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A Feasibility Study of an All-Season Plant Nursery for Food Security

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A Feasibility Study of an All-Season Plant Nursery for Food Security in Mandi, India

Kamand, Himachal Pradesh, India



April 27th 2018

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A FEASIBILITY STUDY OF AN ALL-SEASON PLANT NURSERY FOR FOOD SECURITY IN MANDI, INDIA

An Interactive Qualifying Project submitted to the Faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the degree of Bachelor of Science in cooperation with the Indian Institute of Technology, Mandi
Submitted on May 2, 2018

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April 29, 2018

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Abstract

In the largely agrarian north Indian state of Himachal Pradesh pests, temperature variation, weather conditions and climate change are critical factors affecting the livelihoods of farmers and villagers. The rapidly changing environment is damaging crop production and food security in this region, and in turn driving residents to more urbanized areas to find reliable work. Our team studied the feasibility of an all-season plant nursery to help improve growing conditions and expand opportunities for personal or commercial farming in Himachal Pradesh. Using interview and fieldwork data we designed and built a plant nursery prototype and proposed a nursery trial system with the intent of preserving the culture and livelihoods that sustain this region of India.

Executive Summary

Food security is one of the world's most pressing problems, affecting nearly one billion people globally. The United Nations recognizes this problem in its second sustainable development goal (UNHCR, March 2017). In rural states like Himachal Pradesh, the problem includes the complex challenges of the weather and terrain for dependable crop growth. Agriculture is a vitally important part of life, but the seasonal nature of food production causes inconsistent production periods throughout the year. Communities in regions such as Himachal Pradesh rely on knowledge passed on by previous farmers and good weather to get them through each season, and adding to the complexity are the wide range of pests, temperatures, and weather experienced in the Himachal Pradesh region. Additionally, increasing uncertainty resulting from climate change puts farmers at risk of losing their traditional way of living. These threats can drive people away from farming to pursue more stable work. An all-season plant nursery could potentially lengthen the growing season in order to minimize risks and increase the opportunity for agricultural stability and success.



Figure i: Terrace farming in Himachal Pradesh

There are several aspects of this northern region that make it particularly prone to growing season difficulties. The District of Mandi sits in the foothills of the Himalayas, and as such is a very mountainous region. Mandi has a humid subtropical climate in most areas, with an alpine climate at higher elevations. The elevation, which ranges from 696 meters to 2030 meters, couple with steep inclines, make effective crop growth difficult. Furthermore, the seasonal nature of the weather makes it difficult for farms to be productive year-round. Temperatures range from

over 38 degrees Celsius in the summer to below -1 degrees Celsius in the winter. Plus, Mandi receives an average of 168 centimeters of rain every year, with approximately 48 centimeters of rainfall during July, the first month of monsoon season (Climate: Mandi, 1982-2012).

These weather conditions can be damaging to the primarily agrarian culture of the surrounding region. Temperatures that are too hot or too cold can affect the growth of the seasonal crops. The inconsistent rainfall presents an issue of maintaining irrigation throughout the dry seasons or plants being drowned out by the heavy rainfall of monsoon. These are concerns for farmers who either need to profit off their crops or need the food they are growing for themselves.

Despite the challenges of growing crops in this mountainous region, 71 percent of residents in the province are associated with agricultural livelihoods (Envis Centre: Himachal Pradesh, 2011). While some residents of Himachal Pradesh already use nurseries to protect and grow plants out of season, this practice is not being used to its full potential. This is evident by the low production of vegetables as seen from interviews we conducted. The ability for families or businesses to grow crops throughout the winter and other inclement weather such as during monsoon season may supplement food supplies or profits during a slow period.

The purpose of this project was to study the feasibility of enabling farmers to use plant nurseries and to test a prototype for year-round production in Himachal Pradesh. An all-season plant nursery could allow for a more diverse and consistent food supply year-round and as a result improve food security in the region. The design of a structurally sound building would allow a maximum amount of sunlight while offering durability and effectiveness as well as protection from pests like monkeys. The design and choice of materials for the project were meant to create an affordable nursery that could be easily constructed and maintained by anyone. As such, objectives of the project were to research current nursery and non-nursery farming practices and needs; to identify site and design specific parameters for nursery construction; and to join the best practices for the design and development of nurseries with the needs of the farmers of Mandi. We designed and built a prototype that could assist in year-round crop growth in Mandi, India.

Approach

Three objectives were identified in order to assess the feasibility of an all-season plant nursery in Himachal Pradesh. The three primary objectives and how we planned to approach them are outlined in figure ii below.

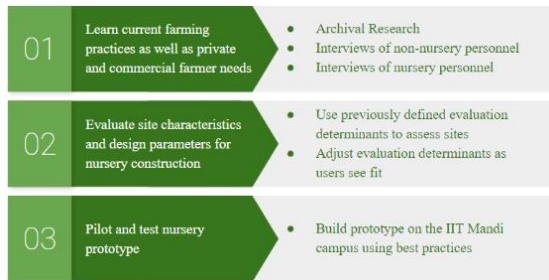


Figure ii: Outline of objectives

Results

Our main findings highlighted issues with water and elevation, with monkeys, and overall concerns about the future of farming. Farmers that live in the higher elevation areas have more difficulty accessing water, and as such, do not have sufficient crop growth. Residents there have to have water shipped to them using trucks with large water tanks, and that water is used for day-to-day needs, not for crops. Additionally, the only crops grown are wheat and maize since monkeys often destroy fruits and vegetables before they can be harvested. Wheat and maize are tougher crops, and as such, are more difficult for monkeys to eat. Lack of fruits and vegetables force families to travel to Mandi to buy produce. Finally, we found that most farmers have no desire for a nursery. There are two reasons for this: water scarcity and lack of training in using greenhouses or nurseries. The farmers we interviewed wanted a solution to their water issues.

Project Outcomes

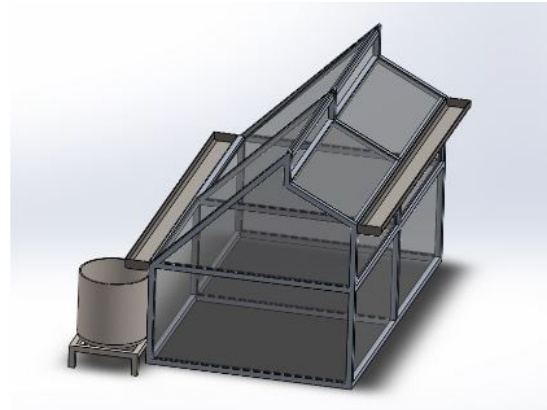


Figure iii: CAD rendering of nursery prototype

We designed an all-season plant nursery with a secure structure to resist monkeys and a water collection system to assist with water scarcity. To encourage farmers without nursery knowledge, we proposed a nursery trial system that would be paid for by a sponsor. In this trial, farmers receive a nursery for one year and after one year they decide whether they want to purchase it. If farmers do not think the nursery helped and they do not want it, they return it to the sponsor. If farmers believe the nursery worked and they wish to keep it they can pay off the nursery over time. This way, farmers can learn how a nursery works without having to front a large investment. With these features, the nursery could help stabilize food security and help preserve the livelihoods in Himachal Pradesh.

