SRISTI UNICEF Innovation Summer School 2017

Project Report

A tool for effective well digging for salt farmers

Team Members

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Date & Location

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Content

Summary

A typical salt farmer digs 12-15 wells every season out of which only 3-4 wells bore brine-water for salt farming. Each of such well is manually dug using a Phavada& takes around 2-3 days for each such well. These wells are around 1-2ft in diameter. The farmers check soil in these well by touch and feel and get to know if there is water available or not, based on which they then insert a boring pipe to get out water. In total, it takes a salt farmer 30-40 days of time and effort to dig wells and find wells with water inside, which the team sought to reduce.The team realized that there is a need for more effective methods for well digging which will allow the farmer to start growing salt earlier and hence increase their production. The team has developed a manually operated rotatory auger blade well digger which can be operated by 2 people and can dig a 15ft hole in 4-5 hours only which reduces the whole well digging procedure to just 4-5 days and in the rest of the days, the farmer can start producing the salt and hence gets additional 20-30 days to produce salt which adds onto his revenue directly.

Figure 1 Final Prototype

Problem Definition

Problem statement

As a convention, a salt farmer digs wide holes (1-2 ft in diameter) which he enters to check soil with hand, based on which he infers presence of underground water. To dig such wide holes takes around 2-3 days each and also exposes them to toxic gases. The effort and time taken to dig such holes can be reduced drastically by changing the well digging mechanism.

Proposed design

The team has designed a rotation based manual well digger using auger blade mechanism to bore well inside the soil surface. The team have taken a blade which is 2.5ft long with 10 cm in diameter. The digging mechanism is complemented by SS connectors and 3ft long connecting rods to allow farmers dig as deep as 18 ft. The rotational mechanism has a T shaped joint& requires 2 people to help it penetrate in ground. It takes around 4-5 hours to dig 15ft deep well using our blade.

Field testing & user feedback

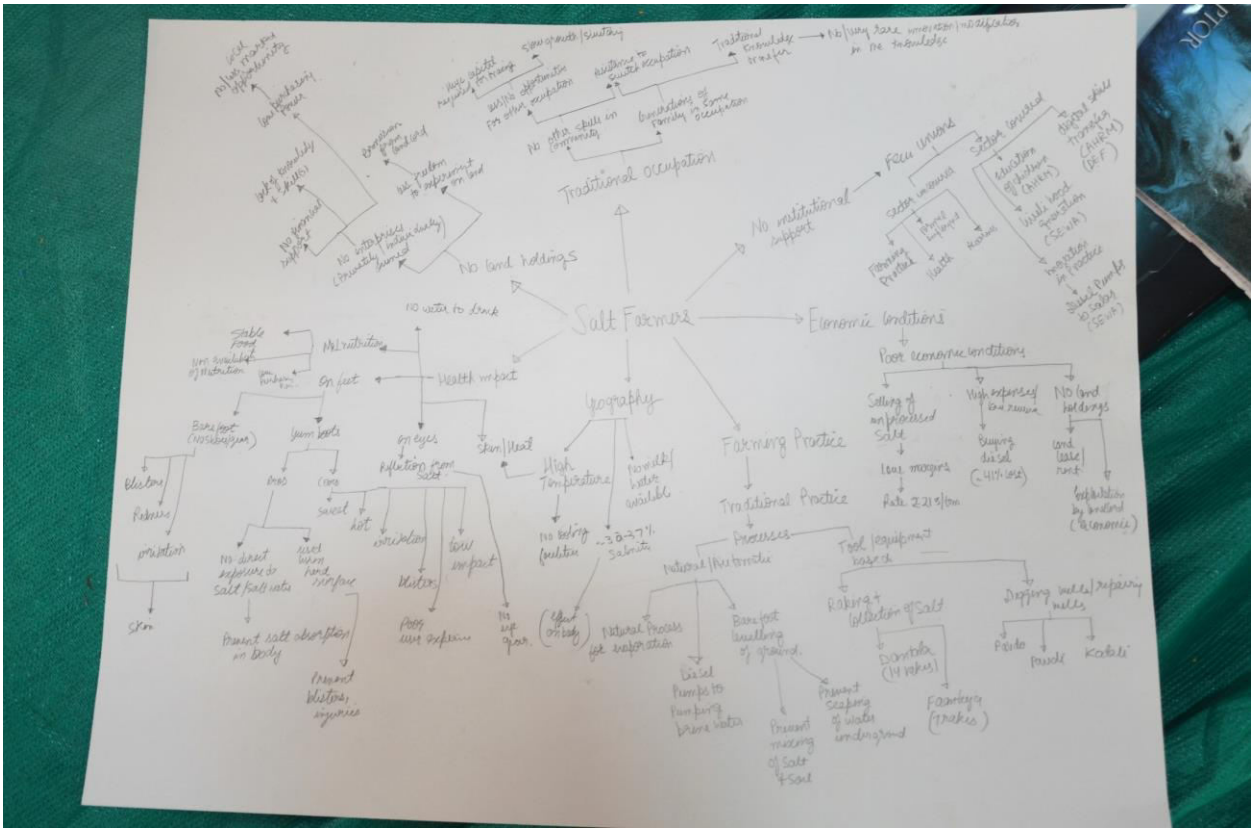
The team has tested the product in Little Rann of Kutch and have dug two holes of 2.5ft & 5ft individually in presence of a salt farmer to take his feedback and notice the spots for improvement. The salt farmer saw the value in the product and accepted that it would help him save a lot of time and effort.

