An Assessment of the Drip Linked Solar System (DLSS) Pilot implemented by VIKAS-CFD in Banaskantha District.

April 2024

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1. Background and Rationale

Most agricultural land in India is irrigated using groundwater pumps that are either connected to the grid or run on diesel. Diesel and electric/grid connected pumps have a large carbon footprint. While the number of farmers using solar photovoltaic–powered pumps has been increasing, these are not often employed for micro irrigation, which is needed to counter the rapid depletion of groundwater.

VIKAS Centre for Development and Saline Area Vitalisation Enterprise Private Limited (Technical Service Organisation) partnered with Arvali Janvikas Kendra & Samvedna Trust with the financial support from AID, USA in an experiment aimed at enhancing productivity and profitability of small and marginal tribal farmers of Banaskhanta district, Gujarat, India since past three years (FY 2021-24).

Small and marginal farmers (having land less than 5 acres) in the region face several challenges. These include uncertain rains, depleting and dropping ground water levels, uncertain access to electricity for agriculture, increasing costs of production (including diesel costs), lower price realisation of crops etc. This in essence leads to lower agriculture productivity and profitability.

1.1 Solar Linked Drip Irrigation System:
The objective of the Solar linked drip irrigation system initiative is to enhance productivity and profitability of small landholding farmers by introducing a technical innovation which addresses climate change concerns as well as issues of poverty.

1.2 Climate Change concerns:
The introduction of solar energy helps to reduce dependence on high carbon emitting pumps run by diesel or electricity and this addresses climate change concerns. Combining this with drip irrigation would address the issue of overuse of ground water adversely impacting the depleting ground water level as well quality & productivity of agriculture soil.

1.3 Poverty
The increasing costs of agriculture inputs, energy and water costs on one hand and reducing price realisation of the agriculture outputs on the other is gradually making agriculture activity non-viable for large number of small farmers. The objective of this system is therefore to address both the above issues.

1.4 The Design Process

Year 2021-22

The experiment began with one farmer from Rani Umri village of Danta taluka. The system was designed to suit the local conditions covering one acre plot of land.

After initiating implementation with this one farmer, several lessons were learned which are summarised below:

- Farmer could use the available water for longer period (extending the agriculture season beyond monsoon to winter and even summer).
- With this he made additional income of Rs. 90,000/- in four months period.
- The system helped save costs of energy, water distribution, weeding labour as well as reduced the use of pesticides
- The quality of agriculture product was better and helped to realise better price in the market (at least a jump of 10%)
- Farmers could use the drip system in at least 9 different crops (increasing crop diversity and therefore resilience to climate vulnerability)
- Saved 75% of ground water and pumping costs (i.e. cost of fossil fuels such as diesel)

Year 2022-23

Encouraged by the positive results (only with one farmer) VIKAS decided to scale up the initiative and add another 12 farmers (six from Danta & six from nearby Amirgadh talukas)

Following process was followed:

- The farmers were selected by the partners – Arvali Janvikas Kendra & Samvedna.
- The plots were measured through GPRS and maps were prepared.
- Water tables in each of the water wells were measured
- After due consultation with farmers design for each of the systems was carried out by team from SAVE Ltd. and VIKAS CFD accommodating the local variations
- A training programme was organised to inform farmers about the technical and financial data to be maintained.
- A local supervisor was appointed to regularly visit each farmer and collect data on operations, water usage and functioning of the system.
- All systems were installed by December 2022 and information was collected till June 2023 (onset of monsoon).

- The information on agriculture process from sowing to harvesting and selling has been collected and analysed.
- The technical and financial data has been analysed to establish the performance of the system and decide the next course of action.
- A review with farmers was organised to get feedback on improvement of the system.

VIKAS-CFD has thus been helping the farmers in the tribal belt of Banaskantha's Danta and Amirgadh talukas since past two years to replace their diesel and grid connected/electric irrigation pumps with solar powered pumps. It is the organization's belief that customized solar-powered pumps, if used to draw groundwater and distribute it through the drip irrigation system, can help farmers save both water and energy.

However, solar pump makers are focused on efficiency and their ability to extract more water for less energy. On the other hand, drip irrigation companies continue to link their systems to existing pumps. Both sides need to reconsider this arrangement since most small and marginal farmers do not need regular pumps with a capacity of 5–7 horsepower (HP). These may have a capacity to draw one lakh litres, but the model designed and developed in-house by VIKAS-CFD draws about 4,000–5,000 litres per hour which are enough to grow a vegetable crop on an acre of land.

VIKAS has designed a customized Drip linked solar pump system (hereinafter DLSS for short- see figures 1 2, 3, 4 and 5) where a solar panel and pump of only 1 Horse Power (Hp) capacity could be used to cultivate a vegetable crop on one acre of land.

