

Developing a Proposal for a Landrace Seed Bank in the Mandi District



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degree of Bachelor of Science

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Abstract


The goal of our project was to assess agriculture in the Mandi district and develop a proposal for a landrace seed bank. These landrace varieties are specially adapted to the region, and could be used to grow crops resistant to the many challenges of climate change such as heat and drought. The seeds could also provide nutritious food for the local farmers, and protect their crops from blight. To achieve the goal our team surveyed several farming communities with a focus on local perception and usage of landrace and commercial seeds, local seed storage techniques, and farmer interest in a seed bank. The surveys supported the need for a local landrace seed bank that can act as a repository for potentially endangered crop varieties, and provide landrace seeds to local farmers. The team proposed a model seed bank to be established at IIT Mandi. To assist in the operation of the seed bank and educate farmers on effective agricultural practices we created an App and website.

Poster and Executive Summary



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Problem

Goal

The goal of this project is to recommend a plan for a landrace seedbank by learning about seed usage and storage techniques in the Mandi district.

Abstract

To achieve this goal our team surveyed several farming communities with a focus on local perception and usage of landrace and commercial seeds, local seed storage techniques, and farmer interest in a seed bank. The surveys supported the need for a local landrace seed bank that can act as a repository for conservation of rare crop varieties as well as cater to the farmers with common seed varieties that are endemic to the region. The team proposed a model seed bank to be established at IIT Mandi. To assist in the operation of the seed bank we created an App and website to help run the seed bank and educate the farmers. We suggest future work be undertaken in the direction of establishing nutritional quality differences between seed varieties.

Protecting Genetic Biodiversity

- Preserve landrace seeds for future generations

Food Security


- Ensures protection against disaster

Future Seed Cross-Breeding

- New crop varieties to tackle future challenges

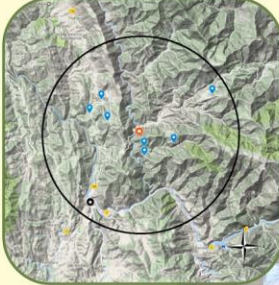
National Identity

- Landrace seeds are an important part of India's agricultural heritage





Methodology & Results

Farmer Interviews



36 surveys
7 villages





A Need to Help Local Farmers

- 75% of farmers claimed they suffered from a lack of agricultural knowledge
- 77% of farmers perceived landrace seeds to be more nutritious

Improper Storage

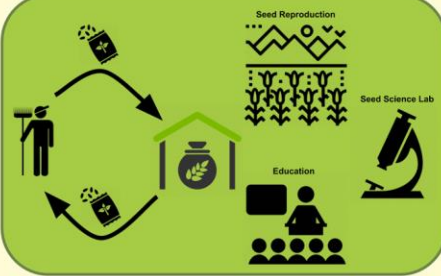
Misuse of Fertilizer

Endangered Crop Varieties

Uninformed Choices

Seed Bank Plan


Seed in and out



Future Outcomes

- Establish a landrace seed bank at IIT
- Educate farmers of proper agricultural practices
- Increase landrace awareness
- Promote community engagement
- Create a model for future seed banks across Himachal Pradesh

**Android App:
An Assistive Tool for Seed Bank Operation**



Features

- Calendar of Educational Events
- Seed stock
- Database of domestic seeds
- Farmer data

1. Introduction

The people of the Mandi district rely heavily on agriculture to support their families and economy. Crop varieties and practices being used are unknown to outsiders of the farming community, because of a lack of documented information. This has allowed many of the farmers' problems to go unnoticed, as well as prevent the exchange of valuable agricultural knowledge, warnings of possible threats and new opportunities.

The current **gap in farmers' agricultural knowledge** is more of concern now than ever, as they face the increasing effects of climate change. A changing climate will make things even more difficult for the farmers of the Mandi district who rely predominantly on rain for irrigation. It is estimated that between the year 2010 and 2039 **crop yields** across the globe will **decline between 4.5 and 9%** (Guiteras, 2007). With rising temperatures, unpredictable rainfall and more natural disasters, the threat of crop failure and seed extinctions becomes ever more prevalent.

Landrace varieties are rich with genetic diversity that could help to protect the global food supply from natural disasters. The seeds could be used to create **new crop varieties**. This would be vital if a **blight or change in climatic conditions** wiped out another popular crop. An example of this was the corn blight of 1970 in the United States where 15% of the crops were wiped out (Muir, 2011). If this were to happen to an agriculturally based economy, like India, the results could be **catastrophic**. As climates change, these landrace varieties could also be crossed with other varieties to make crops that are **adaptable** to a region as well as higher producing. Having access to genetic diversity could be imperative for protecting the world's food supply.

With this in mind, we first determined that agriculture in the Mandi district had to be investigated and documented. We focused specifically on the enigmatic use of landrace and hybrid seeds. Landrace varieties are indigenous seeds that are commonly adapted to the specific agro-climatic conditions of their region. To learn more about these seeds we explored seed usage, seed storage and farmer perception of seeds.

Soon after beginning our investigation of landrace and hybrid seed usage we identified that 75% of farmers struggles with a lack of agricultural knowledge. Some of the most common outcomes from this lack of knowledge were poor storage of seeds, misuse of fertilizers, inadequate choice of seeds, and a lack of awareness of disappearing landrace seed varieties.

After gaining a better understanding of agriculture in the Mandi district and gauging farmers' interest, we concluded that **establishing a landrace seed bank** would be beneficial to farmers. The goal of this project is to create a proposal for a landrace seed bank by learning about seed usage and storage techniques in the Mandi district. This seed bank would allow farmers to exchange and store seeds for little to no cost. It would also provide educational services to the farmers to expand their knowledge about the seeds they are using and how to store them properly.

2. Background

Preserving crop diversity is of extreme importance to people around the world. Crop diversity ensures crop health and food security. Population and industrial growth threatens the genetic diversity of crops as farmers turn to generic seeds and lose the ability and interest to preserve crops specific to their region (Alcazar, 2005). Grains, fruits and vegetables are indispensable food sources for people around the world, especially those in developing countries. A key solution to the loss of genetic diversity is the establishment of seed banks. Seed banks vary in type but all serve the purpose of storing seeds in an attempt to protect genetic diversity.

India remains an agriculturally based country despite the strain of increased urbanization. Indian farmers cultivate a large variety of crops which ultimately produces a rich array of landrace seed. These landraces are unique to each agro-climatic region, as they have adapted to each area's growing conditions (Pandey, Bisht, Bhat, Mehta, 2011). The introduction of genetically modified crops in the 1990's, by commercial seed companies, has begun to threaten these landrace seeds and, therefore, crop diversity (Shiva, Emani, Jafri, 1999). Along with these genetically modified crops the dangers of climate change, natural disaster and drought have been a cause for concern. Seed banks have started to appear in regions around the country. These seed banks have been created by local governments and nonprofit organizations that are invested in protecting seed sovereignty and biodiversity. The non-profit organizations are operated by "seed guardians" who establish and maintain the seed banks (Vachharajani, 2016).

