Introduction

BLUElab India is a student run project team under the umbrella organization of BLUElab (Better Living Using Engineering Laboratory) at the University of Michigan. BLUElab's mission is to co-design sustainable, appropriate technology with partners abroad and domestically. This involves a gate process that focuses on determining the need of the community before attempting to co-design and implement technology. There are several teams that operate under the BLUElab umbrella in different parts of the world. BLUElab India works in a small village called Dolatpura near a larger town called Kalol in Gujarat, India. We are partnered with the SETCO Foundation, a non-profit organization run by relatives of a University of Michigan alumnus that does humanitarian work in the government-built anganwadis (early childhood education and community centers) in and around Kalol.

BLUElab India lends technological expertise to the Setco Foundation so that technological problems, specifically ones that have to do with health, can also be addressed. In addition, BLUElab India team members have relatively unbiased views of Indian culture, allowing us to work with the community and gather information without the influence of preconceived notions.

This past May, six members of BLUElab India's fifteen-member 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 focus on the small agricultural village of Dolatpura and on two problems that the villagers are facing. These two problems are the inhalation of cooking smoke and the lack of discrete, affordable toilets. Moving forward, the team will work to co-design sustainable stove systems and economically viable septic tanks. This report summarizes how we came to this conclusion as well as our plans moving forward.

Past Progress and Achievements

BLUElab India was started the fall of 2013, and we spent the first semester doing research on water-related technologies, on-site water testing, and how to recognize water-related problems. The Setco Foundation, and general research about the region, had given us the impression that water related technologies would be our primary focus. However, we also did research on doing a needs assessment because we had planned our first trip to the area to be May 2014. We hoped to work with the community and establish a need so that, moving forward, we could work in a valuable and relevant area. Because of this, during the Winter 2014 semester, we explored ethnographic research strategies in addition to the water-related technology. As part of our needs assessment preparations, we discussed Indian culture, practiced interview techniques, and attended an entering and exiting communities workshop. To give ourselves a context for water related needs and solutions, in addition to doing research, we prototyped biosand and ceramic filters.

In May 2014, six team members of BLUElab India, including four engineers, a business student, and an economic development major that also speaks Gujarati (the local language), traveled to Gujarat for a month-long needs assessment site visit. The goals of the trip were as follows:

- **Build connections in the community**: informal relationships built by chatting and playing frisbee that are important to success of a technology
- **Establish professional contacts**: villagers who we would work with to co-design and implement technology (as well as contacts in government or industry)

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- **Determine needs**: primary goal of trip (needs would determine focus for next stage of project)
- **Develop capacity and expertise**: practice valuable skills like interviewing people, overcoming a language barrier, and entering a community
- **Documentation**: record information for remainder of team back home so that we could pass on our new knowledge

BLUElab India's needs assessment trip in May 2014 started with a broad-focused approach, and the scope of the project narrowed to the village of Dolatpura after two weeks focusing on the greater Kalol area. Initially, at the request of the SETCO Foundation and in an attempt to gain initial familiarity with the area, the team (we) visited every village with a SETCO anganwadi, in addition to the Gujarati Water Supply Initiative Water Treatment Plant (WTP), and a water testing facility in Godhra. In the first two weeks, we began to gain an understanding of life in the greater Kalol area and made significant progress with water testing and water mapping.

As we learned about the water cycle and the daily lives of individuals, we realized that most of the information we had gathered varied by location. We also noticed that we had not made much progress in diffusing the "novelty factor", and that we were having difficulty building relationships because of our constant movement. As a team, we decided to narrow our focus to a small agricultural village called Dolatpura in order to build stronger relationships and gain a deeper understanding of the needs of a single community. We chose Dolatpura primarily because of its relatively small size, geographic isolation, and economic difficulty.

We spent our last two weeks in India visiting and interacting with people in Dolatpura. Our narrow focus consisted mostly of gathering information through interviews, both formal and informal. We also surveyed the area physically, interacted recreationally with children and adults alike, and delivered a presentation to the community. We feel that the decision to narrow our focus proved effective in both the formation of relationships and the gathering of information. In fact, our needs assessment enabled us to pinpoint two significant needs of the community of Dolatpura.