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- Dr. Ingrid Shockey and Dr. Seth Tuler for their unwavering support, guidance, and editing throughout our time in India.



Pictured left to right: Joseph Evans, Sahil Singla, Hitesh Ramchandani, Abhay Singh Chauhan, Dr. Shubhajit Roy Chowdhury, Benjamin Shaffer, Grace Gerhardt, Jack O'Neill

Authorship

To complete this project, the seven of us collaborated in the following ways:

Abhay Singh Chauhan was responsible for the preliminary CAD model of the nursery as well as confirming the nursery design will be structurally sound. Abhay also helped assemble the nursery prototype.

Joseph Evans conducted major research on nursery structure and technology. He also was the primary writer for the Background, Methodology, Results, and Conclusion. Joseph assisted in writing the Discussion and Project Outcomes, in addition to being the primary writer for the Interview Questions and Evaluation Determinants. Joseph also helped with the interviewing of farmers and with building the nursery prototype.

Grace Gerhardt assisted in research, focusing on the challenges of introducing nursery technologies to rural villages. She assisted in writing the Abstract, Executive Summary, Background, Methodology, and Results. She was the primary writer for Project Outcomes, and helped with interviewing the farmers. Grace also assisted in the construction of the nursery prototype.

Jack O'Neill was the primary writer of the Abstract and helped with research. He assisted in writing the Executive Summary, Background, Methodology, Results, Discussion, and Project Outcomes. Jack designed the final CAD model of the nursery, and assisted in interviewing farmers. He also helped with the construction of the nursery prototype.

Hitesh Ramchandani took care of ordering the materials for the prototype, assisted in the construction of the prototype, and served as the primary translator for farmer interviews.

Sahil Singla confirmed calculations for the dimensions of the prototype, assisted in the construction of the prototype, and helped write the interview questions. Sahil also assisted with translation during interviews.

Benjamin Shaffer wrote most of the Introduction and Executive Summary sections. He assisted in research as well as writing the Background, Methodology, Results, and Discussion. Benjamin assisted in interviewing the farmers, and is the inventor of the Nursery Trial System proposed in Project Outcomes. He also helped construct the nursery prototype.

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1 All-Season Plant Nursery for Improved Food Security

Food security is one of the world's most pressing problems, affecting nearly one billion people globally. The United Nations recognizes this problem in its second sustainable development goal (UNHCR, March 2017). In rural states like Himachal Pradesh, the problem includes the complex challenges of the weather and terrain for dependable crop growth. Agriculture is a vitally important part of life, but the seasonal nature of food production can be problematic for consistent growing conditions. These communities rely on knowledge passed on by previous farmers and good weather to get them through each season. This region experiences a wide range of pests, temperatures, and weather.

Additionally, increasing uncertainty resulting from climate change puts farmers at risk of losing their traditional way of living. The threat of climate change and increased difficulty of being a farmer can drive people away from farming to pursue a larger profit. As a result of this, farming becomes more difficult to make a profit, further repeating the cycle. An all-season nursery could potentially lengthen the growing season in order to minimize risks and increase the opportunity for agricultural stability and success.

There are several aspects of this northern region that make it particularly prone to growing season difficulties. The District of Mandi sits in the foothills of the Himalayas, in the heart of the state. Mandi is a mountainous region with elevations between 696 meters at its lowest and 2030 meters at its highest. The region has a humid subtropical climate in most areas and an alpine climate at higher elevations. The elevation and steep inclines make effective crop growth difficult. Temperatures in the summers can rise to over 38 degrees Celsius and fall to below -1 degrees Celsius during the winters. The seasonal nature of the weather makes it difficult for farms to be productive year-round. Mandi receives an average of 168 centimeters of rain every year and during July, the first month of monsoon season, the average rainfall is 48 centimeters (Climate: Mandi, 1982-2012). These weather conditions can be damaging to the primarily agrarian culture of the surrounding region.

Temperatures that are too hot or too cold can affect the growth of the seasonal crops. The inconsistent rainfall presents an issue of maintaining irrigation throughout the dry seasons or plants being drowned out by the heavy rainfall of monsoon. These

are concerns for farmers who either need the money that their crops will bring in or need the food they are growing for themselves.



Figure 1: Terrace Farming in Himachal Pradesh

Despite the challenges of growing crops in this mountainous region, 71 percent of residents in the province are associated with agricultural livelihoods (Envis Centre: Himachal Pradesh, 2011). While some residents of Himachal Pradesh already use nurseries to protect and grow plants out of season, this practice is not being used to its full potential. This is evident by the low production of vegetables as seen from interviews conducted by the team. The ability for families or businesses to grow crops throughout the winter and other inclement weather such as during monsoon season may supplement food supplies or profits during a slow period.

The purpose of this project is to study the feasibility of enabling farmers to use plant nurseries and test a prototype for year-round production in Himachal Pradesh. If needed, an all-season plant nursery would allow for a more diverse and consistent food supply year-round and as a result improve food security in the region. The design of a structurally sound building could allow a maximum amount of sunlight while offering durability and effectiveness as well as protection from monkeys. Our goal for the design and materials of the project was to create an affordable nursery that could be easily constructed and maintained by anyone. As such, objectives of the project were to research current nursery and non-nursery farming practices as well as stakeholder needs, identify site and design specific parameters for nursery construction, and to join the best practices for the design and development of nurseries with the needs of the people of Mandi. We designed and built a prototype for an all-season plant nursery to assist in year-round crop growth in Mandi, India.

2 Nursery Challenges and Design

The weather conditions present in this region of Himachal Pradesh can provide a good environment for plant growth but can also be harsh for the many different types of plants grown. To give both commercial and sustenance crops a more controlled environment for both in and out of season growth, we investigated more deeply the constraints and requirements that could support farmers in Himachal Pradesh. What we learned is that adding equipment and infrastructure to traditional communities poses a financial risk and potential learning curve that may limit interest. The stakeholders for this project were small-scale farmers and commercial growers. Rain-fed farms account for 80 percent of all food for India, and selling these crops is the main source of income for residents of Himachal Pradesh.



Figure 2: Farming in Kamand Valley

2.1 Challenges of Introducing Nursery Technology

Although an all-season plant nursery seems like a logical solution for farmers trying to grow crops in the difficult climate, there are many challenges involved in introducing nurseries. Nurseries are expensive, and with the per capita income of Himachal Pradesh at 95,582 INR (approximately 1,461 USD) it would take a hefty loan to purchase a nursery (Baldi, 2016). Also, although Census data from 2011 proves

Himachal Pradesh has one of the highest literacy rates in India with nearly 83 percent, only 3 percent of residents have access to internet (Biswas, 2012). Without access to internet, it is difficult for residents to research how nurseries work and how best to use them. Another challenge for farmers without access to internet is they cannot apply for government subsidies or research other agricultural extension benefits. There is a limited amount of help available for farmers, but they can contact the local Agricultural Extension Officer or the Directorate of Agriculture, located in Shimla (Department of Agriculture, 2001). To help combat inconsistent growing conditions, assessing the viability and the need for a simple nursery with options for season extension and out of season crop growth could assist these farmers and households in producing enough food for their families or crops to be sold at local markets. In addition, an advanced prototype could benefit the agricultural research community and provide options for scientific or academic agricultural research for site specific conditions. Our motive was that the benefit of an adaptable plant nursery for growers, is that it has parameters that could be customized by stakeholders. Considerations included size, cost, portability, reparability of materials, and scalability. Simplicity was key; an intuitive design allows for easy maintenance as well as smooth use.

