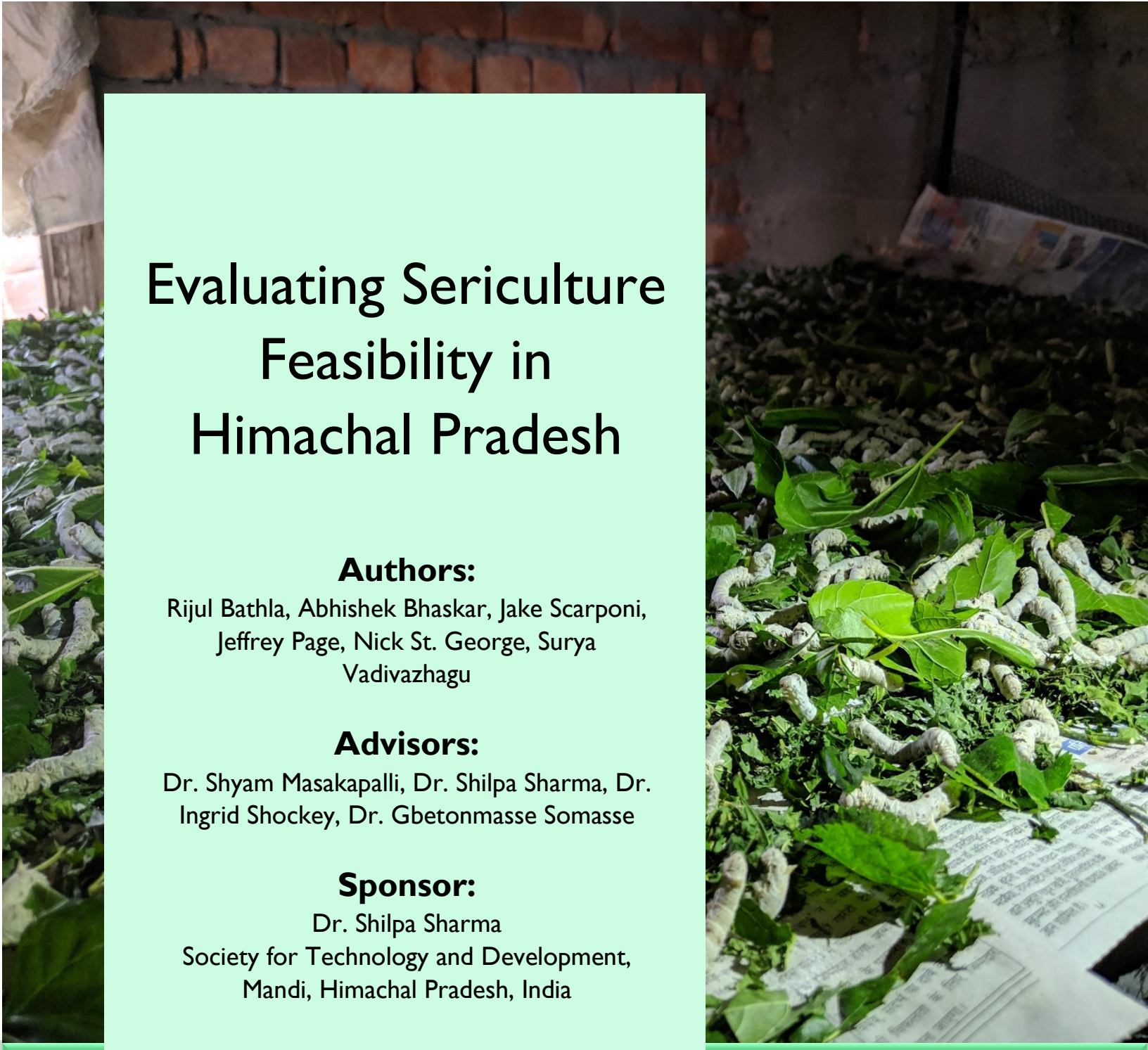

Evaluating Sericulture Feasibility in Himachal Pradesh

Authors:

Rijul Bathla, Abhishek Bhaskar, Jake Scarponi, Jeffrey Page, Nick St. George, Surya Vadivazhagu

Advisors:

Dr. Shyam Masakapalli, Dr. Shilpa Sharma, Dr. Ingrid Shockey, Dr. Gbetonmasse Somasse

Sponsor:

Dr. Shilpa Sharma
Society for Technology and Development,
Mandi, Himachal Pradesh, India

In collaboration with the Indian Institute of Technology, Mandi

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WPI

Evaluating Sericulture Feasibility in Himachal Pradesh

An Interactive Qualifying Project
submitted to the Faculty of
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in partial fulfillment of the requirements for the
degree of Bachelor of Science

by
Rijul Bathla
Abhishek Bhaskar
Jake Scarponi
Jeffrey Page
Nick St. George
Surya Vadivazhagu

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Report Submitted to:

Ingrid Shockey and Gbetonmasse Somasse
Worcester Polytechnic Institute

Abstract

Our team conducted a feasibility study to evaluate if silk production in Mandi, Himachal Pradesh, India can be expanded. We gathered information on: practices within this field; the strengths, weaknesses, opportunities, and threats associated with this industry; and the interests and abilities of local farmers to produce silk. We collected data primarily through interviews and archival research. Regional silk production in HP may soon become endangered, but making it more self-contained and efficient could instigate expansion. We recommend that the government communicates more effectively with producers and processors of silk, and for investments to mitigate certain issues limiting silk producers' ability to be successful, such as diseases killing the silkworms they raise.

Executive Summary

The two largest worldwide producers of silk are China and India. China currently leads in both production and exportation by a large margin. The Society for Technology and Development (STD) sees potential in the expansion of Indian sericulture—the process of farming silk cocoons for textile products—within its traditional role as a small-scale cottage industry that supplements the income of subsistence farmers in Mandi, Himachal Pradesh (HP). State government support has been unable to encourage this expansion in a meaningful way.

Impact

Expanding cottage industry sericulture could respond to the United Nations sustainable development goals of reducing poverty, improving and innovating industry and infrastructure, and increasing employment and economic growth. Opening doors for the many farmers in and around Mandi to increase their income could have an immediately positive impact on the region and its economy. This project's goal, then, was to conduct a feasibility study on increasing sericulture activity in Mandi District in central HP.

State of the art

Silkworms naturally spin cocoons during metamorphosis; the fibers of these cocoons can be reeled into threads and subsequently woven into fabric. Farmers can rear silkworms and collect their cocoons; reelers combine fibers into threads; others can turn threads into products. Typically, very little processing of silk cocoons occurs in HP; raw material is often sent elsewhere in India. In 2013, 7.6 million people in India were employed by sericulture out of 45 million employed throughout India's entire textiles industry (Sharanadavar, 2014). Four types of silk are produced in India, but the most commercially dominant type is mulberry silk. To produce this, *B. Mori L.* caterpillars are laid on a rack covered in hand-picked leaves of the mulberry plant. Meanwhile, tasar silk, for example, is produced by leaving worms on an oak tree and allowing them to feed themselves with this tree's leaves.

Fig. 1: Silkworm cocoons (photo credit: Vadivazhagu, 2019).

Climate change—through changes in atmospheric conditions and temperature—leads to changes in the leaf quality of the mulberry plant, makes pest parasitism harder to control, and dries soil easier (Ram et al., 2016). This potentially challenges mulberry plant cultivation and, therefore, sericulture.

Outside of climate change effects, Himachal Pradesh's climate is capable of seasonal mulberry plant growth and silkworm rearing through March and April, with cocoon harvests and sales in May. Mulberry varieties introduced by the government are capable of two or even three-time annual harvests. The cottage industry model—with micro-companies producing mostly

independent of one another on small scales—works for sericulture in HP because sericulture generally does not require large-scale operations or expensive equipment.

Previous studies on Indian sericulture have shown that a lack of reliable irrigation was once the top concern for farmers when discussing constraints on sericulture expansion, but has moved down their list of priorities, more recently sitting behind input cost (Nagaseshanna, 1993; Shukla, 2011). This proves the effectiveness of the government in providing farmers with eggs of bivoltine hybrid silkworms, which are more resistant to drought (Rangappa, 1996).

Our study

The figure below outlines the methodology for achieving the goal of this project: a feasibility study on increasing sericulture activity in Mandi District in central Himachal Pradesh.