He also appreciated that with this, they need not enter wells hence, preventing their direct exposure to poisonous gases. Compared to 30-45 days spent in well digging for finding brine-water source, an automatic well digging mechanism has a potential of reducing it to a 4-5 days only thus saving a lot of time and effort of the salt farmer which he utilize to produce more salt.

Mind Map

The team in their innovation journey has come up with two iterations of mind map. The first map covers the landscape and defines the right context to explore the problems whereas the second one is more specific to the problem statement.

Mind Map 1



The mind map consists of the following key branches and subsequent sub-branches relevant in context of understanding the conditions of salt farmers are described as below:

1. **Salt farming practice** – Salt farmers of Kutch follows a traditional approach to salt farming which is more than 1000 years old. The team classified the processes into two categories, natural processes and manually operated processes which are described as below:

a) **Natural processes** – The team identified that traditional farming processes were based on two key natural processes, one is the natural evaporation of brine (leveraging sun, no forced convection) and natural crystallization of salts. Both of the processes can be studied and then optimized upon the underlying parameters.
b) **Manually operated processes** – The team identified processes in which salt farmers used hand/feet/manual tools to carry out certain tasks. These tasks include digging of wells, preparing saltpans, levelling of mud surface, raking and collection of salt. Each of the tasks requires different tools

2. **Health implication of farming on salt farmers** – The salt farming practice has serious implications on the health of a salt farmer. Due to high working temperatures (45-50 Degree Celsius), the farmers experience skin burn, skin irritation and infections. The key issue is exposure with high salinity water and salt crystals which causes blisters, rashes and severe bone deformations. Due to the exposure, the content of salt in body increases at a level such that their feet don't get burnt during crucification process. To prevent such exposure, the government has distributed gum boots in the past but its utility is limited in the entire farming process and the user experience is poor. The bright glaze from saltpans causes cataract and blindness in working population. While digging well for boring out brine water, some poisonous gases have also been reported to release which has caused many deaths. Salt farming is demanding and health risks involved contributes to make occupation very hazardous and thus inviting attention of innovators and policy makers.
3. **Exploitation by traders and middlemen** – The salt farmers take loans in advance from salt merchants for their livelihood during the farming period of 8 months (October – May). The salt price is fixed at the beginning of farming season which is often very less (25 paise per kg) as compared to the market value (Rs. 3 per kg). They have no financial savings for themselves and most of the salt farmers live at the mercy of salt traders and merchants.
4. **Lack of diversity of skills** – The salt farming communities have been following traditional methods of farming only and the same knowledge is passed onto next generation. They lack any other skill to help them switch occupations if they ever need to. Given the low margins and attached occupational health hazards, the community has reported to be migrating and switching to agriculture but they haven't been much successful as they lack skills and require huge capital for the same.
5. **Innovation in salt farming methods & techniques** – Since most of the farming techniques the farmers use are traditional and there has been no significant innovation that has taken place in the space, there are a lot of opportunities which can be explored to make the process more affective.