The district of Mandi, located in the state of Himachal Pradesh in the heart of the Himalayas, is heavily dependent on agriculture (Gov. of India). Consisting of mostly small landholding farmers, the district has a multitude of landrace seeds that have been passed down from generation to generation. These seeds are especially important to the farmers because they are adapted to the unique growing conditions presented by varying climates. With little irrigation technology, the farmers of Mandi are extremely dependent on rainfall. Nearly 70% of the water for agriculture comes from monsoons. If the monsoon season does not provide ample water than the crops will suffer (Jreat, 2004). Between this, natural disaster and the possible threat of commercial seeds, the protection of crop diversity has become a rising issue.

Currently, Mandi does not seem to have a seed bank. The possibility of losing unique landrace seeds is of great concern. Therefore, the goal of this project is to research the feasibility of establishing a seed bank in the Mandi District. A seed bank would allow farmers to store and exchange their seeds while also providing a source of seeds that are protected from threats of drought, climate change, natural disaster and commercial seeds.

3. Methodology

In order to accomplish our goal, we created 5 different objectives to guide us:

1. Explore the extent of usage of landrace and hybrid seeds
2. Identify local seed storage techniques used by small scale farmers
3. Study farmers' awareness and perception of landrace and hybrid seeds
4. Investigate pros and cons of landrace and hybrid seeds
5. Develop a plan for a local landrace seed bank

To accomplish these objectives, we conducted surveys with farmers from **7 villages** (Dwardu, Taryambali, Neri, Tihiri, Doohaki, Drang, Namlay) in the Mandi district. These villages (blue markers in Figure 1) were chosen within a **10 km distance** from IIT (orange home icon) since, we determined farmers would not be interested if they had to travel further than the nearest seed distributors in Mandi. We then chose villages at **low, middle, and high altitudes** to account for different climates and crops. Along with these villages, we interviewed officials at the Agricultural Department in Mandi (black star marker).

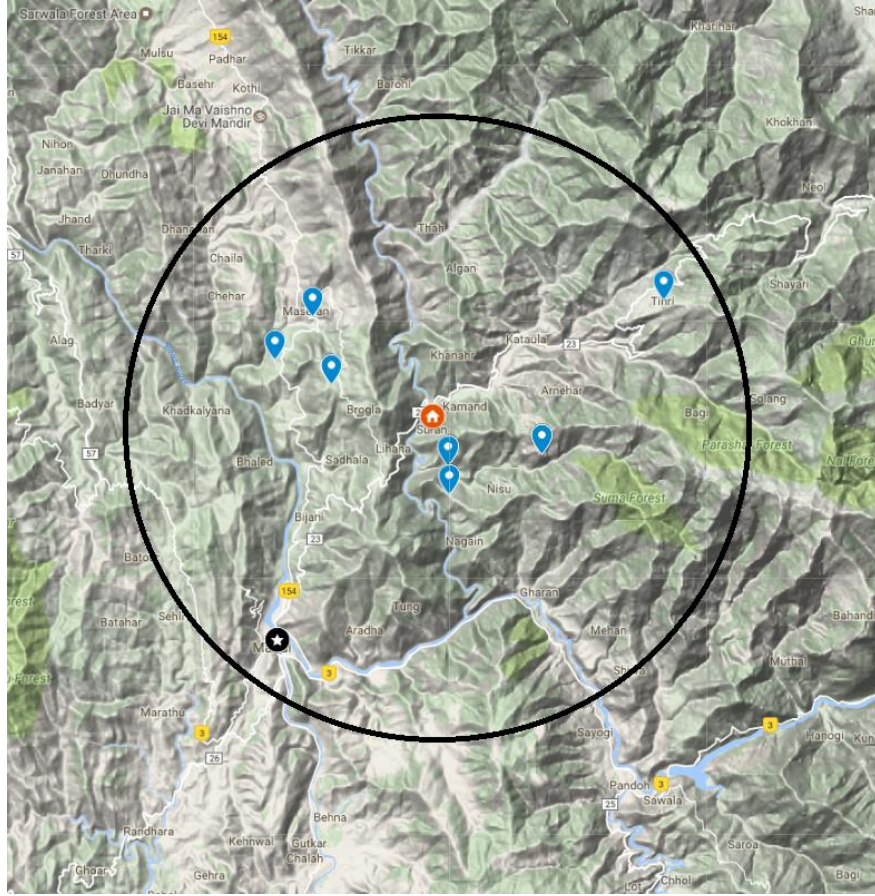


Figure 1: Map Showing Farmer Survey Locations

In these surveys, we focused on crop production, usage and opinions of hybrid and landrace seeds, expenditures, storage techniques, and farmers' interest in a landrace seed bank. To record this data, surveys were conducted by our IIT group members and translated for us to record. Over the course of this project we created three different iterations of our surveys to make them more concise and relevant. (Available in Appendix A)

Our surveys did not identify major differences between landrace and hybrid seeds, so, we conducted a preliminary nutrient test. In this test we looked at the nutrient content of different landrace and hybrid seeds. By conducting this test we wanted to learn whether one of the varieties is nutritionally superior to the other.

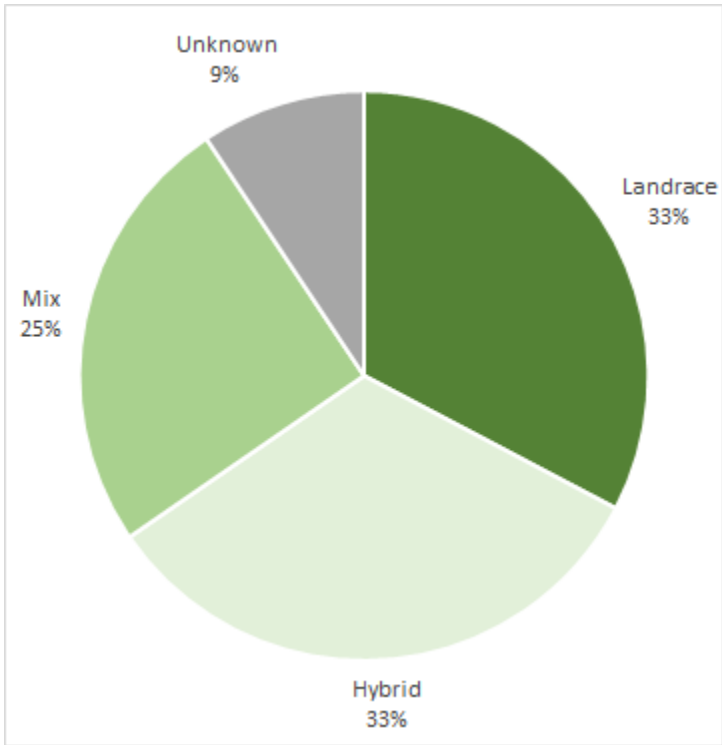
4. Results

The following sections focus on the most relevant and conclusive data found from the local farmer interviews. Each section focuses on how we accomplished each objective, as well as the concluding data.

4.1 Farmers use Landrace and Hybrid Seeds Equally

To come to a better understanding of agriculture in the Mandi district we **surveyed** the farmers' **extent and usage** of landrace and hybrid seeds to determine why they were using each variety. The data below offers the results of these surveys.

