

Isabel Barnet  
Jessica Horowitz  
Hye Yeon Oh

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## **Progress Report**

### **I. Summary**

In Santa Caterina Palopó, Guatemala, inefficient firewood stoves or open fire cooking are the cause of many problems for the women usually in charge of preparing meals. Poor firewood combustion and smoke leaks lead to health problems and the inefficiency of the current designs result in longer times spent on preparing food. To address this need for a less harmful and more efficient (in terms of heat and time) firewood stove, a prototype called the Chaparra Redonda was developed by the women of Santa Catarina during an earlier International Development Design Summit.

From September 2020 to March 2021, our team took on the continuation of the Chaparra Redonda project and aimed to further improve on the effectiveness of its current design that will also address user feedback on mobility/modularity. We worked with our community partner Link4 and also the women of Santa Catarina, who are the intended users for this project. Through this report, we will present our findings and design progress. Hopefully, this will be of help to the relevant parties and those who may be interested in this project.

### **II. Goals**

We have been working with a group of indigenous women from Santa Caterina Palopó, a small, rural community in Guatemala, to improve their current firewood stoves. Through D-Lab funding, collaboration with local women and Link4, and feedback on a previous prototype (Chaparra Redonda), our project aims to design a more user-friendly, space-efficient, structurally-sound firewood stove that can be adapted by the community. Ultimately, we hope this stove will promote safe and efficient cooking without compromising the cultural traditions of preparing a meal, thus helping families save time and money in the long term and providing women with more independence.

### III. Stakeholders

Our two key stakeholders are the following:

#### 1) Link4

Link4 is our community partner - they are a “social company that fosters local innovation and sustainable development through design education.” We will be working with co-founder Omar Crespo and Majo Sáenz from Link4 to better understand the background and culture of the Santa Caterina village and help them deliver results to the earlier Chaparra Redonda through our project.

#### 2) The women of Santa Caterina

The women of Santa Caterina are important stakeholders as they are the intended users of our final stove design. The aim is for them to benefit from the improved stove design that will allow them to cook nutritious and tasty meals for their families, while being less harmful (from reduced smoke) and more efficient in terms of time and money (improved heat distribution and consumption), when compared to a standard firewood stove or open fire methods to prepare food. We will be communicating with these women to better serve their needs through Link 4, which will help with overcoming the language and cultural barrier.

For a more extensive stakeholder analysis, please see Appendix 1.

### IV. Sector Research

Our project is a continuation of the Chaparra Redonda (Appendix 2); hence the detailed report on the Chaparra Redonda will be an insightful reference for us to understand the trials and errors of the previous exploration. In brief, the Chaparra Redonda was a round firewood stove that had two combustion chambers, which increased fire efficiency. However, it had initial feedback that it was too heavy and needed to be more mobile. We hope to improve on this, along with other user needs that we uncover throughout the project.

Regarding cookstoves, data and sources from the Clean Cooking Alliance have helped us gain a preliminary knowledge of firewood stoves usage and alternative stove designs/ technology advancements - specifically, the Handbook for Biomass Cookstove Research, Design, and Development and Guide to Cookstove Technologies and Fuels. Resources from the Alliance will be an important source of further information as we progress with the project.

## V. Methods

The first focus of our project was gaining an understanding of Guatemalan culture, politics, economics, and present-day issues. We assessed current events surrounding COVID-19 and vulnerable populations, the mining industry, and the Maya Biosphere Reserve. Through our sector papers and book reviews, we dove deeper into specific topics and histories.

We then began contextualizing the cookstove project by completing a stakeholder analysis. By discussing questions that had arisen with Libby and Omar, we were able to gain a more complete understanding of the project.

The key to our approach was continuous communication with the intended users of the stove - the women of Santa Caterina. Starting with a 1-hour discussion with Sandra, Alma, and Rosa, we began assessing user needs. We approached this by asking open-ended questions about how they spend their time on a typical day, what kinds of foods they prepare, and what joys and challenges they find with cooking. We consolidated these needs in a spreadsheet and analysed them in Miro by completing a Theory of Change. To determine which needs should be prioritized, we created a document with questions and a spreadsheet that Majo sent to the women. We separated each individual need into four main categories: design, feasibility, fuel, and functionality.



Our next focus was on brainstorming ideas and gaining a technical understanding of the design parameters for cookstoves. The first phase of brainstorming focused on three main design topics: stove dimensions and functionality, and modularity. However, we felt that the brainstorming process would be more enriched with input from the women and organized a virtual co-creation session where the women shared and explained sketches about three features: modularity, chimney, and workspace.

A synthesis of these ideas followed and we continued by developing these ideas into early sketches and later CAD models. Throughout the process, we have had additional feedback sessions with Omar and Majo for iterations to improve the designs.

We are continuously communicating with the women as we discover new design considerations and weigh the tradeoffs of various features in the design process.

Communications have been organized through a collaborative Google Drive folder, Miro, and a Whatsapp group chat.

In terms of stove design and functionality, our ideas (Appendix 3) include creating a hexagonal plancha, which would be ergonomic, space-efficient, and conducive to the addition of modules. We explored simplistic cinder-block designs and stoves on wheels for increased mobility. We considered that modularity could be fostered by including multiple combustion chambers to modulate the amount of surface area heated. We also explored gravity-driven or automatic intake systems for feeding fuel.

For fuel efficiency, we are considering creating a combustion chamber with geometry and features that accommodate turbulence, optimize airflow, and facilitate high temperatures. We are also looking into lightweight structural/refractory materials and effective and available insulating materials to be placed in the body of the stove.

## VI. Findings - User Needs

Below is a list of key user needs we found throughout the project. These will be explained with the background context and knowledge we have gained about the community from speaking with our partners and users.

