भारतीय प्रबंध संस्थान बेंगलूर
INDIAN INSTITUTE OF MANAGEMENT
BANGALORE

IMB 735

DATA-ENABLED INSIGHTS FROM SERICULTURE: JAYALAXMI AGRO TECH

GIRIRAJ AND U DINESH KUMAR

Giriraj, Fellow Programme Student, and U Dinesh Kumar, Professor of Decision Sciences and Information Systems, prepared this case for class discussion. This case is not intended to serve as an endorsement, source of primary data, or to show effective or inefficient handling of decision or business processes.

It is funny how worms can turn leaves into silk.
But funnier far is the cow:
She changes a field of green grass into milk
And not a Professor knows how.

- Dorothy Caruso

Anand Babu Chitav Adigi, co-founder of Jayalaxmi Agro Tech (JAT) who hailed from an agricultural family, returned to his village in Karnataka after working for more than 15 years in the corporate sector across the world. Anand Babu was a trained data scientist and had successfully carried out a few analytics projects. The condition of farmers in his village had not improved even during the age of internet. Anand, through his newly founded company, wanted to understand various issues faced by farmers and help them using his expertise as a data scientist.

According to a survey conducted by Ministry of Finance, 49% of the Indian workforce were engaged in agriculture and allied activities while the contribution of agriculture to the GDP was only 16%.[1] The ratio of income of an agricultural worker to that of a non-agricultural worker remained low at 0.32 in 2011-2012.[2] In 2015, 12,602 farmers had committed suicide, and there was a steady increase in the number of suicides among farmers suggestive of the worsening conditions of farmers in India.[3]

Anand identified that even though there was significant progress in the scientific frontier of agriculture, the adoption of modern farming practices remained low. The key problem was that the current framework provided by the government, the National Agricultural Research System, was not able to efficiently disseminate technological information to the farmers. Most of the farmers were heavily dependent on information provided by suppliers of agricultural inputs like pesticides and fertilizers. Therefore, there was an inherent bias in the information provided and the extensive misinformation led to farmers implementing practices which were technically incorrect. Breaking the language and literacy barriers prevalent in the rural areas was critical to solve this problem of information gap.

The answer lay in utilizing the expanding smartphone and internet penetration in the country to collect data and share the insights with the farmers. Motivated by internet and smart phone penetration in India, Anand developed ‘‘Mobile Agri App Platform’’ that could capture information related to various crops.

One of the focus areas of Jayalaxmi Agro Tech was sericulture since Karnataka accounted for nearly 32% of raw silk production in India in 2016-2017.[4] JAT was interested in gaining insights about sericulture farming in Karnataka and wanted to use the data to gain insights and share it with the sericulture farmers.

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[1] “Economic Survey 2017-2018” (Ministry of Finance, Government of India), accessed on October 12, 2018, http://mofapp.nic.in:8080/economicsurvey/pdf/082-101_Chapter_06_ENGLISH_Vol_01_2017-18.pdf.
[2] Ramesh Chand, “Doubling Farmers’ Income: Rationale, Strategy, Prospects and Action Plan” (National Institution for Transforming India, March 2017), http://niti.gov.in/writereaddata/files/document_publication/DOUBLING%20FARMERS%20INCOME.pdf.
[3] “Accidental Deaths & Suicides in India 2015” (National Crime Records Bureau), accessed on October 17, 2018, http://ncrb.gov.in/StatPublications/ADSI/ADSI2015/adsi-2015-full-report.pdf.
[4] “Central Silk Board Annual Report 2016-17” (Central Silk Board, Ministry of Textiles), accessed on October 17, 2018, http://www.csb.gov.in/assets/Uploads/documents/CSBAR1617English.pdf.