2.2 Site Specific Form and Function

The design for an adaptable plant nursery for use in Himachal Pradesh needs to consider a range of options for cost and local materials. A nursery is a structure where plants are grown from seedlings, whereas a greenhouse is a structure made from predominantly transparent material where plants are grown. Greenhouse temperature control techniques can be either passive or active, meaning they are either independent or dependent on electricity.

The user requirements for the space, the cost of building materials for the nursery, and other customized features add or subtract complexity. A summary of common design considerations can be seen below in Table 1.

Table 1: Design Features for Plant Nurseries

Feature	Considerations
Foundation	Material, cost, dimensions
Insulation	Material, cost, insulation ability
Ventilation	Style, heat loss, insulation ability
Cladding	Material, cost, durability, light penetration
Photovoltaic panels	Cost, dimension, energy output, maintenance
LED lights (Far Red)	Cost, light output, energy consumption, maintenance

Nursery structures are dependent on site-specific conditions such as climate and social considerations around usability. Standard modifications include shape and foundation quality. A standard peak structure, where the roof of the structure is a scalene triangle to maximize area exposed to light, is common in Himachal Pradesh. An outline for building greenhouse foundations is detailed in *The Food and Heat Producing Solar Greenhouse* by Rick Fisher (1976). One approach to building a foundation is to make a base from a solid substance such as concrete or masonry stones, and then surround this by an insulator such as Styrofoam (Fisher, 1976). Additionally, a case study conducted in Northwest Nepal in 2011 found that a mixture of mud brick and straw as a foundation proved to be strong and a great insulator (Fuller, 2012). This study demonstrates that simple solutions using locally obtained material can be exceedingly effective.

Greenhouse structures and shape are chosen for specific environments. The standard peak structure supports different types of pressure that can be put on a greenhouse such as snow load, wind load, dead load, and live load. Snow load and wind load are the stresses that are put on the greenhouse by their respective conditions, dead load is the weight of the structure itself and all of its attachments like pipes and lights, and live load is the weight of any person on the structure during maintenance (Ponce, 2015). The loads that the structure can bear are heavily dependent on the construction materials. A common building material is aluminum, which has the advantage of being lightweight and durable.

Cladding, the covering on a greenhouse, is most commonly glass or polyethylene. Insulation, durability, and transmittance of light and radiation into the greenhouse are important factors when considering what material to use. While glass transmits light extremely well and polyethylene is cheaper and lighter than glass, they are both expensive and hard to obtain. A third option for the cladding is polycar-

bonate. This material is often formed into two sheets of plastic with hollow channels running between them which serves as added structural support and also increases insulation, called twin wall cladding (Abdel-Ghany, 2012).

Passive methods of heating and ventilation are important for a self-sustaining nursery. Storing light energy will heat up the nursery while proper ventilation will allow cooling and humidity control. Proper micro-climate maintenance allows for the most efficient growth of crops in the nursery.

Maximizing light transmittance is important for photosynthesis and heat retention. A large surface area on a south facing wall maximizes the light and radiation that is able to pass through the cladding and into the greenhouse. Radiation that passes through cladding and becomes trapped causes the “greenhouse effect” which heats up the nursery. Multiple layers of cladding create air pockets between layers which increases insulation (McCullagh, 1978).

2.3 Approaches to Temperature Control

Just as in a residential home, insulation, heating, and ventilation are important and closely related in greenhouses. Without the proper insulation, trapped heat from the sun can be lost when temperatures decline, so minimizing heat loss is essential. A large internal volume gives the structure thermal inertia, a property of a structure which describes its ability to retain heat.

Keeping a nursery or greenhouse at an appropriate temperature for the plants presents a great challenge. There are two broad categories of solar energy collection: passive and active. A passive system uses a heat sink to absorb thermal energy during the day and then passively radiates it back out into the greenhouse at night. One common method for keeping the structure heated is storing heat from the sun

in thermal masses. There are different materials used for this, mostly commonly ceramics or water. When added to a greenhouse, they absorb heat during the day and then release it at night. In contrast, active heating involves the use of a thermal mass and powered ventilation. A Ground-to-Air Heat Transfer system (GAHT) uses a fan to blow air through pipes running through the ground. In the summer it vents hot air through pipes in the ground, cooling it off and bringing it back into the nursery. During the winter it vents cool air through the ground that has been heated all summer to heat the nursery up (Schiller, 2017). This setup can be seen in Figure 3.

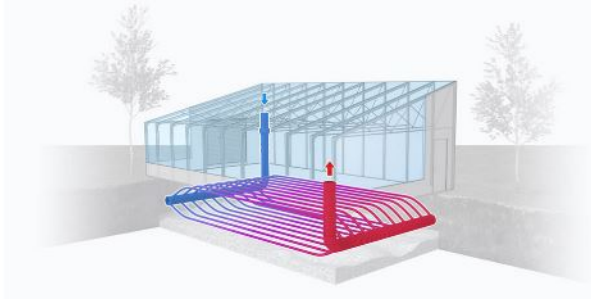


Figure 3: GAHT system in a greenhouse (Schiller, 2017).

Given the generation of carbon dioxide as well as humidity from enclosed spaces, a key aspect of greenhouse microclimate maintenance is its ventilation. An article written by John Worley of the Department of Poultry Science at the University of Georgia states that factors to consider when designing the ventilation system included local wind speed and direction, vent layout, vent area, and whether to use a forced or passive ventilation system (Worley, 2015). There are a number of commonly used ventilation layouts that are each chosen for specific purposes. The University of Thessaly, School of Agriculture, Crop and Animal Production produced a study on the effectiveness of four different layouts, one of which is shown below in Figure 4.

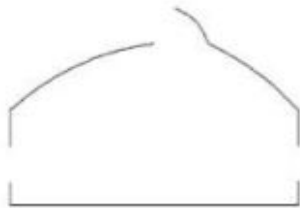


Figure 4: Geometry of side and roof openings configuration (Bartzanas et. al., 2004).

In this study researchers found this configuration that combined open side vents and a roof flap was the best vent layout since it allowed a large quantity of air-flow to be circulated through the greenhouse while maintaining proper airflow inside (Bartzanas et. al., 2004). Another study, done by J. J. Hanan (1978) found that alternating roof vents on either side of a greenhouse employed the cross-flow strategy along with vents on the roof vented heat more efficiently than one single vent type.

Active ventilation is also an option when considering ventilation systems. A second study conducted by the University of Thessaly considered the viability of a system that circulated air using a fan. The researchers found that while there were large differences in microclimate conditions inside the greenhouse between an active and passive ventilation scheme, very little difference in plant transpiration rate was present (Kittas et. al., 2001). Regardless, active ventilation offers a good way to ensure proper rates of ventilation within the greenhouse. In a windy area such as Himachal Pradesh this is important since high winds can potentially be harmful to young or fragile crops.

