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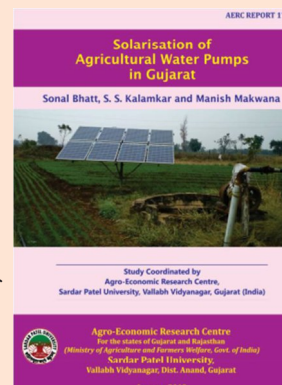
Solarisation of Agricultural Water Pumps in Gujarat

A complex set of factors including global warming, competitive land use and lack of basic infrastructure is creating new challenges for India's vast agrarian population. The ever increasing mismatch between the demand and supply of energy in general and electricity in particular, is posing challenges to farmers located in remote areas and makes them vulnerable to risks, especially the small and marginal farmers. Although the government heavily subsidizes agricultural grid connections, grid electricity in rural India is usually intermittent, fraught with voltage fluctuations, and the waiting time for an initial connection can be quite long. Besides, the power shortages, coal shortages and increasing trade deficit, put food security of nation at the risk. The generation of solar energy and irrigation for agriculture could be intricately related to each other. This is because India is a country that is fret with an irregular and ill-spread monsoon. Hence, irrigation is a pre-requisite for sustaining and increasing agricultural output. This is particularly true for the western states of India and especially Gujarat and Rajasthan, where rainfall is often scanty, uneven and irregular; whereas perennial rivers are few. The role of canal irrigation becomes very crucial in this scenario. However, in the absence of sufficient and reliable canal water supply, the only other option that remains with the farmers is that they irrigate their fields with the help of ground water withdrawn through either electricity or diesel-driven pumps. Provision of power for irrigation and other farm operations therefore, is a high priority area for the States. However, providing farmers reliable energy for pumping is as much of a challenge as making the availability of water, sufficient. Currently, India uses 12 million grid-based (electric) and 9 million diesel irrigation pump sets. However, the high operational cost of diesel pump sets forces farmers to practice deficit irrigation of crops, considerably reducing their yield as well as income. Irrigation pumps used in agriculture account for about 25 per cent of India's total electricity use, consuming 85 million tons of coal annually, and 12 per cent of India's total diesel consumption, more than 4 billion liters of diesel. Scarcity of electricity coupled with the increasing unreliability of monsoon forces the reliance on costly diesel-based pumping systems for irrigation. Hence, the farmers look for alternative fuels such as diesel for running irrigation pump sets. Solar power could be an answer to India's energy woes in irrigated agriculture.

In light of the above, this study attempts to study the status and prospects of solarisation of agricultural pumps in selected districts of Gujarat. The data were collected from three distinct groups of farmers, viz. farmers who had adopted SIPs with the help of subsidy by the government, farmers who had adopted SIPs without any support in the form of subsidy by the government, and the farmers who had not adopted SIPs. The Study conducted in four Selected district of Gujarat i.e. Sabarkantha, Bhavnagar, Narmada and Dahod.

Findings from Field Survey Data

- Except 9 percent households in beneficiary group, all other respondents were males, which indicate the dominance of males in the decision making regarding adoption of the new technology.
- As far as the educational attainment of the sample respondents is concerned, it could be observed that the respondents of the non-beneficiary households were comparatively highly educated having



taken education up to post- graduation level; whereas beneficiary adopters as well as non-adopters has a majority of respondents who had received education up to just the primary level. Here again, non-beneficiary households exhibit a higher receptivity to the novelty of solarization which enabled them to take the risk of investing in SIPs without any government subsidy. Their higher educational level and better awareness may have had to play a part in this decision.

