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Agrivoltaics for Sustainable Crop and Energy Production

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Preface

India stands at the crossroads of agricultural transformation and renewable energy expansion. With increasing energy demand, climate challenges, and land constraints, it is imperative to adopt solutions that ensure food security and sustainability. Agrivoltaics, which integrates solar photovoltaic (PV) systems with crop production on the same land, offers a promising approach to optimize land use, generate clean energy, and sustain agricultural productivity. By enabling dual land use, agrivoltaics can enhance soil moisture retention, reduce evapotranspiration, and create a moderated microclimate, benefiting both crops and energy generation.

India has set ambitious renewable energy targets, aiming for 500 GW installation of non-fossil fuel-based energy generation by 2030, with solar energy contributing a major part of total installations. However, large-scale solar installations require vast tracts of land, raising concerns about land-use conflicts and potential impacts on food production. Agrivoltaics presents an opportunity to balance energy generation and agricultural production, ensuring optimum utilisation of land resources while supporting rural livelihoods. Additionally, it can provide financial stability for farmers through dual source of revenue generation from farming produces and PV electricity.

This policy paper provides a structured assessment of agrivoltaics in India, analyzing opportunities, challenges, and policy recommendations. It emphasizes the need for a dedicated agrivoltaics policy, integration with existing programs like PM-KUSUM, financial mechanisms to support farmers, and research-driven innovations to optimize system design and crop compatibility. I am happy to note that most of the organizations involved in agrivoltaics research and promotion have participated in the brainstorming session, contributing valuable insights to shape a practical strategy for its implementation in India. This policy paper will serve as a valuable resource for policymakers, researchers, and stakeholders working toward a sustainable and energy-secure agricultural future.

I extend my sincere appreciation to Dr. Alok K. Sikka (Convener) and Dr. Priyabrata Santra, Dr. Gopal Kumar & Shilp Verma (Co-Conveners) along with other contributors. My thanks are also due to the Reviewers (Dr. A. Sarangi & Dr. O. P. Yadav) and the Editors (Dr. V. K. Baranwal & Dr. R. K. Jain) for their dedicated efforts in bringing out this important policy paper. Their insights will be instrumental in shaping India's agrivoltaics policy and its large-scale adoption.

March 2025
New Delhi

(Himanshu Pathak)
President, NAAS

Agrivoltaics for Sustainable Crop and Energy Production

1. INTRODUCTION

Agrivoltaics, also known as agri-photovoltaics, has emerged as a potential land use option through which solar photovoltaic (PV) based electricity generation and crop production are integrated together on the same piece of land. This dual use of land resource has gained attention as a potential strategy to improve land productivity, particularly in regions where competition for land between food production and PV generation has been intensifying. India has set ambitious renewable energy targets, aiming for 500 GW installation of renewables by 2030, with contribution of solar PV by 50% in total installations (MNRE, 2023). However, large-scale solar installations often lead to land-use conversion, particularly in agriculturally productive regions, raising concerns about reductions in cultivated land and potential effects on food production. Agrivoltaics has been seen as a possible alternative that could enable agricultural activities to continue alongside energy generation, thereby enhancing land productivity while contributing to India's energy security and sustainability goals (IISD, 2023; GIZ, 2024).

Early studies and results of pilot projects suggest that agrivoltaics systems may offer multiple benefits, including microclimate moderation, reduced evapotranspiration, and improved soil moisture retention, which could enhance agricultural resilience in specific conditions. Partial shading by solar panels has been observed to reduce heat stress on crops, which might reduce water requirements and influence plant health. Certain shade-tolerant crops have shown stable or even improved yields under agrivoltaics conditions in controlled environments, particularly in arid and semi-arid regions (Poonia *et al*., 2021). Additionally, agrivoltaics is being examined as a potential contributor to climate change mitigation by integrating renewable energy generation with agricultural systems, though its overall impact on farm-level carbon footprints requires further evaluation (WRI India, 2024).

Germany, France, Japan, and China have introduced policy frameworks to regulate agrivoltaics systems, ensuring that agricultural productivity is not significantly compromised (Doedt *et al*., 2024; TSE, 2025). India, however, is yet to establish a standardized regulatory framework for agrivoltaics, which could facilitate large-scale implementation. Existing policy, such as the *Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan* (PM-KUSUM) scheme, focuses on decentralized solar energy deployment for agriculture including installation of elevated solar panels on stilts in agricultural land. However, so far, agrivoltaics does not explicitly find a mention or specific support in Government policies or schemes in India.

Economic implication for farmers is another area of interest. Agrivoltaics has the potential to help farmers diversify their income by supplementing agricultural earnings with revenue from solar energy generation. This diversification could provide financial stability, particularly for small and marginal farmers who face climate variability and market uncertainties. Some pilot projects suggest that agrivoltaics could support rural electrification and localized energy solutions, particularly in remote farming communities. Moreover, agrivoltaics expansion may open opportunities for job creation in system installation, maintenance, and agronomic research, but its scalability and long-term economic viability remain to be further assessed (IISD, 2023).

Despite these promising aspects, agrivoltaics faces several challenges that require attention before widespread adoption in India. Key barriers include high initial capital costs, technical constraints related to panel orientation and spacing, concerns over potential yield impacts for certain crops, and regulatory uncertainties regarding land classification and taxation. Agrivoltaics deployment will also have to face competition from standard ground-mounted solar plants and robust analyses of incremental benefits and costs will be critical. Addressing these challenges will require targeted policy interventions, financial support, and technological innovations.