2.4 Power and Supplementary Lighting

Features such as solar panels and LED lights are not necessary for the construction of a functional nursery, but they provide supplementary assistance in areas such as energy consumption or increasing plant growth. Passive methods of heating and cooling do not use electricity, but at the same time do not change conditions as quickly or as radically as active methods that use fossil fuels or coal. Introducing solar panels can decrease or negate the cost of air conditioning and heating each year (Carlini, 2011). By decreasing the cost of non-passive heating and cooling methods, more effective temperature control can be achieved while also keeping the cost of greenhouse maintenance low. Any solar energy produced will help mitigate efficiency losses in the nursery. Photovoltaic panels can be quite expensive and thus it is important to have a well-designed nursery to reduce the necessary size of the panels if affordability is to play a role in the nursery design.

During the winter months there are not enough hours of sunlight in a day to grow plants as efficiently as in the summer (McCullagh, 1978). Supplementation of light is necessary for continuing growth throughout the winter. A study done by Kai Cao in 2016 used Far Red LED lights to offset the light lost

from shorter days. By using Far Red LED lights, the plants did not grow as tall but the overall mass of the plant, meaning the leaves and flowers, had increased in size (Cao, 2016). Increased leaf area allows plants to take in more light energy from the sun. The study also showed increased flowering from plants supplemented with Far Red LED light which correlated to increased crop yield.

2.5 Government Subsidies

For farmers who are willing to invest but still need some monetary assistance, there are government sub-

sidies to help lessen the financial burden. We identified a number of government subsidies that incentivize farmers to switch to the use of nurseries to grow crops. The government schemes relevant to this project include: The Rural Infrastructure Development Fund (R.I.F.D.), The Ministry of New and Renewable Energy solar panel subsidy, the Dr. Y. S. Parmar Kisan Swarozgar Yojna and Japan International Cooperative Agency (J.I.C.A.) scheme, and the Rashtriya Krishi Vikas Yojana Scheme (Department of Agriculture, 2001). A description of these subsidies is presented below in Table 2.

Table 2: Government subsidy schemes

Name	What it subsidizes	Percent subsidy
R.I.F.D.	Drip irrigation and fogger systems up to 1 hectare in size	Up to 80%
Ministry of New and Renewable Energy	Solar Panels for rural farmers	up to 80%
J.I.C.A. & Dr. Y. S. Parmar Kisan Swarozgar Yojna Scheme	Nursery production	Aims to subsidize 100%
R.K.V.Y.	Yearly seed supply	Approximately 50%

Combining all of the considerations with the end user in mind gave us necessary insight into the structure and features of the nursery needed for our purposes. The challenges facing the introduction of nurseries in addition to combining structure, ventilation, and insulation come together in a way that considers who will be using it.

3 Approach: Interviews and Field Tests

Three objectives were identified in order to assess the feasibility of an all-season plant nursery in Himachal Pradesh. The three primary objectives can be found below in Figure 5.

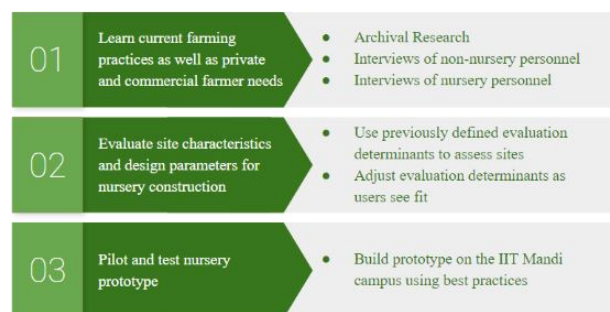


Figure 5: Outline of objectives

3.1 Objective 1: Learn Current Farming Practices as well as Private and Commercial Farmer Needs

Growing crops in Himachal Pradesh is a major source of food and income for its citizens. To learn about how both private and commercial farmers function in this economy, we conducted archival research and interviews with farmers who grow crops with and without nurseries.

We identified Government subsidies from nursery personnel and from our own research that would make building and sustaining nurseries more affordable for farmers attempting to start their own. Each of these programs work to subsidize the cost of nurseries for farmers in rural Himachal Pradesh to increase the number of nurseries in the region.

To engage directly with users of the potential nursery, we located farms in Arnehar, Kataula, and Kamand and interviewed farmers who did not use nurseries. We used an interview guide found in Appendix A. We interviewed them on the types of crops they grow each season, if they sell their crops or keep them, water and electricity availability, and any other problems that they face. The interviews were conducted in Hindi. Photographs and videos of the interviews were taken with the farmers permission for documentation purposes. We located farms in Chail and Kataula that do use nurseries and interviewed farmers and government workers using an interview guide found in Appendix B. We interviewed them on what types of crops can be grown in nurseries, the structure and size, the materials used, and internal climate control. Interviews were conducted in Hindi. Photographs and videos were taken of the nurseries with permission from the owners for documentation purposes. The group can be seen visiting a nursery in Figure 6.



Figure 6: Research in nursery practices

3.2 Objective 2: Evaluate Characteristics of Sites and Design Parameters for Nursery Construction

To further evaluate potential nursery sites and the current nurseries in Himachal Pradesh, we conducted site evaluations with documentation and observation,

as well as interviews with experts on nurseries and horticulture.

After interviewing the farmers, we visited their farmland and took photographs documenting the site conditions, being sure to capture qualities of the farms which might be useful later during the evaluation stage. We also took into consideration different areas of their farmland where a nursery might be effectively placed. We evaluated the farmland based on the amenities in Appendix C.

For greenhouse and nursery operators we followed a similar approach. We asked additional specific questions regarding the greenhouses and took pictures of the various structures for documentation purposes. Later, we evaluated the greenhouses based on the determinants in Appendix D. Photographs of farms without nurseries were taken for documentation purposes and later evaluated based on determinants in Appendix C.

Interviews with experts in related fields were conducted. We contacted Mr. Jagdish and Mr. Hidev from the medicinal plant department at the IIT. They are horticulturists who maintain the medicinal garden and labs on the IIT campus. They provided useful information regarding seasonal plant growth and best practices for farming year-round in Himachal Pradesh. We later visited the Model Floriculture Center in Chail and met with supervisor Dr. Kashop as well as a few other farmers working in an nearby floracultural reserve. This government run farm is primarily operated in greenhouses. We spoke with Dr. Kashop in order to gain practical knowledge of greenhouse operation in Himachal Pradesh. We learned some very valuable information speaking to her and the greenhouse workers here and much of it influenced our greenhouse prototype design.

3.3 Objective 3: Pilot and Test Nursery Prototype

In order to build the prototype on the IIT Mandi campus, we discussed a variety of potential build sites to evaluate. Ultimately, the site chosen was by Maple Mess Hall between two walkways. This site was chosen due to its longest access to light and close proximity to the final presentation area.

The design for the prototype was created based on the results of the research done in the first two objectives. Combining this with our previous research, we came up with a design that seemed like it would be able to address the problem. From here the next

step to begin the construction of the prototype was to acquire all the necessary components. These came from various sources, primarily online retail and accessible gardening stores in Mandi. The aluminum for the frame came from a hardware store in Mandi Town. The first step of the actual construction was to assemble the frame. The prototype is small enough that it would be possible to move the frame after being assembled. This was accomplished using the IIT machine shop tools and the aluminum beams. The next aspect of the construction was to dig a foundation. This serves two purposes, first to allow for a more solid base that would not be blown away or knocked over, and second to give a place for a GAHT system. The tubes act as a way to turn the earth beneath the nursery into a thermal battery. Next we installed the piping for this system, reburying it in the soil. The final step of construction was to place the nursery on the foundation and secure it to the ground using stakes.

