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INDIA AGRIVOLTAICS ALLIANCE

AGRIVOLTAICS IN INDIA

Overview of Projects



Imprint

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Acronyms and Abbreviations

APV	Agrivoltaics
APVRT	Roof Top Agrivoltaics
CAZRI	Central Arid Zone Research Institute
DISCOM	Distribution Company
GIPCL	Gujarat Industries Power Company Ltd.
GSECL	Gujarat State Electricity Corporation Limited
GUVNL	Gujarat Urja Vikas Limited
GoI	Government of India
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
FiT	Feed-in-Tariff
FPO	Farmer Producer Organization
IGEF	Indo-German Energy Forum
IGEF-SO	Indo-German Energy Forum Support Office
JAU	Junagadh Agriculture University
JISL	Jain Irrigation Systems Limited
KUSUM	Kisan Urja Suraksha evam Uthaan Mahabhiyaan
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
NHPC	National Hydroelectric Power Corporation
NHRDF	National Horticultural Research and Development Foundation
NISE	National Institute of Solar Energy
NSEFI	National Solar Energy Federation of India
NTPC	National Thermal Power Corporation
PBI	Performance-based Incentive
PPA	Power Purchase Agreement
REPP	Renewable Energy Power Project
SECI	Solar Energy Corporation of India
STP	Sewage Treatment Plant
TNERC	Tamil Nadu Electricity Regulatory Commission
WUA	Water User Associations



Executive Summary

India's twin imperatives of expanding clean energy capacity and ensuring sustainable agricultural productivity have brought renewed focus to the potential of agrivoltaics, a land-use model that enables simultaneous cultivation and solar energy generation on the same parcel of land. As a land-efficient, climate-smart solution, it holds the potential to align multiple national objectives: renewable energy expansion, farmer income diversification, and productive land use in a water- and climate-constrained future.

This report on Agrivoltaics in India records major progress in the deployment and experimentation of agrivoltaics systems in the country. Since the last issuance of this report in July'23, the number of documented agrivoltaics project sites has increased from 24 to 36 sites, with 12 new sites added across various agro-climatic zones. This growing portfolio is an indicator of India's deepening interest in the synergy between renewable energy generation and sustainable agricultural practices. Some of the key details of this report are:

>10,000 MW

of solar capacity has been sanctioned for installation across 18 states

36

Total Operating Project - Sites

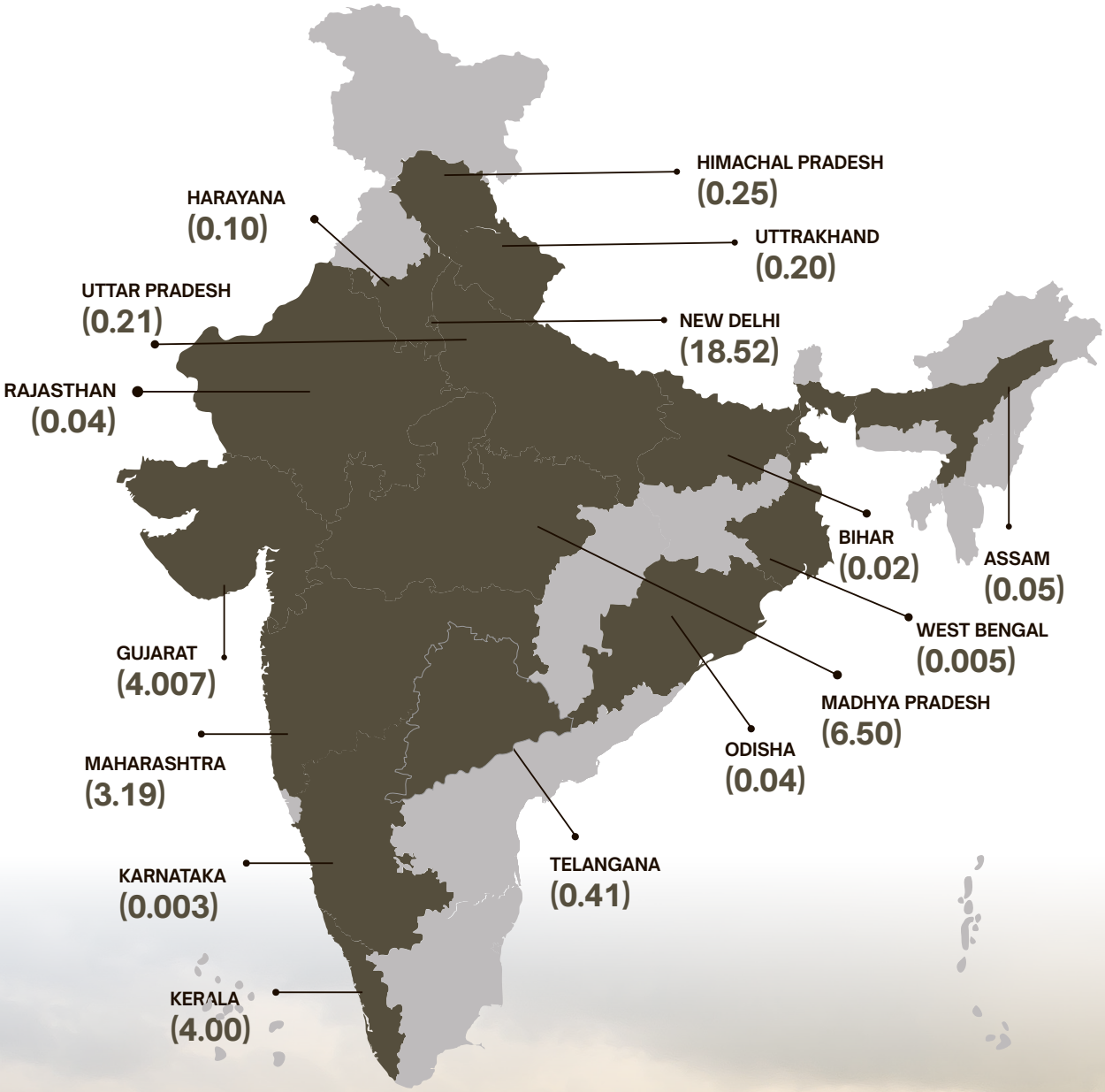
16

States Covered

37.54 MW

Cumulative installed capacity





Total Capacity (MW)

Research institutions, private developers, government utilities, and farmer cooperatives taking up agrivoltaics shows an increase in stakeholder confidence. Apart from farmer led Agri-PV projects, various other models of projects, such as government-owned pilot projects, research pilots, commercials projects, and community-based models are emerging in India.

This report provides a focused documentation of India's current agrivoltaics landscape, with particular emphasis on technical configurations, crop-level outcomes, and institutional arrangements. It covers 37 agrivoltaics sites across 16 states, including both operational projects and those in advanced stages of development. The sites represent a mix of government and research-led pilot installations, farmer-initiated and cooperative-driven projects, as well as private sector investments. The report draws upon site visits, stakeholder consultations, and technical design documentation to create a consolidated evidence base.

The motivation for this study stems from the increasing number of independent agrivoltaic experiments emerging across different agro-climatic zones, often without a clear regulatory framework or standardized technical guidance. While individual projects have started to produce valuable data on system performance and design, a national-level synthesis of technical learnings, crop outcomes, financial models, and institutional barriers has been lacking. This report aims to bridge that gap by compiling distributed knowledge into a single reference document that can guide future scaling, policy formulation, and investment strategies.

This report includes a comparative analysis showing that elevated structures, particularly those integrating bifacial panels with drip irrigation, deliver higher land-equivalent ratios (LER) and better crop performance under partial shading. Shade-tolerant crops such as spinach, legumes, millets, and turmeric have performed reliably across multiple sites, with minimal yield penalties and, in some cases, yield gains. At the system level, energy generation has remained consistent with site-level solar potential, and the ability to recover part of capital investment through solar revenues strengthens project viability. However, significant constraints persist including inconsistent design standards, lack of crop-specific agronomic guidance, limited access to concessional finance, and absence of a national-level regulatory definition have all contributed to project fragmentation and slow scale-up.