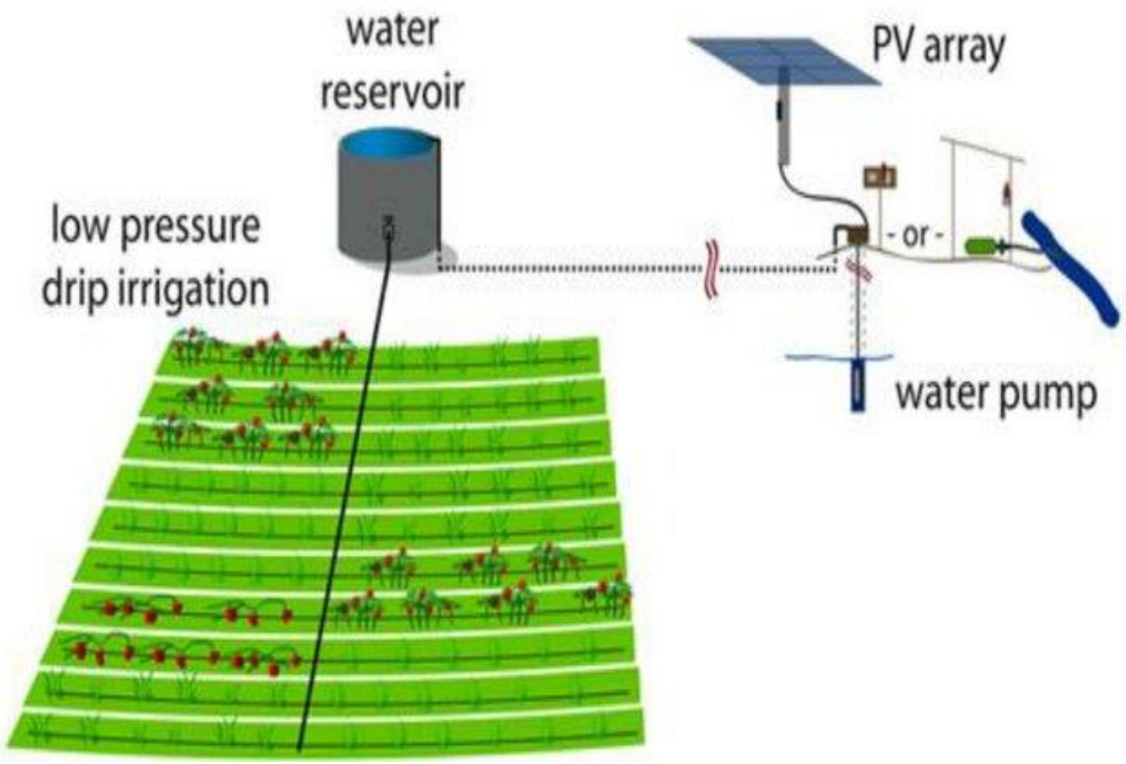


Figure 1.1: Schematic Diagram of a solar pump connected to a drip system

Figure 1.2: Farmer Babubhai with his solar panel. The hilly background demonstrates the topography. Figure 1.3: A well with the submerged pump and pipe drawing water for the drip system.

Figure 1.4: Reservoir from where water flows into the drip with pressure. Figure 1.5: Healthy Brinjal plants irrigated by Drip. Source: Fieldwork by author

2. Objectives of the Study

The objectives of the assessment are to: 1] analyze the changes in farming systems of the drip linked solar pump system adopters (profitability); 2] assess the possibility of carbon offsets by adoption of DLSS among the adopter-farmers.

