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IMB

ANALYTICS EMPOWERING AGRICULTURE: JAYALAXMI AGRO TECH

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> I grew up on the farm, however, with imminent rural migration, I travelled to cities and then abroad. When I went back to my village, after 15 years, I realized that the farmers' problems had remained same. Agriculture, being input intensive, needs constant information, which was fulfilled by pesticide shops in villages. Misinformation and biased information was rampant, which lead to increase in input costs. Accurate information was freely available on the internet; however, it couldn't reach the farmers. With the intention of bridging this critical information gap I decided to create an app for the farmers. This mobile app aims to bridge this digital divide and empower farmers.
>
> - Anand Babu Chitav, Co-founder of Jayalaxmi Agro Tech

Anand Babu Chitav Adigi, co-founder of Jayalaxmi Agro Tech (JAT), looked up from his laptop, seeking answers and insights from the data collected from their application about the diseases and crop varieties accessed by the farmers. The objective of JAT is to provide farm advisory system to help farmers in making decisions related to farm management. JAT had so far developed 20 mobile applications (apps) for various crops and farm animals in four Indian languages, namely, Kannada, Marathi, Oriya and Telugu as well in English that can be used by farmers to identify the affected crops and farm animals. In 2017, approximately 200,000 farmers had downloaded the apps and were actively using it to seek information for their crops.

More than 58% of the rural population in India depended on agriculture[1]. Farming in India has been a high stress profession and one of reasons is the high input costs and uncertain income. Anand was concerned with the high number of farmers' suicides driven by high level of stress suffered by the Indian farmers. According to the Government of India, despite a multi-pronged approach to improve income and social security for farmers, over 12,000 suicides were reported every year since 2013[2]. He was also worried about the increasing fertilizer subsidy and excessive usage of chemicals by the farmers. He wanted to analyze the data which he was collecting through his app and find out if he could gain some insights to understand some of these problems which can be further used to assist farmers. JAT collects usage information of crops by farmers across the India through their application. The information contains location, crop details and number of clicks by farmer on crop-specific mobile application icons such as planting, harvesting, disease, variety, micronutrients, irrigation, fertilizer, possible cure to disease and farming practices.

Anand realized that the farmers' data from JAT apps could provide him with invaluable inputs on cropping and disease patterns; however, he also realized that he should use additional data such as temperature, weather, rainfall, soil quality, irrigation as well as yield of the crops from other sources to get richer insights to solve farmers' problems. Anand through his app had collected data about various crops that had been converted into several Microsoft (MS) Excel sheets. He was wondering about how to analyze the data to gain meaningful insights that can be used to help the farmers. He decided to deep dive into data collected on the chili crop first.

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[1] Source: https://www.ibef.org/industry/agriculture-india.aspx

[2] Source: Source: http://timesofindia.indiatimes.com/india/over-12000-farmer-suicides-per-year-centre-tells-supreme-court/articleshow/58486441.cms, retrieved on 3 May 2017

AGRICULTURE IN INDIA

India has traditionally been an agrarian economy; owing to its fertile soil and river network. Agriculture, fishing and forestry were expected to contribute 15.1%[3] to India's GDP in FY 2017 and this increased by 4.4%[4] over the previous year. Indian agricultural produce included grains, pulses, spices, fruits and vegetables, oilseeds, sugarcane, coffee, tea, cotton, jute and dry fruits. Food grain production was expected to be 272 million tonnes in 2016-17[5]. Allied industries included produce such as milk, meat, eggs, silk and honey. India's agriculture produces topped most of the countries in the world across several products. **Exhibit 1** shows a summary of world food grain production and India's contribution.

Green and White Revolutions

Agriculture has been prevalent in India since ancient times and the agricultural produce was in high demand in the international trade. After its independence in 1947, India relied on imports and food aid to feed its population. After the severe drought of 1965 and 1966, the Indian government reformed the agricultural policy and brought in "Green Revolution", which focused on seeds with superior yields and resistance to diseases, use of fertilizers and pesticides along with dissemination of farming knowledge to increase the yield.

White revolution was initiated by National Dairy Development Board (NDDB) during the late 1960s, since the milk production growth rate had declined to 1.15%. Milk production increased from 17 million tonnes in 1950-51 to 86.6 million tonnes in 2001-02 and India has become one of the largest producers of milk.[6] White revolution was achieved through cooperative production and providing farmers with better breeds of cattle and training them in modern animal husbandry techniques.

