Grassroots Innovation to Enterprise

A Case Study on

A low cost Windmill

ALSTOM CORPORATE FOUNDATION

FOR THE ENVIRONMENT

Gujarat Grassroots Innovations Augmentation Network (GIAN)

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Index

Introduction

Md. Mohhand Mehtar Hussain (38) and Mushtaq Ahmad (28) are resident of Darrang, Assam. Looking for a low-cost alternative to pump water in the fields for the winter crops, they have devised simple windmill made up of bamboo and tin sheets. Married, with one son, Mehtar lives in a joint family with his widowed mother, one sister and brother. The family owns two acres of land, which the two brothers jointly look after. Both have completed their education up to higher secondary and they have been farmers. They produce just enough paddies for their own consumption, with a little surplus in some seasons. The main source of income for the family is a pension of about Rs. 2,500 per month in the name of his late father, who had retired as a Primary school teacher. Though economically poor, theirs is a happy and close-knit family.

Though the water table is not too deep, but drawing water is not easy since electricity supply is erratic and most small farmers cannot afford other means also. Mehtar and his brother while growing paddy in winter season (also called *bodo* paddy), needed irrigation from the well. Continuous pumping by hand involves a lot of effort and drudgery. At the same time, pumping out water by using diesel sets was a big drain on their resources. He pondered over the problem and looked around for a solution.

The depth of water level is around 40 to 50 ft and abundant amount of wind is available in this area.

In 2008, the Network was looking to use another innovation, the Bullet Santi for harvesting salt from salt panes. During one such visit the GIAN team observed that the place had ample amount of winds and the water tables were not deeper than fifty feet. It was soon realized that the windmill could find an application in pumping water for salt farming.

India is the third largest salt producing country in the world with an average annual production of about 157 lakh tonnes. The state of Gujarat contributes around 70% of it. The Little Rann produces 21 per cent of total salt production of India. It is estimated that 54,000 salt workers (Agarias) are engaged in the salt making in the state and more than 10,000 Agaria families are involved in inland salt farming in the Little Rann of Kachchh (LRK)

Because of lack of availability of electricity, farmers are using diesel engine for pumping saline water. On an average, for producing about 1000 tons of salt the expenditure is Rs. One Lakh, out of which about Rs. 60,000/- is spent on fuel (crude oil) alone. Because of limited financial resources, they do not have any buying capacity. The salt traders exploit them by giving them advances for their recurring expenses and then enter into buy back agreement for salt at a very cheap rate. The chain of middle men, traders, transporters and retailers grabs the most of profits leaving behind salt farmers. The result is that after so much of hard work in trying conditions what they get in the end is nothing compared to the labor they put in.

Product Development

On demonstration basis, we have installed wind mills at little desert of Kutchh. The performance of the experimental setup has been accumulated and development was done on basis of observation. Overall response throughout demonstration was overwhelming and the farmers have appreciated and shown their interest in buying such units. According to them it is cheaper and efficient alternative for irrigating saltpans compared to conventional method of lifting ground water through diesel pumps.

- In Jan 2008, the first model worked only when the turbine blades faces the wind direction. It isn't adjustable to the direction of wind flow, it didn't with stand high wind velocity, there were no brake system and life was limited

- In April 2008, All above mentioned issues were addressed in the second model i.e., development of improved multi-directional movement i.e., wind turbine adjusts itself according to the direction of wind.