3. STUDY SITE

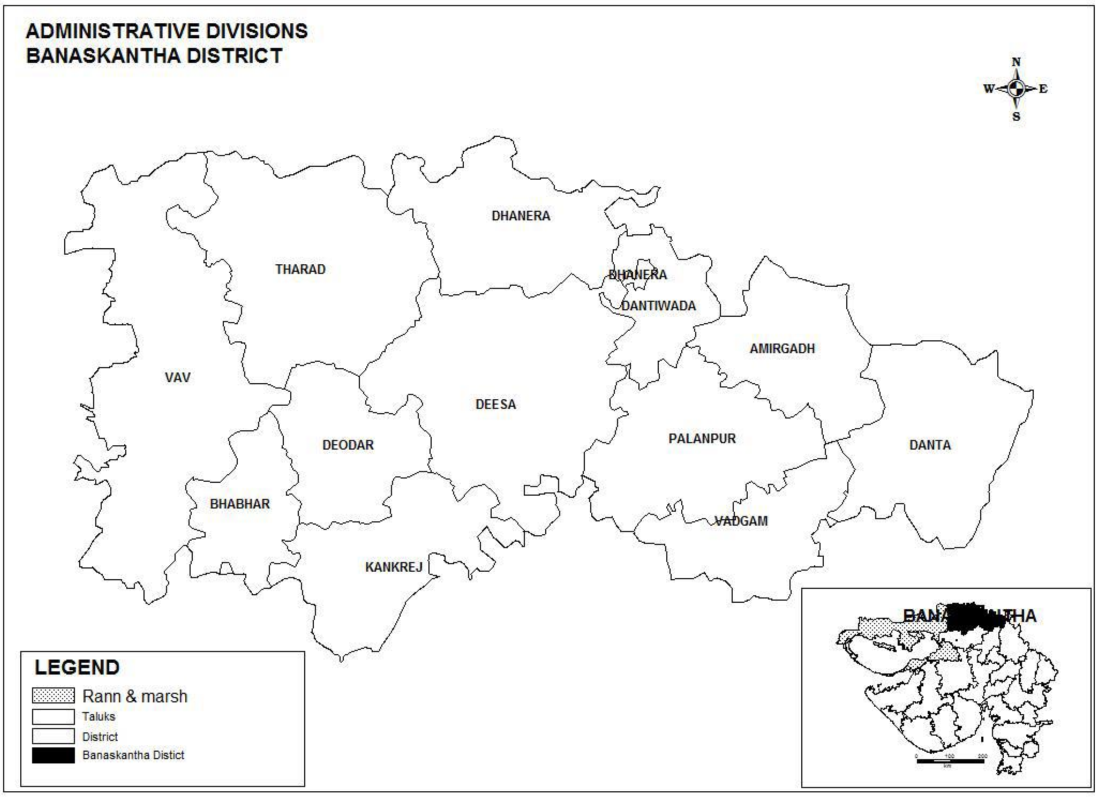


Figure 3.1: Administrative divisions of Banaskantha district. Danta and Amirgadh Talukas fall in the north-eastern part of the district. (Source: CGWB Report 2011)

The study Talukas were Danta and Amirgadh (see figure 3.1) in the north-east of Banaskantha as these were the ones where the DLS intervention has been piloted by VIKAS-CFD since 2022.The district has a semi-arid climate. Extreme temperatures, erratic rainfall and high evaporation are the characteristic features of this type of climate. Since the district experiences a semi arid type of climate, the rivers flowing through it are of ephemeral nature i.e. have water during monsoon only and dry up after monsoon. The drainage network in the district is constituted mainly by the Banas and Sarashwati rivers and their tributaries. In the extreme east, Sabarmati river forms district boundary with Sabarkantha district and in part controls the drainage network of the hilly area east of Danta. The surface water resources of the district are very limited. Groundwater is the main source of irrigation. (CGWB, 2011)

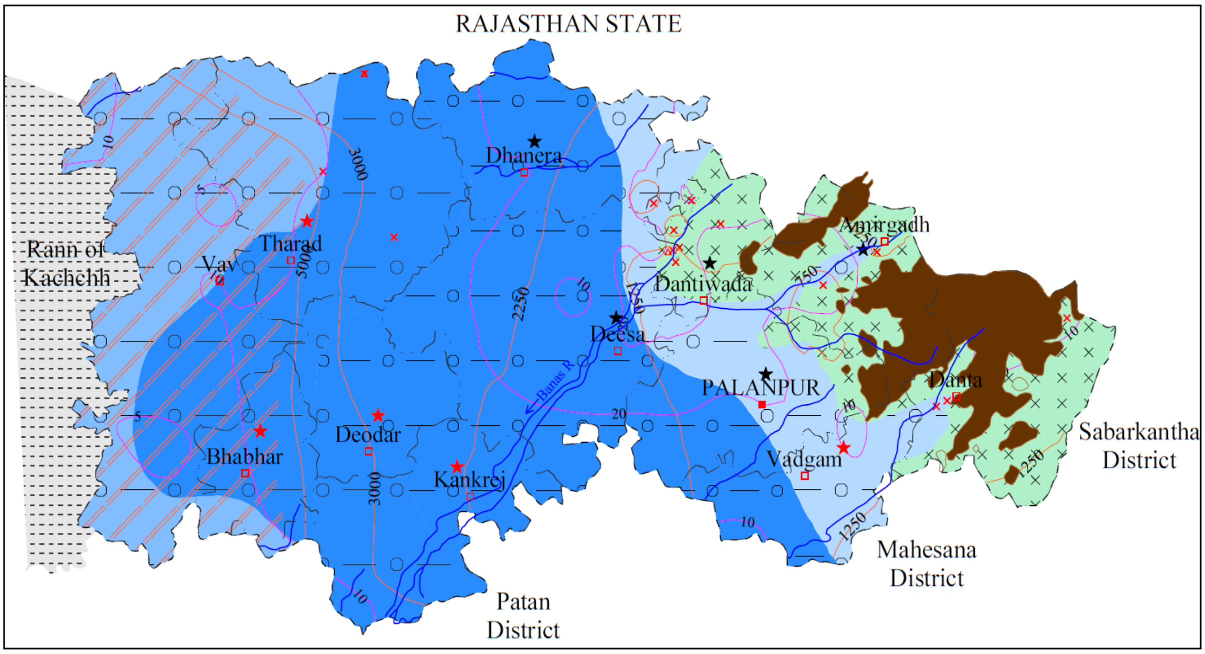


Fig 3.2: Hydrogeological Map-Banaskantha (CGWB-2011 and 2016)