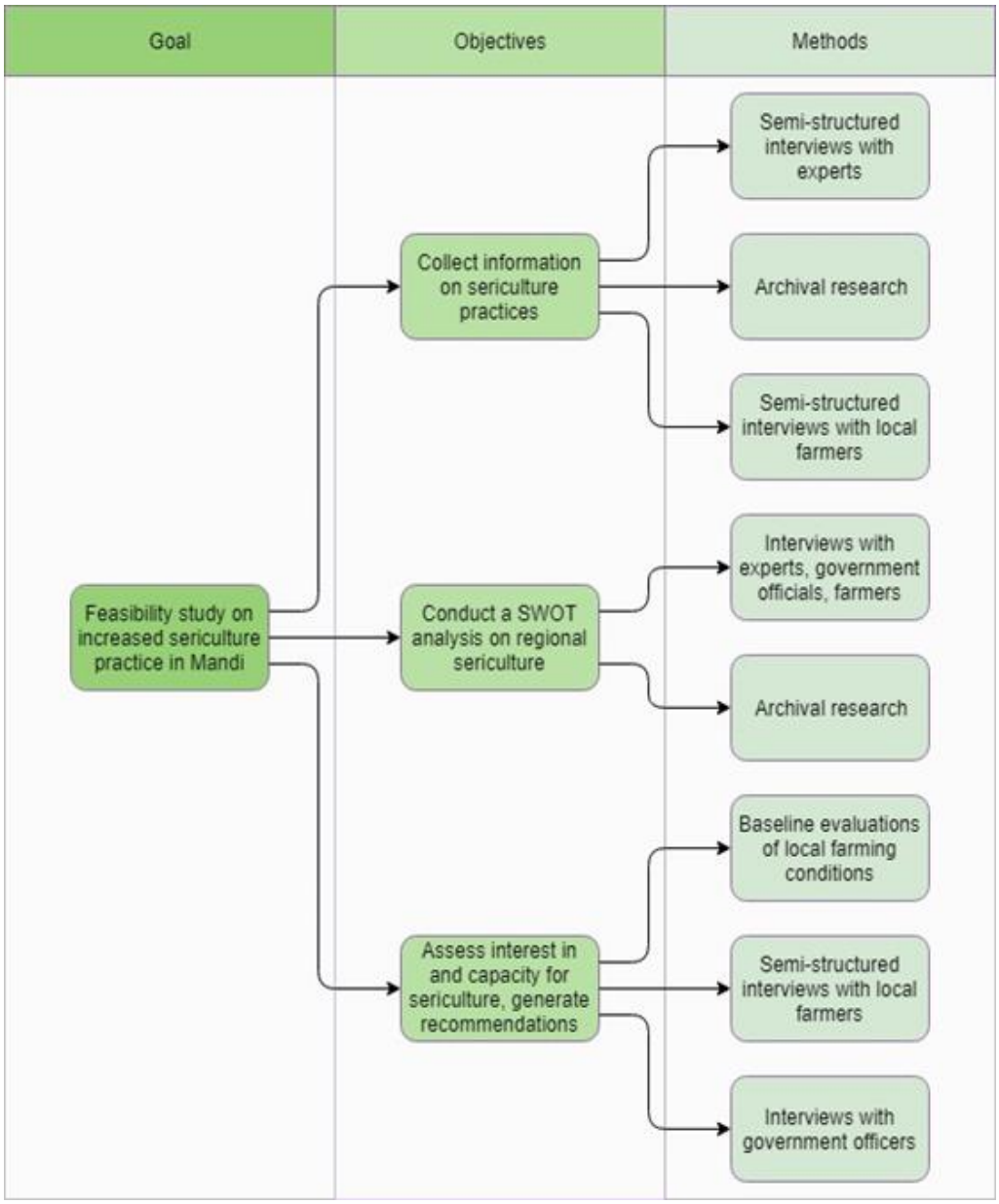

Fig. 2: Methodology flowchart.

Findings

Our interviews revealed a variety of perspectives on what is best for Mandi sericulture. Our results are discussed in detail below. To briefly summarize our most important recommendations that follow these results, they are to:

1. Foster expansion of the nearly non-existent weaving industry in Himachal Pradesh in order to encourage local silk material production and reeling;
2. Research the causes of silkworm disease and ways to prevent and treat them in order to reduce silkworm losses and make rearing a more reliable, consistent source of income;
3. Acquire or breed broader-leaved mulberry trees with higher leaf protein content in order to reduce how many leaves farmers must pluck to feed their silkworms;
4. Support reelers with low-interest loans for buying bulk materials and/or venturing into developing more complete silk products; and
5. Re-evaluate the scheme which delivers subsidies to silk farmers in terms of its criteria and priorities for subsidization.

To begin with the silk processing sector, OP Malhotra, owner of the weaving company Krishna Wool in Mandi, recommends that the government encourages tasar silk production. Oak trees are common at higher altitudes in HP. He also claims that his thicker, warmer tasar silk products are in higher demand than the mulberry products his business creates. Cocoon farmers may be open to this, since tasar silk production does not require the manual plucking of leaves to feed worms, but we would first recommend research on the true extent of oak forests in HP and the people living around them. As the issue stands, a lack of government support and farmer awareness has left HP without any tasar sericulture activity—the government does not buy tasar cocoons from farmers and sell them to processors elsewhere, as it does with some of farmers' mulberry silk cocoons. Malhotra and the president of the STD approve of the cottage industry sericulture model for all types of silk production in HP. They believe it is most viable for the social and geographical landscape in and around Mandi. We therefore do not specifically recommend direct expansion of individual silk farming operations. Dr. Samant, chief scientist of the Govind Ballabh Pant National Institute of Himalayan Environment and Sustainable Development in Kullu, discussed methods farmers can use to keep their soil moist and trees healthy, mitigating effects of climate change on their land. Spreading this information to individual farmers could help to increase their yields.

Several silk farmers were interviewed to discuss their livelihood. All of them received silkworm eggs on a seasonal basis, and sometimes racks on which to raise the worms, from the government. Three applied for but have yet to receive a shed in which to rear worms, despite the fact that one of these had been practicing sericulture for 50 years. More information from farmer and expert interviews is described in the figure below, which summarizes the strengths, weaknesses, opportunities, and threats associated with the regional sericulture industry.

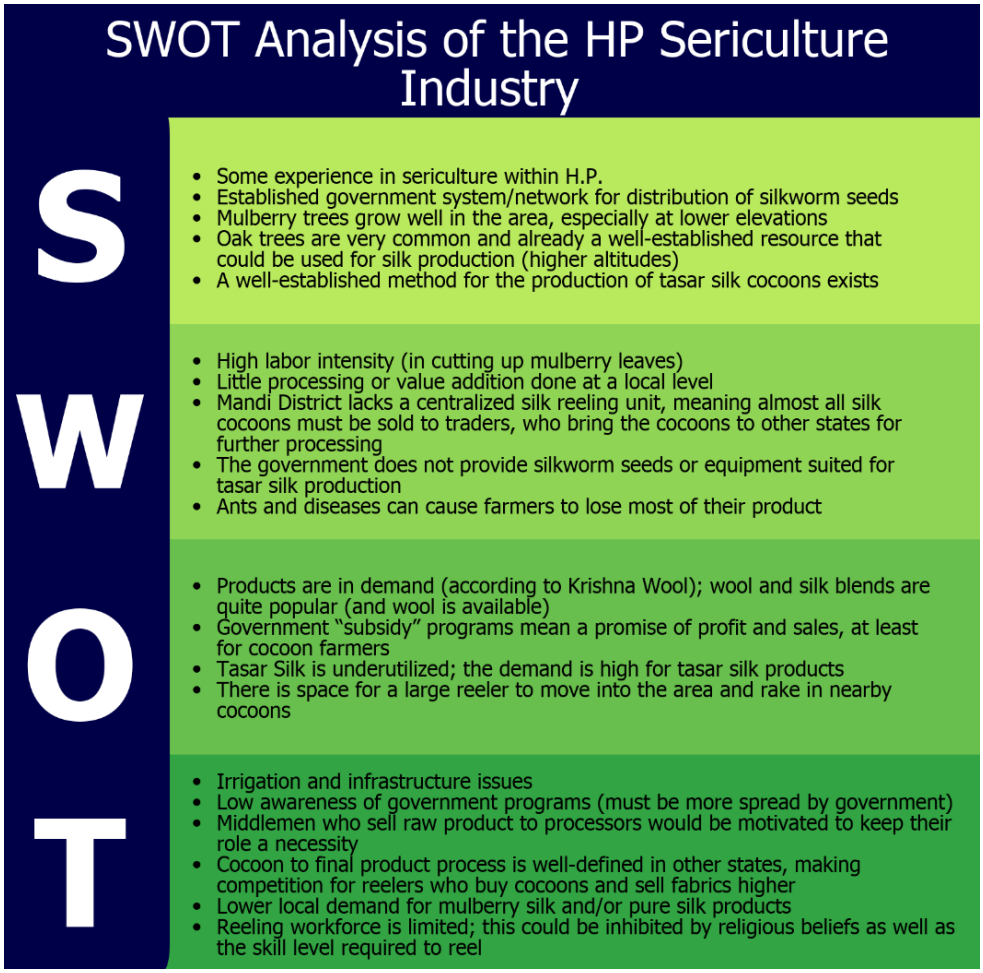

Fig. 3: SWOT analysis summary.

Regarding their interest and capacity to rear silkworms, the two greatest problems faced by cocoon farmers are the tedious work of collecting mulberry leaves and diseases which can kill many worms in a season, eliminating much of their cocoon harvest. Many respondents of this study preferred a small-scale model, but sharing some equipment and resources could make sericulture more profitable and easy for farmers, especially considering many receive little help from the government. Pooling funds for better equipment or sharing mulberry resources does not necessarily mean that farmers would be scaling up; they could continue operating independently as cocoon rearers. We recommend further research into existing operations that follow these guidelines—which do exist—to investigate whether it is helpful to the farmers involved in them.

Sericulture provides subsistence farmers with an opportunity for additional income that does not compete for much land with their crops, but certain issues must be addressed before its implementation can be expanded. Dendrologists could collaborate to research and/or develop a broad-leafed mulberry plant with higher protein content to reduce how many leaves farmers need to pick. Entomologists could provide insight on the causes of silkworm diseases, which are unclear to farmers. Cocoon reelers experience difficulty in the way they must buy cocoons in bulk from the government to last an entire year, which requires them to take out large loans. Reelers would prefer to buy smaller amounts of cocoons, several times a year. It would require the government to take responsibility to store them, but releasing cocoons for purchase throughout the year would save reelers money on loan interest, which could allow them to increase their production. Alternatively, and perhaps more easily on the government's part, lower-interest loans could be given to selected reelers for them to invest in processing silk into woven fabrics instead of selling reeled silk. Lastly, government support seems to need more organization or prioritization. The current merit-based system leaves some farmers alone to struggle. Certain farmers interviewed seemed to be in much greater need of a shed, for example—mainly due to a lack of space available in their home—than others who had been granted one. Those with sheds are few and far between in the first place. Greater communication between sericulture district officers and farmers could help here.

