BLUELAB INDIA PROJECT

May 2015 Feasibility Trip Report

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Introduction

In May 2015, five members of the BLUElab India Project traveled to Gujarat, India in order to perform a feasibility assessment of low-smoke stoves and composting toilet technologies. The need for these technologies was identified during the needs assessment trip carried out in 2014. By surveying literature on existing technology and having frequent phone conversations with family partners during the 2014-2015 academic year, the team was able to hone in on specific designs to be assessed during this trip.

Over the course of the month, the team was able to continue to co-design the improved cooking stoves through discussion with partners as well as the construction of several prototypes. By the end of the month, a final working stove design had been determined, and ideas for potential next steps had been generated. Progress with toilets was less tangible in that there were no prototypes built; however, the team was able to determine that villagers are not opposed to composting toilets. They would be interested in experimenting with a prototype and adopting the technology if the prototype is effective and user-friendly.

Recap of May 2014 Trip

In May 2014, six members of BLUElab India Project's team traveled to the Kalol area for an entire month to carry out an in-depth needs assessment. After conducting informal interviews, recording observations, and building strong relationships, the team decided to work with the small agricultural village of Dolatpura and focus on two problems that the villagers were facing. These two problems were the inhalation of cooking smoke and the lack of usable, affordable toilets. The team produced a report that detailed the results of the needs assessment. In the academic year following the trip, the team worked to co-design socially and economically viable toilets as well as sustainable stove systems.

Progress Over 2014-2015 Academic Year

Over the past year, the team has been working its way through the BLUElab Gate Process. In addition to the toilets and stoves sub-teams, there is a culture sub-team, which had a weekly presentation with cultural information relevant to the design or to the relationship with our community partners. There was also a strong focus on building community relationships amongst the team members; bi-weekly phone calls were made to family partners in Dolatpura. The stoves team was able to begin brainstorming a design and prototyping. The toilets team researched concepts and determined that composting toilets, given the information available, were the most feasible. After deciding this, the team researched issues that surround experimenting with human waste and then planned for a composting experiment. At the end of the academic year, the team selected a new group of leaders that began the transition process in order to be prepared for the upcoming 2015-2016 academic year.

May 2015 Trip Goals

- Overall
  - Strengthen relationships with family partners
  - Assess feasibility of stove and toilet technologies developed during the 2014-2015 academic year
- Stoves
  - Prototype to optimize design
  - Develop implementation strategy for further expansion
- Toilets
  - Gauge interest of families (and other villagers) in composting technology
  - Determine next steps for composting testing and finalizing alpha design

Feasibility of STOVES

Establishing Relationships

Building relationships with our community partners was the most important goal of our trip because a strong, healthy relationship with our partner family is crucial to the co-design process. We had been speaking to our partner family over the phone for the past year and learning about the major problems with their existing stove. Towards the end of the academic year, we learned that there is a stove builder in the village who is related to our stove team's partner family. When we arrived in the village, we were able to meet her and start preliminary conversations about stoves. During the first weekend, she invited us to her daughter's wedding, which was an amazing experience because we not only strengthened our relationship, but also learned a great deal about the vibrant culture and traditional rituals performed at Indian weddings. Due to our level of involvement with the community and personal relationship with her, the stove builder was comfortable enough with us to give critical feedback and suggestions on our design for possible improvements to various features.

After developing a relationship with the stove builder, we moved on to discussing the actual design. Initially, we showed her a diagram and many pictures of our design and discussed some of the benefits that our design would provide. We mentioned that we were still prototyping and wanted to include her in the process so that we could most effectively co-design a stove to solve the problem of smoke inhalation. As we were discussing the design with her, many people became curious about the idea and began asking questions regarding the materials we would be using and the cost of implementing our design. After answering these questions to the best of our ability, we asked the stove builder if we could join her in building a traditional mud stove that she usually builds for families in the village.