- In Dec 2008, third model multi directional movement was further improvised with FRP (Fiber Reinforce Plastic Blades)

- In Feb 2009, forth model a tilting mechanism facility was provided to tilt and lower down the wind mill easily through wire rope at a safe position

- During Jan 2010 to March 2011, fifth model was developed with supporting structure for turbine blade was added, furling tail mechanism and modification in crank mechanism

Comparison with conventional wind mill

Innovative low cost wind mill	**Conventional wind mill**
Low height (15 ft)	Height is more (35 ft)
Innovative blade design (4 No.s)	Multi blades turbine (36 No.s)
Simple crank mechanism which does not requires any major maintenance	Gearbox mechanism, requires high maintenance
Low initial investment	Initial investment is high
Easy to assemble & Dismantle, farmers himself can do it	Assembly and dismantling requires skill , time and labor
Suitable for salt farming – can be shifted after salt season	Difficult to shift once erected and therefore does not suitable for sat farming area

Long duration pilot trials undertaken in Gujarat during January 09 - May 09

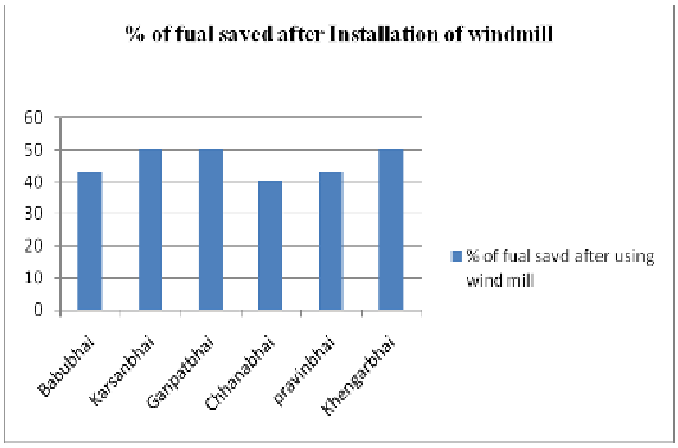
GIAN successfully installed and demonstrated six improved windmills in May 2009 at Little Rann of Kutch at the salt farms of six farmers. GIAN also conducted users' feedback study at the end of salt season in 2009. The results have been very encouraging. The details of wind mill installed and quantitative data of savings made by the farmers are mentioned below:

Sr	Details of the users (salt-farmers)	Installation period	Total no of days wind mill used	Total qty. of diesel used before installation of wind mill	Total Qty of diesel used after installation of wind mill	Qty. of diesel saved (% of saving)	Total amt. saved
1	Karsanbhai Enjar , LRK	Jan 2009	120 days	720 Liters	360 liters	360 liters (50% saving)	Rs.12600
2	Khengar bhai Enjar, LRK	Feb 2009	90 days	600 liters	300 liters	300 liters (50% saving)	Rs.10500
3	Babubhai Kuda , LRK	March 2009	45 days	700 liters	400 liters	300 liters (43% saving)	Rs.10500

4	Ganpat bhai Sadla, LRK	April 2009	30 days	450 liters	225 liters	225 liters (50% saving)	Rs.7875
5	ChhanabhaiKharaghoda,LRK	April 2009	30 days	600 liters	360 liters	240 liters (40% saving)	Rs.8400
6	Pravinbhai LRK	April 2009	30 days	210 liters	120 liters	90 liters (43% saving)	Rs.3150

Cost Effectiveness of the innovated wind mill (Savings done by farmers)

It is very clear from the above chart that after using the wind mill, on an average the diesel consumption has reduced by about 40 per cent in case of all the users. In this design, we observed that on site, turbine blades got damaged in high wind velocity and therefore we felt the need of further design improvements in terms of make more sturdy and safe.



Formal Testing by EQDC (Electronics and Quality Development Centre)

GIAN tied up with EQDC, a Government authorized testing agency to carry out the scientific testing of the wind mill. EQDC is reputed ISO 9001:2008 certified, NABL Accredited & BIS recognized laboratory, working under, DST and Govt. of India. The facility of EQDC is also recognized as Scientific and Industrial Research Organization (SIRO) by Department of Scientific and Industrial Research, Govt. of India. EQDC is providing testing, Calibration, Quality Advisory and technical design consultancy services in the area of engineering technology. We got tested our wind mill by EQDC at laboratory condition as well as field condition. The detailed test report is as below:

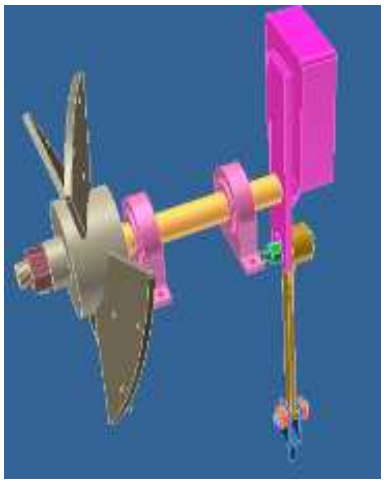
Conclusion of test report

If we can take average of both the calculation, the average 1476 litre / hr @ 14.36 km/hr wind velocity.

Further value addition & Design modification

Looking to our observation in earlier design of wind mill, we modified design by keeping the two points

- To fabricate easily and
- To minimize the maintenance and make it easy. The design made in such a way that even the local person can assemble and dismantle the key parts of wind mills apart from the base stand and turbine. The modifications have been carried in yaw bearings structure, central head having crank mechanism and tail arrangement.



Design Evolution and Review by Alstom Wind

Prior to the start of manufacturing of the windmill, a thorough review of the design was performed by Experts at Alstom Wind. Mr. Pep Prats, Senior Vice President, Engineering, reviewed the design of the windmill along with available wind-speed and topographical data and made the suggestions in the following areas of wind turbine design:

- Provision of furling tail as a safety mechanism to control the wind mill in high wind velocity.
- Suggestion of providing a floating valve to the reciprocating cylinder at the bottom of pump so the wind turbine starts without pressure and with increasing speed the pumping starts easily.
- Modification suggested in crank shaft (crank radius and accordingly pump stroke length).
- Yaw bearing mechanism and its accessories, tail assembly and issues related with its structural strength.
- Rotor fixation on shaft, its safety against extreme condition, its strength to sustain the pulsating load and its fixation with crank mechanism and its smooth functioning.
- Suggestion for taking necessary precautionary measure for protection in an extreme saline environment.
- Safety system for deactivating the turbine when we want to stop it.
- Maintenance aspects of overall wind mills.

With the consultation of innovators and manufactures, GIAN team incorporated all suggestion made by experts except providing the brake system for deactivating the turbine when we want to stop it. We did not incorporated it because it requires further research and add to the cost of the wind mill and also requires further dimensional modification in design of wind turbine. We are working on providing low cost brake system and we tried to incorporate the same for the wind mills to be supplied in Phase 1/2.

IPR protection

GIAN has filed provisional patent application to protect the IPR of the innovator. The patent application number is 1367/KOL/2008 dated 14 August 2008.

Technology Diffusion on Large Scale: a project in association with Alstom Foundation

In order to diffuse this useful technology to salt farmers of the country, GIAN approached Alstom Foundation for financial support via one of their employees, Janak Raguraman, who was interested in contributing to the sustainable space. The request for support was for manufacturing and installation of 130 wind mills. Alstom Foundation considered GIAN proposal positively and approved pilot project of installation of 50 wind mills in Phase 1 on condition that the design of the windmill be validated and approved by experts at Alstom Wind. The project of manufacturing and installation of 50 wind mills is divided into two sub phases; Viz; Manufacturing and installation of 25 wind mills in phase: 1/1 (Period – Feb 2011) and manufacturing and installation of another 25 wind mills in phase 1/2 (Period – October 2011 – Sep 2012).

Identification of Beneficiaries and Site Selection:

We had a talk with the farmers and arranged their visit to one of our windmill demonstration site. They were extremely impressed by the performance of the wind mill and immediately expressed their interests in benefiting from this technology. We found that these are the real and genuine people who need our technology and therefore we decided to allot them the wind mill on preference. We employed following four basic criteria while selection of beneficiaries.