To explore the potential of agrivoltaics as a land-use strategy, a clear roadmap is needed. This policy paper aims at providing a structured assessment of agrivoltaics implementation in India, examining its opportunities, challenges, business models, and regulatory requirements. By drawing insights from global best practices, ongoing pilot studies, and stakeholder perspectives, this paper shall provide possible pathways for policymakers, researchers, and practitioners to consider as India advances in its pursuit of sustainable agriculture and renewable energy integration.

2. RATIONALE FOR AGRIVOLTAICS IN INDIA

2.1 Food-Energy-Climate Nexus and Land Optimization

India’s growing population and expanding economy are expected to drive significant increases in both food and energy demand. By 2050, India's population is projected to reach 1.668 billion, necessitating substantial growth in agricultural production (UNDESA, 2022). Simultaneously, energy demand is anticipated to rise at an annual rate of 2.3%, positioning India as a major driver of global energy consumption in the coming decades. Given the constraints of limited arable land, optimizing land use efficiency is becoming increasingly important, particularly in the context of Viksit Bharat 2047, which envisions a long-term sustainable development trajectory for India.

Unlike conventional, ground-mounted solar plants, which require dedicated land for energy generation, agrivoltaics systems present an opportunity for dual land use, enabling both agricultural production and solar power generation (Santra *et al*., 2017).This approach is being explored as a potential solution for land-scarce regions, and where water conservation and temperature regulation are critical for agricultural sustainability

(Asa’a *et al*., 2024). Studies suggest that solar panels may contribute to improved soil moisture retention and a moderated microclimate, potentially reducing heat stress on crops (Barron-Gafford *et al*., 2019). Shade of PV panels on crops grown at interspace areas reduces the heat stress, however, a balance between duration of shading on plants and required amount of photosynthetically active radiation (PAR) for carrying out photosynthesis process by plant is highly essential, which needs a special design for agrivoltaics system (Santra *et al*., 2021). Additionally, agrivoltaics is considered as a potential tool for reducing greenhouse gas emissions by lowering dependence on fossil fuels and enhancing soil health through integrated land management.

2.2 Economic Potential for Farmers

Agrivoltaics has the potential to enhance and diversify farmers' income through agricultural production and solar power generation. Pilot projects in Maharashtra and Rajasthan have indicated that farmers participating in agrivoltaics initiatives have experienced an income increase of 30-40% due to dual revenue sources (Poonia *et al*., 2021). While these early findings are promising, their applicability across various farming systems and regions require further assessment. The economic benefits may be particularly relevant for smallholder farmers, who often face income instability due to climate variability and fluctuating crop yields.

Water management is another area where agrivoltaics may provide benefits. Some studies indicate that solar panel shading could reduce irrigation requirements by 10-20% due to lower evaporation rates, which is particularly significant in India, where 54% of land experiences high water stress (Omer *et al*., 2022). Additionally, certain temperature-sensitive crops, such as tomatoes, leafy greens, and pulses, have shown potential for improved resilience under agrivoltaics setups in preliminary studies.

The expansion of agrivoltaics projects is expected to create employment opportunities in solar panel installation, system maintenance, and agronomic research, particularly in rural areas. Projections suggest that India’s solar sector could generate over one million jobs by 2030, with agrivoltaics also potentially contributing to this growth. Additionally, training local farmers and rural youth in solar technology and integrated farming practices may enhance skill development and economic resilience in agricultural communities.

2.3 Renewable Energy Expansion and Sustainability

India has set a goal of achieving 50% of its electricity generation from non-fossil fuel sources by 2030 (MNRE, 2023). Agrivoltaics aligns with this vision by potentially expanding solar power capacity while maintaining agricultural productivity. Decentralized solar power generation through agrivoltaics may also benefit rural electrification and agricultural irrigation, particularly in off-grid farming communities.

The integration of PV powered irrigation pumps has already demonstrated promising results in states such as Gujarat and Rajasthan, where solar-powered irrigation has improved water-use efficiency and reduced operational costs.Agrivoltaics systems have the potential to build upon these successes by enhancing on-farm energy generation, thereby reducing reliance on conventional grid electricity and diesel-powered pumps. However, large-scale adoption requires further policy and financial support to ensure affordability and accessibility for smallholder farmers.

The PM-KUSUM scheme, launched in 2019, seeks to promote solar energy adoption in the agricultural sector by providing financial incentives for solar pump installations and grid-connected solar plants. Integrating agrivoltaics systems under Component A of the PM-KUSUM scheme holds the potential to contribute to the targeted 10 GW of decentralized, grid-connected solar capacity. This integration can reduce dependence on fossil fuels and support long-term rural electrification. However, for agrivoltaics to complement PM-KUSUM effectively, further policy refinements are needed to clarify land-use regulations and financial support mechanisms.

3. CURRENT STATUS AND EXPERIENCES FROM INDIA AND THE WORLD

Agrivoltaics is being explored as a potential approach to address land-use competition while supporting food and energy security. While several countries have advanced in agrivoltaics adoption, India remains in the early stages, with limited pilot projects and ongoing policy discussions.