In order to actually test out the prototype and see potential results, we planted various seedlings to be tended to over the next few months. We made observations and monitored the temperature and humidity. This information was to give both quantitative and qualitative analysis of how effectively the nursery is functioning. Although monitoring the growth of the plants through to harvest is not within the scope of this project it will be useful to include the plants to facilitate future observations.

4 Results

4.1 Current Farming Practices and Needs

The following section includes the results and discussion that follow our team’s methodology as outlined above.

4.2 Design Parameters and Site Characteristics for Nursery Construction

We interviewed 11 farmers who grew crops without the use of nurseries and operated in a range of elevations. Without the use of nurseries, both private and commercial farmers are limited to growing a relatively small range of crops. The most common

crops’ sowing and harvesting patterns can be found below in Figure 7.

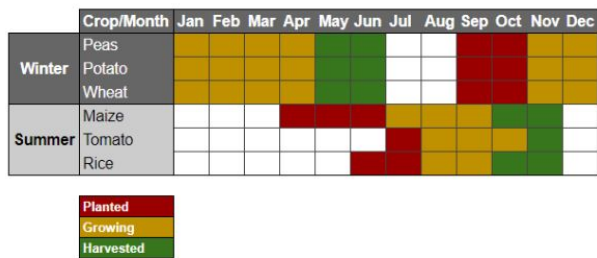


Figure 7: Crop sowing and harvesting seasons

Our initial intent was to interview farmers and record specific needs they might have based on challenges they commonly face. However, we found that interviewing them on their challenges was a more effective approach as many of them did not see any issue with the way they farm or did not have sufficient knowledge of alternative farming methods such as nurseries. In terms of challenges faced, most farmers that we interviewed noted that due to lack of water, as well as the destruction of crops from monkeys, they can only grow wheat and maize. Monkeys will not eat wheat and maize because they prefer to eat softer crops like fruits and vegetables. Farmers who faced crop destruction from monkeys were forced to travel into town to buy produce. Some farmers also expressed a desire for a reliable water collection system for irrigation because many used rainwater as their main source of water for irrigation.

To learn about commercial practices, we interviewed nursery and greenhouse personnel and identified how greenhouses are operated and maintained. We also learned about nuances in the greenhouse structure and function. In Chail, we visited a government-run floriculture center as well as a farmer owned flower nursery. We also visited a farmer owned nursery in Kataula who built his nursery using government subsidy.

Each site had its own technique for maintaining temperature and humidity. At the Model Floriculture Center in Chail, the workers manually opened the vents at 9:00 am in the summer and at 11:00 am in the winter while the vents were closed at 5:00 pm each season. The Floriculture Center also used thermometers and barometers to measure temperature and humidity respectively. For extra ventilation, a nursery made from hard sheet polycarbonate in the Floriculture Center used a honeycombed cardboard structure on one wall so that when wet, cool air was

drawn in and hot air was pushed out. At other sites, such as Chail village and Kataula, workers used their own intuition and experience of the internal conditions when deciding to use the vents and the foggers, which can be seen below in figure 8.



Figure 8: Foggers installed in a greenhouse

We asked workers about the price of different types of nurseries as well as the materials and temperature control methods nurseries use. Dr. Kashop from the Floriculture Center informed us that standard peak structures have a higher construction cost compared to arched structures. Comparatively, with a common size of 250 square meters, standard peak structures cost around 800,000 INR to build while the arched structures only cost around 400,000 INR. We also learned that twin wall polycarbonate is more expensive per unit than polycarbonate film but did not need to be replaced. Conversely the film needed to be replaced every 5 years due to inevitable physical wear

4.3 Design Parameters and Site Characteristics for Nursery Construction

We conducted site assessments to learn how nursery structure and design responds to local conditions. The Model Floriculture Center and nurseries we visited followed two types of structures: standard peak and arched. Each nursery used side and roof vents made from mesh screen. Active ventilation was not used at any of the locations we visited. Both polycarbonate film and twin wall polycarbonate were used as a cladding material but polycarbonate film was used in all but one of the nurseries seen. Every nursery

also used foggers to maintain the internal humidity. Table 2 below shows basic amenities shared by the nurseries we visited.

Table 3: Nursery site evaluations

Amenity	Findings from evaluation
Lighting	Naturally lit
Type of ventilation	Passive: side and roof ventilation
Insulation	None (besides polycarbonate sheets)
Maintainability	<i>Polycarbonate film</i> : needs to be replaced every few years due to natural degradation and destruction from monkeys <i>Hard polycarbonate sheet</i> : can go more than 8 years before being replaced
Irrigation system	Drip irrigation
Internal temperature regulation	Passive, manually regulated
Microclimate regulation	Manually regulated
Structure Shape	Arched

Although these features were adapted from features of nurseries found in research, construction, we found these amenities to be successful in each of the nurseries we visited. As such, we implemented a mix of both into our design of the nursery.

In our site evaluations we considered aspects of the local terrain that could challenge the design, or limit building and maintaining a nursery in that area. Some of these key site parameters included physical accessibility, water, electricity, and crop use. These characteristics are presented per village in below in Table 4.

Table 4: Farmland evaluation by town

	Arnehar	Shegli	Kataula
Village accessibility by vehicle	Very difficult	Very difficult	Easy Access
Water availability	Water delivered with difficulty	Water delivered with difficulty	Locally sourced by river
Electricity availability	Available	Available	Not available outside of main village
Crop usage	Personal consumption only	Most for personal consumption, some for profit	Plenty of crops for profit

Accessibility for each village was included as a measure of how easily materials and goods can enter and leave the village. Factors such as terrain and exposure to sunlight were not included in the table. They were not included because any place where crops are able to be grown then it can be assumed the terrain and sunlight are sufficient for the placement of a nursery. Ultimately, there was little to no variation in farmland characteristics with only some variation in village characteristics which include accessibility by vehicle as well as water availability.

What we did find while interviewing farmers, was an association between elevation and accessibility to water for growing crops. Farmers at higher altitudes were limited by the water they could pump up to their villages. Most collected rainwater to supplement the water they used to irrigate their crops or they exclusively used rainwater to water their crops because they did not have enough water to spare between their daily use. Only wheat and maize was grown in these villages as they do not require as much water as vegetables and cash crops. The high elevation farmers were more interested in water collection than obtaining a nursery. They seemed interested in the prospect of a nursery if a water collection system was added, making it self-irrigating. Farmers at lower elevations had little problem with irrigation water but they were prevented from growing crops that require large amounts of water because of monkeys. Monkeys like to pick at and eat soft foods, like fruits and vegetables, so farmers were reduced to growing only hard

crops like cereals. These farmers were interested in nurseries as they could grow vegetables without fear of monkeys destroying them.

4.4 Piloting and Testing an Improved Nursery Prototype

After taking the results of the prior two objectives into account we modeled the structure of the prototype using CAD software, as show below in Figure 9.