Summary of Project Aims/Discussion of Problems

Our needs assessment site visit opened our eyes to a clearer picture of the needs of the people in Dolatpura. Through our extensive ethnographic research and information gathering, we were able to identify concrete needs that were directly communicated to us from members of the community. With the addition of our own observations, we whittled down the long list of potential projects and eventually settled on our two project foci for the 2014-2015 school year:

1. **Control and/or elimination of harmful cooking smoke**
2. **Sustainable septic tanks**

As mentioned above, contrary to our expectations, we did not find conclusive evidence to suggest that the drinking water is causing systematic sickness or discomfort in Dolatpura (or other villages, for that matter). However, we used Coliscan Easygel to test for fecal coliforms (including *E. coli*) and observed that many water sources *were* contaminated with bacteria. Below is a summary of our data from Dolatpura water testing:

Source	Date	Total Coliforms (/ml)	E. Coli (/ml)
Sump	5/7/2014	60	1.4
Anganwadi Storage	5/7/2014	50	2.2
Direct from tube well	5/12/2014	2.8	0
Home 2 Storage	5/12/2014	1.2	0
Water flowing into sump (direct from tube well)	5/22/2014	1.2	0
Water Tower (dilute Chlorine)	5/22/2014	0	0
Home 1 Storage (steel pot)	5/22/2014	0	0
Anganwadi Storage	5/22/2014	12.6	0
Tap	5/29/2014	9.4	0.4
Drinking water storage	5/30/2014	29	0.2
Cleaning water storage	5/30/2014	9.4	0

The above data should be taken with a grain of salt; because the tests were not lab-grade, and became less effective over the course of the month, we can only use these data to confidently conclude whether or not coliforms are present, and not to conclude the magnitude of contamination.

Even with Coliscan tests that indicated contaminated drinking water, we were unable to tie the test results to poor human health. We talked to many people, and were unable to find a pattern of poor digestive health, diarrhea, nausea, etc. Perhaps there is a connection between health and water quality in Dolatpura, but further research is necessary to make a conclusive assessment. For now, our work suggests that we should focus our efforts in other areas.

This change of plan is exciting; the very fact that our trip to India resulted in a change of focus is a testament to the power of a well executed needs assessment. Below is a summary of our findings in the areas of Cooking and Septic Tanks.

Cooking Smoke

Women are the primary cooks in Dolatpura. They often spend multiple hours per day cooking for large joint families. From speaking with many women in the village we were able to learn a lot about the cooking system. Cooking stoves are usually small pits surrounded by stone or dung, and can be indoors or outdoors. They are specially designed to hold curved pieces of clay to cook rotla: flat bread made from a grain grown in the village. Below is a picture of a standard stove in Dolatpura. The fuel for these stoves included dried dung, dried corncobs, and wood.

Figure 1: A standard cooking stove used in Dolatpura. Note the shape and the rotla cooking.

There are two main problems with the cooking system: smoke and improper ventilation. In regards to smoke, the fuel used for cooking creates a thick, black, unhealthy smoke that irritates the eyes and lungs of the cooks. Evidence of the black smoke can be seen on walls, ceilings, and overhangs, which are stained black. Houses with indoor stoves often do not have adequate ventilation, leading to property damage and harmful conditions for the cooks. Even outdoors, ventilation is an issue. In one home, for example, the outdoor stove is placed under an overhang made of sticks and branches, which is replaced yearly. This overhang does not have ventilation on the roof; the smoke hits the roof and flows upwards from the sides. As a result, the smoke does not travel directly upward, and instead recirculates after hitting the roof. This phenomenon is evidenced by the blackened underside of the overhang.

Interestingly, we found that women overwhelmingly identify cooking smoke as a problem, yet men tend to downplay the significance. Therefore, there is a gap between what women feel is problematic, and what men feel is problematic.

We plan on addressing this need for a family by eliminating the negative effects of cooking smoke. Although much research and design will go into our final project scope, below is a summary of preliminary project ideas to address this need:

Summary of Potential Cooking Smoke Project Ideas:
1. Ventilation System
- Indoors: Build chimney and/or vent
- Outdoors: Build vents in thatched overhangs and/or chimney

2. Modified Fuel
- Develop sustainable fuel source that produces less smoke
- Potential Fuels: Methane from biogas digester (produced from dung, food scraps, etc.)

