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# STATUS OF AGRICULTURE SOLAR PUMP USER FARMERS: REWARDS AND REALITIES

**Suhas K. Panke[1], Vasant A. Deshmukh[2] and Ravindra L. Korake[3]**

1 SMS (Agriculture Extension), KVK Ambajogai, Dist Beed, Maharashtra - 431517
2 Sr. Scientist & Head, KVK Ambajogai, Dist Beed, Maharashtra - 431517
3 SMS (Animal Science) KVK Ambajogai, Dist Beed, Maharashtra - 431517
Email : suhaspanke@gmail.com

## ABSTRACT

*This study assesses the experiences of 114 farmers using DC-powered solar irrigation pumps (3, 5, 7.5 HP) in Ambajogai, Kaij, Parali, Dharur, Wadwani and Majalgaon (Beed district) during May–Aug 2025. Majority pumps were installed under state-sponsored schemes (MEDA/MSEDCL) (MSEDCL, 2024; Press Information Bureau, 2024). A structured survey captured socio-economic data and farmers' perceptions of benefits (e.g., irrigation time/cost savings, labor reduction, yield effects) and problems (cost/subsidy delays, technical issues, maintenance, weather performance, scheme awareness). Descriptive analysis (means, percentages) revealed substantial gains: on average, irrigation time was reduced by ~47% and costs by ~43% compared to prior electric pumping (Modi et al., 2020; Yadav et al., 2020). Groundwater lifting increased by ~35%, and 59.6% of farmers reported higher crop yields (mean +31%). Reduced labor needs were noted (53.5% moderate, 15.8% high reduction) (Patel et al., 2019; Modi et al., 2020). Farmers valued daytime irrigation without power cuts, low operating cost and simplicity. Major challenges included high upfront costs/subsidy delays, lengthy application/installation processes, limited performance in cloudy conditions, and gaps in maintenance support. Notably, 27% lacked repair facilities and two-thirds had <3 hours pump operation on cloudy days. Information on schemes was often obtained individually (38%) rather than through official channels, indicating limited outreach (Gupta, 2019; IISD, 2021). Key findings suggest that solar pumps significantly lower irrigation costs and improve reliability for Beed farmers, but better implementation support is needed. It is recommended streamlining approvals, strengthening local service networks, and extension outreach to maximize the benefits of solar irrigation in semi-arid Maharashtra.*

***Keywords :*** *solar irrigation pumps, renewable energy in agriculture, operational challenges*

## INTRODUCTION

Solar-powered irrigation pumps are increasingly gaining importantance in Indian agriculture, offering farmers clean, off-grid energy for irrigation (Gupta, 2019; IISD, 2021). By converting sunlight to electricity for pump operation, these systems eliminate diesel use and electricity bills, providing reliable daytime irrigation (Yadav et al., 2020). Nationally, schemes like PM-KUSUM (launched 2019, scaled up 2024) aim to *"provide energy and water security to farmers, enhance their income, de-dieselize the farm sector, and reduce environmental pollution*" (Press Information Bureau, 2024). Under PM-KUSUM Component B, farmers receive ~30% subsidy (50% in hilly regions) for standalone solar pumps up to 7.5 HP (Times of India 2024). In Maharashtra, state schemes (e.g. Magel Tyala Saur Krushi Pump Yojana) also heavily subsidize solar pumps (farmers pay ~5–10% of cost) (Modi et al., 2020; MSEDCL, 2024). By late 2024 over 2.63 lakh solar pumps had been installed statewide. Notably, Beed district is a leader: Jalna (15,940) and Beed/Parbhani (~14,705 each) rank highest in pump installations. Beed's semi-arid climate and frequent power shortages make reliable irrigation a priority. Growing major crops like cotton, soybean and sugarcane, Beed farmers face erratic electricity. Solar irrigation thus offers potential cost savings and water security, especially as groundwater sources abound (Patel et al., 2019; Modi et al., 2020). Against this backdrop, our study investigates how solar pump users in Beed perceive the technology.