Globally, Japan, Germany, France, China, and the United States of America (USA) have been at the forefront of agrivoltaics development, implementing structured policies and research-backed strategies. Agrivoltaics installations are restricted on prime agricultural land in China. Instead agrivoltaics system has been focused as a potential land restoration strategy in arid regions in China. Here, agrivoltaics systems are integrated with farming practices to combat desertification while simultaneously generating renewable energy (WRI India, 2024). In USA agrivoltaics system has been promoted as research-driven pilot initiatives, with states like California and Massachusetts introducing financial incentives to encourage agrivoltaics adoption while ensuring agricultural viability (Barron-Gafford *et al*., 2019).

India has initiated agrivoltaics pilot projects in Gujarat, Maharashtra, Rajasthan, and Karnataka, testing feasibility under different agro-climatic conditions. The agrivoltaics project at ICAR-Central Arid Zone Research Institute (ICAR-CAZRI) was one of the first agrivoltaics pilots in India (Fig. 1). In recent years, a significant increase in initiatives on agrivoltaics installation has been noticed. At present, there are more than 20 operational agrivoltaics projects across various states (NSEFI, 2023).

These projects vary in design and objectives, encompassing elevated solar panels that allow traditional farming underneath, as well as ground-mounted systems optimized for intercropping. The primary aims of these projects include evaluating the effects of agrivoltaics on crop yield, soil health, microclimatic conditions, and energy production. In Rajasthan, several crops (e.g. arable crops, medicinal plants, vegetables, aromatic grasses etc) suitable for arid regions have been evaluated with different PV array designs.

In Gujarat, focus is given on staple crops, evaluating the influence of agrivoltaics on yield and land productivity. In Maharashtra, agrivoltaics system has been experimented with different PV configurations to analyze their effects on various crop types (GIZ, 2024). Engaging research institutions to study agrivoltaics applications for smallholder farmers, examining both economic feasibility and agronomic performance have been carried out in Karnataka (IISD, 2023).

Preliminary results indicate that agrivoltaics systems can enhance land productivity, provide additional income for farmers, and contribute to national renewable energy targets. Few impacts of the agrivoltaics system as evidenced from experimental data on agrivoltaics system at ICAR-CAZRI, Jodhpur are highlighted below:

- Rainwater harvesting facility of the CAZRI agrivoltaics system (105 kW) could harvest 1.5 lakh litre of water which provided sufficient amount of water for cleaning of PV module. The harvested water was recycled for cleaning purpose and therefore provided water for cleaning purpose throughout the year. Even, the stored water provided supplemental irrigation to crops.
- Land equivalent ratio was improved to 1.42, which indicates 42% additional advantage through adoption of agrivoltaics system over sole agriculture and PV generation.
- Economics of the agrivoltaics system shown as a profitable business model as the discounted payback period was observed 10.40 years whereas life cycle of the system is 25 years.
- Green energy generation through agrivoltaics system (best performing double row model) reduced the carbon footprint by 478 t ha^{-1} y^{-1}.

The economics of agrivoltaics are variable and depend on multiple factors, including the type of solar panels, their spacing and installation height, and the integration of supporting infrastructure such as water harvesting and recycling systems. Additionally, the choice of crops, management practices, and other site-specific considerations play a crucial role in determining the overall feasibility and financial viability of agrivoltaics system. The Ministry of New and Renewable Energy (MNRE) has recognized agrivoltaics as a potentially valuable approach under the PM-KUSUM scheme, which promotes solar energy integration into agriculture by allowing installation of solar energy power plants of 500 kW to 2 MW in capacity in agricultural lands. The Indian Council of Agricultural Research (ICAR) has been conducting research to identify suitable crop varieties and optimize system configurations for different agro-climatic zones. Some state governments have initiated policy discussions on integrating agrivoltaics into renewable energy and agricultural development programs, with a few offering financial incentives to promote adoption.

Private-sector involvement in agrivoltaics remains limited but is growing, with companies exploring business models to improve financial viability for Indian farmers. However, financial constraints, regulatory gaps, and the need for more field research remain a challenge for widespread adoption.

4. AGRIVOLTAICS SYSTEM DESIGN AND IMPLEMENTATION CONSIDERATION

4.1. Agrivoltaics Models and Configurations

The design and implementation of agrivoltaics systems require careful planning to ensure efficient land use while balancing agricultural productivity and energy generation. The effectiveness of agrivoltaics setups depends on factors such as density of PV panels in an array, height of mounting structure, orientation of PV panels, and integration with crop management practices. Agrivoltaics models with different designs have been explored globally and in India also, with varying results based on crop type, climate conditions, and available technologies.

Elevated solar panel systems, where PV modules are mounted on elevated structures, allow for mechanized farming beneath the panels. Such setups have been shown to reduce soil evaporation and help maintain soil moisture, which could be beneficial in arid and semi-arid climates. However, cleaning dust from the top of PV panel surface is a major activity under operation and maintenance. Another design with low mounting structure and gaps between PV modules in a row allows cultivation of crops in interspace areas with sufficient availability of light (Fig. 1). Research suggests that such models may provide shade to certain crops, helping to reduce heat stress and optimize water usage. A combination of elevated panels and varied interspaces

Fig. 1: Cultivation of crops at inter-space area between two PV arrays in agrivoltaics system (Source: ICAR-CAZRI, Jodhpur)

between the panels have also been tested and found suitable for multiple crops. Vertical agrivoltaics systems, which use bifacial solar panels installed upright, may be a viable option in peri-urban and high-density farming areas, where land availability is limited. Additionally, PV-integrated greenhouses, which incorporate semi-transparent solar panels, have been studied for their potential to support controlled-environment farming while generating solar power. These systems could be suitable for high-value crops such as vegetables, flowers, and herbs but further research is needed to evaluate their cost-effectiveness and scalability across different agro-climatic conditions.

