Design of Zeer Pot: A Practical Solution for Food Storage in Kratie Province, Cambodia

ENGR101
Foundations of Engineering

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University of Canterbury

Summary

A Zeer Pot solution was designed for storing food to slow the effects of decay. It uses local materials and skills to keep a food supply secure and sanitary for longer with no electrical energy used and would be put in place throughout individual homes in the three Cambodian Villages, Koh Khnear, Puntha Chea and Ksach Leav. The solution comes with a total material cost of $0.40 (NZD) per Zeer Pot. It is sensitive to cultural and social norms as it has minimal impact to their existing way of life. The design is as simplistic as possible so there is no need for additional infrastructure or external assistance to put the solution in place. Its construction can be taught to locals so once a new one is required they can make a replacement or additional pot themselves. With the use of materials such as natural bamboo, sand and clay, it has an extremely low environmental impact. The sustainability and ease of construction using local materials and skills along with its non-reliance on an electricity supply make this the best solution for the criteria.

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The Problem Statement

Currently, the refrigeration of food at a household level is not common for three adjacent communities along the Mekong River in the Sambo District in Cambodia. The problem given was to find an affordable, low-energy consuming and safe food storage method that these three communities could use.

The solution should use local materials available to the villages and take advantage of their skills to keep a communal food supply secure and sanitary. A significant criteria aspect is that it must be low energy consuming as the villages currently do not have access to grid power supply. They will have to rely solely on batteries or generators to power the solution. These generators are run off diesel and the villages only run them approximately twice a month. This means that the solution must have its own isolated power supply, either running off a separate generator or off solar panels if it uses electricity. One of the three villages is gaining access to the grid power supply however the other two are not, therefore they cannot rely on a continuous supply of power. The problem statement is to use local materials and skills to keep a food supply secure and sanitary for longer with minimal to no energy used and no environmental or cultural cost.

The solution must be affordable as the villages of Cambodia have little income and the solution must be achievable to their income. The solution must be zero or low energy consuming and must take advantage of the local skills and materials as they can maintain and fix it themselves. By making use of local materials it helps keeps the costs down, if it does break, the part does not have to be delivered in. The design needs to be safe, therefore there cannot be exposed circuits or parts that could injure or hurt somebody. Cambodia is prone to flooding and the solution will be exposed to rain and conditions which could potentially make it dangerous, especially if the solution is electrical. The solution also must be sustainable, not only environmentally sustainable but sustainable for the villages. The proposed design should not cost the village a large amount of money as if that trend continues, they will be unable to afford it. The solution must be sustainable over time and therefore the proposed solution must have a long-life span. Finally, the proposed solution must keep food safe and secure. This influences what materials the food can encounter as it must be safe to eat. It also must protect the food from the elements and pests.

The cost of the storage method is also important as communities and individuals cannot afford a costly storage method, it will need to be affordable to everybody. Therefore, a communal food storage method could be effective as this would not only help keep costs down as more families can contribute, but also minimise the use of materials and therefore be more beneficial to the environment. As their diet does not consist of much meat and tends to be fish, it was decided to make the safe storage method cool to a temperature of six degrees. This temperature was chosen as it is a better temperature for storing fruits, vegetables and fish specific to their diet.

Constraints were split into two categories, hard constraints which the required solution must have to be successful and soft constraints which were less important. Our hard constraints were that the design must cool the food to a suitable temperature, keep the food safe and use little energy. While our soft constraints were that it must be safe to use, low cost for materials, total cost of solution is affordable, a usable volume inside the design for the food, able to be easily maintained and sustainable. We weighted each soft constraint out of ten and the weighting were as follows. The team weighted sustainability highly giving it a weighting of nine, followed by the safety and being easily maintained with a weighting of seven. Next was the cost with it being affordable of a weight of six followed by the storage volume of the solution with a weighting of five, lastly the materials which had a weighting of three.

Research and investigation

Food and Decay

The food supply in Cambodia is largely fresh produce. There is much less processed food than in western society. Some common foods include fish, pork, rice, noodles and fresh vegetables (EWB, 2018). An example of the kind of produce sold at a store in Ksach Leav is shown in Fig. 1.

***Figure 1**: Photo of Ksach Leav produce store (EWB, 2018)*

However fresh produce is more prone to decay. Fish, rice and vegetables all have a fairly high risk of causing food poisoning, which is often caused by the decay of the food (Tricket, 2002). There are two main factors that contribute to decay: natural decay within the food; and contamination by micro-organisms (Tull, 1997). Natural decay in foods is caused by moisture loss and the action of enzymes (Tull, 1997). Moisture can be lost either by surface evaporation or, in fruits and vegetables, by the continuing action of the metabolic systems after harvest (Tull, 1997). The function of the metabolic systems in fruit and vegetables cause water loss through the leaves and skin. Before harvest, this moisture would be replaced but after harvest, it isn't. This causes it to shrink, dry out and become limp (Tull, 1997). After harvest, enzymes will also start to break down the cell structure of the food. This changes the texture and appearance of the food as well as making it more susceptible to the decay caused by micro-organisms (Tricket, 2002).

Food supplies an environment for growth and reproduction of micro-organisms. Micro-organisms, specifically pathogenic micro-organisms, can cause illness if consumed. Contamination is caused by their production of waste and toxins (Tull, 1997). Simply ingesting bacteria can also lead to illness (Tull, 1997). The types of foods most susceptible to bacteria are those that have a pH level close to neutral. This includes a lot of the common foods the people in Koh Khnear, Puntha Chea and Ksach Leav will be eating. **Fig. 2** shows the pH of some common foods (cooked rice would sit around pH 6.0 – 6.7). Meat, Fish, vegetables and rice all have a relatively neutral pH level (Tricket, 2002). Bacteria is also more likely to effect foods with a high-water content for microbial growth. This also includes meat, fish and vegetables (Tricket, 2002).

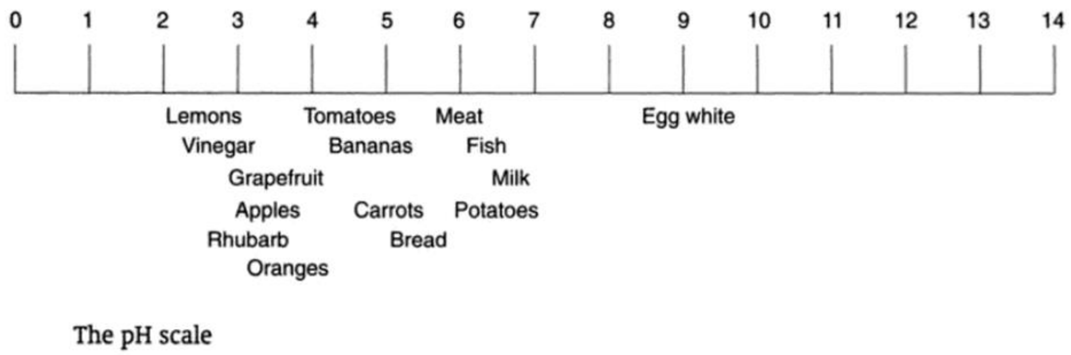


Figure 2: *The pH level of some common foods. Rice sits around 6.0 – 6.7 (Tricket, 2002).*