First Stove Build

We wanted to join the stove builder in the process of building the existing stove that she has been making for years in order for our team to learn about the materials and techniques that she uses for these traditional stoves. We learned over the past year that they use a mixture of different types of dirt called mati to make the stove. The stove builder told us that the mati had to be dug up the day before the build and mixed with a small amount of water. Along with the mati, she collected straw and some water on the day of the build.

First, we started by making the mud mixture. This involved kneading and massaging the mati with some water and the straw until it felt like play-doh or clay. When we finished, the stove builder showed us how to build the U-shaped base structure. We carefully sculpted the stove with her direction. After completing the base structure, she added three little knobs on each side of the stove for the pots and pans to sit on. She carefully measured the knobs with her fingers so that they were centered. We did not know about these knobs while we were prototyping at Michigan so we made sure to discuss how this could be incorporated into our design. The base structure was complete after this and she then smoothed out the surface of the whole stove. After letting the structure dry overnight, the last step was to cover the whole stove in a layer of lapedo, a mixture of red clay and cowdung. This coating created a hard outer layer that helps prevent cracks; it took about two days to dry and after this the stove was ready to use.

First PROTOTYPE

Materials

We went with a SETCO Foundation employee to a nearby town called Kalol, and bought a thin, red galvanized metal sheet. We reasoned that this sheet metal was readily available because many villagers commute to Kalol on a daily basis - either for work or to buy goods.

The sheet metal cost around 200 rupees ($3.17) for a 2 feet by 4 feet piece. Since we needed to cut holes in the sheet metal, we went to another nearby store to purchase tin snips for 300 rupees ($4.76). We also bought 15 feet of wire for about 10 rupees ($0.15).

Process

Our team split up so a few of us could work on forming the chimney while the others made the mud mixture to begin building the foundation of the stove. From the large piece of sheet metal, we cut two pieces, one for the bridge and the other for supporting the pots in front of the chimney. We rolled the remaining sheet metal into a pipe and tied it with some wire. Then we cut an opening at the bottom of the pipe for smoke to go through. Meanwhile the other members of our team were building the base of the stove with the stove builder's help. The process involved taking the prepared mud mixture and forming the standard U-shape. The stove builder suggested that we increase the amount of mud in the back of the stove to provide more support for the chimney. We also added a small U-shaped piece underneath the bridge to support the pots. The stove builder also suggested we add a knob on the bridge so that the pot can sit on all four sides. After smoothing it out, we waited for a day before covering it with the final layer of lapedo.

Testing and Feedback

Two days after the lapedo was applied, we tested our prototype. After cooking on the stove alongside the stove builder we learned that there were many problems. The first, and most important, was that there was too much draft moving through the stove, causing the heat to move quickly through the chimney instead of transferring to the pot. As a result of this irregular heat distribution, the food was cooking unevenly and very slowly.

Another side effect of the natural draft was that the chimney became very hot, causing the paint on the sheet metal to peel off, with much of it falling on the food. This was simple to address - we could easily buy unpainted galvanized sheet metal at the hardware store.

Another problem was that the fuel was being pushed into the hole that was made for the smoke to travel through the chimney. This was causing the heart of the fire to be pushed directly under the chimney, which meant most of the heat traveled out before making contact with the cooking surface. There was also a problem with how the chimney was rolled. Since we were trying to roll the chimney into a circular shape with a 4 inch diameter, there was a place where the metal creased and the pipe was not completely closed. Therefore, there was smoke seeping out of the side of the chimney through this gap. In addition, there was smoke leaking out the gaps between the stove and the pot. This was because the pot sat on the four knobs around the top edge of the stove, which also made it uneven and very difficult to cook cudi (a traditional soup). Some of the stove builder's pots would touch the chimney when placed on the stove, also causing the pot to sit unevenly. Even though we ran into many problems with this stove, we learned a great deal about how to best iterate our design.