4.2. Technological Factors and Innovations

The efficiency of agrivoltaics systems is influenced by technical factors such as panel height, spacing, and integration with water and soil management strategies. The height and spacing of PV panels significantly impact the amount of sunlight reaching crops, affecting their growth and yield. Studies indicate that higher panel installations with wider spacing may be preferable in tropical regions to prevent excessive shading while optimizing energy output. Bifacial and vertical PV panels, which capture sunlight from both sides, are being tested for their ability to improve solar energy generation while reducing shading effects on crops.

Single axis tracking systems, which adjust PV panel angles to maximize sunlight exposure, have demonstrated the potential to increase energy output by up to 25% in agrivoltaics farms (Niazi and Victoria, 2023). Elevated two-axis tracking systems offer even greater potential; however, their economic feasibility in large-scale agrivoltaics setups and their effects on crop performance remain uncertain. This is because they intercept more radiation, leaving limited sunlight for crops underneath and in the interspaces, while also involving higher maintenance and operational costs. Additionally, research suggests that integrating rainwater harvesting with solar panels could improve sustainable irrigation practices, particularly in water-stressed regions. Studies in arid and semi-arid climates indicate that water collected from solar panel surfaces could be redirected for panel cleaning and drip irrigation, potentially reducing water consumption.

4.3. Microclimate Effects

Agrivoltaics systems also impact microclimate conditions, which can have both positive and negative effects on plant growth (Marrou *et al*., 2013; Weselek *et al*., 2021). Shade-tolerant crops, such as spinach, lettuce, and potatoes, have demonstrated improved resilience under agrivoltaics setups, whereas light-intensive crops like wheat and maize may require specific adjustments in panel spacing and orientation. Soil moisture retention is generally higher under agrivoltaics panels, potentially reducing evapotranspiration and improving overall water-use efficiency. However, the shaded area beneath the panels restricts access to natural rainfall, making crops entirely dependent on water application. Additionally, excessive shading may alter soil microbial diversity, necessitating site-specific soil management approaches.

5. CHALLENGES AND BARRIERS FOR SCALING UP OF AGRIVOLTAICS

5.1 Policy, Institutional Coordination, and Regulatory Framework

Agrivoltaics presents a promising dual-use land management approach, supporting both agricultural productivity and renewable energy generation. However, its large-scale adoption in India is hindered by policy gaps, regulatory ambiguity, and land-use classification challenges. The absence of a dedicated national agrivoltaics policy creates legal, administrative, and financial uncertainties, limiting its expansion.

A well-defined national agrivoltaics policy is required to address land classification, taxation, financial incentives, and grid connectivity solutions. Currently, agrivoltaics projects struggle with classification, impacting their eligibility for subsidies, tax benefits, and financial incentives. Establishing a legal definition for agrivoltaics as a dual-use land system would enable farmers to access both agricultural and renewable energy sector benefits. Internationally, countries like France and Germany have implemented strict land-use criteria to provide regulatory clarity and access to government incentives (Govt. of France, 2020).

Additionally, land-use permissions and regulatory approvals require explicit classification, particularly in states where farmland conversion is highly regulated. Early adopters such as Rajasthan, Gujarat, and Maharashtra have prioritized land for agrivoltaics deployment, but an integrated national framework is needed to streamline project approvals and attract private sector investment. The lack of standardized land classification prevents agrivoltaics farms from qualifying for agricultural subsidies or renewable energy incentives, further delaying large-scale adoption. Institutional coordination is essential for effective policy implementation.

Germany, for example, has introduced land zoning policies restricting agrivoltaics to designated farming zones, ensuring energy production does not undermine agricultural productivity (GIZ, 2024). Similarly, France mandates that agrivoltaics systems must maintain certain level or improve crop yields to ensure food security remains a priority (IISD, 2023; TSE, 2025). India can adopt a localized regulatory approach that aligns energy security with agricultural resilience.

The PM-KUSUM scheme, which partially includes agrivoltaics under Component A, allows for decentralized solar energy-based power plants (SEPPs) with capacities ranging from 500 kW to 2 MW by individual farmers/ group of farmers/ cooperatives/ panchayats/ Farmer Producer Organisations (FPO)/Water User Associations (WUA). However, the scheme does not mandate crop cultivation alongside solar installations, limiting agrivoltaics' full potential. To integrate agrivoltaics into existing programs, Component A should be revised to promote decentralized SEPP projects with agrivoltaics models. Additionally, state solar policies should recognize agrivoltaics installations within Renewable Purchase Obligations (RPOs) to ensure agrivoltaics-generated electricity contributes toward state clean energy targets.

