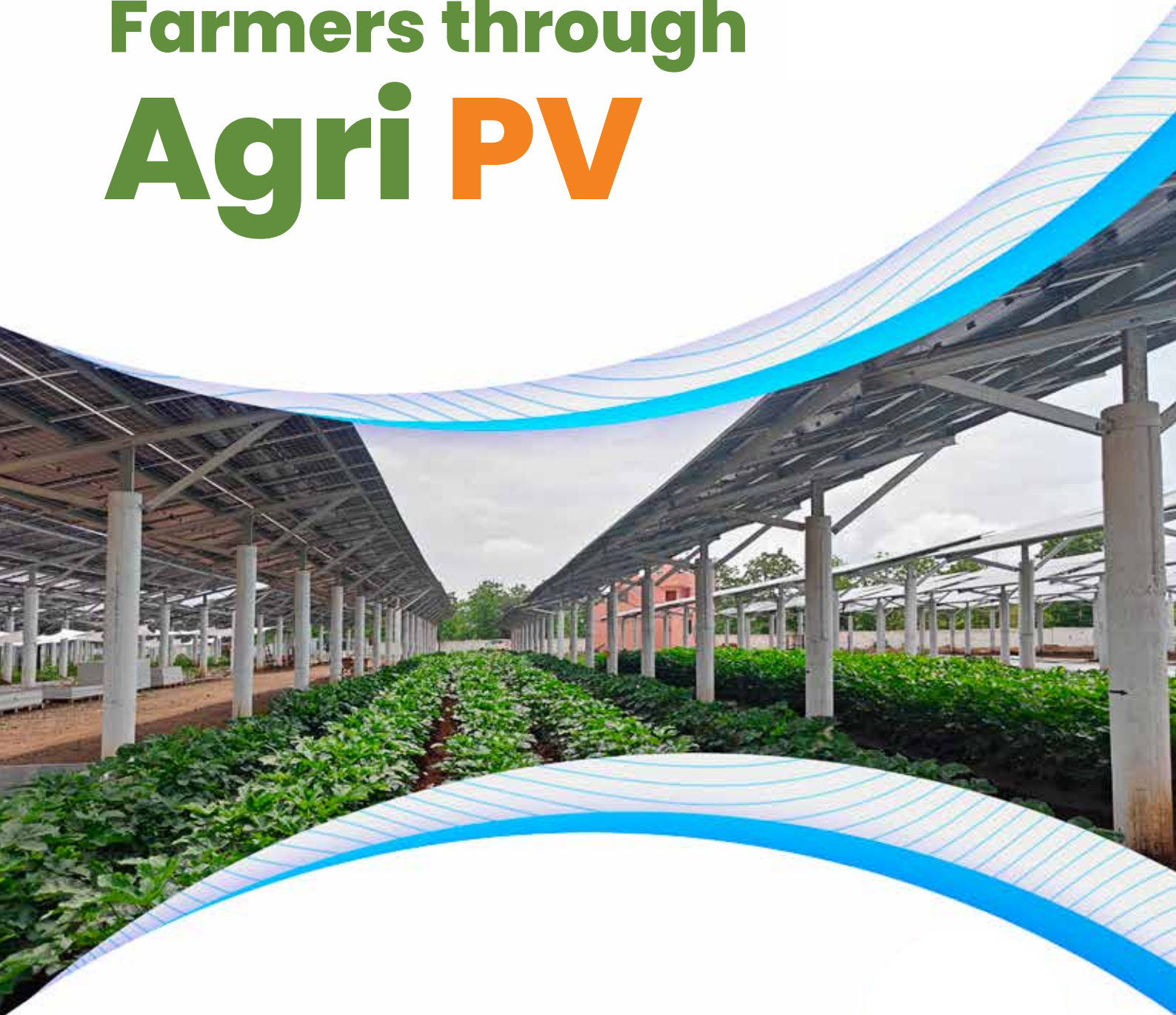




Energy Department
Government of Odisha



Empowering Farmers through Agri PV



JUNE 2026

This report is based on the best available information in the public domain. Every attempt has been made to ensure the correctness of the data. However, Vasudha Foundation does not guarantee the accuracy of the data or accept responsibility for any consequences arising from its use.

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EXECUTIVE SUMMARY

Agri PV (Agri Photovoltaics²) – the dual use of land for solar power generation and agriculture – offers Indian states a strategic pathway to expand renewable energy capacity while strengthening farmer income and climate resilience



Global practice shows that successful Agri PV ecosystems are anchored on clear objectives, such as rural livelihoods, climate adaptation, or energy security, and supported by strong financial incentives, predictable land-use rules, and localised agronomic design. Countries that scale Agri PV emphasise:

- Farmer participation and local ownership models.
- Transparent revenue-sharing and benefit-distribution mechanisms.
- Standardised monitoring frameworks to verify crop yields, soil health, and water impacts.
- Differentiated permitting and blended financing models to reduce project risk.

The evaluation of 22 interventions using sectoral, financial, institutional, and social inclusion criteria indicate:

- Financial interventions emerge as strongest drivers of early adoption, underscoring the importance of de-risking upfront investments. Capital grants combined with performance-linked credit support rank highest (Rank 1), followed closely by other financial measures such as preferential Feed-in-Tariffs (Rank 3) and access to low-interest loans (Rank 4), all of which significantly improve project bankability and farmer participation.
- Regulatory clarity is a critical enabling factor, with state-specific Agri PV guidelines ranking high (Rank 2), reflecting their role in reducing uncertainty, standardising project design, and accelerating approvals.
- Administrative streamlining also plays a significant role, as interventions such as single-window approval mechanisms (Rank 8) reduce procedural delays and transaction costs for both farmers and developers.
- Capacity-building interventions show strong relevance, particularly technical training and certification programmes (Rank 5) and the use of Krishi Vigyan Kendras (KVKs) as Agri PV extension leaders (Rank 9), helping build trust, technical competence, and long-term system performance.
- Lower-ranked interventions, including research hubs, model contracts, and sustainability metrics, remain important for ecosystem maturity and long-term governance but are less critical during the initial scale-up phase.

Taken together, the findings indicate that combining targeted financial incentives, regulatory streamlining, and community-oriented capacity building can position Agri PV as a central instrument for rural economic resilience, distributed renewable energy growth, and climate-smart agriculture.

While the recommendations presented are comprehensive and derived through a rigorous multi-criteria prioritisation framework, their relative sequencing and policy emphasis may vary across states depending on agricultural contexts, land-use patterns, institutional capacity, financial readiness, and stakeholder priorities. Therefore, the interventions should be viewed as an indicative menu for action, from which states can adopt and tailor measures according to local enabling conditions.





2

INTRODUCTION



The rapid expansion of solar power in India has been primarily driven by ground-mounted photovoltaic (GM-PV) systems. While these projects have been instrumental in scaling renewable capacity, they also present challenges, including high land requirement, potential conflicts with agricultural land use, and ecosystem disruption¹. At the same time, agriculture remains the backbone of India’s economy, employing nearly half the workforce and providing livelihoods for small and marginal farmers. The challenge before states is to simultaneously expand renewable energy capacity and safeguard agricultural productivity.

Agri PV (Agri Photovoltaics²), the integration of photovoltaic systems with active agricultural practices on the same land emerges as a promising

1 J, Saraswat, N, Mall, and T, Katiyar., White Paper: The Case for Agri PV Implementation in Uttar Pradesh. Vasudha Foundation; 2024, <https://www.vasudha-foundation.org/wp-content/uploads/Agri-PV-Implementation-in-Uttar-Pradesh.pdf>

2 Agri PV (Agri Photovoltaics) is used throughout this paper as the standard term; it is synonymous with ‘Agrivoltaics,’ ‘Agrovoltaics,’ ‘Agrophotovoltaics (APV),’ which appear in global literature and policy documents due to differing regional naming conventions.

solution. Agri PV enables dual land use, in which solar panels generate clean electricity while crops continue to be cultivated underneath or between them. International experience shows that Agri PV can enhance land productivity up by 60%, increase water efficiency, improve soil health, and strengthen farmers' resilience to climate shocks.

Globally, governments have recognised Agri PV as a strategic tool for climate action, rural development, and energy security. Countries such as Germany, France, the USA, Japan, and China have rolled out a range of technical standards, concessional finance, tax incentives, and legal frameworks to support dual land-use systems.

For Indian states, Agri PV represents a multi-win opportunity:

- Economic: Increases farmer income by diversifying revenue streams from crop produce and power sales.
- Social: Creates jobs in both agricultural and energy sectors while enabling equitable rural development and avoiding rural migration.
- Environmental: Enhances climate resilience through shading, water conservation, and biodiversity co-benefits.
- Energy: Supports state renewable energy targets and reduces grid stress by enabling decentralised energy generation.

This report consolidates an indicative catalogue of interventions developed through global landscape analysis and consultations with key stakeholders across the Agri PV value chain. It further applies a Multi-Criteria Decision Matrix (MCDM) approach to prioritise interventions most relevant to the state context, ensuring evidence-based policymaking and efficient use of public resources.





3

WHY A MULTI-CRITERIA DECISION MATRIX (MCDM) APPROACH IS NEEDED



Designing policy interventions for Agri PV is inherently complex. Policymakers face competing demands: maximising renewable energy deployment, protecting agricultural output, ensuring financial viability for farmers and developers, and maintaining social acceptance. Decisions cannot rely on a single metric such as cost, yield, or installed capacity.

This is where Multi-Criteria Decision Matrix (MCDM) approaches become invaluable. MCDM is a well-established decision-support tool, widely used in energy, agriculture, and infrastructure planning. It enables decision-makers to evaluate multiple interventions simultaneously across diverse criteria, both quantitative and qualitative, and assign weights to reflect state priorities.

3.1 Relevance of MCDM for Agri PV

For Agri PV, an MCDM framework allows one to systematically rank technical, financial, and policy interventions, ensuring that selected measures deliver maximum impact for farmers and the energy system. To arrive at an optimal solution in the presence of competing options requires scientific backing in decision-making strategies. This includes ranking of a set of interventions that belong to the same real-world set where the choice of the best among the better options is tricky and requires some insight. MCDM's versatility is evident from the fact that it can be applied in all areas of decision theory like management, manufacturing, transport, education, agriculture, and more. Hence, it is widely used by policymakers, researchers, and other professionals across domains in interactive decision-making and a decision support system. The first usage of MCDM was found in research pieces written more than six decades ago. Since then, myriad work pieces have incorporated and benefited from MCDM. Moreover, there are numerous review papers on MCDM that examine their assumptions, strengths, and limitations to identify the right approach for the selected application^{3,4,5}. The advantages of applying an MCDM framework to Agri PV planning include the following:

- **Balances Multiple Objectives:** Agri PV projects are expected to deliver on energy, agriculture, environment, and equity. MCDM explicitly captures these multiple dimensions.
- **Provides Transparency:** Policymakers and stakeholders can see why a particular intervention is ranked higher or lower, reducing the risk of ad hoc decision-making.
- **Handles Trade-offs:** For example, an intervention with a higher upfront cost but greater farmer income impact can still be prioritised if social equity is valued more highly.
- **Increases Robustness:** By combining qualitative judgments (e.g., farmer acceptance, ease of implementation) with quantitative measures (e.g., land equivalent ratio, CAPEX), MCDM ensures more grounded and realistic prioritisation.
- **Adaptable to State Contexts:** Different states can adjust weights according to their unique agricultural, energy, and socio-economic context.

3.2 Overview and Workflow of MCDM Approaches

To date, MCDM remains an important area of research, with information on more than 70 different MCDM approaches is available in the public domain. These MCDM approaches employ a few key generic steps that are highlighted in Figure 1⁶. The first step is the identification of the interventions that need to be ranked, followed by an explanation of the criteria for ranking. These criteria may be a conjunction of qualitative and quantitative parameters. The next step involves assigning preferences to the evaluation criteria, which can be done based on various techniques as mentioned in Figure 2. The fourth step is choosing the right MCDM approach for the application, followed by the evaluation of the performance scores. Finally, the ranking is done based on the performance scores, and the results are furnished for the users.

3 Ananda, J., *A critical review of multi-criteria decision-making methods with special reference to forest management and planning*. Ecological Economics; 2009. 68(10):2535-2548, <https://www.sciencedirect.com/science/article/abs/pii/S0921800909002201>

4 Smith, P.G.R., Theberge, J.B., *A review of criteria for evaluating natural areas*. Environmental Management; 1986. 10, 715-734, https://www.researchgate.net/publication/227004541_A_review_of_criteria_for_evaluating_natural_areas

5 Stewart, T. J., *A critical survey on the status of multiple criteria decision-making theory and practice*. OMEGA International. Journal of Management Science; 1992. 20, 569-586, <https://ideas.repec.org/a/eee/jomega/v20y1992i5-6p569-586.html>

6 Singh, A., Malik, S. K., *Major MCDM Techniques and their application – A Review*. IOSR Journal of Engineering; 2014. 04, 15-25, https://www.researchgate.net/publication/272985338_Major_MCDM_Techniques_and_their_application-A_Review

	1. Identify Interventions		4. Choosing the right MCDM Approach
	2. Elucidate the Evaluation Criteria		5. Evaluation of the Performance Score
	3. Assigning Preferences to Evaluation Criteria		6. Ranking of Interventions

Figure 1: Generic steps of MCDM approaches




	1. Equal Weights		5. Gamble Method
	2. Direct Weighting		6. Pair-wise Comparison
	3. Derived Weights		7. Value Swinging
	4. Delphi Technique		8. Method -based on removal effects of criteria (MEREK)

Figure 2: Arriving at weights for prioritising evaluation criteria⁷

Table 1 represents a template of the final decision matrix based on n interventions and m criteria. Here, a_{nm} represents the performance score of the nth intervention against the mth criterion.⁸ A holistic review of around 18 MCDM approaches led to the conclusion that how the performance score is calculated (Step 5) differentiates the MCDM approaches.

Table 1: Final decision matrix template

	Criteria 1	Criteria 2	Criteria m
Intervention 1	a_{11}	a_{12}		a_{1m}
Intervention 2	a_{21}	a_{22}		a_{2m}
.....				
Intervention n	a_{n1}	a_{n2}		a_{nm}

7 Odu, G., *Weighting methods for multi-criteria decision-making technique*. Journal of Applied Sciences and Environmental Management; 2019. 23(8):1449, https://www.researchgate.net/publication/335806989_Weighting_methods_for_multi-criteria_decision-making_technique

8 A, Petrillo, Salomon, V., and Tramarico, C, L., *State-of-the-Art Review on the Analytic Hierarchy Process with Benefits, Opportunities, Costs, and Risks*. Journal of Risk and Financial Management; 2023. 16(8):372, https://www.researchgate.net/publication/373136428_State-of-the-Art_Review_on_the_Analytic_Hierarchy_Process_with_Benefits_Opportunities_Costs_and_Risks

Another key facet that was unfurled during the literature review was the presence of around 5 key MCDM approaches that dominated the research in the last 5 years. Table 2 captures details on those approaches. Also, no approach was dedicatedly used for a particular application. Most researchers selected two or more MCDM approaches and used one for ranking the interventions and the remaining to validate the results obtained from the first approach. This allowed the researchers to overcome the limitations of individual approaches. This also aids in allows circumventing the consequences of mismatches that may lead to suboptimal results.

Table 2: Details on key MCDM approaches^{3,6}

MCDM Approach	Origin	Description
Weighted Sum Model (WSM)	NA	This model is also termed Weighted Linear Combination (WLC). In this model, the weights of the criteria are multiplied by normalised intervention values to arrive at the performance scores. Each criterion is given weights depending on their severity while ensuring that the sum of each weight is 1. These performance scores are then summed up, and the interventions are sorted to arrive at the top intervention.
Techniques for Order Preferences by Similarity to Ideal Solutions (TOPSIS)	Hwang and Yoon in 1981	This approach is based on distance matrices. Here, the Euclidean distance is used for ranking interventions from ideal positive to ideal negative solutions. This approach selects the alternative whose value is closest to the positive ideal solution and farthest from the negative ideal solution.
Analytic Hierarchy Process (AHP)	Thomas L. Saaty in 1970	This approach aggregates separate criteria into a unified criterion. Here, the preferences of the decision elements use a hierarchical structure and pairwise comparison of each intervention by assigning relative importance. If two criteria are of equal importance, value of 1 is assigned to both. On the other hand, a value of 9 indicates the importance of the criteria over all others.
Elimination Et Choice Translating Reality (ELECTRE)	1968	This is an outranking model that uses pairwise comparison by using concordance and discordance indexes. Here, the concordance index expresses the fuzzy membership value of the intervention, and the discordance index measures the comparability the interventions
Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE)	Jean-Pierre Barns and Bertrand Mareschal in 1983	Another outranking which tries to outrank one alternative by the other using a preference function and a net outranking flow. It allows the decision-maker to partially or completely rank the interventions by defining a preference function for each criterion.

