistan, with better fertilizer use yielding a reduction in overall fertilizer cost of 18% while increasing yield by 15% (Imran 2018); better fertilizer usage has resulted in similar increases in cotton productivity in Maharashtra India (Singh 2012).

3.2 - SOCIAL LEARNING IN FARMING

Adoption of farming innovations such as soil testing can often be slow in developing countries (Feder 1993). The rate of adoption is often influenced by the peers and communities which surround the farmer (Foster 1995). In India, when Bt cotton was first introduced, there was significant social pressure which impeded its adoption. In some cases adoption relied on more progressive farmers to take risks and display success before more skeptical farmers would try (Maertens 2017). Once the early adopters had good results, many other farmers were quick to follow (Stone 2007). Some NGO's and private sector organizations utilize these social learning effects through the use of "show farmers" in India, where local farmers may be featured in media or brought to villages to extol the virtue of new agricultural products or techniques; this approach was effective in spreading information on organic cotton farming in Telangana (Flachs 2017).

3.3 - AGRICULTURAL APP REVIEW

To fill the information gaps between farmers and markets, including farming, markets and finance, both public and private sectors are taking advantage of mobile technologies. Agricultural Apps are one popular approach. Some organizations in India are using mobile platforms and applications as their major way to communicate among researchers, employees and farmers (Ganesan et al. 2013). There are 10 apps listed as empowering tools to facilitate agricultural development. They are Kisan Suvidha, IFFCO Kisan Agriculture, RML Farmer – Krishi Mitr, Pusa Krishi, AgriApp, Kheti-badi, Whatsapp, Krishi Gyan, Crop Insurance and AgriMarket (Claro Energy 2018).

The mobile apps available on the market can be categorized into different groups with various focuses. For instance, there are apps (e.g. AgriMarket, Kisan Suvidha, Crop Insurance, etc.) that aim at the

provision of market, weather, financial and farming information. Kisan Suvidha was launched by Prime Minister Narendra Modi in 2016. With a neat design, the app offers critical information, including weather, input dealers, market prices, plant protection and expert advisories (Bera 2016). AgriMarket was launched by the Government of India and it allows farmers to check crop prices within 50km of their device locations (Claro Energy 2018). Sriganesh Lokanathan and Harsha de Silva (2010) argue that providing access to market information is fundamental to the reduction of transaction costs and the increase of farmers' engagement in market activities.

Some apps (e.g. IFFCO Kisan Agriculture and RML Farmer – Krishi Mitr) are especially successful by providing customized services to help farmers make informed decisions. Both apps were launched in 2007. IFFCO Kisan has 4 million users and its services include Agro ICT Services (Green Sim Card), Call Center, Urban Gardening, Software Solutions, Commodity Services, Rural Distribution and Cattle Feed (IFFCO Kisan 2020). RML has services including RMLdirect and Micro Level Analysis (i.e. RML-EDGE and RMLpro). RMLdirect is a SMS based service providing personalized information, such as weather, farm solutions, market data, health and education (RML 2020). Mittal and Tripathi (2009) conducted an assessment on these two apps through focus groups and interviews. They found that all interviewees reported positive economic benefits of mobile phones. Farmers recognized easy access and personalized content as main advantages of mobile information services (Mittal & Tripathi 2009).

[Table 1 Mobile phone-based information services for farmers]

Particulars	**IFFCO-IKSL**	**Reuters-RML**
Service started	June 2007	October 2007 (pilot in January 2007)
Locations of survey	Uttar Pradesh, Rajasthan	Maharashtra
Cost	Free voice messages Helpline service at a cost of Re 1/min	Rs 175 for three months Rs 350 for six months Rs 650 for one year
Nature of delivery	Voice message	SMS-text message for two crops subscribed by the farmer
No. of daily messages	5	4
Nature of information provided	Weather, Crop/animal husbandry, advisory, Market prices, Fertilizer availability, Electricity timings, Government schemes	Weather, Crop-advisory (one crop), Market price (for 2 crops and 3 markets each), News (commodity-specific and general)
Other services offered	Customized advisory through helpline	None
Subscribers (at the time of investigation: August-October 2008)	UttarPradesh: 200,000 Rajasthan: 65,000	Maharashtra: 77,000 All India: 82,000

