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Can solar irrigation scale without accelerating water stress?

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In an exclusive interview with *AgroSpectrum*, **Amulya Gupta, Director at Oswal Pumps**, argues that Indiaâ??s solar irrigation revolution is reshaping the economics of farming but could also intensify groundwater stress if not backed by stronger water governance. He highlights how solar-powered irrigation can become a powerful climate-resilience tool while warning that unchecked expansion in water-stressed regions may deepen ecological imbalances.

Gupta advocates for a shift from pump installation targets to integrated policies that combine solarisation, groundwater monitoring, crop diversification, and energy-market incentives. As India accelerates its renewable energy ambitions, he contends that the future of sustainable agriculture will depend on aligning farmer incomes, clean energy growth, and aquifer health within a single policy framework.

Indiaâ??s solar irrigation push is often celebrated as a climate and energy success story, but critics argue it may unintentionally incentivise excessive groundwater extraction. How do you assess this â??groundwater paradox,â?? and is current policy architecture adequately prepared for it?

Indiaâ??s solar irrigation journey sits at the intersection of two critical priorities: energy transition and agricultural resilience. Over the last few years, weâ??ve seen strong momentum under schemes like PM-KUSUM, with solar pumps increasingly replacing diesel and unreliable grid supply.

The â??groundwater paradoxâ?• is a valid concern, but it is not a new problem created by solar; rather, solar changes the economics of an existing one. When energy becomes abundant and near-zero marginal cost, the incentive to pump more water naturally increases.

That said, current policy architecture is evolving in the right direction but remains incomplete. While there is strong support for deployment, the regulatory ecosystem around groundwater extraction, such as aquifer-level monitoring, usage caps, and pricing signals, has not scaled at the same pace. The next phase of policy must move beyond installation targets and integrate water governance frameworks to ensure that solar irrigation remains sustainable in the long term.

Historically, subsidised electricity for agriculture contributed to unsustainable groundwater use in several states. In what ways does solar-powered irrigation fundamentally differ from earlier power subsidy regimes, and where do the risks remain structurally similar?

Historically, subsidised or free electricity led to inefficient water use because farmers were insulated from the true cost of extraction. However, supply was still constrained as limited hours of power meant pumping was restricted in practice.

Solar fundamentally changes this dynamic. It provides reliable, daytime energy, improving productivity and reducing dependence on diesel. This is a significant structural improvement for farmer income and energy sustainability.

However, the similarity lies in the pricing signal, or lack of it. In both systems, when the marginal cost of energy approaches zero, the incentive to conserve water weakens. The key difference is that solar creates an opportunity to redesign incentives, particularly through grid-connected systems, something that was not feasible in earlier regimes.

Many experts argue that the real challenge is not solarisation itself, but the absence of strong groundwater governance mechanisms. Can India realistically scale decentralised solar irrigation without parallel reforms in water pricing, aquifer monitoring, and crop incentives?

The challenge is not whether solar irrigation can scale, it already is, but whether it can scale sustainably. India extracts nearly 25 per cent of the worldâ??s groundwater making it the largest user globally. Without robust groundwater governance, solar irrigation risks accelerating an already critical situation. Large parts of northwestern and peninsular India are classified as over-exploited or critical in terms of groundwater levels.

What is needed is not a slowdown in solar adoption, but a parallel strengthening of governance frameworks. This includes digitised aquifer mapping, real-time monitoring systems, and policy instruments that align water use with local ecological conditions. Without these, outcomes will remain highly uneven across regions.

There is increasing discussion around feeder-level solarisation and grid-connected pump models that allow farmers to sell excess electricity back to utilities. Do you believe these models can create economic incentives for water conservation, or are the behavioural outcomes still uncertain?

One of the most promising shifts in recent policy thinking is the move toward feeder-level solarisation and grid-connected pump models. Under Component C of PM-KUSUM, farmers can feed surplus solar power back into the grid, creating an additional revenue stream.

This model has the potential to fundamentally change farmer behaviour. When electricity has a market value, the incentive shifts from maximising water extraction to optimising energy use. Early pilots in states like Gujarat have demonstrated that farmers are willing to sell excess power when tariffs are attractive and payments are reliable.

However, behavioural outcomes are still evolving. The success of this model depends heavily on DISCOM financial health, tariff structures, and trust in timely payments. While the intent is aligned with sustainability, execution will determine long-term impact.

States like Punjab, Haryana, and parts of Maharashtra already face severe aquifer depletion driven by water-intensive cropping patterns. Could rapid solar irrigation deployment deepen regional ecological imbalances unless linked to crop diversification strategies?

Groundwater stress in states like Punjab, Haryana, and Maharashtra is closely tied to cropping patterns. For instance, paddy cultivation in Punjab consumes nearly 4,000â??5,000 litres of water per kilogram of rice.

In such regions, solar irrigation, if deployed in isolation, can exacerbate depletion by removing energy constraints on pumping. This is particularly concerning in over-exploited aquifers where recharge rates are already low.

To avoid deepening these imbalances, solar deployment must be aligned with crop diversification strategies. Unless farmers are incentivised to shift toward less water-intensive crops, the underlying drivers of groundwater depletion will remain unchanged, regardless of the energy source.

From a policy standpoint, how should India balance three competing priorities, farmer income security, renewable energy expansion, and long-term groundwater sustainability, especially when short-term political incentives often favour higher water extraction?

Indiaâ??s policy challenge lies in balancing three equally important priorities: farmer income security, renewable energy expansion, and groundwater sustainability. Each of these has strong economic and political drivers, and often, short-term incentives favour higher agricultural output and water use.

However, there is a growing recognition that these goals do not have to be mutually exclusive. Integrated models, where farmers earn from both agriculture and energy generation, can create more sustainable income streams. For example, decentralised solarisation combined with assured buy-back mechanisms can provide predictable revenue while reducing pressure on groundwater.

The focus should shift from isolated interventions to system-level design, where incentives across sectors are aligned rather than conflicting.

Climate change is expected to increase rainfall variability and agricultural stress across India. In that context, could solar irrigation become indispensable for climate resilience even if it creates additional groundwater pressures, and how should policymakers navigate that trade-off?

Climate change is intensifying the need for reliable irrigation. India has seen increasing rainfall variability, with more frequent droughts and extreme weather events affecting agricultural output.

In this context, solar irrigation becomes a critical resilience tool. It ensures that farmers have access to energy for irrigation even when grid supply is unreliable or diesel costs are prohibitive.

At the same time, increased reliance on groundwater cannot be ignored. The policy approach must therefore focus on managing this trade-off, leveraging solar for resilience while strengthening safeguards against over-extraction. Delaying solar adoption is not a viable option; managing its externalities is.

Looking ahead, what would a genuinely sustainable solar irrigation ecosystem require beyond panel deployment, in terms of regulation, data systems, water accounting, financing models, and institutional coordination?

The next phase of Indiaâ??s solar irrigation journey must move beyond deployment metrics. While installation numbers are important, they do not capture sustainability outcomes.

A genuinely sustainable ecosystem will require stronger integration between energy and water policy, supported by digital infrastructure and institutional coordination. This includes better groundwater data systems, clearer regulatory frameworks, and financing models that encourage efficient water use alongside solar adoption.

There is also a need to rethink success metrics, from counting pumps installed to measuring improvements in water-use efficiency, farmer income diversification, and aquifer health.

-- Suchetana Choudhury (suchetana.choudhuri@agrospectrumindia.com)