3.3 Basis for Method Selection and Multi-Criteria Structuring in Agri PV

This paper uses the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) approach for evaluating the intervention ranking because of the following reasons:

- This approach handles mixed quantitative and qualitative criteria via normalisation of Agri PV interventions and combining heterogeneous metrics (₹/ha, % Internal Rate of Return (IRR) uplift, ₹/MW, etc.). TOPSIS normalises criteria into a comparable space and computes distance to ideal and anti-ideal points, so a mixed-unit aggregation is mathematically consistent.⁹
- It produces an easy-to-interpret closeness score (ranking). TOPSIS yields a relative closeness index (0–1) showing how near each intervention is to the positive ideal – ideal for communicating prioritisation to non-technical stakeholders and for transparent policy reporting.⁹
- It is well-established to rank sites and interventions in Agri PV, demonstrating field acceptance.¹⁰

To ensure that the prioritisation of Agri PV interventions reflect the full spectrum of real-world considerations relevant to India’s agricultural, energy, and socio-economic context, the evaluation framework groups criteria into four overarching categories: Technical, Financial, Regulatory/Institutional, and Community/Capacity Building. The categories are described below:

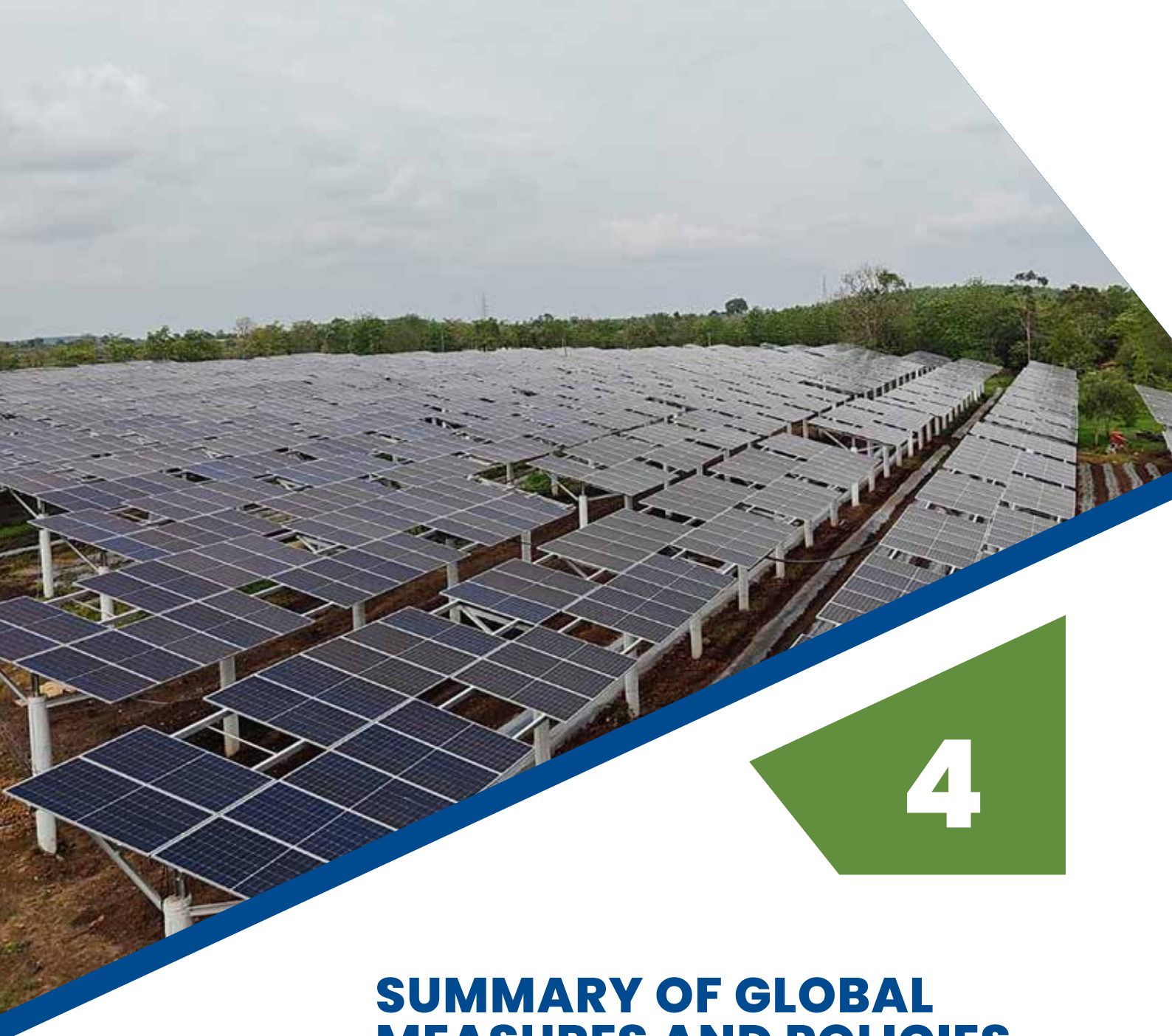
- 1. Technical:** Agri PV solutions must simultaneously meet the operational needs of farming and energy generation. Technical interventions directly influence system performance, crop compatibility, yield stability, and overall deployment feasibility. It directly affects energy output, crop yield, land-equivalent performance and determines suitability across diverse agro-climatic zones.
- 2. Financial:** Given the high upfront costs of Agri PV systems, financial interventions such as grants, guarantees, or concessional credit strongly influence adoption by affecting farmer income, project IRR, debt service coverage ratio, and address levels and fiscal efficiency, considering limited availability of public budget.
- 3. Regulatory and Institutional:** Agri PV deployment intersects land-use laws, energy regulations, agricultural policy, and state-level administrative processes. Regulatory and institutional interventions address bottlenecks that impede approvals, grid integration, inter-departmental coordination, or land classification clarity.
- 4. Community and Capacity Building:** Agri PV succeeds only when local communities, especially small and marginal farmers, perceive clear benefits and feel empowered to participate. These interventions are aimed at strengthening long-term adoption, maintenance, and community engagement.

These four categories reflect the full ecosystem that enables Agri PV deployment. Treating them as distinct but complementary dimensions ensures that no intervention is prioritised solely for its techno-economic merit while ignoring institutional feasibility or social equity.

⁹ Taherdoost, H. & Madanchian, M.A. *Comprehensive Survey and Literature Review on TOPSIS*. International Journal of Service, Science, Management, Engineering, and Technology (IJSSMET); 2024, 15(1), pp. 1-65, <https://www.igi-global.com/article/a-comprehensive-survey-and-literature-review-on-topsis/347947>

¹⁰ Kedar, M. & Wilfreid, Z. *Optimizing Agri-PV Systematic Methodology to Assess Key Design Parameters*. Energies, MDPI; 2025, 18(14), p. 3877, <https://www.mdpi.com/1996-1073/18/14/3877>





4

SUMMARY OF GLOBAL MEASURES AND POLICIES FOR AGRI PV



Agri PV has evolved from niche experiments to an emerging pillar of land-use innovation globally. The practice of co-locating farming and solar generation, once marginal, is now gaining traction across multiple continents – offering solutions to land-use competition, farm income diversification, and renewable energy targets – and is increasingly backed by peer-reviewed research, standardised monitoring. The following section explores how Agri PV is unfolding across different countries, highlighting the institutional mechanisms and policy support measures adopted.

4.1 United States of America



Flagship Programme

- (USDA) Rural Energy for America Program (REAP).¹¹



Layered Benefits

Federal and state-level programmes offer the following support:

- Grants (up to 50% of the project cost) and loan guarantees to farmers and small businesses.
- Investment Tax Credits (ITC) covering 30% of installation costs till 2032 and additional benefits for domestic manufacturing, installations in low-income or tribal lands, etc.¹²
- Consumers can layer ITC over REAP benefits making it financially viable in comparison to ground-mounted utility solar.¹³
- U.S. Department of Energy (DOE) through its 2018 Dual-Use Solar Tariff Adder under Massachusetts's SMART (Solar Massachusetts Renewable Target) programme¹⁴ provided a base compensation rate for solar projects and 'additional tariffs' for meeting certain criteria like energy storage, low-income energy access, and dual land-use agricultural integration.¹⁵
- State-government-backed demonstration sites and state legislations to support Agri PV pilots and grants with some pilots promoting a local community solar model through Agri PV systems.¹⁶
- States like Massachusetts (UMass Clean Energy Extension) have navigated complex permitting rules effectively for Agri PV projects.
- *Pre-application agronomic review*: Specialists check whether the proposed Agri PV site maintains soil health, crop productivity, and conforms to agricultural best practices.
 - » *Mitigating legal uncertainty*: Draft legal text for towns to adopt in zoning bylaws, reducing local confusion about whether Agri PV is an energy or an agricultural activity.
 - » *Standardised documentation*: Lease and grazing contracts are standardised to help farmers avoid predatory leases and to ensure compatibility between solar generation and crop production/grazing¹⁷ - lowering transaction costs and time.
 - » *Clear guidelines around tax assessment rules*¹⁸: Dual Land-use projects can retain agricultural assessment if farming is continued under the solar modules.



-
- 11 USDA (2024), Rural Energy for America Program (REAP) – Renewable energy systems and energy efficiency improvement guaranteed loans and grants, Federal Register, 89 (61), p. 21410-21420, <https://www.rd.usda.gov/programs-services/energy-programs/rural-energy-america-program-renewable-energy-systems-energy-efficiency-improvement-guaranteed-loans>
- 12 U.S. Department of Energy (2022), Federal solar tax credits for business, https://www.energy.gov/sites/default/files/2024-02/508%20Federal%20Solar%20Tax%20Credits%20for%20Businesses_Feb24.pdf
- 13 PV Magazine USA (2025), Third-generation farmers harvest tax credits from 590 kW agrivoltaic installation, <https://pv-magazine-usa.com/2025/07/31/third-generation-farmers-harvest-tax-credits-from-590-kw-agrivoltaic-installation/#:-:text=pv%20magazine%20USA-,Third%2Dgeneration%20farmers%20harvest%20tax%20credits%20from%20590%20kW%20agrivoltaic,solar%20energy%20with%20minimal%20investment>
- 14 Commonwealth of Massachusetts, Executive Office of Energy and Environmental Affairs, Department of Energy Resources (2018), Guideline regarding the definition of Agricultural Solar Tariff Generation Units (Solar Massachusetts Renewable Target) Program, <https://www.mass.gov/doc/guideline-regarding-the-definition-of-agricultural-solar-tariff-generation/download>
- 15 UMass Clean Energy Extension (2024), Dual-Use: Agriculture and Solar Photovoltaics, <https://www.umass.edu/agriculture-food-environment/clean-energy/fact-sheets/dual-use-agriculture-solar-photovoltaics>
- 16 PV Magazine USA (2022), Community solar collective to deploy 500 MW of projects on farmland, <https://pv-magazine-usa.com/2023/05/22/community-solar-collective-to-deploy-500-mw-of-projects-on-farmland/>
- 17 Commonwealth of Massachusetts, Department of Energy Resources (2020) Massachusetts Model Zoning Bylaw for the Regulation of Solar Energy Systems, <https://www.energy.gov/eere/solar/articles/massachusetts-model-zoning-bylaw-regulation-solar-energy-systems>
- 18 Klavens Law Group (2022), MA Clean Energy Act eases path for agrivoltaic projects, <https://klavenslawgroup.com/ma-clean-energy-act-eases-path-for-agrivoltaic-projects/>

- **Power Offtake Strategy:** Power sales depend on state-level policy and regional wholesale markets. In some cases,¹⁹ farmers pooled Agri PV projects into co-operative-led model where subscribers (local households, businesses) buy shares of output. Farmers pooled and formed a single legal entity (co-operative or LLC), where:
 - » Local households, small businesses, food processors, schools, and municipalities subscribe by purchasing shares (often kW blocks) of the project.
 - » Shareholders receive bill credits on their utility bills proportional to their share.
 - » The utility acts as the billing platform.



Supportive Policy Measures

USDA's National Institute for Food and Agriculture (NIFA) under the project Sustainably Co-locating Agricultural and Photovoltaic Electricity Systems (SCAPES)²⁰ built scientific and socio-economic evidence²¹ through:

- Operationalising multi-institutional, multi-million and multi-year public research grants, for setting up regionally diverse experiments overcoming *single-site syndrome*.
- Collaboration with plant physiologists and economists to measure farmer profitability and ecosystem services.
- Allocating dedicated research budget for Agri PV signaling priority at the federal-level

Further, the Department through its project SCAPES built regionally relevant evidence through modelling and economics by:

- Adopting standardised, multi-layered measurement protocols (Greg Barron-Gafford-style metrics²²) across multiple sites to measure plant physiology, microclimate, soil moisture, and yield datasets which is far more persuasive than relying on ad hoc trials. Standardisation of such metrics enables meaningful comparisons across diverse environments – from arid Arizona desert sites comparable to humid Midwest and Northeastern U.S. – thereby strengthening the scientific credibility, transferability and policy relevance of Agri PV performance data.
- Generating longitudinal datasets across different agro-climates to generate crop suitability maps (considering shade-tolerance, irrigation requirement and local climate).
- Providing extensive guidance to stakeholders and identifying practical constraints through public outreach programmes and stakeholder engagement.
- Generating farm-level cost-benefit models (crop yield vs. kWh tradeoffs, irrigation savings, etc.) and business models for farmers, co-operatives, and developers.

19 Minnesota Cooperative Model (developed by BlueWave Solar) – a co-operative based Agri PV project – Ross, B. (2023), Innovative project shows how solar power benefits extend to sustainable farming, Better Energy, <https://betterenergy.org/blog/innovative-project-shows-how-solar-power-benefits-extend-to-sustainable-farming/>, Casey, T. (2024), The killer combo of agrivoltaics and community solar is coming for your fossil fuels, CleanTechnica, <https://cleantechnica.com/2024/08/23/the-killer-combo-of-agrivoltaics-community-solar-is-coming-for-your-fossil-fuels/>

20 U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA) (2021), Sustainably co-locating agricultural and photovoltaic electricity systems (SCAPES), <https://www.nifa.usda.gov/about-nifa/blogs/agrivoltaics-could-bring-agriculture-renewable-energy-together>

21 USDA NIFA (2023), Agrivoltaics could bring agriculture and renewable energy together, <https://www.nifa.usda.gov/about-nifa/blogs/agrivoltaics-could-bring-agriculture-renewable-energy-together#:~:text=Agrivoltaics%20Could%20Bring%20Agriculture%20and%20Renewable%20Energy%20Together,-June%2030%2C%202023&text=Renewable%20energy%20production%20is%20growing,abundant%20and%20for%20easily%20distributed.>

22 Agri photovoltaic field trials conducted by University of Arizona were the earliest and set the baseline for the projects that followed to measure dual benefits of agriculture under PV, for example: microclimate monitoring, crop yield, plant physiology, phenology, panel output (kWh), panel surface temperatures, soil health metrics (organic carbon, microbial activity, etc.), labour hours, water savings, etc. through low-cost, replicable sensor setups (for example, soil moisture probes, shade-tolerant data loggers, IR thermometers, etc.)

Through DOE's Innovative Solar Practices Integrated with Rural Economies (InSPIRE)²³, scientific data and decision support tools (GIS siting layers, PV and crop yield modelling) have been made available for lenders, utilities and policymakers. Further, the test beds built across the country helped provide engineering, siting, and deployment guidance for developers.



Outcome of the Measures

- USDA's REAP acted as a key policy anchor, signaling federal commitment to rural energy access and positing Agri PV as a viable technology offering for scaling.
- REAP lowered the barriers for adoption by enabling access to financial incentives for farmers, cooperatives and small businesses.
- SCAPES and InSPIRE provided scientific and technical foundation that de-risks Agri PV.
- Data from test beds and standardised protocols informed replicable approaches for crop selection, site planning, and stakeholder engagement, creating a roadmap for wider deployment.

Through robust evidence, Agri PV gained broader acceptance among farmers, cooperatives, and investors.

4.2 Germany



Flagship Programme

Federal Ministry of Agriculture, Food and Regional Identity (BMLEH)'s **Agri Solar** Program and German Federal Ministry of Education and Research (BMBF)'s **FONA (Research for Sustainability) Program (APV RESOLA)**²⁴



Layered Benefits

- Federal programmes such as Agri Solar Program (BMLEH) provide innovation and demonstration funding in the form of grants covering up to 50% of the project costs and concessional loans to farmers and small businesses
- The APV-RESOLA (Resource Efficient Land Use)²⁵ programme, funded by BMBF, tested and optimised dual use of land for agriculture and solar power generation. An innovation group led by Fraunhofer ISE involving private sector, academia, and research-built pilot systems that showed results – land use efficiency gains up to 160%, that were promising especially during hot dry summers
- In addition to the grants, low-interest loans (KfW Renewable Energy loans)²⁶ up to €50 million per project are provided for Agri PV projects with favorable terms (e.g., multi-year repayment-free start at competitive rates i.e., 2-4%)

23 National Renewable Energy Laboratory (NREL) (2021), Innovative solar practices integrated with rural economies and ecosystems (InSPIRE), <https://openei.org/wiki/InSPIRE>

24 Federal Ministry of Education and Research (2015-2020), Agrophotovoltaics – Resource Efficient Land Use (APV-RESOLA), BMBF FONA, <https://www.ise.fraunhofer.de/en/research-projects/apv-resola.html>

25 Deutsches Institut für Normung (2021), DIN SPEC 91434:2021-05, Agri-photovoltaic systems – Requirements for primary agricultural use, <https://www.dinmedia.de/en/technical-rule/din-spec-91434/337886742>

26 Clean Energy for EU Islands, Loan (KfW Renewable Energy Standard) – Repayment terms, <https://clean-energy-islands.ec.europa.eu/countries/germany/legal/electricity-support/loan-kfw-renewable-energy-standard>

- Further, Rentebank (Germany's agricultural development bank) provides low-interest loans and state government guarantees for Agri PV projects that follow Fraunhofer's due diligence framework²⁷



Supportive Policy Measures

- Fraunhofer ISE (Institute for Solar Energy System), a public research institution leads and coordinates several Agri PV research initiatives that are technically feasible and compatible with agricultural productivity and ecological sustainability. It has been executing innovative project trials such as:
 - » High-elevation Agri PV.
 - » Vertical installations.
 - » VackerPower, a research programme evaluating dual land-use systems on arable lands, quantifying energy production alongside crop yield, soil health, and micro-climate effects.
- Further, standardised technical specifications for Agri PV were developed and adopted (DIN SPEC 19434)²⁸ that:
 - » Established planning, operation, and measurement indicators (light, distribution, minimum photosynthetic active radiation (PAR) under panels, documentation and test methods) to demonstrate that agricultural use remains primary.
 - » Required documentation of agricultural activity (crop rotation, grazing records, irrigation patterns) to prevent reclassification of 'industrial solar-use'.
 - » Provided a common due diligence framework, combining agronomic, technical and economic assessment.
- Assessment services provided by Fraunhofer ISE partners and eminent labs offered modelling tools (yield, microclimate) for monitoring and impact measurement mitigating the perceived risks for Agri PV projects and standardize O&M expectations.
- Rules²⁹ governing the Renewable Energy Sources Act (EEG 2023) were amended to treat Agri PV as a special plant and not as conventional ground mounted PV. This was achieved by listing Agri PV projects under 'Innovation tenders'³⁰ by which, projects winning the auctions receive higher tariffs than conventional ground mounted PV and, in some cases³¹, premium payments (1.2-euro cent per kWh with phased reductions in later years) above the regular feed-in-tariff, because of added agricultural and ecological value. During 2023-2026, 200 MW/year of Agri PV capacity has been reserved for innovation tenders.
- DIN SPEC 91434 provides legal clarity on agricultural status of the land. The standards establish a 'main-use' test to determine whether land under Agri PV installations can retain its agricultural classification for the purposes of taxation, eligibility under the EU Common Agricultural Policy (CAP) direct payments, and access to national agricultural support schemes. The parameters considered under this test include:

27 Landwirtschaftliche Rentebank (2024), <https://www.rentenbank.de/en/press/Rentenbank-plans-funding-volume-of-approx.-EUR-10-billion-in-2025/>

28 Deutsches Institut für Normung (2021), DIN SPEC 91434:2021-05, Agri-photovoltaic systems Requirements for primary agricultural use, <https://www.dinmedia.de/en/technical-rule/din-spec-91434/337886742>

29 Federal Ministry for Economic Affairs and Climate Action (2022), Renewable Energy Sources Act (EEG, 2023), §85c: Special photovoltaic installations https://www.gesetze-im-internet.de/eeg_2014/BjNRI06610014.html

30 Juniper, E. (2023), EEG 2023 introduces support for agrivoltaic systems through innovation tenders, <https://ratedpower.com/blog/eeg-2023-solar-market/>

31 Trommsdorff, M., & Vollprecht, J. Current legal framework for agrivoltaics in Germany. 2023 <https://solar-media.s3.amazonaws.com/assets/Pubs/PVTP%2034/Current%20legal%20framework%20for%20agrivoltaics%20in%20Germany.pdf>

- » If $\geq 66\%$ of the reference crop yield is maintained, the land is considered to be primarily used for agriculture.³²
- » The percentage of area lost to PV structures must not exceed 10–15% range.³³
- » Crop yield, soil moisture, and microclimate data must be recorded for at least 1–2 growing seasons and submitted to local authorities for assessment.³⁴
- » Each installation must also adhere to a ground coverage ratio (GCR) of 20–25%³⁵ depending on the system configuration (overhead, interspace, or vertical)
- » Retention of agricultural classification allow faster approval for small-scale Agri PV (project area <2–2.5 ha.).³⁶
- As a power offtake strategy, citizen energy cooperatives³⁷ were formed after the enactment of EEG 2023 that let farmers and citizens jointly own projects, with local households, businesses as off-takers (for example, in Bavaria, farmer-led co-operatives built vertical Agri PV with apples and berries, financed partly by citizens buying shares, subscribers get dividends and green power at fixed prices).³⁸



Outcome of the Measures

- Concessional finance (i.e. long cost long-tenure debt) with favorable terms including multi-year repayment free-start offered at competitive rates improves debt serviceability and bankability for developer/farmer business models.
- Further, data collected from pilot projects across diverse agricultural settings, including vineyards, orchards, arable lands and pastures was made accessible to various stakeholders, including financial institutions, policymakers, and researchers. This exercise reduced perceived risks associated with investments and facilitated informed decision-making.