Figure 2, shown below, shows the overall split between landrace and hybrid seeds used by the farmers. As you can see, there is an **even split between landrace and hybrid** seeds in the



Mandi district. In figure 2, the slice labeled “Mix” indicates percentage of farmers who use a combination of landrace and hybrid seeds: most commonly half landrace and half hybrid in one plot.

Figure 2: Seed Split by Type

Figure 3, shown below, shows all crops that are commonly grown in the Mandi district (Not including *arbi*, *kodra*, lady finger, *matar*, pea, and radish due to small sample size), and shows the split between landrace and hybrid.

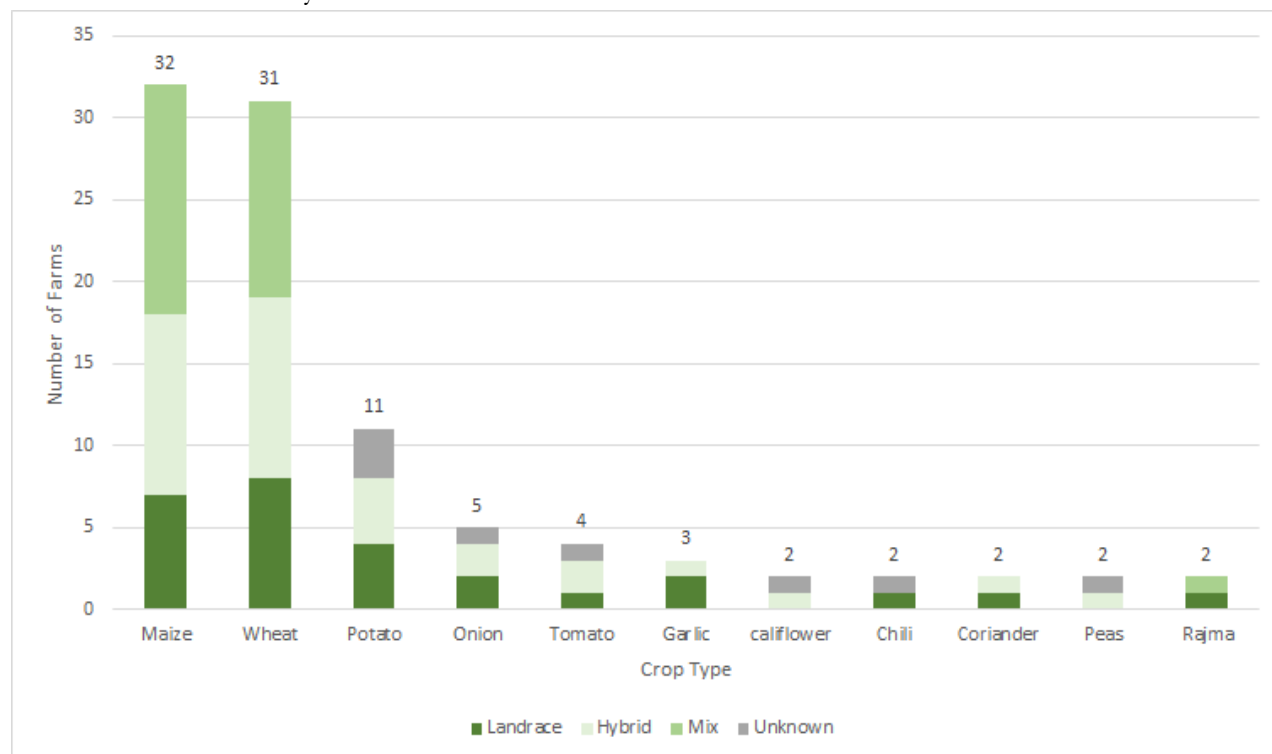


Figure 3: Prevalence of Crops on Farms, with Landrace Hybrid Split

Less common crops are usually landrace, with **48% landrace, 27% hybrid, 3% mix, and 21% unknown**, for crops with **five or fewer instances** of use. These crops are also commonly grown in a **smaller areas**, averaging at 1.6 *bighas* (one *bigha* equals one quarter of an acre) or smaller, compared to the overall average of 3.5 *bighas*.

As you can see in figure 3, **maize and wheat** are the most commonly grown, found in almost **100% of farms**. They also account for the most seeds and largest areas. As major crops of the area their split between landrace and hybrid is important.

The following is breakdown of how farmers use maize and wheat. **49% of maize is eaten, 48% sold**, and 3% used for animal feed. 87% of wheat is eaten, and 13% sold. 100% of all landrace crops were used solely for home consumption. It is important to note that **farms that sold crops are significantly larger**. The median size of a farm that sold crops is 9.9 *bighas*, while the median size of a farm that doesn't sell crop is 5.1 *bighas*. Compare this to the 1.6 *bigha* average of less common landrace varieties, and it becomes obvious that many landrace varieties are being given **fewer resources**, while land and money is instead being invested into growing larger amounts of hybrid seeds, as the farmer hopes to sell them for profit.

These hybrid seeds can be expensive. Maize seeds cost an average of 59 rupees per kilogram

and wheat seeds cost an average of 20 Rs/Kg. Farmers used an average of 16.7 kilograms of maize seeds and 41.3 kilograms of wheat seeds. This represents a cost of 985 rupees and 830 rupees respectively. **Landrace seeds are free** as 93.3% of landrace seeds came from the farmer, while 100% of **hybrid seeds were bought** from a supplier. It's difficult to see whether the profits brought in by hybrid seeds is more or less beneficial than the low cost of the landrace seeds. Either way, to compete with the growing interest in hybrid seeds, it is important that landrace seeds stay free and readily available.

4.2 Most Farmers use Inadequate Storage Methods

One part of our survey focused on identifying seed storage techniques used by local farmers. We focused on **techniques** that would be useful for storing seeds in the prospective seed bank. As we delved deeper into the issue, we realized many farmers are using **incorrect** storage techniques,

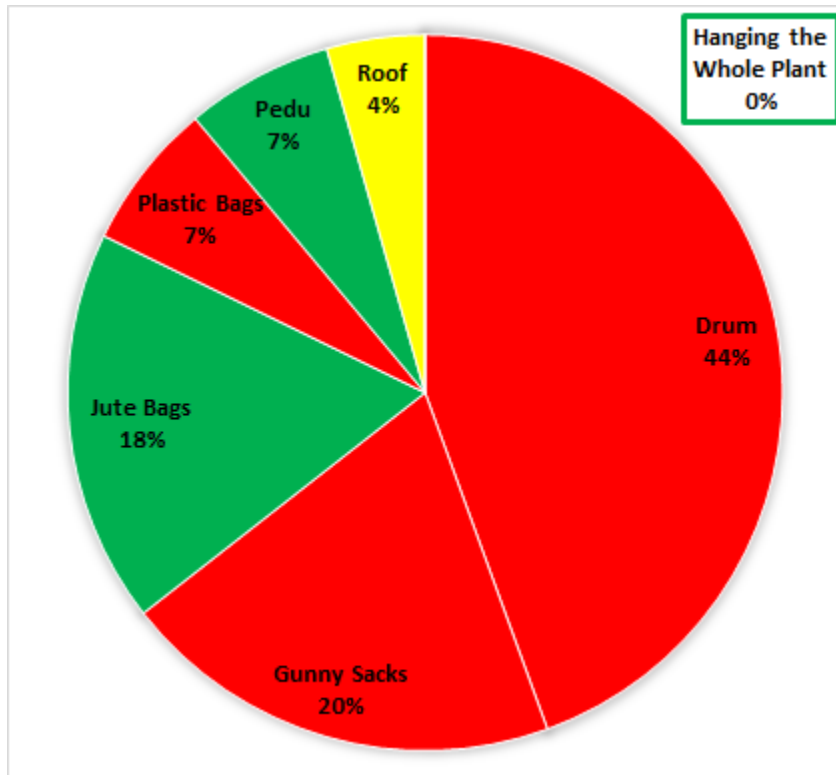


Figure 4: Farmer Use of Seed Storage Methods

further throwing landrace seeds in **danger**.