### 1. The stove and plancha are an ideal size

#### a. Dimensions

Family Size	Plancha area (cm)
5-6	30 x 50
8-10 *biggest needed	60 x 50

These measurements for the stove were recommendations from Rosa and Omar, upon a review of our preliminary designs.

- The height should be 85 cm. The women in Guatemala are on average the shortest in the world at 1.51m<sup>1</sup>
- 30 x 50 cm (or 40 x 40) is suitable for a family of up to four (this may even be on the larger size) and two modules would be enough to cover the cooking needs for even the larger households, which are also common in Guatemala

#### b. Number of burners

Again upon Rosa's experience and knowledge, **four concentric burners** on the plancha would be most ideal with larger sized-burners at the front and smaller ones at the back.

*On the right is an example of the concentric burners that are commonly used in Guatemalan stoves*



<sup>1</sup> <https://www.worlddata.info/average-bodyheight.php>

## **2. The stove is made of accessible and affordable materials**

- Cinder blocks
- Bricks
- Wood
- Metal

## **3. The stove is modular**

Culturally, there are large households in Guatemala with an average of six people, but the size also goes through many changes depending on the circumstance. Larger households can reach up to 15 members. In order to accommodate this **changing size of households**, the modularity idea was suggested by Omar from Link4

By 'modularity', we are referring to the idea that the stove can be used as not only a single unit, but combined with several units to form a larger stove setup. Besides the feature to have a larger stove top surface, modularity provides the following advantages:

- a. **Fuel efficiency** - due to the ability to adjust the section of the stove lit at different times
- b. Ease of **maintenance**, repair, and replacement of parts.
- c. **Mobility** - due to the reduced weight of the individual pieces

## **4. The stove has an effective chimney system**

Household air pollution from cooking and heating contributes to nearly 4,500 deaths every year due to particulate matter from open wood stoves which can cause respiratory and other ailments.<sup>2</sup> To reduce smoke in homes, the chimney should be effective at redirecting smoke outside. It should be modular to fit custom stove configurations and made from accessible materials, but it must be as **air-tight** as possible.

The chimney must be able to interface with the layout of various types of homes. Some homes in Santa Catarina are multi-family homes with multiple stories, so the chimney may need to go through thick walls on lower levels. Homes with roof access may find it easier to cut through roofing to fit the chimney. Therefore, the chimney design should be **flexible**.

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<sup>2</sup><https://www.cleancookingalliance.org/country-profiles/focus-countries/2-guatemala.html>

## **5. The stove has a shelf for drying wood**

A “load” of firewood has 40 logs. On average, a family consumes 3 loads per week. Usually 1 weeks worth of firewood (3 loads) is dried at a time. Therefore, the stove should dry between 1-1.5 loads (40-60 logs) per module. During the rainy season, the wood requires more than one day to dry.

The storage shelf for drying wood should make use of the heat from the stove (i.e. placed beneath the combustion chamber). Each log is cut to roughly 6x6x36 cm, so the shelf must be designed to fit **40-60 logs** in each module.

## **6. The stove includes workspace for cooking preparations**

The women have stated that they like to cook with a preparation table beside the stove, and an auxiliary table behind them. We are looking to integrate a work surface into the modular configurations of the stoves.

## **7. The stove is easy to clean**

The materials that make up the stove should be easy to wipe down, including the stovetop and base. This also includes having a **removable ash-tray** that can be cleaned out as the wood burns, which is something many of the women ideated during the co-design session.

## **8. The stove is structurally sound and durable**

Because the wooden base of the Chaparra Redonda previously failed, we will be redesigning the base into something more durable, while still maintaining mobility, affordability and accessibility of materials.

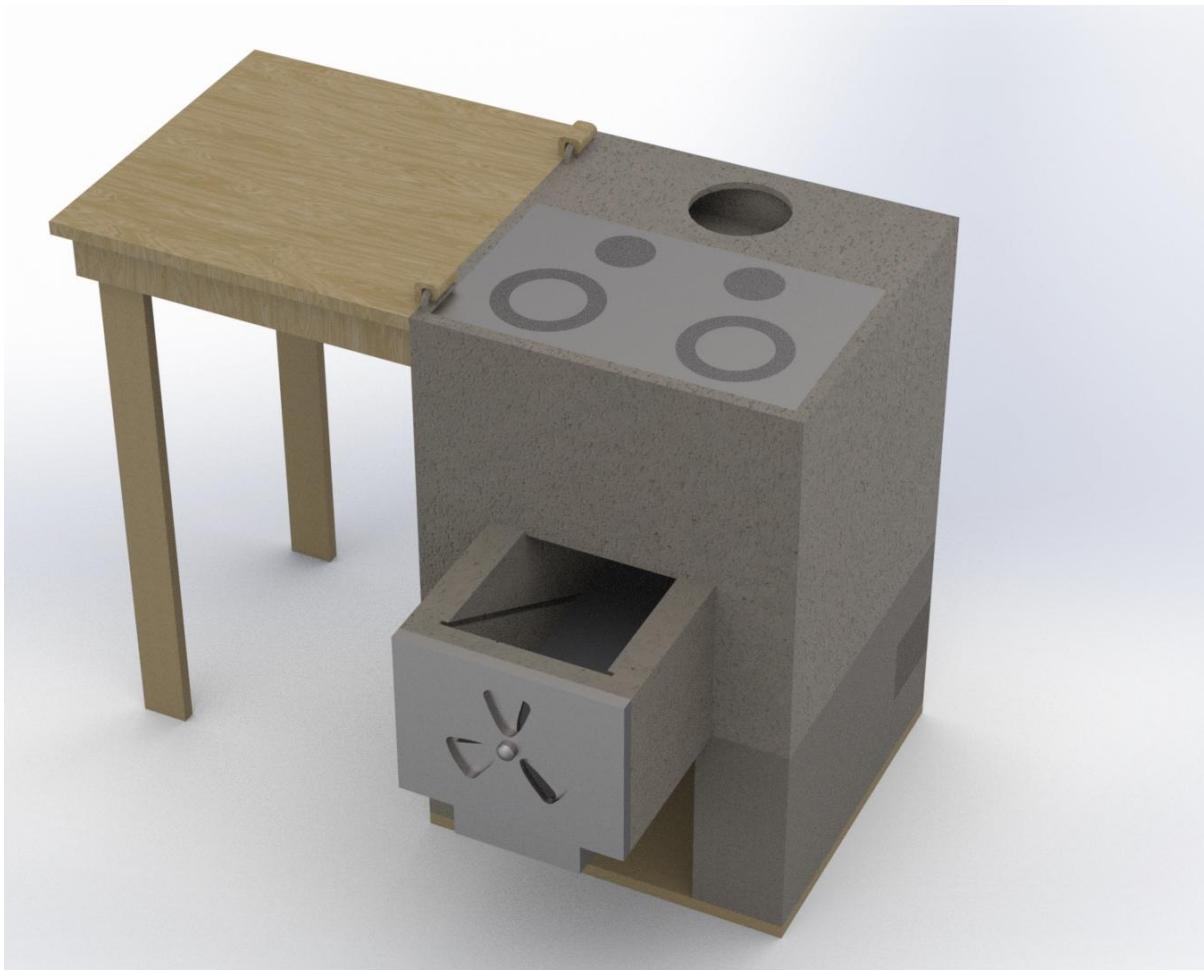
In addition to these user needs, efficient fuel consumption and reduced fire supervision were also important needs that would directly provide improvements in cost and time to the users. However, due to the limited research environment for testing of fire and fuel efficiency, we have decided to focus initially on optimizing the stove’s usability and modularity structure.