Second PROTOTYPE

Materials

For this prototype, we purchased the materials from the same hardware store. We bought a smaller piece of 1 foot by 2 feet unpainted galvanized sheet metal that was a thinner gauge to make it easier to roll into a cylinder. The cost of the metal was approximately 150 rupees ($2.38) and was readily available. Because we had trouble with rolling the sheet metal, we decided to abandon the wire and use a notch technique to hold the chimney in the cylindrical shape.

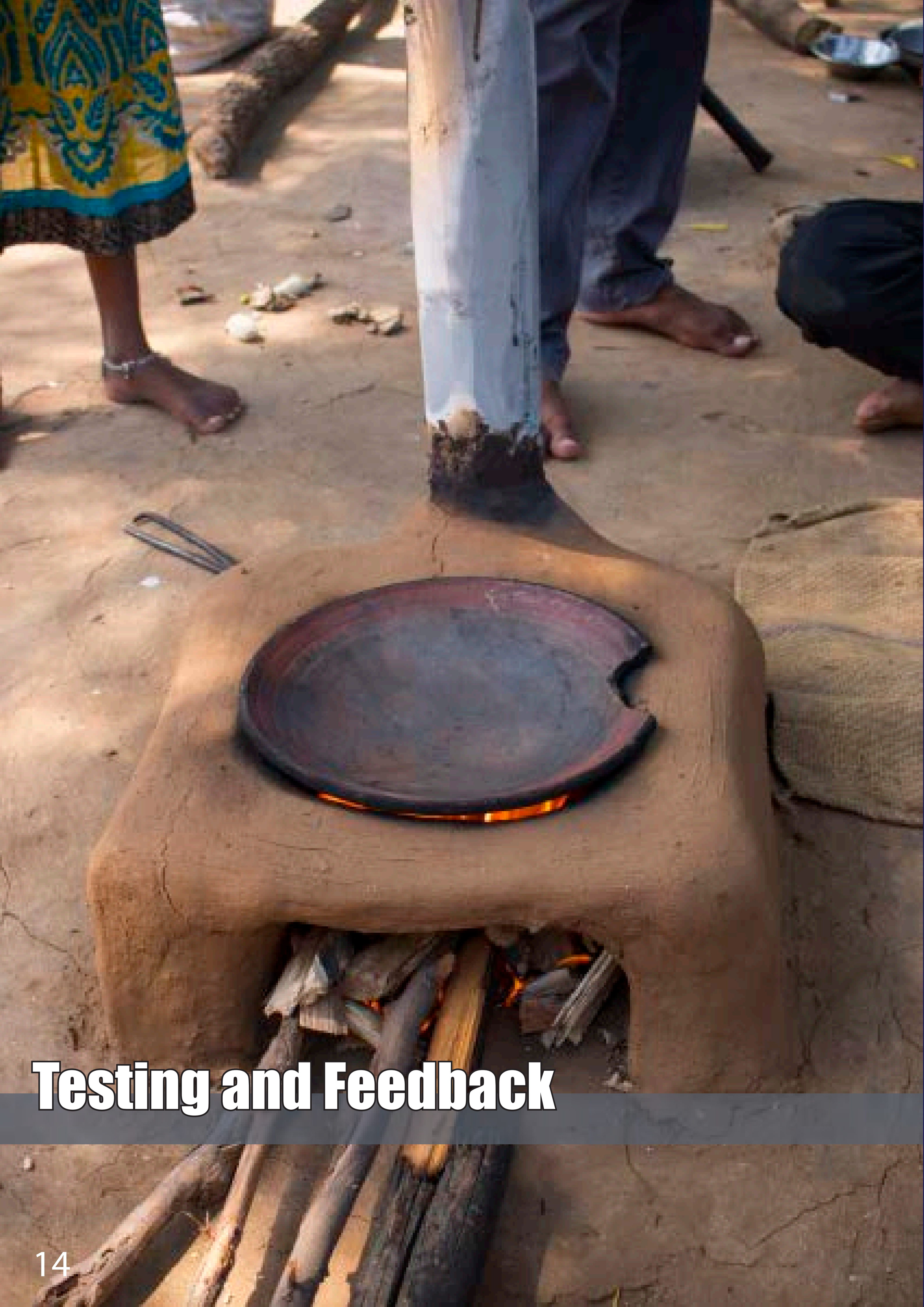
Process

The creation of the mati-based mixture was the exact same process as it was for the previous prototype. The stove builder prepared the mixture before we came to the village on the day of the build so that when we arrived we could immediately make the chimney and build the stove. Because we had difficulty making the sheet metal into the cylindrical shape in the previous iteration, we decided to bend the edges of the sheet (1 inch wide) so that when they were brought together they could be be notched and sealed.

