India's agrivoltaics revolution

India's energy transition and its agricultural future are deeply intertwined. The government wants 500 GW of fossil fuel-free electricity generation capacity by 2030, while doubling farmers' incomes at the same time. These priorities are rarely discussed together, but agrivoltaics has the potential to put farmers at the core of India's clean energy strategy.

With more than 100 million farmers and land availability shrinking, India cannot afford to trade food security for energy security. Conventional ground-mounted solar projects already account for more than 90 GW of the country's 120 GW of installed solar capacity, according to statistics from the Ministry of New and Renewable Energy (MNRE). These projects sometimes overlap with agricultural land, affecting cultivation. Agrivoltaics offers a solution. By allowing simultaneous land use for crops and power generation, it shields harvests from heat and water stress, diversifies farmer incomes, and strengthens rural power networks.

Countries such as Japan, France, and Germany have already demonstrated these benefits at scale with supportive policies and technology standards, while agrivoltaics in India is still in its infancy. Most initiatives remain pilots, driven by research institutes or individual developers. Even under the government's Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM-KUSUM) scheme – which provides support for farmers to install solar pumps and grid-connected renewable energy plants – many solar plants on farmland are designed primarily for energy generation, with cultivation discontinued after commissioning. This is not agrivoltaics.

Photo: CSTEP

Farmers attend a training workshop at the Krishi Vigyan Kendra in Sagar, Madhya Pradesh.

Farmers who have leased land for solar projects typically receive higher payments than their baseline income from crop yields. Although this is a stable revenue source, it is incremental and does not result in meaningful change for their families. Farmers with fragmented land holdings focus on short-term gains rather than long-term benefits. On the one hand, they are skeptical and fear the loss of control over their land and are wary of variance in crop yields due to solar panels. On the other hand, developers prefer minimal intervention of farmers instead of perceiving them to be partners with local expertise. This stalemate has stunted the growth of agrivoltaics in India.

Sweat equity

A successful and sustainable path for agrivoltaics requires reimagining the role of farmers. They need to be able to participate in the development process, hold equity, and ultimately become energy entrepreneurs. Farmer producer organizations can allow even marginal farmers to pool resources and negotiate better terms with solar developers. Owning a stake in the PV plant allows for significant earnings from electricity sales, enabling sustainable wealth creation.

Solar developers also need to recognize the value of farmers' "sweat equity." Farmers might not be able to contribute capital, but their stewardship of the land, provi-

sion of labor, and knowledge of crop patterns are invaluable assets. Developers can work with these critical inputs to design projects where panel height, tilt, and spacing are optimized with crops, ensuring complementary agriculture and electricity production.

Farmer-centric business models also have ripple effects in the growth of rural economies. The additional electricity generation from agrivoltaics opens the door to investments in infrastructure such as cold storage and food processing units. This has potential to reduce post-harvest losses and raise farmgate prices.

In the northeastern states of India, agrivoltaics could support the cultivation of medicinal herbs while powering dairy or livestock ventures. High-value products from these geographies, such as artisanal cheese and cured meats, have immense potential. In Jammu and Kashmir to the north, agrivoltaics can not only enhance saffron and apple cultivation but also support the production of processed delicacies with improved harvests. These integrated models encourage synergized rural enterprises in clean energy and agriculture, diversifying incomes and creating jobs across the agrivoltaics value chain.

Access to finance

Affordable finance remains one of the biggest barriers for farmers in India's agrivoltaics ecosystem. The Agricultural Infrastructure Fund already provides concessional loans for farm infrastructure that can be extended to agrivoltaics ventures. For widespread adoption, especially among risk-averse or land-poor farmers, new and innovative financing models are needed.

Blended finance models are one option to derisk early-stage projects. Public grants, concessional debt, private equity, and corporate social responsibility funding can be combined for this purpose. This will enable smallholders to participate with minimal cash outlay or through in-kind contributions, such as labor or land. Democratized finance can ensure that agrivoltaics is not limited to wealthy farmers.

A dedicated national agrivoltaics scheme, like India's rooftop solar program, could set capacity targets, provide viability gap funding, and issue clear technical guidelines. Agricultural universities, the Indian Council of Agricultural Research (ICAR), and Krishi Vigyan Kendras (agricultural science centers) can serve as regional test beds, identifying optimal crop-photovoltaic combinations and providing training to farmers.

Capacity building is just as important. Training programs on agrivoltaics, PV operations, and basic maintenance can create skilled rural jobs and strengthen local ownership. At the policy level, measures such as net metering, virtual/group net metering (allowing multiple farmers to share benefits), and peer-to-peer trading can provide farmers with greater flexibility to use or sell electricity.

Climate zones

Given India's size and diverse climate zones, a one-size-fits-all model will not work. In the northwestern states, such as Punjab and Haryana, elevated solar structures above vegetable fields can mitigate extreme heat while preserving irrigation access. In the northeastern regions, small grid-connected systems can provide reliable electricity while maintaining high cropping intensity. In arid regions, including states such as Rajasthan, Gujarat, and parts of Maharashtra, agrivoltaics can support shade-tolerant crops. Each region will need tailored designs, combining the efforts of state governments, ICAR, MNRE, developers, and farmers.

India's renewable energy transition cannot succeed by displacing agriculture or by treating farmers as spectators. Agrivoltaics presents a unique opportunity to achieve both energy security and rural prosperity, but only if farmers are treated as true partners in design, financing, and operation.

The path forward requires supportive policy frameworks with clear technical guidelines. Building trust between developers and farmers will allow strong local participation and ensure that decades of research inform project designs.

Recent efforts, including state-level pilots, farmer training programs, and draft policy discussions, signal that India's agrivoltaics era is beginning to take shape. Aligning all these elements will enable scaling agrivoltaics from pilots to a mainstream pillar of India's renewable energy landscape in the near future. pv

Saptak Ghosh and Shantanu Roy

> *"The path forward requires supportive policy frameworks with clear technical guidelines"*

About the authors

***Saptak Ghosh** is sector head for renewables and energy conservation at the Center for Study of Science, Technology and Policy (CSTEP), a research think tank in India. He has extensive expertise in distributed renewable energy and innovative clean energy applications, working closely with policymakers and industry leaders to advance sustainable energy solutions across India.*

***Shantanu Roy** is sector coordinator for renewables and energy conservation at CSTEP. With over 15 years of experience spanning renewables, thermal power, and oil and gas, he collaborates with government and industry to accelerate renewable energy adoption throughout the country.*