A quick breakdown of the storage methods shown in figure 4 shows a pattern of improper seed storage. Red colors indicate ineffective storage methods, while green methods would be preferable. Drums were the most commonly used, with 71% of surveyed farmers using them as their main storage method. **Drums are an ineffective storage method;** due to the **lack of airflow and sunlight** in a drum, seeds can easily become **infected by insects or rot**. 65% of these farmers used medicinal herbs or pills in these drums to deter

insects, disease and rot, compared to 50% of farmers using leaves in other storage devices.

This data shows that the majority of farmers are facing issues with rot, as they use the medicinal herbs to deter it. Farmers who use **drums** as their **primary storage** method, face issues with rot at an even higher rate. 65% of farmers using drums as their primary storage method reported insect infestations while 50% of farmers overall reported insect infestations. There is a parallel between

reporting insect infestations and using medicinal plants to deter them, as seen above, the numbers are the exact same. These numbers together suggest that the major issues of seed rot are caused by lack of farmer knowledge in proper storage techniques.

After establishing the existence of the storage problem, it is important to know how it is affecting the community as well as their seeds. 64% of farmers reported landrace seeds are their preferred seed source if available. If unavailable, the same farmers are forced to buy hybrid seeds. In some cases, insect infestations during storage make landrace seeds **unfit for planting**, causing farmers to **switch to hybrid** seeds. Currently, if farmers lose seeds to an insect infestation, it can **permanently diminish** their **ability to grow** that crop variety in the future, as **replacing landrace seeds is extremely difficult due to it being impossible to buy them**. This can cause extra expense to the farmer as he is forced to buy hybrid seeds. Even worse, it could cause the **loss of an endangered crop** varieties. If a species is reduced to a small amount of seeds and infected by insects, it could be impossible for it to grow again. Luckily there is a solution. Some farmers we talked to claimed that if seeds are **stored hygienically** there will be no problems with pests. The reportedly hygienic methods were as follows:

- Storing seeds in containers with airflow, such as:
 - Jute bags
 - Gunny sacks
- Exposing seeds to regular sunlight, especially infected seeds
- Storing maize in the husk, hanging

As you can see on the chart, no farmers claimed to use hanging the whole plant as a primary storage method, but occasionally farmers would show they were using the method for a small amount of seeds and vouch for its effectiveness. The use of ineffective storage methods must be addressed to protect endangered landrace seeds.

4.3 Farmers Consider Landrace Foods More “Nutritious”

To better **understand** why farmers are choosing either landrace, hybrid, or both types of seeds we included questions on our survey to **gauge** their **perception** of the seeds. From our preliminary interviews, we compiled a list of **pros and cons** for both types of seeds. We put this list into a multiple-choice format on our survey so that farmers could easily pick what they thought the pros and cons were. There were two pros that stood out clearly. We found that 77% of farmers felt landrace crops were more “**nutritious**” than hybrid. While landrace was perceived by farmers to be more nutritious, nearly 73% of farmers said that hybrid seeds produced a **higher crop yield**.

One of the major reasons for creating a landrace seed bank in the Mandi district would be to **preserve genetic diversity**. Part of preserving genetic diversity is **protecting** landrace seeds that are in danger of going **extinct**. 57% of farmers were aware of landrace seeds going extinct but did not necessarily know why or which varieties. Of the varieties mentioned, the two most common were kodra and red rice. Although no farmers expressed direct interest in the conservation of seeds, 90% of farmers expressed interest in participating in the landrace seed bank.

4.4 Landrace and Hybrid Foods are Nutritionally Similar in Broad Terms

Further nutritional analysis is essential for determining if the high nutritional content of landrace seeds, touted by local farmers is true. If the landrace seeds are proven to be more nutritious the seed bank becomes even more important. It would be crucial in preserving the higher nutritional content for the local farmers and their families and ensuring that they are eating a healthy diet. On a larger scale, these landrace varieties could potentially become high nutrition crops consumed by a global population. The seed bank would act as safeguard, ensuring access to these crops if they were discovered to truly be more nutritious.

Thermogravimetric analysis (TGA) was done on landrace and hybrid maize seed samples to determine if there was a difference in **nutritional content**, as previously reported by farmers. Thermogravimetric analysis is a method of thermal analysis where chemical and physical properties of a sample are measured as a function of increasing temperature (Coats & Redfern, 1963). Retief 2011 has demonstrated that TGA can be used for determining the content of Protein, Carbohydrates, Lipids or Fats and moisture in seed samples.

In our tests, samples were heated up to 800 degrees Celsius at a constant rate, during which a continuous measurement of the samples mass was taken. **Major nutritional blocks** such as **protein** and **carbohydrates** will burn at set temperatures, leading to a mass loss. The percent of total mass lost at these temperatures thresholds will show its nutritional content.

This method was used on one sample of landrace maize and one sample of hybrid maize. Shown below in figure 5 is a comparison of the resultant graphs from both our trials. As can be seen there is **no major differences** between landrace and hybrid. Further tests on the collected seed varieties along with replicates is ongoing in the lab of Mentor (Dr Shyam K Masakapalli) at IIT Mandi.