3. Portable Stove System
- Placed outdoors for natural ventilation
- Light enough to be easily moved indoors or outdoors
- Potential Materials: Brick, Stone, and Dung

Septic Tanks & Toilets

One of the common complaints we heard from villagers was the lack of working bathrooms in Dolatpura. People estimate that about twenty homes have toilets built by the Nagar Palika (regional leadership). The toilets built by the Nagar Palika consist of a small, brick/concrete, portable-toilet size structure, with a 5-foot diameter and 5-foot deep hole. The villagers are expected to finish the installation by digging an additional 15 feet down and building a septic tank, which costs about 20,000 rupees ($330). Some people in the village said that they could not afford the $300+ it would cost to finish the septic tank under the current system. Below is an image of an outhouse installed by the local government. Next to it is the 5-foot deep hole they started to dig.

Figure 2: The outhouse is on the left and the pit for the septic tank is on the right.

A need for a private toilet was expressed more by the women than the men. Some women were more comfortable than others with relieving themselves out in the open, but most women said it was only acceptable to relieve themselves in total isolation in the early morning or night. Many women said they could only relieve themselves once a day, which is very hazardous to their health, making them more prone to UTIs. The root cause behind this issue is the social stigma associated with women using the bathroom in public or otherwise. Most men replied that they could relieve themselves anywhere. In addition to women, elderly people also wish they had access to toilets. One elderly man mentioned that it was hard for him to walk out to the fields to relieve himself every day, and that it would become even harder as he ages. The same man mentioned that accessible toilets would make it easier for sick and injured people to relieve themselves discretely. Beyond the issues of convenience and comfort, because many people relieve themselves anywhere, the chance of fecal contamination of the water or food supply is much greater.

As with cooking smoke, below is a short summary of potential solutions to this problem:

Summary of Potential Septic Tank Project Ideas:
1. Finish and improve installation of septic tanks for existing toilet

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- Lower costs (main priority)
- Reduce build time
- Increase system life

2. Design a complete human waste removal system for individual homes
- Ergonomic bathroom design
- Low maintenance waste treatment system
- Lower the cost of installation

With both of these projects, we are going to solve human needs problems while working within the confines of cultural and social norms. For example, we see that, in the case of women wanting access to toilets, the root of the problem is the stigma associated with women relieving themselves in public or semi-public places. However, we understand that it is not our place to attempt to change the social norms in the village, and plan on working with them, not against them. For similar reasons, we quickly ruled out community toilets as a viable solution to this problem. Working with the culture will help us create more effective solutions while maintaining good relationships in the town.

Remaining Project Plans

BLUElab India has a concrete plan for the entire project process from Fall 2014 through June 2015. Drawing from BLUElab's structured "Gate Process," we have developed a timeline for the Fall 2014 and Winter 2015 semesters, in addition to Dolatpura site visits in March and May of 2015. Measures of success are built into each stage of this timeline to ensure that we stay on track to accomplish our goals. Additionally, in order to progress through select important stages in our timeline (called "Gates"), we must seek and obtain feedback and approval from our two faculty advisors, graduate student advisor, and peers on the Executive Board of BLUElab. These checks hold us accountable for our progress and guarantee that our work is held to the highest standard. Below is a figure that illustrates the BLUElab gate process.
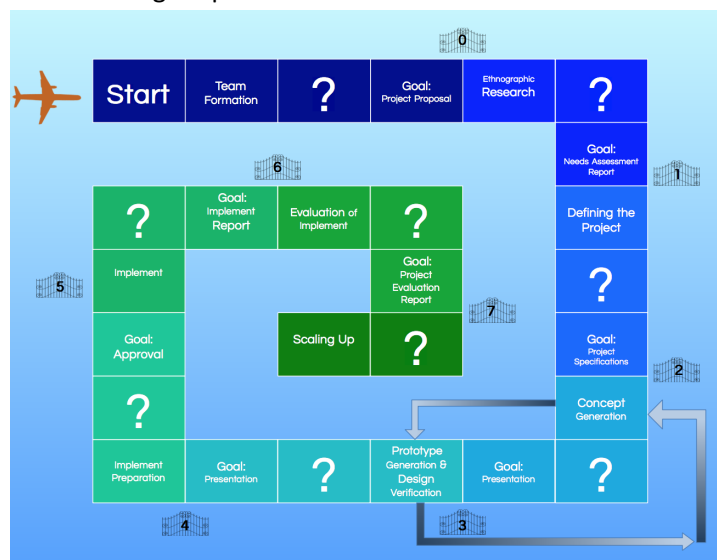

Figure 3: BLUElab Gate Process

Fall 2014

The overarching goal of the Fall 2014 semester is to prepare the team for designing, building, testing, and iterating technology in the Winter 2015 semester. To accomplish this goal, we will thoroughly research stove, ventilation, toilet, and septic tank technology, in addition to related areas. Our method of choice is a comprehensive literature review (Internal Due Date: Nov. 3); we will familiarize ourselves with basic design models, past designs, and cutting edge innovation related to our projects. This body of research will enable us to draw from an extensive pool of knowledge when designing our own technology. Once the literature review is complete, the two "sub-teams" (Stoves/Ventilation & Septic Tanks) will present summaries of their literature review to the entire team.