Legend Hydrogeological Map

	Wells Feasible	Rigs Suitable	Depth of Well (m)	Discharge (lpm)	Artificial Recharge Structure Suitable
Soft Rock Aquifer	Dug Well Tubewell	Manual Direct Rotary, Reverse Rotary	10-25 50-100	200-300 600-1000	Percolation Tanks/ Ponds, Recharge Wells,
Soft Rock Aquifer	Dug Well Tubewell	Manual Direct Rotary Reverse Rotary	15-30 100-300	200-300 800-1000	Percolation Tanks/ Ponds, Recharge Wells, Recharge Shaft
Soft Rock Aquifer	Dug Well Tubewell	Manual Direct Rotary Reverse Rotary	15- 30 100-300	200-300 1000-1200	Percolation Tanks/ Ponds, Recharge Wells, Recharge Shaft
Hard Rock Aquifer	Dug Well Borewell	Manual Down the Hole Hammer (DTH)	10-25 100-200	60-150 100-300	Percolation Tanks/ Ponds, Recharge Wells, Check Dams, Nalla Bunds.
Hilly Areas	Not Suitable				Check Dam, Nalla Bund, Gully Plug
Saline Area	Not Suitable except localised fresh water pockets				
20	Pre-monsoon Decadal mean (1993-2000) Depth to Water Level (mbgl)		2000	Electrical Conductivity (µS/cm at 25° C)	
	Fluoride > Maximum Permissible Limit (1.5 mg/l)			Nitrate > Maximum Permissible Limit (100 mg/l)	
	Over Exploited Taluka			Dark Taluka	
	Drainage			District/Taluka HQS	
	Rann/Marsh				

Source: Central Groundwater Board 2011 and 2016. District Irrigation Plan, PMKSY, 2016

The north-eastern part of the district is mainly occupied by metasediments and Post Delhi intrusives (see fig 3.2 and legend above). Danta and Amirgadh talukas fall in the hard rock aquifer and hilly areas zone. These formations generally do not form very good aquifer system. The depth of dug wells ranges from 15-30 mbgl and of bore wells ranges from 100-200 mbgl. Depth to water level in the dug wells varies from 5 -14 mbgl and in borewells from 15 to 60 mbgl. The successful bore wells drilled so far, yielded in the range of 30- 1036m^3 /day with an average yield of 240m^3/day.

4. METHODOLOGY

This assessment primarily adopted the broad framework of understanding the Relevance and quality of DLSS design, Effectiveness in terms of profitability and area under irrigation to date of the pilot DLSS intervention as it is planned to scale it up soon. We started with the following broad research questions: 1. Who are the adopters of DLS technology and what are their social and economic backgrounds? 2. Whether the adopters were keen to bring more land under this technology or expanded the area under irrigation after adoption? 3. Do the adopters really achieve higher income due to DLS adoption? 4. Do the farmers change their cropping pattern towards high-valued crops along with DLSS adoption? 5. What are the implications for carbon emissions and water saving with DLSS adoption?

The study villages were selected based on the Pilot intervention of DLSS systems in the villages. Quantitative information was collected through a structured questionnaire, answered by eight selected farmers. To realize the specific objectives, the following methodology was employed:

1. Analysis of changes in farming system in terms of cropping in three agricultural seasons and profitability through "with-or-without" (cross sectional) comparison between adopters and non-adopters.

2. Focus group discussion – among adopters and non-adopters separately in intervened villages to gather qualitative socio-economic information on choices related to – cropping system, cropping pattern, agricultural labour, water use, challenges faced with the DLSS etc.

4.1 Sample Size

Purposively the villages with adoption of DLSS where water-saving and carbon saving practices are found were selected-this was usually one adopter per village as this was a pilot intervention. Secondary information was collected regarding adoption from VIKAS-CFD as they made the first intervention for DLSS in villages of Danta and Amirgadh taluka in North Gujarat. We selected 12 adopters and five (5) non-adopters from the same talukas of Banaskantha district.

4.2 Scope of the study

Major socio-economic changes cannot be seen with 1-2 years of income, as the income and consumption gap would be narrow. The DLSS pilot adopters are all very recent and therefore there is a possibility that they have still not realized the full benefits of the technology due to lack of experience. Very few women were interviewed due to shortage of study period. Their views are likely to be different from men in water and crop management. The study has not collected data on growing water demand and income from sectors such as dairy and livestock in these talukas as it was beyond the scope. Certain amount of hand holding is still ongoing as this is a pilot intervention. Farmer/Adopters chosen for the pilot have a larger land holding than the average in these talukas as they opted to take the risk of installing the DLSS for the first time.

5. RESULTS

5.1 Profile of the farmers

The DLSS adopters are tribal farmers from the socially and economically marginalized Bhil and Garasia tribal communities generally owning one to three acres of land (See table 5.1and 5.2).All adopters have their own sources of irrigation including wells and bore wells on their owned land. Prior to adopting the DLSS, these farmers used to flood irrigate all their land through water from wells and bore wells. The capacity of pump sets that they used rangedfrom5- 7.5HP.