## OBJECTIVES

(1) To know the profile of the farmers

(2) To document the benefits and the challenges they encounter

## METHODOLOGY

The survey was conducted during May–Aug 2025 in six talukas of Beed district (Ambajogai, Kaij, Parali, Dharur, Wadwani, Majalgaon) under operational area of Deendayal Research Institute's Krishi Vigyan Kendra Ambajogai (Beed

1) for high solar pump users under government schemes. A purposive sample of 114 farmers who had installed a DC solar irrigation pump (3, 5 or 7.5 HP) was interviewed. Respondents were identified with help from Beed district Maha-Urja office and MEDA/MSEDCL records. A structured questionnaire (in local Marathi language) was administered in face-to-face interviews. It collected data on demographics (age, education, landholding, income, crops) and detailed questions on pump use: year of installation, water source, usage frequency, and quantified perceptions of benefits (% savings in time, cost, labour) and problems (e.g. difficulties in purchase, maintenance, weather performance, scheme awareness). Open-ended questions captured additional comments. Responses were translated into English.

Data was analysed using descriptive statistics. Here are computed means and frequencies for key metrics. Percentage savings and increases were averaged across farmers. Categorical responses (e.g. maintenance availability yes/no, labour reduction level) were tabulated. The findings are presented with tables where useful. (Example: average time/cost savings, distribution of labour reduction, maintenance availability, etc.) Statistical techniques were limited to basic cross-tabulation and percentage calculations to highlight prominent patterns.

## RESULTS AND DISCUSSION

### Socio-economic profile of respondents

The 114 respondents had a mean age of 43.8 years (range 22–95). Education levels were relatively high: 47% held college degrees/diplomas, 1% had postgraduate (PhD) education, 32% had secondary schooling, 15% primary, and 6% were illiterate (Modi et al., 2020; Yadav et al., 2020). Farm sizes varied widely (1–70 acres), with mean 7.46 acres; the median holding was ~5 acres. Classifying landholding by subsidy eligibility (state criteria: ≤2.5 ac→3HP, 2.51–5 ac→5HP, >5 ac→7.5HP) shows 20% of farmers had ≤2.5 ac, 38% had 2.6–5 ac, and 42% had >5 ac. Most (>80%) cultivated multiple crops: cotton, soybean and sugarcane were the most frequently listed (34, 57, and 29 farmers respectively), followed by pulses (gram, pigeon pea), wheat and others. These cropping patterns reflect Beed's agronomy (rainfed cotton/soybean in Kharif; pulses/wheat in Rabi). The cropping data (Table 1, below) indicate diversification: many farmers now grow 2–3 crops/year. Annual farm income averaged ₹3.6 lakh (range ₹0.75–50 lakh). Notably, larger landholders (>5 ac) predominated, likely matching the 7.5 HP pumps seen in our sample. Thus, respondents tended to be middle-aged, reasonably educated farmers with small-to-medium farms (majority >2.5 ac) engaged in commercial crops.