Refrigeration is a common method of storing food to minimise the effects of decay. Reducing the temperature of the food reduces the activity of the enzymes breaking down cell structure and harmful bacteria. It will also reduce the effects of evaporation that dries out the food. All reactions that are caused by these factors are affected by temperature. Lower temperature gives a lower rate of reaction, as described by the Arrhenious equation (Burrows, Holman, Parsons, Pilling, & Price, 2017).

$$k = Ae^{\frac{-E_a}{RT}} \qquad (1)$$

Where k is the rate of reaction, A is a pre-exponential factor, E_a is activation energy, R is the universal gas constant and T is temperature. The negative, inverse, exponential relationship between the rate of reaction (k) and the temperature (T) means that a lower temperature will give a lower rate of reaction. This holds for all the decaying reactions that occur in food. Refrigeration can therefore be a very effective solution to slowing the process of decay.

Population and Capacity

A design solution needs to cater for everyone in each village. In Koh Khnear, the total population is 795 people to 103 households. Puntha Chea has the same number of households but only 477 people. A design solution should therefore cater to the number of people rather than just the number of households. Due to the difference in the number of people per household, a solution that only caters to the number of households would be insufficient for the people of Koh Khnear or inefficient use of material for Puntha Chea. **Table 1** shows the population, number of households and average number of people per household for each of the three villages.

Table 1 *- Population, number of households and average number of people per household for each of the three villages. Data retrieved from the EWB Challenge website.*

	Population	Number of Households	Average Number of People per Household
Koh Khnear	795	103	7.7
Puntha Chea	477	103	4.6
Ksach Leav	339	56	6.1

Climate

The Kratie province, where the villages are located, is a tropical climate. There is a lot of rainfall during the middle of the year, but it becomes very dry during November to March. The temperature does not change much throughout the year. The wet months tend to be slightly warmer, averaging 30.1 °C in the hottest month of April. The coldest month is December with an average temperature of 25.4 °C. Overall, the variation in temperature is very low, but the variation in rainfall is very high. **Fig. 3** shows the variation in rainfall and temperature month by month. The Kratie Province also has a very high humidity due to its tropical climate. The average humidity by month is shown in **Fig. 4**.