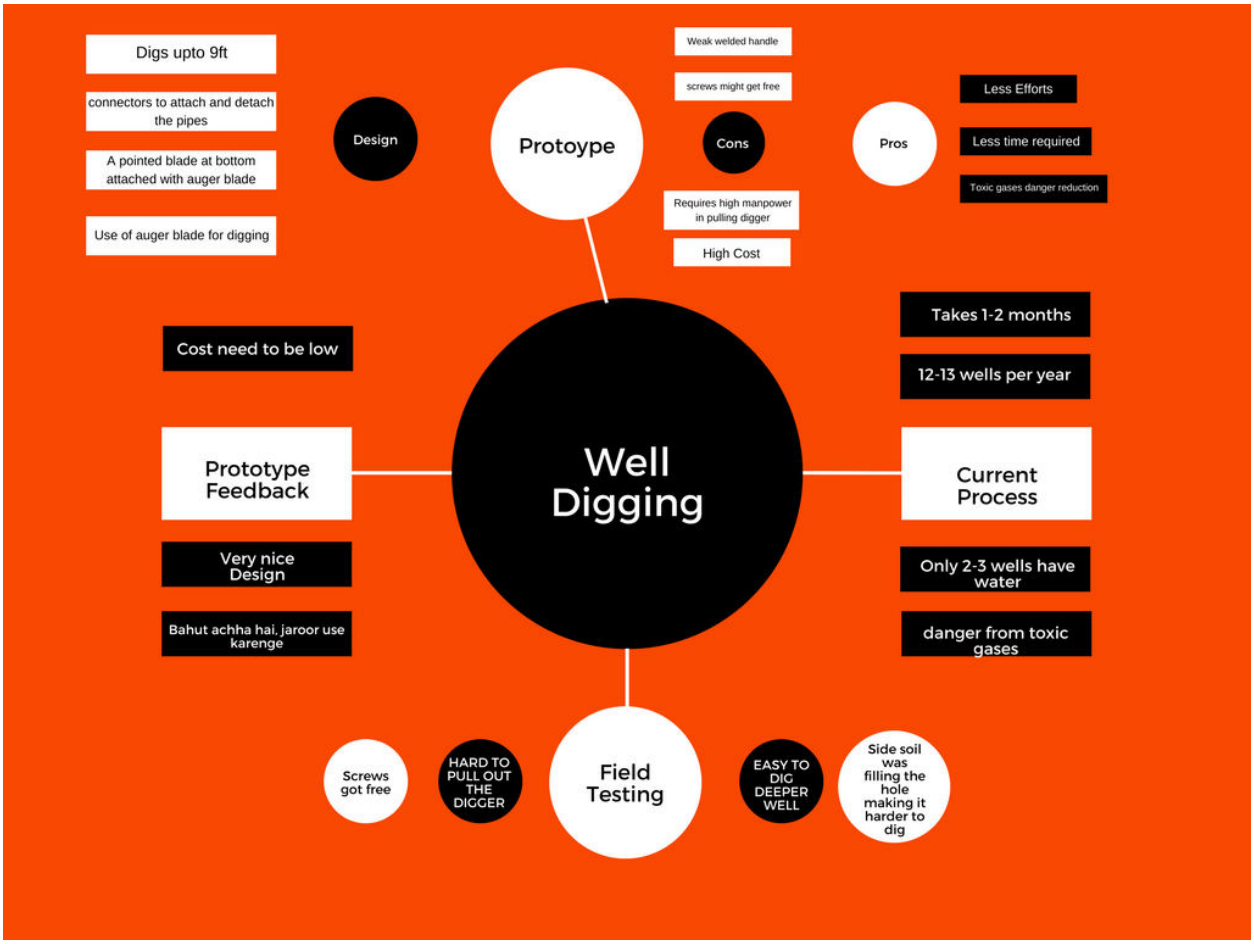
Feedback by Professor Anil Gupta on Mind Map1

The team discussed their mind map with Professor Anil Gupta to seek his insights. The professor guided the team by sharing all the relevant contacts which had significant experience in the field to help the team. Professor also informed the team about the residue which often gets wasted in high volume during the salt formation and cleaning process which could be of high value to the farmers as it contains high concentration of some specific minerals. The team could not find anything related to the residue from their online search in the given time, which in local language is called 'Biten'. Professor motivated the team to emphasize on understanding the practices

which exposes the farmers to saline water and salt which demands protective gear. Professor further bring to notice about an invention of automatic turning machine for salt farmers which was invented to eliminate the manual barefoot leveling of mud. Professor listened to all the teams with great enthusiasm, passion and in great detail which charged every team with motivation.