CONNECTED INDIA – THE MOBILE EXPLOSION

India has around 299.24 million smart phones users[7]. In urban India, the Internet user base grew by 7% to 263 million for year-on-year period ended October 2016, which is expected to be 275-285 million by June 2017[8, vii]. For the same annual period ending October 2016, rural India's Internet user base grew by 22% to 157 million and is forecasted to reach 170-180 million by June 2017 as shown in **Exhibit 2**. Mobile usage across urban and rural areas boomed significantly after the launch of Prime Minister's Digital India. India adds 15,000 new internet users every day[9]. India has a fast-growing mobile services market with

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[3] Source: Monthly Economic Report, March 2017, Economy Division, Department of Economic Affairs, Ministry of Finance, page (http://dea.gov.in/sites/default/files/MER_March%202017.pdf), page 8, Table 1

[4] Ibid

[5] Source: Second Advanced Estimates of Production of Foodgrains for 2016-17, Department of Agriculture, Cooperation and Farmers welfare, Directorate of Economics & Statistics, page 1

[6] Source: http://www.fao.org/wairdocs/lead/x6170e/x6170e2z.htm

[7] Source : (https://www.statista.com/statistics/467163/forecast-of-smartphone-users-in-india/)

[8] Source : (https://www.statista.com/statistics/467163/forecast-of-smartphone-users-in-india/)

[9] Source : http://www.hindustantimes.com/business-news/reliance-jio-s-fight-with-other-telcos-could-be-rural-india-s-gain/story-i7sPEGyuHk0GpODKfljJ6N.html

excellent potential for the future. As per the data from the Telecom Regulatory Authority of India (TRAI) in 2017, urban connectivity in India was showing a monthly growth rate of 1.6% and the monthly growth rate of rural connectivity was at 0.56. This mobile explosion in rural areas was an opportunity for Anand to reach the farmers and help them by providing timely and accurate information. They could use this information to grow the right varieties, manage crop diseases and to initiate any timely corrective actions.

GENESIS AND JOURNEY OF JAYALAXMI AGRO TECH

Genesis of JAT

Ever since farming started by growing crops, raising livestock and catching fish, farmers have always sought information about the right crops, choice of fertilizers and insecticides and so on. However, in developing countries such as India due to information gap (digital divide), agriculture became "input-intensive" and NOT "knowledge-intensive". Some of the pressing problems that most of the farmers faced (revealed from JAT field visits) because of the information gap are as follows:

- Lack of awareness on varieties: 90% of the farmers are not aware of disease-resistant varieties, drought-resistant varieties, etc.
- Irrigation and water wastage: Indian farmers water the soil instead of watering the plant. The farmers spend 3000 liters of water to grow 1 kg of rice, while it requires around 2000[10] liters of water.
- Disease management: Whenever there is disease or pest, farmers depend on the pesticide shop dealer to recommend the spray. This is leading to irrational use of chemical pesticides.
- Micronutrient management: Many farmers are unable to differentiate disease and micronutrient deficiency.
- Mono-crop culture: Many farmers have been growing single crop for decades as they do not have knowledge to grow other crops.
- Fertilizer calculation: Most farmers (99%) in India are not aware of Nitrogen-Phosphorus-Potassium (NPK) fertilizer calculations[11].
- Lack of awareness on traditional/cultural aspects of farming: Many youth are not aware of traditional and cultural agricultural practices.

Agriculture is seen as not-profitable and hence youths have been losing interest in farming and started migrating to urban area in search of jobs. This kind of polarization leads to several social problems. Anand believed that this problem will persist until agriculture becomes "knowledge intensive" for which information is the key. While smartphone penetration is growing even in rural areas, there is huge potential to use farmer's android phones as primary tool to deliver the knowledge/information in a constructive and simple manner.

[10] Source :http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/5000-litres-of-water-to-grow-1-kg-of-rice/article2613414.ece

[11] Source :http://164.100.47.193/lsscommittee/Agriculture/16_Agriculture_29.pdf

Farmers need several inputs on agriculture, starting from seeds, variety of crops, fertilizers, water, pesticides, micronutrients, irrigation, diseases etc. Non-availability of agricultural inputs at reasonable costs and at the right time was a major concern for the farmers. Lack of proper, reliable and independent information placed the farmers at the mercy of sales agents of companies (selling inputs such as pesticides and chemicals) who are motivated by profit rather than the interest of the farmers. Lack of credit also pushes farmers to purchase inputs from local suppliers who often provide substandard inputs. All this adds to the cost of farming. This poses a need for independent and reliable information which is available freely at any time to the farmers.