(Table from Mittal & Tripathi 2009)

Kheti-badi promotes organic and natural farming and connects organic farmers with buyers (Kheti-badi 2018). Apps such as Whatsapp and Krishi Gyan meet farmers' social needs. They offer farmers and people who are enthusiastic about agriculture connection and social support (The Pioneer 2013). Apps such as SmartCrop, Mandi Trades and Kisaan Market facilitate produce transactions and serve as online marketplaces (Reddy 2019; Claro Energy 2018) .

Compared to these mature apps, Cheruvu's app only functions as a pilot at this stage. First, it provides limited information around soil tests and pesticide usage. This information, however, wouldn't be valued much by farmers if instructions are not placed in position. Second, the small customer base doesn't allow it to study user behavior. Therefore, the team doesn't know which feature is most valued by customers and it can't find a value proposition in the market. Third, the short time of its operation limits network effect.

4. METHODS

4.1 - SURVEY METHODOLOGY

In our survey, we sought to determine personal and household characteristics and the wealth of the respondents. We interviewed 548 respondents and asked 33 questions. A full list of survey questions can be found in the appendix.

4.2 - INTERVIEW METHODOLOGY

Our first round of interviews were driven by three main questions: How do farmers in Telangana, India share knowledge and information about cotton farming with one another? What are the technological tools that will help them disseminate information about best practices and increase yields? What changes can be made to the tools that Cheruvu has already developed in order to reach farmers better and promote effective engagement with these tools? Our second round of interviews focused on these three driving questions: What would prevent people from utilizing Cheruvu's advice? Who used the app and what did they find useful about it? What changes could be made to the app to make it more useful for a larger segment of the population?

We created a list of farmers randomly by using a number generator. If the farmer we chose randomly was not available on the day of the interview, we went through our list and found another farmer in the same village who was available instead.

4.3 - QUANTITATIVE ANALYSIS

Our team used a quantitative approach to analyze the survey data. RStudio (R) was employed as a main tool for linear regression analysis. Tableau was used as a supplement for data visualization of demographic basics.

4.3.1 - DATASET BUILDUP

Survey responses

In total, the survey got 548 responses. After deleting invalid responses and outliers, there are 533 valid responses, which were used as the dataset for regression analysis.

Data Cleaning

15 responses were deleted from the original collection. Among them, 13 were deleted because of missing data. Farmers left "Cotton Yield 2018 (Quintals)", "Acres of Cotton" and "Income from Cotton 2018 (Rupees)" blank. The remaining 2 deleted responses were due to outliers such as 300,000 kg per acre of yield and 20,000 acres of cotton. The numbers were astronomical and thus considered to be user errors. Without these outliers, the range of acres of cotton was from 0.1 to 35 acres and the range of yield per acre was from 0 to 25 quintals.

4.3.2 - THRESHOLD AND REASONING

We used 5% significance level as a general threshold to screen independent variables. It means that independent variables that were not statistically significant (i.e. p-value > 5%) would be reviewed and evaluated by our team. Those variables with p-value > 10% were directly taken out from regression models. However, if the variables had p-value between 5% and 10%, the decision would be a judgement call, based on the combination of the variables' definition and the goal of this survey.

5. RESULTS

5.1 - DEMOGRAPHIC BASICS

[Table 2 Demographic basics of the survey]

Gender	Male -494 (92.7%)	Female – 39 (7.3%)
Age	Mean: 46.9, SD 10.7	Range: 19-85
Household Size	• 1-2: 26 • 3-5: 435 • 6-8: 72 • 10+: 8	
Household Workforce	• 0: 14 • 1: 100 • 2: 291 • 3: 56 • 4: 47 • 5+: 21	
Equipment	Yes: 195	No: 336
Livestock	Yes: 256	No: 277

5.2 - REGRESSION ANALYSIS RESULT

This section presents the analysis for two outcome variables: “Yield per Acre” and “Income per Acre”. “Yield per Acre” is the average number of quintals (100kg) of cotton that farmers grew in 2018; this represents productivity. “Income per Acre” is the average dollar amount farmers earned by from one acre of cotton. To find the relationship between inputs and productivity, we divided Total Inputs 2018 by Acres of Cotton to get Inputs per Acre; this is the average dollar amount that farmers invested in one acre of cotton.