Moving forward, the team will make contact with and begin to develop relationships with two specific families in Dolatpura. Our non-profit will help facilitate the logistics of choosing specific families and communicating remotely. This step is critical; before we move on to concept generation and design, we must have specific design requirements applicable to specific people. This milestone marks the beginnings of "co-design": designing technology *with* people in Dolatpura instead of designing technology *for* people in Dolatpura.

Once we understand the specific design requirements related to each family, we can seek approval from the BLUElab Executive Board and our advisors to pass through "Gate 2" (see above for a visual representation of the Gate Process). After passing Gate 2, BLUElab India will be in the Concept Generation phase. Drawing from our body of research in the literature review, we will brainstorm several (or many) general design ideas to work on. From here, the team will begin to design these concepts with the intention of eventually building them. In early December, the team will have a "Progress Review", where team members will present the current state of their concept generation and design work.

The ultimate measure of success in Fall 2014 is whether or not the team is prepared to begin the design, build, test, and iterate process in Winter 2015. To fill a critical skill gap, all team members will receive training with safety, tools, and heavy machinery from the Wilson Center to prepare for build sessions. If the literature review and concept generation are complete (in addition to some preliminary design), the team will be well prepared to build technology. With the addition of making consistent contact with two specific families and developing real design requirements, the team will be prepared to build *sustainable* technology.

Winter 2015

The goal of the Winter 2015 semester is to develop sustainable, effective technology with two specific families (one for each project) and prepare the team for site visits in Dolatpura. To accomplish this goal, we will build on the design work done in Fall Semester, and progress into the "design, build, test, iterate" process. In addition, BLUElab India leadership will assemble diverse, skilled teams of people to travel to Dolatpura during Spring break and in May, and then begin intense cultural and social preparations.

The first step in the Winter 2015 process is to finish the initial design phase and begin building prototypes in the Wilson Center. This phase is extremely fluid and flexible; some concepts or designs may be scrapped after building and testing in the Wilson Center. Other concepts or designs may be more promising, warranting iteration to refine the design and prototype. The end goal of this phase is to

present one or more valid designs and prototypes for each project in a Design Review. After seeking approval and feedback from our support system, this Design Review signals the completion of Gate 3. At this point in the process, we will have one or more effective designs (with working prototypes) that are in-line with each family's design requirements.

Travel preparations will begin shortly after the start of the second semester. We are planning on traveling for the entire month of May 2015, to conduct a feasibility and implementation site visit. We are also considering traveling for one week in March 2015 to supplement the feasibility component of the project. BLUElab India leadership will carefully select (from a list of applicants) one or two small teams of people to travel for these site visits. Six people will travel in May, and four people will travel in March (if March site visit is finalized). Half of each team will be composed of team members that traveled to Gujarat last May, in order to bring experience and familiarity to the table. It is extremely important that we bring familiar faces back to India each year to maintain continuing relationships. Additionally, the teams will be evenly balanced by gender to help navigate social norms in Dolatpura. Remaining skills will be thoroughly covered by the team composition; for each team we will ensure that at least one team member speaks Gujarati, and that each project is evenly represented.

Once the travel teams are selected, we will begin an intense phase of cultural and social training to prepare the teams for their upcoming experiences. All team members will gain a basic understanding of social norms, common Gujarati phrases, and important aspects of the local culture. Much of this training will be based on the prior experiences of those that traveled to Dolatpura in May 2014. After the completion of this training, team members will be prepared for site visits.

Implementation of Solutions

The culmination of our intense preparation during the 2014-2015 school year will be the month-long site visit in May 2015. The main goals of this trip are to access the feasibility of implementing one or more of our designs and then implement the actual technology. The specifics of this trip will be planned in Winter 2015, but the BLUElab Gate Process dictates the general outline of this trip.