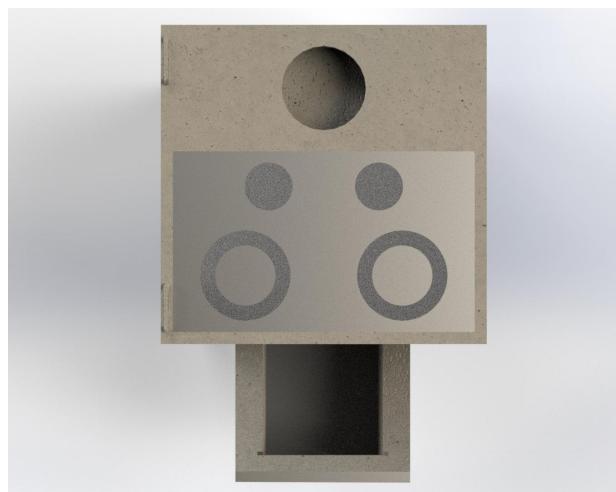
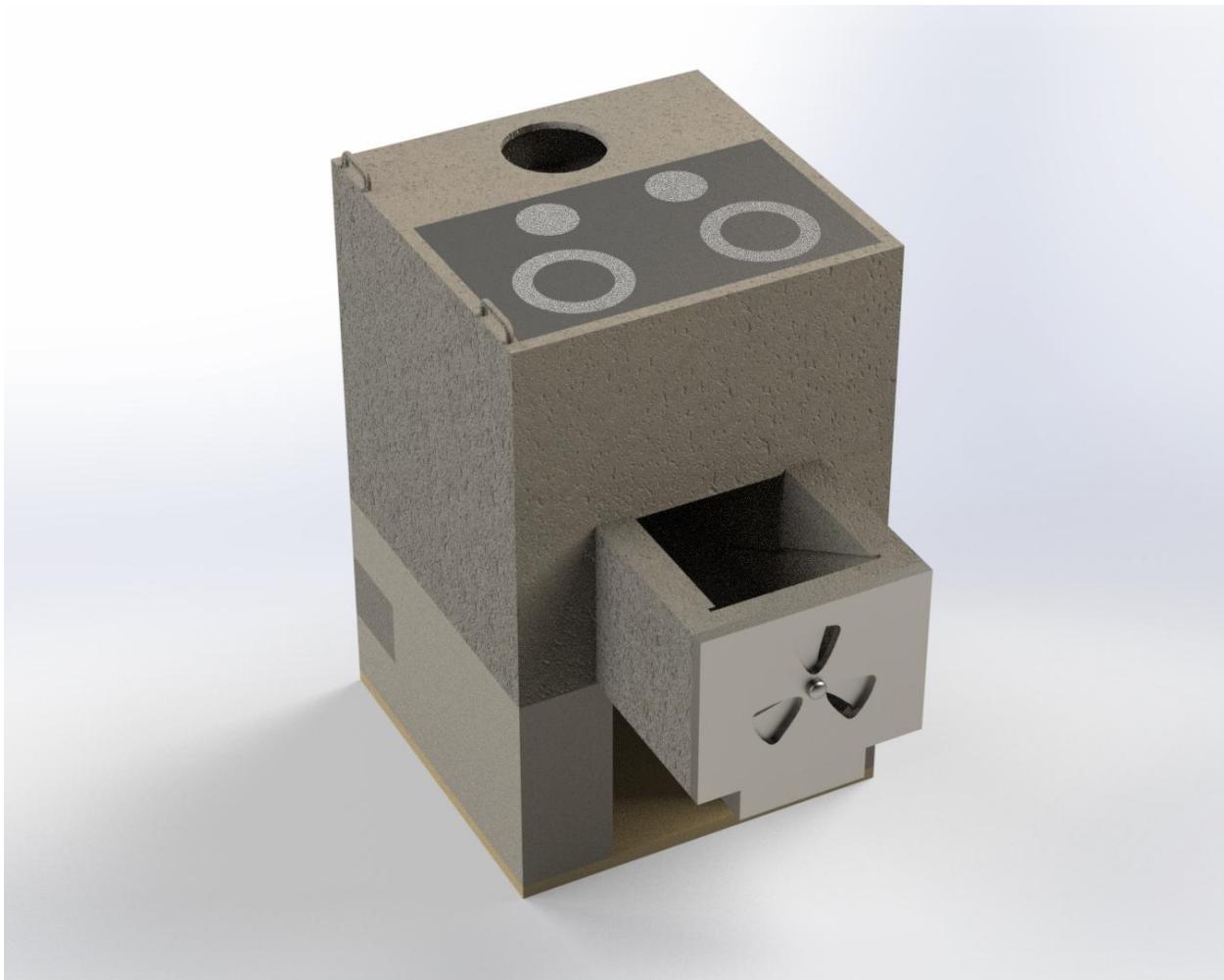
## **VII. Designs**