To bridge this knowledge gap of the farmers and to prevent the farmers from getting exploited at the hands of the local money lenders and the pesticide dealers, JAT created a knowledge heavy mobile application for the farmers. They have developed a suite of 25+ crop-specific mobile applications in Indian regional language with audio visuals. Their objective is to deliver the most happening technologies such as Mobility, Analytics and Cloud into the hands of farmers even in the absence of Internet.

JAT Journey: 200,000 Farmers and Ticking

The mobile apps developed by JAT are very easy to use and are available in many Indian languages which even illiterate farmers can use. There was no charge for the information accessed by the farmers. The application could be downloaded by the farmers either from internet or through Bluetooth connection from their Agri-pole devices. 'Agri-pole' is a hardware device developed to address the connectivity gap. It enabled farmers to download the app in the absence of internet. When the farmer comes near the agri-pole, he has to switch on the bluetooth, select the particular crop app, click option download and the app gets downloaded on his phone. Once the app is downloaded in one smart phone, then it can be easily shared with others, does not require download in every mobile. Internet connection is not needed by farmers to use the application. These Agri-pole devices have been installed in 300 Indian villages. Access data from the app is pushed to a central server in real time basis if there is internet connection on the phone or whenever the phone gets connected to Internet. The sections accessed by the farmers and frequency of access of specific section (plant, disease, etc.) were stored on a daily basis in the centralized database. This data gathered from the application provided information at individual phone number level on daily basis on the type of information accessed by the farmers. An analytics platform also part of this application created basic visualization of this captured data.

JAT has won many prestigious awards for their initiatives in the agriculture sector; a few of them are mentioned here.

- Jayalaxmi Agrotech is winner of "Digital India innovation challenge" in agriculture category.[12] .
- Jayalaxmi Agrotech's innovative solution received **Presidential award from Honorable president Sri. Pranab Mukherjee**[13].
- Jayalaxmi Agrotech bagged prestigious awards such as '**mBillionth award**' from Digital Empowerment Foundation and '**Mobile for social good'** award from Vodaphone Foundation for

[12] Source : https://innovate.mygov.in/ifdic1/
[13] Source : https://innovate.mygov.in/ifdic1/

their efforts in bringing social transformation in agriculture sector.[14] [xiii].

ANALYZING THE DATA COLLECTED THROUGH THE APP.

Over a period of 2 years since the JAT application was rolled out, there has been a consistent increase in the download of the application by the farmers. There has been an increase in the user base for the application as shown in **Exhibit 3,** where we see that overall number of users after April 2016 was more than the earlier months. Much application usage data gets collected on real time basis. Data was collected on every application usage by the farmer and a new record was created in the Google firebase database. This data mainly consisted of the place/location of the farmer, crop which is accessed, phone number from where the application is being used and also contained information on every section of the application used and provided the number of times the specific section was accessed. Structure and description of the data captured by the JAT app is provided in **Exhibits 4 and 5,** respectively.

JAT wanted to gain insights using the data and to test some claims about how the application could benefit the farmers. This would help them in further increasing the user base for the application. It would aid in reaching out to more and more organizations as well as the government to address the more pressing issues in agriculture sector such as crop price volatility, yield prediction. The app would also help to assess farmer distress in a specific area and could help in reducing the prevalent farmer suicides.

Having successfully created and distributed the app across Karnataka and other states in India, JAT wanted to understand the usage of their application in various states and districts. They wanted to understand not just from the perspective of the pattern of app usage but also to draw some inferences on the varieties and diseases prevalent in specific areas. They wanted to understand if the app could help the farmers to take more informed decisions and reduce their distress by improving the yield in some way. The data which was collected by the app was used as a proxy for the actual varieties grown by the farmers and diseases prevalent in a specific area. If we assume that a specific disease or a specific variety is being accessed more in a specific area, then that disease might be prevalent in that area. It could provide insights about how the diseases and varieties are linked to each other, if the farmers are accessing the app in the earlier life cycle of the crop (if the information on earlier life cycle diseases was accessed more) and taking corrective action to avoid a damaging impact on their crops. JAT data may assist to check whether the variety and disease pattern has changed over a period of time and also if the other factors such as temperature, humidity, and rainfall have any effect on the diseases whose information was being accessed by the farmers. These were few of the answers which Anand was seeking from the daily app usage data.