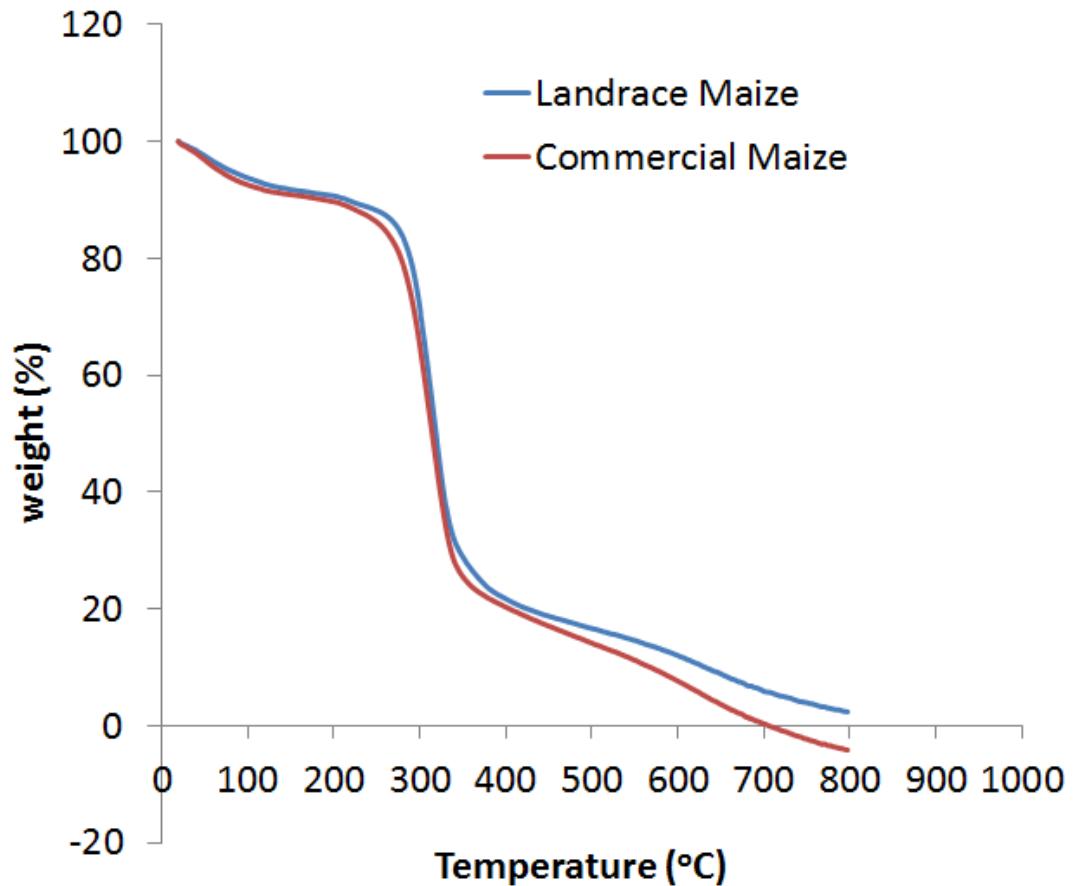


Figure 5: TGA plot of maize seeds subjected to temperature up to 800°C. The initial weight of seed powder taken is scaled as 100%. The gradual loss of weight with temperature depends on the content of moisture, protein, lipid, carbohydrate and minerals. The final remaining is the ash content. The first derivatives (not shown here) can be used for exact quantifications of the nutritional components. Further tests are ongoing.

5. Discussion

Our surveys show that farmers are currently growing hybrid and landrace varieties in fairly equal amounts. Both seed types are important to the farmer's success and therefore both must be preserved. Hybrid seeds are readily available according to farmers, but landraces are typically stored by individual farmers and have no large supply. A seed bank would provide these farmers a **central location to store their seeds** and allow them access to previously unavailable landrace seeds. Landrace seeds have the potential to **adapt the global food supply** to a **changing climate**, **protect** crops against **blight**, and are a source of **national pride**. It is vital to protect these seed varieties to promote **food security** in Himachal Pradesh, India, and the world.

Without a centralized source, landrace varieties are vulnerable to a variety of threats. These include but are not limited to: improper storage, rising popularity of hybrid varieties, and lack of knowledge.

5.1 Improper Storage Threatens Landrace Seeds

Improper home storage can damage seeds. 71% of farmers are using drums as a storage methods, and this is putting many of their landrace seeds at risk. Due to the lack of airflow and sunlight in a drum, seeds can easily become infected by insects or rot. These seeds are often unusable when it comes time to plant. **Endangered landrace** species could easily be **lost** or damaged by farmers using such techniques. Currently, if farmers lose seeds to an insect infestation, it can **permanently diminish** their ability to grow that crop variety in the future, as replacing landrace seeds is extremely difficult.

5.2 Landrace Varieties Struggle to Compete with Hybrid's High Yield

Landrace seeds are also threatened by the growing appeal of hybrid high yield varieties. Larger farms are choosing to supplement their income by growing an excess of **high yield hybrid** seeds to be **sold at market**. Farms that **sell crops have an average size of 9.9 bighas**, compared to the **5.1 bigha average size of a non-selling farm**. Farmers only sell hybrid crops, as they are perceived by 73% of farmers to be higher yielding, and thus more profitable. Experts at the Department of Agriculture Mandi warned that as farmers become more interested in these profits they are likely to continue to **move away from landrace varieties** towards hybrids. They also warned that as the area's population continues to grow (it grew 10% from 2001 to 2011) hybrids will likely become more popular as their higher production will provide food for more people from the same amount of land. This shift could constitute a **threat** against the **genetic diversity** provided by landrace varieties. There are already a large number of landrace seed varieties reported in very few farms and raised in small areas averaging 1.6 *bighas* compared to the overall average of 3.7 *bighas* per crop. These varieties are more vulnerable purely due to being less common and grown on smaller

areas. If landrace crops fail to be cultivated, they are unable to properly reproduce and could become endangered. The much larger area of the commercial hybrid farm shows many hybrid varieties are being grown in larger numbers and at a higher frequency. If farmers choose to grow hybrid varieties over landrace, **landrace seeds** could become **extinct or endangered** due to **lack of use** and production as well as lack of central source.

5.3 Permanent Landrace Seed Supply Protects Landrace Seeds from Insects

The primary function of the seed bank is to protect and proliferate landrace seed varieties. This provides an important service to the community: a varied, constant, and free source of landrace seeds. Currently, if farmers lose seeds to an insect infestation, it can permanently diminish their ability to grow that crop variety in the future, as replacing landrace seeds is extremely difficult. The seed bank would act as a **permanent supply** of these **landrace varieties**, allowing farmers to replace any lost seeds. Farmers would have the ability to **deposit seeds** each harvest and **withdraw seeds** for planting the next season. This would greatly increase their ability to grow their preferred varieties of seeds, as well as protect endangered varieties. This supply would allow farmers to **replace seeds** lost to insects, or plant varieties that had decreased in prevalence.

5.4 Free Landrace Seeds Provide Economic Benefit to Farmer over Hybrids

According to our survey, the majority of farmers **spend money on hybrid** seeds annually, while making **no profit**. This is because two thirds of farmers use all their crops for home consumption. Easier access to free landrace seed varieties through the seed bank would reduce this cost. The average total cost for maize and wheat crops is 1815 rupees. Average farmer income in Himachal Pradesh in 2013 was 6426 rupees per month or 70,686 rupees a year (National Sample Survey Office, 2013), so buying seeds represents a significant expense for farmers, with no return of income from the farm. A reduction in this expense could have positive impact on a farmer's production, potentially allowing them to sell crops. A **seed bank** could potentially **eliminate this cost**, as it would provide **free access** to landrace seed varieties.