The report concludes by outlining a structured roadmap for institutional and policy action. Recommendations include formal recognition of agrivoltaics within national land use and energy frameworks; development of agrivoltaics specific design and performance standards; piloting of blended finance models that include risk-sharing for farmers and developers; and establishment of performance monitoring protocols across agro-climatic zones. The report recommends the need for inter-ministerial convergence particularly between Ministry of New and Renewable energy, Ministry of Agriculture & Farmer's Welfare, and Ministry of Rural Development as a precondition for scaling agrivoltaics beyond isolated pilots. If supported through targeted policy reform and institutional alignment, agrivoltaics can contribute meaningfully to India's 2030 targets while offering a replicable model for integrated land use and climate resilient agriculture.





Introduction

India's energy and agricultural priorities are increasingly converging on the same land. With the levelized cost of solar energy now lower than that of coal-based generation, policy and investment focus have decisively shifted toward large-scale solar deployment. India has committed to achieving 500 GW of installed renewable energy capacity by 2030, with solar energy expected to contribute approximately 300 GW.

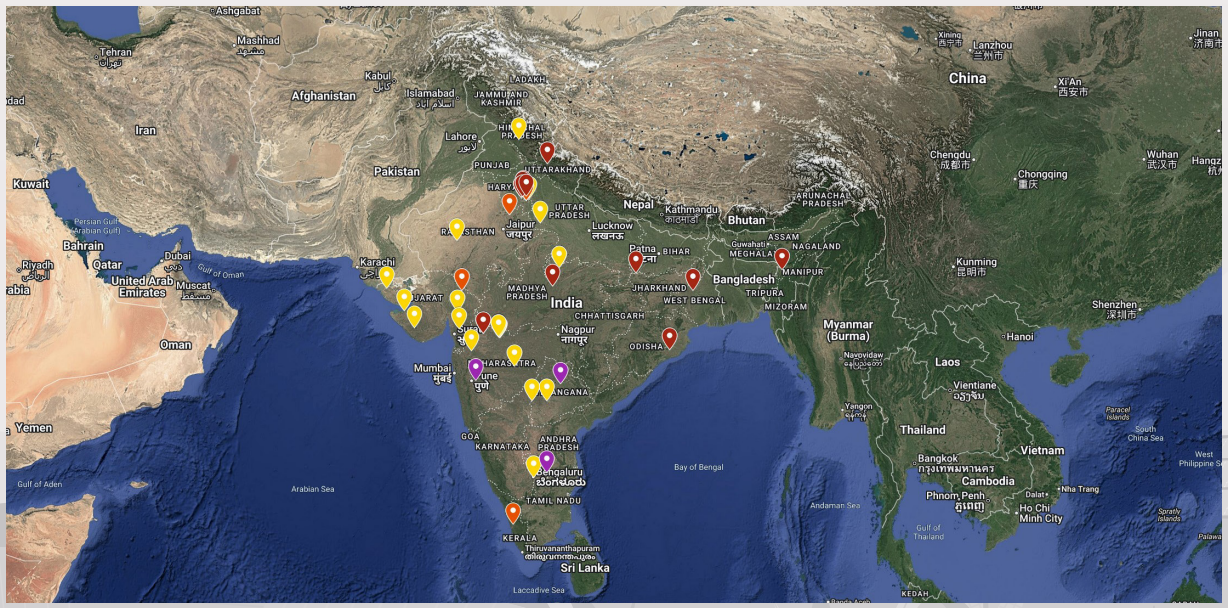
As an emerging economy, India has witnessed a rapid increase in electricity demand in recent years and is projected to sustain this growth at an annual rate of over 6 percent [1]. With no signs of this momentum slowing, the country is on course to significantly expand its power generation capacity[12]. In line with global decarbonization efforts, the Government of India has set an ambitious renewable energy target of 500 GW by 2030, with approximately 300 GW expected from solar energy [13].

At the same time, the agriculture sector continues to face deep-rooted structural challenges, including land fragmentation, resource degradation, and increased climate vulnerability. In this context, agrivoltaics has emerged as a promising solution, offering the ability to use the same land for both energy generation and agricultural production. Against this backdrop, there is a growing need to understand how agrivoltaics is being adopted on the ground, what implementation models are emerging, what outcomes are being observed, and what institutional conditions are enabling or constraining its deployment.