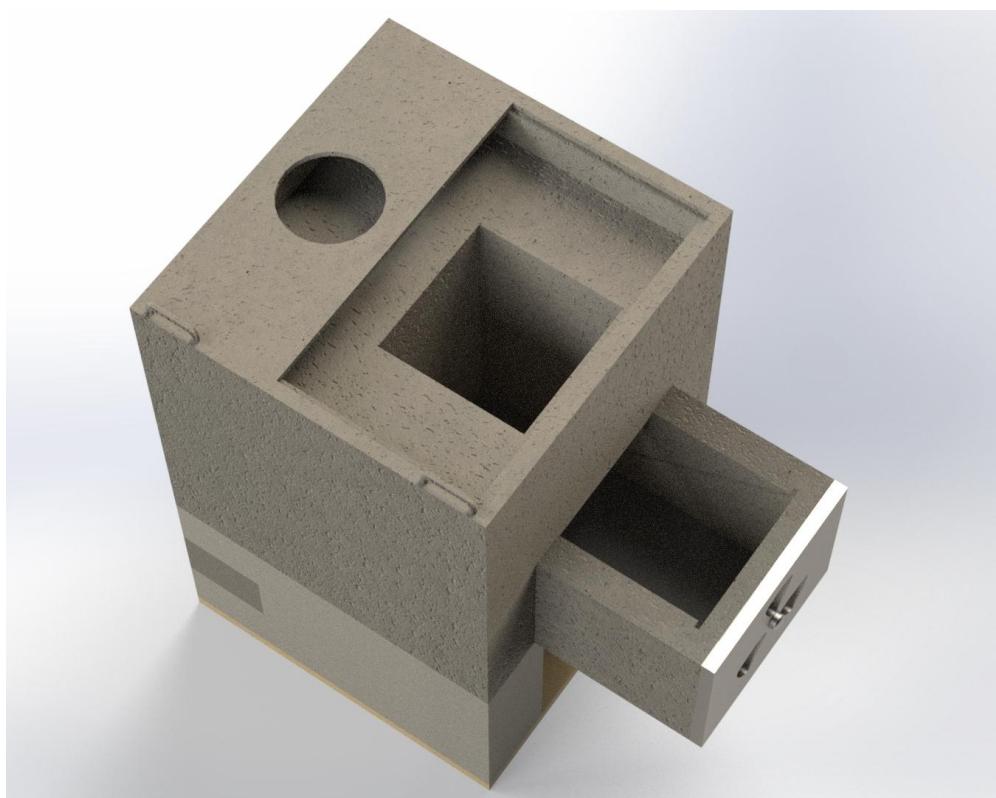
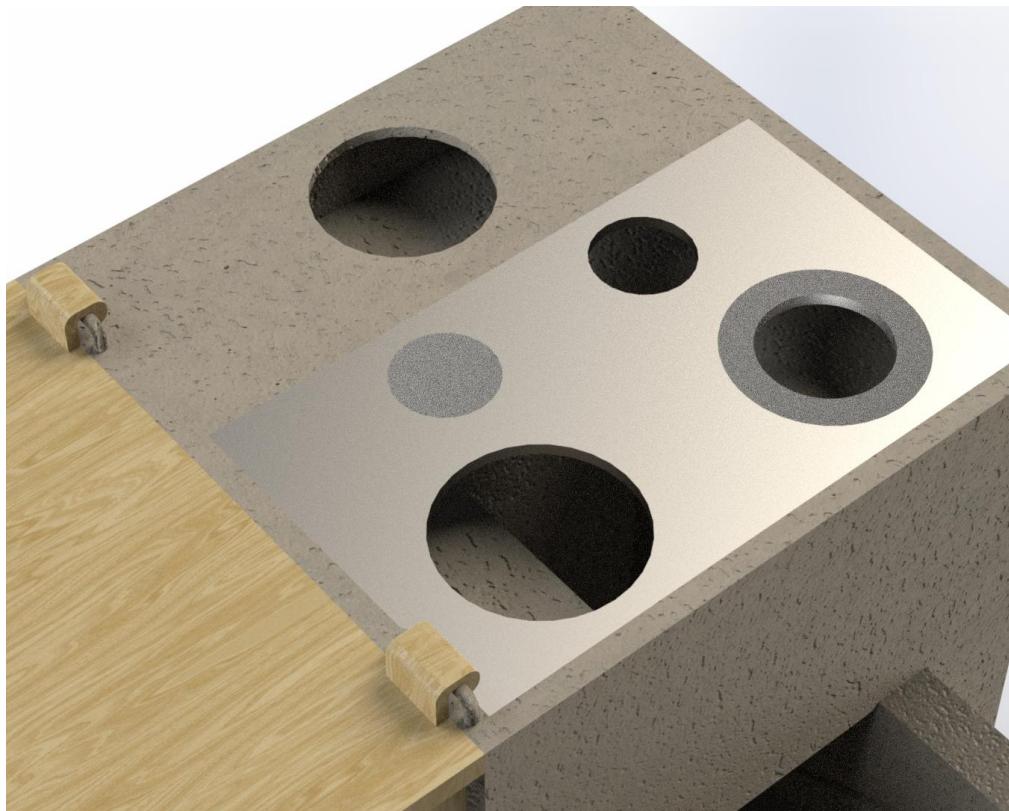
Based on this list, we set out to develop a design that would satisfy as many of the users' needs as possible.