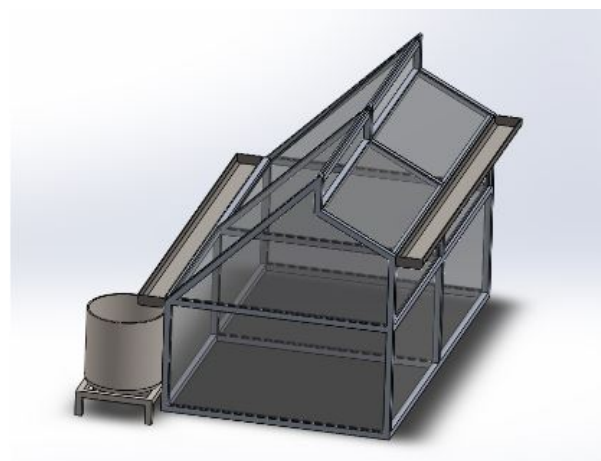


Figure 9: Nursery prototype model using CAD software

This design was based on the research into similar projects, such as Robert Fuller and Alex Zand's paper Solar Greenhouse Technology for Food Security, published in 2012 and conducted in Northwest Nepal. We added amenities to address the challenges described by our stakeholders. The key features are highlighted below in Table 5.

Table 5: Key Features

Nursery Feature	Solution
Ventilation	Roof vents, exhaust fans
Heating	Thermal mass, solar insulation
Structure	Standard peak
Irrigation system	Gravity fed drip irrigation
Water collection	Gutters, water storage tank

We built the prototype frame out of aluminum in a standard peak shape. The prototype contains two separate sections divided by twin wall polycarbonate. One section is clad with twin wall polycarbonate and one partially covered with polycarbonate film to allow access to the inside of the nursery. Having two differently clad sections was done to compare their insulating properties with each other. The final prototype can be seen below in Figure 10.



Figure 10: Final Prototype of Nursery

5 Discussion

Nurseries have been used very successfully in the region to both expand and diversify crop yield. Farmers who used nurseries were able to grow for both personal use and profit. Some farmers even produced enough so they did not have the need to buy produce from other farms. This success was very encouraging for our study as it validates the hypothesis that nurseries positively impact farmers in Himachal Pradesh. Unfortunately, the farmers who would benefit most from this project were also those who were least likely to install a nursery. We found during our interviews that poorer and less accessible farms grew fewer types of crops and for a shorter season. An improved nursery could potentially solve these issues, but we found several reasons these farmers were not using them. The most important factor was the up-front cost of construction and materials. Most farmers were not aware of the subsidies available to them. Even with government subsidy the money spent building the nursery is not refunded until sometime after the construction has been completed. The second reason was that farmers with no experience in greenhouses were unsure if they would make returns from the investment. The final factor that kept farmers from using a greenhouse-style nursery was that they felt they would not have enough water to supply the needs of the plants. The farmers felt this way because they used government water on tap for daily use but collected rainwater for their crops. Rain water is scarce

during certain seasons so some farmers believed that they did not have enough water to grow crops other than wheat and maize.

There are government schemes for nursery subsidies, but these must be applied to separately. Since there are many different subsidies to apply for, this may cause some confusion amongst the farmers about the application process. However, each application is separate, meaning that if one application is rejected there are others that farmers can apply to. The applications can be found on the website listed in Recommendations.

6 Project Outcomes

To promote and expand farming in Himachal Pradesh, we propose two recommendations that will make the use of improved plant nurseries feasible for interested growers.



Figure 11: Abhay digging the foundation for the nursery prototype

First, a nursery designed for conditions found in Himachal Pradesh should be improved with important amenities. Based on the farmers' need for more water for crops, gutters and a small water tank should be added to assist in self-sufficiency and water collection. Farmers at higher altitudes primarily use rainwater to water their crops, so a system for harvesting rainwater would assist farmers in obtaining water for their crops. The gutters would run water to the storage tank, which will sit on a small table that folds out of the main structure. A valve connecting the tank to a hose runs into the structure. When the plants need to be watered, turning a valve would open the pipe up into a drip irrigation system. This water collection system would allow the design to be viable in more locations including those where water is scarce. Additionally, the design would use an

aluminum frame, which is light and allows the structure to be moved around easily if need be. Hinges and pins as opposed to fixed corners would be used so the nursery can be folded to help ease the stress of transportation.

We also propose a trial period for farmers who cannot afford to pay out of pocket immediately or for farmers who wish to learn more about how a nursery works before investing. During an interview, Parwata and Disha, two women in Kataula, said that they did not know how to properly use a nursery to justify the purchase. Jogender Singh, a man from Arnehar Village, told us he did not have enough money to afford a nursery. To address these problems we created a table outlining issues expressed by farmers and our proposed solution to their problem which can be seen on the next page in Figure 12.

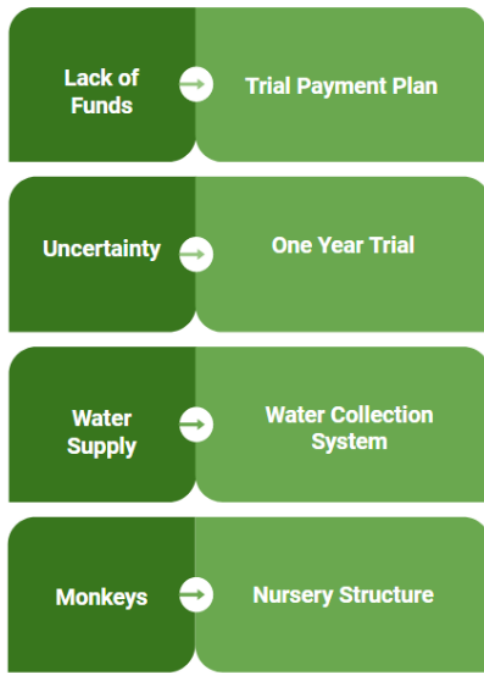


Figure 12: Summary of farmer concerns and ways to address them

Farmers participating in the program would receive a physical nursery on trial for one year. After the year is over, the farmers determine if a nursery is worth the investment. If the farmers decide they want to keep the nursery, they pay off the price as they continue to use it. On the other hand, if farmers decide they do not want to keep the nursery, it would be returned and loaned to another farmer. For larger farms it would also be possible to purchase more nurseries but they would be responsible for covering the upfront cost of additional systems.

This solution addresses the issues faced by the farmers who are not already using nurseries and attempts to overcome them. There will not be an upfront cost for the farmers because it will be covered by a sponsoring organization. This will also cover the issues of the wait time for subsidies. If after the year that a farmer is given to use a nursery they are interested in keeping it, the profits from the increased production provided by the nursery would cover the payments. Since the farmer would be making payments on the subsidy-reduced cost it will not take very long for this project to be paid off. This also helps farmers who are afraid of the commitment to a nursery due to lack of knowledge. This proposal would give farmers a comfortable way to assess if this would be a good fit for their needs.

We recommend that the prototype be put through a year of rigorous testing, during which a wide variety of crops are tested and shown to be viable under most conditions. Throughout this trial year, farmers can visit the prototype model to learn more about how to use the improved nursery.