5.2.1 - DEPENDENT VARIABLE: YIELD PER ACRE

Independent variables that are statistically significant

Using the screening criteria, our team found that independent variables that are statistically significant are as follows: a subset of the Villages, Debt, Cotton Yield 2018 (quintals), Inputs per Acre, Chicken, Goat, Pig, Buffalo, Cow and Dog. Among them, Cotton Yield and Inputs per Acre are positively correlated with Yield per Acre while Debt is negatively correlated with Yield per Acre. It may be that farmers who have debt face financial pressure, which doesn’t allow them to invest sufficiently in cotton farming. This may adversely affect their cotton yield. The positive correlation between Inputs per Acre and Yield per Acre shows that investment in pesticide, fertilizer and labor will increase yield. In addition, owning livestock seems likely to reduce farmers’ cotton yield as the result shows that some dummy variables of livestock, such as chickens and goats, are negatively correlated with Yield per Acre.

[Table 3 Regression output of independent variables]

Independent variables	Estimate	Std. Error	T value	Pr(>|t|)
Debt	-1.84E-06	5.73E-07	-3.202	0.00146
Cotton Yield 2018 (Quintals)	1.24E-01	1.30E-02	9.559	< 2e-16
Inputs per Acre ($)	6.75E-05	1.19E-05	5.688	2.35E-08

Adjusted R-squared

This linear regression model has an Adjusted R-squared of 38.14%, meaning these variables together explained 38.14% of variance in Yield per Acre.

5.2.2 - DEPENDENT VARIABLE: INCOME PER ACRE

Independent variables that are statistically significant

The independent variables that are statistically significant are: Village, Home Toilet, Income from Cotton 2018 (Rupees), Inputs per Acre. Income per Acre is positively correlated with Home Toilet, Income from

Cotton 2018 and Inputs per Acre. It's assumed that the possession of at least one toilet at a farmer's home demonstrates their wealth level. The positive coefficient means that if a farmer has a toilet at home, they will have higher income.

The assumption is that when a farmer is in a good financial position, they have money to invest in inputs and better farming practices. This may lead to better-quality and higher quantities of cotton which can be sold at a better price, which may explain the positive correlation between Inputs per Acre and Income per Acre. It's very likely that investment on inputs result in better-quality cotton. Meanwhile, farmers in some villages have relatively higher income than farmers in other villages. There could be multiple reasons for this. One reason is that farmers in one village tend to have the same broker who gives them similar prices. This results in a variance of income between villages. Another reason is that farmers in the same village usually share farming practices which help them cultivate cotton of similar quality, leading to similar selling prices.

[Table 4 Regression output of independent variables]

Independent variables	**Estimate**	**Std. Error**	**T value**	**Pr(>|t|)**
Home Toilet (Yes)	1.34E+04	4.50E+03	2.981	0.00303
Income from Cotton 2018 (Rupees)	1.93E-01	5.45E-03	35.498	< 2e-16
Inputs per Acre ($)	4.10E-01	7.58E+00	6.064	2.81E-09

Adjusted R-squared

This linear regression model has an Adjusted R-squared of 76.11%. It means that these variables together explained 76.11% of variance in Income per Acre.