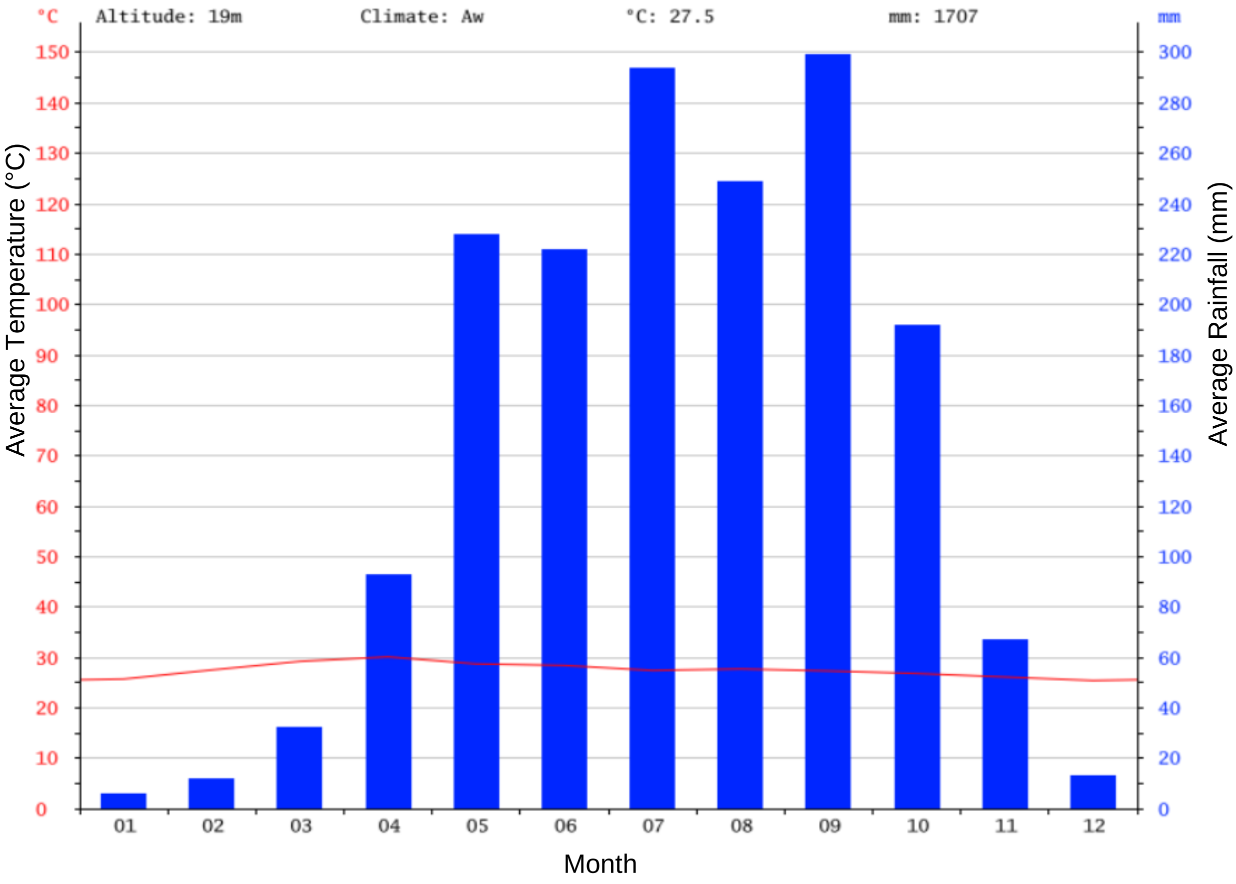


***Figure 3**:* Average temperature and rainfall in the Kratie Province by month (World Wide Travel Organisation, 2012).

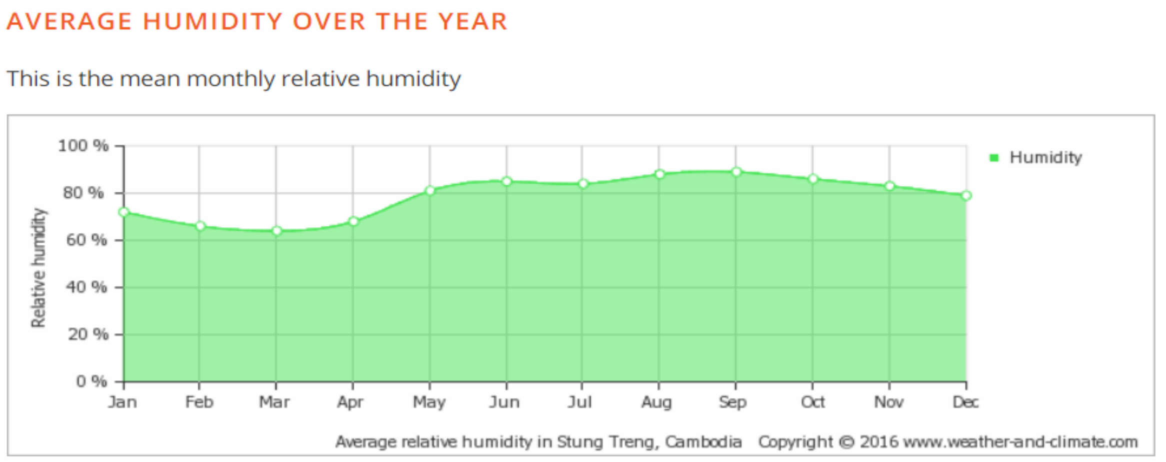


***Figure 4**:* Average relative humidity per month in the Kratie Province (AM Online Projects, 2016)

Local Requirements

A list of common materials and their prices in the villages is included as Appendix A. This was retrieved from the EWB Challenge website. Appendix B also shows responses to what people of the village think would be most important in a design solution. Some of the more common requirements include:

- Community owned and managed;
- Simplicity;
- Indigenous techniques;
- Acceptable to the community;
- Reduces waste and reuses materials

These requirements can best be summarised by the locals' desire to use sustainable materials in a way that utilises local techniques and skills and is sympathetic to social and cultural norms. Abundant, sustainable materials of the area include water, bamboo, sand, soil and clay. As seen in Appendix B, these are all relatively cheap materials. They are also easily reusable or recyclable. Using local, sustainable materials is also best for utilising the local skills and trades. Locals will be experienced in dealing with these materials, which makes construction and maintenance of a solution much easier and sympathetic to their skills. To be most sensitive to cultural and social norms, it is best to have a design solution with a minimal impact to their way of life. This would mean making it as simplistic as possible so there is no need for additional infrastructure or external assistance.

Alternative Solution

Four solutions were considered to solve the problem statement. These were a communal fridge, multiple small fridges, a zeer pot and a cold slab.

Communal Fridge

The communal fridge (**Figure 5**) would be solar powered or have an isolated power supply dependent on the resources available in Cambodia. This fridge had various flaws and benefits. It would be constructed like a deep freezer where large amounts of food could be stored. Having the hinge of the door horizontal rather than vertical meant that the door would always be closed due to gravity. This would also help keep the animals and pests out. This communal fridge could be placed slightly recessed within the ground. Due to Cambodia having moist soil from the rain, the water will draw heat energy from the fridge, consequently making the fridge cooler. This means that less energy will be required to keep the fridge cool, saving power and money. In doing this, the fridge would receive less direct sunlight, also resulting in a cooler fridge as the surface area exposured is reduced. A major constraint is if the fridge was recessed into the ground that it must keep the contents within the fridge safe. It also must be able to fit the food supplies easily for each village. Koh Khnear village has approximately seven to eight people per home, so they will need to have several. Puntha Chea has four to five people per home while Ksach Leav has six people per home. Each fridge will cater for three households in each village. The communal fridge would be placed under a hut with a slanting roof (**Figure 5**) to stop the rain sitting on the roof. Implementing this hut would make sure the fridge does not receive unnecessary amounts of rain water as this could potentially flood the fridge. Solar panels would also be placed on top of the roof to help provide the fridge power.

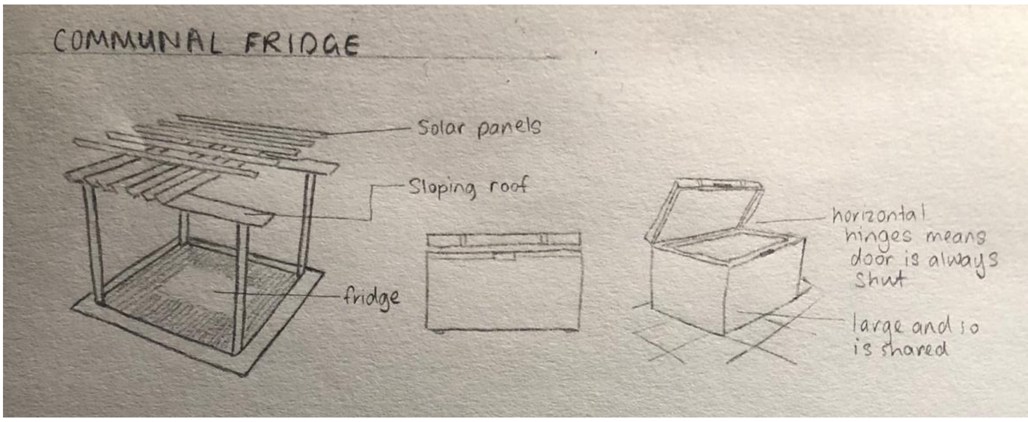


Figure 5: *Sketch of communal fridge concept.*

Multiple Small Fridges

These could also be implemented so each family had their own supply of food. This would reduce the chance of people removing other people's food out of the communal fridge and other issues that come with sharing. These fridges must be big enough to store food for each village. Because there will be many fridges the power supply and material used relative to the communal fridge would be greater. The power supply cannot exceed three times the amount the communal fridge would generate. The cost of total production cannot exceed double the cost for the communal fridge. Consequently, the small fridges would need to be made from cheaper materials. **Figure 6** below shows the small fridge concept.

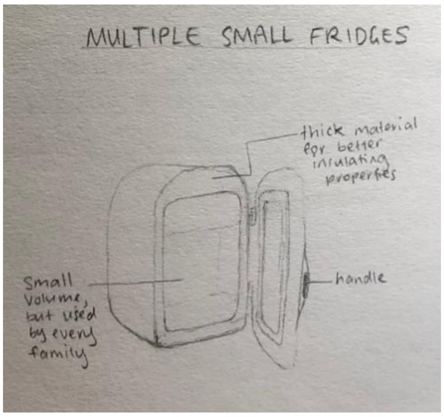


Figure 6: *Sketch of multiple small fridges concept*

Zeer Pot

The Zeer Pot concept would consist of one Earthwise pot placed within another (**Figure 7**). Food supplies would be in the centre pot. Between the middle pot and outer pot, wet sand would be implemented to draw heat from the centre pot, keeping the food in the centre cool. Because of this no external power supply is needed to cool the food supplies as it uses evaporative cooling. This concept can store 12 kg worth of fruit and vegetables (Practical Action, 2018). The Zeer pot must last six months and cannot let the wet sand reach the food supplies within the centre pot. This form of storing food is convenient as every family can have their own and it is also environmentally friendly and sustainable. The locals can easily make this solution and when they may require a new one, local materials can be sourced and used. The Zeer pot is unable to hold large amounts food and it can be fragile if not looked after carefully. Its construction can be taught to locals so once a new one is required they can make a replacement or additional pot themselves. Over time, the zeer pot construction can be passed on to future generation and could become a tradition within the Cambodian village.