Overview of Agrivoltaics Projects in India

Interactive map with location of all plants covered in this report can be found here. Any plants to be added or any information to be modified kindly get in touch with **_agropv@energyforum.in or admin@nsefi.in.**

Agrivoltaics Map | Agrivoltaics website :



Description of Projects

1. Khare Energy Private Limited- 4.5 MW- under PM KUSUM

Table 1. Properties of 4.5 MW Agrivoltaics project by Khare Energy Pvt. Ltd.

Project name	Adarsh Jeevan Solar Farm
Date of commission	01-02-25
Installed capacity	4.5 MWp (2.25+2.25 MWp)
State, city	Sagar, Madhya Pradesh
GPS location	23°47'14.1"N 78°43'41.9"E
Project Objective	Farmer Income Enhancement, PM KUSUM-A, Commercial and Research.
Ownership	Farmer - Mr. Anand Jain and Mrs. Manoj Jain
Project developer	Khare Energy Pvt Ltd., Indore
EPC (Engineering, Procurement, and Construction)	Khare Energy Pvt Ltd., Indore
Operation & Maintenance	Khare Energy Pvt Ltd., Indore
Research Partner	Technical - Khare Energy Pvt Ltd., Indore Agricultural - Open for partnership / support
Consumption of Power	Grid Export under PM KUSUM-A at INR 3.07 Rs/unit under 25 years PPA with MP Government
Type of Agrivoltaics Plant	Proprietary Elevated RCC Structure for Agri-PV Applications by Khare Energy Pvt Ltd
Module Technology	Top-con Bifacial
Mounting Structure	Fixed Tilt, 3.5 Mtr, 20 degree
Tracking	N.A.
Cleaning	Manual, Water based, Water reused in agricultural activities
Water Management	Rainwater harvesting at farm point, drip and sprinkler irrigation
Crops	Capsicum, Tomato, Garlic, Onion, Mustard, Wheat, Maize, Spinach, Strawberries, Lettuce, Broccoli, Capsicum, Baby corn
Farming Activity	Intercropping, rotational farming, all three crops i.e. Rabi, Kharif and Zayad, mulching and drip irrigation, seasonal crop as well as long term fruit plantation
Brief of the Project	Adarsh Jeevan Solar Farm in Sagar, Madhya Pradesh, is a flagship agrivoltaics project by Khare Energy Pvt. Ltd., developed under the PM-KUSUM-A scheme. Spread across 16 acres, the farm combines elevated solar generation with multi-crop farming, showcasing Khare Energy's proprietary RCC-based structure. This model enables dual land use, promotes organic agriculture, and enhances farmer incomes while contributing clean energy to the grid. The project has been recognized by national and international stakeholders, including GIZ, EY, and IARI.
Key Objectives	Demonstrate scalable agrivoltaics infrastructure for rural India Optimize land productivity by integrating solar energy with agriculture Enhance farmer income through diversified cropping and energy co-benefits Promote climate-resilient and water-efficient farming practices Support government goals on renewable energy and sustainable livelihoods

Project name	Adarsh Jeevan Solar Farm
Additional Information, if any	Adarsh Jeevan Solar Farm, developed by Khare Energy Pvt. Ltd. in Sagar, Madhya Pradesh, is a 4.5 MWp (2.25 + 2.25 MWp) agrivoltaics project under PM-KUSUM-A, spanning 16 acres. With a total cost of ₹9.5 Cr / 2 MW, the project is financed through 70% bank loan and 30% farmer equity. It features Khare Energy's proprietary elevated RCC structures, enabling dual use of land for solar energy generation and diversified cropping. The project ensures dual revenue: ₹1.1–1.2 Cr/year/2 MW from power sales via a 25-year PPA, and ₹10–12 lakh/year/ 2MW from agri-horti produce. Digitally managed through Khare's in-house Agri-PV SaaS, the model yields an IRR of over 15% with a payback of 7–8 years, and is a scalable benchmark for sustainable, farmer-owned solar infrastructure.