Fig. 4: An interview with a worker at a reeling unit in Bilaspur (photo credit: Vadivazhagu, 2019).

Sericulture works as it exists in and around Mandi, but still harbors an untapped potential for generating income for marginalized farmers, especially those farming for subsistence. Certain steps can be taken together by reelers, farmers, and the government to help realize this potential.

Acknowledgements

We would like to extend an extreme thanks to Dr. Shilpa Sharma of the Society for Technology and Development, our sponsoring non-government organization, for her outstanding assistance during all of our field work, and for all the knowledge with which she helped us complete our project. We would also like to acknowledge Mohit Barthwal for the help he has lent as our teaching assistant. Finally, we thank the Society for Technology and Development for leading us in our study of increased sericulture in Himachal Pradesh, proposing this project, and supporting us throughout our research.

Authorship

This project was created in roughly equal parts by all team members through various contributions during field work, report writing, and other miscellaneous tasks. Report writing was an especially collaborative effort; members of this team wrote new material while revising and editing others' work. Reviewing report components together as a team helped maintain consistency with regards to writing style and the information presented. Advisor feedback was reviewed and taken into consideration by all teammates before it was addressed with revisions. There were few tasks that anyone worked on in complete independence.

Teammates from the Indian Institute of Technology, Mandi participated especially in group fieldwork, fine-tuning survey methods, and results analysis. Their role here was important towards data collection and generating recommendations.

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Chapter 1. Sericulture: Expanding Opportunities for Himalayan Livelihoods

The two largest worldwide producers of silk are China and India, with China currently leading in both production and exportation by a large margin. The dramatic gap between these two leaders can be attributed to infrastructure lag in India. The country's venture into world markets has been slowed by comparatively less advanced technology for silk production.

The Society for Technology and Development (STD) is a non-profit NGO that has worked since 1990 for the welfare of marginalized sectors in the Mandi district of Himachal Pradesh (HP), India (STD, 2016). Under this umbrella, professionals from fields of engineering, education, social, agricultural, and horticultural sciences work alongside field researchers and artisans. Their main objectives are: to improve the employment and income of local populations by introducing technology which can complement traditional skills; to improve production mechanisms in order to add value to local products; and to form connections with the government and other organizations working within their field. The STD sees an opportunity for Himachali farmers to expand silk cocoon production, also known as sericulture. Fig. 1 shows silkworm cocoons, which are processed to produce silk fabrics.

Fig. 1: Silkworm cocoons (photo credit: Vadivazhagu, 2019).

Sericulture has taken up an important role as a cottage industry and a supplemental income source for agrarian Indian communities. Despite efforts of Himachal Pradesh's government, sericulture is an uncommon livelihood in this state. Technical and marketing support may address bottlenecks in sericulture's implementation, but the concerns of silk farmers are unclear. A 2014 study gives some clues, indicating that many barriers for improved industry standards are present. For example, most of the silk reeling industry consists of scattered micro-companies operating with "low margins" and "little capacity to invest in upgrading technology" (Astudillo et al., 2014, pp. 158-167). Also, development of new practices has generally focused on increasing silk yields, but studies suggest that more conservative practices that preserve product quality—e.g., better irrigation and effective raw material use—could improve sericulture's revenue stream. This could enhance the sustainability of silk and advance its economic viability.

The significance of expanding sericulture, by virtue of its potential for boosting both local incomes and therefore the state economy, responds to a few of the United Nations' sustainable development goals. These include opportunities to: reduce poverty and hunger; improve and innovate industry and infrastructure; and increase employment and economic growth within HP. Creating agricultural opportunities that are resistant to climate change are also of interest in a region that sees 70% of local livelihoods tied to farming (Government of India, 2016).

Thus, this project's goal was to conduct a feasibility study on increasing sericulture activity in Mandi District in central HP. We approached this goal by studying viable and optimized silk cocoon production methods, gaining an understanding of economic factors surrounding regional sericulture, and assessing the local capacity for and interest in this field's expansion.

Chapter 2. The Sericulture Processes, Industry, and Infrastructure

Before assessing the feasibility for sericulture in Mandi, we wanted to understand the steps that end with a final silk product. A summary of these steps can be found in Fig. 4. Sericulture is the process of growing silk cocoons for their silk filament in order to reel fibers and subsequently weave fabric. During its natural life cycle, a silkworm—of the species *B. mori L.*—hatches, grows, spins a cocoon, and becomes a moth capable of laying eggs (Babu, 2012). In nature, silkworm eggs normally hatch once a year, but ideal lab conditions can allow for up to three annual hatchings (Prakash et al., 2003). The silkworm larvae that hatch from these eggs—which produce different types of silk depending on their diet—are most often fed mulberry leaves (Murugesh, 2013).

Fig. 2: A crate of mulberry silk cocoons to be sold (Ghosh, 2018).

Genetic variations of the silkworm *B. mori L.* are referred to as "races." Indian races have a long larval stage and are more tolerant of high temperatures and humidity, producing good silk filament quality in their cocoons (Murugesh, 2013). Generally, silkworms that reproduce more frequently are smaller, with lighter silk cocoons and shorter life spans; the lowest filament quality is found in worms that breed twice yearly (Murugesh, 2013). Molting patterns may also vary across silkworms, but all commercially-bred, domesticated silkworms undergo metamorphosis at the same point in their development (Murugesh, 2013).

Fig. 3: Silkworms being reared on a rack bedded with mulberry leaves (photo credit: Vadivazhagu, 2019).

Over the course of twenty to thirty days of nurturing, typical larvae grow into caterpillars roughly 9 centimeters long (Babu, 2012). Each caterpillar eventually forms a cocoon by secreting a protein-like substance that hardens as it reaches air, becoming silk. Marketable cocoons, shown in fig. 2 above, are usually taken to local markets and sold to other farmers, silk fiber reelers, or exporters for further processing elsewhere.

At this point, the cocoon is ready for stoving and reeling. These processes first heat the cocoon in water to more easily extract its filaments. This will kill the silkworm inside if it is still alive, although some cocoons are spared to become moths for breeding purposes (Babu, 2012). Once the filament has been drawn out, several cocoons are reeled together to form threads of three to ten silk fibers. The fiber may be sold, woven into yarns and fabrics, or turned into final products such as clothing (Babu, 2012; Prakash et al., 2003). In addition, slight technical variations from this general norm result in variations in silk quality. Generally, the final product is a strong silk fabric that can be dyed while retaining its lustrous and absorbent properties.

These processes do not require much equipment, aside from a few specialty processing tools. For example, most small-scale reelers rely on the charka (Prakash et al., 2003). This is a simple, inexpensive device with a long tradition of use in a variety of different Indian textile industries. The charka can be operated by two workers, who could be members of a silk cocoon farmer's family. Somewhat larger Indian operations may use a cottage basin system, using a comparatively expensive machine that allows for more cocoons to be boiled and reeled together simultaneously. Many Chinese production sites, meanwhile, have even larger and more complex mechanized operations.

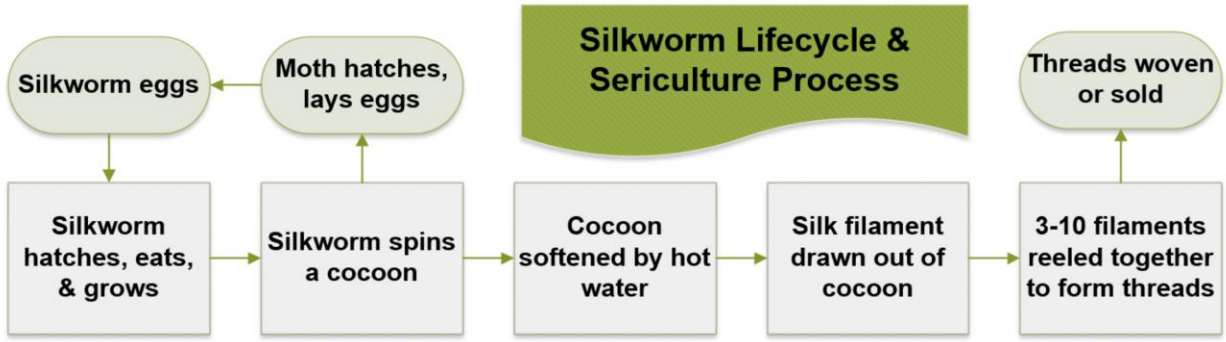

Fig. 4: Summary of the production process of silk.

Sericulture in the context of the Indian agricultural economy

The Indian sericulture industry occupies a sizable portion of its textile sector. In 2013, 7.6 million people throughout India were employed in sericulture out of 45 million employed throughout India's entire textiles industry (Sharanadavar, 2014). Furthermore, India is in a unique position compared to China in that it can produce four distinct kinds of silk: mulberry, tasar, eri, and muga silk (Kumaresan, 2002). Worth noting, however, is that 90% of the world's commercial silk is mulberry silk (Types of Silk, 2013).

Fig. 5: A cocoon farmer's mulberry tree (photo credit: Vadivazhagu, 2019).

Given its reliance on mulberry plant leaves, as in other countries, India's sericulture industry may be vulnerable to the effects of climate change. Changing atmospheric conditions are causing changes in both soil quality and characteristics of the leaves of the mulberry plant. This plant does benefit from increased CO_2 levels, since it photosynthesizes inefficiently (Ram et al., 2016)—higher CO_2 levels mean that photosynthetic reactions occur more frequently. However, the mulberry plant thrives best in a cooler climate; higher global temperatures can cause stress that degrades leaf quality (Ram et al., 2016). The most limiting factor to mulberry plant growth and quality, though, is an inability to control pest parasitism (Ram et al., 2016).