- *Women Farmers:* Mostly women are involved in the day to day activities of salt farming at the salt field. Man usually goes to sell the salt to the nearby villages. Therefore most of the tedious work of manually lifting of the water, harvesting the salt from pan and accumulating the salt at one place are being carried out by the women. To reduce the strain on these women, who balance this hard work with household work, we decided to give preference to women salt farmers

- *Age of the Salt Farmers:* Mostly old people are involved in the salt farming because the younger generation is not ready to carry out this tedious, laborious task that yields low income and instead go to nearby towns for their livelihood. Our second preference was hence to help older age farmers.

- *Land holding and owning diesel engine:* We have given the preference to those farmers who have small farm land (less than 5 acre) and those who are not capable of buying the diesel engine for water pumping.

- *No access to electricity* - We also gave priority to those farmers who were very poor and did not have access to electricity and were using counterpoise weight & bucket method for lifting water.

In order to justify the proper use of all 25 wind mills, we have also shifted all the six windmills from the Chanch Village (where farmers have electricity and huge salt farming area) and allocated it to other small farmers at village Kathivadar and Kadiyali. There are hence 31 windmills in this region, and their use is benefitting the salt farmers immensely.

Tie Up With Manufacturer

GIAN filed a patent application to protect the IPR of innovators and transferred the technology to an Ahmedabad-based enterprise, Chaudhary Designers and Fabricators, for large scale commercialization. Mr. Kaushikbhai Chaudhary -the owner of the firm and manufacturing Solar Water Heater, Solar distillation Units on commercial scale. His firm is also involved in precision fabrication of engineering items since last 30 years. GIAN entered into agreement with Chaudhary Designers & fabricators for manufacturing and supply of 50 wind mills under project.

Project Launch

We launched the project on 14th March 2011 in the presence of 15 salt farmers. Innovator Shri Mehtar Hussain and Mustaq Ahmed, owner of Salt Farmers cooperative Shri Samjibhai Patel and representative of Rotary Club launched the project by cutting the ribbon and unlocked the first wind mill of the project.

The simplicity, smooth functioning and the output of the windmill won the hearts of the Salt Farmers. Mr. Samjibhai, President Chamunda Salt Works, Cooperative of Salt Farmers said " Adoption of wind mill is the first step for them towards the sustainable salt farming by using eco friendly method of pumping salt water and efforts of GIAN and Alstom Foundation would go a long way in the livelihood and empowerment of salt farmers"

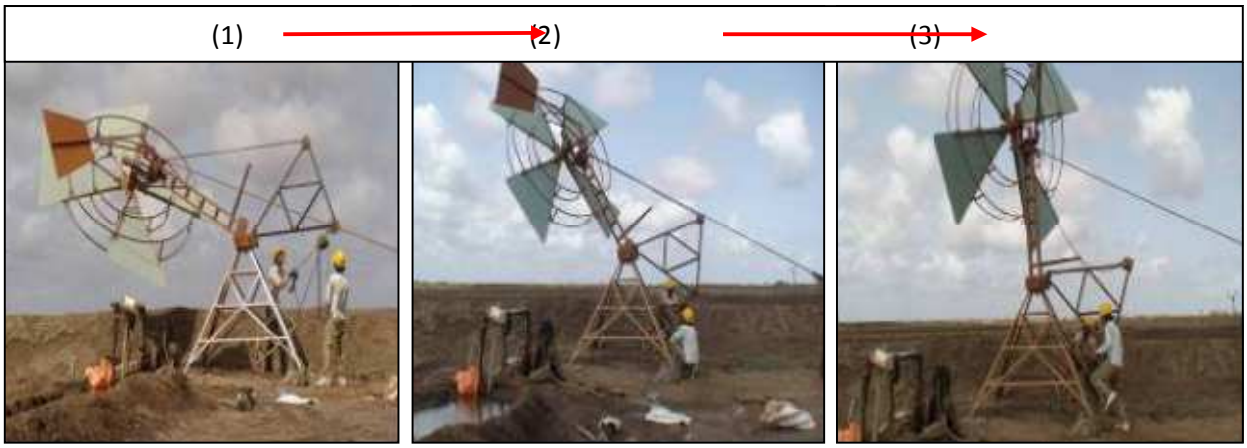
Live demonstration and hands-on training to Salt Farmers