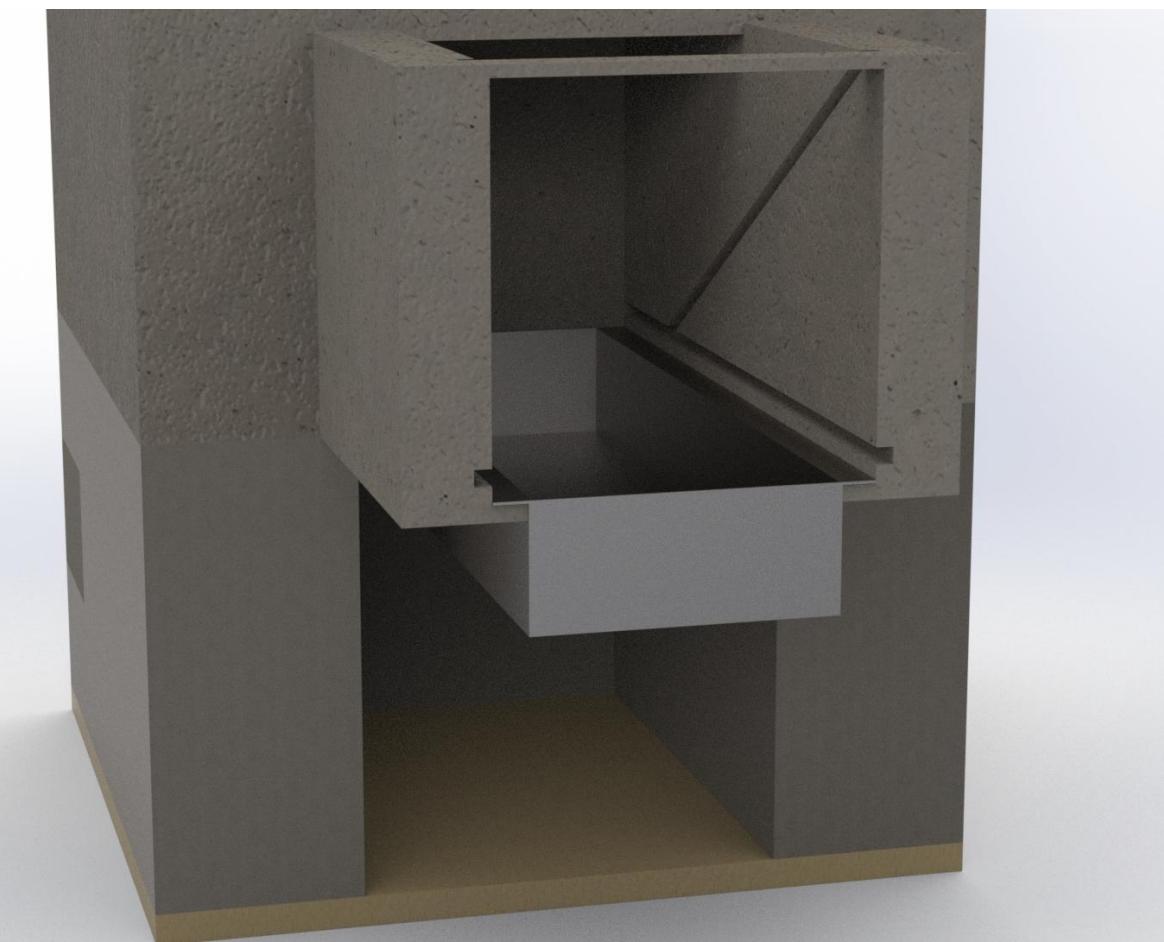
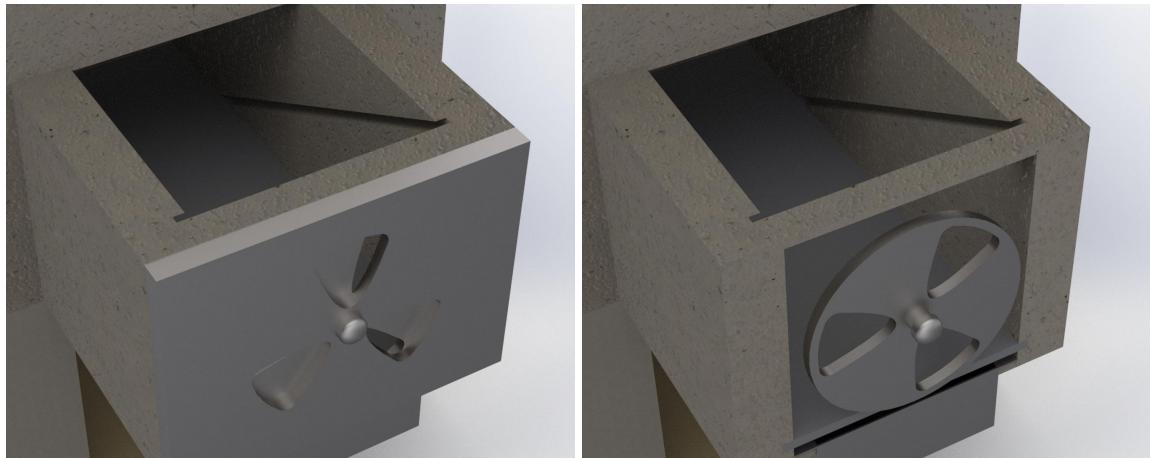
Initially, we explored the idea of a design that would have replaceable stovetops (for example a plancha, grill, comal) that would allow for customization of a stove setup based on a family's cooking preferences. However, we realized that this was not feasible because of the disproportionate use of the different types of stovetops - a plancha was almost always being used (even throughout the night), whereas grills are often used perhaps once a month (hence, most kitchens have a much smaller grill), and a clay comal is no longer as commonly used. See Appendix 4 for an example of a typical cooking schedule and day of a woman in Santa Catarina.