- In case of caste distribution, dominance of scheduled tribe (ST) households was observed to be highest amongst beneficiary adopters followed by households from other backward castes and general category farmers. Amongst the non-beneficiary adopters, the highest proportion was that of other backward castes (OBCs), whereas the non-adopters were also primarily from the STs followed by those from OBC and general category farmers. Thus, the caste of the farmer was not found to have a major impact upon the adoption of SIPs in the study area.
- More than 90 per cent of beneficiary as well as non-adopter households were having farming as their principal occupation while 75 per cent of non- beneficiary households had trading as their principal occupation. Hence, SIP is an attractive option for sample respondents who are primarily engaged in cultivation, while those who could afford to install an SIP without subsidy were the ones who had an income from trading as well.
- From the field data, it was found that on average, selected households had around 21 years of experience in farming. Across groups, beneficiary households were more experienced in farming (about 30 years) followed by 21 years of experience by non-adopters while the non-beneficiary respondents hardly had 14 years of experience in farming. Thus, a longer experience with farming attracts the farmers towards SIPs, but this may not be a significant factor for seeking subsidy for the same.
- It was found that all the non-beneficiary sample households were from APL category, while almost half each of selected households from beneficiary as well as from non-adopter groups were from APL and BPL category. Few of the beneficiary households were also from AAY category. It follows that the beneficiaries of subsidy belong to disadvantaged groups as they are the ones who may have been specifically favored according to the policy norms. On the other hand, non-beneficiary adopters may not have received subsidy, but have still adopted solarisation because one, they could perhaps afford it and two, because they were convinced about its benefits. The house structure of a majority of beneficiaries was found to be kaccha type, while that of all 100 per cent of the non-beneficiary adopters was found to be 'pucca' type, hinting at a higher economic strength of the latter.
- The average land holding size of selected beneficiary households was 3.25 ha and non-adopters was 2.95 ha respectively, while the corresponding figure for non-beneficiary households was 10.34 ha, indicating the large land holdings size with non-beneficiary households. Thus, the non-beneficiaries had the largest land holding amongst the sample respondents.
- Further, out of the total operational land holdings with selected households, almost all land under operation of non-beneficiary



household was under irrigation, while in case of beneficiary households, about 80 per cent land was under the coverage of irrigation. The non-adopters irrigated about 60 per cent of their operational land holdings with available sources of irrigation. Thus, despite having a large size of land holdings, non-beneficiaries had sufficient water and sources of

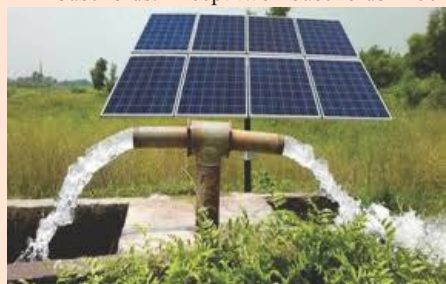
irrigation to irrigate their crops. Due to the security afforded by way of irrigated land, the assurance of returns on agriculture is invariably higher, which may have encouraged these farmers to opt for investing in the installation of SIPs on their farms even

without availing any subsidy, i.e. by making expenditure from their own funds. The same is not the case with non-adopters who had a considerable amount of unirrigated land, due to which; adopting SIP may not be their priority.

- In case of selected beneficiary households, gross cropped was increased by about 37 per cent after solarisation while gross irrigated area was increased by 57 percent. The area under irrigation of selected beneficiaries increased by about 11 per cent (to GCA), which is reflected in an increase in the cropping intensity to 181 per cent from 145 per cent previously. After solarization, proportion of gross cropped area during rabi and summer crops registered a significant increase. Also, the coverage of irrigation by selected beneficiaries registered an increase of almost ten per cent, even as the gross cropped area (GCA) in the kharif season had declined. Thus, solarization has resulted in the expansion of irrigated area, cropping intensity and GCA of beneficiary sample farmers.
- In case of non-beneficiary households, it surprisingly to note that despite of 76 per cent increase in gross cropped area and gross irrigated was increased by 34 per cent, cropping intensity after adopting solarisation has declined indicate increase in area during Kharif season.
- While the cropping intensity of beneficiaries sample adopters of SIP is the highest, the non-beneficiaries recorded the lowest cropping intensity amongst the three groups. On the other hand, the non-adopters of SIPs showed the highest cropping intensity. Thus, it could be concluded that the position of non- adopters could be further strengthened if they were to adopt solarization of their irrigation pumps.
- For beneficiary SIP users, in the Kharif season under rainfed cultivation, the cropping of vegetables had increased, while on irrigated land during Kharif, they increased the cropping of paddy and soyabean. In the rabi season, the cropping of irrigated crops like gram, wheat, maize and potato showed an increase. Similarly, in the summer season, due to availability of reliable power through the SIP, the cropping area of almost all crops such as bajra, moong, maize, maize, lemon and fodder and fruit crops increased. Thus, the change in the cropping pattern was relatively in favour of irrigated crops in the study areas.
- In case of non-beneficiary households, major crops grown during Kharif season were cotton, groundnut and urad while wheat and onion were major crops grown during rabi season. In fact, land under kharif crops has showed an increase after solarization, of which significant increase (as a percentage of gross cropped area) was recorded in groundnut under rainfed conditions.
- In case of non-adopter households, major crops grown during Kharif season were castor, cotton, paddy, maize and pulses; while wheat and gram along with fodder crops were the major crops grown during rabi season. A significant portion of the area under cultivation during the summer season was allotted under fodder crops which indicates the importance laid on the supply of fodder in the study area, as also the non-availability of irrigation during the summer season which does not permit the cultivation of crops that are irrigation intensive. Hence, the non- adopters miss out on the opportunity to earn more by a flourishing cultivation of crops such as bajra, fodder, maize, moong, lemon and vegetables as done by the beneficiary adopters of SIPs.
- All the beneficiary and non-beneficiary households owned submersible pumps for drawing out water for irrigation. Out of the total, three fourths of the beneficiary households owned a submersible AC pump while the remaining owned submersible DC pumps. However, in case of non-beneficiary households, the ownership of AC and DC pumps was both fifty per cent each. It was observed that 60 per cent of the non-adopters owned surface AC pumps while remaining households had submersible AC pumps. In total, two-thirds of the selected households owned submersible AC pumps; 40 per cent of the households had submersible DC pumps while the remaining had surface AC pumps.
- Out of the total selected sample households, three-fourths were not having grid connection on their farm indicating that they would