Agriculture is one of the primary sources of income within the state of Himachal Pradesh, India; estimates state it accounts for nearly 70% of employment (Government of India, 2016). However, the state has seen a shift in recent years towards industrial development (Directorate of Employment, 2015), and agriculture faces many challenges

for future development within the state. Some of these challenges include: low profits from traditional crops; a high dependence on regulated irrigation, which is scarce; and inadequate infrastructural support from the government (Government of India, 2016). Despite facing a negative trend in silk production, the state government of HP has not issued any additional subsidies towards or better communication efforts about existing programs working with marginalized farmers. The national government, meanwhile, announced initiatives in 2018 to make India completely self-reliant in the silk production industry, being committed to infrastructure development and increasing silk product quality (Ministry of Textiles, Press Information Bureau, 2018).

As noted earlier, the charka that is commonly used in Indian reeling is less efficient than more recent technologies (Kumaresan, 2002). All charka operation is done by hand, but the tool requires little capital investment or skilled labor to maintain. Automated silk reeling machines have been popularized in China, Japan, and Korea, but most require large capital investments and skilled labor for maintenance. This makes the technology difficult to implement for most rural, family-run silk farms (Kiyokawa, 1993). Efforts continue to be made to introduce automation in India to encourage sericulture. These are primarily made through subsidization (Central Silk Technological Research Institute, 2017). Fig. 6 shows a modern reeling machine built for a group of reelers in Bilaspur by the government. Sericulture does already have a presence in HP, with many micro-companies facilitating silk exports. These micro-companies may be collectively referred to as a cottage industry. They include family-run farms working with privately-owned equipment, although cooperation exists for sharing some expensive equipment. Cottage industries are common within HP, composing about 40 percent of its total industrial output (Sharda, 2018). Sericulture is viewed as a viable cottage industry thanks to its manual labor-intensive nature and the fact that it can be done at a local level with minimal large-scale organization or expensive technologies.

Fig. 6: Modern reeling machine (photo credit: Vadivazhagu, 2019).

Outside of climate change effects, the climate of HP is capable of seasonal mulberry plant growth and silkworm rearing through March and April, with cocoon harvests and sales in May. Mulberry varieties introduced by the government are capable of two or even three annual harvests, allowing for more cocoon farming. At higher altitudes in HP, oak trees are naturally common. If oak leaves replace mulberry leaves as fodder, silkworms will produce brown, slightly coarser tasar silk, making tasar a reasonable alternative to mulberry silk in these areas.

In sum, the Indian sericulture industry is well-established, albeit underdeveloped, but is and will continue to be affected by climate change. Himachal Pradesh—including the district of Mandi—also has the resources and the climate to support a sericulture industry growing multiple types of silk. A map of HP can be found below; Mandi District is outlined in red.

Fig. 7: Map of Mandi District within Himachal Pradesh (Google, Inc., 2019).

Mission of the Society for Technology and Development (STD)

The Society for Technology and Development seeks to improve local economies by integrating technology to enhance and support traditional skills. This NGO has seen success throughout much of northern India with an established "Core Long Term Program" focusing on increasing export diversity, strengthening local communities, and agricultural standardization (STD, 2016). The NGO once studied honey production with rural HP farmers, for example, and drew up an economic plan to diversify raw honey into different products (STD, 2016).

While improving sericulture has the potential to improve the income and the quality of life for farmers, such a development could have impacts of a broader scope. Supplemental income granted to farmers could stimulate the local economy through increased spending. With a greater silk supply, it is possible that silk's price may decrease.

Looking ahead: supporting research

Established literature indicates both promise and issues with regard to regional sericulture feasibility. Astudillo, Thalwitz, and Vollrath's 2014 life cycle assessment is thorough in its examination of a full sericulture scheme and its effect on a single component's viability. It was conducted in southern India and posits key factors for sustainable sericulture development and increasing export viability. It discusses many market aspects and compares Indian and Chinese sericulture. Researchers found that India saw a lack of management and suboptimal post-farm cocoon processing procedures (Astudillo, Thalwitz, & Vollrath, 2014).

Shukla conducted a survey in 2011 to determine constraints on Indian mulberry silk production. This investigation involved direct contact with rural farmers and developed

conclusions based on their opinions. It concluded that the top three constraints on sericulture farmers' operations were input cost, a lack of reliable irrigation, and a lack of family involvement, respectively. Problematic irrigation was noted in Nagaseshanna's 1993 farm study of Anantapur District as most harshly affecting small-scale farmers. Here, it is noted that droughts occur frequently and unpredictably in India. Other factors that limited farmers' expansion, ranging from silkworm egg quality to a lack of credit support by the government, were also found. The fact that Shukla's 2011 survey recorded irrigation problems as only the second biggest farmer concern indicates that in the years following Nageseshanna's study, the government provided more benefits to cocoon farmers. In 1996, a certain plan did indeed provide farmers with enhanced bivoltine hybrid cocoons, which are more resistant to drought (Rangappa, 1996). In sum, these studies helped to inform us on what issues silk farmers typically encounter.

Chapter 3. Interviews and Lines of Research

The following section details data collection strategies that were used to investigate sericulture feasibility in Mandi. Fig. 8 summarizes our objectives and associated methods.

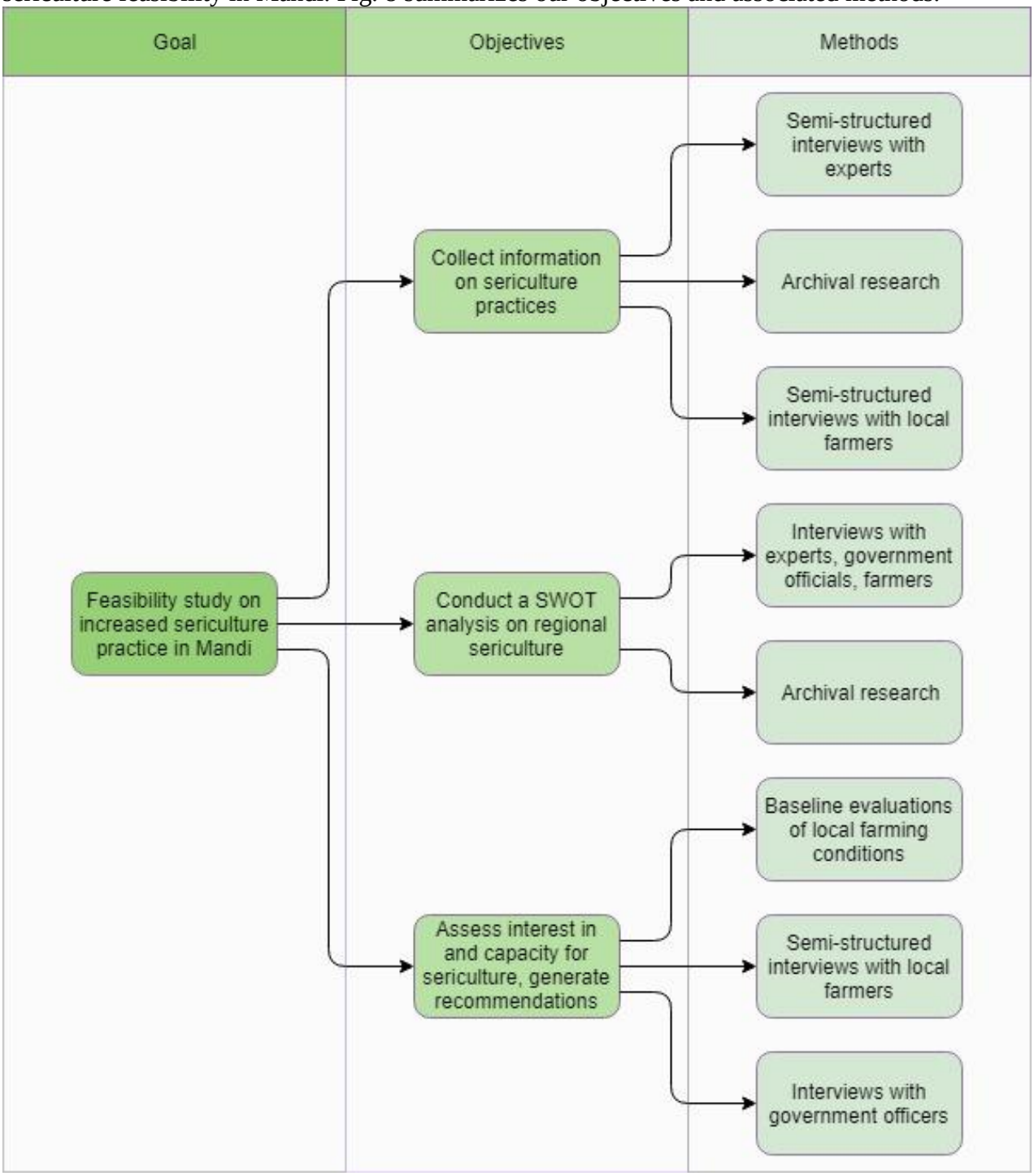

Fig. 8: Flowchart outlining project methodology for collecting data.

Collecting information on silk production practices

To understand sericulture and farming practices, we interviewed experts in relevant fields, including agricultural and climate specialists at the GB Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD). To gain the perspective of silk processors, we interviewed representatives of Krishna Wool and a reeling station in Bilaspur, the latter as in fig. 9. We also conducted archival research for a basic understanding of sericulture.

Our interviews were semi-standardized; a list of topics and questions was composed to lead conversation with experts, but dialog was left open to follow-up discussion/explanation (Berg, 2009). Interviews with farmers were similar. Semi-standardized interviews were more casual and conversational, encouraging trust between parties. We documented detailed observations on how farmers in HP raise silkworms at various sites through photography and notetaking.

Fig. 9: Interview with rep. of a Bilaspur reeling unit (photo credit: Vadivazhagu, 2019).