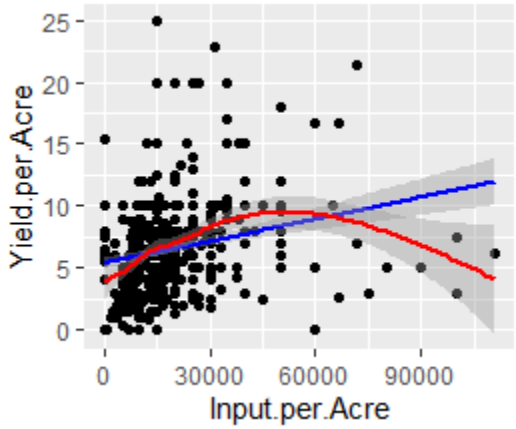
Correlation with Input per Acre

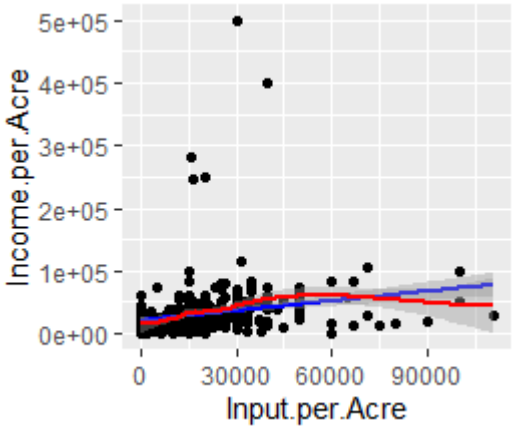
Our team examined the correlation between the dependent variables and Input per Acre. Input per Acre is a dollar amount farmers spent on fertilizer, pesticides and labor. One hypothesis is that if fertilizer, pesticides and labor affects cotton growth, the increase of Input per Acre will increase Yield per Acre.

Our team also used R to check the correlation between Yield per Acre and Input per Acre. Another hypothesis is that if fertilizer, pesticides and labor affects cotton quality, the increase of Input per Acre will increase Income per Acre as cotton can be priced higher. We then did an analysis between Income per Acre and Input per Acre to see if inputs could affect farmers' income.

The results showed that the correlation between Yield per Acre and Input per Acre is 0.24, and the correlation between Income per Acre and Input per Acre is 0.21. Although they are positively correlated,

the evidence here is not strong enough to conclude a strong correlation. Possible reasons can be inaccuracy of farmers' estimates on inputs and low application efficiency of inputs.

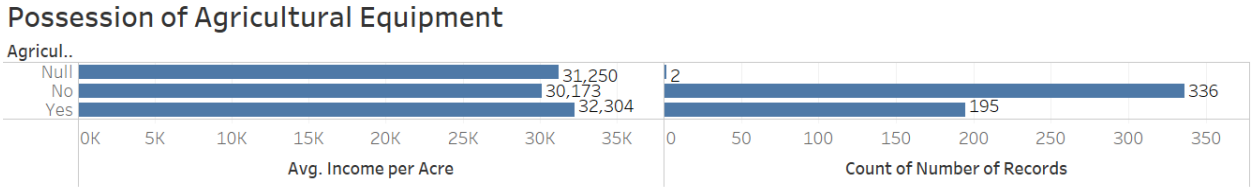




5.2.3 - ADDITIONAL FINDINGS

Impact of Agricultural Equipment/Transport

Our regression models do not show a significant relationship between the possession of agricultural equipment (i.e. Tractor, Plow, Bullock Cart, Auto (Three Wheeler), etc.) and Yield per Acre/Income per Acre. However, the Tableau analysis shows that the average Income per Acre of farmers with agricultural equipment (32,304 Rupees) is higher than that of farmers without agricultural equipment (30,173 Rupees). Although the 7% difference is not significant enough to demonstrate any correlation, it could be interesting for further studies.



Average of Income per Acre and count of Number of Records for each Agricultural Equipment.

5.3 - FINDINGS FROM INTERVIEWS

5.3.1 - SOURCES OF INFORMATION

IN THE FARMING PROCESS

The farmers we interviewed received information mostly from their own experience, advice from elders, advice from neighbors, or advice from fertilizer shopkeepers. Working from their own experience was the most common answer. Interviewees felt confident that given their experience they did not need to seek out much additional information. This base of information came from past family members who taught them how to farm, or from their immediate neighbors or village elders. These were seen as trusted and accessible sources of information who would also have knowledge of the local environment.