have adopted solarization for availing SIPs to meet the irrigation needs of their crops. On an average, the per unit rate paid by the selected households was around Rs. 0.80 with an average bill of about Rs. 5100/- per annum while in case of non-beneficiary households, a flat rate of tariff was being paid entailing an annual expenditure of Rs. 6267/-. However, notwithstanding the comparative expenditure, the greater problem was observed with the availability of farm electricity connections which is available only with the greatest difficulty; and there is a large waiting list for getting new connections. Even if the connection is available, the supply is intermittent with a maximum of eight hours in a day and that too at inconvenient times, irrespective of the season. Thus, in order to irrigate the crop during day time with uninterrupted power supply, the SIP is the most convenient option available which selected households have installed on their farms.

- The average depth of ground water reported by beneficiary households was around 110 feet while for the non-beneficiary households, the ground water depth was reported to be five times more. Even then, they were found to have installed an SIP from their own funds which indicates that they found the SIP to be useful even under conditions of a greater depth of ground water.
- As far as the ownership of diesel and electric pumps is concerned, more than 75 per cent of sample households reported of owning diesel pumps as well as electric ones, with the latter being more dominant. Besides using their own pumps, they also used the services of rented diesel and petrol-run pumps as and when required to meet the gaps in the grid-supplied electricity. On an average, the selected households owned pumps having a power of around 5 HP. It is noteworthy that almost all the selected households were in the practice of irrigating their crops through flood method instead of drip irrigation; including those that were however having an additional provision for drip irrigation also, while a few households reported to be using sprinkler method for irrigating their crops.
- In the selected villages and specifically from the location of sample households, the average distance of the canal or river was found to be more than 900 meters. Around 20-25 per cent of selected households were having a facility for water storage with them, while around 31 per cent of the beneficiary households had developed a facility for artificial recharge. In case of non-beneficiary SIP users, about 50 per cent households had made provisions for artificial ground water recharge. Thus, ground water recharging was found to be more of a priority with non-beneficiary sample farmers.
- The land area covered by the installed solar pumps was around 1.5 ha in case of beneficiary households and 3 ha for non-beneficiary households. Except two households in beneficiary category those



who have solar PV panels installed at their home, all the selected households had solar panels installed on their farms. All the installed solar PV panels were manually rotated systems and none

of them was found to have an automatic rotation mechanism. On an average, four poles were installed with a mean number of stand poles between 20-25, having an average size of panel of 2 feet by 5 feet. Mean area covered by the each stand pole varied from as small as 5 feet by 5 feet in case of beneficiary households; and 12 feet by 24 feet in case of non-beneficiary households. Thus, the non-beneficiary sample households were found to have allotted more land area under the coverage of their SIPs.