SWOT analysis

SWOT is an acronym for the Strengths, Weaknesses, Opportunities, and Threats associated with a business or industry. SWOT analyses are often used as one of the first steps when a business plans to make an adjustment in their operating strategy. We collected data through archival research and interviews with both local farmers and experts in the sericulture field. All interviews were sought out via snowball sampling.

Dr. Shilpa Sharma of STD Mandi connected students to a sericulture development district officer in Mandi town, who offered several contacts with potentially useful insight. Dr. Shyam Masakapalli reached out to Dr. Samant, the head scientist at GBPNIHESD, who offered insight on regional agriculture and climate change. Representatives of Krishna Wool were able to provide market information useful towards describing SWOT analysis factors. Silk cocoon farmers themselves also gave their perspectives on the state of their industry in this context.

Semi-standardized interviews allowed for the identification of key aspects of individual silk industry efforts that are or are not successful. One key detail drawn from interviews was to ask about the perception of sericulture within farming communities. This encompasses the focus of the next objective, but still played an important role in our SWOT analysis.

Assessing interest & capacities

The final objective of this project was to assess the regional interest and ability of industry peoples to improve sericulture in and around Mandi, and to generate recommendations to do so with research findings in mind. We conducted baseline evaluations to gather information regarding a farmer's situation, which helped us understand their farm's performance and their standard of living. Site assessments involved observations of physical landscapes, irrigation methods, and infrastructure that were useful in evaluating what resources a given farmer had available. Photos and written notes created a record of this information for the sake of comparison between farms.

Our connections with government officers and silk processers offered insight on government program success and industry roadblocks, although gathering cocoon farmers' perspectives was most critical towards generating recommendations. This is because farmer interviews highlighted the challenges they have faced within their livelihood. We collected data from silk farmers regarding their motivation for harvesting silk and sought suggestions for industry improvement based on their experiences. Farmers who used to practice sericulture and subsequently gave up were also interviewed to reveal industry weaknesses. Semi-structured interviews provided opportunities to tailor questions to individual farmers, and to gain additional insight not originally sought after. Team members and Dr. Sharma translated interviews between English and Hindi or local dialects. Snowball sampling was used to find additional farmer interviewees; referrals came from fellow farmers as well as district officials.

Fig. 10: A collage of silkworm rearer interviewees (photo credit: Vadivazhagu, 2019).

Chapter 4. Results and Discussion

The following section highlights results of data collected, organized by project objective. A map of locations at which field work took place can be found below, in fig. 11.

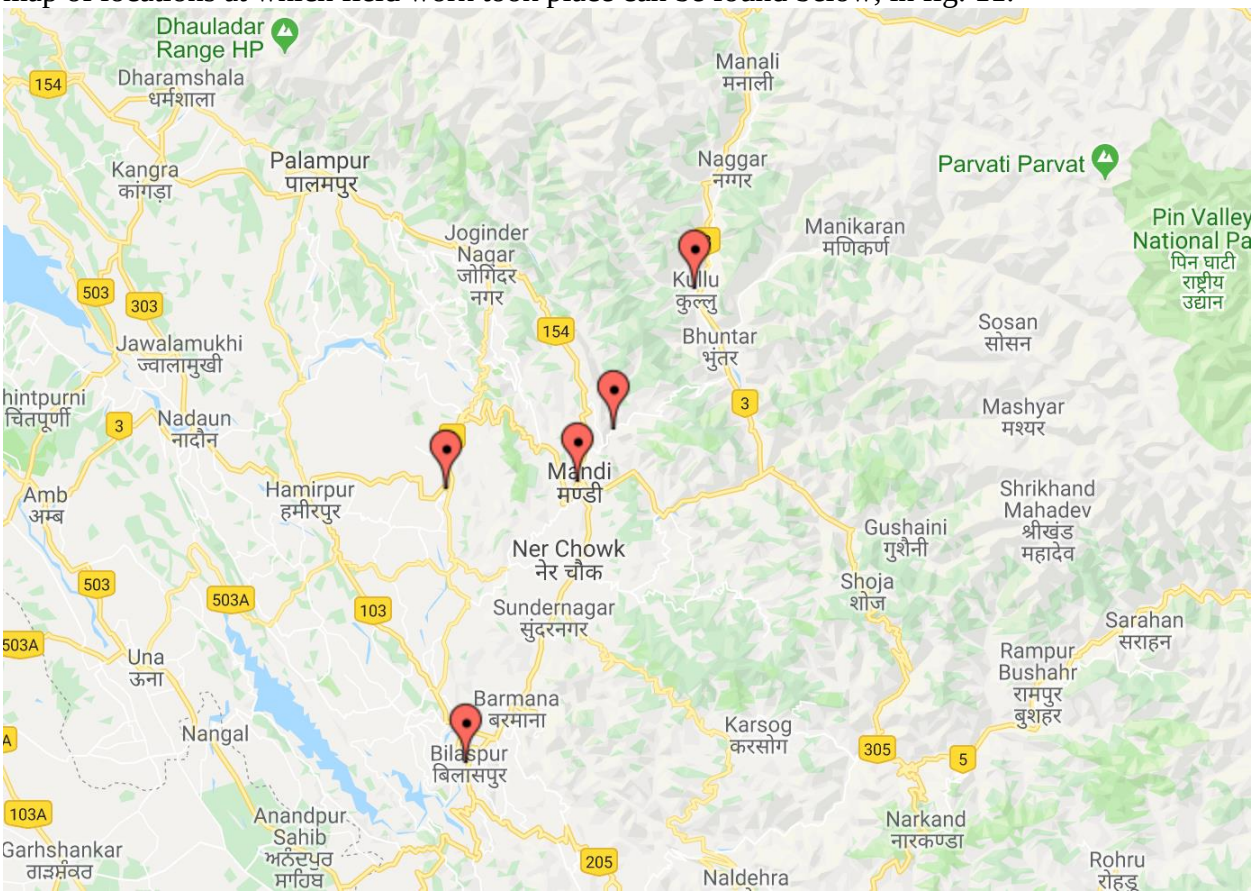

Fig. 11: A map of locations at which all field work took place (Google, Inc., 2019).

Silk production practices

To identify best practices in the sericulture industry, we spoke with a range of professionals and experts in this field, including the president of the STD, the owner of Krishna Wool, and several locally active silkworm rearers. We learned that roughly 2% of land in Himachal Pradesh is cultivated, making mulberry plant growth challenging. Omprakash Malhotra, aforementioned owner of Krishna Wool, recommends increasing production of and government subsidies for tasar silk because of the convenience of natural oak forests. Malhotra described a method of covering oaks with nets to keep pests away, allowing silkworms to eat leaves without much farmer upkeep or protection; this method is typical in tasar silk production. Malhotra has written many letters to the HP government to raise awareness about the potential of tasar silk but has not received any responses. He claims that his thicker, warmer tasar silk products are in higher demand in Mandi than his mulberry silk items.

Fig. 12: Krishna Wool weaver showing mulberry (left) vs. tasar (right) silk (photo credit: Vadivazhagu, 2019).

The STD president—who has had experience working in silk—and Malhotra both approve of the cottage industry sericulture model, with a collective organization of small-scale farmers over a large-scale industrial cooperative. They believe it is most viable and suitable for the social and geographical landscape of Mandi.

Dr. Samant had many thoughts regarding good, sustainable farming practices. He has been working with farmers and colleagues to spread information about climate change impacts and sustaining ecological development. From his research, it was found that HP farmers tend to harvest resources too aggressively. For example, cutting too many limbs too quickly from trees can damage them, lessening the moisture retained in surrounding soil. Sustainable lopping cuts only smaller branches from mature trees over younger ones. This ensures that more trees survive, and soil quality is maintained better, especially during droughts.

Cocoon farmers discussed strategies to mitigate pests and other setbacks frugally; most lack significant merit-based government subsidies for sheds and other major resources to grow their worms. Ants, for example, can bite and kill many worms sitting crowded on a rack shelf very quickly, and are hard to find amongst the caterpillars. Cocoon farmers therefore spread limestone powder near their silkworm racks. Infectious diseases may also plague silkworms, causing mass death. Some rearers think feeding worms wet leaves just after rainfall may cause these; others are less certain. A dedicated botanical study has yet to be conducted on this issue. Silkworms also need to be kept in cool, dim environments, which are maintained by draping windows to block out light. If the weather is too cold—below 22ºC or so—farmers use small heaters to keep their worms warm.

Spirituality in HP also seemed to play a role in its sericulture. HP has been described as relatively religious and philosophically respectful of the intrinsic value of life. Malhotra claimed this can lead to people feeling conflicted on the stoving and reeling processes, which kill the developing moth inside its cocoon. Thus, Malhotra has a hard time finding workers to reel silk cocoons. Farmers themselves typically leave the cocoons outside under the sun to dry out. This kills the moth without giving farmers a sense that they have directly killed it. Interviews with them further revealed that years of engaging in sericulture as a family tradition led to ambivalence towards the silkworms' fate. The reeling labor issue probably remains because these farmers typically do no reeling themselves.

We discussed with the Sericulture Officer of Gorth Village how one would become engaged in silkworm rearing in HP at this time. He described how one would need to follow a series of steps that could take years. Most of this time would be dedicated to preparing infrastructure capable of harboring the worms. A would-be rearer would first need to essentially grow a mulberry plantation. After submitting various applications, the farmer would receive visits from officers of the state government, who would train them in basic rearing techniques. After

thorough evaluations over time and more application submissions, he or she would be selected for subsidies based on their cocoon rearing performance.

SWOT analysis

Fig. 13 below summarizes aspects of regional sericulture which apply to analyses of its own strengths, weaknesses, opportunities, and threats as an industry.