4.3 Japan



Flagship Programme

Ministry of Agriculture, Forestry and Fisheries (MAFF)'s Solar Sharing Policy Framework and Green Growth Strategy for 2050 Carbon Neutral references Agri PV as part of the agriculture–energy playbook.³⁹ MAFF Basic Plan for Food, Agriculture, and Rural Areas⁴⁰ recommends Agri PV where agricultural land and power generation can co-exist. Further, Japan utilised 'solar sharing' concept for reviving its abandoned agricultural lands and to tackle the ageing agricultural workforce.⁴¹



32 Section 5.2: Main-Use Test for Agricultural Status (DIN SPEC 91434) (2021)

33 Section 5.3: Main-Use Test for Agricultural Status (DIN SPEC 91434) (2021)

34 Section 6.1: Monitoring and Data Reporting (DIN SPEC 91434) (2021)

35 Section 5: Agricultural Performance and Site Design Criteria (DIN SPEC 91434) (2021)

36 Section 7.2: Retention of Agricultural Classification and Simplified Approval for Small-Scale Systems (DIN SPEC 91434) (2021)

37 Bürgerenergie Bayern e.V. About Bürgerenergie Bayern/member cooperatives, <https://buengerenergie.bayern/>

38 Bayern Innovativ (2024), Arable farming and green electricity, <https://www.bayern-innovativ.de/en/emagazine/detail/en/page/arable-farming-and-green-electricity>

39 Cabinet Secretariat (2021), Green Growth Strategy Through Achieving Carbon Neutrality in 2050, https://www.japan.go.jp/kizuna/_userdata/pdf/2021/autumn2021/green_growth_strategy.pdf

40 MAFF (2020), Basic Plan for Food, Agriculture and Rural Areas, https://www.maff.go.jp/e//policies/law_plan/index.html

41 Renewable Energy Institute (2025), Revitalizing Agriculture with Solar Sharing – PV Contributing to Local Prosperity, <https://www.renewable-ei.org/en/activities/reports/20250618.php>



Layered Benefits

- The Japanese government introduced ‘solar sharing’ as a concept in 2004 with demountable structures for dual land-use which later in 2013 led to conditional approval of Agri PV on all farmland categories⁴², which provided:
 - » Partial land-use conversion must be reversible.⁴³
 - » Agricultural practice must continue at a decent level.
 - » Annual reporting to local agricultural commissions is required.
- Power Offtake Measures: Japan introduced 20-year FiT (Feed-in-Tariff) that made farmer and developer-owned solar sharing bankable.
- In 2022, the introduction of FiP.⁴⁴ (Feed-in-Premium) added a premium on the market price for power. Developers combined FiP with corporate PPAs (on-site or self-consumption models) to manage price risk.⁴⁵
- Ministry of Economy, Trade, and Industry (METI) continues annual procurement price/surcharge settings under FiT and FiP, keeping revenue frameworks predictable even as projects migrate to non-FiT routes.⁴⁶



Supportive Policy Measures

In 2018, the initial 3-year permit duration was extended to 10-years for farmer-owned land or for a low-quality farmland⁴⁷. In 2021, the 2 meter minimum height for vertical Agri PV systems was waived⁴³ and the 80% reference yield rule was relaxed for cultivation on devastated lands (focus shifted on proof of cultivation over yield threshold) which streamlined land-use conversion of devastated lands⁴⁸, easing approvals at local agricultural committees.⁴⁹

- 2021 MAFF directive gave a major boost to the sector by providing:
 - » Exemption from temporary conversion permits since the land is classified as ‘underutilised’.
 - » Local agricultural committees could approve Agri PV with less scrutiny if the applicant shows minimal proof of cultivation.
- To demonstrate ongoing agricultural activity, project owners are required to submit an annual proof-of-cultivation to the local agricultural committee – the authority responsible for reviewing Agri PV applications and approving temporary land-use conversions. The report must include photographic evidence of crop growth, along with a diagram or map identifying the cultivated

42 Tajima, M., Iida, T., (2021) Evolution of agrivoltaic farms in Japan, American Institute of Physics Inc.

43 Doedt, S., Staake, C., et. al. *Agrivoltaics in Japan: A Legal Framework Analysis*, AgriVoltaics Conference Proceedings; 2022 – Originally, Agri PV structures had to be at least 2 m above the ground to avoid shading on crops and allow machinery access. Since Japan is typhoon-prone and tall structures are more vulnerable to storm damage, this rule was waived, further, orchards, vineyards, etc. don't need overhead clearance – opening doors for vertical agrivoltaics and row-based PV strips

44 As FiT Prices fell, FiP was introduced in 2022, where developers instead of selling at fixed FiT, sell their power in wholesale electricity market (JPEx) at market price, but get an extra premium on top of the market price per kWh. Buyer pays the market price while the government pays the FiP premium (retail electricity companies collect this money from consumers and businesses in their utility bills as ‘renewable energy surcharge’)

45 Ministry of Economy, Trade and Industry (METI) (2022), Renewable Energy Purchase Prices, Surcharge Rate, and Other Details related to FiT and FiP Schemes from FY2022 Onward to be Determined, https://www.meti.go.jp/english/press/2022/0325_004.html

46 METI (2025), https://www.meti.go.jp/english/press/2025/0321_001.html

47 Ministry of Agriculture, Forestry and Fisheries (MAFF) (2023)

48 Devastated land refers to abandoned, degraded, or underutilized farmland that is no longer productively cultivated, often because of soil erosion, depopulation, aging farmers, or past natural disasters (typhoons, tsunamis, earthquakes). Since Japan has severe farmland scarcity, MAFF prioritizes re-activating devastated land rather than let it sit die.

49 Earth Com Inc. (2021) Detailed application procedure for solar sharing: including agricultural operation plan, <https://earthcom-eco.jp/column/investment/solarsharing-application-procedure>

and harvested areas under the PV installation. These policy reporting duties ensure that the farm remains classified as bona fide agricultural land, maintaining its eligibility for agricultural status and related benefits.



Outcome of the Measures

- The 2021 MAFF directive lowered the compliance risk for farmers by relaxing the reference yield rule to 80%.
- Introduction of FiT de-risked early cashflows while FiP and corporate PPAs created new farmer co-operative models once FiT prices fell.

4.4 France



Flagship Programme

- APER Law⁵⁰ (Law on the Acceleration of Production of Renewable Energies) and April 2024 Decree.⁵¹
- APER Law aligns with France's Solar Pact 2030 and other national climate strategies.
- Formation of National Agrivoltaics Association⁵² brings together energy, agri-food, finance, insurance, and academia together and works on training, certification, advocacy, shaping policy and regulation.
- A private sector initiative called 'Cultivons Demain' launched in 2020⁵³ was set up with a goal to equip 300 farms with dynamic Agri PV systems by 2025. This in line with France's renewable energy and farm resilience goals.



Layered Benefits

- APER Law increase the space between this line and the heading agrivoltaics in the French Energy Code⁵⁴ as installations that must deliver at least one of the four agricultural services:
 - » Agronomic enhancement.
 - » Climate adaptation.
 - » Hazard protection, or
 - » Animal welfare – while preserving sustainable agricultural production.
- Energy Regulatory Commission (CRE) calls for "Innovative PV" projects. In 2020, of 31 selected projects, 72% were Agri PV projects⁵⁵ and such measures drive early market-scale deployment

50 Law No. 2023-175 of March 2023 concerning the acceleration of the production of renewable energies, Official Journal of Republic of France, <https://www.legifrance.gouv.fr/jorf/id/JORFSCATA000047294305>

51 Pinsent Masons (2024), Rising opportunities for agrivoltaic energy projects under France's regulatory strategy, <https://www.pinsentmasons.com/out-law/analysis/rising-opportunities-agrivoltaic-energy-projects-under-regulatory-strategy>

52 PV Magazine International (2021), French PV companies set up agrivoltaics association, <https://www.pv-magazine.com/2021/06/10/frenchpv-companies-set-up-agrivoltaics-association/>

53 Sun'Agri (2020), <https://sunagri.fr/en/la-commission-de-regulation-de-lenergie-confirme-la-montee-en-regime-de-lagrivoltaisme-et-recompense-22-projets-utilisant-la-technologie-de-sunagri/>

54 Article L314-36 inserted by Article 54 of the APER Law, 2023

55 Renewable Market Watch (2020), The French Energy Regulatory Commission (CRE) Awards 22 Agro Photovoltaic (Agrivoltaic) Projects Using Technology of Sun'Agri, <https://renewablemarketwatch.com/blog/the-french-energy-regulatory-commission-cre-awards-22-agro-photovoltaic-agrivoltaic-projects-using-technology-of-sun-agri/>



Supportive Policy Measures

- APER Law 2023 and April 2024 Decree set a maximum PV ground coverage of 40%, with limited exceptions for small or experimental projects. Agricultural yields must remain at least 90% of local reference yield and the loss of exploitable land cannot exceed 10%. Compliance is verified through pre-commissioning inspections, a six-year post-installation review, and regular audits every 3-5 years for proven technologies. Non-compliance may result in contract termination or dismantling of the installation.⁵⁶
- Land idle for more than 10 years would be designated for traditional (non-Agrivoltaic) while Agri PV remain the default framework for productive farmland.⁵⁷
- In 2022, AFNOR (organisation responsible for developing, publishing and promoting standards across industries) introduced high-standard voluntary labelling scheme for Agri PV projects. This label ensures that projects prioritise agricultural use, adhere to maximum PV ground coverage and minimum crop yield requirements, and avoid farmland for non-agricultural purposes, thereby promoting sustainable dual land use.
- Industry-Research partnerships (Lightsource bp & National Research Institute for Agriculture, Food and Environment (INRAE) have advanced research and innovation in Agri PV⁵⁸ by:
 - » Developing data-driven agronomic insights: Fontenet pilot site (Charente-Maritime, BayWa r.e. (a renewable energy developer))⁵⁹ showed drop in soil temperature, increase in soil moisture and produce forage that was rich in nitrogen and minerals, thereby improving its digestibility.⁶⁰
 - » Multi-regional validation: Research spans across multiple climatic zones (Mediterranean Southwest, Burgundy, Dordogne) confirming consistent microclimate benefits in diverse settings.^{61, 62}
 - » PNR Agri PV platform⁶³ hosts 45 projects supported by 66 industry partners.
- Agronomic monitoring in Agri PV systems involve comprehensive, multi-level observation to evaluate crop performance under solar installations. Sun'Agri's dynamic monitoring approach uses a reference plot grown adjacent to the Agri PV system to track crop development stages, vegetative growth, water and temperature stress, sunlight exposure, and harvest performance.
- Similarly, Total Solar Energy (TSE's) demonstration trials operate pilot sites of over 70 ha., observed for periods ranging from three to nine years under a consistent testing protocol that compares Agri PV plots with control plots to assess impacts on crop yield, quality, climate resilience, varietal behavior, and rotational practices.

56 PV Magazine (2024), France issues new rules for agrivoltaics, <https://www.pv-magazine.com/2024/04/09/france-issues-new-rules-for-agrivoltaics/>

57 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>

58 Lightsource bp (2023), Lightsource bp joins forces to progress AgriPV Research, Innovation and Learning, <https://lightsourcebp.com/news/france-lightsource-bp-joins-forces-with-inrae-to-progress-agripv-research-innovation-and-learning/>

59 UsineNouvelle (2025), BayWa re supports research on agrivoltaics, <https://www.usinenouvelle.com/article/baywa-r-e-aide-la-recherche-sur-l-agrivoltaisme.N2228305>

60 PV Magazine International (2024), New agrivoltaics data shows improved grass, forage production under solar panels, <https://www.pv-magazine.com/2024/06/28/new-agrivoltaics-data-shows-improved-grass-forage-production-under-solar-panels/>

61 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>

62 Renewable Market Watch (2020), The French Energy Regulatory Commission (CRE) Awards 22 Agro Photovoltaic (Agrivoltaic) Projects Using Technology of Sun'Agri, <https://renewablemarketwatch.com/blog/the-french-energy-regulatory-commission-cre-awards-22-agro-photovoltaic-agrivoltaic-projects-using-technology-of-sun-agri/>

63 PNR Agri PV Platform, <https://pnr.agripv.inrae.fr/bibliographie>

- Complimenting these efforts, INRAE, along with IRESTA (an agricultural research and experimentation institute) and BayWa.re., conducts scientific monitoring using advanced sensors measuring radiation, humidity, soil moisture, and temperature, with real-time data feeding into models designed to optimise shading controls according to plant water and light requirements.
- Further, farmer organisations (both public and private) created charters⁶⁴ that developers must respect and adhere to if they want local participation and endorsement with the following principles:⁶⁵
 - » Agricultural primacy: Energy production cannot displace food/fiber production and solar must be a means to strengthen agriculture, not replace it.
 - » Crop specificity: Each department within the organisation defined ‘acceptable’ crop types and farming models (for example, viticulture in Vaucluse, cereals in Drome, etc.) and Agrivoltaic design (height, space, tracking) must suit the local agronomic realities.
 - » Compatibility tests: Projects must demonstrate (with trials or data) that yields; soil quality and biodiversity will be preserved or enhanced.
 - » Farmer participation: Priority will be given to projects led by or co-owned with local farmers and that lease contracts must ensure fair rent.
 - » Reversibility clauses: Developers must commit to dismantling PV infrastructure at the end of project life and restore farmland condition.
- Agricultural Union Doctrine (2022), a joint doctrine⁶⁶ issued by large farmer co-operatives⁶⁷ reframes Agri PV as a social contract – where energy developers are required to strengthen livelihoods of farmers, not merely rent land and include the following provisions:
 - » Projects must prove that they increase resilience or competitiveness of the farm (for example, shading vineyards from heat stress, reducing irrigation needs) and denied energy-only projects where panels dominate land-use (for example: height adjustable panels reduce environmental stress and climate risk while preserving crop productivity. This improves agricultural income, revenue streams and livelihoods amidst climate stress⁶⁸).
 - » Require transparent contracts where farmers capture a fair share of revenues (not token rents) and needs models like joint ventures, co-operatives, or minimum rent tied to energy output.
 - » Must secure continuity of farms, for example, rental contracts cannot displace heirs or force sales and that income streams should support young farmers.
 - » Land must remain classified as agricultural and farmers would have a veto power in project design and would stand against the developer deals that bypass rural stakeholders.
 - » Include remuneration for farmers that are tied to project turnover instead of a fixed land lease rent so that a farmer can earn base rent (safeguard) and a percentage of electricity sale (to

64 Direction Departementale des Territoires d’Indre-et-Loire (2021), https://www.indre-et-loire.gouv.fr/content/download/32154/207021/file/DDT37-SUDT-document%20cadredeveloppement%20photovoltaique_V20211020.pdf

65 TSE (2024), Expert Breakdown of Agricultural Safeguards in the Agrivoltaic Decree, <https://www.tse.energy/en/articles/agrivoltaisme-mathieu-debonnet-president-tse-decrypte-le-decret?>

66 Federation Nationale des Syndicats d’Exploitants Agricoles, Assemblée Permanente des Chambres d’Agriculture, & Jeunes Agriculteurs (2022), https://www.jeunes-agriculteurs.fr/wp-content/uploads/2022/11/doctrine_agripv_fnsea_apca_ja.pdf

67 EnergyNews.pro: Terr’abouts Project Highlights Local Framework Application (2024), <https://energynews.pro/en/france-authorization-for-a-450-mwp-agrivoltaic-project-in-the-landes-region-of-france/>

68 Federation Nationale des Syndicats d’Exploitants Agricoles, Assemblée Permanente des Chambres d’Agriculture, & Jeunes Agriculteurs (2022), https://www.jeunes-agriculteurs.fr/wp-content/uploads/2022/11/doctrine_agripv_fnsea_apca_ja.pdf

ensure that the farmer benefits when electricity prices are high and a minimum guaranteed income when prices fall).

- Such provisions ensure that farmers benefit from a share of solar revenues through contractual participation clauses avoiding the need for upfront investment or equity ownership while minimising financial and administrative burdens when working with corporate partners.