DERIVING INSIGHTS FROM SERICULTURE

Silk in Indian Culture

Silk has always played an integral part in Indian culture. The bride adorned in silk saree, be it the exquisite Banarasi silk or the magnificent Kanchipuram silk, gives life to the colorful traditional Indian wedding. Known as the "Queen of textiles", this smooth glistening fabric is used in making brocades, draperies, and furnishings which are used for auspicious occasions. Considered a symbol of luxury, prestige and grandeur, the treasured silk fabric is often gifted between families during festivities.

The outstanding craftsmanship of Indian silk weavers is visible in the interplay of colors, motifs, geometries, and textures in silk sarees. These sarees often have fine gold or silver threads, also called Zari, woven into the silk fabric to create mesmerizing patterns. The holy city of Varanasi in Uttar Pradesh is famous for Banarasi silk sarees which are intricately woven with silk and gold or silver. The Kanchipuram silk sarees from Tamil Nadu display imagery inspired by Hindu scriptures like Ramayana and Mahabharata. The award winning 2008 film ''*Kanchivaram*'' features the life and struggles of silk weavers in Kanchipuram. Mysore silk, from Karnataka, is known for use of genuine mulberry silk and pure gold zari work. The Mysore Silk Weaving Factory, which was established in 1912 by the then Maharaja of Mysore, is the oldest silk manufacturing unit in India. The state of Assam is famous for its indigenous wild silk varieties, namely, the golden Muga, white Pat, and the warm Eri silk. Considering the uniqueness of Banarasi, Kanchipuram, Mysore, and Muga varieties of silk, the geographical indication tag was granted to these crafts by the Government of India. Other famous silks of India include the Ikats of Odisha, the Patolas of Gujarat, the Bandhani work of Rajasthan and Gujarat, etc.

Silk also represents purity and sanctity, which is why it plays a fundamental role in the performance of traditional religious functions in India. Idols of Hindu deities are embellished with silk, which exemplifies its role in religion. Silk has also been mentioned in the *Bhagavad Gita*.

History of Silk

Silk has thousands of years of history and it has shaped the history of the world. When scientists analyzed soil samples from 8,500 years old tombs located in Henan province in China, they found evidence of silk proteins in the samples.[5] Chinese legend says that a silkworm cocoon fell into the teacup of the Chinese empress Leizu and she was amazed by the shimmering long threads of silk that emerged from it. The empress was considered as the Goddess of Silk and credited with the introduction of sericulture and silk weaving.

Silk was a fabric of luxury initially reserved only for the Chinese royal family. However, as time passed, the use of silk proliferated, transcending geographies and cultures. Silk, famous for its smooth texture and

[5] Charles Q. Choi, Live Science Contributor | January 10, and 2017 06:57am ET, "Oldest Evidence of Silk Found in 8,500-Year-Old Tombs," Live Science, accessed on October 17, 2018, https://www.livescience.com/57437-oldest-evidence-of-silk-found-china.html.

sheen, gradually gained a huge market across Asia. The importance of silk trade is underlined in the naming of the ancient network of trade routes connecting the east and the west as the ‘‘Silk Road’’.

In India, there has been archaeological evidence, from the sites of Harappa and Chanhu-daro, suggesting that the use of silk dates to the time of the Indus Valley Civilization.[6] The sericulture during those times employed wild varieties of silkworms.

The Science of Sericulture

Silk is composed of fibers made of an insoluble protein called fibroin. Several species of insects produce silk for various purposes, for example, moths for the cocoon stage in their lifecycles and spiders for spinning their webs. The commercial rearing of silkworms for silk production is called sericulture. Commercial silk is mainly obtained from the cocoons made by larvae of the domestic silk moth or *Bombyx mori*. The larvae of the *Bombyx mori* silk moth feed exclusively on the leaves of the mulberry tree. These silk moths are completely domesticated due to years of artificial selection and have lost the ability of flight. Other types of commercial silk include the varieties Tropical Tasar, Oak Tasar, Eri, and Muga, all of which come from various species of wild silkworms. The silk obtained from these varieties are collectively called Vanya silk.