ABOUT CHILIES

Information about 25+ crops was accessed across India by the farmers through this app. JAT wanted to test claims and hypotheses using the collected app data mainly to understand the disease patterns for various crops, their relationship with the varieties grown, effect of weather conditions on the disease pattern and any shift in the varieties or disease patterns . We cannot test claims made by Anand for all the

[14] Source : http://www.millenniumalliance.in/imgs/Final_Award_Round_1-4.pdf)

crops together as the crop cultivation, areas of cultivation, crop features and needs as well as crop diseases are different for all the crops. Hence, data for a specific crop was chosen to test the few claims made by JAT. The crop chosen was Chili (green, red and dry).

According to the Spice Board of India, total chili production in India was 1.4 million tonnes in 2015-16 and chilies worth INR 40 billion were exported, which had increased by 12% over the previous year[ix]. India has been the largest producer, consumer and exporter of chilies in the world. In India, chilies are majorly grown in the states of Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Orissa, West Bengal, Rajasthan and Tamil Nadu. Different varieties of chilies grown in India are Bird's Eye Chili (*Dhani*), *Byadagi, Ellachipur Sannam, Guntur Sannam, Hindpur, Jwala, Kanthari,* Kashmir *Chilli and* Madhya Pradesh *G.T. Sannam*. Major chilli varieties in Karnataka are *Badagi Kaddi, Poosa Jawal, Arka, CH01*, etc.

In Karnataka, chilli is grown in districts of *Dharwad, Mysore, Hasan, Bangalore, Bellary, Hubli, Gadag* and *Byadgi.*

Chili was chosen as a sample crop to analyze the data collected from the JAT application since it is restricted to specific districts and the presence of JAT app in these districts was also high and hence better data was available from these districts.

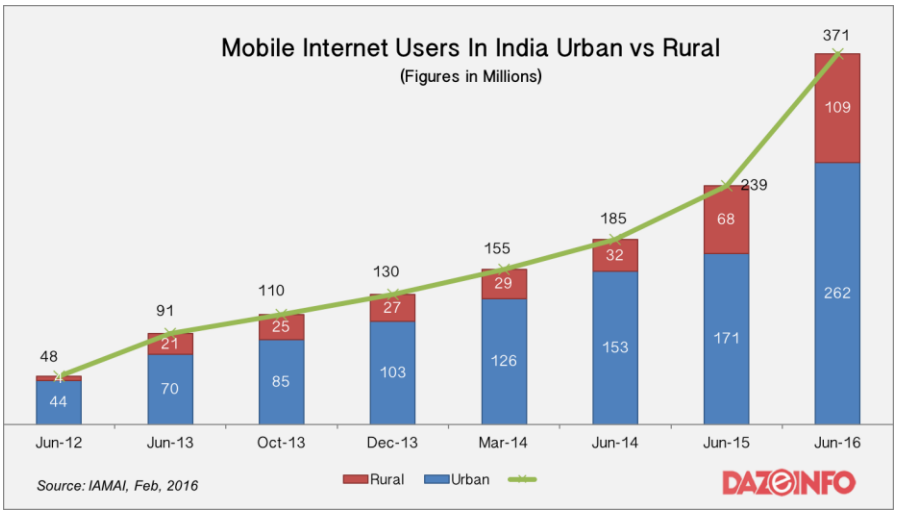
Exhibit 1: World Foodgrains Production Summary