See Appendix 5 for a sketch of our synthesized design concepts. See Appendix 6 for specific dimensions.









- ✓ The stove and plancha are an ideal size
- ✓ The stove is made of accessible and affordable materials
- ✓ The stove is modular
- ✓ The stove has an effective chimney system
- ✓ The stove has a shelf for drying wood
- ✓ The stove includes workspace for cooking preparations
- ✓ The stove is easy to clean
- ✓ The stove is structurally sound and durable

Feedback:

- Removable ashtray - the response was positive as ashtrays are currently not very common; most stoves have just a chamber of cement that becomes dirty. However, this removable ashtray would allow for easy cleaning

## VIII. Moving Forward

In the remaining weeks of the semester, we plan to communicate with our partners in Guatemala to assess locally-available materials and manufacturing capacities as well as clearly outline the specifications and parameters for our stove design. After this, we will brainstorm ideas to create a more modular, usable stove, and develop preliminary sketch models. After the semester ends, we anticipate continuing to work on this project, focusing especially on prototyping and testing remotely to validate our designs and developing a bill of materials and projected costs. We expect to involve our local partners in this process, potentially initiating relationships with remote fabricators. When travel becomes safe once again, we hope to visit Santa Caterina Palopó, as well.

Through the semester and beyond, feedback from Omar, Majo, and the women of Santa Catarina Palopó will be critical in assessing project progress and successfully co-creating an improved stove. Additionally, as we move further into the design and implementation process, we plan to continually reference our list of user needs to ensure we are meeting the essential requirements and prioritizing the voices of Sandra, Rosa, and Alma. Finally, regardless of whether we are able to travel to Guatemala, we plan to use virtual tools and consistent communication for long-term monitoring of the stove after implementation.

## Appendix

### 1. Stakeholder Analysis

#### Part 1: Stakeholder Identification

Stakeholder	Interests at stake in relation to project	Effect of project on interests -, 0, or +	Importance of stakeholder for success of project U = unknown 1 = little/no importance 2 = some importance 3 = moderate importance 4 = high importance 5 = critical player	Degree of influence of stakeholder U = unknown 1 = little/no influence 2 = some influence 3 = moderate influence 4 = high influence 5 = critical influence
MIT D-Lab Team	Develop innovative solutions to improve the Chaparra Redonda's design so that it can be brought to market	+	5	5
	Support women of Santa Caterina by providing a less harmful and more efficient (in both time and heat) stove alternative	+		
Women of Santa Caterina	Cook tasty and nutritious meals for their families	+	5	4
	See their design get manufactured and come to market	+		
	Decrease time needed to tend to stove and increase ability to multitask	+		
	Reduce spending on firewood costs	+		
	Prefer a stove with better mobility (to move around within home)	+		
	Reduce smoke in kitchen caused by firewood combustion, which causes a safety hazard	+		
Link4	Deliver results for the earlier Chaparra Redonda project	+	5	5

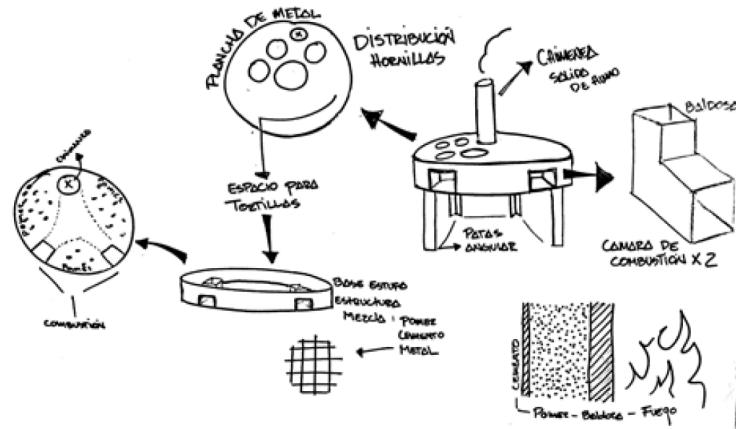
	Involve women of the community in the process for better product adoption	+		
	"Generate a desirable offer that encourages families to invest and change domestic cooking habits daily to improve health and reduce costs in the consumption of wood fuel and the environmental impact"	+		
	Negotiate an affordable price for the resulting stove	+		
Global Alliance for Clean Cookstoves	Ensure 100M households adopt clean cooking solution by the year 2020	+	3 (financing)	U
	"Create a thriving global <i>market</i> for clean and efficient cookstoves and fuels"	+		
	"Focus on high <i>quality</i> approaches that can be brought to <i>scale</i> "	+		
	Bring partners and donors to the table	+		
Guatemalan Government	Provide aid from "aid within the 2023 plan for the adoption of stoves"	+	3 (financing)	1
	Stimulate the economy	+		
Materials Distributors	Earn profit	+	5	3
Local Stove	Earn profit	+	4	2 (option of local
Manufacturer (not women of Santa Caterina)	Have access to the tools and supply chain needed to build the stove	+		manufacturers?)
Stove Distributors	Earn profit	+	5	3 (seems like we're promoting sales of stove to local markets)
	Sufficient consumer demand	+		
Local Bank	Reduce risk for microfinancing	0/-	4 (break the price perception barrier to promote affordability)	2
	Generate interest from loans	+		
Local Health Org	Reduce respiratory illness due to biofuel emissions	+	1	1