- None of the installed solar panels had a meter installed in order to record the total power generated and used by the farmers. None of the solar PV power generation unit was linked with the grid; due to which there was no contract made with the power DISCOM associated with the *Gujarat Vidyut Nigam Limited*. Hence, the unused surplus solar power generated by the SIP owners was

stored in solar storage cells, which were installed by about 79 percent of beneficiary households and all 100 per cent of non-beneficiary households. However, these were used only for field operations and not for commercial purposes.

- The prevailing water rates per hectare of canal irrigation with the help of gravity flow was estimated to be in the range between Rs. 650-700/, per annum while through canal lift, tube-well and purchased water, the same ranged between Rs. 50-100/- per hour. Clearly therefore, canal irrigation was quite cheap, but if water would be purchased from the SIP, it could turn out to be even cheaper. However, the solar power generated was mostly used for agricultural purposes while a few of beneficiary households used for household purposes as well.
- The selected farmers were asked about the reasons for adoption of solar power generation unit on their farm. About 96 per cent of selected beneficiary respondents mentioned that non-availability of electricity connection or inadequacy of supply of grid power coupled with the opportunity to take the advantage of subsidy being offered by the government were two major reasons for opting for SIPs; followed by high cost of running electric pumps and the opportunity of using environment-friendly renewable technology (86 per cent). More than three-fourths of the respondents also cited other reasons such as the desire to try out a new technology, the recommendation of fellow farmers/friends/relatives, personal relations with the person who marketed solar technology to them, desire to be free of the inconvenience suffered due to odd hours at which electricity was supplied, unreliability of electricity supply, savings on the cost of fertilizers and weeding, savings on electricity bills and the desire to avoid the hassle of irrigating crops during the night hours when electricity was supplied.
- The non-beneficiary households that had installed solar PV panels at their own cost mentioned that the reason for their action was a desire to try out a new technology (100%). However, 75 per cent of them also revealed that their desire sprung from the need to avoid the hassles connected with irrigating at night or other inconvenient hours during the day time. Also, since they did not have an agricultural electricity connection and did not hope to get it in the near future, purchasing an SIP was their chance to meet their irrigation needs in a reliable way, even if the benefit of subsidy was not available.
- About 50 per cent of the non-beneficiary households mentioned that two reasons were behind their decision to go for an SIP. One, they wanted to try out the cheaper (or rather free) alternative of renewable energy because it was an economically sound decision for them; and two, because it was environment-friendly to use solar power. Hence, it could be said that the non-beneficiaries were also aware of the environmental implications of their energy use; and given an option to use renewable energy, were only too happy to use the same.
- When the beneficiary respondents were asked about the conditions for the eligibility of receiving the subsidy, it was mentioned that the subsidy was available under multiple conditions as per scheme guidelines.
- For instance, households falling under a particular caste or category; households which were devoid of a grid connection for electricity; farmers owning a specified size of landholding; farmers having availability of a tank or *diggi* on the farm itself; female land-owners; farmers belonging to the income group of Below Poverty Line (BPL) category etc. were some groups that were given a priority in the disbursement of subsidy for installation of an SIP.
- Out of the total selected beneficiary respondents, 86 percent had installed SIPs without micro-irrigation system (MIS). This is of crucial importance because MIS could serve as a means to economize on water use, given that solar power with which ground water is withdrawn through the SIP is 'free'. However, it is sad to note that so far, only 14 per cent of the beneficiaries reported to have installed MIS attached with the SIP. It is however, interesting to note that 75 per cent of the non-beneficiary sample households (who were not bound by the norms for receiving subsidy) had installed SIPs attached with MIS facility on their own initiative.
- It can be seen that the mean depth of groundwater till the present time had remained almost unchanged, i.e. about 110-115 feet as

reported by beneficiary sample households and about 450-500 feet as reported by the non-beneficiary sample farmers. On an average, during rabi season, it took around 6-6.5 hours to irrigate one bigha of land whereas the same was irrigated in about 8-9 hours during the summer. Before solarization, the average use of diesel during rabi season was reported to be around 15-18 litres per bigha, while the same increased to around 20-22 litres per bigha during the irrigation of summer crops.