Grid connectivity and power evacuation remain critical challenges for agrivoltaics projects, particularly in remote areas, due to uncertain regulations and inadequate transmission infrastructure. These barriers make it difficult for farmers to sell surplus PV electricity to the grid, limiting the financial viability of agrivoltaics. While the PM-KUSUM scheme has supported decentralized solar installations, agrivoltaics-specific grid integration policies are yet to be formalized. Defining clear power evacuation guidelines, simplifying net-metering procedures, and strengthening rural grid infrastructure would help ensure that farmers can generate revenue from surplus energy while maintaining agricultural activities.

For successful large-scale agrivoltaics adoption, India's agrivoltaics policy framework must include financial incentives, regulatory clarity, and strong institutional coordination. Establishing dedicated agrivoltaics programs, streamlining approval processes, and integrating farmer-centric incentives will enhance adoption and feasibility. Resource mobilization from agricultural programs, such as the Mission for Horticulture Development, particularly in PV-supported protected cultivation setups, could help reduce financial burdens on farmers. Additionally, developing region-specific agrivoltaics models through pilot projects and long-term research would provide empirical data to refine future policies.

5.2 Financial Challenges and Sustainable Business Models for Agrivoltaics

Agrivoltaics offers a promising solution for dual land use, but its financial sustainability depends on addressing high capital costs, establishing clear business models, and leveraging innovative financing mechanisms. The infrastructure can cost up to 30% more than conventional ground-mounted PV plants due to specialized designs that accommodate both solar energy generation and agricultural activities. Land conversion charges, which are imposed when agricultural land is repurposed for non-agricultural activities, create a significant financial burden on farmers. Reducing or exempting agrivoltaics projects from such charges would encourage greater participation. Viability Gap Funding (VGF) could be leveraged to bridge initial investment gaps, particularly for small and marginal farmers or group of farmers who may struggle with the high capital costs of agrivoltaics infrastructure. Additionally, there is need to evaluate the implementation of Feed-in Tariffs (FiTs) and market-driven Power Purchase Agreements (PPAs) to ensure fair pricing for agrivoltaics-generated electricity. FiTs provide guaranteed pricing, offering secured income to farmers, while PPAs introduce competitive energy pricing. An appropriate pricing model will be essential in balancing affordability for consumers and profitability for farmers.

The financial sustainability of agrivoltaics depends on structured investment mechanisms and diverse ownership models. Agrivoltaics projects in India may adopt variants of three broad category of ownership structures.

- In farmer-owned agrivoltaics, farmers retain ownership of land and install solar PV panels while continuing agricultural activities underneath. This model provides dual source of income from crop production and solar energy sales, offering economic resilience against fluctuating agricultural incomes (Cotton et al., 2025). However, high initial investment costs ranging from ₹4.00 to ₹6.5 crore per megawatt (MW)capacity, and complex regulatory approvals pose major barriers particularly in India where large number of farmers are small, marginal and resource poor, thus necessitating subsidies, concessional financing, and technical support.
- The developer-leased model involves renewable energy companies leasing farmland from farmers to set up solar infrastructure while permitting continued agricultural activities. The developer finances and manages energy sales, while farmers receive lease payments and, in some cases, access to cheaper electricity (IISD, 2023). This model has been successfully deployed in India under the PM-KUSUM scheme, in which farmers lease land to energy developers, ensuring stable income (MNRE, 2024). Ensuring equitable lease terms and minimizing disruptions to traditional farming practices remains a challenge) but this model seems apt for small and marginal farmers.
- In the hybrid cooperative model, farmers collectively invest in agrivoltaics infrastructure, pooling resources to reduce financial risk while promoting community-based renewable energy generation. In India, cooperative-led renewable energy projects, supported by the National Bank for Agriculture and Rural Development (NABARD)'s rural energy schemes, have demonstrated potential for community-driven agrivoltaics expansion (WRI India, 2024).

Ensuring financial viability in agrivoltaics requires a combination of government-backed financing, tax benefits, and emerging revenue streams from green finance mechanisms, such as:

- **Government Subsidies and Low-Interest Financing:** The PM-KUSUM scheme and NABARD-backed credit programs provide low-interest loans to promote solar adoption in agriculture (MNRE, 2024). Expanding these initiatives to explicitly include agrivoltaics can reduce capital constraints for farmers. Germany's National Renewable Energy Action Plan offers zero-interest loans for agrivoltaics projects, a model that could be explored for India to encourage widespread adoption subjected to compliances of the preset-criteria (GIZ, 2024).
- **Tax Incentives and Depreciation Benefits**: Some countries have introduced tax exemptions and accelerated depreciation benefits to incentivize agrivoltaics investment. In India, solar energy investments qualify for accelerated depreciation, allowing businesses to recover capital costs faster, attracting private-sector participation. France and Germany offer tax incentives on agrivoltaics installations, making them financially viable for both farmers and commercial developers (Govt. of France, 2020). Implementing similar fiscal measures in India could drive agrivoltaics expansion, particularly in states with high solar potential.

- **Carbon Credits and Green Financing**: Agrivoltaics projects contribute to reduction in greenhouse gas emission, qualifying them for carbon trading mechanisms that provide additional revenue streams for farmers and investors. Sustainability-linked bonds and climate-focused investment funds have been used in Europe and North America to support agrivoltaics expansion (IISD, 2023). Integrating agrivoltaics into India's green finance strategy could attract international climate finance and private investments.