7 Conclusion

Farmers in Himachal Pradesh, India, face difficult growing conditions, and in turn deal with lack of crop variation and short growing seasons. This problem manifests in unsustainable local practices and farmers needing to import other produce to supplement their diet. The goal of our improved plant nursery was to assist in off-season plant growth, add variation to crop growth, and support food security in rural regions. This project could introduce a relatively simple technology to address what we have identified to be the primary problems these farmers are facing. It also aims to preserve the local knowledge of farming and food production in a world which is becoming more urbanized.

From our interviews, we have seen that farmers are more accepting of nurseries if there are no upfront costs, and if there are added benefits such as water harvesting and prevention of crop destruction from monkeys. In fact, while the climate presented some difficulties to the farmers, water deprivation and monkeys were a bigger issue than originally thought. Those without nurseries expressed concern about the limited supply of irrigation water and about monkeys stealing any vegetables they might decide to grow. The concept of a portable nursery loan system will allow a non-committal learning experience with nurseries to Himachal Pradesh.

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8 Supplemental Materials

Appendices

Appendix A: Local farmer questionnaire

Quantitative Questions:

- What plants do you grow? (Summer, Winter, Cash Crops)
- What plants are grown during the different seasons?
- How much of each crop is produced each season?
- Are the plants you grow for private or commercial use?
- Do you use fertilizer? If so, what kind?
- What are the best conditions to grow each kind of crop?
- How do you obtain water for your crops?
- What crops do you eat during the different seasons?
- How big is your village? (Size, Population)

Qualitative Questions:

- Would you use a greenhouse that extends the growing season?
- Would you use a greenhouse that increases crop production?
- Is obtaining water a problem for you?
- Is obtaining miscellaneous materials / building materials difficult for your village?
- Do you have access to electricity?
 - How much/little?
 - Is consistent electricity during the winter a problem?
- What would you pay for a greenhouse that extends the growing season and increases crop yields?
- How much of your crop output would you want the greenhouse to provide?
- Would you want a water collection system?
- What types of plants would you grow in a greenhouse?
- How would you modify the greenhouse to suit your needs?

Appendix B: Nursery personnel questionnaire

Quantitative Questions:

- What plants do you grow? (Classify them as summer and winter plants)
- Who are the end users of the production from the greenhouse?
- What are the dimensions of the greenhouse?
- How many people work in the greenhouse throughout the year?
- What is the construction cost of the greenhouse?
- What is the maintenance cost of the greenhouse? (divide on the basis of cost of electricity, heating mechs, etc)
- Would you like to have automation in your greenhouse?
- Do you use any system for monitoring the various factors like temperature, humidity etc?
- What are the Ideal conditions (temperature, humidity etc) to grow a particular type of crop? (We'll ask about the crops they grow and classify them on the basis of summer and winter plants).
- How many summer plants survive in winter and vice versa?

Qualitative Questions:

- What is the material used to make greenhouse? Why?
- What is the structure made up of? Why?
- How is the greenhouse heated?
- Do you use any methods to store heat? If yes, why in particular those?
- What ventilation methods do you use to avoid overheating? Why?
- Do you use any artificial lightning in greenhouse? If yes, how often?
- What irrigation methods do you use and why?
- Do you face any problems or challenges with your greenhouse?
- Are there any innovative or unique technologies used in your greenhouse?

Appendix C: Farmland evaluation

Evaluation Determinant	Criteria	Evaluation
Accessibility	How physically accessible is the farm? difficulty of shipping material	
Water availability	Locally Sourced? Rainfall? Delivered? Lifted?	
Electricity availability	How easily accessible is electricity? Available for surplus energy usage? Is it used in any farming practices?	
Seasonal temperature variation	Are temperature fluctuations an issue for the crops? Any techniques used currently to buffer night and day temperature fluctuations? Different during other seasons?	
Local airflow conditions	Is there significant wind throughout the year? In monsoon season Any particular need for shielding from high winds or for improving ventilation?	
Population	How many individuals rely on your crop? What amount of your crop is for personal consumption?	
Approximate size	Are the buildings developed? What is the number of buildings?	

Appendix D: Nursery evaluation

Evaluation Determinant	Criteria	Evaluation
Lighting	How is the nursery lit? Do they have supplemental lights? Do they use natural light?	
Quality of ventilation	What types of ventilation do they use? Is the ventilation they use active or passive?	
Insulation	Does the nursery use insulation? What type of insulation does the nursery use?	
Maintainability	Is the nursery cheap to maintain? Is the nursery easily maintained? Does the nursery need to be repaired often?	
Irrigation system/ water collection	How does the nursery water their plants? Does the nursery collect and store water? If so, how?	
Energy supply	What type of energy is used to power the nursery?	
Water drainage	Can the water the plants don't use be drained away? Is the drainage active or passive?	
Internal temperature regulation	How is the internal temperature regulated? Is it active or passive?	
Microclimate regulation	How are conditions like humidity, temperature, and ventilation regulated? Automated? Manual?	

Appendix E: Crop Growth Map

X = Sown

O = Harvested

1 = Time between Sowing and Harvesting

Month/Crop					
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					


Appendix F: Nursery Questionnaire Answers

Interview Location	Location Interview/Interviewee	Date of Interview	Questionnaire Used	Question ID	Response(s)
Botanical Garden	Jagdish & Barden?	March 22	Farmer	1	Sale - wheat, potato, corn, peas; Self - wheat, potato, mustard, lucine, swapnut, cotton tree
				2	Summer - lucine, cottontree, swapnut; Winter - wheat, mustard, peas
				3	They use cow dung because they think using fertilizer makes the vegetables taste bad
				5	They use rainwater to water all of their plants, HP gets a lot of rain relative to other states
				10 & 11	They would only be interested if it guaranteed increased yield
				14	They do not have access to electricity
				6	they would pay 1 lakh (100,000) rupees for a 3 hectare nursery
				18	they don't know anything about growing mushrooms
				20	They don't collect rainwater because they would have to take away from the space to grow crops
				Chall	Dr. Kashop
2	end users are the Government				
3	Each greenhouse is different, usually between 120-225 m ²				
4	8 people work through the year				
5	For 125m ² greenhouse - 5 lakh for a 225m ² greenhouse - 9 lakh (Maintenance is included in these prices)				
6	1-4 Lakh, polycarbonate sheets are replaced every 3-4 years. Double layer polycarbonate can go +8 years before being replaced.				
7	They don't need automation				
8	Humidity control is manual but they have sprinklers to make it humid only 1 summer plant in winter survived from 10				
10					
11	NA				
12	NA				
13	No				
14	They already maintain their greenhouse, they did not receive subsidies because they are gov't run				
15	Polycarbonate sheet (250 microns), shade net (outside), water net (inside) or double layer polycarbonate.				
16	Steel				
17	Heated using the sun and by lighting fires or coals on the inside				
18	They do not have any active (electrical) methods or passive methods other than the polycarbonate they use passive ventilation. Both side and top vents, they open them in the morning and close them at night, this prevents overheating and too much heat loss. They also use shades to prevent too high of a temp.				
19	they do not use artificial lighting				
20	they do not use artificial lighting				
21	they use sprinklers to water and keep the humidity as well as drip irrigation for the main source of water				
22	the monkeys rip holes in the polycarbonate sheets during the summer				
23	they do not place greenhouses next to each other because the snow will rip them, they use fly traps as well as pesticides, they have a pool of water to use as irrigation, use a 'cooler for cooling summer plants. Only 15-25 plants can be put ever m ² because if there are too many then there is too much carbon dioxide.				
Chall	Farmers who build their greenhouse	March 29	Nursery Personnel	1	They grow carnations
				2	People buying carnations all over asia
				3	around 225 m ²
				4	NA
				5	NA
				6	They use passive heating methods and cooling methods
				7	No they don't need automation
				8	Everything is monitored manually
				9	NA
				10	They grow carnations year round
				11	NA
				12	NA
				13	No
				14	They maintain themselves and got the subsidy
				15	White tarps
				16	Steel
				17	By the sun
				18	None
				19	Side and Top ventilation
				20	No
				21	They use drip irrigation
Arnehar Village	Jogender Singh	Mar 31	Farmer	1	Wheat and Maize
				2	Summer - Maize Winter - Wheat
				4	Private they don't sell
				6	No Data
				7	They collect rainwater
				8	Wheat during summer maize during winter, they get vegetables from kataula 2x weekly
				9	20-25 homes 100-150 people
				10	He wouldn't because he needs more water first
				11	He wouldn't because he needs more water first
				12	Yes for crop growth it is
				13	Everything needs to be shipped up the mountain
				14	They have electricity it is not a problem
15	He doesn't know enough about nurseries to pay for one				
16	N/A				
20	Yes he would pay for a greenhouse if it had water collection				
22	he would want a water collection system for irrigation				
				1	Rice and wheat