Mind Map 2

The second mind map prepared by the team for the chosen need statement related to well digging is depicted as below:



The refined mind map after mentor feedback as depicted in the picture has the following key branches:

1. **Current Process of Well digging:**Currently the farmers dig holes using a “Phavada” which takes approximately 2-3 days per well & they usually dig 12-15 wells in one season.
2. **On field testing/ user experience:** The ergonomics of the digger must allow the farmer to dig well with the least strain on body.
3. **Prototype design:** The well diggers prototypes have been conceptualized and then were assessed on multiple parameters including digging time, weight, size/compatibility, cost etc as depicted in the picture.

4. **User feedback:** The team considered the user feedback to be very important in designing the well digger. Based on the user feedback and on field trails, the design was iterated accordingly.

Field Visit

Figure 2 Salt Pan in Little Kutch

Introduction for the field visit

The team after performing the PAS and mind mapping decided to visit the district of Kharaghoda to meet the community of salt farmers and understand their problems. The landscape analysis and problems identified through secondary research (online sources) needed to be checked up with the ground reality for two main reasons. One reason being the need to validate the

correctness of the identified problem and the second reason as to bring details to further refine our problems by careful observation of processes and interviewing the stakeholders. By considering the feedback given to the team by professor on their mind map (Link), the team decided to visit the community of salt farmers in the district of Kharaghoda. The team also prepared an exhaustive questionnaire to ask the identified stakeholders. The team left for Kharaghoda the night after receiving and reflecting upon the feedback from professor Anil Gupta and fellow colleagues. The description of the field visit, key observations and insights are described as below:

Field visit - Day 1

Departure time from Grambharti: 29th May 2017, 3:45 am

Place: Kharaghoda district to Little Kutch

Guide: Ambu Patel

Team Members
Anurag Gangwar (IIT Delhi)
Aditya Kumar (IIT Delhi)
Nikita Tiwari (NIT Raipur)
HrishikeshSomchatwar (Priyadarshini College)

Itinerary

07:30 am: – Arrive at Kharaghoda village, Meet Ambu Patel (Guide)
07:30 am – 01:30 pm: – Visit to Little Rann to see the salt farms & understanding salt farming
01:30 pm – 02:30 pm: – Lunch at Ganatar NGO
02:30 pm – 05:30 pm: – Time to plan and reflect at Ganatar NGO
05:30 pm – 08:30 pm: – Interview with 7 Salt farmers to understand their problems
08:30 pm – 09:30 pm: – Discussion with Ambupatel (Guide)
09:30 pm – 10:30 pm: – Dinner
10:30 pm – 00:00 am: – Team discussion and planning for day 2

About Community Leader (Our guide/supervisor)

Name: Mr. Ambu Patel
Mobile Number:+91 9925291048
Interview by: Anurag Gangwar, HrishikeshSomchatwar, Nikita Tiwari, Aditya Kumar

The team met Ambu Patel early morning when they arrived the district of Kharaghoda. Ambu Patel is a community leader who has been born and brought up in the same district, in a family of salt farmers. In local language, a salt farmer is called an Agariya. Being brought up in an Agariya family, he told the team about the hardships he has witnessed in the community. He has seen and experienced malnutrition, people dying due to lack or water, house of people burning due to stoves, people dying in well due to release of poisonous gases etc. Given the hardships he somehow managed to educated himself and for more than 20 years, he has been working in this community and also spread awareness about the conditions which Agariya community have been facing. He alone over the 20 years, has managed to share more than 80,000 pictures of the conditions and the area with the world. He has published articles, journals and two books on salt farmers of Kutch, for which he has been honored by numerous awards including the best journalist award 2015. Some of his initiatives for the community include initiatives related to tailoring and beautification etc, creating opportunities more than 300 rural widows in the community.