MMT	Wheat			Coarse Grains			Rice Milled		
	2014-15	2015-16[1]	2016-17[2]	2014-15	2015-16[1]	2016-17[2]	2014-15	2015-16[1]	2016-17[2]
United States	55.1	56.1	62.9	377.2	367.0	402.6	7.1	6.1	7.1
Canada	29.4	27.6	31.7	22.0	25.6	25.6	0.0	0.0	0.0
Mexico	3.7	3.8	3.9	32.7	32.4	33.2	0.2	0.2	0.2
Russia	59.1	61.0	72.5	40.4	37.4	40.8	0.7	0.7	0.7
Ukraine	24.8	27.3	26.8	39.4	33.4	39.2	0.0	0.0	0.0
China	126.2	130.2	128.9	222.8	231.8	227.9	144.6	145.8	144.9
India	95.9	86.5	87.0	43.1	38.5	44.2	105.5	104.4	106.5
Indonesia	0.0	0.0	0.0	9.0	10.5	10.9	35.6	36.2	37.2
Pakistan	26.0	25.1	25.6	5.3	5.7	6.1	6.9	6.8	6.8
Thailand	0.0	0.0	0.0	4.9	4.8	5.3	18.8	15.8	18.6
Argentina	13.9	11.3	16.0	36.8	37.9	46.2	1.0	0.9	0.9
Brazil	6.0	5.5	6.7	87.7	69.1	96.0	8.5	7.2	8.2
Australia	23.7	24.2	35.0	12.6	12.4	16.6	0.5	0.2	0.6
South Africa	1.8	1.4	1.9	11.1	8.7	15.6	0.0	0.0	0.0
Turkey	15.3	19.5	17.3	9.4	14.3	10.9	0.5	0.5	0.5
Other	247.3	255.7	235.3	353.7	321.5	325.0	148.9	147.4	149.0
World	728.1	735.2	751.4	1308.0	1251.1	1346.1	478.6	472.2	481.1

MMT – Million Metric Tonnes, 1 – Preliminary Estimates, 2 – Projections

Source: Compiled by authors from World Agricultural Production, Circular Series WAP 04-17, April 2017, United States Department of Agriculture

Exhibit 2



Source : https://dazeinfo.com/2016/02/08/mobile-internet-users-in-india-2016-smartphone-adoption-2015/

Exhibit 3

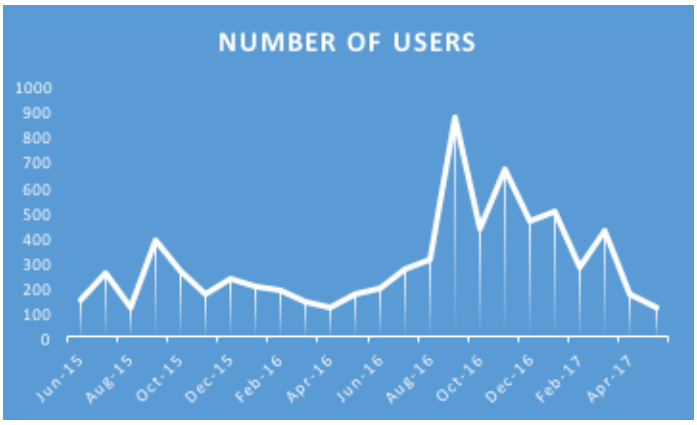


Exhibit 4

Variable Description of Data from Agro-Case data file

Variable	Description
Year	Month and year of data collected
Number of users	Number of users using the app in that month-year
Usage	Number of times app is used in that month-year
F, I, M, G, H, DT, W	Number of clicks for the specific section (abbreviation explained in exhibit V)
D1-D11	Number of times a specific disease is accessed (disease name in exhibit V)
V1-V10	Number of times a specific variety is accessed (Variety name in exhibit V)

"Belagavi_Weather" and "Dharwad_Weather" data sheet contains the month-on-month disease access data from Belagavi and Dharwad districts of Karnataka along with the average temperature and humidity in that specific month. "Disease index" sheet contains favorable temperature and humidity conditions for the diseases mentioned.

Exhibit 5

Code	Description
P	Plantation
F	Fertilizer
I	Irrigation
M	Micronutrient
D1	Dumping-off
D2	Fruit Rot
D3	Powdery Mildew
D4	Bacterial Leaf Spot
D5	Cercospora Leaf Spot
D6	Leaf Curl
D7	Fusarium Wilt
D8	Fruit Borer
D9	Thirps
D10	Mites
D11	Aphids
V1	Badagi Kaddi
V2	Poosa Jawal
V3	Arka Lohith
V4	Arka Supal
V5	Arka Meghana
V6	Arkeshwar
V7	Arka Hareeth
V8	Arka Abhir
V9	Bhaghya Laxmi
V10	C H 01
G	Growth hormone
H	Harvesting
DT	Decision tree
W	Weather