Outcome of the Measures

- Reversibility audits under APER 2023 and 2024 Decree ensure that Agri PV installations can be dismantled and soil can be fully restored, preserving the long-term viability of the land for farming.
- CRE, by selecting Agri PV Project as Innovative PV solution directly incentivised investments in projects, giving them visibility, financial support (through preferential tariffs, or regulatory approval), and a path to grid connection. This lowers barriers for early adopters, encourages more developers to enter the market, and allows practical demonstration of the technology.
- AFNOR labelling in addition to existing legal checks, offer assurance to farmers, local authorities, and investors, creating a benchmark for high-quality Agri PV projects, providing assurance installations meet agronomic, environmental, and land-use criteria. This improves investor and public confidence, streamlines permitting, and reinforces the principle of agriculture-first.
- Collaborative programmes between Lightsource bp, INRAE and BayWa r.e., and IRESTA have generated data-driven insights validating Agri PV performance across climatic zones.
- Localised, crop-specific project design with regional customisation (linking panel height, spacing and tracking systems adjust to crop types) have ensured agronomic compatibility and community acceptance. Developer compliance with farmer charters have become a prerequisite for local endorsement, ensuring social license and responsible land stewardship

4.4 China



Flagship Programme

- National Energy Administration (NEA)'s Photovoltaic Poverty Alleviation (PVPA)⁶⁹: Government tied PV deployment to rural income generation and poverty reduction. This political framing unlocked huge capital and administrative support, labelling Agri PV as 'PV Plus' Projects.
- China channeled surplus PV production capacity during 2019-2022 into politically and socially useful projects and innovative solar applications.
- On the other hand, massive domestic PV industry and R&D on glasshouse PV, dynamic shading, mounting structures, etc. allowed rapid cost declines and many localised engineering solutions.



Layered Benefits

- During 2019-22, China accomplished an inter-ministerial collaboration to promote integrated PV and the Ministries jointly issued guidelines/action plans to promote dual land-use models

⁶⁹ State Council Information Office of the People's Republic of China (2021), Solar power dawns light of prosperity in China's impoverished areas, https://english.www.gov.cn/news/topnews/202104/07/content_WS606d0179c6d0719374afc22d.html

alongside other interventions.⁷⁰

- Local governments offered land access, streamlined permitting, and grid connections in exchange for developers integrating ‘poverty alleviation’ or ‘rural revitalisation’ components (such as farm lease payments or cooperative jobs).
- PVPA Programme and subsequent provincial programmes combined subsidies, concessional financing, developer-led leasing so that farmers received direct cash flows (in the form of lease, shares or cooperative arrangements).⁷¹



Supportive Policy Measures

- Business models under PVPA programme included⁷²:
 - » Developer builds and pays village/farmer lease amount.
 - » Village/cooperative ownership or joint ventures.
 - » State or State-Owned Enterprise (SOE)-led projects integrated horizontally across generation, grid connection and revenue distribution.
- *Power Offtake Strategy*: China has encouraged enterprises to self-consume the energy thereby enabling local offtake (industrial parks, processing plants, and local grids) to use PV power directly – catering local demand rather than export.
- While the initial phase of roll-out demonstrated the potential of agrivoltaics, central government brought out more structured guidelines to prevent overuse of high-quality cropland for PV installations and directing efforts towards degraded or marginal lands. These limitations, include:⁷³
 - » Prohibiting PV projects on high-quality arable land, forested areas, and grasslands to protect essential agricultural resources and maintain food security.⁷⁴
 - » Ensuring that projects continue agricultural activity in their respective plots and enforcing fines/project shutdown orders for that violate land-use regulations.



Outcome of the Measures

- Financing of Agri PV in China combined government subsidies, developer-led leasing models, and concessional finance that ultimately reduced farmer up-front costs and created local buy-in. PVPA programme raised farmer incomes and reduced intra-village inequality where it was implemented.
- State-led demonstration (SOE) supported large demonstrations including fishery PV, greenhouse PV clusters, etc.⁷⁵ This helped in proving technical feasibility of combining PV with farming, aquaculture, or greenhouse cultivation and built confidence among provincial governments and private firms.⁷⁶

70 State Council of the People's Republic of China (2021), Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035, https://www.gov.cn/xinwen/2021-03/13/content_5592681.htm

71 H, Xiao, F, Song, X, Zheng, & J, Chen., Community-based energy revolution: An evaluation of China's photovoltaic poverty alleviation Program's economic and social benefits, *Energy Policy*; 2023, Vol. 177, <http://ae.ruc.edu.cn/docs/2023-05/06cfed579652429f9a5f9952bcb3579f.pdf>

72 S, Xu, Q, Zhang, LYang, (2024), Policy evaluation and optimization for photovoltaic poverty alleviation projects in Anhui Province of China, *PMC Sci. Rep.*, <https://pmc.ncbi.nlm.nih.gov/articles/PMC11436965/>

73 Wall Street Journal (2023), Chinese solar farms are crowding out much needed crops, <https://www.wsj.com/world/china/china-solar-power-farms-food-security-fb104751>

74 B, Tan. et. al., Chinese adapting land policy is guiding “photovoltaic plus” as a nature-based solution towards future, *Nature-Based Solutions*; 2024. Vol. 6, <https://www.sciencedirect.com/science/article/pii/S2772411524000922>

75 IEA PVPS (2021), National Survey Report of PV Power Applications in China

76 China Daily (2024), Agrivoltaics lights up rural revitalization efforts, <https://epaper.chinadaily.com.cn/a/202401/04/>

4.5 Italy



Flagship Programme

- Ministry for Environment and Energy Security's TU FER (Consolidated Law on Renewable Energy Sources) explicitly differentiated Agri PV from conventional ground-mounted PV⁷⁷ which streamlined authorisation procedures.
- Italy positions Agri PV as a strategic instrument for sustainable land use, energy transition, and for climate-resilient agriculture.



Layered Benefits

- Ambitious deployment targets have been set (1.04 GW by 2026) for Agri PV projects under the Agrivoltaic Incentive Decree (No. 436/2023) and eligible projects are said to receive up to 40% capital cost grants.
- Farmers with Agri PV can self-consume a portion of electricity generated for their own needs (farm machinery, irrigation systems, heating, etc.) where energy produced and self-consumed is exempt from grid fees, suffer less Value Added Tax (VAT), and accelerated depreciation for investments, aligning with the broader policy of energy independence through distributed energy generation.



Supportive Policy Measures

- TU FER streamlined authorisation procedures, provided they meet technical and environmental standards:⁷⁸
 - » *Free Agri PV installations*: For Agri PV plants below 5 MW, no specific permits or authorisations are required, unless the site falls under protected (landscape or environmental) areas. In such cases, a non-binding opinion is required and this must be issued within 30 days or is deemed granted by default:
 - PV panels must be at least 2m above the ground and supports must be easily removable
 - Agri PV must be installed by agricultural entrepreneurs or joint ventures between them and project developers, ensuring that farm operations remain under the agricultural party, while energy production and technical responsibilities are handled by the developer
 - » *Simplified Enabling Procedure (PAS)*: For Agri PV plants between 5-10 MW, the developer has to submit project documents on a digital platform (SUER) for approval and is tacitly granted if the authority doesn't object/respond within 30-75 days of application.
 - » *Single Authorization (AU)*: For larger or complex projects, all permits would be required including environmental impact assessment (EIA), landscape authorisation, etc. would be subjected to a lengthier process.

WS6596051aa310513d4e562338.html

77 Tedioli Studio Legale (2025), Advanced agrivoltaics in Italy: innovation, sustainability, and regulation for the future of rural energy, <https://www.tedioli.com/en/italy-advanced-agrivoltaics-innovation-regulation-sustainable-rural-energy/>

78 Rödl & Partner, Studio Legale Tedioli, & Michele Rizzo Law (2025), The Consolidated Law on Renewable Sources (TUFER) an important reform of the Italian Energy Sector, <https://www.roedl.com/insights/renewable-energy/2025/april/consolidated-law-renewable-sources-italy>

- » TU EFR will soon introduce 'acceleration zones'⁷⁹ – areas with priority for renewable energy siting (degraded land, unused sites) where:
 - Authorisation is faster
 - EIA may not be required
- » Landscape authority input is still sought but effectively non-binding. The Agrivoltaic Incentive Decree (No. 436/2023)⁸⁰ says that systems must include sensors and monitoring tools to track:
 - Soil fertility
 - Micro-climate conditions
 - Resilience to climate change
- PV must ensure genuine compatibility with ongoing agricultural activities – ensuring integration with irrigation systems, providing beneficial shading, and supporting suitable crop arrangements in accordance with the CREA-GSE guidelines⁸¹ (joint framework developed by the Council for Agricultural Research and Agricultural Economic Analysis and Energy Services Manager⁸²) that define national standards for Agri-energy coexistence and sustainable dual land-use:⁸³
 - » System must be designed to integrate agricultural activity and energy production spatially and technologically.
 - » Synergistic production of electricity and agricultural products without compromising on continuity of agricultural or pastoral activities.
 - » Adopt innovative integrated solutions such as elevated modules mounted above ground.
 - » Comprehensive monitoring systems must be in place to track:
 - Impact on cultivation.
 - Water savings.
 - Agricultural productivity for different crops.
 - Continuity of agricultural activity by the concerned farms.
 - Soil fertility recovery.
 - Micro-climate conditions.
 - Resilience to climate change.

79 Bio Solar (2025), Authorizations for Photovoltaic Systems on Agricultural Land: What's New in 2025, <https://www.biosolar.it/blog/autorizzazioni-impianto-fotovoltaico-terreno-agricolo?>

80 Ministry of the Environment and Energy Security (2023), Ministerial Decree No. 436, Criteria and procedures for incentivizing the development of agrivoltaic systems, Gazette of the Italian Republic, <https://www.lavoripubblici.it/normativa/20231222/Decreto-Ministero-dell-Ambiente-e-della-Sicurezza-Energetica-22-dicembre-2023-n-436-27323.html>

81 CREA stands for Council for Agricultural Research and Economics – premier agricultural research institution in Italy and GES is a state-owned Italian joint-stock company which incentivizes renewable energy generation and energy efficiency across the country

82 GSE maintains a registry for renewable energy communities, ensuring that both producers and consumers in the community can access and trade energy credits.

83 a) and b) define conditions to be met by a Free Agri PV system while a), b), c), and d) are mandatory guidelines to be qualify as an advanced Agri PV plant (eligible for GSE incentives) and all guidelines are to be met for accessing PNRR funding (Italy's National Recovery and Resilience Plan)

- Legislative decree 28/2011⁸⁴ governs renewable energy development in Italy, including permitting processes for PV plants. In 2023, clarifications to Article 6 of the Decree 28/2011 allowed advanced Agri PV systems of sizes greater than 10 MW to benefit from PAS (simplified enabling procedure, that is faster⁸⁵), provided those sites are located within 3 km of industrial or commercial zones.
- Campania region in Southern Italy approved the guidelines⁸⁶ (Litar) aimed to streamline permits and ensure that projects are environmentally and agriculturally sustainable.⁸⁷
 - » Significant portion of the Agri PV project land must be kept open for farming, ensuring agricultural productivity is maintained.
 - » Farming must remain viable on the land with yield not falling below 70% of the pre-installation agricultural productivity.
 - » Changes to local biodiversity, water usage, and soil conditions should be minimised.
- Power Offtake:
 - » Farmers involved in Agri PV projects are encouraged to enter into long-term PPAs with private companies or public entities (including major agricultural firms like Coca-Cola, Heineken), thereby creating a stable demand for electricity generated.⁸⁸
 - » Some regions allow direct power consumption by local industries or communities through PPAs.
 - » Sale of electricity as described above is facilitated either through PPAs or FiT, however, participation in carbon offset schemes and emission reduction trading are relevant in projects where Agri PV can help reduce substantial carbon emissions.



Outcome of the Measures

- Introduction of TU FER and related decrees simplified authorisation for Agri PV reducing administrative burdens and enabling faster deployment through PAS, making Agri-PV projects more bankable.
- CREA-GSE guidelines and regional frameworks ensured that agricultural compatibility is not breached.
- Decree No. 436/2023 encouraged adoption of advanced Agri PV systems.
- By allowing self-consumption of electricity, providing VAT relief and accelerated depreciation, Agri PV improved farm economics and reduced operational costs. Long-term PPAs with Agri-industrial buyers created stable revenue streams.
- Italy positioned Agri PV as a pillar of sustainable land management and decarbonisation, targeting 1.04 GW capacity by 2026 under the National Recovery and Resilience Plan. This dual-use approach mitigates land-use conflicts and demonstrates a replicable model for climate resilient agriculture integrated with renewable energy expansion.

84 Republic of Italy (2011), Legislative Decree No. 28 of 2011: Implementation of Directive 2009/28/EC on the promotion of the use of energy from renewable energy sources (amended in 2023), Official Gazette of the Italian Republic, <https://www.gazzettaufficiale.it>

85 Lengthy, single authorization process simplified for projects greater than 10 MW in areas which have fewer environmental and landscape restrictions

86 Regional guideline that aims to align with national framework for Agri PV systems, simplifying project approval process and ensuring uniformity across regions

87 Campania Region (2025), Technical-Agronomic Lines (Litar v.40) for agrivoltaic systems: Harmonizing authorization processes, maximizing agricultural productivity, and minimizing environmental impacts, <https://www.regione.campania.it/>

88 Smith, J. Agrivoltaics in Sicily: Power purchase agreements linking agriculture and industry for renewable energy generation, Renewable Energy Daily; 2024, <https://www.renewableenergydaily.com/agrivoltaics-sicily-ppas>

4.6 Australia

Flagship Programme

There are no comprehensive national regulations specific to Agri PV. However, there are guidance documents and reports from state government bodies and academia groups.



Layered Benefits

There are no comprehensive national regulations specific to Agri PV. However, there are guidance documents and reports from state government bodies and academia groups.

Supportive Policy Measures

Reports from New South Wales Agri PV Resource Centre recommends:

- Environmental Impact Statement (EIS) explicitly include co-location plans detailing how agricultural activities such as grazing and biodiversity management will be integrated with solar infrastructure.
- Conducting agricultural impact assessments to quantify potential gains or losses in productivity, soil health, and ecosystem services.
- Embedding agricultural systems thinking into project design to ensure that solar developments enhance, rather than displace, long-term agricultural viability.
- There are guidelines developed for community-based research organisations and private developers⁸⁹ around Agri PV for grazing and Agri PV for large-scale solar.⁹⁰
- Benefit Sharing Guidelines⁹¹ under the Renewable Energy Planning Framework in Australia were introduced to ensure equitable and sustainable distribution of benefits from large-scale renewable energy (can include large Agri PV projects) to local communities that host them.

Outcome of the Measures

Pilot projects and University-led studies have demonstrated that dual land-use approaches can support farm incomes, while contributing to clean energy goals. State-level research and private sector initiatives have led to the development of voluntary best-practice frameworks for Agri PV

89 Clean Energy Council (2023), Solar and Agriculture could be a perfect match, <https://cleanenergycouncil.org.au/news-resources/agrisolar>

90 EnergyCo & NSW Government (2025), Agrivoltaics Handbook, <https://www.energyco.nsw.gov.au/agrivoltaics-handbook>

91 Benefit-Sharing Guideline (2024), Department of Planning, Housing, and Infrastructure, Guidance for large-scale renewable energy projects, <https://www.planning.nsw.gov.au/sites/default/files/2024-11/benefit-sharing-guideline.pdf>

4.7 Netherlands



Flagship Programme

- Ministry of Economic Affairs and Climate Policy (via Netherlands Enterprise Agency (RVO))⁹² made a policy recommendation that solar parks should also have other functions, such as combining agriculture with solar panels.
- This was keeping in mind the high land-use competition (for housing, agriculture, infrastructure and nature), and the need for improving spatial efficiency.
- RVO's guidance defines the kind of projects that align with the Dutch government's long-term vision for renewable energy development and sustainable land use.
- Dutch National Environmental Vision (NOVI) 2020 talks about "zonneladder" (solar ladder), a preferential hierarchy⁹³ siting for solar infrastructure. Under that framework, multipurpose use such as Agri PV is recognised as a potential exception – particularly in rural/agricultural areas where dual land-use would be advantageous.⁹⁴ Solar farms are considered important for reducing grid congestion.⁹⁵



Layered Benefits

- RVO's guidance can influence permit approvals, grant project eligibility, and shape regional energy strategies.
- Certain provinces (North Brabant, Friesland, etc.) in Netherlands promote Agri PV through local incentives that consider it as an agricultural innovation⁹⁶ or as a cooperative or farmer group-led project.⁹⁷ Several large-scale demonstration projects have been funded on similar basis under agricultural innovation.⁹⁸



Supportive Policy Measures

- Dutch Environmental Permitting (General Provisions Act) allow simplified permit procedures for a smaller non-controversial project, however, there are no defined rules or yield thresholds set for Agri PV.
- Hence, Agri PV is unregulated and existing environmental zoning plans consider dual land-use applications on a case-to-case basis.⁹⁹

⁹² Netherlands Enterprise Agency (RVO), Solar energy on land: Spatial integration of solar parks, Government of Netherlands, <https://www.rvo.nl/onderwerpen/zonne-energie/velden>

⁹³ Dutch Government's preferential hierarchy for solar deployment is as follows (priority is in the order of their listing):

- » Installation of solar panels on rooftops
- » Deployment on land in urban areas
- » Deployment on land in rural areas
- » Installation on agricultural land, which should be restricted as much as possible to preserve land for food production and biodiversity

⁹⁴ Netherlands Enterprise Agency (2025), Solar energy policy, <https://www.rvo.nl/onderwerpen/zonne-energie/beleid>

⁹⁵ van der Weijden, C. et. al., Expert Guide to Agrivoltaics and Floating Photovoltaics in the Netherlands, CMS Expert Guides; 2025, <https://cms.law/en/int/expert-guides/cms-expert-guide-to-agrivoltaics-and-floating-photovoltaics/netherlands>

⁹⁶ PV Magazine International (2023), Agrivoltaics for raspberries, <https://www.pv-magazine.com/2023/06/14/agrivoltaics-for-raspberries/>

⁹⁷ ACeRS (2023), Proposed ban threatens budding agrivoltaic industry in the Netherlands, <https://digital.bnpenengage.com/emagazine-acers-bulletin-september-2023/news/>

⁹⁸ Stichting Wageningen Research (2021), Sunbiose: Development of scalable agrivoltaic systems, <https://projecten.topsectorenergie.nl/projecten/sunbiose-35309>

⁹⁹ CMS Law (2025), CMS Expert Guide to Agrivoltaics and Floating Photovoltaics in the Netherlands, <https://cms.law/en/int/expert-guides/cms-expert-guide-to-agrivoltaics-and-floating-photovoltaics/the-netherlands>

- Agri PV can form an exception to the ban on development of solar parks on agricultural land.¹⁰⁰ An environmental building permit can only be granted if the intended use is in accordance with the applicable environmental zoning plan. Hence, Agri PV projects will usually require a permit to deviate from the existing zoning plan.
- Power Offtake: Few Agri PV pilots are set up with primary intent of catering to the farm's own energy needs (power cold storage, irrigation, and machinery during harvesting and packing).¹⁰¹ Several other pilot projects injected their power to grid under a general subsidy arrangement available to a conventional renewable energy generating station and no unique PPA was tied to any project.