## Part 2: Outlining Stakeholder Participation Strategies

Stage in project process	Type of participation			
	Information-sharing (one-way flow)	Consultation (two-way flow)	Collaboration (increasing control over decision-making)	Empowerment (transfer of control over decisions and resources)
Project Identification	MIT D-Lab team		Link4 introduces project	
	researches and evaluates relevant topics (Eg. Guatemalan cooking culture, alternative fuels, current stove designs, Chaparra Redonda)		to MIT D-Lab team	
Preparation & Appraisal	MIT D-Lab team generates design concepts and tests prototypes	MIT D-Lab and Link 4 team interview women of Santa Catarina about their needs		Global Alliance for Clean Cookstoves (I think) finances D-Lab project
Implementation		Women of Santa Catarina provide feedback on prototypes, which D-Lab team uses to iterate design	MIT D-Lab team works with materials distributor, manufacturers, local women to design/prototype feasible solutions	Training local community (manufacturers, residents of Santa Caterina) in stove production, use, and maintenance
Supervision & Monitoring		Link4 shares feedback and information about Guatemalan culture to MIT D-Lab team		
Evaluation	-Users give feedback to D-Lab team on the new cookstove -Financer (GACC) evaluates project			

## 2. Chaparra Redonda - Reference Images

### - How it works



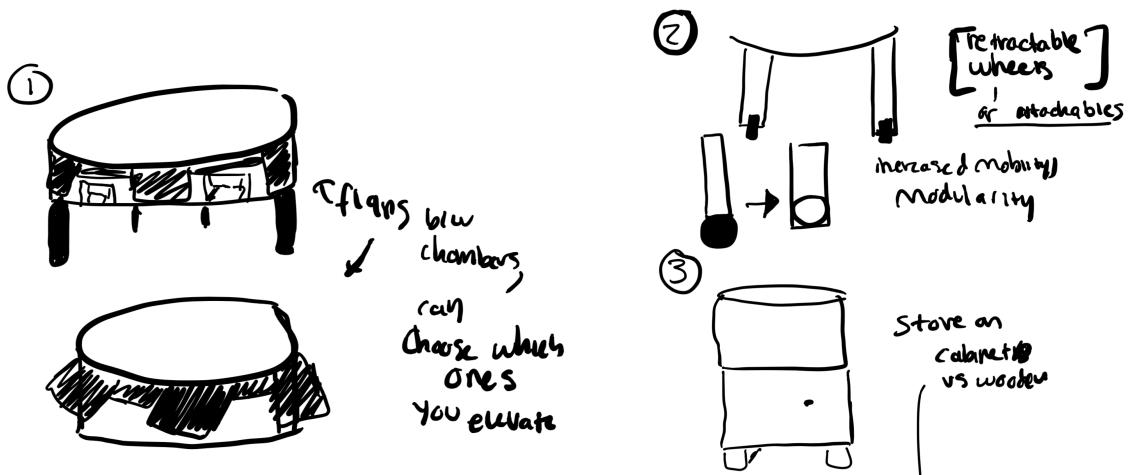
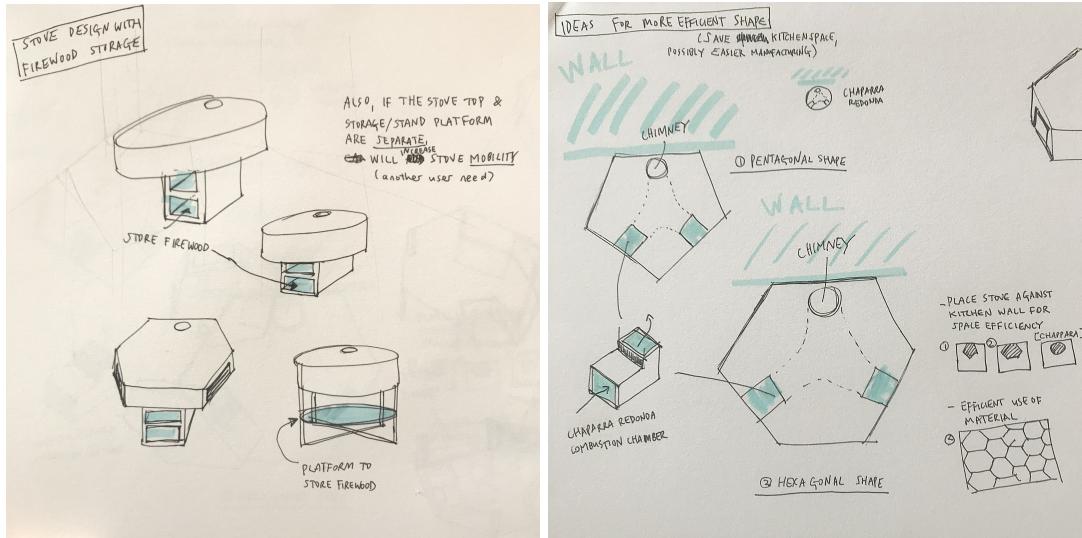
### - Prototype



- Combustion Chamber



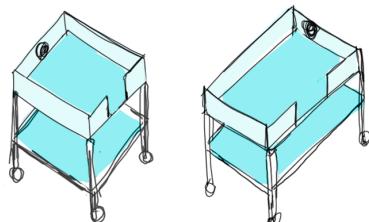
### 3. Previous Design Concepts



(COLOURS ARE JUST FOR EASY REFERENCE)

#### [BASE + MODULAR STOVETOP IDEA]

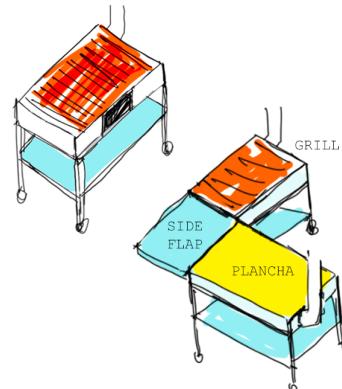
##### - BASE



##### - MODULAR STOVETOPS



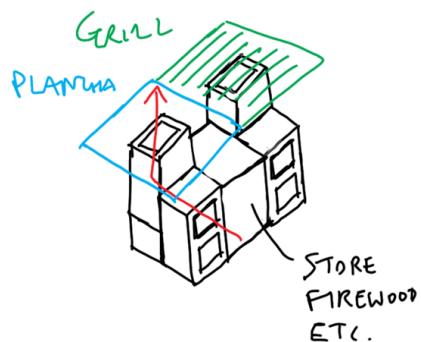
#### EXAMPLE OF ASSEMBLY.