Mulberry silkworm varieties can be classified based on the voltinism, that is, the number of broods or generations the silkworm undergoes in one year. They are classified as univoltine, bivoltine, or multivoltine depending on whether the silkworm variety undergoes one, two, or more than two broods, respectively in a year. Larvae of univoltine races are highly sensitive to environmental fluctuations but provide very high-quality silk. Bivoltine races are robust to environmental fluctuations and provide good quality silk. Multivoltine races possess resistance to environmental fluctuations but the quality of cocoons is poor.

Eggs of the silk moth take two to three weeks to hatch into caterpillars. The larvae continuously feed on the leaves of the mulberry tree. After molting four times, the larvae start spinning the silk cocoons to undergo metamorphosis to silk moths. The larvae between the molting phases are called larval instars. The new hatchlings and the second-instar larvae are commonly called ‘‘Chawki’’ in India. In two to three weeks, the silk moth emerges from the cocoons.

The first stage of sericulture is acquisition of silk worm eggs either by buying good quality eggs or by using the eggs laid by in-house silk moths. The eggs are incubated in a carefully controlled environment. The silkworm hatchlings are then continuously fed fresh finely chopped mulberry leaves. The larvae are placed in a suitable support or mountage for facilitating the spinning of cocoons. Commonly used mountages include Chandrika, screen-type mountage, plastic mountage, bamboo strip mountage, and rotary mountage. The type of mountage used has an effect on the quality and quantity of silk cocoons obtained. The larvae are prone to many infections like Nocemabombycis and Grasserie. Therefore, thorough disinfection of the rearing houses is necessary. The humidity and temperature of the rearing

[6] I. L. Good, J. M. Kenoyer, and R. H. Meadow, “New Evidence for Early Silk in the Indus Civilization,” *Archaeometry* 51, no. 3 (June 2009): 457–66, https://doi.org/10.1111/j.1475-4754.2008.00454.x.

house must be carefully controlled for ensuring the right environmental conditions for the growth of silkworms. The health of the larvae is dependent on various factors like rate of pupation and fewer larval deaths in the mountage. When the larval stage duration is low, there is less chance of infection. While the cocoons are being spun, the silkworm also secretes a protein called sericin, which is a gum that binds the silk filaments together in the cocoon. The cocoons are placed in boiling water to kill the pupae and preserve the long silk filaments. The cocoons are then sorted and graded according to quality. The silk filaments are reeled from the cocoons during which each filament is checked for any flaw. The reeled filaments are converted into skeins, which are further bundled into books weighing 2-4 kg. Multiple silk filaments are twisted to obtain the required diameter of the silk thread. The gum sericin is removed in a process called degumming to impart the required luster to the silk. Finally, the silk threads undergo various finishing processes to make it suitable for manufacturing different types of silk fabrics.

Sericulture involves cultivation of mulberry trees and the leaves of mulberry trees are used for feeding silkworms. The quality of the leaves is critical to the health of the silkworms, thereby on the quality of silk produced. The mulberry plantations must be well-irrigated and adequately fertilized. The young stages of the silkworm require tender leaves rich in nutrients. The later stages of the silkworm require leaves with comparatively less water and more fiber. The level of nutrients like Nitrogen, Phosphorus, and Potassium in the soil must be controlled carefully to ensure good yield.

Advances in biotechnology allowed the development of high-yielding and robust varieties of silkworms. In India, the Central Sericultural Research and Training Institute, Mysuru is involved in the research and development of these artificial breeds of silkworms. Hybrids with pure bivoltine parentage are commonly called bivoltine hybrids while other breeds are commonly called cross-breeds. The development of bivoltine hybrid varieties of silkworms proved to be a huge boost to the quality and quantity of silk produced. The bivoltine hybrid varieties were engineered to be robust to the tropical climate found in places where sericulture is extensively practiced in India.