General insights on geography and Agariya community

As reported by Ambu Patel, salt farming has been taking place over the place for more than 1000 years but the techniques and methods haven't evolved much with time. The place which the team visited for meeting the salt farmers is a place called little Rann. The word Rann refers to a desert but little Rann is a mud desert. The place was once under the ocean and an earthquake

resulted in shifting of the underlying tectonic plates as a result of which the surface of little run consists of semi-wet saline mud and it house brine water at 50-60 ft depth from the surface. Every year many families from the neighboring villages come to the little Rann for salt farming, one of which is Kharaghoda. The number of families being involved in salt farming are decreasing year by year as over the past few years, there has been a huge number of deaths and heavy migration of salt farmers to neighboring villages due to poor margins on salt production, malnutrition, lack of drinking water, lack of healthcare facilities etc. Due to health hazards of salt farmers, malnutrition and lack of drinking water, there is high mortality rate, one death in every three days as reported by Ambu Patel. Poor design of shelter with dry husk often leads to fire in the houses which has burnt many families in the past. These problems have not been brought into the main light and the limited initiatives what so ever by governments and nonprofits which though looks really good on their websites, but has no ground impact as pointed out by Ambu Patel and other agariyas. The population of Kharaghoda village is 12000 out of which 6000 are salt farmers (Agariya). There is one PHC in the area, 20 ASHA workers and 15 angarvadis for children.

Insights from interview with Salt workers

Community leader: Mr. Ambu Patel
Mobile Number: +91 9925291048
Interview by: Anurag Gangwar, Aditya Kumar, HrishikeshSomchatwar& Nikita Tiwari

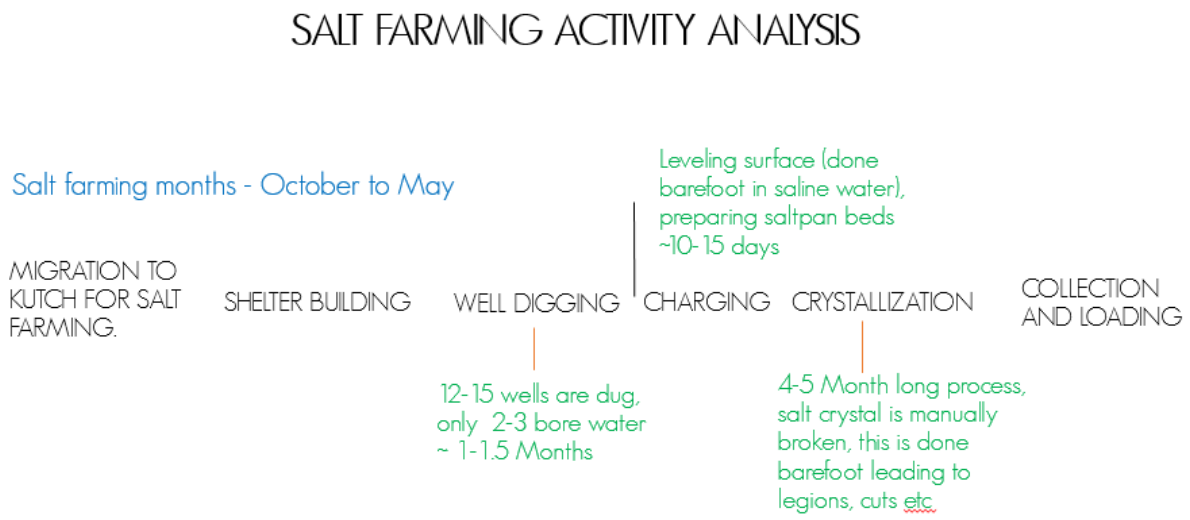
The team in the evening after visiting the salt farms, arranged an interaction session with the salt farmers to understand their problems and get insights on salt farming procedures. As the discussion progressed, the first problem which was on their mind was that of drinking water. There is an acute shortage of water in the community which was uncovered in the discussion. It's

a bit interesting to note and rather ironic to say that where there is abundance of saline water, there is such an acute shortage of drinking water. The government sends a water tank in every 15 days, to relieve the communities only during the salt farming period starting from 15th October 2017 to 15th May 2017. Further the group told stories of people who had lost their lives while digging wells due to release of poisonous gases from underneath.