Design Changes

This prototype included a few design changes from the previous one. Our first change was to increase the overall size of the stove, giving more room for the larger pots and increase the size of the combustion chamber. Another modification was to move the opening to the chimney higher up, affecting a couple things. First, it prevented the fuel from being pushed into the opening. Second, it caused airflow to move upwards to transfer heat to the pot before leaving through the chimney. The third revision was to decrease the diameter of the chimney from 4 inches to 3 inches to reduce the draft through the stove so that more heat could be transferred to pots. Finally, we changed the opening for the pot so there would be no gap between the pot and stove. This meant the pot sat lower in the stove.

This presumably sealed any gaps that could have been made while forming the chimney and also allow it to retain its shape better. Unfortunately, this method proved to be very time-consuming and required a lot of hard labor. By the time the chimney was made, the base structure of the stove was built. It was much longer and wider than the previous prototype, and consequently required considerably more of the mati mixture. We carefully inserted the chimney a little farther back from the main combustion space and also made sure to move the opening to the chimney farther upward to prevent clogging by fuel. Finally, we shaped and smoothed the opening for the pots so that they would sit snug and lower into the stove.



Testing and Feedback

This stove prototype worked very well. There was no smoke escaping from the front or the sides of stove. The stove builder made her whole lunch on it because it heated up so well. Another major achievement was that the smoke coming out of the chimney was colorless, which meant there was complete combustion of the fuel. This indicated that the stove was more fuel efficient. After using the new prototype for several days, the stove builder was very excited and said she would only cook on this stove from that point on.

Third PROTOTYPE

Design Changes

With the third iteration, we made one major design feature change, which was to decrease the height of the chimney to allow the stove to fit under roofs and decrease the draft through the stove. Before building a third prototype in the village, we decided to develop a more efficient method of creating the chimney from the sheet metal. Since the last prototype's chimney was arduous to create and required the help of two or three people, we experimented with different ways of rolling and bending a chimney from the sheet metal. Using the same material, we came up with a technique where instead of trying to tightly roll the sheet metal to create a 3-inch diameter cylinder, the sheet metal was rolled into a loose cylinder and then tightened by twisting the wire that held it together. This way the stove builder could easily adjust the diameter of the chimney to 3 inches by using a pair of pliers.

Process

The purpose of making this prototype was to confirm the new stove design and building process with the stove builder. We wanted to teach her how to work with the metal to form the chimney and clarify any questions she had with the design. We supervised this build and watched the stove builder form the whole stove. She added some of her own design features; she made the stove a little taller and made the back of the stove more square so she could set her cooking utensils down. Unfortunately, due to time constraints we did not have time to test this prototype but based off of the conversations with the stove builder after we left, the stove was a success.

Stove Buildir

During the last week of our trip, we conducted a workshop for the stove builders and women in the village to introduce them to our new stove design. The main purpose of the workshop was to gauge the response to our design and see if anyone was willing to try to build it. We asked the stove builder that we co-designed with to run the workshop because the women in the village were more comfortable hearing about the stoves from someone they knew. Before the workshop, we created a brochure to hand out to everyone detailing our design with pictures so it was easy to understand. We specified some key design principles that are crucial to making the stove work such as the location of the smoke outlet, the diameter of the chimney, and the enclosed combustion area. We did not want to specify any dimensions for the stove because the stove builders construct each stove to fit their personal needs, usually