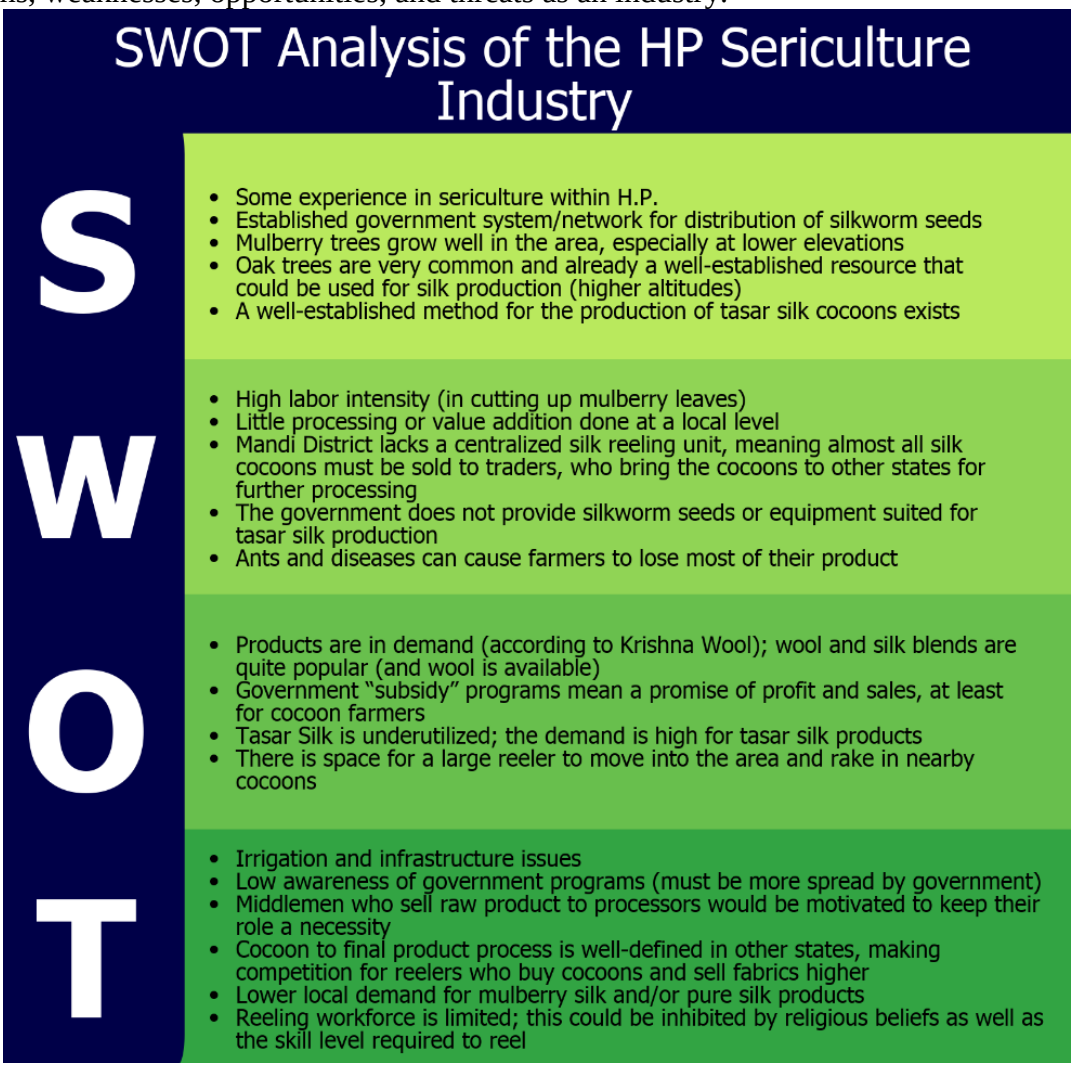

Fig. 13: Regional sericulture industry SWOT analysis summary.

To expand upon important and/or surprising findings: the conditions and climate of Himachal Pradesh are well-suited to silkworm rearing. There is very little silk processing or value addition done at a local level. The overwhelming majority of the cocoons produced in HP are sold to other states. Reelers feel as though most available support from the government goes to cocoon farmers, and that this makes cocoon prices too high for reelers to be successful. Meanwhile, many farmers struggle to get the support they need from the government. The production of tasar silk can be supported by regional resources, but is currently not being utilized or encouraged. This presents an area of potential growth for the industry. Religious or moral conflicts with killing silkworms is an unexpected factor which forms an obstacle to regional sericulture's growth by impeding the reeling sector. Additional explanation of our SWOT analysis can be found in Appendix A.

Interest and capacities surrounding sericulture

Findings from our interviews confirm some initial expectations, but also bring to light new issues and aspects. It is not uncommon that cocoon farmers use silk rearing seasonally as their primary income source; most are otherwise subsistence farmers of wheat and maize crops. All also stated that they would continue their respective sericulture operations, although it is worth noting that sericulture is a traditional family endeavor for them. There was also consensus between farmers that harvesting mulberry leaves often involves dangerous climbing of trees.

The farmers we interviewed typically earned between 900 and 1000 rupees per kg, producing an average of 20kg in a season. A chart of interviewed farmers' typical cocoon selling prices, per kilogram, can be found below in fig. 14. Most described disease as the biggest threat to their cocoon farming. Apparently, some recent seasons have seen cocoon product reduced to as little as 5kg due to silkworm disease. Despite the existence of state government subsidies, all farmers mentioned having trouble getting some of the equipment they needed from these programs. The vast majority had no shed; their silkworm rearing racks occupied space in their homes. One farmer has sold cocoons to the government for fifty years, but still has been granted no shed.

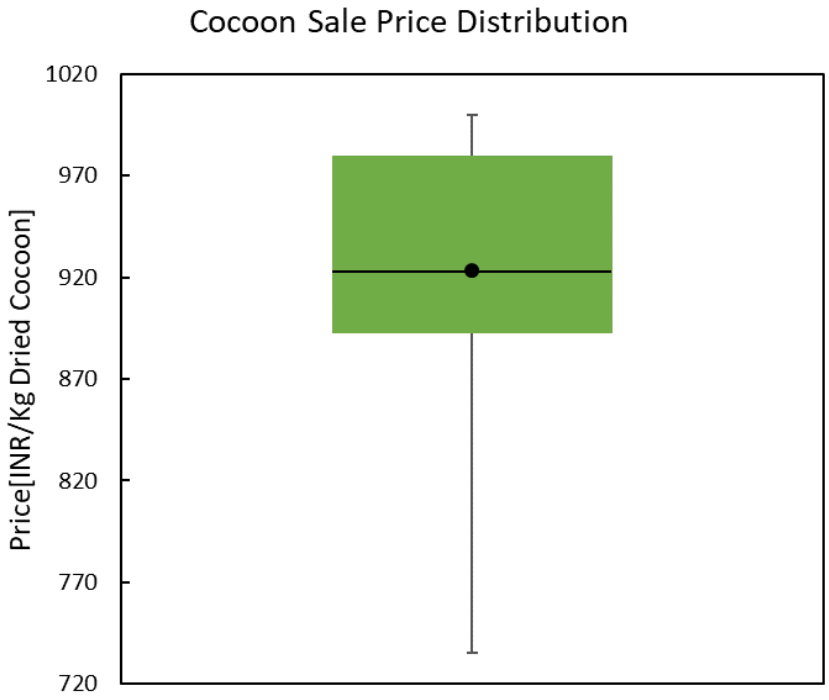

Fig. 14: The selling prices of one kilogram of cocoons, according to ten interviewed farmers. The average price, indicated by a black line, is 923.5 INR/kg of dried cocoon material.

A pair of former silk farmers indicated that while aided by government subsidies, sericulture was not their preferred means of making money. Both farmers were part of the same cooperative and received the same governmental benefits, and both found that sericulture work was tiring and not worth doing when they had alternatives. In order to feed their silkworms, they hand-picked tender mulberry leaves and used scissors to cut them into small, consumable pieces. It is unclear why they cut up the leaves, since other farmers simply place leaves or large pieces of them directly on worm racks. Hand-plucking leaves, though, is a consistent activity amongst all cocoon farmers. While the cocoon-generating season lasts only 45 days, one of our two former rearers explained that her "[silk]worms eat too many leaves! Those 45 days were

exhausting." The pair further elaborated that owning cultivated land encouraged smaller-scale farmers to grow less input-heavy cash crops like tomatoes, which they described as much preferable over cocoon farming. They explained that there were no substantial obstacles keeping them from rearing worms again besides a lack of interest brought on by the tedious work. In order for farming cocoons to be worth doing from their perspective, it would either have to be conducted on a larger scale, or be made a far less tiresome process. These farmers experienced no irrigation issues while farming cocoons—all farmers interviewed relied on rainfall—and the cocoon season did not appear to interrupt any of their other annual activities. From these farmers' responses, it seems that those not currently engaged in cocoon farming may be encouraged to do so if they were ensured the process was scaled up or less input-heavy.

Discussion with government officials on silkworm rearing revealed interesting points. The Sericulture Officer located in Gorth Village, who had been in office for over 30 years, described how the 1990s were a much greater time for sericulture than the present. There was more rearing, higher demand for cocoons, and more fabric production in HP; the industry was experiencing a boom. Unfortunately, as time has passed, and more buyers of cocoons came from foreign countries and other Indian states, rearers grew older, and producing the same volume of cocoons became more challenging. As the cocoon supply lessened, people took less interest in sericulture due to its manual labor requirements and decreased foreign profits. Reeling business opportunities became scarcer, which in turn left less reeled silk for weaving businesses to process. The number of companies producing silk fabrics went down, and the industry entered a bust.