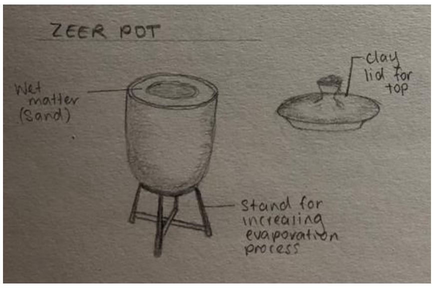


Figure 7: *Sketch of zeer pot concept*

Stone Slab

Finally, the stone-cold slab (**Figure 8**) is like the zeer pot. It requires no additional power source as the cold stone draws heat from the food keeping it cool. This concept must last six months and must not let the food get dirty. It is convenient as it can be placed in every home and can be as big or small as desired. On the other hand, the stone is costlier then the zeer pot and is difficult to put together.

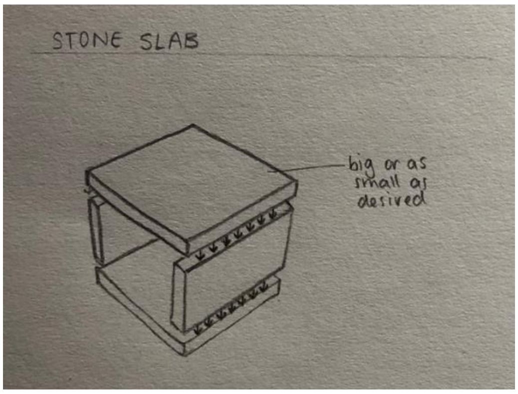


Figure 8: *Sketch of cold slab concept*

Table 2: *Kepner-Tregoe diagram comparing the four solutions.*

Solutions		**Individual Fridge**		**Zeer Pot**		**Communal Fridge**		**Cold Slab**	
Hard									
1. Suitable Temperature (6°C)		Yes		Yes		Yes		Yes	
2. Keeps food safe during the whole year		Yes		Yes		Yes		Yes	
2. Low energy used		No		Yes		Yes		Yes	
Soft	Weight	Rating	Score	Rating	Score	Ratin g	Score	Rati ng	Score
Safety	7			7	49	8	56	7	49
Materials	3			9	27	6	18	6	18
Cost	6			9	54	6	36	6	36
Volume	5			6	30	8	40	7	35
Easy to maintain	7			9	63	4	28	6	42
Sustainable	9			9	81	4	36	6	54
Score					304		214		234

The KT diagram was split into hard and soft constraints. The hard constraints were non-negotiable, if they were not met the solution was eliminated. This was the case for the individual fridge which used excessive quantities of energy. Soft constraints were given a weight and rating from one to ten (ten being the best).

The Zeer Pot was the chosen solution. It requires no power supply, every family in the village can attain one and is easy to make. The KT diagram above backs up this choice.

Recommended Solutions

The Zeer Pot was the chosen solution for the Cambodian Villages. It requires no power supply, every family in the village can attain one and is easy to make, environmentally friendly and sustainable. The KT diagram (**Table 2**) backs up this choice. It was chosen as it obliges to the specifications and constraints better than the other solutions. A major benefit of the zeer pot is that it does not rely on any source of power to operate. This is because it is made by placing one pot within another. Between the two pots consists of sand and water which draws heat from the food placed in the centre pot. Every household in the three villages can have their own Zeer Pot and it is environmentally friendly. To set up the zeer pot a smaller pot plant is placed within a bigger pot plant then sand and water is placed between the two pot plants. Food contents are placed in the centre pot and the lid is placed on top. **Figure 9** on the next page shows the solution in detail.

The materials for the zeer pot are quite simple. It consists of two pots, a pot lid, sand, water and a bamboo stand. **Table 3** below summarises the costs of resources.

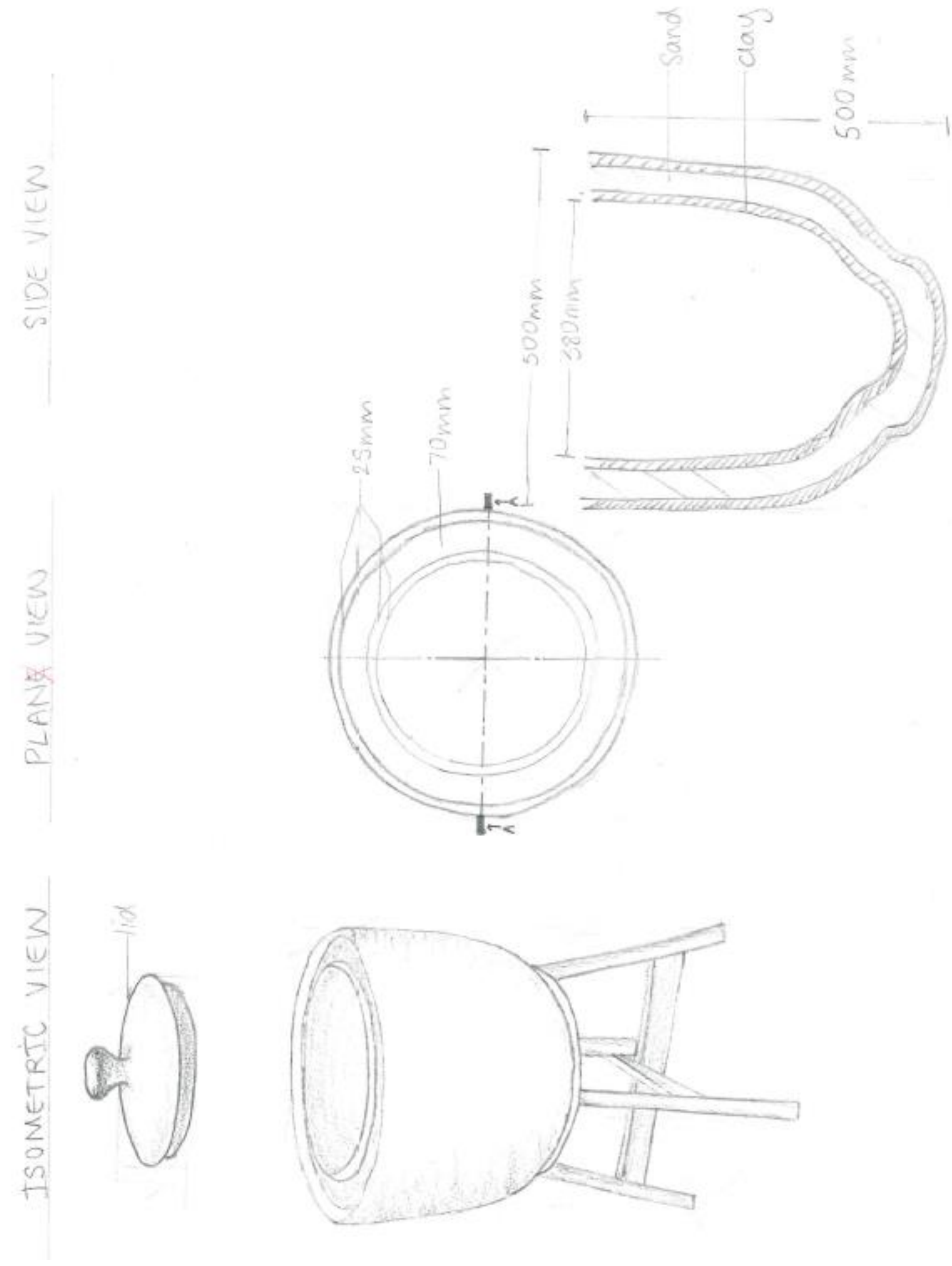
Table 3: *Costs of resources for a single zeer pot (Appendix A)*