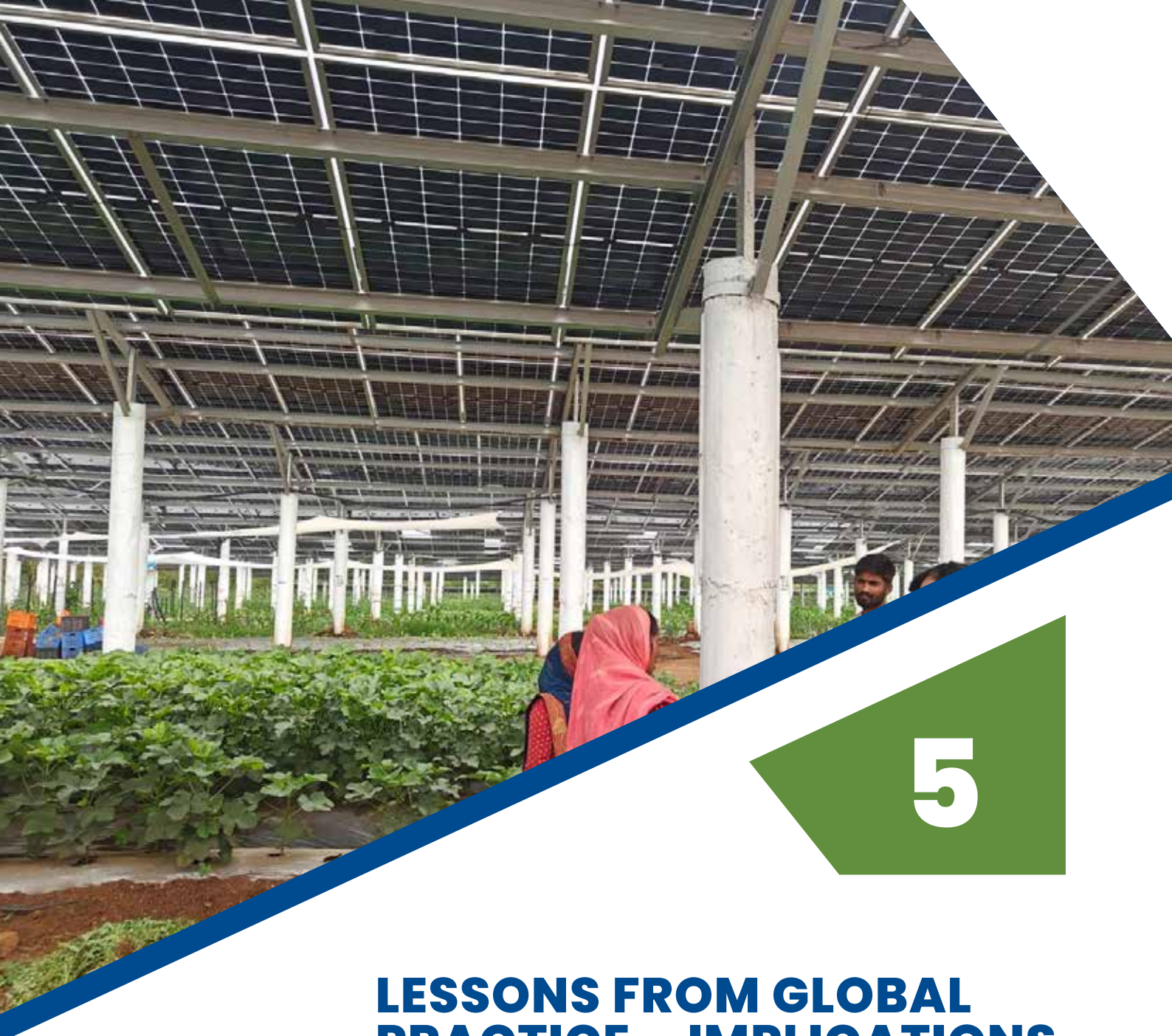
Outcome of the Measures

- Provincial initiative, largely, have contributed to the growth of Agri PV (as an agricultural innovation and farmer-led models) enabling access to innovation grants and strengthening local ownership.
- Pilot projects designed for on-farm energy-use demonstrate how Agri PV can reduce energy costs and grid dependency.



¹⁰⁰ Nature protection concerns – particularly nitrogen deposition and emissions during construction and operation of Agri PV projects are among the most significant regulatory issue in the Netherlands. Nitrogen deposition is strictly regulated under the EU Habitats Directive, and any project with potential nitrogen impacts must undergo AERIUS modelling to assess effects on protected Natura 2000 sites. If calculated nitrogen levels exceed established thresholds, the project developer is required to obtain a Nature Permit before implementation.

¹⁰¹ A, Bhambhani., BayWa r.e. completes agrivoltaic facility in the Netherlands, Taiyang News; 2021 <https://taiyangnews.info/business/baywa-completes-agrivoltaic-facility-in-the-netherlands>



5

LESSONS FROM GLOBAL PRACTICE – IMPLICATIONS FOR THE STATE-LEVEL AGRI PV ECOSYSTEM



Different countries anchor Agri PV to different policy goals, and that significantly shapes rules and incentives. China framed Agri PV as a poverty-alleviation instrument, the U.S. emphasised rural energy access, Italy centres Agri PV on climate-resilient agriculture and farm income, and the Netherlands treats it as a spatial-efficiency tool to relieve land-use pressure. For India or for any Indian state, choosing a clear primary anchor (example: rural livelihood, climate adaptation, energy security or a combination of all) will help align incentives, permits, monitoring, and make trade-offs explicit.

1. Clarification on Land-use

Land conversion rules and revenue codes are the most frequent bottlenecks worldwide. Indian states can treat Agri PV (particularly elevated systems) as an agriculture-related improvement or ancillary agricultural activity in the state land codes, where possible. The state should further enable service contracts or joint venture/cooperative models so farmers retain land title and agricultural status, and provide a clear legal template that preserves farmer subsidies, insurance and credit access. Where conversion remains necessary, a fast-track, predictable conversion/approval route with time-bound decisions, capped fees, etc., are necessary to avoid lengthy uncertainty that affects the bankability of the project. Where temporary conversion frameworks are in place, states can introduce clear improvement and remediation pathways, defining performance criteria such as continued cultivation or minimum yield thresholds. These pathways should also specify conditions for permit revocation. For example, if harvest yields fail to meet requirements, the local government can guide improvement measures, and if no improvement is seen, the temporary conversion permit can be revoked.

2. Treating Agri PV as a Social Contract

Global practices show farmer buy-in matters more than pure economics. Provisions that encourage timely lease payments, inclusion of revenue-sharing clauses, agricultural primacy, explicit reversibility clauses and restoration bonds, etc. can be mandated in the contract. These measures are intended to protect farmers from predatory pricing and ensure that developers have a vested, ongoing interest in maintaining the land's agricultural productivity.

Further, the project design has to be inclusive, compatible, and localised, reflecting regional agro-climatic conditions, cropping systems, and farm practices. In other words, system design (height, tilt, row spacing, foundation type, etc.) should align with the crops cultivated, machinery used, and water management methods on the site. Inclusive planning ensures that small and marginal farmers can meaningfully participate – through cooperative or joint venture structures – rather than being displaced. Localisation also supports crop-solar compatibility, enhances social acceptance, and minimises the risk of technology mismatch with local agricultural realities.

3. Standardised Monitoring and Compliance metrics

Standardisation of multi-layered monitoring metrics (in Agri PV, that includes plant physiology, microclimate, soil moisture, yields, etc.) using a metric set across demonstration sites allows cross-regional comparison (arid vs. humid), makes claims about water savings and yields effects verifiable. Submission of periodic monitoring reports (yield relative to baseline, soil health indicators, etc.) should be part of the project compliance and linked to grants/benefits. Such transparent data will protect farmers from underperforming projects or misleading claims, while for the government, it ensures that public funds and subsidies are tied to measurable outcomes.

4. Differentiated Permitting

A size-sensitive permitting procedure, say, simplified or deemed project approvals for small, removable, elevated Agri PV of less than 5 MW, and a more detailed and comprehensive permitting procedure for large installations can effectively reduce bureaucratic delays and transaction costs for installations in low-conflict, high-potential sites. Further, the government can create “acceleration zones” (degraded land, fallow land, or low biodiversity areas) where approvals and incentive levels can be accelerated.

5. Power Procurement and Tariff Design

A diversified revenue framework – centered on a Feed-in-Premium (FiP) rather than a fixed Feed-in-Tariff (FiT) – provides greater flexibility and financial sustainability for Agri PV projects. Developers can retain access to multiple market routes, including wheeling arrangements, corporate PPAs and participation in wholesale spot and short-term balancing markets. Further, a preferential procurement model can be designed for projects with farmer co-ownership or robust local benefit-sharing frameworks. Additionally, on-farm storage incentives should be encouraged wherever self-consumption supports high-value agricultural uses such as cold storage or irrigation. These measures, individually or collectively can attract private investments to market-linked returns, reduce subsidy burdens for the government and diversify income streams for farmers.

Power generation from Agri PV projects deliver dual outcomes – clean energy and agricultural resilience – and therefore holds higher social and environmental value for corporate buyers. States can formalise this value by creating a “Social RE” label or crediting mechanism under the existing RPO regime or Indian Carbon Markets. This would allow companies procuring Agri PV power to claim enhanced compliance benefits, encouraging voluntary premium PPAs and improving project bankability.

6. Targeted Blended Finance and Performance-linked Grants

A balanced financing approach should pair small capital grants (especially for elevated or semi transparent Agri PV systems) with concessional credit facilities (such as first-loss guarantees) and insurance products to reduce farmer and lender risk. As discussed in the above sections, a portion of the grant can be linked to verifiable outcomes, such as crop yields, measurable water savings, etc.

7. Integrate Agri PV into Rural Development and Market Infrastructure

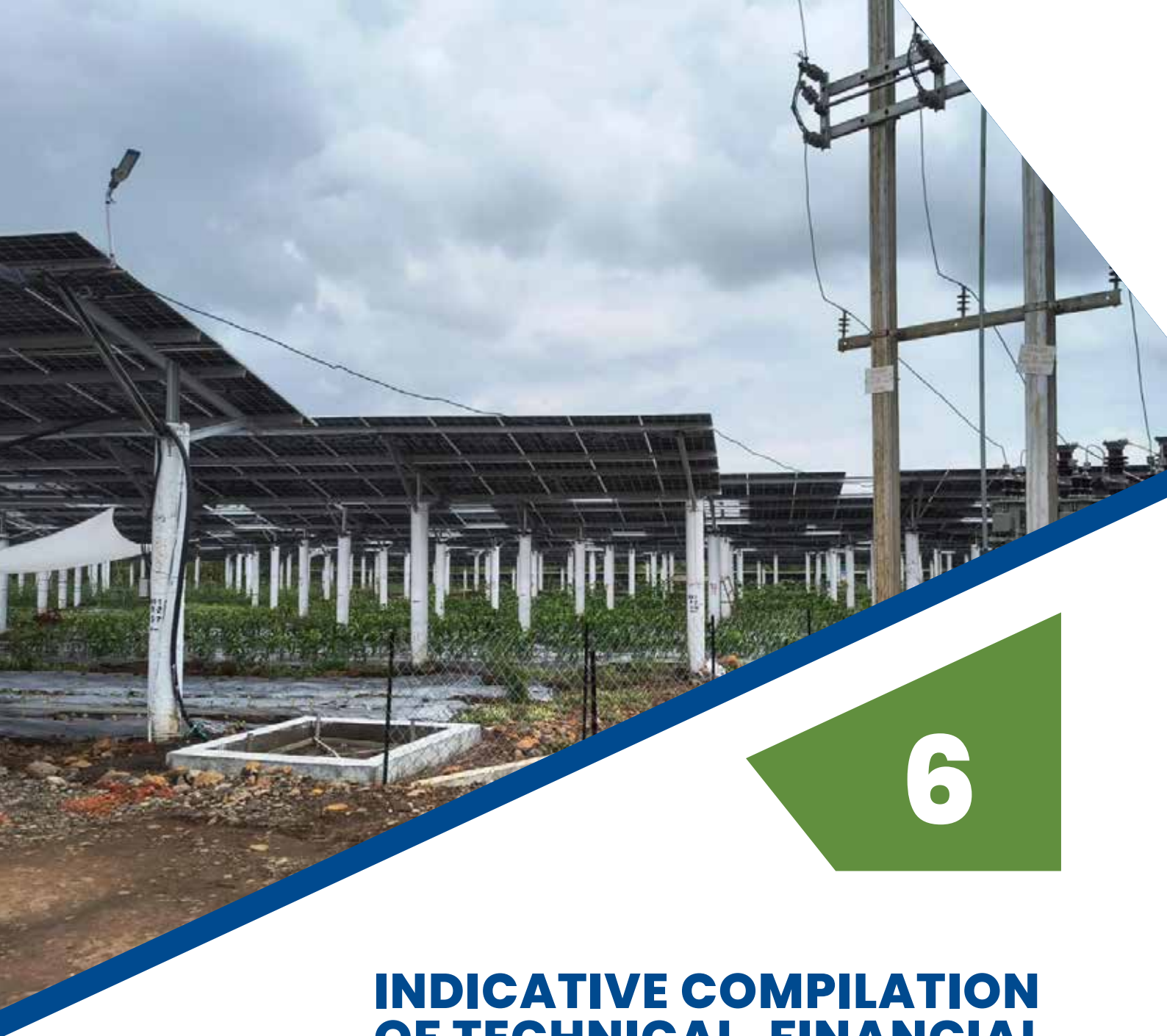
Integrating Agri PV into the local economy ensures that the benefits of on-farm energy extend beyond electricity generation. States can create producer channels, aggregation points, and cold-chain incentives so that farmers can capture greater value from increased or stabilised yields made possible by solar power. Where Agri PV enables surplus on-farm electricity, local industrial or agro-processing offtake through PPAs with nearby industries (cold storage, food processors, etc.) should be encouraged. This strengthens rural value chains and transforms Agri PV from a stand-alone energy asset into a local economic enabler.



8. Procurement and Tender Design

States can design tender schemes that explicitly reward agricultural outcomes alongside energy production. Tender scoring can include parameters such as water-use efficiency, agronomic compatibility and other co-benefits.





6

INDICATIVE COMPILATION OF TECHNICAL, FINANCIAL, AND POLICY INSTRUMENTS TO SUPPORT AGRIPV SYSTEMS



This section presents a comprehensive, practitioner-focused catalogue of interventions designed to rapidly and responsibly scale Agri PV deployments at the state level. Built from a synthesis of international best-practices, national pilots, and stakeholder inputs across the Agri PV value chain, the catalogue groups instruments into three practical clusters – technical, financial, and policy/institutional – highlights cross-cutting enablers (monitoring, capacity building, and procurement design). Each instrument is described with its objective and who should lead implementation (government agency, DISCOM, financier, or FPO).

The aim is to give state decision-makers a one-stop reference that can

be used to assemble a prioritised, evidence-backed package of interventions. It also combines “fast wins” that unlock capacity quickly with longer-term enablers that reduce risk, lower public costs, and ensure equitable benefits for small and marginal farmers.

The interventions presented in this section constitute an indicative set, synthesised from an extensive review of global literature, international regulations, and emerging evidence from Indian pilots and field-level insights from India. The list is not exhaustive and can be tailored to the specific agricultural, regulatory, and institutional contexts of different states.