State of Sericulture in India

Sericulture has high employment potential since it is a labor-intensive process. It was estimated that production of one kilogram of raw silk required 11 man-days of labor. Sericulture required low investments in the order of Rs. 12,000 to Rs. 15,000 per acre of irrigated land while ensuring net income levels of up to Rs. 30,000 per acre per annum.[7] The advantage of adopting sericulture is that nearly 60% of the gross value of commercial silk is received by the sericulturists and it can be practiced even with low land holdings. The mulberry cultivation associated with sericulture helps in maintaining green cover and mitigates soil erosion. All these factors make sericulture a suitable occupation to uplift the rural economy in India.

India has been the second largest producer of silk in the world second to China. It has been the only country which produces all five known commercial varieties of silk, namely, mulberry, tropical tasar, oak tasar, eri, and muga. India was also a major exporter of silk which is evident from earnings in the order of

[7] "Sericulture » Central Silk Board," accessed on October 12, 2018, http://www.csb.gov.in/silk-sericulture/sericulture/.

Rs. 2093.42 crore from silk exports in 2016-2017.[8] The statistics on production of various silk varieties in India during 2017-2018, 2016-2017, and 2015-2016 are given in **Exhibit 1.**

Analysis of Sericulture Data from Karnataka

Jayalaxmi Agro Tech collected farmer level data on sericulture practices in the districts of Belagavi, Bellary, Chikballapur, Mandya, and Tumakuru. The insights derived from this data can help towards building better policy interventions to improve the welfare of sericulturists in Karnataka. Anand said:

> The data collected from the sericulture farmers can be used for conducting simple hypothesis tests and build regression models to understand factors that are associated with income generated in agriculture. The idea is to share the insights with sericulture farmers so that they can take informed decisions".

The development strategy adopted during the Green Revolution period focused on increasing agricultural productivity through the adoption of modern technology and high yielding varieties of crops. The strategy failed to consider improvement of farmers' welfare by increasing their income. According to the 2010-2011 agricultural census, 85% of the total operational agricultural landholdings belonged to the small and marginal landholding categories with less than two hectares of land area.[9] In this regard, the suitability of an agricultural profession depends upon whether it can generate viable profits from these small landholdings. It was widely believed that sericulture was such a profession. According to the Central Silk Board, farmers could earn a net income of INR 30,000 (1 USD was approximately 71 rupees during December 2018) per acre per annum from sericulture.[10] In this context, Anand wanted to understand how profitable sericulture in Karnataka was.

Sericulture has been a women-friendly occupation. Handling of silkworms, reeling of cocoons, and quality control are activities which are suited for women because these activities require a high degree of finesse. Nearly 60% of the workforce engaged in downstream processing activities in sericulture comprises women.[11] Although sericulture provides gainful employment to women, Anand believed that the percentage of women owning, and operating silk production facilities is substantially low.

Sericulture is a knowledge intensive agricultural profession. For example, the knowledge about hybrid varieties is critical to the success of the crop. Bivoltine hybrid varieties of silkworms are robust to environmental fluctuations, thus minimizing crop loss due to climatic variations and possibly leading to lower variability in income. Central Sericultural Research and Training Institute, Mysuru provides several courses such as short-term courses in post-cocoon technology and seed technology, and intensive training

[8] "Functioning of Central Silk Board & Performance of Indian Silk Industry 2018" (Central Silk Board, Bangalore), accessed on September 8, 2018, http://www.csb.gov.in/assets/Uploads/documents/note-on-sericulture.pdf.
[9] "All India Report on Agriculture Census 2010-11" (Agriculture Census Division, Ministry of Agriculture and Farmers Welfare), accessed November 2, 2018, https://agcensus.nic.in/document/ac1011/reports/Chapter-4Analysis(allIndiaASG)2010.pdf.
[10] "Sericulture » Central Silk Board." accessed on October 12, 2018, http://www.csb.gov.in/silk-sericulture/sericulture/.
[11] G. S. Rani, *Women in Sericulture* (Discovery Publishing House, 2006) accessed November 2, 2018, https://books.google.co.in/books?id=pYwHdzMAvIEC.

in bivoltine sericulture.[12] Such training enables farmers to understand and implement scientific practices, thereby improving their income from sericulture. Anand also thought that such training might be providing a good platform to make farmers aware about the importance of crop insurance as well.