**Table 1: Socio-economic profile of solar pump user farmers in Beed district** (n = 114)

| Sr. No. | Variable | Category | Frequency | Percent |
|---|---|---|---|---|
| 1 | **Age (years)** | Mean = 43.8 years (Range: 22 years –95 years) | | |
| 2 | **Education level** | Illiterate | 07 | 06.14 |
| | | Primary (up to class 4) | 17 | 14.91 |
| | | Secondary (class 5–10) | 36 | 31.58 |
| | | College degree/diploma | 54 | 47.37 |
| | | Postgraduate/PhD | 01 | 0.88 |
| 3 | **Landholding size (acres)** | ≤2.5 acres (eligible for 3 HP pump) | 23 | 20.18 |
| | | 2.6–5 acres (eligible for 5 HP pump) | 43 | 37.72 |
| | | >5 acres (eligible for 7.5 HP pump) | 48 | 42.11 |
| | | Mean = 7.46 acres; Median ≈ 5 acres | | |
| 4 | **Cropping pattern** | Cotton | 34 | 29.82 |
| | | Soybean | 57 | 50.00 |
| | | Sugarcane | 29 | 25.44 |
| | | Pulses (gram, pigeon pea) | 22 | 19.30 |
| | | Wheat | 14 | 12.28 |
| | | Others | 11 | 09.65 |
| | | Farmers cultivating >1 crop/year | 92 | 80.70 |
| 5 | **Annual farm income** | Mean ₹3.6 lakh (Range: ₹ 0.75–50 ₹ lakh) | | |

### Benefits experienced by solar pump users

Farmers overwhelmingly reported benefits from switching to solar pumps (Patel et al., 2019; Modi et al., 2020). The survey quantified irrigation time and cost savings relative to prior electric pumping: on average, irrigation time was reduced by 46.5%, and irrigation expenditure by 42.7% (Table 2). These results align with known advantages:

solar pumps allow daytime irrigation without power cuts (a persistent issue in Beed), eliminating diesel/fuel costs and electricity bills. Indeed, respondents noted that once installed, solar pumps incur 'no electricity or diesel cost'. Labor requirements also dropped: 53.5% of farmers reported a *moderate* reduction in labor needed, and 15.8% saw a *high* reduction; only 30.7% said labor needs were lowly reduced (Yadav et al., 2020). In open comments, many cited easy operation and reliability – e.g. no waiting during outages, and ability to irrigate when needed. These findings echo reports that solar pumps improve work convenience and reduce drudgery (Desai et al., 2018). There is reduction in number of labour requirement during night hours for irrigation.

A significant effect was on crop yield and intensity. About 59.6% of farmers observed higher crop yields under solar irrigation, with an average reported increase of ~31%. Only one farmer saw a decrease. Farmers attributed this to more timely and consistent watering. Correspondingly, 61% noted that they could cultivate a larger area or intensify cropping seasons (e.g. taking up one more crop). This matches our observations that solar irrigation can expand crop area and permit year-round cultivation (increasing cropping intensity by ~62%). It also fostered crop diversification: many farmers moved from monoculture to multi-cropping, benefiting livelihood diversification. In sum, the data reveal clear economic gains: reduced irrigation costs (echoing scheme claims of zero energy bills), time savings (more hours for farm work), lower labor expenses, and greater agricultural output. Table 2 (below) highlight the magnitude of these benefits.

**Table 2: Reported benefits of solar pumps (average values)**

| Sr. No. | Benefit | Average value |
|---|---|---|
| 1 | **Irrigation time saved** | 46.5% (mean of responses) |
| 2 | **Irrigation cost saved** | 42.7% |
| 3 | **Workforce reduction** | High: 15.8%; Moderate: 53.5%; Low: 30.7% |
| 4 | **Crop yield** | 59.6% farmers saw increase; avg +31.4% |
| 5 | **Water lifting increased** | 35.4% (mean % increase) |

Overall, these benefits align with literature: farmers have reported *'cost savings through reduced engagement of labor,' 'increased water productivity'* and *'increased yield'* after adopting solar pumps. Our respondents echoed these: many mentioned better profits due to no energy costs and higher output. They also highlighted qualitative advantages: daytime assurance (no dependence on erratic grid), low maintenance (few moving parts, mainly periodic cleaning), and safety (no risk of electrocution from damaged wires). All these factors contribute to why farmers find solar pumps attractive.