Fertilizer shops were a consistent source of farming information. This specifically came up when farmers were dealing with pressing issues that arose recently, such as how to deal with a specific pest or disease; farmers would bring pictures or samples of the issue they were facing, and buy inputs based on that advice.

The government did not come up often with regards to farming information, but when it did the interviewees spoke very positively about them. One interviewee explained his experience with a government agricultural worker. He was very satisfied with the advice he received and his crop for 2019 and said that he would go to the government agency again next year. Others felt that the government should have more responsibility in helping them out; when seeds or inputs were the problem, they felt the government should step in and enforce prices and quality for seeds and inputs. Similarly others felt that the government could play a better role in setting fair sale prices for cotton.

IN THE SELLING PROCESS

The market was mentioned most often as the place farmers would sell their cotton. Farmers store their cotton and transport it to the market where they would liaise with a buyer who would weigh the cotton, assign a grade, and then pay them. In our interviews farmers often complained about this process: some thought the scales weighing the cotton were unfair, while others thought the sellers had too much power to determine the grade of the cotton. There were however farmers on the other end who thought it was fair, and one who would sell to the market if they had a vehicle. Access to a vehicle and fuel costs were large barriers to selling to the market. One farmer would gather together a group of farmers to share the cost of transporting their crop for this reason.

Selling to brokers was the second most common method mentioned by the farmers in our interviews; these are travelling buyers who visit the farms directly and buy from the farmers. Others were tied in a contractual agreement with these brokers as they helped them finance the farming operation. Many of our farmers felt very comfortable with this relationship, and felt the brokers gave a good price; this is especially true for farmers who did not farm much cotton. Some complained that the brokers had too much leeway in assigning the grade of the cotton, while one respondent thought they took too much of a margin.

Lastly there were a few cases of an even more direct sales method; one farmer mentioned selling directly to cotton ginning plants, while another said that they sold directly to the government. Both were very

enthusiastic and positive about these arrangements, implying that it was by far the best option available to either of them.

The decision of when to sell cotton was more directly related to finances than who to sell to. Most farmers stored their cotton and sold when they needed the money. Only one farmer mentioned that they would monitor the prices and sell when the price was high.

5.3.2 - APPLICATION/SMARTPHONE RELATED

In our first round of interviews we wanted to understand the farmers' baseline usage of smartphones. When asked further about the general use of their smartphones, most farmers responded that they hardly used it. When farmers did use their smartphone, the overwhelming majority only used communication apps such as WhatsApp. Upon further questioning it became evident that even if the farmer owned a smartphone, it was often in use by another member of the family, such as a brother or child. Only one farmer had spent any considerable time with the Cheruvu app or was planning on using it all over the course of the farming season.

We revisited the topic in our second round of interviews after a full cropping season. After a year there would have been more opportunity for farmers to use the app and for us to gather feedback. However, there were few farmers who could speak substantively about using the app. We ran into similar issues where another family member had primary possession of the smartphone over the course of the past 6 months, or that it was viewed as a family appliance and children often used it for entertainment purposes rather than the Cheruvu app.

Earlier studies focus more on successful apps and their features, such as free messages and value-added services. Little attention is drawn on non-users. Our team intended to find out reasons for the low adoption and utilization of Cheruvu's app. The majority of the farmers interviewed in the second round listed their own lack of education as the primary reason they would not interact further with the Cheruvu application. One farmer did use more digital sources of information, but relied on YouTube instead of the Cheruvu application. One farmer did report using the app, but described taking only some of the advice given, and ignoring the rest. As discussed earlier, farmers tend to rely on their own experience or those directly around them when they need advice. One farmer specifically mentioned that he could not trust the advice of the app as the weather that year was particularly wet, and could not be sure that the app would give suitable advice given that environment. Finally the social idea discussed above was displayed, where one farmer said they would rather do the same as other farmers in the village and fail rather than possibly succeed by operating differently.