Figure 1. **Crops grown at the 4.5MW plant by Khare Energy Pvt. Ltd.**



Figure 2. **Panel structures of the 4.5 MW plant by Khare Energy Pvt. Ltd.**



2. Talf Solar India- 4.25 MW

Table 2. **Properties of 4.25 MW Agrivoltaics project by Talf Solar**

Project name	4.25 MW Agrivoltaics project supplying power to leading educational institutions, including Hindu College, Miranda House, Hansraj College, St. Stephens College
Date of commission	12-04-24
Installed capacity	4.25 MWp DC
State, city	Delhi
GPS location	https://maps.app.goo.gl/m7gFoiXAnCcQCiug8
Project Objective	Supply solar power to non-profit institutions in Delhi, helping them save on their electricity bills, and supplementing the income farmers can earn from their land, while at the same allowing the continuation of agricultural income for the farmers through the use of spaced-out, extra high solar structures.
Ownership	Private Developer
Project developer	Talf Solar India
EPC (Engineering, Procurement, and Construction)	Handled in-house
Operation & Maintenance	Handled in-house
Research Partner	N.A.
Consumption of Power	Grid export, for ultimate use by non-profit educational institutions
Type of Agrivoltaics Plant	Elevated structure with extra spacing and single axis tracker.
Module Technology	Confidential
Mounting Structure	High-Rise structure. Other information is confidential
Tracking	None
Cleaning	Manual, once per week
Water Management	Mix of sources
Crops	Grain crops for now, other options being explored with the support of GIZ.
Farming Activity	The farmers that own the land and others
Lessons Learnt/ Challenges	There is very little knowledge of what crops work best in Agrivoltaics projects, that balance the requirements of the solar plant and agricultural activities. Support from agencies / universities to help in this endeavor would be welcome.
A Brief about the Project	The project was conceived in 2022 however, its implementation took far longer than anticipated due to the uncertainties caused by uncertainties in various policies.
Additional Information, if any	Talf Solar invested in spaced-out, high-rise structures and the use of glass-backed panels, despite the cost implications in order to improve the yield of agricultural activities.

Figure 3. Crops grown at the 4.2 MW plant by Talf Solar



Figure 4. Panel structures of the 4.2 MW plant by Talf Solar



3. Bosch Limited- 4 MW

Table 3. **Properties of project at Cochin Airport**

Project name	Cochin International Airport Limited (CIAL)
Date of commission	18-08-2015
Installed capacity DC	4 MWp DC
State, city	Kerala, Cochin
GPS location	10.15667, 76.38253
Type of project	Commercial
Project developer	Bosch Ltd.
EPC	Bosch Ltd.
Ownership structure	Cochin International Airport Limited (CIAL)
Operation & Maintenance	Sun Ray Products Pvt. Ltd.
Scientific partner	N.A.
Financing structure	PPA with Kerala State Electricity Board. Debt financed by Deutsche Bank
Type of Agrivoltaics plant	Interspace
Module technology	265Wp Renesola polycrystalline, centralized inverters 1MW by ABB India with MPPT (refers to only one part of the plant)
Mounting structure	Conventional ground-mounted PV design
Tracking	N.A.
Cleaning & water management	Manual cleaning with water Water used for crop irrigation Cleaning is required about two times per month
Agricultural aspects	N.A.
Crops	-Over 20 different vegetables, among them: yam, long yard bean, drumstick, mountain ginger, turmeric, cabbage, cauliflower, snake gourd, bitter gourd, bottle gourd, ash gourd, blonde cucumber, eggplant, tomato, pumpkin, and okra The edges of the area are also further beautified by curry leaf trees, drumstick trees, buddha bamboo, small mango trees, as well as eugenia and alamanda flowers
Crop cultivation	Formerly barren land has been improved by applying natural fertilizers like cow manure 60-80 tons per year cumulative production reported Fully organic cultivation
Further aspects	N.A.

The Cochin Airport boasts an impressive array of eight solar plants situated within its premises. Among these, the largest solar plant spans a vast area of 45 acres, with approximately 20 acres dedicated to Agrivoltaics practices as of December 2021.