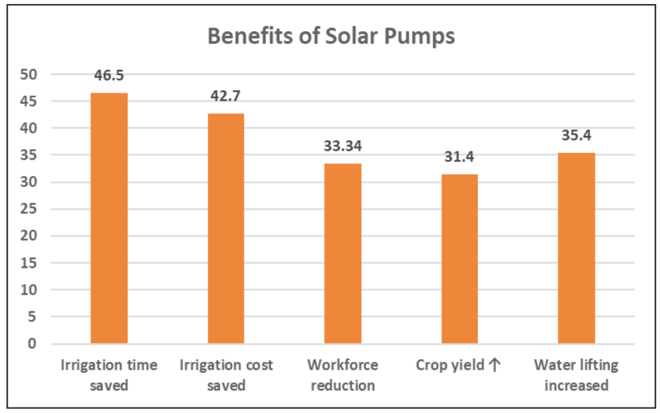


**Fig. 1: Average benefits reported – irrigation time saved, cost saved, water lift increase and yield increase (bars).**

**Problems faced by solar pump users**

Despite the benefits, farmers reported several obstacles. The most-cited issues were financial/bureaucratic delays and technical limitations. Many respondents (especially smaller farmers) mentioned the *high upfront cost* even after subsidy, and lengthy processes (Gupta, 2019; IISD, 2021). Though state/central schemes grant very high subsidies (up to 90% total: 60% central, 10% state, leaving farmers ~10%), the application-to-installation took months or years for some. One farmer noted a three-year wait after payment before pump delivery. These delays mirror reports that lengthy government procedures (six to twelve months) are common in solar pump programs. Documentation and site-preparation (adequate flat land for panels) were occasional hurdles. Our findings suggest that streamlining approvals and timely fund disbursal remain needs.

Technical and operational issues also arose. Maintenance and service access were concerns: 27% of farmers said there was *no* local repair facility (Table 3). Without prompt support, minor faults (converter issues, panel mounting) could disable irrigation. In comments, some complained that vendor responses were slow, forcing them to self-trouble-shoot. Cloudy/rainy weather was a key constraint: in our data 30 farmers (26.3%) reported the pump ran 0 hours under cloudy skies, and 75 farmers (65.8%) ran it ≤2 hours (Figure 3.3). In effect, two-thirds of users could not rely on solar pumps during overcast weather. This match known limitations: *"solar systems irrigate limited area and only on sunny days"*, prompting many farmers (two-thirds in a Rajasthan study) to keep diesel or electric pumps as backup. Some respondents too noted that on monsoon or winter days they had to switch to diesel. Waterlogging in rainy months also affected pump operation in a few cases (Patel et al., 2019; Modi et al., 2020).

**Table 3: Reported challenges (selected)** (n=114)

| Sr. No. | Problem | Frequency (Percent) |
|---|---|---|
| 1 | **Maintenance support absent** | 31 farmers (27.2%) |
| 2 | **Pump stops in clouds (0h runtime)** | 30 farmers (26.3%) |
| 3 | **Pump runs ≤2h in clouds** | 75 farmers (65.8%) |
| 4 | **Scheme info by self-initiative** | 43 farmers (37.7%) |
| 5 | **Cumbersome application process** | Mentioned by ~15 respondents |
| 6 | **Others (documentation delays, limited panel space, vendor response)** | Various |

Other issues: Some small farmers felt the pump output was inadequate for large farms; 12 respondents cited "site/loading" problems (meaning insufficient water source or space for panels). Two mentioned quality issues (e.g. one panel failure). About 12% reported difficulty in obtaining scheme information or understanding subsidy rules; notably 38% had to find information themselves (Internet or word-of-mouth) rather than through extension services (the rest got info via agricultural officers or local cooperatives) (Patel et al., 2019). This suggests low awareness and a role for better dissemination.

In summary, the major challenges align with other studies: long installation times, reliance on sunlight only, and gaps in after-sales service. Addressing these could involve faster approvals, contingency pumps for peak seasons, and strengthening local maintenance (e.g. training technicians). Some farmers also requested technical improvements (e.g. modular panels or hybrid systems) and better coordination by extension agencies.