Table 5.1: Farmer Adopter Profiles

Farmer name	Tribal/Non-Tribal	Village name	Taluka	Total Land holding (acres)[1]
Genabhai	Tribal	Bhayla	Amirgadh	3
Nathabhai	Tribal	Gaura	Amirgadh	2
Ashokbhai	Tribal	Tundiya	Danta	2
Mohanji	Tribal	Rangpur	Danta	3
Sureshbhai	Tribal	Samaiya	Danta	1
Ramanbhai	Tribal	Tekari	Danta	1
Annabhai	Tribal	Nadavas (ghoda)	Amirgadh	1
Nagjibhai	Tribal	Rani Umbari	Danta	2
Babu Lalu	Tribal	Beda	Danta	2
Virma Anda	Tribal	Jambupani	Amirgadh	1.45
Mahendrabhai	Tribal	Pith	Danta	2
Shankar Mansa	Tribal	Virampur	Amirgadh	4.5

[1] *Some of these farmers own more than 3 acres of land but those land parcels are not contiguous and are scattered across the village in parcels. For the purpose of this study, only the land where drip with solar was installed has been considered along with adjoining/contiguous land as total land holdings. Source: Fieldwork and secondary data*

Table 5.1: Farmer Non-Adopter Profiles

Farmer name	Tribal/non-tribal	Village name	Taluka	Total Land holding (acres)
Savjibhai	Tribal	Bhayla	Danta	2
Babubhai	Tribal	Gaura	Danta	3
Maljibhai	Tribal	Tundiya	Danta	2.5
Rambhai	Tribal	Rangpur	Danta	2
Shankarbhai	Tribal	Samaiya	Danta	2

5.2 Changes in Water use Pre and Post DLSS

As shown in Table 5.2, volume of water used by most farmers through electric/diesel powered pumps from their wells and bore wells during winter and summer was huge. These high horsepower motors (greater than 5 Hp) extract huge amounts of water (more than 1billionlitres of water in a single cropping season) resulting in quick sinking of well and bore well groundwater levels. Wells used to go dry in summer or even early winter and bore well water levels have presently reached below 300 feet. In addition, the farmers also sell water (pumped by bore wells) to neighbours or distant farmers in exchange for one-third of the produce irrigated by their well water. With the installation of DLSS, the savings in groundwater are massive-ranging from 70-86 % (see table 5.2) and are enough to produce one or even two crops of vegetables and/or one cereal (Bajri/Maize-see section on area under crops and income post DLSS and also tables 5.3,5.4 and 5.5).

Table:5.2 Water Use Pre and Post DLSS (in cu. mtrs) in 2022-24

Farmer	Volume of Water used to irrigate with DLSS (winter/summer)	Volume of Water (cu.mtrs) used to irrigate without DLSS (winter/summer)	Savings in Water (in cu.mtrs) Post DLSS	% savings over previous method
Genabhai	2477	8400	5923	70%
Nathabhai	2413.3	9900	7487	75%
Ashokbhai	3809	No motor/Rainfed farmer	3809 (more water used)	-
Mohanji	2533.2	9675	7142	73%
Sureshbhai	4968	1987.2	1490.4	74%
Ramanbhai	2024	1498	1295.2	86%
Annabhai	2354	5400	3046	56%
Nagjibhai	1810.4	11232	9422	83%
Babu Lalu	2287	9360	7073	75.6%
Virma Anda	3450	11232	7782	69.3%
Mahendrabhai	1674	6048	4374	72.3%
Shankar Mansa	1335	9792	8457	86.4%

5.3 Crop diversity and Increase in Area Under Cultivation Post DLSS

Prior to the DLSS installation, the farmers used to grow mainly cotton and maize during kharif and wheat/Castor during rabi/winter with a few farmers who still had water access through wells/borewells growing summer crops like Bajri and few vegetables (see tables 5.3 and 5.4).

Table 5.3: Crops grown pre DLSS

Farmers	Season wise Crops grown before DLSS		
	Kharif	Winter/Rabi	summer/Zaid
Genabhai	Cotton, Maize, Castor	Wheat, Castor	Nil
Babubhai	Cotton, Maize, Castor	Wheat	Nil
Ramanbhai	Cotton, Maize, Castor	Wheat	Nil
Annabhai	Cotton, Maize, Castor	Wheat, Castor	Nil
Virma	Cotton, Maize, Castor	Wheat	Brinjal, Tomato

Source: Fieldwork

Hardly any vegetables were being grown due to lack of water availability post wheat harvesting. Water in the wells used to last until March beginning on average and then used to either dry up or the incoming seepage/flow used to become a trickle. Thus, farmers were unable to sometimes even complete irrigating the wheat crops towards the end (pers comm-farmer adopters).

There is a clear shift in the cropping pattern after adoption of DLSS (see Tables 5.4 and 5.5). The adopter farmers are now able to irrigate wheat with drip as well as take a couple of vegetable crops in winter and/or summer. Vegetables are high return crops. Although scarcity of water is a driver in adoption of DLSSs, Increased area under irrigation, higher incomes from that and cost savings are also a motivating factor (see tables 5.5,5.6 and 5.7). Vegetable cultivation has gone up substantially in summer. Horticulturists sometimes recover half of their investments of the drip within one or two seasons of vegetables growing. This is thanks to the drip system and the customized single Hp pump which allows only as much water as is required for the crop and this also allows for water to recharge the well as volume of discharge is regulated by one Horse power pumps. On the other hand, high horse power pumps extract such huge amounts of water in a short time which does not allow groundwater in wells/bore wells to be replenished.