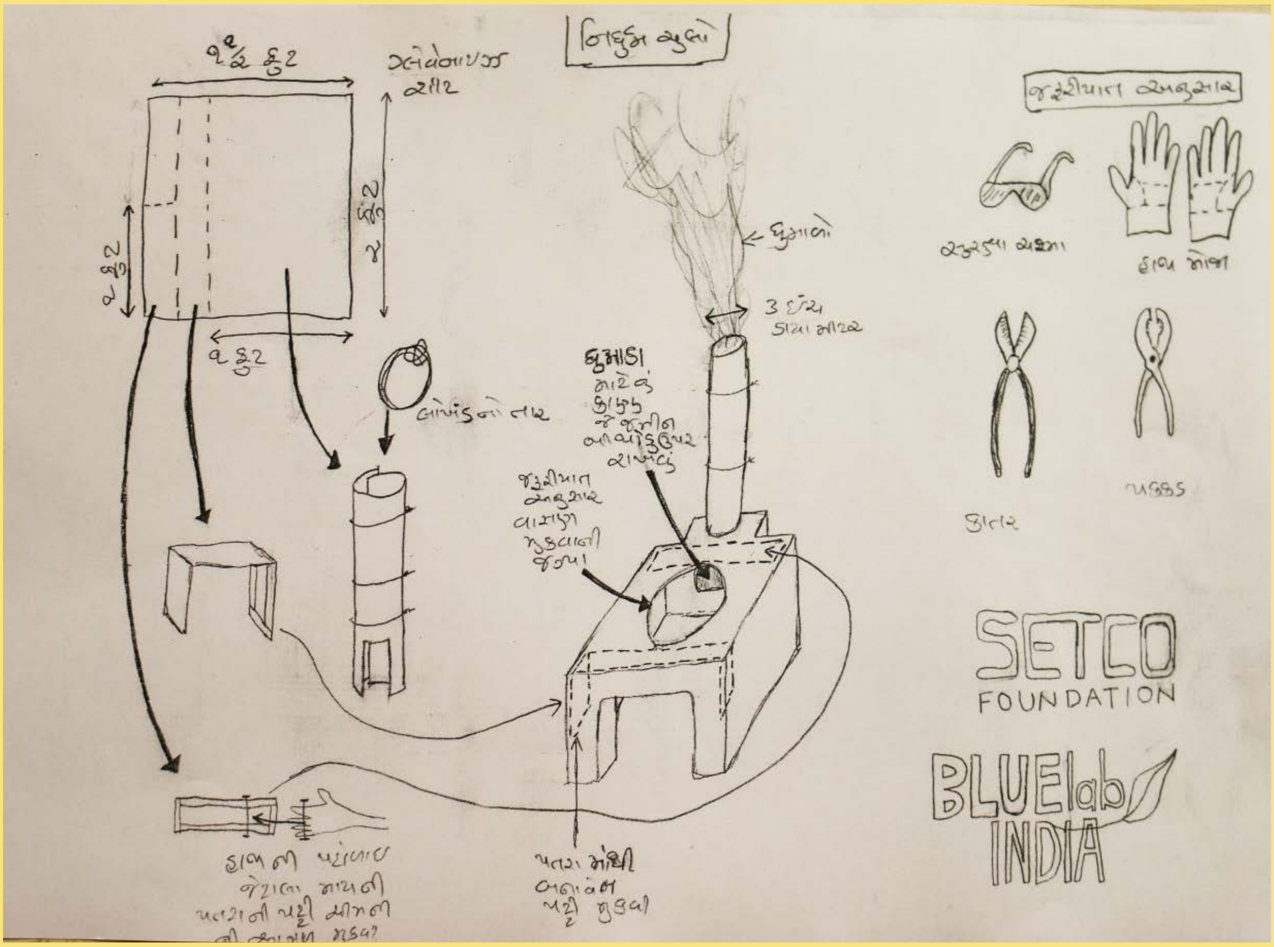
Monitoring Systems

While we were building our prototypes, we realized that many stove builders had suggestions to improve our design. Before leaving, we proposed a monitoring system to track the changes that were being made to the stoves while we were gone. The system involved an employee from the SETCO Foundation visiting the village to find out who had constructed a stove using our design and collect their contact information. Then he or she would go to that person's home to ask if they could take a picture of the stove and ask a few basic questions about any changes they might have made. We created a shared document between our team and the SETCO Foundation where all of the information can be stored so we can continue to improve and test our design.

ng Workshop

using their hands as the only metric of measurement.