While detailed information on the Agrivoltaics project at Cochin Airport was limited during the time of this report, the project has reported a cumulative annual production of approximately 60- 80 tons through completely organic cultivation. Moreover, the airport has established strong market connections and directly sells its agricultural produce to regular consumers and passengers, generating additional revenue. This agricultural endeavour predominantly involves interspace cultivation, contributing to its success.

Figure 5. **Agrivoltaics plant at Cochin Airport (Credit: CIAL)**



Figure 6. **Agrivoltaics plant with elephant foot yam at Cochin Airport (Credit: CIAL)**



4. Sunmaster Private Limited- 4 MW

Table 4. Properties of Sunmaster Agri PV Plant Mundela- 4MW

Project name	Sunmaster Agri PV Plant Mundela
Date of commission	15-05-2025
Installed capacity	4 MWp DC
State, city	New Delhi, India
GPS location	28.600498, 76.894432
Project Objective	The purpose of this plant was to conceptualize and promote the integration of solar energy with mobility, as it is located adjacent to the DTC EV bus depot. The electricity generated by the solar system is intended for use within the depot, supporting the transition to electric mobility. Additionally, the project aligns with the vision of our Honourable PM Modi Ji for last-mile independent electricity connectivity, aiming to enhance energy access. The initiative also involves increasing open areas by 50% to expand cropping opportunities and diversify cropping patterns, ultimately boosting farmers' income through multiple cropping practices.
Ownership	Private Developer
Project developer	SAEV P LTD
EPC (Engineering, Procurement, and Construction)	SAEV P LTD (Sunmaster)
Operation & Maintenance	SAEV P LTD (Sunmaster)
Research Partner	N.A.
Consumption of Power	Local consumption + Export to DTC Bus Depot
Type of Agrivoltaics Plant	Elevated Structure 1.4Acre/Mw with 3.5mtr Elevation
Module Technology	CUT CELL BIFACIAL N TYPE TOPCON
Mounting Structure	12 Degree / 3.5 Meter / Fixed /15% open area
Tracking	N.A.
Cleaning	Robotic Cleaning
Water Management	Rainwater / Drip / Borewell
Crops	Finger Millet (Ragi), Broccoli, Foxtail Millet (Setaria italica), Cauliflower, Kodo Millet (Paspalum scrobiculatum), Asparagus, French Beans, Potatoes, Mushrooms, Cherry Tomatoes, Onions, Spring Onions, Spinach, Kale, Lettuce, Carrots, Beets, Radishes, Broccoli, Cauliflower, Asparagus (perennial, tolerates some shade), Snow Peas, Mushrooms.
Farming Activity	Seasonal Variation / Rotational Farming
Lessons Learnt/ Challenges	A challenge faced is the integration and connectivity with the power grid.
A Brief about the Project	This project not only promotes eco-friendly energy solutions but also enhances agricultural productivity and income opportunities for local farmers through multi-cropping practices. Overall, the initiative contributes to sustainable development, clean energy adoption, and improved rural livelihood.

5. Sunmaster Private Limited- 2. 8 MW

Table 5. **Properties of SunMaster Agrivoltaics System**

Project name	SunMaster APV
Date of commission	26-03-2021
Installed capacity DC	2 MWp
State, city	Delhi, India
GPS location	28.58209, 76.86706
Type of project	Research
Project developer	SunMaster
EPC	SunMaster
Ownership structure	Private
Operation & Maintenance	SunMaster & dedicated cleaning company
Scientific partner	N.A.
Financing structure	N.A.
Type of Agrivoltaics plant	Overhead, 4.3m elevation
Module technology	SunPower
Mounting structure	Hot Dip Galv
Tracking	Fixed Tilt
Cleaning & water management	Telescopic water brush and manual dry cleaning
Agricultural aspects	Research field
Crops	Brinjals, Lettuce, Spinach, Lady Finger, Potatoes, Tomatoes, Bottle Guard, Fenugreek, Coriander, Cucumber
Crop cultivation	Mango, turmeric, pomegranate
Further aspects	Massive steel structure and foundations