5.3.3 - OTHER INSIGHTS FROM INTERVIEWS

One of the biggest determinants of a good crop was access to water. When farmers had a well or a canal nearby, they indicated that they felt secure and satisfied. However, when water was out of reach and they were forced to rely on the increasingly erratic rains, they had worse outcomes. For example, when asked the reason for cultivating cotton, one farmer explained that insufficient water facilities left him no choice. Cotton demands less water than other crops. Some farmers said they would rather grow rice, but water constraints left them with no choice but to grow cotton.

Labor costs were also a challenge for farmers with many indicating it was their biggest expense. While some relied solely on family labor, many hired workers to help sow, weed and pick their cotton. In the second round of interviews that took place in March 2020, many farmers indicated they would be switching to rice next season because of the reduced labor cost associated with it. The high cost of pesticides and fertilizers was another challenge for farmers. Most farmers felt they were forced to buy them in order to have a chance at a successful crop, but sometimes they were not satisfied with the results and they still faced problems. Several were so dissatisfied with the cost and the perceived negative health consequences that they expressed a desire to switch to organic production.

6. DISCUSSION – ADVICE FOR CHERUVU

Our analysis suggests that increased input expenditure per acre has a statistically significant effect on both income and yield per acre; if Cheruvu can reach more individuals they can help farmers manage their input spend wisely to reap these rewards. Our project was focused around how Cheruvu can improve their app, and by doing so, improve the livelihoods of the farmers they work with. To that end we focused our analysis on how the cotton farmers of Telangana acquire farming knowledge, how a smartphone application might fit into that environment, and how those apply to Cheruvu as they continue to develop their app.

6.1 - TRUSTED SOURCES OF INFORMATION : SOCIAL NETWORKS, LOCAL EXPERTS, AND THE GOVERNMENT

From our interviews we know that farmers tend to rely on the information that has been passed down to them by their family, or on the advice of nearby neighbors of village elders. Not only did these social networks act as a strong source of information, but in one of our interviews they prevented a farmer from adopting new technologies; rather than follow the advice of Cheruvu this farmer preferred to succeed and fail with the village then adopt farming practices that differed from the village. In the literature we have seen social pressures delay the adoption of Bt cotton despite proof of success; social learning has also been used successfully by those implementing Show Farmer initiatives. Cheruvu can utilize these network effects by working with people in positions of influence such as village elders or individually successful farmers. This may hasten the adoption of Cheruvu's product in villages.

When the advice given by family or the local community was not sufficient, farmers tended to turn to the local fertilizer shops for advice. Each growing season is different, and farmers must adapt to immediate conditions to survive. Currently the fertilizer shops have a monopoly on providing this timely information. Cheruvu may be able to provide greater services to the farmers by having live assistance, a database of information, or facts on common issues that their customers can refer to.

This timely information extends to the sale of cotton. Farmers' need based selling method is not necessarily conducive to maximizing profits over the course of a growing season. Some of this may come down to the lack of timely information for the sale price of cotton. Kumar et al. (2016) described how economic decision making can often be sub-optimal in small holding farmers when compared to larger management groups (Kumar, 2016). If they had better information on what brokers vs. the market vs. the

government was offering, farmers may be able to make more effective decisions to maximize profitability.

Our data also showed that those with access to agricultural equipment had higher income per acre. Like the AgriMarket app being deployed by the Government of India, Cheruvu can add value by utilizing its app to collect and disseminate selling price information to its users in Telangana. They may also be able to add a simple calculation tool to help farmers maximize value over the course of a growing season, or a way to connect groups of farmers to a vehicle, giving greater access to selling at the markets.

Whenever farmers had government help, be it receiving inputs or selling to the government, they spoke highly and passionately about it. The role of the government seems to be vital in these communities, and we have seen in the literature the power of public-private partnerships in deploying infrastructure and extension services. Cheruvu may be able to gain a stronger foothold in its communities if it forms a more explicit partnership with the government and it's schemes. Private-public partnerships to better connect local context to government schemes is a common occurrence in India.