On the day of the workshop, a small team from the SETCO Foundation accompanied us to the village. After speaking with the stove builder, we decided to conduct this workshop in her backyard around our working prototype. The prototype provided a platform for the stove builder to speak about her experiences with the stove and the building process. The workshop lasted about 30 minutes and afterwards, we asked if anyone was interested in the new stove design. After answering some questions about materials and cost, we found out that more than 50% of the people in attendance were interested. This was a great sign, but we were not prepared to implement our design throughout the entire village since we had not yet created a sustainable expansion strategy.



Feasibility of Toilets

Discussing Technology

The May 2015 trip also served as a feasibility assessment for the toilets project. During this trip, the travelers interviewed multiple families. The interviews were conducted by gender. Through an interview with the men in the family, the team discovered that they were interested in the alpha design with two underground soak-pits and a urine diverter. On the other hand, the women in the same family were uncomfortable with the idea of a composting toilet. The main reason for their discomfort was that they did not want any contact with human waste. Within the community, a social hierarchy exists where members of the higher classes are stigmatized if they come in contact with human waste. This social stigma was not, however, a unanimous characteristic in Dolatpura.

The team continued to interview more community members, with a focus on private discussions with women, to better understand gender-specific preferences and to avoid any social pressures. While speaking to the women, the team noted that many households were interested in learning more about the impacts of human compost on crops, maintenance involved with composting, and the usability characteristics of the technology. In fact, many of the women wanted a prototype implemented in the village. They believed a prototype would assist them in understanding how the technology works and the effects that human fertilizer has on crops.

In addition to our feasibility assessment, SETCO Foundation conducted a Participatory Rural Appraisal (PRA) within nearby villages, such as Katol, during 2015. A PRA is similar to a needs assessment. SETCO facilitated dialogue between individuals to empower them to identify problems within their community. SETCO then hoped to provide them with resources from the government and NGOs that can assist in solving these problems. These issues can vary: education, health, social, and economic. Through this PRA, SETCO Foundation identified a drastic increase in chemical fertilizer usage to maintain crop yields. In addition, they found that there was a need for toilets within households. Therefore, they decided to select 40 families in Katol to implement composting toilets developed by the organization Sulabh International. The Foundation believes that Sulabh's toilets will alleviate the high costs associated with fertilizer and health concerns for women. Our team hopes to exchange knowledge with SETCO during their toilet implementation in Katol in order for both parties to optimize the efficacy of their efforts.

Future Plans

Toilets

The future plan for toilets is to begin a human waste composting experiment. This process will take about 6 months to 1 year to complete. The team will replicate the climate of Dolatpura in Ann Arbor to determine the relationships between several key variables involved in the composting process. These variables include temperature, moisture content, as well as amount and type of organic cover material used. At the same time, the team will continue conversations with the partner family to finalize a design. Once the team and partner family have approved that design, the team will develop and test the prototype.

Stoves

The future plan for the stoves sub-team is to monitor the status of the stove design in Dolatpura and stay updated on any adaptations that are being made by the stove builders. In addition, further prototyping in the US will continue, using fewer or different materials to investigate possible solutions to cost, safety, and durability concerns raised by the residents of Dolatpura. To conduct a thorough quantitative assessment of our stove design, the team will develop a comparative validation protocol. This will allow team members to collect data from tests like water boiling and controlled cooking for a direct comparative analysis of our design to the existing stoves. In addition, the team will begin working on a two burner version of the stove, as most families prefer them.