We gave hands-on training to the users about how to use and maintain the wind mill and minimum regular checkups they have to do by their own. We explained to them the mechanism of critical components like cylinder which pumps the water and how to change the washers etc. We also gave them training about how to stop the wind mill by using the rope braking mechanism.

Installation, Commissioning and Maintenance

(Development of small device to speed up the installation process)

We experienced that the installation of intermediate structure and blade frame ring of the wind mill requires too much labor and hard work. It is also a risky operation and chances of accident are much higher. Due to the salt harvesting and main season to sell the salt in the nearby villages it is hard to find the labor. Therefore in order to ease the installation operation, we tried out many mechanisms but no one fits our need. Finally we were able to design a novel mechanism that utilizes a truss type structure operated through a chain pulley device.



Using this, speeds up the installation process and it also reduces the risk factor, which was earlier associated with the installation process. This also requires less labor to erect the windmill.

A truss type structure made from angle is used to make the windmill upright with Blade frame ring, Blade and Tail. The truss has three ends and has a shape of triangle. The first end of the truss is hinged to the lower structure of the windmill, second end is tied to the outer body windmill yaw bearing through the chain or Rope and the third end is attached to the manual chain pulley system to lift the windmill about the pivot.

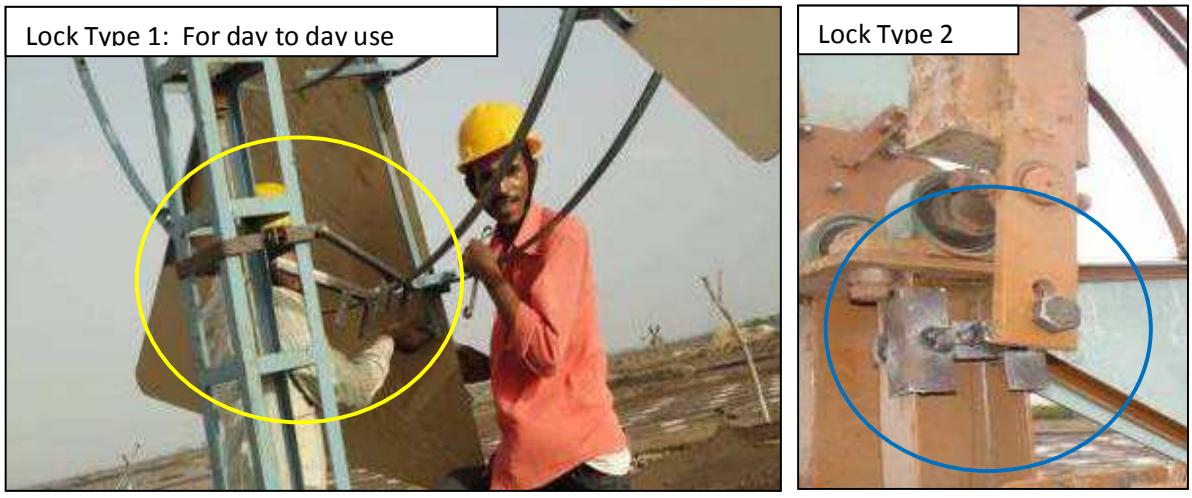
Additional Design Review and Modification

During our regular supervision and routine inspection of all wind mill installed, we came to know that link connecting the universal coupling and connecting rod got slightly bend in two wind mills. We felt the need of design correction of this component. We approached Prof. Soni, Visiting Faculty at Nirma University and Retired Professor of Mechanical Engineering. At L.D. Engineering College, Ahmedabad, we discussed the problem with him and

rectified the design as per the suggestions given by him. The result was a new sturdy universal joint. The details of modification are as below.