6.2 – LACK OF EDUCATION IS A BARRIER TO ADOPTION OF SMART TECHNOLOGIES

In most of our interviews with the farmers of Telangana after the cotton season, the primary reason given for not using the app was the perceived lack of education. Farmers did not feel confident to use smartphones in general, and even more hesitant to use them for the farming advice on which their livelihoods relied. This is a large barrier that must be overcome should interventions such as the Cheruvu app wish to gain widespread adoption.

Because of this we cannot recommend that Cheruvu abandons the paper form in favor of the app. Rather there is value in including more information on the form, such as how to deal with common problems, weather forecasts, or selling prices as described above. Doing so would help Cheruvu's customers by giving them another source of information that is in an accessible format. If Cheruvu wishes for older, less educated farmers to use the app they must invest more time during the installation phase of the app to train the farmers on how to use it. This may help lower the perceived barrier to adoption. Otherwise they can prioritize younger, more educated farmers for the app, while still having the option of a paper delivery for those farmers less comfortable with smartphones.

Perhaps in time these trends will change. Farmers may become more educated as many of the government and NGO programs of the past begin to bear fruit. Or the farmers will simply grow older and retire, and hand off their farms to their more educated children. Also as smartphones continue to drop in price and adoption within the household increases, farmers will be able to have a smartphone of their own which will allow them to use it more frequently. They may become comfortable with smartphones and an application may become a more effective vector for information dissemination.

7. CONCLUSION

As a provider of soil testing for cotton farmers in Telangana, Cheruvu occupies an important part of the agriculture extension ecosystem and provides the local supply for this valuable service. As they transition into becoming a digital goods provider, we found that the people of Telangana are undergoing a similar transformation. It will be important for Cheruvu and other similar providers to ensure that they do not move too far ahead of the market and alienate anyone that would require their services. In the discussion section we laid out some advice within the analysis of our data collection on how Cheruvu might manage this transition. We have collected all of those points below:

1. Do not abandon the paper form
2. Improve the information provided on the paper form
3. If possible become a Timely Information provider
4. Help connect farmers to each other and sellers
5. Work closely with Government Schemes if possible
6. Spend more time educating farmers on use of the app
7. Target younger, more educated farmers for the app
8. Leverage Social Networks by working with influential persons in communities

We'd like to thank Cheruvu for the opportunity to work with them on this project. It was a pleasure for all of us to learn from them and their customers. We'd also like to thank the School for Environment and Sustainability for organizing the Master's Project, and Professor Arun Agrawal for agreeing to be our faculty advisor through this process.

APPENDICES

APPENDIX 1 – SURVEY QUESTIONS

Question
1. Name
2. TempID
3. Age
4. Gender
5. Mobile Number
6. Village Name
7. Mandal
8. Do you own livestock?
9. Do you own agricultural equipment?
10. To which caste do you belong?
11. How many members are in your household?
12. How many members of your household work on the farm?
13. How many children (below 18 years) live in your household?
14. How many members who were formerly in your household moved to the city?
15. What is the highest level of education attained by someone currently living within your household?
16. Do you have electricity in your home?
17. Do you have a toilet in your home?
18. How much debt do you have?
19. What was your cotton yield in 2019? (Quintals)
20. How much was your income from cotton in 2019? (Rupees)
21. How many acres of cotton did you cultivate last year?
22. How much did you spend on inputs (fertilizer, pesticides, labor) for your farm in 2019? (Rupees)
If they answered yes to Question 9
1. Tractor
2. Plow
3. Bullock Cart
4. Auto (Three Wheeler)
5. Other (Please Describe)
If they answered yes to Question 8
1. Chicken
2. Goat
3. Pig
4. Buffalo
5. Cow
6. Dog

APPENDIX 2 – SURVEY DATA

Round 1 Data – Raw (outliers included)

Cheruvu Survey Round 1 Data.xlsx

Round 1 Data – Processed for Regression

SurveyData-missing data deleted-new.cs

APPENDIX 3 – FIRST INTERVIEW QUESTION LIST

First Interview

Title of interview project:

Cheruvu – Information Sharing Amongst Cotton Farmers in Telangana, India

Project goals/questions:

1. How do farmers in Telangana India share knowledge and information about cotton farming with one another?

2. What are the technological tools will help them disseminate information about best practices and yields?

3. What changes can be made to the tools that Cheruvu has already developed in order to reach farmers better and promote effective engagement with the tools?