Table5.4: Crops grown post DLSS

Farmers	Season wise Crops grown after DLSS	
	Winter/Rabi	summer/Zaid
Genabhai	Wheat, tomato, fenugreek, Spinach, okra, Coriander	Bajri, Cluster beans
Babubhai	Fennel, Okra	Cluster beans
Ramanbhai	Okra, cluster beans, beans	Brinjal
Annabhai	Castor, sapota, tomato	Brinjal, Tomato
Virmabhai	Beans, Alfa alfa-fodder	Okra, Cluster beans
	Castor, cotton, wheat	Green gram,
	Wheat, castor, chickpea	Chillies, groundnut, cluster beans
	Beans, okra Tomato, Brinjal,	

Source: Fieldwork

Table 5.5: Increase in Area under cultivation after DLSS adoption from year 1 to year 2

Farmer name	Total Land holding (acres)	DLSS land coverage (acres) in year 1 [2022-23]	DLSS land coverage (acres) in year 2 [2023-24]	Percent increase in irrigated area after DLSS
Genabhai	3	0.90	1.35	50%
Nathabhai	2	1.0	1.18	18%
Ashokbhai	2	1.91	-	0%
Mohanji	3	1.27	2.10	65%
Sureshbhai	1	1.00	2.0	100%
Ramanbhai	1	1.00	2.10	110%
Annabhai	1	0.90	0.9	0%
Nagjibhai	2	1.00	2.10	110%
Babu Lalu	2	1.32	1.32	0%
Virma Anda	1.45	1.03	1.45	41%
Mahendrabhai	2	0	1.75	0%
Shankar Mansa	4.5	1	2.09	109%

Source: Fieldwork

5.4 Changes in Agri-input costs and agricultural income post DLSS

While carrying out focus group discussions with adopters, they pointed out that DLSS has helped reduce agriculture input costs substantially especially the labour costs of weeding, pesticide buying and spraying and even fertilizer and electricity costs. Further some farmers even mentioned inputs like seed quantity has reduced and output quality of grain and vegetables has improved considerably. Production too has gone up of maize, wheat and pearl millets. Non adopters mentioned rising agri-input costs as a major burden and cause of less income while adopters mentioned the increase in profitability post DLSS installation (see tables 5.5, 5.6, 5.7 and figure 5.1).

Table 5.6 Net income for farmers without DLSS and with DLSS in winter and summer (2022-24)

Farmer name	Income Without DLSS (Rs.)	Expense Without DLSS (Rs.)	Profit Without DLSS (Rs.)	DLSS Benefits Winter crop (Rs.)	DLSS Benefits Summer crops (Rs.)	Total Benefit (Rs.)
Shankar Mansa	1,00,000	25,000	75,000	33,350	35,000	68,350
Natha Hita	2,50,000	87,000	1,63,000	45,150	35,000	80,150
Mahendra Bhura	33,000	15,000	18,000	11,150	20,000	31,150
Mohanji Mankaji	65,000	45,000	20,000	33,500	35,000	68,500
Narsha Hoja	65,000	25,000	40,000	33,150	35,000	68,150
Suresh Neta	55,000	28,000	27,000	27,440	30,000	57,440
Nagji Kodarvi	82,000	55,000	27,000	38,025	40,000	78,025

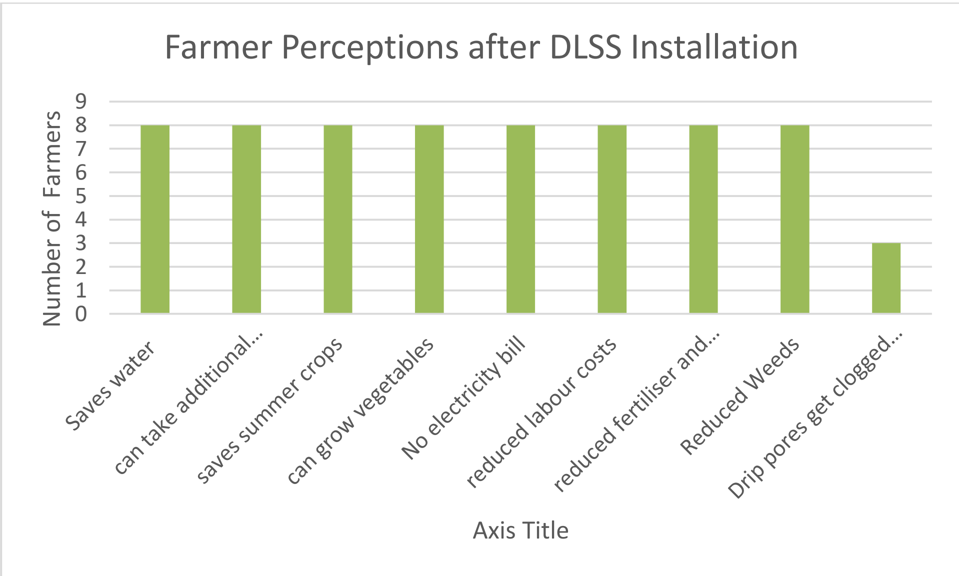
Table 5.6 shows the changes experienced by farmers who used to have adequate water to grow crops in winter and summer but using flood irrigation and how their expenses on inputs changed after adopting the DLSS. At the same time, Table 5.7 shows the five farmers who could never take a summer crop due to non-availability of water earlier i.e. prior to adoption of DLSS. For these farmers the ability to take an additional crop and increase the area under irrigation has come as a great blessing. Agricultural incomes have risen ranging from 50% to 655% more so due to vegetable cultivation and also better yields from Maize, Castor and wheat.