Long-term interest in sericulture is low; children of current cocoon farmers express interest in leaving villages to pursue a college education and professional employment. Fig. 15 shows the ages of cocoon farmer interviewees; they are all adults who have reared worms for many years. There is minimal interest especially in the tedious labor involved silkworm rearing.

Fig. 15: Chart showing the age of each of ten cocoon farmers interviewed. The average age, illustrated by a black line, was 51 years old.

Discussion

Looking at our data, we see interesting trends and details in unfamiliar territory. Tasar silk cocoon production occurring somewhat autonomously on oak trees saves farmers the hard labor of having to hand-pick leaves, which our former mulberry silk cocoon farmers found tedious, and which our current farmers found potentially dangerous. The demand for tasar silk products Malhotra expressed also reveals an unexpected source of potential. However, tasar silk production does have issues limiting its implementation. A lack of both government support and farmer awareness leaves would-be farmers of tasar silk without useful knowledge or resources for getting started. Furthermore, there may be fewer guaranteed buyers or fair prices for tasar silk than for mulberry silk; government schemes which purchase mulberry cocoons at certain prices already exist. Finding non-government buyers even of mulberry silk has proven challenging and less profitable—there are few processors in HP traders from other areas hold a lot of pricing power if they are the most accessible buyers. Farming tasar silk over mulberry also does not change the reeling process or the death of the silkworm inside its cocoon. Still, any governmental support at all could potentially stimulate an emerging market for more tasar silk.

Many respondents of this study prefer a small-scale model, but the idea of a sericulture cooperative amongst farmers should not be completely disregarded. Villages or farms which lack the capital or mulberry assets to start practicing sericulture on a profitable scale could benefit from sharing equipment and resources with nearby farms. Automating some processes, introducing higher-end technology, or hiring out certain tasks to a greater pool of labor could all assist in making sericulture work easier for individual farmers. This would involve splitting profits more, although expansion could draw in more revenue. Difficulty encountered in finding fair prices for cocoons also makes a strong case for forming cooperatives—farmers could gain more control over the market in the immediate area.

Chapter 5. Project Outcomes

To briefly summarize our most important recommendations, they are to:

1. Foster expansion of the nearly non-existent weaving industry in Himachal Pradesh in order to encourage local silk material production and reeling;
2. Research the causes of silkworm disease and ways to prevent and treat them in order to reduce silkworm losses and make rearing a more reliable, consistent source of income;
3. Acquire or breed broader-leaved mulberry trees with higher leaf protein content in order to reduce how many leaves farmers must pluck to feed their silkworms;
4. Support reelers with low-interest loans for buying bulk materials and/or venturing into developing more complete silk products; and
5. Re-evaluate the scheme which delivers subsidies to silk farmers in terms of its criteria and priorities for subsidization.

Ultimately, we found that sericulture provides farmers with an opportunity for supplemental income that does not compete for land or seasonal time commitments with other crops, can be effectively done by one person, and can be a primary source of income for subsistence farmers. For these reasons, sericulture could be worthwhile for many farmers who have few opportunities to make money. If more reeling and weaving were done locally, local silk cocoon farmers could see more consistent means of selling cocoons.

Sericulture is a time-consuming and demanding activity. Gathering mulberry leaves often forces farmers to climb trees. Tending to worms requires a lot of time, especially in the last 10 to 15 days of their larval stage, during which they consume far more foliage. It can be difficult to prevent the spread of diseases in a worm population, and extra care must be taken to ensure that leaves are dry and that pests do not invade worm racks.

Fig. 16: Interview with cocoon farmer living near a reeling unit (photo credit: Vadivazhagu, 2019).

Many of these issues could be remedied by cooperation between farms. Experts agree that a small-scale model is best, but cooperation does not necessitate a “cooperative” or upscaling; closely-situated farms could stand to share resources like mulberry trees, or pool funds for shared equipment to ease labor burdens. This could allow more farmers to be jump-started into an engagement in sericulture. This vein of cooperation already exists where the government has given small groups of farmers subsidies that provide additional equipment to them as a unit, as in Gorth Village. These farmers still work individually on their rearing tasks. Before further implementation of schemes like this, however, we would first recommend deeper research in their success over more traditional, individual cocoon farming operations.

Silk production could benefit from some small innovations to make certain steps in the process easier. Climbing trees to pluck mulberry leaves is difficult and sometimes dangerous; the interviewee shown in fig. 16 above broke both legs after falling from a mulberry tree. An inexpensive, simple device with a long arm and a set of clippers at one end could help with this issue, being able to trim most leaves from the ground. A team of government-funded dendrologists could perhaps collaborate on researching and/or developing a shorter mulberry plant, but this plant would take up too much land area and be incapable of producing as many leaves. A mulberry plant with broader leaves and a higher protein content would be more helpful; farmers would simply have to pick fewer leaves to feed their worms sufficiently. This option could be much more effective than the use of a clipping tool, which would have to be purchased or distributed while not decreasing a farmer's actual required amount of labor.

Worth briefly noting is that if young people are disinterested in sericulture because of its basis in manual labor, they may become interested in developing solutions such as those listed above. A higher education could be used to develop mulberry trees with broader leaves, or a device for plucking those leaves.

Reeling units currently shoulder a large operation cost. Owners must purchase all the cocoons for a year at once, which often forces them to take out large loans with steep interest rates. These may be hard to pay off thanks to fluctuating silk prices, especially considering an uncertainty in the coming year's demand that may lead to over-buying. Fig. 17 shows bags filled with extra cocoons a reeling station is not prepared to process because there is no buyer for them in the immediate future. The price of reeled silk is, on average, about 1800 INR per kilogram, but booms and busts in this are common over time. Reelers would appreciate if the government stored cocoons and released them for purchase once every month or two, but the government does not want to take up the responsibility of storage. It is not uncommon for rats and pests to chew up and destroy silk cocoons they come across. Moreover, if reelers were allotted with more start-up capital, e.g. a subsidy or low-interest loan, they could invest in equipment for processing beyond the reeling stage, even to the development of final products, which demand steadier, higher prices. They could also afford to hire professionals to train their own workers in weaving and other processing steps.

Fig. 17: Bulk mulberry cocoons being stored at a reeling unit (photo credit: Vadivazhagu, 2019).

Developing final products could bring more revenue into reeling stations, and the surrounding economy could be stimulated by this in a few ways. Reelers could employ more workers, sell products locally rather than sell materials to other states, and buy more silk cocoons from nearby. HP silk is typically of the highest-ranked A4 grade, but Himachali reelers often still buy cocoons from southern India, which are cheaper thanks to a greater market supply. If reelers could diversify and/or develop their products, they could help to keep much more labor and many more sales local, making sericulture in and around Mandi more self-sufficient and sustainable.

The sericulture industry in HP could also benefit greatly from more consistent, organized state government support. The Karnataka Silk Board, for example, consists of a dedicated team of people working on improving and ensuring quality in that state's silk industry. With this, they are able to quickly get legislative changes that help farmers effectively out to the state government for implementation. Himachal has several issues in communication between marginalized worm rearers and the Textile Board; support provided is either not enough or not prioritized to support farmers that need it the most. Merit-based support may mean that those struggling already will only continue to struggle. From farmer interviews, we see that few receive the sheds that make their jobs much less intrusive on their lives. Even a farmer who has been raising silkworms for over fifty years lacks solid government support, other than receiving worm eggs, which are provided by the government to all rearers. Reelers could also benefit greatly from government support in order to get into the weaving business, which could provide them with a better profit margin and allow them to more comfortably buy cocoons in bulk. This support could probably most easily come in the form of low-interest loans to cover costs of entry into weaving.

Rearers, when selling cocoons, are often held at the mercy of non-government cocoon buyers. One interviewee told how she was essentially forced to accept only 700 INR for a kilogram of cocoons, despite their high quality. Another described his difficulty in rearing worms in the rainy season, but that he received far lower price than normal for cocoons harvested then. An average bulk cocoon price is 900 INR per kilogram, but a lack of any hands-on involvement by the government in this niche market means that farmers often must compromise. Farmers could gain some power as sellers if local reelers were encouraged to establish themselves and become potentially competitive for the raw material they need from farmers.

Finally, we recommend additional support from more researchers. Farmers reported several issues with disease and pests damaging their silkworms' health. A large chunk of their seasonal cocoon yields can be quickly lost to disease, and yet causes of these infections are generally unknown. One farmer postulated that he historically would observe the worms dying after a rainstorm, and how his worm yield was very low during the rainy season. Another fed her silkworms moist leaves just after a rainstorm, and noted many of them dying off that year. These two both believe that having too much moisture in their mulberry leaves is dangerous for the health of their worms; perhaps it relates to the temperature of the bed of leaves on which the worms sit. Hiring an entomologist or biologist to investigate the causes of these diseases could prove invaluable to farmers. The deadliest pest to worms are biting ants; these can be defended against with limestone powder around worm racks, although some farmers were unaware of this approach. Communication between farmers could always help spread useful tips. This also goes

Fig. 18: Limestone powder spread to deter ants from climbing onto a rack (photo credit: Vadivazhagu, 2019).

for the farming methods encouraged by Dr. Samant that work, for example, to keep soil moist in the face of climate change.

Conclusions

The government and the STD believe that sericulture is not practiced to its full potential in Mandi, and that this livelihood can aid in uplifting marginalized farmers and stimulating Himachal Pradesh's state economy. Our work leads us to believe that they both are correct. We believe there are measures which could address bottlenecks in sericulture's implementation in and around Mandi, enabling stakeholders from a variety of positions to get involved with sericulture's improvement in a profitable way.