One story which helped the team understand the problem of poisonous release of effluents was that of an old farmer who went inside the well to check and clean the inserted pipe for water. Son of this old man was standing and talking to him from up outside the well, and then suddenly the old man stopped speaking. The son panicked and noticed that his father got unconscious and fell at the bottom. The son then called someone from the neighboring farm and tied rope around him and sent him in the well to get his father back up, and on his way down, the gas release was so intense that that person also got unconscious the moment he went inside, seeing this the son dragged him out immediately with the rope and sprinkled water on his face to get him conscious. The same person again went inside with an attempt to hold his breath to keep his senses live and then grabbed his father as fast as he could. The whole process took around 1.5 hours and his father was saved. Many people as reported by the group of farmers, aren't lucky as that father & son.
The well which gives water is preserved for the next season and such old wells are big hot spots for poisonous gases. This being the common knowledge is still overseen an ignored by the farmer as they have this confidence that there had been no accident with them till now so there will not be any in future also, a very common fallacy they get themselves into which leave them become victims of such accidents. Another need which was put forward by the farmers was a mechanism to automatically switch off the diesel pump when the water from the well has stopped coming as it burns their oil and harms the pump also. It was reported that on average a family takes up a loan of Rs. 1.5-2 Lakhs from the merchants out of which 70,000-80,000 is spent in diesel for the pump. The average rate at which the farmer sells the salt is 25 paise per kg and he is able to produce 700-800 metric ton of salt in one season. Credit for special needs such as for marriage in family, heath purposes, food etc is also provided to the farmers by merchants only which is balanced by the salt they produced.

Farming practice insights from interaction with salt farmers

Typically salt farming takes place for 8 months, starting from October to May every year and each farm is managed by one family. These families start approaching local salt merchants and traders to get advance credit to begin farming and all salt which the salt farmer produces goes to the trader. After the season, all the salt produced is valued and if it has any overhead, it's paid to the farmer otherwise, the remaining amount is carried on for the next season as a debt.These loans are given based on the value of the salt as required by the merchant based on an average price of 25 paise per kg. On average there are 1200-1300 Agariya families which undertake the salt farming every year.



Key Salt farming steps

a) Building shelter
b) Digging well
c) Building of charger
d) Chargers
e) Crystallizer
f) Leveling of mud
g) Salt production

Keys insights from each step involved in salt farming

1. **Building shelter** - An Agariya family carries all their belongings, tools and equipment in a truck to little Kutch. The first thing an Agariya family does is to make a shelter for themselves to save themselves from high winds, dust and scorching heat.

2. **Digging wells** - The next immediate step of salt farming is to find a source of brine water for which an Agariya manually digs a well and check for brine water availability. The well dug is usually 10-15ft and the color of mud helps Agariya determine the presence of brine water under the well. It often happens that some wells don't pour brine water and on average an Agariya have to dig around 10-15 wells out of which they find brine water in 2-3 wells only which takes around a month (Each well on average takes 3 days). Once the well which has water is found, a pipe of around 30-40ft is inserted manually inside the well to pump out the water since the water bed lies at a depth of around 50-60 ft. To these farmers, finding a well which pours brine water is like a lucky draw and they keep trying for it unless and until they find one. For every well which has water is then tested for its salinity using a meter which is often given to Agariya by merchants. The salinity of ground water is reported to be 18, which is 6 times the salinity of sea water (Salinity 3). From fertile wells brine water is pumped to large salt chargers (described below) using diesel pumps.

The pipe which they insert inside any well expose them to poisonous gases coming from underneath. A number of cases of immediate deaths have been reported to take place inside the well only. The nature of such gases and its effect on the body has not been studied till now. Also, there is no way for the Agariya to pre-determine the presence of gas release. They use very basic tests including matchstick test to see if the gas extinguishes fire or not, which clearly is not reliable at all.

3. **Building chargers:** A charger is a group of 4-6 square shaped flat areas which is dug manually. Each of the area has different height which is connected by a canal system. The working mechanism of the whole charger is very well thought and is a perfect example of traditional science and frugality at the grassroots. The purpose which the design solves is to increase salinity (salt saturation) of the water, bringing it near to its crystallization point and also removing impurities along the way. Brine water is pumped directly from the well, into one part of the charger which is usually at the highest elevation. In this part, the water typically has salinity of 18 and as this water moves through the canal system, the salinity of water changes through each block of different elevation. The design provides large area for evaporation and the sophisticated canal system helps in separation of calcium, magnesium and ferric salts which settles in each portion as impurities and the water with increased salinity moves through the canal. As the water progresses through different portions of the charger, the salinity increases. The number of partition and blocks of chargers are such to finally collect water with salinity of 24 units, which is a required condition for salt (NaCl) crystallization. This is usually collected at the final block of the charger from which another canal transfer the water to crystallizer where salt is produced.