- Besides, on an average, an expenditure of Rs. 6,533 and Rs. 10,375 per annum was incurred respectively by the beneficiary and non-beneficiary households on repairs of electric pumps. They also reported to be spending Rs. 3,988 and 6,250 per annum respectively on the repairs and maintenance of diesel pumps. The expenditure on irrigation with the help of electric pumps which was about Rs. 4,287 in case of beneficiary households and Rs. 2,500 for non-beneficiary households; was reported to have come down to Rs. 1,228/- for beneficiary households and no expenditure for non-beneficiary households after solarization.
- After solarization of irrigation pumps, crop diversification was observed in case of almost half of the selected beneficiary households, while no such difference was reported in case of the cropping pattern followed by non-beneficiary households. Positive change in productivity post the installation of SIP was reported by most of households.
- The advantages of SIPs as mentioned by the selected households were many, such as i) near-zero maintenance cost, near-zero cost of operation, iii) good quality of power supply i.e. absence of frequent outages or fluctuations as before, iv) savings on the cost of labour, v) availability of power for 'free', vi) freedom from the hassle of having.
- One important observation from the field survey was that none of the sample beneficiaries or non-beneficiaries reported sale of water withdrawn through the SIP to any other farmers in their vicinity or a neighbouring village. In other words, water markets in selected study villages were reported to have zero impact due to the onset of SIPs. The adopters of SIPs also did not report a single instance of renting out power cells which they used in order to store solar power generated on their farms. Hence, they were in no position to generate supplementary income by using the surplus solar power for ground water withdrawal and sale of irrigation service. Hence, apart from achieving self-sufficiency in the matter of farm power for irrigation purposes, there was no added advantage of SIPs rendered to the adopters, either beneficiary or non-beneficiary.
- The disadvantages of SIPs were sought to be identified by the selected adopter households. Most of them opined that the solar PV panels needed to be placed at a greater height so that the land underneath could be used for cultivation instead of going waste. They also desired that service centers would be available at nearby locations in order to address occasional break-downs or problems occurring in the SIPs.
- The non-adopter households were asked the reasons for non-adoption of SIPs. Lack of funds was the major reason for not adopting the SIP; followed by opposition from family members, hesitation to invest such a large amount in a hitherto untested technology, risk aversion, too little land making the purchase of an SIP unviable, prior possession of an electricity connection



charging a flat-rate for usage, low confidence in the government agency which promoted SIPs to them; as well as a delayed knowledge and exposure to SIPs.

- On the other hand, the non-adopters of SIPs focused a lot more on other factors which could expand the coverage of solarized irrigation in Gujarat. They underlined the need to increase the awareness about SIPs amongst farmers through concerted efforts for communicating the same. They also opined that the portability of the solarized engines instead of fixation with irrigation pump at a certain point; would greatly enhance their utility for the users. Further, if the individual SIPs were to be connected with the grid in order to evacuate the surplus power generated therefrom into the grid, it could not only prevent the wastage of solar power but also provide the farmers with a supplementary source of income by way of selling solar power. This was already being done in other parts of Gujarat and was touted as a well-thought-out and well-appreciated measure by the government. However, along with a subsidy for installing SIPs and connectivity with the grid, the farmers were also in need of assistance for taking insurance against risks of damage of SIPs or theft of their solar panels.

Policy Implications:

- Majority of the beneficiary farmers suggested that solarized irrigation could be expanded in Gujarat if the SIPs were made more user-friendly in terms of their requirement of space, technical features as well as financing; including that for insurance.
- Non-adopters of SIPs underlined the need to increase the awareness about SIPs amongst farmers through concerted efforts for communicating the same. They also opined that the portability of the solarized engines instead of fixation at a certain point, would greatly enhance their utility for the users.
- Further, if the individual SIPs were to be connected with the grid in order to evacuate the surplus power generated therefrom into the grid, it could not only prevent the wastage of solar power but also provide the farmers with a supplementary source of income by way of selling solar power.
- The farmers were also in need of assistance for taking insurance against risks of damage of SIPs or theft of their solar panels.
- Also, the procedure for availing subsidy should be simplified and the criteria for eligibility should be relaxed so as to include more farmers as beneficiaries
- The amount of subsidy should be increased in order to encourage more adoption of this technology.
- SIPs are not accompanied by micro-irrigation systems or efforts to raise the ground water tables as envisaged in the policy. The 'push' factors such as costs and hassles of procuring farm fuels such as diesel and electricity are more important than 'pull' factors of solar power in attracting farmers towards solarization of their irrigation pumps.

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