The first one to two weeks of the trip will be spent accessing the feasibility of implementation. This process involves ongoing communication and interaction with the specific families we will have been working with remotely all year. We will compare the remotely gathered information to the actual conditions in the village and access whether design changes need to be made. We will also ensure that design requirements are still clear to both our team and the families. If we deem our design to be feasible, we will move on to the implementation phase.

During the implementation phase, we will work with the specific families to build the designated technology. We will prepare visually intuitive and detailed construction, maintenance, and normal use instructions to share with the families. A critical aspect of implementation is working with these families. Because BLUElab emphasizes co-design, we feel that the families must feel enthusiastic and extremely invested in the project for it to be sustainable. To achieve this during the implementation trip, we will work around the families' schedule and require that they put in some construction time along with our team members. This requirement will boost the sense of ownership on the part of the families, as well as aid in passing along technical knowledge to the people who are actually going to use the equipment.

After successfully completing construction, we will continue traveling to the village for the rest of the trip to monitor the performance of the technology and gauge the level of enthusiasm and

commitment from the families. This final part of the site visit will allow us to fix any problems, and make sure that the owners of the new equipment are well equipped to use it and perform their own maintenance when needed. This, especially, is why the technology needs to be simple, effective, and easy to maintain. Throughout the summer and following school year, we will routinely call to check up on the status of the families and the technology. We are committed to sustainable technology; a septic tank that breaks and goes unused after one month is not sustainable!

We are also considering traveling for a week during Spring Break in March, 2015. The purpose of this trip would be to get a head start on the feasibility aspect of implementation. Whether or not we decide to pursue this venture depends on availability of funding, state of the project, and estimated build times for technology. If it turns out that we will need extended time in May to build, a Spring Break trip may be necessary.

Long Term Goals

There are two directions we could take our project in the long term and our long term goals are likely a combination of both. As we continue to maintain our relationship with the people of Dolatpura, we may explore other problems that the community is facing and work to co-design technology to address those problems. This would ensure that future members of BLUElab India get some experience in needs assessment, co-design, prototyping, implementation, and design iteration. Another possibility is the expansion of any successful technology that we develop. The first step would be to spread the technology to other families in Dolatpura, and then, after working with the people of Dolatpura to iterate on our design, spread the technology to other villages that experience similar problems and express a desire for technology to lessen them. We will utilize the logistical expertise and help of our non-profit partner to help make these decisions.

While it would be nice to implement two or more successful technologies in a number of villages in rural Gujarat, long-term success of our project will be measured by the strength and quality of our relationship with our partners in rural India. Ultimately, we would like to continue to address the needs of the community, regardless of the area in which the solutions lie. Perhaps, in the future, our contribution will be an improved education system in an early childhood education center or a several-week long English language workshop. Our group brings an outside perspective, a dedicated group, and a lot of enthusiasm to our half of the "co-design" equation.

Proposed Budget

Category	Item	In USD
Travel (March 2015)	Flights (feasibility site visit)	6,000
Travel (May 2015)	Flights (implementation site visit)	9,000
Travel (March 2015)	Miscellaneous travel and lodging (i.e. in-country train tickets)	1,000
Travel (May 2015)	Miscellaneous travel and lodging (i.e. in-country train tickets)	1,200
Prototypes (pre-India)	Materials for prototyping septic tanks systems and stove/ventilation designs	1,000
Prototypes (in-country)	Materials for prototyping septic tanks systems and stove/ventilation designs	1,000
Surveys/Test	Materials for surveys or tests (i.e. water tests or paper)	200
Miscellaneous	Portable phones, workshop materials, other unforeseen costs	500
Future	Future travel (design iteration site visit), materials, etc.	15,000
Total		34,900

With half of the funding we have requested, we could do a feasibility site visit and an implementation site visit; however, it would become difficult to iterate on our design or address any unforeseen problems that require another immediate site visit.

Conclusion

BLUElab India is committed to working with families in Dolatpura to improve human health and standards of living. With the help of BLUElab, our advisors, our non-profit partner (Setco Foundation), and The DOW Sustainability Fellows Program, we feel confident in our ability to research, design, and engineer sustainable solutions to major problems in Dolatpura. We have a strong support system that will check our progress and keep us on the right track. In terms of financial support, funding from this program will help fund our site visits and facilitate face-to-face interaction between our team and families in Dolatpura. It is incredibly important that we maintain real connections with people in the town; virtual communication alone is not enough to accomplish this.

Thank you for considering our proposal; we look forward to your response.