Resource	**Cost ($NZD)**
2x pot plant	0.07
Sand	0.30
Water	--
Pot lid	0.03
Stand	--
Total	0.40

The cost of the pot and pot lid was approximated to be proportional to brick. Area of sand was calculated by subtracting the area of the inside pot plant from the area of the outside pot plant. The calculation was 0.05 m^3 of sand needed. Total cost of production of each zeer pot was $0.40 (NZD). This means it would cost $41.20 (NZD) for each household to own a zeer pot in the Koh Khnear village and Puntha Chea village. To do the same for the Ksach Leav village it would cost $22.40 (NZD).

The design in context

The project is for those who do not have modern appliances in Cambodia and help them find a low-energy consuming refrigerator. However, Cambodia is a tropical monsoon climate, so Cambodia is always hot, the average annual temperature is above 22°C, and the coldest month is generally above 16°C. Therefore, they need a refrigerator that can reduce the use of electricity and ensure that many people can store food. However, Cambodia's technology is lagging other developed countries, so this refrigerator needs to select lower technology to ensure that they can independently repair and maintain. As a result, zeer pot is the best method, because this project not only needs to guarantee low energy consumption, but they can already carry out their own post-maintenance and maintenance so zeer pot is the best choice among many choices. The following two figures show how the design of the Zeer Pot cools the inner contents.



ISOMETRIC VIEW
lid
PLANE VIEW
25mm
70mm
SIDE VIEW
500mm
380mm
Sand
clay
500 mm

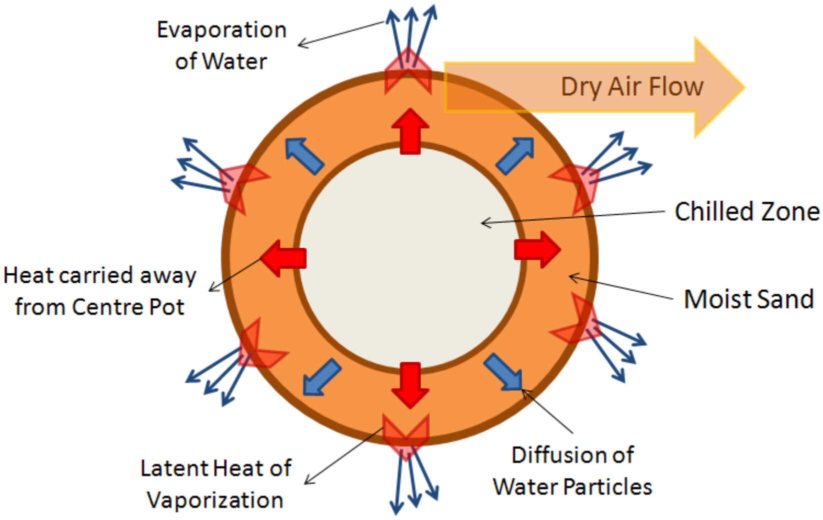


***Figure 10**: Diagram visualising how the design of the Zeer Pot cools the inner pot area.*

The total cost for producing one zeer pot is $0.4 (NZD) and will last at least six months 0.05 m^3 of sand is needed per zeer pot, this will need to be replaced every six months.

The zeer pot will have to be cleaned out on a weekly basis to clear out dirt and old food matter. This will help to keep it hygienic and stop small bits of food rotting and forming a habitat for bacteria to grow. There is also a need to top up the water supply into the sand area daily as it evaporates, however the water does not have to be safe for drinking and can be unfiltered. Every six months the sand between the two will pots will need to be replaced as over time you will lose sand volume and it will eventually become slimy.

This design has considered the life cycle of the zeer pot with it having the least environmental damage out of all the proposed designs. When the zeer pot is no longer fit for use, as it is made up of clay, soil, sand and bamboo these materials have very little impact on the environment. The bamboo is native to the environment and will naturally decompose while the sand and soil will also have little impact along with the clay as no animals will consume these and they do not leech any toxic chemicals into the ground or water ways. The zeer pot will last for six months but if looked after and maintained then will last indefinitely.

The zeer pot solution can become a tradition within the Cambodian village. This is because it is easy to construct and the elders within the villages can pass down the knowledge to their children and/or grandchildren who then do the same many years later. The zeer pot will only need to be replaced if it is not looked after well due to it being fragile. Therefore, the zeer pot could potentially stay within a family for generations becoming a tradition.

Final evaluation

The zeer pot uses no form of electricity but uses evaporative cooling to keep the contents cool. Therefore, it meets the criteria of being low energy consuming. The villages do not have to worry about extra use of generators or batteries to power the solution. The solution takes advantage of the villager's skills as they can build the zeer pot themselves. It is easy to build and maintain and it uses local materials and skills which also helps to reduce the cost for the villages.

It keeps the food secure and sanitary as it is fully covered and has a lid which is placed on top to keep pests and bugs out. It is environmentally friendly as the materials are non-toxic and contain no metals or plastic which can harm the environment. Although it is easily built and maintained, it is more fragile than other concepts meaning it can more easily break and it will require more maintenance than other solutions. The solution is very safe as it does not use electricity there is no danger of electrocution. Although small and so it is difficult to accommodate for large numbers of people many would have to be made. However, it compensates for this as it is easy to make, and the local people can build it themselves as is as non-invasive as possible to their culture. The proposed zeer pot solution meets the specifications made which is why it is the recommended solution.

As Cambodia has a reasonably high humidity, there is some concern that the evaporative cooling rate wouldn't be quick enough to significantly cool the contents of the zeer pot. The zeer pot is most effective with a humidity of less than 60% however the Cambodian climate has a humidity slightly higher than this. To help with the evaporative cooling rate of the design, a small solar powered fan placed at the base of the zeer pot below the stand would help with air circulation and increase air-flow to the base. This would help increase the evaporation of the water and therefore further lower the temperature inside the pot.