4. Building crystallizer & leveling: A separate square shaped pans are made where common salt is crystallized. To have a sustained and controlled growth of the crystals, the surface of these pans are first leveled with feet. The leveling starts with pouring in water and pressing the surface firmly with bare feet for 6-7 days, after which when a decently firmed surface is obtained and small crystals of salt start forming they continue the leveling with gum boots to make the underneath surface even more firm to prevent percolation of salt water underneath the surface and to provide a robust surface to facilitate consistent crystal growth across the surface for the next 4-5 months.

5. Raking and salt production: Once the surface of the saltpan is prepared through levelling, the salt farmers transfer the collected water from the charger (water with salinity 24) to the pan and then put grasses/husk in the water and leave it for a couple of days to allow crystal to grow on its surface. Once the crystals are grown on the grass/husk, the salt farmer crushes it manually and then take out the grass/husk in the water leaving behind the formed crystals of salt. The crystals formed at this stage gets attached to the ground (firmed at leveling stage) and start growing which continuously need to be detached and collected along the saltpan which a salt farmer does using a long wooden rake. This production and collection of salt goes on continuously for 4 months. The continuous raking process involves a standard wooden blade which often causes blisters, muscle plain and also finger deformation of the salt farmer.

6. Collection and loading: In the last month of the salt farming season, the salt farmer collects the produced salt and prepare for loading and delivering it to the merchant. The merchant sends his trucks directly in the Rann to procure the salt.

Field visit – Day 2

Place: Kharaghoda district to Little Kutch

Team Members
Anurag Gangwar (IIT Delhi)
Aditya Kumar (IIT Delhi)
Nikita Tiwari (NIT Raipur)
Hrishikesh Somchatwar (Priyadarshini College)

Itinerary
07:30 am – 08:00 am: – Breakfast
08:00 am - 08:30 pm: – Interview with salt merchant in a salt processing unit.
08:30 am – 11:30 am: – Visit to Munna Bhai's workshop to check out his frugal innovation
12:30 pm – 01:30 pm: – Lunch at Ganatar NGO
01:30 pm – 05:30 pm: – Reflection and team discussion
05:30 pm – 06:30 pm: – Visit to Little Rann to collect physical samples
06:30 – Departure for Grambharti

Insights from interview by the salt merchant

Interview by: Anurag Gangwar, HrishikeshSomchatwar, Nikita Tiwari, Aditya Kumar, Bhakti

The team met the salt merchant who informed the team about how the salt is processed and about the unit economics of his plant. The team identified that the merchant has his own bag of problems and frustrations. He told the team that a lot of salt farmers are migrating to different villages and shifting to agriculture and that there are a lot of serious problems which needs immediate attention of government and policy makers. He gets the salt directly from salt farmers and then clean it, process it, package and it then send it to traders for retail. He makes Rs. 2 per kg out of which Re 1 is the cost of packaging, 50 paise is the cost of labor + electricity and the rest 50 paise goes to the merchant, whereas the same kilo has MRP of Rs 14. This margin is very low for the merchant to manage his operation and he claimed that more than 50 % local merchants have shut down and in the coming 1-2 years most of the local traders/merchants will be gone. The government policies are in favor of the incumbents only such as Tata, Reliance etc and they being the local players can't commercialize their product in the market as they require licenses which are very expensive for these local players to afford. The merchant also informed the team that according to government mandate, it's required for salt manufacturers to add iodine and PFC (Potassium Ferro cyanide), which according to the merchant is poisonous to consume. They were adding 200 grams of PFC in 100 tonnes of salt before packaging. Before the team was leaving, the merchant asked the team which problem are you students working on, they told him about the problems caused due to direct exposure of salt farmers to saline water which causes blisters, redness, blisters etc and in reaction the merchant responded a bit surprised and disappointed, he told them that there are more severe problems in the village such as malnutrition, lack of drinking water etc. He also told the team that if someone the people are able to make a decent living then they will take care of the small problems themselves.