6.1 Technical Interventions

Table 3: Key technical interventions, descriptions, and rationale

Intervention	Description	Rationale
State-specific technical Agri PV Guidelines	Siting criteria, structural heights, wind load, foundational design, crop-specific shading thresholds, access for farm machinery, erosion control, etc.	Establishing technical standards ensures safe, crop-compatible designs and reduces variability in project quality. It also gives developers clarity, reducing approval delays
State-level demonstration/pilot and standardised monitoring	Fixed number of demonstration sites across agro-climates of the state that report data on weather, irradiance, soil moisture, crop yield, and energy yield	Demonstrations reduce farmer and investor uncertainty by generating real-world evidence on crop yield, energy output, and micro-climatic effects across agro-climatic zones. Standardised monitoring builds a long-term data repository
Prioritise Agri PV siting using Geographic Information System (GIS)	Demarcate high-value Agri PV zones where crop benefits or water savings are high, with the help of GIS overlaid on soil type and crop calendars through a detailed potential assessment	GIS-based identification of high-value zones ensures land is allocated where Agri PV produces maximum agricultural or water-saving benefits, improving land-use efficiency and reducing siting conflicts
Technical training and certification courses	Integrate PV engineering, agronomy, and socio-economic engagement into training programmes through structured industry-academia partnerships	Building a skilled workforce lowers Operational and Maintenance (O&M) risks, ensures quality installation, and supports job creation in rural areas
Research and Development (R&D) for crop-compatible modules	Development of efficient, durable, crop-compatible solar modules, such as semi-transparent and bifacial modules, tailored for agricultural use	Tailoring module technology to agricultural needs improves light distribution, increases crop yield stability, and enhances the dual-use value of Agri PV system

Intervention	Description	Rationale
Sustainability and Environmental Impact metrics	Metrics include soil moisture, soil temperature, module temperature, etc. (See Appendix II for various micro-climate parameters, standards, and measuring instruments)	Clear metrics allow evaluation of long-term soil, water, and biodiversity impacts, ensuring environmentally responsible deployment and compliance with sustainability goals
Collaboration between research bodies, private firms and academia	Collaboration in the form of research and innovation hubs among government research institutions, private industry and academic bodies on developing standardised practices, solve operation challenges, and create scalable and context-specific Agri PV models	Multi-stakeholder collaboration accelerates innovation, improves technology localisation, and ensures research addresses real farmer and developer needs

6.2 Financial Interventions

Table 4: Key financial interventions, description, and rationale

Intervention	Description	Rationale
Capital grants and performance-linked credit support	Support for demonstrations and early adopters (first-loss capital), especially for elevated structures, linking disbursements to monitoring and verification (M&V)	This measure can reduce the high upfront cost of Agri PV structures and de-risk early adopters, while tying disbursements to monitoring ensures accountability and generates reliable performance data for scaling
Preferential Feed-in-Tariffs (FiTs)	Guarantee a higher, technology-appropriate tariff for electricity generated from Agri PV systems – particularly those using elevated structures	Preferential FiTs or premiums can ensure project bankability, create a stable income stream for farmers through long-term PPAs, can accelerate market uptake, encourage innovation in crop-compatible system designs, and enable wider participation among small and medium-scale farmers who may otherwise face financial barriers
Concessional Loans	Low-interest credit to farmers and Agri PV developers	Addresses credit constraints – particularly for small and marginal farmers – by lowering overall capital costs

Intervention	Description	Rationale
Stacked Financial Incentives	Packaged benefits include capital subsidy, FITs, etc.	Allows flexible, risk-adjusted financing packages that meet diverse stakeholder needs, reduce overall project risk, and improve bankability across different Agri PV business models
Demand aggregation	Pool procurement of Agri PV components or services across multiple farmers or project developers to enable bulk purchasing	This lowers procurement and installation costs through economies of scale, increase bargaining power for farmers and Farmer Producing Organizations (FPOs)
Revenue-stacking for farmers	Potential revenue streams include – energy, lease payments, carbon/ environmental credits, and water savings. State governments can define these revenue streams in tariff frameworks and permit PPAs that reflect split ownership (of farmer and developer) in models where the projects are developed by a third-party on leased land	Multiple income streams diversify and stabilise farmer income, making Agri PV economically attractive
Tax incentives and reduced stamp duty	Reduce stamp duty, registration fees for Agri PV lease deeds, etc.	Lower transaction costs make Agri PV leases, equipment acquisition, and project development more affordable
Tailored business models	Build cost-benefit and business models for farmers, developers, and FPOs	Transparent financial and agronomic insights for decision-making help farmers understand trade-offs and support the design of a viable farmer-developer-FPO business arrangement. FPO- or co-operative-led models strengthen collective ownership and negotiation power, reduce transaction costs, and ensure farmer-centric project governance – critical for equitable and scalable Agri PV deployment

6.3 Regulatory and Institutional Interventions

Table 5: Key regulatory interventions, description, and rationale

Intervention	Description	Rationale
Dedicated Agri PV Coordinating Agency	A single state-level body mandated to plan, coordinate, and oversee all Agri PV activities	A single coordinating agency eliminates departmental fragmentation and accelerates decision-making through unified governance
Integrate Agri PV into State Solar Policy	Embed Agri PV provisions, targets, and incentives into the state's existing Solar Policy framework (with a scope for releasing detailed guidelines)	Provides policy certainty and clarity for developers and investors
State-level Knowledge Hub	A central platform for data, guidelines, research, and stakeholder resources on Agri PV	Ensures knowledge continuity, supports evidence-based planning and enhances transparency
Local Markets and Cold-Chain Infrastructure for Agri PV crops	Establish local markets and cold storage for shade-tolerant or Agri PV compatible produce	Strengthens value chains and ensures economic viability for farmers adopting new crop mixes
Land-use Governance	Define permissible Agri PV, especially on agricultural land and permit agricultural land leasing for Agri PV, subject to crop-yield safeguards; Set up clear processes and timelines for adjudicating Agri PV-related land conflicts (See Annexure I and Appendix II for a detailed case study on addressing land use conversion for Agri PV projects)	Reduces ambiguity for land officers and investors, preventing misclassification disputes; Land use permits unlock land availability while ensuring agricultural continuity and farmer protection; Speedy dispute resolution minimises project delays and lowers investor and farmer risks
Integrate Agri PV into Agricultural and Rural Development Plans	Align Agri PV with broader state farming, water-use, rural livelihood, etc. programmes	Ensures synergy across sectors and avoids policy conflicts at the implementation stage

Intervention	Description	Rationale
Single-window Approval System	Integrate agriculture, energy, land, revenue, environment (if applicable), and local body approvals under one portal	Reduces time, transaction costs, and bureaucratic hurdles for project developers and farmers
Incentive for On-Farm Storage	Incentivise on-farm consumption of energy	Enhances grid stability and farmer self-sufficiency
Involve Krishi Vigyan Kendras (KVKs) in Agri PV Extension Services	Use KVKs to deliver farmer training, facilitate demonstration trials, provide technical support, and market guidance	Leverage trusted local institutions like KVKs to ensure wide, equitable farmer outreach and adoption

6.4 Community and Capacity Building Interventions

Table 6: Key community-linked and capacity building interventions, description, and rationale

Intervention	Description	Rationale
Multi-Channel Farmer Education	Farmer-oriented training on Agri PV benefits, operation, safety and deployment procedures through in-person and digital channels; share documented evidence, local demonstration and farmer testimonials from existing Agri PV pilots	Ensures broad awareness and improves farmer confidence by making information accessible across regions; builds trust and reduces perceived risk
Capacity Building for Project Stakeholders	Train officials and stakeholders across land and revenue departments, finance, technology	Strengthens institutional ability to plan, regulate, and support Agri PV deployment effectively and consistently

The table below lists the final set of interventions assessed through the MCDM framework for prioritisation.

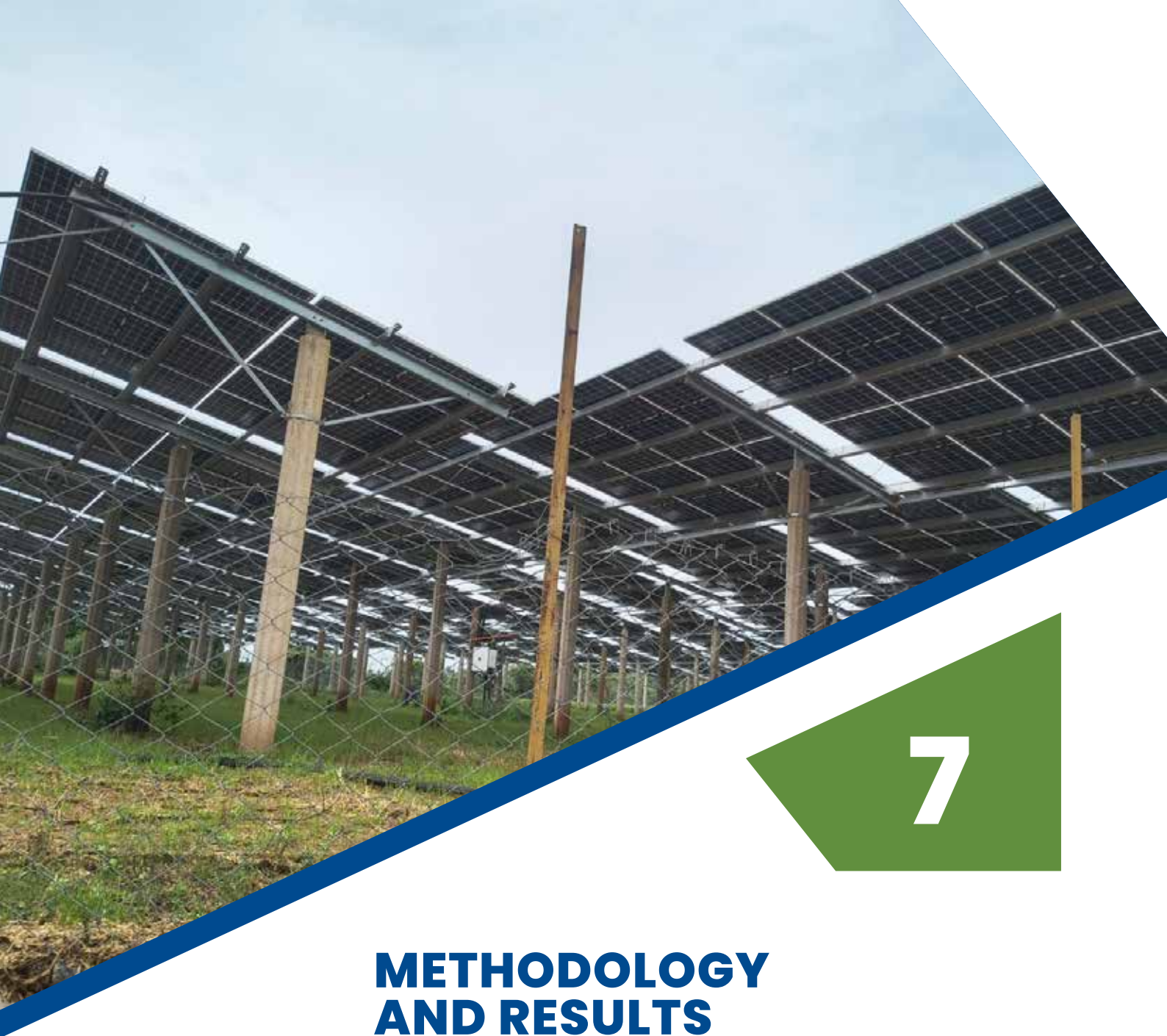
Table 7: Indicative list of interventions for MCDM evaluation

Intervention ID	Category	Intervention Name
T1	Technical	State-specific Agri PV Guidelines
T2	Technical	State-level demonstration, monitoring and evaluation framework
T3	Technical	Prioritise Agri PV siting (GIS)
T4	Technical	Technical training and certification courses

Intervention ID	Category	Intervention Name
T5	Technical	Develop sustainability and environmental metrics
F1	Financial	Capital grants and performance-linked credit support
F2	Financial	Preferential feed-in-tariffs for Agri PV
F3	Financial	Facilitate access to low-interest loans
F4	Financial	Demand aggregation and procurement
F5	Financial	Support for FPOs and cooperative-led models
F6	Financial	Innovation tenders and special allotment for Agri PV projects
R1	Regulatory	Integrate Agri PV into the existing UP solar policy
R2	Regulatory	State Agri PV knowledge hub
R3	Regulatory	Markets and premium valuation of Agri PV power and crops
R4	Regulatory	Land use permits
R5	Regulatory	Mechanisms for land-use dispute resolution
R6	Regulatory	Model contracts and lease agreements for benefits sharing
R7	Regulatory	Single window approval for Agri PV projects
C1	Community	Involve KVKs as Agri PV extension leaders
C2	Community	Farmer education via multi-channel outreach
C3	Community	Build the capacities of all stakeholders
C4	Community	Research and collaboration with agricultural universities







7

METHODOLOGY AND RESULTS

Given the diversity of technical, financial, regulatory, and community-based interventions, the methodology combines quantitative indicators (Tier 1) and qualitative judgements (Tier 2), as described in the earlier section, to generate a composite ranking of interventions based on their expected impact, feasibility and inclusiveness.



The process was designed to maintain (a) analytical consistency, (b) minimise duplication among overlapping interventions/criteria, and (c) reflect ground-level realities in the Indian policy and market context.

And an indicative list of 22 interventions is described in Appendix III, Part A

7.1 Step-wise Approach

Step 1: Identification of Interventions

A long list of potential interventions was compiled through literature

review, policy analysis, and consultations with experts. Interventions were grouped under four thematic pillars:

- **Technical** (e.g., Agri PV siting, design standards).
- **Financial** (e.g., grants, Feed-in-Tariffs).
- **Regulatory** (e.g., land permits, coordination mechanisms), and
- **Community and Capacity** (e.g., farmer training, involving Krishi Vigyan Kendra (KVKs)).

During the construction of the decision matrix, overlapping interventions and those dependent on the prior implementation of others were removed to ensure independence and avoid double-counting in the scoring process.

Step 2: Identification of Evaluation Criteria and Their Corresponding Weights for MCDM Analysis

For optimising the process of prioritising interventions in Agri PV, it is essential to differentiate among them and arrive at a systematic ranking. These interventions can be assessed through a combination of quantitative and qualitative factors, collectively termed as evaluation criteria.

A key consideration is that not all criteria should be included indiscriminately, as several may represent the same facet (e.g., cost and financial burden). Therefore, we adopt a two-tiered approach to ensure comprehensiveness while minimising redundancy.

Tier 1: Quantitative Criteria (Sum = 100)

1. Short-term Deployment Enablement (30%)

- » **Definition:** Incremental net income per farmer/hectare from Agri PV (via crop stability, energy sales, lower input costs).
- » **Why:** Farmer benefit is the primary policy driver for Agri PV adoption.
- » **Metric:** ₹/ha/year or % increase in farmer income compared to baseline.

2. Financial Viability/Bankability (30%)

- » **Definition:** The extent to which interventions improve project IRR, DSCR, or reduce risk profile.
- » **Why:** Determines the ability to crowd in private capital and sustainable scaling.
- » **Metric:** IRR uplift, risk reduction, concessional financing leverage.

3. Public Cost-effectiveness (40%)

- » **Definition:** Efficiency of public spending in supporting Agri PV.
- » **Why:** Limited fiscal space requires prioritising high-impact, low-cost interventions.
- » **Metric:** ₹ per MW deployed, or ₹ per farmer supported.

Tier 2: Qualitative Criteria (Sum = 100)

1. Institutional and Regulatory Feasibility (50%)

- » **Definition:** Ease of aligning with existing land, energy, and agricultural policies.
- » **Why:** Interventions requiring minimal legal/administrative changes can be implemented quickly.
- » **Scoring:** High (minor tweaks), Medium (moderate changes), Low (major reforms).

2. **Social Equity and Inclusiveness (50%)**

- » **Definition:** The extent to which interventions ensure access for small/marginal farmers, FPOs, women farmers.
- » **Why:** Critical for political acceptance and avoiding concentration of benefits.
- » **Scoring:** High (inclusive by design), Medium (needs enabling support), Low (exclusionary)

Step 3: Data Compilation and Scoring

Quantitative Indicators

- Short-term deployment enablement was estimated as the additional income per hectare for participating farmers, derived from pilot data, literature values (₹/ha/year).
- Financial viability was expressed as an average of the percentage improvement in project IRR or risk-adjusted return, capturing the combined effect of concessional finance, guarantees, or risk-sharing mechanisms.
- Public-cost effectiveness represented the estimated fiscal outlay per MW of the Agri PV deployed (₹/MW).

To maintain comparability across diverse variables, all quantitative indicators were converted into standardised scores on a 1-5 scale, where 5 represents the most desirable outcome and 1 the least. For each of the three quantitative dimensions – short-term deployment enablement, financial viability and public cost effectiveness, a mix of qualitative judgement, empirical or literature-based ranges were established to define realistic upper and lower bounds in the Indian Agri PV context.

All interventions were evaluated against the selected quantitative and qualitative criteria to construct a decision matrix, D

$$D = [S_{ij}]$$

Where i = 1, 2, ..., 22 denotes the interventions and j = 1, 2, ... 5 denotes the evaluation criteria considered and S_{ij} represents the raw score assigned to intervention i for criterion j.

$$\begin{bmatrix} S_{11} & \dots & S_{15} \\ \vdots & \ddots & \vdots \\ S_{22,1} & \dots & S_{22,5} \end{bmatrix}$$

Each intervention’s raw value (e.g., ₹/ha/year, IRR uplift %, ₹/MW) was then mapped on the 1-5 scale as under:

Table 8: Interpretation of scores and corresponding ranges for quantitative criteria

Score	Interpretation	Short-term Deployment (₹/ha/year)	Financial Viability (IRR uplift %)	Public Cost-Effectiveness (₹/MW)
5	Very High	>1,00,000	>4%	>2,00,00,000
4	High	50,000-1,00,000	2-4%	1,50,00,000-2,00,00,000
3	Medium	20,000-50,000	1-2%	1,00,00,000-1,50,00,000
2	Low	5,000-20,000	0.5-1%	5,00,000-1,00,00,000
1	Very Low	<5,000 or none	<0.5% or neutral	>5,00,000

To assess the role that financial instruments and regulatory measures can play in accelerating Agri PV deployment, a sensitivity analysis (for detailed calculation assumptions, please refer to Annexure II) was conducted to evaluate how capital grants, feed-in-tariff improvements and concessional loan interest rates can influence the IRR of typical Agri PV business models:

$$IRR_{uplift} = IRR(\text{with intervention}) - IRR(\text{base case})$$

The results show:

- A capital grant of ₹1.05 Crore¹⁰² reduces upfront investment requirements (CAPEX) substantially, improving IRR by more than five percentage points – indicating that such mechanisms can strongly enhance investor confidence, especially in early-stage markets where equipment and installation costs remain relatively high.
- Reducing interest rates from commercial levels (10%¹⁰³) to concessional rates (7-8%) improves IRR by up to 1.88 percentage points, helping projects reach positive return thresholds – concessional finance alone may not achieve viable returns, but it plays an important role as an enabler when combined with tariff or capital grant support.
- Improving FiT rates from ₹3.00 to ₹3.50 per kWh improves IRR by 3.47 percentage points, highlighting the importance of tariff-based revenue certainty – demonstrating that even marginal tariff improvement can significantly improve project financial viability.

Table 9: IRR uplift from key financial interventions for a typical Agri PV business model

Interventions	IRR Uplift (percentage points, pp)
Capital Grant	5.06
Tariff Increase	3.47
Concessional Finance	1.88

The qualitative tier captures institutional realism and social inclusiveness of each intervention. Each criterion was assessed using a three-level ordinal scale – High (H), Medium (M), or Low (L) – which was subsequently translated into numeric equivalents (5,3, and 1) for aggregation. The qualitative assessment of interventions was informed by structured interactions and detailed discussions with the State Renewable Energy Development Agencies of five states. Agency responses were captured for each intervention, and the qualitative score reported in this white paper represents the average of these responses. Notwithstanding this aggregation, the framework allows full flexibility for individual states to adopt or prioritise intervention pathways that best align with their institutional capacities, policy leadership, and readiness to develop a robust Agri PV ecosystem.