Adapting technology and emerging scientific practices results in better yields. For instance, mechanization of farming activities potentially reduces the cost and increases profit. The financial status of the sericulturists also influences their income. Anand wanted to quantify these effects and understand which factors significantly influenced the income of sericulturists. Furthermore, understanding geographical variations in the yield as well as factors of production is key to identifying which areas require more attention in terms of aid provided. Finally, these insights have the potential to fine tune the sericulture profession and improve the welfare of farmers through appropriate policy interventions.

The data collected by JAT and their descriptions are provided in **Exhibit 2.**

[12] Source: http://www.csrtimys.res.in/training/structured

Exhibit 1

Silk production in India

Sl. No.	Particulars	2017-18	2016-17	2015-16
1	Mulberry Plantation (lakh ha.)	2.26	2.168	2.089
2	Mulberry Raw Silk (Metric Tonnes)			
2.1	Bivoltine	5855	5266	4613
2.2	Cross-Breed	16207	16007	15865
	Sub Total	22062	21273	20478
3	Vanya Silk (Metric Tonnes)			
3.1	Tasar	3018	3268	2819
3.2	Eri Spun Silk	6661	5637	5060
3.3	Muga	190	170	166
	Sub Total	9869	9075	8045
	Total	31931	30348	28523

Source: "Functioning of Central Silk Board & Performance of Indian Silk Industry 2018" (Central Silk Board, Bangalore), accessed on September 8, 2018, http://www.csb.gov.in/assets/Uploads/documents/note-on-sericulture.pdf.

Exhibit 2

Variables used in the analysis and their descriptions

Variable	Description
person_id	Unique individual identifier
District	District (Tumakuru, Bellary, Belagavi, Mandya, Chikballapur)
income_per_acre	Yield in terms of net income per acre of landholding
Gender	Gender of the farmer
Female	1 = Female; 0 = male
training_on_sericulture	1 = Received training on sericulture; 0 = otherwise
crop_insured	1 = Crop insured; 0 = otherwise
chawki_bivol	1 = Bivoltine hybrid used; 0 = a combination of bivoltine hybrid and other hybrids used or non-bivoltine hybrids used alone
loan_amount	Amount of loan taken by the farmer
loan_repaid	1 = Loan repaid; 0 = otherwise

Exhibit 2 (Contd.)

seri_total_subsidy	Total subsidy received from the sericulture department
rearing_cost	Cost of rearing silkworms
instrument_mgmt_cost	Cost of managing the instruments required for sericulture
years_of_exp_in_sericulture	Number of years of experience of the farmer in sericulture
krishi_pond	1 = Pond constructed under the Krishi Bhagya scheme; 0 = otherwise
rain_harvesting	1 = Rainwater harvesting mechanisms in place; 0 = otherwise
borewell_recharge	1 = Borewell periodically recharged with water; 0 = otherwise
bio_fertilizers	1 = Biofertilizers used; 0 = otherwise
own_compost_manure	1 = Compost manure produced inhouse; 0 = otherwise
own_vermi_compost	1 = Vermi compost produced inhouse; 0 = otherwise
mechanization	1 = Farming is mechanized; 0 = otherwise
affected_by_pest	1 = Mulberry plantations affected by pest; 0 = otherwise
mulberry_diseases	1 = Mulberry plantations affected by diseases; 0 = otherwise
temp_mgmt	1 = Temperature management system in place in rearing house; 0 = otherwise
airvent_temp_mgmt	1 = Airvent temperature management system in place in rearing house; 0 = otherwise
humidity_mgmt	1 = Humidity management system in place in rearing house; 0 = otherwise
rotary_mounting	1 = Rotary mountage used for rearing the larvae; 0 = otherwise

Source: Jayalaxmi Agro Tech