Introduction:

Cheruvu is a start-up business that is trying to improve farmers' wellbeing. We recognize that cotton farmers in Telangana are struggling to make profits. One of the things we see making things difficult for farmers is the time and money they spend on inputs and when they add them. When we say inputs, we mean what goes into your farm, that includes water and fertilizer. We believe that with more information on their soil farmer's will have more information to use when they make decisions about irrigation and fertilizers on their farms. With more information sharing, we also believe that farmers will know more about market conditions - who is selling cotton, who is buying cotton, when, and at what prices -which will allow them to get the best price for their cotton. Because of this, Cheruvu created an app which you can use on a smartphone which gives you this information. We are trying to learn what is helpful about it and what can be improved.

Farmer background

First I want to find out a bit more about you and your farm.

1. How long have you had this farm?

2. a. What crops do you grow on your farm?

   b. How long have you grown these crops?

3. How predictable are the weather patterns – like the rains?

4. What do you find to be your biggest successes on your farm?

5. What are the biggest hardships for you in farming?

6. Are you satisfied with your farm as it is?

Information sharing without the app

Now I have some questions about how you get information and make decisions about farming.

7. Who do you consult when making decisions about your farm?

8. How do you decide the type of fertilizer and the quantity of fertilizer you apply to your field?

9. How do you decide when to apply it?

10. How do you decide how much water your crop needs?

11. What information do you have about the type of soil on your farm?

12. How do you decide when to sell your cotton and who to sell it to?

Barriers to using the app

Now I am going to ask you questions about smartphones and apps that run on smartphones. This will help us understand what farmers think is useful about apps and what is not.

13. What access do you have to a smartphone that can run apps?14. How comfortable are you with using a smartphone app?

a. If they own their own go to question 14
b. If they only have access through a friend or family:
    i. Are you interested in having your own smartphone?

14. How comfortable are you with using a smartphone app?

15. Who do you think could benefit most from using an agriculture app?

Information sharing with the app

16. Have you used the Cheruvu app?

1. Yes - go to question 17\
2. No - Skip 17-19

Desired modifications to the app

17. If you could change something about the design of the app, what would it be?

    - If you worked at Cheruvu, what changes would you make?

18. What information do you think is missing on the app?

19. What helpful things could Cheruvu do to share information with farmers besides an app?

20. Is there anything important to you about the condition of cotton farmers in Telangana that I haven’t asked that you would like me to know?

APPENDIX 4 – SECOND INTERVIEW QUESTION LIST

Second Interview

Project goals/questions:

1. What would prevent people from utilizing Cheruvu's advice (even if they found it useful)?

2. Who used the app and what did they find useful about it?

3. What could be changed about the app to make it more of use for more people?

Questions

1. What were your successes over the past year?
2. What were some difficulties you had over the past year?
3. Where did you buy your inputs from?
    a. Seeds
    b. Fertilizers
    c. Pesticides
    d. Labor
3. What was your biggest expense?
4. Where did you go for farming information this year? I.e., fertilizer use, expected rainfall, etc.

6. What types of information did you ask for, and where did you get it from?

7. How many times did you use the Cheruvu app (if any)

- If yes, what did you find helpful?

- What could be improved?
    - If no, is there any feature that would make you decide to use the app?

8. What information sources did you use?

9. Did you follow the advice from Cheruvu at all?

- If yes, did you find it helpful?

- What specific pieces of advice did you use?

- If no, why not?

10. Would you trust the App more than the Fertilizer shop or other sources of information?

11. How (to whom) did you sell/are you selling your cotton this year? And why?

12. Are you satisfied with your farm?

13. What is the one thing you would change about your farm?

14. What other apps do you use on your smartphone?

15. Do you use any other farming related apps?

16. Do you use your smartphone for banking?

17. Why do you choose to farm cotton?

18. Would you consider another crop?

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