Using the methodology outlined above, each Agri PV intervention was scored quantitatively and qualitatively (See Appendix III: Part B and Part C). The following sub-section presents the computation of composite scores and prioritisation rankings, for which we used the following equations:

¹⁰² The capital grant value of ₹1.05 crore is aligned with the financial support structure available under the PM-KUSUM Component C-2 program, <https://mnre.gov.in/en/pradhan-mantri-kisan-urja-suraksha-evam-utthaan-mahabhayaan-pm-kusum/>

¹⁰³ 10% interest rate reflects a typical average lending rate for Indian farmers, though actual rates can range from about 7% to as high as 16%, depending on the type of infrastructure being financed for the loan purpose

$$\text{Quantitative Score } (A_i) = \sum_{j=1}^3 w_j \times S_{ij}$$

$$\text{Qualitative Score}(A_i) = \sum_{k=4}^5 w_k \times S_{ik}$$

Where, i = index for intervention (e.g., T1, F1, etc.) and j = index for evaluation criterion (e.g., short-term deployment, financial viability), k = index for sub-components if a criterion is composed of multiple sub-indicators (e.g., financial viability includes IRR uplift, concessional finance, and risk mitigation), w_j = weight assigned to criterion j and S_{ij} = score of intervention I for criterion j

Next, we normalised the scores to ensure compatibility across criteria with different units before aggregation and ranking, using the vector normalisation formula

$$r_{ij} = \frac{s_{ij}}{\sqrt{\sum_{i=1}^n s_{ij}^2}}$$

Where, i = 1,2, ..., n = index for intervention, j = 1,2, ..., m = index for criterion, s_{ij} = raw score of intervention I for criterion j and r_{ij} = normalised score of intervention I for criterion j between 0 and 1

Once weighted and normalised, we rank using the TOPSIS approach based on Euclidean distance from ideal and negative-ideal solutions

$$V^+ = \{\max(v1, j, v2j, \dots, vn, j)\}$$

$$V^- = \{\min(v1, j, v2j, \dots, vn, j)\}$$

Where, v_{ij} = weighted and normalised score of intervention i for criterion j, Positive Ideal Solution (PIS) V^+ = the best value for each criterion across all interventions and Negative Ideal Solution (NIS) V^- = the worst value for each criterion across all interventions.

We now use the Euclidean distance approach, which is used in TOPSIS to measure how far each intervention is from the ideal and negative-ideal solution in a multi-dimensional criterion space, combining all criteria into a single metric for ranking.

Euclidean distance from PIS and NIS are equated using the following formulas:

$$D_{i+} = \sqrt{\sum_{j=1}^m (r_{ij} - v_{j+})^2}$$

$$D_{i-} = \sqrt{\sum_{j=1}^m (r_{ij} - v_{j-})^2}$$

Where, D_{i+} = distance of intervention I from the positive ideal solution, D_{i-} = distance of intervention i from the negative ideal solution

$$C_i = \frac{D_{i-}}{D_{i+} + D_{i-}}$$

C_i = represents the relative closeness to the idea solution, i , and a higher C_i means the intervention is closer to the ideal solution and requires high priority for implementation. The value C_i is the final composite score for ranking interventions (See Appendix III: Part C and Part D)

7.2 Results

The TOPSIS analysis was conducted to objectively prioritise Agri PV interventions using both quantitative and qualitative criteria related to feasibility, socio-economic impact, policy relevance and scalability. The closeness coefficient (C_i) values described in Table 11, ranging from 0.094 to 0.816, represent the relative desirability of each intervention, with higher values indicating greater overall priority. Based on C_i scores, the 22 interventions were ranked to identify the most impactful policy, financial, technical and capacity-building strategies (See Appendix III: Part E for the complete listing).

Overall Prioritisation Outcomes

Capital grants and performance-linked credit support rank highest ($C_i = 0.816$, Rank 1), highlighting the dominant importance of financial mechanisms in accelerating Agri PV adoption. This is followed by key regulatory and pricing reforms such as state-specific Agri PV guidelines ($C_i = 0.706$, Rank 2) and Preferential FIT ($C_i = 0.662$, Rank 3), indicating the need for policy certainty and attractive revenue pathways for farmers and developers.

Interventions supporting access to finance and risk mitigation, such as low-interest loans (Rank 4) and mechanisms to streamline administrative processes (single-window clearances, Rank 8) occupy top positions. Capacity-building measures, including technical training and certification (Rank 5) and using KVKs as Agri PV extension leaders (Rank 9) also score highly, emphasising the importance of building trusted knowledge systems to ensure farmer confidence and technical competence.

At the lower end of the ranking, highly specialised interventions such as sustainability and environmental metrics (Rank 22), state-level knowledge hubs (Rank 20), and model lease agreements (Rank 19) receive lower prioritisation due to limited immediate applicability or slower perceived impact relative to financial incentives and enabling regulation.

Table 10: MCDM-TOPSIS results showing Closeness Coefficients (C_i) and ranked interventions

Intervention Name	Closeness Coefficient (C_i)	Rank
Capital grants and performance-linked credit support	0.815545617	1
State-specific Agri PV guidelines	0.705954718	2
Preferential FIT for Agri PV	0.662390653	3
Facilitate access to low-interest loans	0.642446406	4
Technical training and certification courses	0.625667632	5
Demand aggregation and procurement	0.620856215	6
Integrate Agri PV into the existing UP Solar Policy	0.620856215	7

Intervention Name	Closeness Coefficient (Ci)	Rank
Single window approval for Agri PV projects	0.620856215	8
Involve KVKs as Agri PV extension leaders	0.609534328	9
Research and collaboration with agricultural universities	0.553790494	10
Land-Use permits	0.552742676	11
Mechanisms for land-use dispute resolution	0.469898039	12
Farmer education via multi-channel outreach	0.469898039	13
Innovation tenders and special allotment for Agri PV projects	0.464167007	14
State-level demonstration, monitoring and evaluation framework	0.410006065	15
Markets and premium valuation of Agri PV power and crops	0.395491448	16
Support for FPOs and the cooperative-led model	0.389268433	17
Prioritise Agri PV siting (GIS)	0.347356543	18
Model contracts and lease agreements for benefit sharing	0.237299513	19
State Agri PV Knowledge Hub	0.172057592	20
Build the capacities of all stakeholders	0.172057592	21
Develop sustainability and environmental metrics	0.094891377	22







RECOMMENDATIONS

The MCDM-TOPSIS analysis not only identifies which interventions carry the highest relative priority but also offers guidance on the optimal sequencing and bundling of policy interventions required to build a viable Agri PV ecosystem. Based on the evaluation of feasibility, socio-economic value, institutional readiness, and inclusivity, the following recommendations are proposed:



a. Prioritise Financial De-risking as a Foundation for Market Creation

Since financial instruments received the highest closeness coefficients, policy should emphasise on mechanisms that lower capital costs and stabilise returns, enabling broader adoption among small and marginal farmers, alongside crowding-in private financing.

b. Provide Long-term Policy Signalling Through a Streamlined Regulatory Framework

Long-term policy vision is critical to build market confidence and reduce uncertainties associated with approvals and land-use processes. Establishing clear state-specific Agri PV guidelines and integrating Agri PV within existing renewable energy policies can create predictable regulatory pathways that can strengthen stakeholder trust.

c. Strengthen Institutions Through Coordination and Demonstration

Developing coordinated institutional platforms – through KVKs, agricultural Universities, and FPOs – can help establish practical demonstration sites that provide real-time evidence on crop performance, system design, and farm economics. These sites can also serve as centres for farmer training, technical support, and knowledge sharing.

d. Embed Farmer-centric Governance and Equitable Benefit-sharing Systems

Although governance-related interventions such as model contracts and lease agreements for benefit sharing, support for FPO/co-operative-led models, etc, rank lower in the TOPSIS prioritisation, they remain essential for securing long-term social legitimacy and ensuring that farmers benefit fairly as deployment expands.

e. Enable Efficient Land-use Permissions and Spatial Planning

Land classification and site selection are major operational bottlenecks for Agri PV deployment. Streamlined land-use permitting processes supported by GIS-based siting frameworks and harmonised land records can reduce project delays and minimise land-related disputes.

f. Develop Pricing and Market Mechanisms to Strengthen Revenue Certainty

Beyond capital support, market-based instruments are essential for long-term viability. Introducing premium valuation models for Agri PV produce and power, differentiated procurement frameworks and value-chain integration (e.g., agro-processing, cold storage, local energy use, etc.) can diversify farmer income streams and improve commercial attractiveness.

g. Strengthen Multi-stakeholder Capacity and Awareness Ecosystems

Scaling Agri PV requires an informed and skilled ecosystem. Structured capacity building and outreach programmes targeting farmers, local government agencies, DISCOMs, financial institutions, and extension networks can bridge information gaps and improve adoption readiness across the system.

Annexure I: Case Study: Addressing Land-use Conversion Constraints for Agri PV

For setting up Agri PV projects, the current legal regime governing land-use requires the farmers/ developers to ensure that the land is converted from agricultural to non-agricultural land. Land conversion is recognised as a regulatory hurdle as it attracts a conversion fee, premium, associated costs and the approvals are subjected to bureaucratic delays, lengthy revenue procedures, inspections, rejection risks, etc. Further, due to conversion, the farmer may lose out on benefits like agricultural subsidies, crop insurance, lending, etc. On the other end, unauthorised land use may attract penalties, criminal action, and restraint/demolition. Land-use and governance are state-legislated subject matters, and different states treat this issue differently (See Appendix I). For example, states like Karnataka and Uttar Pradesh have fast-tracked the approval process where the land conversion is automatically granted on payment of conversion fine and required fees whereas states like Madhya Pradesh, Odisha and Tamil Nadu require prior land-use conversion under traditional revenue codes. In Uttar Pradesh and Madhya Pradesh, “improvement” of land is considered an agricultural activity that includes: construction of tanks, wells, water channels, embankments for storing/supplying water for agri-use, drainage or flood protection works, tree planting, reclaiming, clearing, enclosing, levelling land, and erecting irrigation infrastructure or farm sheds.

Upon analysing different land revenue codes, the following recommendations are suggested to overcome this hurdle:

Key Recommendations

Agri PV Without PM-KUSUM Component A (Off-grid)

- Categorise Agri PV as “improvement of land” or “ancillary agricultural activity” (for example, cold storages and basic processing of crops can be classified as an ancillary agricultural activity) or “*agricultural operations*” under State Land Revenue Codes, as agri-related infrastructure that can be permitted without land conversion (for profitable use of holding). These structures should be used for irrigation or water supply for agricultural activities. (Ancillary agricultural activity in Odisha, for example, is decided on a case-by-case basis)
- Exercise the ‘Right to Improvement’ provision under State Land Revenue Codes to enhance agricultural cultivation through dual land-use.
- Seek approval before the appropriate authority (District Collector) by submitting activities being carried out on the land to avoid any enforcement or penal action against farmer or developer
- Some Indian states (Kerala, Haryana, Himachal Pradesh, and Punjab) have a broader and inclusive definition of agricultural activity in their land revenue legislations (like agro-processing on farm holdings, farm-based enterprises, etc.) allowing allied or ancillary activities to be treated as agricultural without requiring land conversion

Agri PV With PM-KUSUM Component A (Grid-connected)

- Agri PV is not a change in land-use, since cultivation, the primary use of the land, continues.
- Refer to the MNRE Guidelines on PM-KUSUM Component A, which state that land will remain under agricultural use, provided farming activities continue subject to the prescribed conditions.
- Establish that panels are non-permanent structures and are removable, and further, quantify

the micro-climate benefits that is improving the crop yield (under the right to improvement or for profitable use of landholding)

- Invest the earnings from the sale of solar power in agricultural activity (on-farm reinvestment) on the same agricultural land that can support the argument that no material change of land use has occurred

Common to both (1) and (2)

- In projects where the land is leased for developing Agri PV project, structure the project as a Joint Venture or Co-operative (FPOs) instead of a lease with farmer as the shareholder, thereby retaining the land ownership with the farmer and agricultural status (exploring business partnership instead of a lease, and where the developer is a service provider and farmer is actively involved in agriculture)
- More specifically, it can be drafted as a service contract where the developer acts on behalf of the farmer (owns a mere structure and no right on the land title)
- Borrow provisions from UP Renewable Energy Policy, which grants a ceiling-limit exemption for solar projects on agricultural land (12.5 acres as per the State Revenue Code)

Annexure II: Financial Model Assumptions and Cash Flow Calculations for IRR Analysis

Parameter	Value with Units
Project Capacity	1,000 kW
Capacity Factor	0.16
Annual Generation	14,01,600 kWh
Base Tariff	₹3.00/ kWh
CAPEX	₹4,50,00,000
OPEX	₹9,00,000
Project Life	25 years
Debt share	70%
Interest rate	7%
Tenure	12 years
Equity	30%
Inflation rate	3%
Annual Revenue (base)	₹42,04,800
Loan amount	₹3,15,00,000
Annual debt service	₹39,65,913
Degradation	0.5%

Year	Generation (kWh)	Revenue (₹)	OPEX (₹)	Debt Service (₹)	Net Cashflow (before Debt) (₹)	Equity Cashflow (in ₹)
0	0	0	0	0	-4,50,00,000	-1,35,00,000
1	14,01,600	42,04,800	9,00,000	39,65,912.64	33,04,800	-6,61,113
2	13,94,592	48,81,072	9,27,000	39,65,912.64	39,54,072	-11,841
3	13,87,619	41,62,857	9,54,810	39,65,912.64	32,08,047	-7,57,866
4	13,80,681	41,42,043	9,83,454	39,65,912.64	31,58,589	-8,07,324
5	13,73,778	41,21,333	10,12,958	39,65,912.64	31,08,375	-8,57,538
6	13,66,909	41,00,726	10,43,347	39,65,912.64	30,57,379	-9,08,533
7	13,60,074	40,80,222	10,74,647	39,65,912.64	30,05,575	-9,60,337
8	13,53,274	40,59,821	11,06,886	39,65,912.64	29,52,935	-10,12,978
9	13,46,507	40,39,522	11,40,093	39,65,912.64	28,99,429	-10,66,484
10	13,39,775	40,19,324	11,74,296	39,65,912.64	28,45,029	-11,20,884
11	13,33,076	39,99,228	12,09,525	39,65,912.64	27,89,703	-11,76,210
12	13,26,411	39,79,232	12,45,810	39,65,912.64	27,33,421	-12,32,491
13	13,19,779	39,59,336	12,83,185	0.00	26,76,151	26,76,151
14	13,13,180	39,39,539	13,21,680	0.00	26,17,859	26,17,859
15	13,06,614	39,19,841	13,61,331	0.00	25,58,510	25,58,510
16	13,00,081	39,00,242	14,02,171	0.00	24,98,071	24,98,071
17	12,93,580	38,80,741	14,44,236	0.00	24,36,505	24,36,505
18	12,87,112	38,61,337	14,87,563	0.00	23,73,774	23,73,774
19	12,80,677	38,42,030	15,32,190	0.00	23,09,841	23,09,841
20	12,74,273	38,22,820	15,78,155	0.00	22,44,665	22,44,665
21	12,67,902	38,03,706	16,25,500	0.00	21,78,206	21,78,206
22	12,61,563	37,84,688	16,74,265	0.00	21,10,423	21,10,423
23	12,55,255	37,65,764	17,24,493	0.00	20,41,271	20,41,271
24	12,48,978	37,46,935	17,76,228	0.00	19,70,707	19,70,707
25	12,42,734	37,28,201	18,29,515	0.00	18,98,686	18,98,686

Appendix I: State Land-use Regulations Governing Agricultural Land for Solar and Agri PV Projects

1. Madhya Pradesh

Applicable Legislation:

1. Madhya Pradesh Land Revenue Code Act, 1959 (with amendments up to 2011), hereinafter, the 1959 Act.
2. Madhya Pradesh Ceiling on Agricultural Holdings, 1960 (with amendments up to 2015), hereinafter the 1960 Act.¹⁰⁴
3. Madhya Pradesh Renewable Energy Policy 2025, hereinafter the 2025 Policy
 - a. If a farmer leases the land for non-agricultural (example, commercial) activity, the land must be formally converted from agricultural to non-agricultural use.¹⁰⁵
 - b. The farmer/buyer must intimate the District Collector (or Tahsildar/Sub-Divisional Officer) within 90 days of acquisition/lease of the intention to convert.¹⁰⁶
 - c. Conversion application must be completed within 1 year from that date
 - d. Commercial activity must commence within 3 years after conversion is granted
 - e. Penalty for diversion without permission¹⁰⁷: 20% of the market value of the diverted land alongside 50% of the total payable amount (premium for conversion and reassessed revenue for the new purpose).¹⁰⁸
 - f. 50% reimbursement of stamp duty on private land purchases and 50% rebate on circle rates for government land acquisitions for renewable energy projects; however these provisions do not eliminate the need for formal land conversion

Diversion means using land assessed to one purpose under Section 59 to any other purpose mentioned therein but using land for the purpose of agriculture where it is assessed with reference to any other purpose shall not be deemed to be diversion

2. Uttar Pradesh

Applicable Legislations:

1. UP Solar Energy Policy, 2022, hereinafter the 2022 Policy.
2. Uttar Pradesh Revenue Code, 2006, hereinafter the 2006 Code.
 - a. Installing solar power projects¹⁰⁹ on private agricultural land is allowed without having to convert it to non-agricultural use. Land automatically receives a “deemed non-agricultural status” upon approval by UPNEDA.

¹⁰⁴ Ceiling limits prescribed under the 1960 Act: 15 acres for families less than or equal to 5 members and 18 acres for families greater than 5 members

¹⁰⁵ Section 165(4) Proviso (b)(i) read with Section 172(1) of the 1959 Act

¹⁰⁶ Section 15 of the 1960 Act

¹⁰⁷ Section 172(4) of the 1959 Act

¹⁰⁸ Other legal actions under the 1959 Act include: lease being declared void, eviction of the lessee from the land, and forfeiture of any structures or investments made on it, as provided under provisions like 248 of the 1959 Act. In addition, authorities may impose daily penalties for continued non-compliance, and in certain cases, initiate criminal proceedings against the parties involved. These measures collectively aim to deter the misuse of agricultural land and ensure adherence to the prescribed land-use norms.