There are many open avenues for further research in the vein of our project specifically. Interviewing more farmers not involved in sericulture to gain an outside perspective on the industry, and to hear what might motivate them to engage with it, could help generate new ideas on how to improve it. Researching ways in which farmers can sustainably raise more pragmatic mulberry varieties using the resources available could make raising silkworms safer and easier. By gathering and distributing detailed information on government subsidies, i.e., the application process as well as the approval and awarding processes, one could more effectively research and recommend improvements to that particular scheme. Finally, an investigation of tasar silk's implementation elsewhere could suggest whether it is truly suitable for Himachal Pradesh. We feel that our project has confirmed the general feasibility of increased sericulture implementation in Mandi. We also assert that this will take certain measures from stakeholders across the board, and that there is, of course, always room for deeper investigation.

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Supplemental Materials

Appendix A: Elaboration on SWOT analysis results

The silk industry within Himachal Pradesh is small. Our research has indicated that there are 18 farms practicing sericulture in the Mandi area, with a 45-day silk production season occurring between March and April. The farmers experienced no conflict between silk production and their other agricultural products, and felt silk did not compete with their other crops. As part of our work, we conducted a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of the Himachal Pradesh sericulture industry. Such an analysis can be used as a tool to better understand the benefits and challenges one might find in the sericulture industry, allowing one to assess the feasibility of its different facets. The analysis is discussed below.

The strengths of the industry include an established network for the distribution of mulberry-producing silkworm seeds/eggs. The government provides seeds to farmers as a part of a government scheme. Mulberry trees necessary for producing mulberry silk can grow well in the area and can be found at low elevations. Interviews with several experts have shown that Mandi District is also a well-suited for the production of tasar silk. Oak trees necessary for tasar silk production are very common at higher elevations; an abundance of them are available as a resource for potential tasar cocoon farmers to use. Methods for production of tasar silk are also well-defined, and resources other than trees that are needed to feed the worms are minimal. The production of tasar silk can be done by allowing silk worms to grow on a brown oak tree covered in a net. Netting can prevent birds and pests from killing and/or eating the worms as they grow cocoons.

The silk industry in its current state has several weaknesses. From cocoon farmers' perspective, rearing silkworms requires a significant amount of work. Farmers who left sericulture several years ago felt that having to cut leaves in order to feed mulberry-silk-producing silkworms made it a very labor intensive process. From the perspective of people buying silk cocoons, employing local people to work in the reeling of silk production is difficult. Omprakash Malhotra of Krishna Wool revealed in an interview that he is the only major silk reeler in the area, and buys between one and two percent of the total silk cocoons produced in the Mandi District. As Krishna Wool is the only major reeler in the area and comprises a small fraction of cocoon purchasing, one can conclude that very little value addition through silk reeling is done at the local level. Interviews with experts have shown that most cocoons are sold to traders, who then sell the cocoons wholesale in Karnataka, among other places.

Expansion in local silk reeling with larger, more capable facilities would be possible and potentially highly profitable for the local economy, since the silk would no longer be processed in other states. According to Malhotra, the raw materials needed for an increase in reeling in the area are available. A large number of silk cocoons are produced in Mandi District, but again, they are currently sold without being processed locally. Another potential expansion area for the industry lies in tasar silk, which has certain advantages specific to the area over mulberry silk. The prevalence of naturally occurring oak forests in Mandi could make the farming of tasar silk cocoons easy to implement. This means there is an opportunity for the integration of government incentives and schemes similar to those present in mulberry silk production. According to Malhotra, his tasar silk is in demand on both a local and national level.

A long-term threat to sericulture is found in climate change. Scientists at the GBPNIHESD told us how climate change is affecting the area's agriculture and water resources. Climate change is shifting areas in which tree growth is possible as well as reducing these areas

altogether. Water is becoming scarcer and more difficult to obtain; many of our farmers indeed rely primarily if not purely on rainfall for their livelihoods. This means that irrigation can become a more pressing issue over time for them. Interviews have also shown that there are issues in “last mile delivery” when it comes to funding from state and national government sericulture programs; considerable support barely fails to reach farmers themselves. More familiarity with these programs needs to be spread in order to expand regional sericulture. The reeling workforce is limited due to both a lack of skilled reelers in HP and religious beliefs that oppose the killing of silkworms, which occurs during reeling.

Appendix B: Poster

Report summary poster for presentation at IIT Mandi.

Appendix C: Interview questionnaires

Silk farmer interview outline: Below is a generalized sample set of semi-standardized interview questions and topics for local Himachali farmers who farm silk cocoons.

1. Background interviewee information
    1. May we have your age, name and gender, and permission to publish this information?
    2. How long have you been farming silk cocoons and breeding silkworms?
        1. What caused you to start doing so? Was it your own initiative or some outside influence (government, NGO, etc.)?
2. Operations of their silk cocoon farm
    1. How much land do you own (units)?
    2. How many people, besides yourself, work on your farm (for sericulture or otherwise)?
        1. If > 1, are most of your workers family or hired workers?
            1. Demographics of workers (age & gender)?
    3. What does your farm produce besides silk?
        1. Is silk your primary, secondary, etc. source of income? What comes first?
    4. What technical equipment does your farm use (for sericulture or otherwise)?
        1. Do you share this with anyone/any other farms?
    5. What type of silk do you produce?
    6. Time spent on silkworms & silkworm related things (e.g. mulberry plants) vs. other things (e.g. other crops, livestock)?
        1. Does sericulture consume a lot of your budget?
    7. Where does your farm draw water from?
        1. Does your access to water restrict any of your operations?
    8. Has your silk production changed much over time?
        1. Do you think it will change in the future (generational farming, etc.)?
        2. Has access to water or other resources changed at all over long periods?
    9. Is your scheme supported by a larger initiative, e.g. do you receive silkworm eggs annually from someone else?
3. Buying and selling silk
    1. Does your community connect or cooperate in silk production, or does your farm operate alone in the market?
    2. Do you sell cocoons themselves or extract your silk filaments for selling?
        1. If there's a third party involved for processing, who is this and what do they do? Are they state-run?
    3. Where do you go to sell your silk, and who do you sell it to?
        1. Do you sell to any state organizations? If so, do they draw products from many farms?
        2. How much time does it take for you to get to where you sell your silk?
    4. How many cocoons or how much silk do you sell per year, and at what price?
        1. Is this price fixed by a government buyer or some other factor?
        2. Do you interact with other sellers? Do you see remarkable competition?
4. Government or NGO support
    1. Are you aware of government/NGO assistance available to you?
    2. How easy is this information to find?

3. Do you receive any government or NGO support?

5. Open-mindedness to change
    1. How willing would you be to accepting a new silk farming scheme?
    2. Has anyone ever approached you with recommendations before? If so, what are your thoughts/how have you responded, if at all?
6. Farmer's Perspectives
    1. Are there any outstanding obstacles that make it harder for you to breed silkworms or turn a profit, in particular?
    2. What are changes or improvements in the market or your operations that would help you?
    3. Do you have any thoughts on the silk reeling process and its effect of killing the silkworm inside the cocoon?
        1. Is this something a lot of people in this field discuss or disagree on?
    4. Do you think sericulture will continue to be practical? Why or why not?
7. Do you know of anyone else who does or has in the past farmed silk, or would have any insight on sericulture?

Non-silk farmer interview outline: Below is a generalized sample set of semi-standardized interview questions and topics for local Himachali farmers who do not farm silk cocoons.

1. Background interviewee information
    1. May we have your age, name and gender, and permission to publish this information?
2. Current production
    1. How much land do you own (units)?
    2. What do you currently farm?
    3. How many people, besides yourself, work on your farm (for sericulture or otherwise)?
        1. If > 1, are most of your workers family or hired workers?
            1. Demographics of workers (age & gender)?
    4. How did you get into the situation of farming what you do?
    5. Can you walk us through a workday on your farm?
    6. What are the priorities of your livelihood?
3. Past experience with silk
    1. If our interviewee has given up on silk farming:
        1. Why have you left sericulture?
        2. What were the biggest factors that led you to farm silk, and the subsequent factors that led you to stop?
            1. Were they internal (personal reasons) or external (environmental)?
        3. How long did you farm cocoons?
    2. Do you know anyone currently involved in silk production?
    3. What are your opinions on the future of silk production? Do you see it as promising or practical?
4. Hesitations for adopting sericulture
    1. Is operational cost in adoption of sericulture an issue for you?
    2. Is water access problematic on your farm?
    3. Do you have any thoughts on the silk reeling process and its effect of killing the silkworm inside the cocoon?

        1. Is this something a lot of people in this field discuss or disagree on?
    4. Are you aware of NGO/government sericulture support programs?
5. Measure of success in Farming
    1. What are your sales and/or exports like? Is your farm profitable?
    2. Is your farm having any general difficulties?
        1. What are some factors that may keep you from solving these problems?
    3. If you had more resources (time, land, money, manpower), would you do anything differently? If so, what?
6. Family History with Farming
    1. Are you a first generation farmer? How long have you been doing this?
    2. Is everyone in the family involved in the process?
7. Open-mindedness to Change
    1. Given your knowledge and/or experience, are you willing to ever switch to producing silk or any other particular product?
    2. If not silk, what is motivating your interest in a particular product?
8. Do you know of anyone else who does or has in the past farmed silk, or would have any insight on sericulture?

Questions for silk reelers: Below are questions asked of silk reelers which address certain important topics of conversation.

1. How much cocoon material do you process annually (and what time of the year does this occur)?
2. Where and how do you get cocoons from, if not produced right here by you?
3. What kind of equipment do you use to reel?
4. What do your operating costs look like?
    1. Where do you sell your product to, how much, and at what price?
    2. Do you have any difficulty selling, either finding buyers or a fair price?
5. Where do you find workers to reel? Have you found any difficulty in this?
6. How many reelers are employed at this station?
7. Is your operation involved with or assisted by the government in any way?
8. Do you see a lot of competition in selling your products?