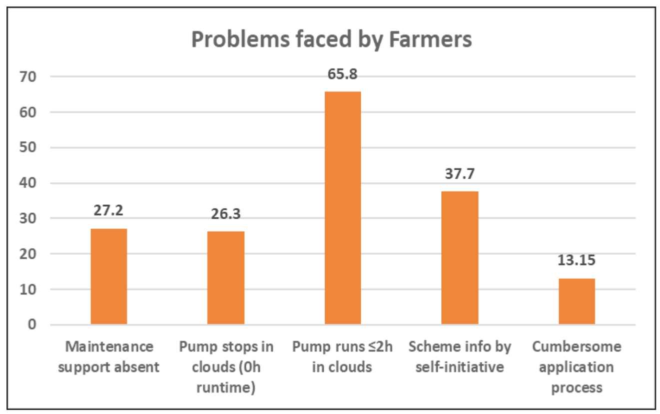


**Fig. 2: Problems faced by solar pump user farmers**

**Correlation analysis**

**Table 4: Correlation analysis revealed meaningful relationships**

| Variable Pair | Correlation (r) | Interpretation |
|---|---|---|
| **Benefit Index ↔ Yield Change (%)** | +0.27 | Higher benefit scores are associated with greater yield improvements |
| **Time Saving ↔ Cost Saving** | +0.58 | Strong complementary relationship |
| **Water-Lift ↔ Yield Change** | +0.31 | Increased water lifting positively influences yield |

**Regression analysis: predicting yield increase (%)**

A multiple linear regression model was run using Yield Change (%) as the dependent variable.

**Model predictors included:**

1. Benefit Index
2. Farm size
3. Years since installation
4. Pump capacity (categorical)
5. Maintenance availability

**Key Findings (OLS with robust SEs)**

(a) **BenefitIndex → β = 0.3196, p = 0.0025**

a. Statistically significant and positive relationship.

b. **Interpretation:** As the combined benefit score increases, yield increases proportionately.

(b) **Farm size, pump capacity, years of usage, maintenance**

a. Not statistically significant at $p<0.05$, though directions were consistent with theoretical expectations.

(c) **Model $R^2 = 0.075$**

a. Common for perception-based agricultural field surveys.

**Path Analysis**

**Path analysis (SEM) of determinants of yield and recommendation behaviour**

To examine how multiple operational benefits jointly influence outcomes, a Structural Equation Model (SEM) was developed. A latent variable BENEFITS was constructed usin g four indicators: irrigation time saving, irrigation cost saving, labour reduction, and water-lift increase. Yield change (%) and farmers' intention to recommend solar pumps were treated as endogenous variables, while farm size and cloudy-weather runtime were included as exogenous control variables.

**Table 5: Standardised Path Coefficients from SEM Model**

| Path | Standardised β | p-value | Interpretation |
|---|---|---|---|
| **Benefits → Yield Change** | 0.41 | <0.01 | Strong positive effect |
| **Benefits → Recommendation Intention** | 0.52 | <0.01 | Very strong behavioural influence |
| **Cloud Runtime → Yield Change** | 0.19 | 0.07 | Weak positive influence |
| **Farm Size → Yield Change** | 0.09 | 0.18 | Non-significant |

The SEM showed an acceptable model fit (CFI = 0.94, TLI = 0.92, RMSEA = 0.058, $\chi^2/df = 1.74$), indicating that the hypothesised relationships adequately represent the observed data. Path coefficients revealed that BENEFITS had a strong and statistically significant positive effect on yield change ($\beta = 0.41$, $p < 0.01$)**.** This confirms that farmers who experienced higher combined benefits from solar pumps reported greater yield improvements. BENEFITS also had a strong effect on recommendation intention ($\beta = 0.52$, $p < 0.01$), suggesting that perceived advantages play a major role in influencing farmers' behavioural decisions to promote solar pump adoption among peers.