Lock incorporated in the windmill to stop its functioning

With the starting of the rainy season all the salt farmers start to windup the activities at the salt farming fields. During this period of nearly 2 to 3 months the farmers usually visits the field once or twice a month. Therefore it is necessary to lock the windmill from the safety point of view and as a precaution to avoid any kind of damage. The windmill has been locked in three ways; Following are the locks incorporated photos of the windmill.



The encircled portion shows two different types of lock being incorporated in the windmill

Performance Measurement

In order to check the performance of the wind mill in terms of water discharge, we measured the performance. Performance of the windmill. Performance of the windmill has been measured using the anemometer and a container of 25 lt. And recording the data in the video and later analyzed to measure the performance of the windmill. Following formula is used to calculate the average wind speed, using the speed recorded by the anemometer:

Formula: V (avg.) = (V1+V2+V3+V4+……+Vn)/n

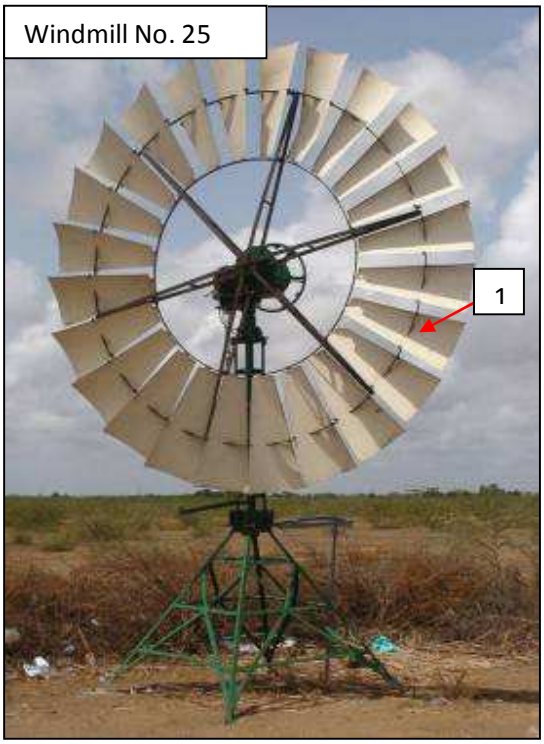
Discharge (l/hr) = (Container size)/ (Time to fill the container)

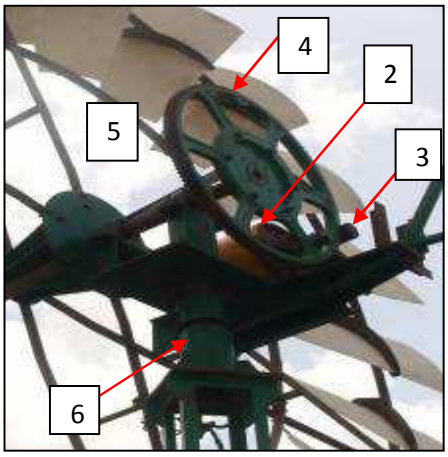
Sr.	**25/04/2011**		**7/05/2011**		**Conclusion**
	Reading (Km/hr)		**Reading Km/hr)**		
	1	**2**		**2**	The Avg. output of the windmill