5.5 Classes at Seed Bank will Improve Farmers' Agricultural Knowledge

A secondary function of the seed bank is to serve as an **education center** to the farmers. **75% of farmers claimed a lack of agricultural knowledge** was affecting their yield. The seed bank would offer classes to help fill these gaps. An increase in agricultural knowledge would improve farmers' yields, improve health, save money, and help to preserve landrace varieties. Classes would cover topics such as **proper seed storage**: allowing farmers to properly preserve their own their own seeds: protecting varieties from insects and eliminating the need for expensive hybrid replacements. Other classes would cover how to **properly use fertilizer**, as improper usage can

cause soil degradation and health problems; and **proper agricultural techniques**.

5.6 Further Testing is Needed to Determine Nutritional Benefits of Landrace Seeds

With **77% of farmers claiming landrace seeds to be more “nutritious”** it was very important for us to know if this was a real added benefit. To deduce whether landrace seeds were truly more nutritious we conducted nutritional testing on two maize seeds. Thermogravimetric analysis showed that in the case of maize there was **no difference in terms of nutrition** between landrace and hybrid seeds, but our results are still inconclusive. With only one sample tested, our **sample size is not large enough** to inspire any confidence or rule out any error. Testing was also only done on maize, one of the two major crops. An increased sample size is needed, as well as testing using wheat and other collected crop seeds, before any substantial conclusions can be drawn.

Testing should also include details about other important aspects of nutrition such as vitamin and essential amino acid contents, but our current method of thermogravimetric analysis is not accurate enough to detect them due to their miniscule mass. **Vitamins are a major part of nutrition** and could account for the discrepancy between our results and farmer perception. Atomic absorption and flame emission spectrophotometry testing could be used to test for Vitamins C and A, calcium, and potassium in a **future study** (Asghari, Palizban, & Bakhshaei, 2015). Similar tests could also be used for other nutritional aspects, such as minerals content.

Although testing for differences in nutritional value between landrace vs commercial was inconclusive there is still enough evidence to establish a need for a landrace seed bank. Landrace seeds must be protected and preserved to ensure the global food supply is secure for generations to come. With this need established, our proposal for a seed bank is below. In it you will find our recommendations for most aspects of the seed bank.

6. Proposal for a Landrace Seed Bank

Based on the information gathered from our farmer surveys, there is a need for a seed bank. This bank will protect endangered landrace species, give better, low cost, access to seeds for farmers, and educate farmers in sound agricultural practices. The proposal below contains the details of the seed bank, detailing the costs and resources necessary to run it, and the processes required to make it successful. Here is a basic diagram of the seed bank.

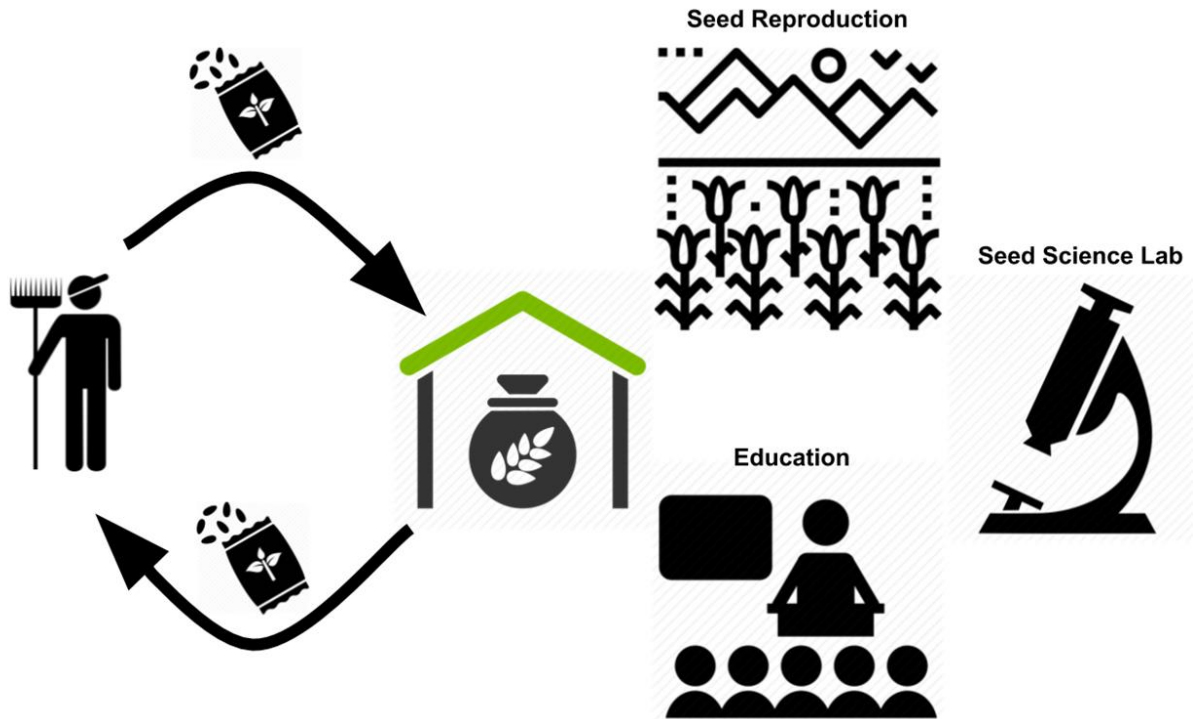


Figure 6: Seed Bank Plan

The left part of the diagram represents the farmers withdrawing and depositing seeds to the bank. The right part of the diagram represents the different parts of the seed bank. The seed reproduction field is where new seeds are grown. The seed science lab serves as a space to test the health of the seeds. The education center works with local farmers to spread agricultural awareness. Each one of these parts is necessary for a successful seed bank.

6.1 Proposed Storage Methods



Figure 7: Maize Hung in the Husk

It is important that the seeds are stored using an effective and proven method. Improper storage methods can cause a large loss of seeds. 71% of farmers we surveyed faced problems from incorrect storage, impacting their ability to sustain a useable number of landrace seeds. Common threats to seeds are insect infestations, seed rot, and a decrease in germination rates. The seed storage methods we are recommending for the seed bank have been recommended as effective by local farmers as well as supported by research.

Maize is one of the most vulnerable crops to improper storage. 50% of farmers complained it would become infested with a bug called cun, ruining the seeds. Other farmers assured us that if the seeds were **stored hygienically** they would be free of bugs and store well. The most effective storage method is to harvest the cobs whole with the **husks still intact**, shown in figure 6. Two corn husks are then tied together and hung in an area with plenty of airflow. Placing the cobs **in the sun** monthly eliminates any threat of infection (Vernooy).

The other most commonly grown crop is wheat. Although it doesn't face as many issues as maize, its proper storage is still very important. One of the most effective methods is storing the wheat in gunny or jute

bags, shown in figure 8. It is extremely low cost, and easily accessible. The nature of the bag allows for **airflow** keeping the seeds dry and fresh. These seeds should also be placed in the sun every month or so to prevent insects and keep the seeds dry. Barley will also be stored the same way (Vernooy).

Other commonly grown seeds such as the pulse Rajma can be stored in a **pedu**. Many local farmers have stopped using this practice due to the time and effort required, but it is still one of the most effective methods available (Vernooy).