All-Season Plant Nursery to Increase Food Security


Kataula Village	Mina	Mar 31	Farmer	2	rice - rainy wheat - winter
				4	they do not produce enough to sell anything
				5	they use cow dung as fertilizer
				7	They use river water for crops
				13	Water is not a problem monkeys are
				14	They do not have electricity on the farm side of the river
				15	they would pay 1 lakh for a 4x10 m nursery (15-30 k w/ subsidies)
				16	N/A
				19	they would not need a water collection system
				21	they would grow vegetables to because it would be protected from monkeys
Kataula Village	Prakash and Proresh	Mar 31	Nursery Personnel	1	Tomato, broccoli, cucumber, radish, carrot (all year) pepper (march-april)
				2	They are (owners)
				5	1.87 lakh
				7	No they would rather just manually control it
				8	They go into the nursery and use their judgement. They use foggers for humidity control
				12	Polycarbonate sheets and netting over the vents
				13	steel and aluminum
				14	It is heated using sunlight and insulation properties of the cladding
				15	No they dont
				16	they use top and side vent (passive ventilation)
Kataula Village	Prakash	Apr 1	Farmer	1	Potato, plum, apple, pomegranate, lemon, garlic, tomato and wheat
				2	winter - wheat and potato summer - garlic, plum, lemon, pomegranate, apple, tomato
				3	In terms of profit per season - (capsicum - 30k Rps); (Potatoes - 100k Rps); (tomatoes - 70k Rps)
				4	they grow vegetables to sell
				5	No data
				7	they have drip irrigation from the river
				8	Eat summer crops in winter and winter crops in summer
				9	no data
				10	They use one
				11	They do
Kataula Village	Parwata & Disha	Apr 1	Farmer	1	Peas, Tomato, potato, wheat, garlic, ladyfinger, radish
				2	winter - lady finger, radish, wheat
				4	they dont sell any plants because they don't produce enough
				5	they use cow dung as fertilizer
				7	through a pump attached to a waterfall
				10	they would use one if the Gov't paid
				11	they would use one if the Gov't paid
				12	No they live by the river and have water pumps
				14	yes they do have electricity
				15	she doesn't know enough about nurseries to invest in one

Appendix G: Project Poster



Worcester Polytechnic Institute
1865

All-Season Plant Nursery




Indian Institute of Technology Mandi

Abhay Chauhan, Benjamin Shaffer, Grace Gerhardt,
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Abstract

In the largely agrarian north Indian state of Himachal Pradesh pests, temperature variation, weather conditions and climate change are critical factors affecting the livelihoods of farmers and villagers. The rapidly changing environment is damaging crop production and food security in this region, in turn drives residents to more urbanized areas to find reliable work. Our team studied the feasibility of an all-season plant nursery to help improve growing conditions and expand opportunities for personal or commercial farming in Himachal Pradesh. Using interview and fieldwork data we designed and built a plant nursery prototype and proposed a nursery trial system with the intent of preserving the livelihoods and culture that sustain this region of India.



Goal

The goal of our project is to assess the need for an all-season plant nursery which would add variation in crop growth and support food security in rural areas of Himachal Pradesh.

01	Learn current farming practices as well as private and commercial farmer needs	<ul style="list-style-type: none"> Archival Research Interviews of non-nursery personnel Interviews of nursery personnel
02	Evaluate site characteristics and design parameters for nursery construction	<ul style="list-style-type: none"> Use previously defined evaluation determinants to assess sites Adjust evaluation determinants as users see fit
03	Pilot and test nursery prototype	<ul style="list-style-type: none"> Build prototype on the IIT Mandi campus using best practices

Results

Difficult Climate

+

Monkeys

+

Water Deprivation

Current Farming Challenges

Government Subsidies Available

Name	What it subsidizes	Percent Subsidy
R.I.F.D.	Drip irrigation and fogger systems up to 1 hectare in size	Up to 80%
Ministry of New and Renewable Energy	Solar panels for rural farmers	50-70%
J.I.C.A. & Dr. Y. S. Parmar Kisan Swarozgar Yojna Scheme	Nursery production	Aims to subsidize 100%
R.K.V.Y.	Yearly seed supply	Approximately 50%

Recommendations

Lack of Funds
→
Trial Payment Plan

Uncertainty
→
One Year Trial

Water Supply
→
Water Collection System

Monkeys
→
Nursery Structure

Appendix H: Supplementary Photographs



Visiting the Model Floriculture Center in Chail

GENERAL FLORICULTURE SCENARIO HIMACHAL PRADESH		
1	TOTAL CULTIVABLE AREA	6.08 Lac Ha.
2	PER CAPITA CULTIVABLE AREA	0.10 Ha.
3	TOTAL IRRIGATED AREA	1,02,617 Ha.
4	PERCENTAGE OF IRRIGATED AREA TO TOTAL CULTIVABLE AREA	16.68%
5	AREA UNDER FLORICULTURE CROPS (2010-11)	812.90 Ha.
6	ESTIMATED PRODUCTION OF FLOWER SPIKES (2010-11)	13.78 Crore Nos.
7	ESTIMATED PRODUCTION OF LOOSE FLOWERS (2010-11)	35561.00 MT
8	ESTIMATED GROSS VALUE OF FLORICULTURE CROPS (2010-11)	Rs. 77.26 Crores
9	ESTIMATED NUMBER OF FLOWER GROWERS (2010-11)	3000 Nos.
10	REGISTERED FLORICULTURE SOCIETIES/FEDERATIONS (2010-11)	48 Nos.

Information regarding floriculture in Himachal Pradesh



Farmer owned floricultural greenhouse in Chail



Underground heating system in the nursery prototype