The sustainability and ease of construction using local materials and skills along with its non-reliance on an electricity supply make this the best solution for the criteria. Although possibly small, it can be adapted and due to its cheap construction, it is easy to make many of them and test them to optimise. For a solution to use electricity it has its difficulties due to the lack of grid connection and the expense of solar panels and batteries. Resources needed such as pottery, sand and water are all easily accessible and cheap to obtain. The zeer pot uses these natural materials which are very environmentally friendly, and locals can build and make them themselves. It is adaptable and can change over time to suit their needs. It is a skill which is easy to pass onto future generations and does not require training locals with how to repair, rather only requires a once off demonstration on how to make it. It can be placed in individual houses, so it is very convenient. It can be fixed by any member of the village as it does not involve electrical circuits, so they have no need to have to get someone out there with the required skills to fix it as that could become costly.

Team learning and experiences

In this project, the team's biggest goal was to find a refrigerator which can reduce energy use (reduce power consumption and try to use other methods instead of electricity). The group hoped to find a way to run a refrigeration system without using electricity and the hope that it supports the villages. The group conducted various discussions and research to find the most suitable way to design the solution. The internet was utilised as the primary source for research on the solutions to find the information that was needed to make an informed decision. Communication is extremely important in any group work. Therefore, the group interactions mainly concentrated in three locations, the workshop, the library and the engineering core buildings. Facebook messenger was also a useful tool for interaction as the team could arrange meetings and ask questions when desired. However, the team work proved to be a hard challenge at times as English was Chen's second language. This limited the communication within the group. Chen felt that opinions could not be expressed clearly at times, which was detrimental to the performance of the team.

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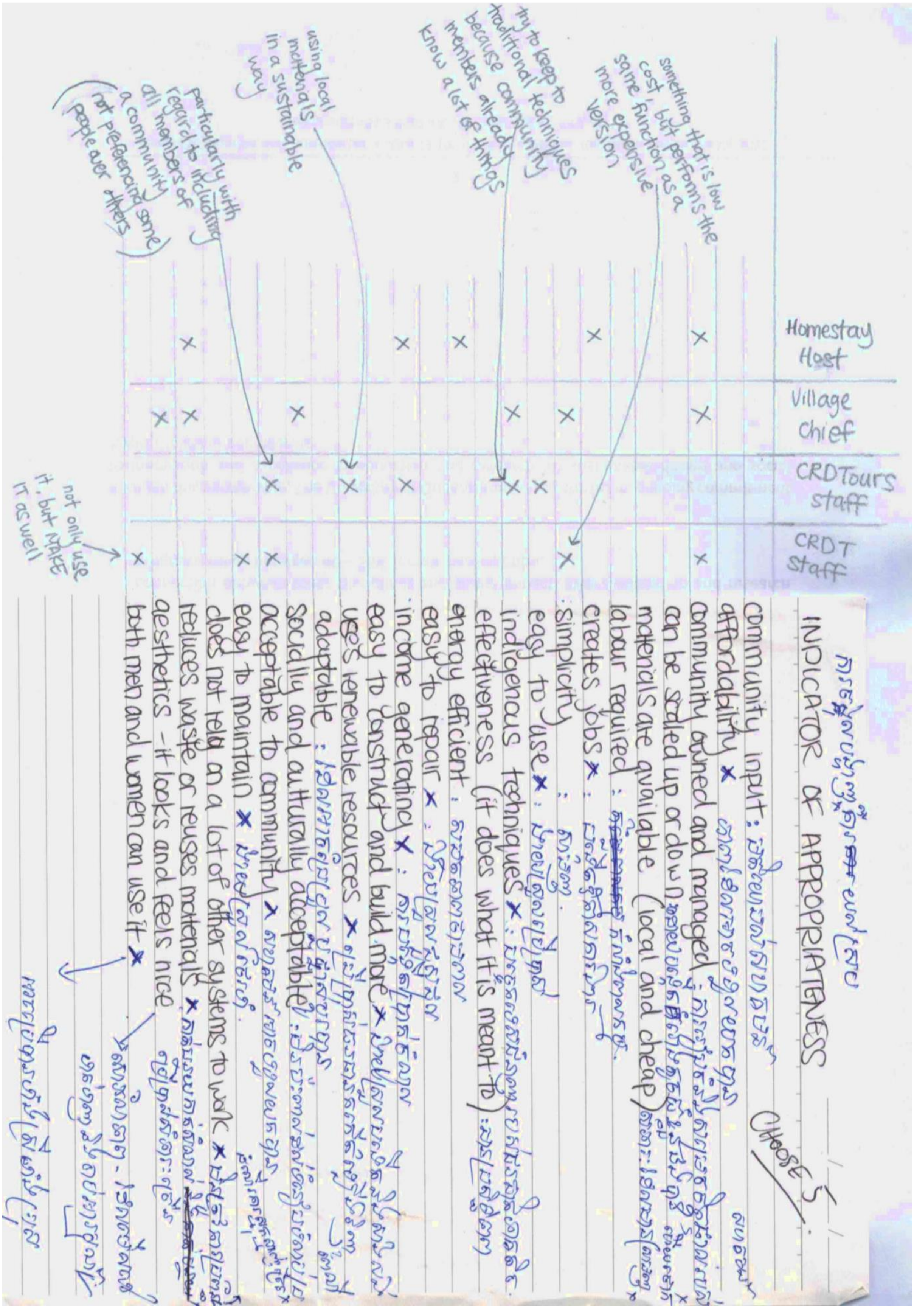
Appendix A

Item	Approximate Cost in Kratie Town		
	Real	USD	
small shovel	10,000		
16mm x 30mm nut and bolt		0.3	
spanner set (#8 - #24)		11	
spanner set (#8 - #32)		21	
individual spanner		1.5	
16mm steel rod		$2/m	**cheaper when purchased in bulk*
plastic hose 50mm diameter		$2.5/m	
plastic hose 10-12mm diameter		$0.50/m	
Fuel	4000R per litre		
thick rope		1/m	
thin rope	1,500/m		
fishing wire	3000R per 30m		
fishing net		$7/kg	
metal chain		$7/m	
25m2 tarp		$30	
chicken wire		$1/m	
clear plastic		$4 per 3m sheet	
Bucket	3000R		
Funnel		$1	
Soap	2000R		
Plastic Bowl	1500R		
Brick	100R		
Sand for brick mortar		$12.5/m3	
Cement bags		$3.70	
Sand used for render		$15.00/m3	
Grout		$3/kg	
Small tube of glue		$1	
Plastic pipe (49mm)		$0.85/m	
Plastic pipe (100mm)		$3.30/m	

Appendix B


INDICATOR OF APPROPRIATENESS
CHOOSE 5
Homestay Host
Village Chief
CRDTours staff
CRDT Staff
community input
affordability
community owned and managed
can be scaled up or down
materials are available (local and cheap)
labour required
creates jobs
simplicity
easy to use
indigenous techniques
effectiveness (it does what it's meant to)
energy efficient
easy to repair
income generating
easy to construct and build more
uses renewable resources
adaptable
socially and culturally acceptable
acceptable to community
easy to maintain
does not hold on a lot of other systems to work
reduces waste or reuses materials
aesthetics - it looks and feels nice
both men and women can use it
something that is low cost, but performs the same function as a more expensive version
try to keep to traditional techniques because community members already know a lot of things
using local materials in a sustainable way
particularly with regard to including all members of a community (not preferencing some people over others)
not only use it, but MAKE it as well

Appendix C

ENGR101/2018

Assignment 1 – Major Design Project

EWB 2.a Problem Definition and Constraints

Problem Statement

The Problem initially given to us:

Presently, the refrigeration of food at a household level for three adjacent communities along the Mekong River in the Sambo District in Cambodia is not common. The problem given was to find an affordable, low/non-energy consuming safe food storage method that these three communities could use.