Figure 8: Jute Bag

6.2 Structure and Location

The seed bank must be placed at a central location from all the villages, with easy access. It must also have access to staff, transportation, and open area for the seed bank. Considering all of these factors, we have decided the best place for a **seed bank would be IIT**.

The seed bank should be a simple concrete room. There should be a few windows for proper air ventilation to prevent seed rot. There should be hooks inside and outside to properly hang jute and gunny bags, as well as maize for drying. There should also be simple shelves to keep containers off the floor to prevent insect infestations.

The **botanical gardens** will serve as areas for seed proliferation, allowing the seed bank to sustain and improve its **seed supply**. The already existing seed **bio labs** will be used for occasional **germination testing**, to assure a batch of seeds is still viable.

6.3 Seed Management

An important part of a seed bank is who will run it. Local *Krisbi-Kendras* are run by governmentally trained agriculture staff. Our seed bank would at first be run by a member of this staff, possibly a few interested grad students, and a few interested local farmers. The **staff member** and **grad students** would work in collaboration to **train the local farmers**. Once the local farmers were well trained they would take over running the seed bank.

Regular **education programs** would be held for other farmers by the seed bank staff in collaboration with IIT professors and grad students. These programs would focus on the costs and benefits of seed varieties, proper seed storage methods, and preventing depletion of land.

Other seed bank management duties would include:

- Monitoring outtake and input of seeds
- Seed processing/occasional drying
- General maintenance
- Germination testing
- Desk work

6.4 Seed Bank Transactions: Seed in and out

An extremely important aspect of the seed bank's operations is where the seeds come from, how they are distributed, and how they are replenished.

Startup funding will first be procured from **IIT** through a **grant**. If we are unable to procure funding through IIT then requests can be made to other government agencies for assistance such as DBT, DST, and NASF. This funding will allow for the seed bank to be built, employees to be paid, and cover other general startup costs. This funding will also be used to purchase some

difficult to access landrace seeds. Other **landrace seeds will be deposited by local farmers** with the understanding that during the next season they will have access to an **equal amount of free seeds** for their farms through this barter. Seeds that exist in small amounts will be grown in the botanical gardens, so a large supply is available.

Farmers donating seeds and removing seeds each year will continue to be the standard practice of the seed bank. Farmers who needs seeds but are unable to donate will be able to purchase seeds at a small cost or donate their labor to the farm instead.

Germination testing must be done to all stored seeds on a regular basis. The first test should be done as soon as seeds arrive at the seedbank to determine if their quality is high enough to warrant preservation. Regular seed germination testing will then be conducted minimally bi-annually.

Collection size*	Test size*	Number of tests**
≥ 1000	25 - 50	4 - 10
≥ 500	25	2 - 4
≥ 250	10	2 - 4
< 250	No test	0

Figure 9: Seed Germination Testing Sizes

Figure 9, created by the Millennium Seed Bank Partnership, shows the appropriate size of each test depending on how many seeds you have available. The sample size must be no smaller than 10, as it is the smallest number that allows for still meaningful data.

There is a simple homemade way of testing seeds by simply placing them on wet paper towel in a plastic bag, but the seed bank will most

likely be using the seed lab’s more elaborate setup. Each test ends when all seeds have germinated or a designated period of time has passed. **If fewer than 70% of the seeds germinate, the quality is too low** to justify continuing storage. The percentage germinated should be recorded in the database with the corresponding seed.

After some time a pattern will be established and it will be easy to predict at what point a batch of seeds will have significantly decreased in quality. Knowing this data will allow for the caretaker to predict when new seeds will be needed. This means new seeds will be grown in the botanical gardens to replace seeds that have just gone bad.

As previously stated, seeds will be planted in the botanical gardens to allow for old seeds to be replenished. In order to tend the plants correctly, the farming practices of local farmers must be documented. Important aspects include: how the ground is tilled for the seed, how they should be planted, if they need to be watered, what amounts of fertilizer are most effective, when the plant is ready for harvest, and how to harvest the seeds. Other information that must discovered is the size of plot needed to regularly replenish the seeds, and any necessary farming supplies.

After the seeds are harvested they must be properly processed for storage. The processing techniques of the local farmers will be documented and put into practice much like the farming techniques. Common home processing techniques are well known and are listed in appendix B to be used as an initial technique.

6.5 Outreach and Maintenance

Digital accessibility is imperative for keeping a spread out community connected to the seed bank. As many farmers' **only access to the internet is an Android phone**, an app and mobile website will be very important to reaching out to them. Shown in figure 10, the main focus of the app will be a **database** showing the **amount** of each **variety of seeds** available in the seed bank, as well as information about the seed and **proper storage techniques**. Seeds will be tracked in the database using **Passport data**. This information is very valuable as it will allow for genetic information of the seeds to be recorded and tracked. (GBIF)

The following information will be tracked in the passport:

- The name of the village where the seeds were retrieved from
- A mark of the village on a map
- The elevation of the village
- Genus and Species
- Amount stored
- Picture of seeds and crop if possible
- Serial number assigned to batch
- Storage method
- Percent in germination testing
- Data of last germination test

Each crop has its own page on the app providing information about the crop such as how to grow it, store it, and what it can be used for. The page also informs the user of the available seed stock at the seed bank. This allows the farmer to avoid unnecessary trips to the seed bank, as they can always visit when they seeds they want are in stock.

Another aspect of the database will be to **track the farmers visiting** the seed bank. It will include the following information

- Name of Farmer
- Name of Village
- Map marker of Village
- Amount/Variety of seeds donated
- Corresponding serial numbers of seeds



Figure 10: Android Application

- Amount/Varieties of requested seeds for next season
- Lesson Interests
- Interested in Volunteering?
- Contact Information

Such a database will allow for the correct amount of seeds to be given to the corresponding farmers each year. Tracking farmers' educational interests will allow for lessons that target the farmers' interests and needs effectively. Volunteering interest will allow for easy contact to any interested farmers when additional work at the seed bank is available.

The last aspect of the app is a calendar of events and government programs. Any agricultural classes, informational meetings, or other such events can be listed on the calendar. Farmers using the app can then check the calendar to see what classes are available at any time. This additional convenience will make it easy for farmers to be aware of classes and schedule to attend them.

7. Conclusion

Currently, the survival of landrace varieties in the Mandi district is dependent on individual farmer conservation. Farmers are aware of the importance of landrace seeds on their own farms but do not see the macroscopic implications of a landrace extinction. The ever increasing presence of climate change will continue to threaten these seeds if conservation efforts are not made.

From our surveys in villages near IIT we discovered that there were several areas of possible improvement on farms. Many of these problems like improper storage of seeds, unawareness of endangered seeds and poor seed selection, originate from a lack of farmer knowledge. In an effort to help mitigate these problems and promote conservation we chose to develop a plan for a landrace seed bank. The seed bank would protect and improve access to a wide array of landrace seed varieties. This will allow for protection of landrace seeds. Access to these seeds will improve food security in Mandi, as more genetic diversity allows for protection from blight, and the ability to breed crops with more favorable qualities. Landrace seeds could help to create higher producing, drought resistant crops to fight the effects of climate change. The free access to seeds for farmers could help to improve their economic situation, as well as the classes provided at the seed bank. Armed with more knowledge and more seed varieties the farmers will be able to grow more consistent yields at a lower cost, a great achievement in food security.