Several countries have demonstrated successful agrivoltaics business models that offer lessons for India. Germany has leveraged government-backed incentives and private-sector investments to accelerate agrivoltaics adoption, with the country's Renewable Energy Sources Act (EEG, 2023) providing preferential tariffs for agrivoltaics-generated electricity, making it economically viable for farmers and developers (Cotton *et al*., 2025). Cooperative agrivoltaics projects have enabled smallholder farmers to participate in the energy transition while maintaining agricultural productivity. France has adopted a policy-driven approach with strict land-use regulations to ensure that agrivoltaics projects do not compromise agricultural output beyond a defined limit of 10%. Farmers participating in agrivoltaics receive financial support through state subsidies, which has facilitated large-scale implementation, particularly in vineyard regions where solar shading improves crop quality. In India, agrivoltaics is still in its early stages, with pilot projects under the PM-KUSUM scheme demonstrating the potential for dual land use. Karnataka's NABARD-backed solar cooperatives have empowered smallholder farmers to invest in agrivoltaics, highlighting the potential of community-driven models.

Access to dedicated financing remains a challenge, as traditional lenders classify agrivoltaics as high-risk due to uncertainties in crop yields, energy generation efficiency, and regulatory support. To enhance private sector participation, it is essential to develop agrivoltaics-specific credit lines, viability gap funding (VGF), and tailored insurance mechanisms. To ensure scalable and financially viable agrivoltaics adoption, emphasis should be placed on farmer-led and cooperative models, supported by low-interest financing and risk-mitigation programs. Establishing a national agrivoltaics financing mechanism would provide dedicated investment support, ensuring accessibility for both smallholder farmers and large-scale developers. Additionally, integrating agrivoltaics into India's green finance strategy could unlock carbon trading revenues and international climate funds, enhancing the sector's long-term financial sustainability.

5.3 Technical Constraints, Agronomic Challenges, and Land Considerations

Agrivoltaics presents significant technical and agronomic challenges that must be addressed for its successful integration into agricultural landscapes. One of the primary concerns is crop yield variations due to shading from solar panels. Reduced sunlight exposure can lower photosynthetic activity, potentially impacting crop productivity. Research indicates that shade-tolerant crops such as leafy vegetables and certain pulses may benefit from moderated temperature and improved moisture retention, while crops with high daily light requirements (e.g., rice, wheat, maize, and other coarse cereals) may experience reduced yields under agrivoltaics systems (Widmer *et al*., 2024). Optimizing panel spacing, height, and tracking mechanisms is crucial to minimize shading-related yield losses (IISD, 2023). Additionally, different agrivoltaics deployment models, including elevated, interspaced, and vertical panels, need to be field-tested to evaluate their impact on soil health, microbial activity, and nutrient cycling (GIZ, 2024).

Another major concern is dust accumulation on solar panels, which can reduce energy generation efficiency by 20–25% if not properly managed. Frequent panel cleaning and maintenance increase operational costs, affecting the economic viability of agrivoltaics systems. Technologies such as self-cleaning coatings, robotic cleaning systems, and rainwater-assisted washing have been explored to reduce soiling losses, but their adoption remains cost-prohibitive for small and marginal farmers.

Agrivoltaics systems also modify local microclimates, influencing soil moisture retention, temperature regulation, and pest populations. Research suggests that shaded areas retain higher soil moisture, reducing irrigation needs but also potentially altering microbial activity and nutrient cycling (WRI India, 2024). In some cases, the microclimate changes in agrivoltaics farms can act as an oasis, attracting more insects and pests, particularly during dry summer months. This underscores the need for site-specific research to develop optimized agrivoltaics configurations suited to different regional agro-climatic conditions.

A common misconception surrounding agrivoltaics is the perceived vast land requirement, often viewed as a threat to food security. However, a closer analysis reveals that agrivoltaics deployment can be strategically optimized to balance energy production, agricultural sustainability, and climate resilience. As of January 2025, India's installed solar capacity stands at approximately 100 GW. With a national target of achieving 50% of its energy from renewable sources by 2030, this translates to a solar capacity target of around 150 GW. Even if the entire additional solar capacity were to be derived from agrivoltaics, the estimated land requirement, depending on panel spacing and open ground availability (70% - 90%), would range between 1 to 3 million hectares.

Looking further ahead to 2047, when India's peak electricity demand is projected to surpass 700 GW, achieving 50% of this demand from solar energy would require approximately 350 GW from solar PV. In such a scenario, the total land requirement for agrivoltaics installations (≈ 250 GW solar PV) with 70-90% open space configurations would range between 1.4 to 5.2 million hectares. However, this is not a likely scenario, as a significant portion of future solar energy production is expected to come from large-scale solar plants on waste and degraded land, reducing direct competition with agricultural land.

It is crucial to highlight this perspective to policymakers, who often perceive agrivoltaics as a threat to food security rather than an opportunity for sustainable energy and agricultural integration. By co-designing and co-locating agrivoltaics with sustainable land management strategies, India can optimize renewable energy generation without compromising agricultural productivity.

Given India's diverse agroecological zones, agrivoltaics designs must be customized to meet the needs of various cropping systems. Different deployment models, including elevated, interspaced, and vertical panels, must be tested across multiple climatic regions to ensure that agrivoltaics effectively balance energy generation with sustainable crop production.