(needs to be researched) to therefore come up with the best problem statement

- what sort of food do they eat in the village, (temp that fridge needs to be)
- how big is the village?

will one family get a storage method, or will it be shared? (therefore, this impacts the size it needs to be) this also affects the cost that the fridge will cost - if shared more families can contribute towards the cost etc.

We then did some research as to the common types of food that they eat so we could design a food storage method specific for their use such as being the correct temperature.

Types of food most commonly eaten:

- Fish
- Rice
- Fruit
- Vegetables

As they do not eat a lot of meat and tend to eat fish instead. We decided to make the safe storage method at a temperature of 6 degrees. This temperature was chosen as it is a better temperature for storing fruits, vegetables and fish.

The cost of the storage method is also important as communities and individuals can’t afford a costly storage method, it will need to be affordable to everybody. Therefore because of this factor we decided to make a communal food storage method. This would not only help keep costs down as more families can contribute, but also minimise the use of materials and therefore be more beneficial to the environment.

Based on this our problem statement is:

Use local materials and skills to keep a communal food supply secure and sanitary for longer with minimal to no energy, environmental or cultural cost.

Design Specifications and Constraints

Supplement the problem definition statement(s) with a set of design specifications and design constraints which must be met for a successful design solution.

The solution must be:

- Affordable
- low/non-energy consuming
- Local skills/materials
- Safe
- Sustainable
- Long life span
- Easily maintained by locals
- Secure

Research:

Dining Etiquette:

Meals are served communal style with multiple dishes set in the middle of the table to share. Food is served as the dishes are cooked rather than in any set courses. Adult males and guests eat first followed by others according to status. The food preparers typically eat last. It is considered poor etiquette to finish everything on the plate. It is also bad manners to leave chopsticks sticking up out of your bowl.

https://diningforwomen.org/customsandcuisine/customs-and-cuisine-of-cambodia/

• Usually, a meal is made up of lots of dishes in the middle of the table which everyone helps themself to. At restaurants, if you order separately you will get a single plate of what you ordered like you would in the UK.

https://karislambert.wordpress.com/2016/03/19/cambodian-table-manners/

https://data.opendevelopmentmekong.net/dataset/b789b447-5fdc-4a9c-a1b4-c5969ad643fb/resource/9fec36bc-a47c-47c1-9d0b-e54d1483c7dd/download/KratieProvince09.06.2014.pdf - number of people in village.

ENGR101/2018

Appendix D

Assignment 2 – Major Design Project

EWB 2.b Brainstorming and Solution Selection

Brainstorming & Solution Selection Introduction

Brainstorm ideas for how to provide an engineering solution to the problem. The idea here is to spend some time as a group being as creative as possible, writing down ideas or sketches without criticising or analysing them. (No noes. Do not say no to an idea.) Some of the best ideas will come from what, at first, seem to be the silliest ideas. Even if individual ideas seem silly, they can stimulate movement towards truly innovative and practical ideas. Record all ideas as they occur.

Idea Classification and Refinement Task:

After you have exhausted the generation of ideas through brainstorming, classify your ideas into groups/categories as the first step in refining your thoughts prior to decision-making. Try to find the common themes amongst different ideas and begin to combine and adapt ideas into a smaller list of practical suggestions worthy of further consideration.

Consider your problem definition outcomes that you have already completed and assess how each potential design solution meets the design specifications and constraints. Consider using an evaluation matrix to compare ideas. Be prepared at this stage to adapt and modify the better ideas as necessary and discard the ones which have major flaws.

Preferred Design Solution Decision:

Decide, as a group, which design solution to pursue for the remainder of your project. Make sure you briefly summarise your reasons for choosing your preferred solution. If there is information lacking that prevents you from finalising your decision at this stage, arrange to meet again as a group within the next few days to make your decision. Decide on the next steps that need to be taken to progress your chosen design solution and assign tasks to each group member. Your group is expected to meet at least once outside of the workshop sessions each week.

Your assignment should include:

- Cover sheet, page 1 of this document
- A list of all ideas and suggestions as they were first proposed.
- How these ideas were evaluated.
    - A categorised, refined list/diagram of ideas from those first proposed.

- o Consider the ideas against the design specification and considerations from Assignment 2.a.
- o An evaluation matrix is encouraged.

· A preferred design solution with supporting statements outlining the reasons it was chosen.

http://www.iitmandi.ac.in/istp/projects/2014/reports/Group%2007%20Food%20Preservation.pdf

Types of food most commonly eaten:

- Fish
- Rice
- Fruit
- Vegetables

As they do not eat a lot of meat and tend to eat fish instead. We decided to make the safe storage method at a temperature of 6 degrees. This temperature was chosen as it is a better temperature for storing fruits, vegetables and fish.

The cost of the storage method is also important as communities and individuals can't afford a costly storage method, it will need to be affordable to everybody. Therefore because of this factor we decided to make a communal food storage method. This would not only help keep costs down as more families can contribute, but also minimise the use of materials and therefore be more beneficial to the environment.

Based on this our problem statement is:

Use local materials and skills to keep a communal food supply secure and sanitary for longer with minimal to no energy, environmental or cultural cost.

Design Specifications and Constraints

The solution must be:

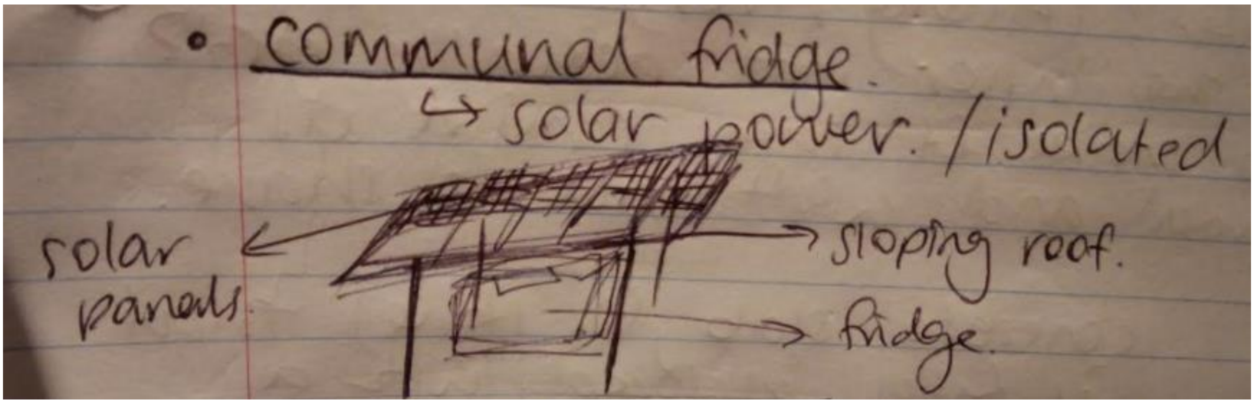
- Affordable
- low/non-energy consuming
- Local skills/materials
- Safe
- Sustainable
- Long life span
- Easily maintained by locals
- Secure

Brainstorming and selecting solution:

Introduction: ideas (even if crazy!)