1	20	15		17.5	calculated from the above data is found to be 2716.9 l/hr @ 20.05 km/hr. As the site is near to the sea soar it has a good wind speed available in the area for whole day. Therefore calculating the average discharge in a day @ 10 hr of wind availability will deliver 27,160 lt of water in 10 hr. It is important to note that this discharge is far beyond the expectation of farmers and very much satisfactory for the users, because some of them are lifting water through manual method which is very time consuming and involves physical labor. It has direct impact on cost saving in terms of diesel consumption for those who are employing diesel engine.
2	21.4	13.5		21.1	
3	19	12.8		19.6	
4	20.6	14.9		21.5	
5	20.6	15.7		25.9	
6	18.2	15.3		26.8	
7	16.2	16.7		21.2	
8	15.5	17.2		23.3	
9	15.5	20.2		22.8	
10	15.6	20.4		14.5	
11	15.6	20.6		25.4	
12	17.4	19.7		28.9	
13	17.9	19.5		34.9	
15	17.9			26.7	
16	17.3			24.4	
17	19.3				
18	19.7				
Total	307.7	221.5		354.5	
Avg(Km/hr)	17.91	17.03		**23.6**	
Total time (sec)	50	50		27	
Container size	30	30		25	
Discharge (l/hr)	2160	2160		**3333**	

Design & Installation of Power generating Wind mill

On June 10 2011, we also installed one power generating windmill at village Kadiyali. The windmill has been installed near to the small hut so that batteries, inverters and other instruments can be kept safely. Multi blade rotor has been used for power generating windmill as the rpm and initial torque achieved is quite good. Following are the specification of the windmill:





1. Rotor

2. Permanent MagnetGenerator

3. Pinion on the PMG Shaft

4. Gear on the Rotor Shaft

The power generating windmill has been installed using the three poles and chain pulley system. The following pictures shows the installation process,

During the dry span of the rainy season, we did the trials to measure the performance of the power generating windmill. Ammeter, voltmeter, 24 volt battery and anemometer are the instrument used to collect readings.

During the visit, high fluctuating wind speed was recorded using the anemometer. In order to prevent the rotor from achieving unsafe speeds, its speed is reduced by applying a braking force to the rotor. This braking force is typically achieved by short circuiting the three ends of the generating. Doing so generates an opposite torque on the generator that is transferred via the pinion on to the rotating rotor.

During one such high wind speed, brakes are applied again to reduce the rpm of the rotor, the pinion was damaged. Due to this, the data cannot be collected. The Generator and the gear on the rotor shaft have since been dismantled and taken to the workshop. We were also working on the new designs to improve the performance of the power generating windmill.

Status of the work carried out by GIAN from 2008- 2010

Innovator Shri Mehtar Hussain has installed about 7 units in North East region. Centre for Energy, Indian Institute of Technology Guwahati has done the technical analysis and feasibility study in the year March 2007. As per the report, the performance of the wind turbine installed at Mahariapatharwas found to be the best giving a maximum discharge of 60 liter/min at 3.2 m/s. In the report, the scientist also made recommendation to increase the performance of the wind mill.

Prof. Murli Damodaran (wearing the cap) with his team of faculties and student

During the years 2007-2011, innovators have gone through long iteration process to come up with commercially ready design of a low cost wind mill in the year 2011.

Visit by Prof. Murli Damodaran, IIT Gandhinagar

On 23 May 2011, Prof. Murli Damodaran, distinguished faculty from IITGN visited the site with his team. Prof. Damodaran has volunteered to work with GIAN and Alstom Foundation on this project through the student involvement. He found the wind mill very useful and very practical low cost solution for the salt farmers. Prof. Murli appreciated the work done by GIAN with the support of Alstom Foundation. Prof. Murli Damodaran expressed his willingness to work in following aspects to make the wind mill design more robust and efficient through the involvement of students as well as faculties.

- Computational design analysis and optimization to assess questions on blade profiles, blade angles and so on with a goal for optimizing the performance of the wind mill. These will be done as final B. Tech. or M. Tech. thesis projects (about two semesters).
- Designing a low-cost braking system to stop the operation of the wind mill instead of resorting to tethering using ropes,
- Improving the method of collection of field test data for validating the computational data designing solutions for moderating the behavior of the system at varying wind speeds to achieve desirable objectives, estimation of desirable operational speed limits to prevent excessive leakage of the water pump, mitigation of system vibrations and other performance issues.
- Exploring the possibilities of wind tunnel testing of the blades, either at IIT Delhi or at IIT Kanpur. IITGN will also look at the version which is used to produce electricity and other faculty members will address issues pertaining to integration, storage, transmission and pricing.