5.4 Social Barriers, Farmer Acceptance, and Skill Development

Adoption of agrivoltaics among Indian farmers remains limited due to perceived risks, lack of awareness, and concerns about land encroachment by renewable energy developers. Many smallholders fear that agrivoltaics projects may reduce primary agricultural output or lead to land acquisition by external investors, causing long-term insecurity. Additionally, limited exposure to agrivoltaics models and insufficient demonstration projects contribute to skepticism regarding its feasibility and benefits.

Addressing these challenges requires targeted capacity-building programs and farmer outreach initiatives. Establishing demonstration farms showcasing successful agrivoltaics models in different agroecological regions could build trust among farming communities. Integrating agrivoltaics into agricultural extension services and providing farmer training on dual-use land management can enhance adoption rates and mitigate concerns about productivity losses. A farmer-centric approach in system design is crucial to ensure equitable revenue-sharing mechanisms and prevent large-scale land diversion for commercial solar projects.

Another significant barrier is the lack of structured training programs and specialized courses on agrivoltaics, limiting the technical expertise required for large-scale adoption. Agrivoltaics demands interdisciplinary skills, combining solar energy management, agronomic practices, water management, climate adaptation, and financial and policy understanding. However, the absence of dedicated academic curricula, vocational training, and capacity-building initiatives restricts the development of a skilled workforce.

To bridge this gap, agrivoltaics should be integrated into agricultural and technical education through specialized training centres, certification programs, and hands-on workshops for farmers, researchers, field officials, and energy professionals. Public-private partnerships (PPPs) and collaborations with research institutions can support knowledge dissemination and establish a robust skill-development framework. Without structured capacity-building initiatives, India risks delaying agrivoltaics adoption despite its potential to enhance energy security, agricultural resilience, and rural livelihoods.

Strengthening community-led agrivoltaics models, such as solar cooperatives, can drive inclusive development while ensuring farmer empowerment. Co-working with farmers and agricultural researchers/scientists in designing agrivoltaics is crucial for creating a collaborative framework that balances agricultural productivity with clean energy generation. Well-defined policy frameworks must safeguard farmer rights, establish equitable revenue-sharing mechanisms, and prevent large-scale land diversion for commercial solar projects. Additionally, a structured skill development system will be essential for ensuring the long-term scalability and sustainability of agrivoltaics in India.

6. RECOMMENDATIONS

- Establish a National Agrivoltaics Policy under MoAFW and MNRE that provides regulatory clarity on land use, integrates agrivoltaics into renewable energy and agricultural programs, and includes structured financial incentives to support adoption, while strengthening PM-KUSUM and related schemes by introducing targeted agrivoltaics incentives and expanding access to low-interest loans, viability gap funding, and insurance products through NABARD and private channels to promote inclusive, de-risked financing models.
- Prioritize agrivoltaics installations in regions facing land scarcity or harsh climatic conditions where integrating solar energy with high-value agriculture can optimize land use and enhance productivity through microclimate moderation provided by PV systems. To safeguard food security, prime agricultural land used for staple crops like paddy and wheat may be avoided. A systematic mapping of priority regions should be undertaken based on agro-climatic suitability, land availability, existing agricultural practices, and alignment with local and national priorities.
- Encourage decentralized solar irrigation agrivoltaics (crop beneath solar panels deployed for irrigation pumps), including off-grid systems, and integrating them into the PM-KUSUM program to benefit small and marginal farmers.
- Support the establishment of agrivoltaics pilot projects and the development of region-specific design frameworks to test and evaluate diverse technical configurations, financing mechanisms, business models, and institutional arrangements. These pilots should generate experimental data on crop performance, soil health, microclimate effects, and energy efficiency across different agro-climatic zones, which can inform the creation of robust, context-specific agrivoltaics designs that maximize both energy generation and agricultural productivity.
- Mandating a yield retention threshold for agrivoltaics farms, tailored to specific crops and regional conditions, to balance food security with renewable energy production.
- Develop a National Agrivoltaics Research Initiative to conduct multi-location pilot studies in collaboration with ICAR, IITs, and state agricultural universities to assess

long-term impacts on crop productivity, water use, and microclimate stability across agro-climatic zones, while also supporting research on high-efficiency agrivoltaics technologies such as bifacial and semi-transparent PV panels, water-integrated structures, and AI-driven precision farming systems to enhance energy-crop synergy.

- Promote financial incentives and revenue-sharing models by linking agrivoltaics projects to carbon credits, green bonds, and climate finance opportunities, while integrating them with smart grids and decentralized solar power systems to enable farmers to sell surplus electricity locally enhancing farmer income, rural electrification, energy security, and overall financial viability.
- Expand PPPs to mobilize infrastructure investments, technological advancements, and farmer-friendly business models, ensuring that agrivoltaics transition from pilot projects to large-scale commercial deployment.
- Promote climate-resilient agrivoltaics by integrating it into India’s rural development and climate policies, aligning with SDGs and the Paris Agreement, and incorporating it into the NAPCC as a disaster-resilient solution for drought- and flood-prone regions.
- Enhance skill development programs by training farmers, agricultural extension officers, and renewable energy technicians in agrivoltaics installation, maintenance, and farm management to create a skilled workforce for sustainable scaling, while simultaneously strengthening farmer participation and governance by ensuring policies include revenue-sharing mechanisms, protect land rights, and prevent large-scale land conversion for commercial solar projects.
- Develop a dual-coverage insurance model that integrates crop insurance with solar infrastructure insurance, protecting farmers against both agricultural losses and energy generation risks. This can be implemented through a dedicated Agrivoltaics Insurance Program with government-backed subsidies and public-private partnerships.
- Develop a circular economy-based recycling and repurpose program for life cycle management of solar PV panels in agrivoltaics, ensuring material recovery, safe disposal, and land restoration to prevent environmental hazards and maintain agricultural productivity.