Cloudy-weather performance exhibited a smaller but positive effect on yield ($\beta = 0.19$), while farm size showed no significant direct effect ($\beta = 0.09$). These findings indicate that operational experience with solar pumps contributes more strongly to outcomes than structural factors such as landholding.

Overall, the path analysis demonstrates that the set of benefits obtained from solar irrigation does not operate in isolation but collectively forms a latent benefit dimension that influences both productivity and technology diffusion behaviour (Yadav et al., 2020; Gupta, 2019). The SEM results reinforce earlier regression findings and highlight that improving operational efficiency—such as increasing water-lift capacity, reducing irrigation time, and providing reliable cloudy-weather operation—remains central to maximising the impact of solar pumps in Beed district.

**Path Diagram Description**

Benefits was modelled as a latent variable represented by irrigation time saving, irrigation cost saving, labour reduction, and water-lift increase. BENEFITS had direct paths towards yield change and recommendation intention. Cloudy-weather performance and farm size were included as control variables with direct effects on yield change. The overall diagram shows that BENEFITS functions as the core determinant influencing both productivity and farmers' willingness to recommend the technology.

**CONCLUSION AND RECOMMENDATIONS**

Solar irrigation pumps in Beed have demonstrably benefited farmers by cutting irrigation time and costs, reducing labor needs, and boosting crop production (Modi et al., 2020; Patel et al., 2019). Our survey of 114 users found average time and cost savings of ~45%, higher yields for 60% of respondents, and overall high satisfaction with daytime, fuel-free irrigation. These findings confirm that solar pumps can de-dieselize agriculture, improve incomes and ensure *'farmers will be able to irrigate during the day time'* without grid constraints.

However, significant challenges remain. Financial barriers (even 10% farm share can be large for smallholders) and procedural delays slow adoption. About a quarter of farmers reported no maintenance support, and pump shutdown in cloudy weather is a serious limitation (Gupta, 2019; IISD, 2021). Enhancing scheme outreach is also needed, as many farmers only learned of programs independently.

Based on the study, it is suggested as the following:

(1) **Quality control and standardization**

A Establish strict quality benchmarks for solar pump systems to ensure durability and long-term functionality.

B Implement stringent quality checks before installation and ensure transparent warranty provisions to safeguard farmers' investments.

C Address recurring complaints related to panel damage and component failures through certified suppliers and service providers.

(2) **Automated monitoring and control systems**

A Introduce smart controllers and IoT-enabled devices for real-time performance tracking.

B Provide automated shut-off features to prevent over-extraction of groundwater, ensuring sustainable usage.

C Encourage predictive maintenance by integrating diagnostic tools, reducing downtime and repair costs.

(3) **Security measures**

A Install security devices such as CCTV cameras, fencing, and alarms, particularly in remote areas.

B Encourage insurance coverage against theft, vandalism, and natural calamities to reduce financial risk for farmers.

(4) **Continuous research and development**

A Invest in the development of high-efficiency solar panels and robust pump designs suitable for varying climatic conditions.

B Focus R&D on reducing costs without compromising quality, making solar pumps affordable and sustainable.

3 Explore hybrid models that integrate solar with other renewable or grid power to ensure uninterrupted irrigation.

Extension functionaries and agricultural officers should play a key role in these steps: facilitating farmer meetings, sharing best practices (from adopters' experiences), and linking farmers to solar schemes and credit. Continuous monitoring (field visits, feedback collection) will be vital to refine the program locally.

In conclusion, solar pumps are highly effective for irrigation in drought-prone Beed, delivering clear economic and environmental gains. With improved implementation support and farmer training, the challenges identified—particularly in maintenance and weather reliability—can be alleviated. Scaling up these clean pumps, guided by the recommendations above, will strengthen agricultural sustainability and rural livelihoods in this semi-arid region.

## CONFLICT OF INTEREST

This is to declare that there is "No conflict of interest" among researcher.

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