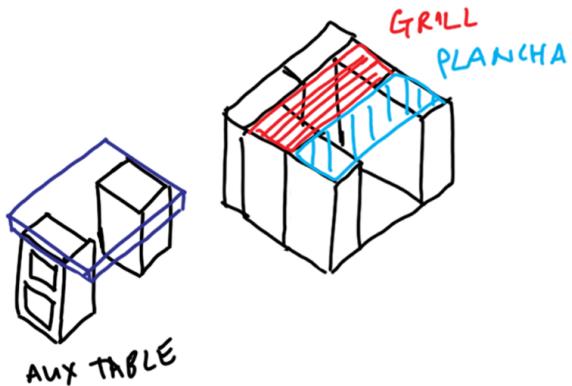
### CINDER BLOCKS FOR COMBUSTION CHAMBER



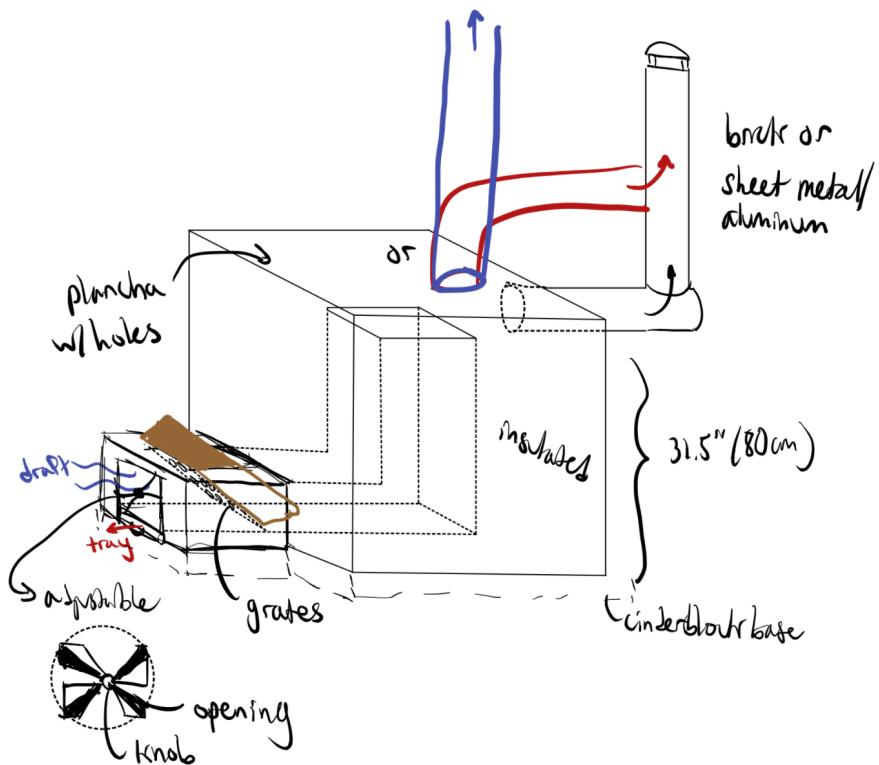
- These cinder block rocket stoves would need a chimney solution



### CINDER BLOCKS FOR STRUCTURE + MODULAR STOVETOP



### gravity feed concept

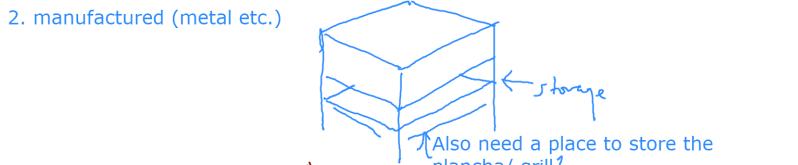


#### 4. Alma's Daily Schedule

Time	Duration	Task
5:30	30 mins	Wakes up, grooming
6 am	5 mins	Starting fire for breakfast
	30-45 mins	Preparing breakfast (typically eggs, beans, coffee, tortillas)
7:30	?	Cleaning house, children help
11 am	30 mins	Preparing fire for lunch
	1-1.5 hours	Preparing lunch (usually tortillas)
2 pm	3 hours	Time for self; weaving; reading
5 pm	1 hour	Preparing dinner
6 pm	?	Reading, studying
?	?	Prepares tortillas for next day
11 pm		Goes to bed

## 5. Synthesized Design Concepts

stove base      1. cinder blocks/ bricks  
Idea: DIY brick base  
- customize ideal shape/ size



stove top

1. horizontal



2. gravity feed



chimney

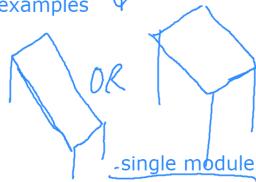
chimney pieces can be assembled-->



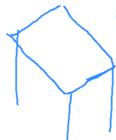
coming out of side

coming out of top

module examples



(1)



(2)



(2)

grill

plancha



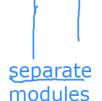
(2)



(4)



(2)



separate modules