Socio-ecological and institutional context of Wind Mill Project: Gujarat

Note by Prof. Anil K Gupta

Prof. Anil K Gupta, Founder of Honeybee Network and Honorary Secretary, GIAN visited the site and very well appreciated the wind mill installation as an alternative of manual method and diesel engine. Prof Gupta also met beneficiaries and heard the feedback from users.

Prof. Gupta was deeply impressed with the change the project is bringing about in the life of salt workers. He also suggested to the farmers that they should contribute a small amount of their annual earnings to a corpus fund so that other salt famers could benefit from this technology. The idea was heard favorably, and the salt corporative is working to

define this arrangements.

Economic Benefit:

A	**Users who do not have diesel engine & used to operate counterpoise**

Sr.	Name of beneficiaries	Land area (acre)	Man days (Manpower) saved/ month	**Saving in Rs./month (man rate @Rs.200 /day**	**Total savings in a season (6 months)**	**How much willing to pay in 1 season**
1	FulibenUkabhaiBamaniya	1.2	30	6000	36000	500
2	Mukeshbhai Bholabhai	1.2	30	6000	36000	700
3	Manubhai Takubhai Solanki	0.8	20	4000	24000	500
4	Bholabhai Bambhaniya	0.8	22	4400	26400	500
5	Babubhai RambhaiBamaniya	0.8	20	4000	24000	500
6	ValkubhaiBijalbhai	0.8	18	3600	21600	500
	Total (Users Total N1 = 6)	5.6	140	28000	168000	
	Avg. saving in Rs/users/season					28000
	Avg. savings in Rs/Acre/season					30000
	<u>Conclusion:</u> Using the wind mill, now the salt workers do not have to rely on labors much and hence they make a saving of an average Rs.28000/- season per person. Similarly, saving per acre of land per season comes to be Rs. 30,000/- . This also saves them a lot of drudgery					

Innovators speak

".....We are very proud that GIAN with the help of a renowned company Alstom Foundation took interest in our windmill and improved it so much that it could change the lives of so many families. We are very happy that their savings have increased resulting in improved livelihood. GIAN, NIF and Alstom Foundation made our wind mill useful for others and our dream comes through...."

Project Outcome

The project has been launched with the aim of alleviating the lives of poor salt farmers by providing a low cost non-conventional water pumping windmill. The windmills will directly impact the lives of 25 salt farmer families; almost 150 to 200 individuals. With the Installation of the 25 windmills including one variant designed for power generation, the first phase of project has been completed successfully.

Each windmill is expected to pump around 3 million liters of brine each year. This will lead to the saving of more than 2600 liters of diesel fuel each year. Reduced fuel consumption will help in reducing emission CO and CO2. This much of fuel saved per year per windmill will result in reducing the emission of CO2 by approximately 7 tons per year; the 25 windmills together can reduce greenhouse emissions by about 150 tons each year. Considering the success of the project phase 1/1, GIAN is sure of the emergence of new partnership and that many more agencies would come forward to join hands to replicate this model at a larger scale. GIAN has had tremendous learning during the planning and implementation phase, and can now scale up this activity manifold in different areas as per the site requirements.

TU Delft students during their project with GIAN initiated the creation of Chakardi Salt, an edible salt brand for the consumer market. Chakardi Salt aims to be the first India fair-trades eco-friendly salt. The profits from the salt sales can be put back into funding more windmills making it a viable and sustainable business model. Currently the project is being supported by Enviu, a Dutch not-for-profit incubator.

https://creativityatgrassroots.wordpress.com/2013/04/19/winds-of-prosperity/