We have developed a detailed plan for a landrace seed bank located on IIT's campus. The proposed seed bank will offer a source of education for farmers while also lowering their seed expenditures and preserving the genetic diversity of the area. To help facilitate farmer involvement and establish a baseline source of documentation, we created an Android app and website. These tools will allow for better management of the seed bank and an easy source of knowledge for the farmers. We hope that this plan and app will serve as a model and inspiration for future seed banks in rural districts like Mandi.

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Appendix A: Survey Questions

This appendix contains our three drafts of the survey, with the third draft being the final draft.

First Draft

Below is the first draft of our survey questions. The survey leads with basic details about the farmer, then details about each of their crops, and finally with specific questions.

Basic Details:

1. Name of the farmer
2. Village
3. Education
4. Total land owned
5. Sex
6. Age
7. Marital Status
8. Number of family members
9. Total land cultivated in the summer/total left fallow
10. Total land cultivated in the winter/total left fallow
11. Best growing month
 - a. Major crop
 - b. Amount sown
 - c. Amount harvested
 - d. Amount of loss

Crop Details (on a crop by crop basis):

1. Crop name
2. Area the crop is grown in
3. Quantity of the crop harvested
4. Amount of a harvest used for home consumption
5. Amount used for sale
6. Price that harvest is sold at
7. Quantity of seeds needed
8. Where seeds are acquired
9. Cost of seeds
10. If the seed is landrace or hybrid

Specific Questions:

1. What factors affect your yield?
2. How do you sell your crop?
3. Do you have Storage Facility and Market for your yield?
4. Are you aware of government plans & facilities?
5. What is the source of your seeds?
6. Do you have a preferred seed source?
7. What techniques do you use for seed storage?
8. Do you face any problem in seeds storage or seed availability for crop production?
9. Do you know why/what landrace varieties are going extinct?
10. Do you face any loss in quality of land?
11. Where are you/your family from? Outside Himachal?
12. Can we have samples of seeds?
13. Any queries for the interviewer?

Second Draft

In our second draft we removed the seasonal questions and added a number of questions to get a better understanding of the local condition.

Basic Details:

1. Name of the farmer
2. Village
3. Education
4. Total land owned
5. Major crop
6. Sex
7. Age
8. Marital Status
9. Number of family members

Crop Details (on a crop by crop basis):

11. Crop name
12. Area the crop is grown in
13. Quantity of the crop harvested
14. Amount of a harvest used for home consumption
15. Amount used for sale
16. Price that harvest is sold at
17. Quantity of seeds needed for that crop
18. Where seeds are found

19. Cost of seeds
20. If the seed is landrace or hybrid
21. How long they have been using that crop

Specific Questions:

14. Do you know what a landrace seed is?
15. Do you know what landrace varieties are going extinct and why?
16. What factors affect your yield?
17. What seeds/crops are most susceptible to each factor?
18. What is the source of your seeds?
19. Why?
20. What is your preferred seed source?
21. Why?
22. What do you like and dislike about landrace and hybrid seeds?
23. Landrace seed Pros:
24. Landrace seed Cons:
25. Hybrid seed Pros:
26. Hybrid seed Cons:
27. Do you Use fertilizer?
28. How much does it cost?
29. How do you fertilize different kinds of plants?
30. What techniques do you use to store which seeds?
31. How long have you used that technique?
32. How do you build the storage device?
33. Why do you use that technique?
34. How close are you to a water source?
35. How do you water your crops?
36. Do you face any loss in quality of land?
37. Do you sell your crop?
38. Why do you sell/not sell crop?
39. How do you sell your crop?
40. Are you aware of government plans & facilities?
41. If yes, what plans and do you use them?
42. Would you be interested in nearby landrace seed bank?
43. What would you like in a seed bank?
44. What kind of phone do you use?
45. Would you use a free app telling you of available seed bank stock?
46. Are there any changes would you like to see made to the app?
47. Can we have samples of seeds? Were these seeds stored in the specified technique?
48. Any queries for the interviewer?

Third Draft

In our third draft the number of questions was reduced due to details we gained through survey, unnecessary questions, and long survey times.

Basic Details:

1. Name of the farmer
2. Village
3. Education
4. Total land owned
5. Major crop
6. Sex
7. Age
8. Number of family members

Crop Details (on a crop by crop basis):

22. Crop name
23. Area the crop is grown in
24. Quantity of the crop harvested
25. Amount of a harvest used for home consumption
26. Amount used for sale
27. Price that harvest is sold at
28. Quantity of seeds needed for that crop
29. Where seeds are found
30. Cost of seeds
31. If the seed is landrace or hybrid

Specific Questions:

49. What factors affect your yield?
50. If C (lack of knowledge), what knowledge is lacking?
51. What is your preferred seed source?
52. Why?
53. What do you like and dislike about landrace and hybrid seeds?
54. Landrace seed Pros:
55. If a (more nutritious), explain nutritious?
56. Landrace seed Cons:
57. Hybrid seed Pros:
58. Hybrid seed Cons:
59. Do you know what landrace varieties are going extinct?
60. Why?

61. Do you face any loss in quality of land?
62. What techniques do you use to store which seeds?
63. Do you face any storage problems?
64. Is your storage hygienic?
65. Why?
66. Would you be interested in nearby landrace seed bank?
67. What would you like in a seed bank?
68. What Facilities would you like in a seed bank?
69. What seed varieties would you like in a seed bank?
70. What kind of phone do you use?
71. Would you use a free application telling you of available seed bank stock?
72. Can we have samples of seeds?

Appendix B: Seed Processing Techniques

There are two distinct categories of seeds, dry seed pods and wet fleshy seeds.

Processing dry seeds is fairly simple:

1. Harvest dried seed pods
2. Place in paper bag to dry for two weeks
3. Separate seeds from “chaff” (other plant material)
 - a. Method 1: Thrashing
 - i. Rub seeds between your hands
 - b. Method 2: Winnowing, shown in figure 11
 - i. Set containers in front of the fan as shown below
 - ii. Pour seeds from standing height in front of the fan
 - iii. This separates the seeds by density: the denser seeds land closer to the fan and the chaff is blown away.

Processing fleshy seeds is a slightly more involved process:

1. Harvest the fruit
2. Cut the fruit open and scoop out the seeds
3. Add seeds to a water filled container
4. Store the container in a warm area to ferment
5. Stir the container daily to separate pulp from the seeds
6. Once the mixture becomes frothy from fermentation, pour water, pulp, and floating seeds off the seed mixture
7. Continue to pour water onto the seeds until they're clean
8. Dry the seeds in hanging mesh bags or on a dry paper towel

It is very important the seeds are **not dried in direct sunlight or excessive heat**, as it can prevent the seeds from germinating.

Dry seeds of both varieties are stored in a labeled container such as a jar or an envelope in a **cool dry location with constant humidity and temperature**. This method gives most seeds a shelf life of one to five years depending on their variety (Hutton, 2010).



Figure 11: Example of Winnowing