Qualitative discussions with adopters threw up interesting perceptions of DLSS adopter farmers on the benefits which have been captured in figure 5.1. All unanimously agreed that they could take multiple vegetable crops in winter and summer just because of water availability. Prior to installing the DLSS they would run out of water by February/March and sometimes even before that as water levels would drop with high Hp pumps and proliferation of bore wells in neighbouring farms. Table 5.7 shows a very significant result of DLSS: farmers who could never take a summer crop earlier as they had no water are now able to take a summer crop. Not only that but they are earning sizeable net incomes ranging from 1.4 lakhs to 73,000 rupees per acre. This kind of income indicates a high potential for farmers to invest in DLSS in the near future.

Table5.7 :Net income per crop for farmers who had no water in Summer for irrigation prior to installing DLSS (2022-24)

Farmer name	Income Without DLSS (Rs.)	Expense Without DLSS (Rs.)	Profit Without DLSS (Rs.)	DLSS Benefit Winter crop (Rs.)	DLSS Benefits Summer crops (Rs.)	Total Benefit (Rs.)
Gena Pema	1,90,000	85,000	1,05,000	43,625	1,00,000	1,43,625
Babu Lalu	70,000	30,000	40,000	30,975	65,000	95,975
Raman Uda	48,000	25,000	23,000	25,100	50,000	75,100
Virma Anda	80,000	50,000	30,000	25,940	60,000	85,940
Anna China	-	-		33,420	40,000	73,420

Figure5.1: Perceptions of farmers after DLSS



All could take additional summer crops whereas earlier they would either run out of water or have to rely on getting water from neighbours with water in bore wells to save their winter/summer crops. Furthermore, labour costs like weeding, fertilizer and pesticide applications, someone to switch on the pumps when electricity was available have all come down. Substantial savings in input costs and extra income from high value vegetable crops has benefitted the small and marginal tribal farmers. Electricity bills have come down by thousands as they have started using drip in wheat and other winter crops as well as kharif crops when rain plays truant.

Thus from the results it is clear that adopter farmers could use the available water for longer period (extending the agriculture season beyond monsoon to winter and summer). An additional income ranging from Rs. 75,000/- to 1,00,000/- in four months period at the same time saving on the costs of energy, water distribution, weeding labour as well as pesticides. Drip irrigation resulted in better and targeted water provision resulting in better quality of crop and therefore the crops fetched at least an improved income of 10 percent in the market. DLSS helped to grow at least 9 different crops (increasing crop options) in two seasons and helped save at least 75% of ground water and pumping costs for each farmer.

5.5 Savings in Carbon Emissions

Use of Solar powered electric pumps has greatly reduced the negative environmental externality of using diesel powered pumps and electric pumps which are grid connected. Both Diesel and grid connected pumps have a much larger footprint than a solar powered pump. A single diesel pump is estimated to release 5.2 tons of carbon dioxide annually. Not only is the diesel pump harmful in terms of carbon emissions but it also increases the fuel cost of inputs for farmers. Thus when solar powered pumps are used in conjunction with drip sets, the pumps are operational for less than half the time that diesel pumps were used. Hence not only is diesel less used but also water consumption is only 25% of the earlier flood irrigation system. Hence it is a win-win for the farmer with fuel costs completely gone and water availability increased 75% more than earlier scenario.

6. DISCUSSION

Relevance and Quality of design

Given the geohydrology (see figure 3.2) of the intervention region, the livelihood concerns of the tribal community, nature and size of land holding, the intervention is on target to achieve better quality of life for the marginalized tribal community and with minimal or no environmental cost. The best part of the intervention is the patented design and customization of the solar panel capacity and pump capacity with the characteristic depth (head) of water levels in dug-wells and the topography of the land. The single horse-powered pumps and twin solar panels work very efficiently to provide just the right amount of power, head and water to a couple of acres of land. This design eliminates the need to regulate unbridled withdrawal of groundwater from a potentially vulnerable area.