Insights and inspiration from Munna Bhai (Grassroot inventor of roller for salt levelling)

Figure 3Munna Bhai

The team met Munna Bhai, a salt farmer on the first day of their visit. There they came to know about a frugal invention which Munn Bhai has executed himself. The invention consisted of a roller to help himself and other farmers at levelling stage. Munna Bhai has frugal workshop where he makes the roller for farmers and sell it for Rs. 1200 per piece and it takes him one complete day to produce one unit. The team loved interacting with Munna Bhai and his family. We was the only one around which had identified a need and then created a solution for himself and other for this specific problem. Given below are some pictures of the invention and the team interacting with Munna Bhai and his family.

Design Concepts

Design concept 1

Feedback by mentors

Mentors advised the team to consider wide iron rods for making the auger blade as it will provide the necessary load to help effective digging without any turning or bending of the rod. Also the team was suggested to look for automatic motor driven auger drill for well digging but the option was eliminated due to high costs which a salt farmer couldn't bear. Mentors further asked the team to try it as fast as possible to get more practical challenges.

Design concept 2

Feedback by mentors

Mentors appreciated the choice of material and the connections. Further it was brought to the notice of the team that the handle must be long enough to reduce the individual load while turning the blade. Also, the farther one is from the center there will be less chances of nausea caused due to rotation around the blade.

Special Concepts – Not prototyped due to limited program duration and resources.

Figure 4 Digger with chairs to give load while digging

Figure 5 Digger with Loading Capacity

Prototype development

Version 1.0

Figure 6 Prototype Version one

Feedback from mentors

1. The stainless steel used for making the connectors and handles for it being light weight led us to compromise on the strength of the digger. Mentors advised us that we must use iron pipes and connectors as the SS rods will not be able to bear the strain.

2. The welding had scope for improvements in at the connections.

Version 2.0

Figure 7 Prototype Version 2.0

Field trial Insights

Problems identified in the prototype

1. Major connections were made using screws which we realized with digging were getting free as they were unable to bear stress while rotation.
2. In the prototype a T-shaped join was formed using welding which we realized was weak as it got off during field trial.
3. Too much power required to pull the Digger once dug.
4. External load was needed to allow smooth digging in the ground.
5. Handle was getting hot.
6. The side soil was filling the hole, wind and all were very big factor in doing so.

Further insights from the field trial

1. Initial digging was a little tougher compared to the deeper digging.
2. Moisture content was more, deep down.
3. When the blade was half down, it was easy to pull but when it was pressed deep. It became hard to pull, in fact we were unable to pull.
4. Blade was welded nicely with the rod and that welding was comparatively stronger.

5. The wind and the slope made the soil to come into the hole and filled the hole, making it tighter and also hard to drill.

Things needed to be worked in next prototype

1. Need to reduce cost.
2. Rotational motion can be improved so that vertical strength can be applied parallel with the rotational motion by adding load on the blade.
3. Need to work on the strength joint and handle strength.
4. Mechanism for preventing the side soil from entering the well while digging.
5. Some attachment for better grip in handle and for heating issues as well.

Version 3.0 – Final prototype

Figure 8 Version 3.0 Prototype

Bill of Material

Total Material Cost – Rs. 2500

Limitations

Reasons solution may not be a success

1. **Technological/user experience**
    a) The screw gets hard to rotate as the blade gets deeper and load is required to push it while rotating. This load can be manually exerted but is advised to be produced using a weight.
    b) As the blade gets deeper, it gets hard to pull out the blade combined with the weight of the soil.
    c) The iron based handle was very hard and it gets very hot in Kutch which needs to be taken care of to make it more user friendly.
2. **Behavioral**
    a) As informed by the salt farmers, the concept would take a bit of time to be accepted by the salt farmers as they would have to give up their traditional practice of well digging using basic tools.
    b) The processes related to well digging using our auger blade would be different to that by a basic phavada which may result in inertia.
    c) Problems in adoption and learnability
3. **Dissemination**
    a) The product must cost less to the farmers else it would limit its reach to limited farmers only.
    b) A proper ecosystem for its manufacturing, repairing and selling needs to be set up in place.

Road ahead

The team has developed the well digger for salt farmers which has been tested locally in Grambharti and also in, little Rann of Kutch. Since the team has developed the product off season, the members have decided to come back to Kutch in the month of October when the salt farming starts and stay with the community to test the well digger and help optimize the processes for the farmers. A lot of unmet social needs have been identified during the field visit which the team has come to realized and is looking forward to work on them in future.

Team Pictures