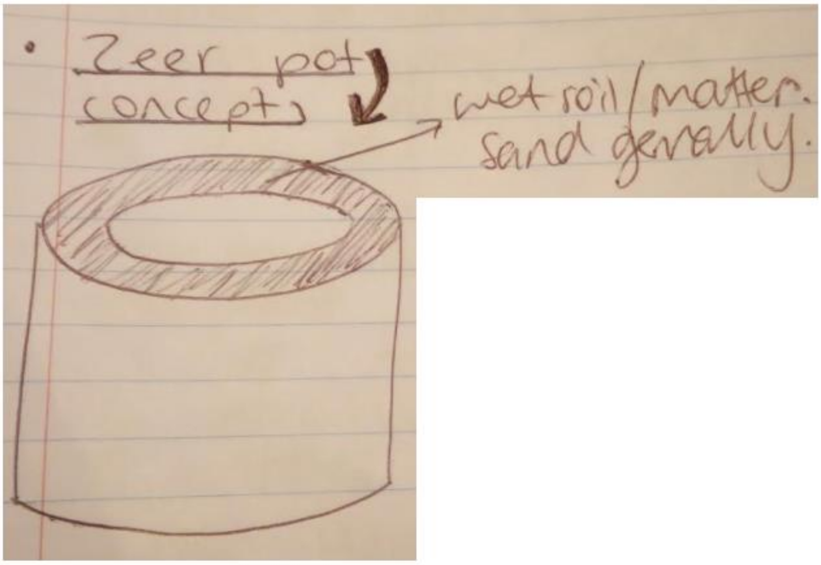
- Communal fridge

  Solar powered/isolated power supply



- Fridge design (see above)

  Deep freezer styled larger more water tight - prone to flooding - keeps insects/animals out. As door does not accidentally get left open due to gravity
- Could put a fridge in ground 100% watertight as constraint, could help with keeping it cool, using less power as ground insulating and less sun exposure to heat it up
- Could have multiple small fridges in houses, benefits of not having to shared, would have to be large enough to store the food types the family want. Constraints cost and materials and power supply. Would mean every small fridge would need a seperate power supply
- Zeer pot concept



- Consists of one earthwise pot set into another, with the payer of wet sand between. As the moisture evaporates, it cools the inner pot. Can store up to 12 kgs of fruit and vegs. Completely seperate power supply, however constraint is how long would it last? And access to water. Does not have to be drinking water. As needs to be topped up every day. How cool would the pot get? How to make it safe. However is convenient as not shared
- Cold slab

Concrete slab (or stone) that is fully enclosed, with a lid that covers it. Like the zeer pot, it is completely off the grid and could be installed in individual houses for convenience.

Idea classification and refinement task

- **<u>Powered</u>**
- Larger communal fridge
  - Dividers for individual spaces or separation of food
  - Would still need to be multiple to accommodate population of up to 800 in Koh Khnear
- Solar panels
- Multiple small fridges own isolated power supplies, either with battery powered or solar, with large solar panels to charge batteries
  - Less efficient use of power: if connected to a grid format, would draw more power
  - Batteries would have to be imported
  - Expensive $$
  - Convenient, easy food storage
- Fridges in the ground
  - Better insulation and less direct sunlight therefore less power use

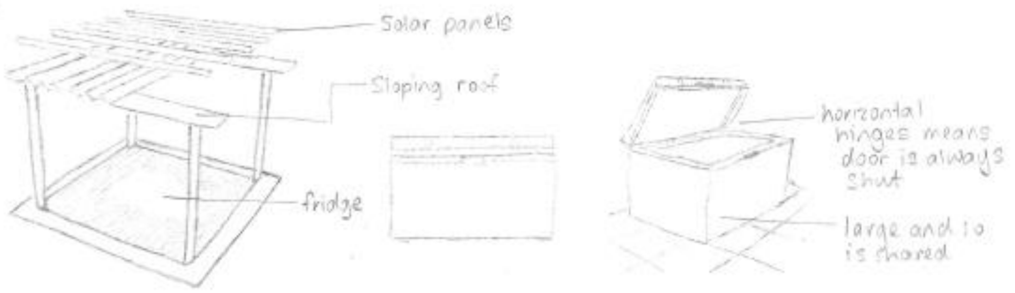
    - Trip hazard?
- **<u>Non powered</u>**
- Zeer pot concept
    - Small, difficult to accommodate enough people, many would have to be made
    - Uses no form of electricity
    - Environmentally friendly
    - Easy to build/maintain, uses local materials and skills
    - Although easily built/maintained, it is more fragile than other concepts meaning more maintenance
- Concrete slab idea
    - Can be adapted to use electricity or not
    - Can use local materials/skills
    - Easier to meet size requirements than zeer pot
    - Concrete can crack and leak; needs a way to waterproof

- **<u>Worthy of further consideration</u>**
- Zeer pot concept: uses natural materials, very environmentally friendly, locals can build and make themselves, can even adapt the design over time to make it more suitable to their needs. Easy to pass onto future generations would not require training locals with how to repair, rather only requires a once off demonstration with how to make. Placed in individual houses so would be more convenient.
- Communal fridge as a deep freezer design:
  Able to get down to a lower and more accurate and controlled temperature, (can chose desired temp). Large so can store larger quantities of food. Door won't accidentally open as gravity holds it down. Uses solar panels so it does not need to be connected to the grid power, but can be potentially be connected to grid power supply when power is connected to the village. May have to be two or three of them placed in the village as some have 127 people.

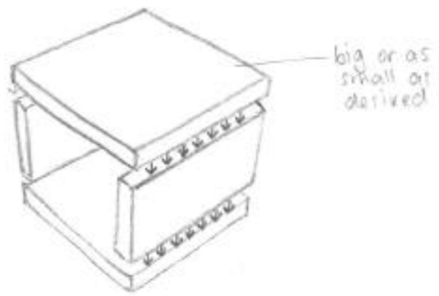
Preferred design decision - Zeer pot

The sustainability and ease of construction using local materials and skills along with its non-reliance on an electricity supply make this the best solution for the criteria. Although possibly small, it can be adapted and due to its cheap construction, it is not a problem to making a lot of them and test them to optimise their abilities. Electricity can be difficult to use due to the lack of grid connection and the expense of solar panels and batteries. Resources needed such as pottery, sand and water are all easily accessible.

COMMUNAL FRIDGE



STONE SLAB



ZEER POT

MULTIPLE SMALL FRIDGES