The dedication, professionalism and commitment of the programme team managers are a very important factor in the efficiency of the implementation to date. During the visits to village clusters in Danta and Amirgadh, it was evident that excellent work had been done by the team to win over the trust of the villagers, technically and socially which is often a challenge as this type of intervention is not common in these talukas. While solar pumps have been distributed by some civil society organisations in the programme talukas, they have not been linked to drip sets and the pumps are also high horse power ones which actually deplete groundwater rapidly if unregulated.

Since this was only a pilot, once the initial groundwork is done it might be advisable to focus more narrowly on specific activities such as providing better quality drip tubes, better platforms for the solar panels and tanks/reservoir as well as partnering with local NGOs to carry out land levelling and improving agronomic practices to get better outputs.

Effectiveness to date

All twelve farmers who adopted the drip irrigation linked to solar pumps methodology have vouched for substantial reduced costs of agri-inputs, increased area under cultivation, improved crop yield, water saving (efficient water use-more crop per drop) and others would like to use the same system next year. When we met with neighbouring farmers to the adopters they were visibly impressed and wanted a similar system for their farms so demand is quite clear. There is also a prevailing attitude that villagers are willing to save and to pay for new wells/bore wells as well as other technologies if they are sure they will work. The system was used only 25% of the available water (saving 75% of ground water). This is up to 50% of its installed capacity of water use meaning thereby that farmers can use the same system to cover two acres of land instead of one acre of land currently used.

The team has also put good management and maintenance procedures in place for the project. In terms of developing increased livelihoods and income generation as well as environmental conservation ideas this intervention holds great promise as the farmers belong to several tribal, marginalised groups who would benefit greatly from this customised intervention. As yet in the area visited it was too early to verify impact to date but clearly the results are looking good to give rise to wider impacts than foreseen. A very important impact has been the reduction in groundwater use by DLSS ranging from 70-80 per cent over flood irrigation and consequent excessive dependence on the bore wells and higher horsepower pumps. VIKAS-CFD & SAVE Pvt Ltd. have the track record to be very effective and its co-ordination activities are clearly needed. The potential impact of this programme is very high.

Table 5.8 Potential Contribution Required Per farmer per year for DLSS installation

One time Cost of DLSS Installation*	Net Income earned by Farmer per acre	Percentage of cost met
INR 400000	INR 148000	30%

**Cost of System includes Pump-1 Hp, Solar Panel, Drip system and Pipes*

Potential sustainability

In terms of sustainability amongst those reached it should be emphasised that this project should work as much as possible essentially with the poor and more vulnerable farmers. VIKAS CFD does most of its work by building trust and confidence and by demonstrating how to develop livelihoods through real examples and highly participatory methods and by making the villagers financially responsible for their own projects. Wherever feasible therefore VIKAS-CFD endeavours to build in as much sustainability as possible from the outset.

Conclusions

The Drip linked solar system for micro-irrigation implemented by VIKAS-CFD & SAVE Pvt Ltd have been designed very well to meet the irrigation needs of small and marginal tribal subsistence farmers who are most in need of surplus cash income. The outcomes from installation of DLSS can be summarised as follows:

1. Most significantly, the micro solar powered pumping system ensures that environmental, social and economic costs of irrigation and agricultural inputs are minimised.

2. The system addresses environmental cost reduction by elimination of carbon emissions as solar panels are used to generate electricity for pumping water.

3. The system addresses natural resource conservation by ensuring reduction of dependence on groundwater by 75% and using only 25% of the available water, hence it saves 75% of ground water.
   This water saving was a critical outcome as it showed that after the initial year, only up to 50% of the system's installed capacity of water was used thus allowing the farmers to cover two acres of land instead of the initial one acre of land that they had used.

4. The system has succeeded in reducing agricultural input costs by as much as 30-40% over the previous system.

   The targeted water flow to roots of crops reduces weeding, improves crop growth, improve soil health and aeration thus improving crop yields and growth.

   This in turn reduces labour costs as weeding, pumping, spraying presides all is reduced or eliminated altogether from input costs.

   This improves cash flow of farmers who are small and marginalised and most in need of cash.

5. It also has helped to reduce risks of farmers as they are able to grow as many as 18 crops by mixing long term as well as short term crops reducing climate vulnerability and increasing cash flow.

6. The DLSS has also helped farmers extend their agriculture season from one monsoon crop to three crops in a year.

7. The system runs without much physical involvement while earlier farmers had to remain physically present when electricity was available to control and operate the pumps. Now they do not need to be present while irrigation is on. Hence the system reduces drudgery and allows will help household members to pursue other economic and social activities.

8. Last but not the least the additional cash surplus that the system allows farmers to earn is sufficient to allow them to invest partially or give a strong contribution in installation cost of the system.

It is strongly recommended that this system be scaled up after ensuring a few other holistic interventions such as land levelling and agronomy for example.

References

1.Groundwater Technical Report Banaskantha. CGWB, 2011 and 2017

2.Inas Kamal El-Din El-Gafy and Walid Farouk El-Bably (2016): Assessing greenhouse gasses emitted from on-farm irrigation pumps: Case studies from Egypt. Ain Shams Engineering Journal Volume 7, Issue 3, September 2016, Pages 939-951

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