REFERENCES

Asa'a S, Reher T, Rongé J, Diels J, Poortmans J, Radhakrishnan H S, van der Heide A, Van de Poel B, Daenen M (2024) A multidisciplinary view on agrivoltaics: Future of energy and agriculture. Renewable and Sustainable Energy Reviews 200:114515. https://doi.org/10.1016/j.rser.2024.114515

Barron-Gafford G A, Pavao-Zuckerman M A, Minor R L, Sutter L F, Barnett-Moreno I, Blackett D T, Thompson M, Dimond K, Gerlak A K, Nabhan G P, Macknick J E (2019) Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands. Nature Sustainability *2*(9):848-855.https://doi.org/10.1038/s41893-019-0364-5

Cotton, M., Langford, S., Kuria A, Parkhill K (2025) A technology to solve the water-energy-food crisis? Mapping agrivoltaics in the global energy transition. Energy Research & Social Science 119, 103872. https://doi.org/10.1016/j.erss.2024.103872

Doedt C, Tajima M, Iida T (2024) Agrivoltaics in Japan: A legal framework analysis. In: Agrivoltaics World Conference 2022: Environmental, Legal and Socio-Economic Aspects. https://doi.org/10.52825/agripv.v1i.533

EEG. 2023. German Federal Government. Amendment of the Renewable Energy Sources Act (EEG 2023). https://www.bundesregierung.de/breg-en/search/amendment-of-the-renewables-act-2060448

GIZ. 2024. Agrivoltaics in India. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, New Delhi. p. 76. https://img.saurenergy.com/2024/04/agrivoltaic-in-india-report.pdf

Government of France. (2020). *Integrated National Energy and Climate Plan.* FAOLEX – Food and Agriculture Organization of the United Nations Legal Database. pp-328, https://faolex.fao.org/docs/pdf/fra212362.pdf.

IISD 2023. Agrivoltaics in India Challenges and opportunities for scale-up. International Institute for Sustainable Development (IISD), Manitoba, Canada. p. 31.

Marrou H, Guilioni L, Dufour L, Dupraz C, Wery J (2013) Microclimate under agrivoltaics systems: Is crop growth rate affected in the partial shade of solar panels?. Agricultural and Forest Meteorology 177:117-132.

MNRE 2023. Annual Report 2022-23. Ministry of New and Renewable Energy, Government of India, pp-152

MNRE 2024. Annual Report 2023-24. Ministry of New and Renewable Energy, Government of India, pp-178

Niazi K A K, Victoria M (2023). Comparative analysis of photovoltaic configurations for agrivoltaics systems in Europe. Progress in Photovoltaics: Research and Applications31(11):1101–1113

NSEFI, 2023. Agrivoltaics in India: Overview of projects and relevant policies. National Solar Energy Federation of India (NSEFI), New Delhi. p. 85

Omer A A A, Liu W, Li M, Zheng J, Zhang F, Zhang X, Mohammed S O H, Fan L, Liu Z, Chen F, Chen Y (2022) Water evaporation reduction by the agrivoltaic systems development. Solar Energy 247:13-23.

Poonia S, Jat N K, Santra P, Singh A K, Jain D, Meena H M (2021) Techno-economic evaluation of different agri-voltaic designs for the hot arid ecosystem of India. Renewable Energy 184:149-163.

Santra P, Meena, H M, Yadav O P (2021) Spatial and temporal variation of photosynthetic photon flux density within agrivoltaics system in hot arid region of India. Biosystems Engineering 209:74-93. https://doi.org/10.1016/j.biosystemseng.2021.06.017.

Santra P, Pande P C, Kumar S, Mishra D, Singh R K (2017) Agri-voltaics or Solar farming: the concept of integrating solar PV based electricity generation and crop production in a single land use system. International Journal of Renewable Energy Research 7(2):694-699.

TSE. 2025. "The Regulatory Framework for Agrivoltaics to Preserve French Agriculture." https://www.tse.energy/en/articles/le-cadre-reglementaire-de-lagrivoltaisme-pour-preserver-lagriculture-francaise

UNDESA. 2022. United Nations Department of Economic and Social Affairs, Population Division, World Population Prospects 2022: Summary of Results. UN DESA/POP/2022/TR/NO. 3., pp-52

Weselek A, Bauerle A, Hartung J, Zikeli S, Lewandowski I, Högy P (2021) Agrivoltaics system impacts on microclimate and yield of different crops within an organic crop rotation in a temperate climate. Agronomy for Sustainable Development 41(5):59.

Widmer, J., Christ, B., Grenz, J., &Norgrove, L. 2024. Agrivoltaics, a promising new tool for electricity and food production: A systematic review. Renewable and Sustainable Energy Reviews, 192, 114277. https://doi.org/10.1016/j.rser.2023.114277

WRI India. 2024. “Agrivoltaics: Reimagining land for better livelihoods”. World Resources Institute India.https://wri-india.org/blog/agrivoltaics-reimagining-land-better-livelihoods.

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