¹⁰⁹ Clause 12.1.a under the 2022 Policy: The State will promote setting up of Solar Power Project/Solar Farm on private land. Project developer shall be permitted to set-up Solar Power Project/Solar Farm on private agricultural land. Permission from State Government, for change of land use from agriculture to non-agriculture of land purchased by solar project developer for setting up solar park will be deemed. Further, the 2022 policy provides for 100% stamp duty exemption on land used for solar power plants/solar parks

- b. Further, developers can exceed the usual agricultural ownership limits (land ceiling), as long as they get project approval from UPNEDA
- c. Developers can lease the government and private land on a non-transferable 30-year term, with the land remaining registered in the owner's name. Lease rates are based on market value and are facilitated by the District Collectors
- d. 100% stamp-duty exemption on land used for solar projects¹¹⁰

3. Odisha

Applicable Legislation:

1. Odisha Land Reforms (Amendment) Act, 1960 (with amendments up to 2023), hereinafter referred to as the 1960 Act
2. Odisha Renewable Energy Policy 2022, hereinafter referred to as the 2022 Policy
 - a. Any agricultural land-use for non-agricultural purposes (like commercial solar) must be converted beforehand¹¹¹
 - b. Exemption of stamp duty, land conversion charges, and registration fees for renewable energy projects¹¹²

Others:

- In 2020, SECI and OREDA jointly implemented grid-connected Agri PV projects under which land from interested farmers are taken into lease for 25 years, and the government directly executes the lease deeds

4. Tamil Nadu

Applicable Legislation:

1. The Change of Land-use Rules, 2017, under the Tamil Nadu Town & Country Planning Act, 1971, hereinafter referred to as 2017 Rules and 1971 Act, respectively
2. Tamil Nadu District Municipalities Act, 1920, hereinafter referred to as the 1920 Act
3. Tamil Nadu Panchayats Act, 1994, hereinafter referred to as the 1994 Act
4. Tamil Nadu Combined Development and Building Rules (TN-CDBR), 2019, hereinafter referred to as the 2019 Act
 - a. Land conversion charges of 3% of property value as per the Stamp Act Director of Town and Country Planning (DTCP) Approval is necessary for land use change¹¹³

Notes:

Section 59 of the 1959 Act (Variation of land revenue according to the purpose for which a land is used)

- Explanation (5): Where land use for any one purpose is diverted to any other purpose, and land revenue is assessed thereon under the provisions of this section, the Sub-Divisional Officer shall also have the power to impose a premium on the diversion in accordance with rules made under this code

¹¹⁰ Clause 12.2 of the 2022 Policy

¹¹¹ Section 8A of the 1960 Act

¹¹² Clause 10.6 of the 2022 Policy

¹¹³ Section 47A of the 1971 Act

- » Provided that no premium shall be imposed for the diversion of any land for charitable purposes
- Explanation (2): Where land assessed for use for any one purpose is diverted to any other purpose, the land revenue payable upon such land shall, notwithstanding that the term for which the assessment may have been fixed has not expired, be liable to be altered and assessed in accordance with the purpose to which it has been diverted
 - » (2a): The alteration or assessment referred to in sub-section (2) shall be carried out by the Sub-Divisional Officer

Appendix II: Micro-climate Parameters, Models and Standards for Measuring Instruments

<p>Micro-climate and crop response (Agronomic metrics)</p>	<ul style="list-style-type: none"> ▪ STICS (INRAE): Soil-plant-atmosphere model for water, carbon, N-balance, crop growth ▪ Functional-Structural Plant Models (FSPM): Simulate light interception at the organ level, fruit sizing, and canopy microclimates for trees/vineyards
<p>Sensors in micro-climate monitoring</p>	<ul style="list-style-type: none"> ▪ Class A/B/C pyranometers (ISO 9060:2018): GHI measurements ▪ Albedometer facing pyranometer arrangement to measure reflected radiation ▪ PAR/quantum sensors: measure PAR ($\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) under canopy and at control plots for crop physiology ▪ Pyrheliometer for measuring Direct Normal Irradiance in concentrating or tracking setups ▪ Air temperature and relative humidity sensors (shielded, aspirated boxes) placed at canopy height and reference heights ▪ Anemometer and wind vane: wind speed/direction to understand convective cooling and structural loads ▪ Rain gauge for precipitation ▪ Leaf-wetness sensors: disease risk and micro-climate moisture ▪ Soil moisture probes (TDR (Time Domain Reflectometry), capacitance) at multiple depths (Soil/Plant: TDR – WDO Siting Rules) ▪ Light/Irradiance, Irradiance sensors – ISO 9060 (2018) ▪ Soil temperature sensors/thermistors ▪ Soil electrical conductivity/salinity sensors ▪ Dendrometers/trunk band sensors and sap flow for tree vigour ▪ NDVI/multi-spectral sensors to estimate biomass stress ▪ Module back-surface temperature sensors (thermocouples/RTD – Resistance Temperature Detector) to assess cooling effects

Appendix III: Part A – Master-list of Interventions, their Category and Lead Agency for Implementation for Building MCDM Matrix (State: Uttar Pradesh)

Intervention ID	Category	Intervention Name	Lead Agency
T1	Technical	State-specific Agri PV Guidelines	UPNEDA & DAFW
T2	Technical	State-level demonstration, monitoring and evaluation framework	UPNEDA & KVKS (DAFW)
T3	Technical	Prioritise Agri PV siting (GIS)	UPNEDA & DAFW
T4	Technical	R&D funding for optimal array geometry	DIEP
T5	Technical	Technical Training and Certification Courses	SCVT, UPSDM & UPNEDA
T6	Technical	Support crop-compatible PV module development	DIEP
T7	Technical	Develop sustainability and environmental metrics	DAFW
T8	Technical	Promote cross-sector R&D collaboration	UPNEDA & DAFW
T9	Technical	Promote Agri PV as a climate-smart and climate-resilient agricultural strategy	DASE, DoEFCC
F1	Financial	Capital grants and performance-linked credit support	UPFD
F2	Financial	Preferential Feed-in-Tariffs for Agri PV	UPERC & UPPCL
F3	Financial	Facilitate access to low-interest loans	UPFD & NABARD
F4	Financial	Demand aggregation and procurement	SFABC, UPDASP
F5	Financial	Tax incentives and reduced stamp duty	UPFD
F6	Financial	Tailored insurance for elevated PVs	IRDAI
F7	Financial	Support for FPOs and the cooperative-led model	NABARD, UPFD and UPNEDA
F8	Financial	Innovation tenders and special allotment for Agri PV projects	UPNEDA
R1	Regulatory	Create a dedicated Agri PV coordination agency	UPNEDA & DASE
R2	Regulatory	Integrate Agri PV into the existing UP Solar Policy	UPNEDA
R3	Regulatory	State Agri PV Knowledge Hub	UPNEDA & DAFW
R4	Regulatory	Markets and Premium valuation of Agri PV power and crops	DAMAFT
R5	Regulatory	Land Use Permits	BoR, UPSLSA

Intervention ID	Category	Intervention Name	Lead Agency
R6	Regulatory	Mechanisms for land-use dispute resolution	BoR, UPSLSA
R7	Regulatory	Model contracts and lease agreements for benefits sharing	UPNEDA
R8	Regulatory	Single window approval for Agri PV projects	DASE
R9	Regulatory	Public procurement of Agri PV power	UPPCL & DASE
C1	Community	Involve KVKs as Agri PV extension leaders	DAFW & KVK
C2	Community	Farmer education via multi-channel outreach	KVK, NGOs
C3	Community	Build capacities of all stakeholders	UPNEDA
C4	Community	Certification programmes for technicians and farmers	SCVT, UPSDM & UPNEDA

Acronym	Abbreviation
DAFW	Department of Agriculture & Farmer's Welfare, Government of Uttar Pradesh
KVK	Krishi Vigyan Kendras
DIEP	Directorate of Industries and Enterprise Promotion
SCVT	State Council for Vocational Training, Uttar Pradesh
UPSDM	Uttar Pradesh Skill Development Mission
UPFD	Uttar Pradesh Finance Department
UPPCL	Uttar Pradesh Power Corporation Limited
NABARD	National Bank for Agriculture and Rural Development
DoEFCC	Department of Environment Forest and Climate Change, Government of Uttar Pradesh
SFABC	Small Farmers Agribusiness Consortium
UPDASP	Uttar Pradesh Diversified Agriculture Support Project
IRDAI	Insurance Regulatory and Development Authority of India
DASE	Department of Additional Sources of Energy
DAMAFT	Directorate of Agricultural Marketing and Agriculture Foreign Trade
BoR	Board of Revenue, Uttar Pradesh
UPSLSA	Uttar Pradesh State Legal Services Authority
Technical	Technical
Financial	Financial
Regulatory	Regulatory and Institutional
Community	Community and Capacity building

Appendix III: Part B – Financial Viability Scoring for Each Parameter (IRR, Concessional Finance and Risk Mitigation)

Intervention ID	Concessional Finance	Risk Mitigation	IRR	Avg_Financial
T1	3	4	4	3.67
T2	3	3	3	3.00
T3	3	3	3	3.00
T4	3	2	3	2.67
T5	1	2	1	1.33
F1	5	5	5	5.00
F2	5	3	5	4.33
F3	4	3	4	3.67
F4	3	3	3	3.00
F5	2	3	2	2.33
F6	4	3	4	3.67
R1	3	3	3	3.00
R2	1	2	1	1.33
R3	4	3	4	3.67
R4	3	4	4	3.67
R5	3	3	3	3.00
R6	2	3	2	2.33
R7	3	3	3	3.00
C1	2	3	2	2.33
C2	3	3	3	3.00
C3	1	2	1	1.33
C4	3	4	2	3.00

Intervention ID	Institutional Feasibility	Social Equity	Rationale
T1	High	Medium	Fits into existing state policy-making but needs targeted measures to ensure benefits reach smallholders
T2	Medium	High	Requires coordination and modest capacity building, but directly supports farmer learning and inclusive uptake
T3	Medium	Medium	GIS needs inter-departmental data-sharing and planning, and is neutral unless explicit benefit-sharing is designed
T4	High	High	Can be rolled out through existing extension/education channels (high feasibility) and improves access to opportunities for smallholders and technicians
T5	Medium	Low	Technical metric development is implementable but primarily informs policy rather than directly benefitting farmers
F1	High	High	Grant/credit mechanisms are administratively feasible through existing schemes and directly subsidise smallholders
F2	High	Medium	Tariff changes are straightforward under the power policy, but benefits may accrue to asset owners without targeting
F3	Medium	High	Requires banking/product adjustments and credit appraisal capacity, but improves smallholder affordability when targeted
F4	Medium	High	Needs organisational mechanisms (FPO/aggregators) to implement and can enable smallholders via pooled bargaining
F5	Medium	High	Building FPO capacity needs programmatic support and strongly empowers smallholders
F6	Medium	Medium	Procurement design and administration are manageable, but require oversight, and equity depends on allocation rules
R1	High	Medium	Policy integration is administratively simple within state energy departments, but may not automatically ensure inclusive access

Intervention ID	Institutional Feasibility	Social Equity	Rationale
R2	Medium	Medium	Setting up a hub is feasible but requires sustained funding and staffing with indirect and variable equity benefits
R3	Medium	Medium	Developing market mechanisms is technically feasible with stakeholder work, and equity depends on market design and farmer access
R4	High	Medium	Streamlining permits can be done within existing land administration, but tenure/lease terms determine smallholders' benefit
R5	Medium	High	Institutionalising dispute resolution requires process design and capacity, and protects tenant/smallholder rights when effective
R6	Medium	Medium	Single-window systems are an established reform with administrative precedent, but may favour well-resourced applicants absent safeguards
R7	High	Medium	Single-window systems are an established reform with administrative precedent, but may favour well-resourced applicants absent safeguards
C1	High	High	Governments can procure through existing procurement frameworks, though buyer-centric models may not target smallholders
C2	Medium	High	KVKs are existing agricultural extension platforms enabling rapid rollout and directly reach and support small and marginal farmers
C3	Medium	Medium	Capacity building needs resources and time, and benefits accrue broadly but unevenly unless targeted
C4	High	High	Rated high because Agricultural Universities have strong research and extension capacity, and their involvement ensures Agri PV knowledge reaches small and marginal farmers, improving equity

Appendix III: Part C – Interventions and their MCDM Scores Across Quantitative and Qualitative Parameters and their Respective Weightages as Set in the Evaluation Criteria

Inter-vention ID	MCDM Score					Weighted MCDM Score				
	Quantitative			Qualitative		Quantitative			Qualitative	
	Short term	Financial	Public Cost	Inst. Feasibility	Social Equity	Short term	Financial	Public Cost	Inst. Feasibility	Social Equity
T1	4	3.67	5	5	3	1.2	1.10	2	2.5	1.5
T2	2	3.00	3	3	5	0.6	0.90	1.2	1.5	2.5
T3	3	3.00	4	3	3	0.9	0.90	1.6	1.5	1.5
T4	2	2.67	4	5	5	0.6	0.80	1.6	2.5	2.5
T5	1	1.33	5	3	1	0.3	0.40	2	1.5	0.5
F1	5	5.00	2	5	5	1.5	1.50	0.8	2.5	2.5
F2	5	4.33	3	5	3	1.5	1.30	1.2	2.5	1.5
F3	4	3.67	4	3	5	1.2	1.10	1.6	1.5	2.5
F4	3	3.00	5	3	5	0.9	0.90	2	1.5	2.5
F5	2	2.33	3	3	5	0.6	0.70	1.2	1.5	2.5
F6	4	3.67	4	3	3	1.2	1.10	1.6	1.5	1.5
R1	3	3.00	5	5	3	0.9	0.90	2	2.5	1.5
R2	1	1.33	4	3	3	0.3	0.40	1.6	1.5	1.5
R3	3	3.67	4	3	3	0.9	1.10	1.6	1.5	1.5
R4	4	3.67	3	5	3	1.2	1.10	1.2	2.5	1.5
R5	2	3.00	4	3	5	0.6	0.90	1.6	1.5	2.5
R6	2	2.33	4	3	3	0.6	0.70	1.6	1.5	1.5
R7	3	3.00	5	5	3	0.9	0.90	2	2.5	1.5
C1	2	2.33	4	5	5	0.6	0.70	1.6	2.5	2.5
C2	2	3.00	4	3	5	0.6	0.90	1.6	1.5	2.5
C3	1	1.33	4	3	3	0.3	0.40	1.6	1.5	1.5
C4	2	3.00	4	5	5	0.6	0.90	1.6	2.5	2.5

Appendix III: Part D – Interventions and their TOPSIS Decision-Making Results: Euclidean Distances and Closeness Coefficients

Intervention ID	Quantitative_Normalised	Qualitative_Normalised	Weighted_Quantitative	Weighted_Quantitative	Positive Ideal	Negative Ideal	Sum of Distances	Closeness Coefficient
T1	0.075345929	0.047904192	0.037672964	0.023952096	0.013473054	0.032346603	0.045819657	0.71
T2	0.029692614	0.047904192	0.014846307	0.023952096	0.026506216	0.018420035	0.044926251	0.41
T3	0.047084584	0.026946108	0.023542292	0.013473054	0.027809689	0.014801156	0.042610844	0.35
T4	0.036657548	0.074850299	0.018328774	0.03742515	0.019334419	0.032332319	0.05167651	0.63
T5	0.029692614	0.011976048	0.014846307	0.005988024	0.038850343	0.004073061	0.042923404	0.09
F1	0.058814999	0.074850299	0.0294075	0.03742515	0.008265465	0.03654488	0.044810345	0.82
F2	0.065168974	0.047904192	0.032584487	0.023952096	0.014401937	0.028256647	0.042658584	0.66
F3	0.061951256	0.047904192	0.030975628	0.023952096	0.015045846	0.027034129	0.042079975	0.64
F4	0.058814999	0.047904192	0.0294075	0.023952096	0.015806362	0.025883263	0.041689625	0.62
F5	0.025456631	0.047904192	0.012728315	0.023952096	0.028350638	0.018070146	0.046420784	0.39
F6	0.061951256	0.026946108	0.030975628	0.013473054	0.02487081	0.021544417	0.046415228	0.46
R1	0.058814999	0.047904192	0.0294075	0.023952096	0.015806362	0.025883263	0.041689625	0.62
R2	0.021546492	0.026946108	0.010773246	0.013473054	0.03601802	0.00748503	0.043503049	0.17
R3	0.052786869	0.026946108	0.026393435	0.013473054	0.026475095	0.017320969	0.043796064	0.40
R4	0.049923512	0.047904192	0.024961756	0.023952096	0.018522905	0.02289152	0.041414425	0.55
R5	0.039142115	0.047904192	0.019571058	0.023952096	0.022565509	0.020002734	0.042568243	0.47
R6	0.034254442	0.026946108	0.017127221	0.013473054	0.031556781	0.009818283	0.041375064	0.24
R7	0.058814999	0.047904192	0.0294075	0.023952096	0.015806362	0.025883263	0.041689625	0.62
C1	0.034254442	0.074850299	0.017127221	0.03742515	0.020545743	0.032072821	0.052618565	0.61
C2	0.039142115	0.047904192	0.019571058	0.023952096	0.022565509	0.020002734	0.042568243	0.47
C3	0.021546492	0.026946108	0.010773246	0.013473054	0.03601802	0.00748503	0.043503049	0.17
C4	0.039142115	0.074850299	0.019571058	0.03742515	0.032079473	0.039813825	0.071893297	0.55

Appendix III: Part E – Interventions and their Ranking Based on TOPSIS Score

Intervention ID	Category	Intervention Name	Closeness Coefficient (Ci)	Rank
F1	Financial	Capital grants and performance-linked credit support	0.815545617	1
T1	Technical	State-specific Agri PV Guidelines	0.705954718	2
F2	Financial	Preferential Feed-in-Tariffs for Agri PV	0.662390653	3
F3	Financial	Facilitate access to low-interest loans	0.642446406	4
T4	Technical	Technical Training and Certification Courses	0.625667632	5
F4	Financial	Demand aggregation and procurement	0.620856215	6
R1	Regulatory	Integrate Agri PV into existing UP Solar Policy	0.620856215	7
R7	Regulatory	Single window approval for Agri PV projects	0.620856215	8
C1	Community	Involve KVKs as Agri PV extension leaders	0.609534328	9
C4	Community	Research and collaboration with Agricultural Universities	0.553790494	10
R4	Regulatory	Land-use Permits	0.552742676	11
R5	Regulatory	Mechanisms for land-use dispute resolution	0.469898039	12
C2	Community	Farmer education via multi-channel outreach	0.469898039	13
F6	Financial	Innovation tenders and special allotment for Agri PV projects	0.464167007	14
T2	Technical	State-level demonstration, monitoring and evaluation framework	0.410006065	15
R3	Regulatory	Markets and Premium valuation of Agri PV power and crops	0.395491448	16
F5	Financial	Support for FPOs and the cooperative-led model	0.389268433	17
T3	Technical	Prioritise Agri PV siting (GIS)	0.347356543	18
R6	Regulatory	Model contracts and lease agreements for benefit sharing	0.237299513	19
R2	Regulatory	State Agri PV Knowledge Hub	0.172057592	20
C3	Community	Build the Icapacities of all stakeholders	0.172057592	21
T5	Technical	Develop sustainability and environmental metrics	0.094891377	22

NOTES



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