



Collective models for solar irrigation in smallholder systems: Overcoming institutional barriers in Bangladesh

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Solar-powered irrigation pumps (SIPs) offer a sustainable, low-carbon alternative to diesel-powered irrigation in smallholder systems, yet their high upfront costs necessitate collective ownership models. This policy brief examines the findings from a mixed-methods study and a pilot implementation of group-based solar irrigation contracts in Bangladesh. The research reveals that while there is strong farmer demand for solar technology, current institutional and regulatory frameworks systematically undermine collective adoption.

- Smallholder irrigation in Bangladesh is currently constrained by high diesel costs and fragmented landholdings, making the near-zero marginal cost of solar pumping attractive to farmers.
- Existing regulatory requirements for formal group registration are administratively prohibitive for the small, localised farmer groups that naturally form around shared pump command areas.
- A lack of organisational capacity within implementing agencies leads to "workarounds" where contracts are signed with individual managers, transforming intended collective models into private fee-for-service arrangements.
- Fragmented procurement processes and a reliance on multiple contractors for different installation stages create significant delays, eroding farmer trust and missing critical cropping windows.
- Policy reforms must focus on streamlining registration for small water user groups, enhancing the capacity of agencies like the Bangladesh Agricultural Development Corporation (BADC) to facilitate group governance, and consolidating the technology supply chain.

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The policy challenge: Fragmented land and high energy costs

Agricultural productivity across much of South Asia is hindered by the fragmented nature of smallholder farming, where average plot sizes are typically below one hectare (FAO, 2018). This scale makes individual investment in irrigation infrastructure economically unviable for most farmers, forcing a reliance on expensive and often unreliable diesel-powered pumps (Binswanger & Rosenzweig, 1986). In Bangladesh, irrigation costs can comprise up to 25% of total production costs for Boro rice, creating a substantial financial burden and leaving farmers vulnerable to fuel price volatility (BADC, 2024).

Solar-powered irrigation pumps present a transformative solution by replacing variable fuel costs with a fixed capital investment and near-zero marginal operating costs. However, the high initial cost of SIPs means that for solar technology to benefit the majority of smallholders, it must be accessed through shared or collective arrangements. While technical feasibility is well-established, the institutional conditions required to sustain these collective models remain poorly understood. Without effective coordination, solar irrigation risks replicating the same inequities and inefficiencies found in traditional private pump markets (Shah, 1993; Mukherji et al., 2012).

Research Design

This study utilised a mixed-methods design to investigate whether and how group-based solar irrigation contracts can overcome coordination failures among smallholders in Bangladesh (Bhogale et al, 2026). The research combined qualitative formative fieldwork in five districts with an embedded implementation pilot involving nineteen sites pre-selected by BADC. The pilot experimentally varied access to group-lease contracts for shared solar pumps to monitor logistical feasibility and document implementation frictions. A follow-up qualitative evaluation was conducted to understand why certain collective arrangements succeeded while others faced substantial delays or failure.

Key research findings

The primary takeaway from the research is that although demand for jointly owned solar irrigation is high, group-based contracts are currently hampered by significant institutional barriers.

Regulatory mismatch and administrative burdens

Bangladesh's legal framework for cooperatives and water user groups is misaligned with the needs of small-scale irrigation. Formal registration processes under the Cooperative Act or the Bangladesh Water Development Board rules are designed for large-scale schemes involving hundreds of farmers. For the small groups of ten to 30 farmers that form around a single SIP, the time and cost of registration – often taking up to six months – are prohibitive relative to the seasonal urgency of farming.

The rise of individualised "workarounds"

Due to these regulatory hurdles, implementing agencies have adopted informal workarounds that undermine the goal of collective ownership. Contracts are frequently signed with an individual "scheme manager" rather than a formally recognised group. While this simplifies administration for the agency, it places all legal and financial liability on the manager, who then functions as a private operator. Consequently, other farmers become mere customers rather than co-owners with a voice in governance, essentially replicating the private pump rental models that SIPs were meant to replace.

Institutional and logistical bottlenecks

The study identified a critical lack of organisational capacity within state agencies to support group governance (Ostrom, 1990; Bardhan, 1993). Agency staff are often stretched across large regions and lack the mandate or training to facilitate group formation or resolve internal conflicts. Furthermore, the SIP installation process is highly fragmented, involving multiple specialised contractors for civil works, electrical systems, and pipelines. This structure creates "hold-up" problems where a delay by one contractor stalls the entire project, leading to missed cropping windows and a loss of trust among participating farmers.

Policy recommendations

To successfully scale collective solar irrigation models, the following policy interventions are recommended:

1. Simplify registration for small water user groups

The government should introduce a streamlined, expedited registration pathway specifically for small-scale irrigation groups. Reducing the administrative requirements and fees for groups of fewer than 50 members would allow these entities to gain formal legal standing without the burdens associated with large-scale cooperatives.

2. Enhance organisational support for group facilitation

Implementing agencies such as BADC need an expanded mandate and dedicated resources to support group governance. This includes providing training for staff in group facilitation and monitoring to ensure that SIP management is equitable and transparent, rather than solely relying on individual managers.

3. Introduce a graduated autonomy model

To reduce risk, BADC should implement a phased transition of control. In Phase 1, BADC should retain ownership and manage operations while the group builds trust and technical familiarity. In Phase 2, the group assumes responsibility for fees and routine maintenance with technical backstopping. Full ownership should only be transferred in Phase 3 after the group demonstrates functional governance, allowing for "learning-by-doing."

4. Consolidate the SIP procurement and installation chain

The current fragmented approach to installation should be replaced with a model that prioritises end-to-end delivery by a single accountable entity. By consolidating the supply chain and reducing reliance on multiple uncoordinated contractors, agencies can ensure more reliable installation timelines and reduce the risks borne by farmers during the transition to solar technology.

5. Leverage digital tools for transparency

Digital platforms—such as mobile apps or SMS-based systems—should be deployed to automate fee recording and irrigation scheduling. Transparent, real-time logging of financial transactions visible to all members reduces opportunities for manager abuse and builds the collective trust necessary for long-term sustainability.

6. Pilot alternative financing models

Financing must align with agricultural cash flows. BADC should pilot output-based payments (a share of harvested rice) or seasonal schedules where lease payments are concentrated after the harvest, when farmers have cash on hand. Community guarantee funds could also be used to provide a buffer for groups facing temporary climate or market shocks.

Conclusion

The transition to solar irrigation in smallholder systems is as much a governance challenge as it is a technological one. While solar pumps offer a clear pathway toward low-carbon agricultural growth, their potential can only be realised if the institutional environment supports collective action. Addressing

regulatory barriers and enhancing the capacity of implementing agencies to support farmer groups are essential steps for ensuring that solar irrigation is both inclusive and sustainable at scale.

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