Figure 8. **Below Panel View of SunMaster APV plant, Delhi (Credit: SunMaster**



6. Sunmaster Private Limited- 2.5 MW

Table 6. **Properties of Sunmaster Agri PV Plant Issapur Dhasa 2 - 2.5 MW**

Project name	Sunmaster Agri PV Plant Issapur Dhasa 2
Date of commission	20-10-2023
Installed capacity	2500 kWp DC
State, city	New Delhi, India
GPS location	28°34'18.7"N 76°51'23.0"E
Project Objective	The focus is on advancing farming practices through research and demonstration, utilizing techniques like bifacial solar panels. By optimizing land for multiple uses and increasing open areas by 22%, the aim is to multiply farmer income significantly.
Ownership	Private Developer
Project developer	SAEV P LTD
EPC (Engineering, Procurement, and Construction)	SAEV P LTD (Sunmaster)
Operation & Maintenance	SAEV P LTD (Sunmaster)
Research Partner	N.A.
Consumption of Power	Local consumption + Export to Grid
Type of Agrivoltaics Plant	Elevated Structure 1.6Acre/Mw
Module Technology	MONO PERC CUT CELL BIFACIAL
Mounting Structure	13 Degree / 5 Meter / Fixed / 22% open area
Tracking	N.A.
Cleaning	Water-based/Dry cleaning; Frequency: Weekly
Water Management	Rainwater / Drip / Borewell
Crops	Finger Millet (Ragi), Broccoli, Foxtail Millet (Setaria italica), Cauliflower Kodo Millet (Paspalum scrobiculatum), Asparagus, French Beans, Potatoes, Mushrooms
Farming Activity	Seasonal Variation / Rotational Farming
Lessons Learnt/ Challenges	It was observed that millet crops can be grown in areas with light to moderate shade, in addition to regular seasonal vegetables. Manual cleaning of solar panels was a challenge; however, this was addressed by implementing a robotic cleaning system, which reduced the cleaning frequency to twice a month.
A Brief about the Project	The project seeks to leverage solar energy to effectively fulfill the region's power requirements. Its primary objectives focus on decreasing dependence on non-renewable resources, encouraging sustainable agricultural methods, and fostering environmentally conscious growth. Notable outcomes of the initiative include the construction of a substantial solar photovoltaic facility, substantial reductions in energy expenses for local farmers and businesses, and the advancement of renewable energy usage within the community.



Figure 9. Aerial View of the Sunmaster Agri PV Plant Issapur Dhasa 2 - 2.5 MW



Figure 10. Panel Structure at the Sunmaster Agri PV Plant Issapur Dhasa 2 - 2.5 MW



Figure 11. Cow shed at the Sun master Agri PV Plant Issapur Dhasa 2 - 2.5 MW



7. Sunmaster Private Limited- 2.4 MW

Table 7. **Properties of Sunmaster Agri PV Plant Qutabgarh – 2.4 MW**

Project name	Sunmaster Agri PV Plant Qutabgarh
Date of commission	01-04-2024
Installed capacity	2400 kWp DC
State, city	New Delhi, India
GPS location	28.796869, 76.963013
Project Objective	Research, showcasing practical applications, optimizing dual-use land, increasing farmer income, and generating energy for last-mile connectivity.
Ownership	Private Developer
Project developer	SAEV P LTD
EPC (Engineering, Procurement, and Construction)	SAEV P LTD (Sunmaster)
Operation & Maintenance	SAEV P LTD (Sunmaster)
Research Partner	N.A.
Consumption of Power	Local consumption + Export to Grid
Type of Agrivoltaics Plant	Elevated Structure 1.3Acre/Mw
Module Technology	MONO PERC CUT CELL BIFACIAL
Mounting Structure	15 Degree / 4.2 Meter / Fixed / 9% open area
Tracking	N.A.
Cleaning	Water-based/Dry cleaning; Frequency: 15 Days
Water Management	Rainwater / Drip / Borewell
Crops	Spinach, Coriander (Cilantro), Fenugreek, Lettuce, Carrot, Turnip, Sweet potato, Beetroot, Ginger, Radish, Onion.
Farming Activity	Seasonal Variation / Rotational Farming
Lessons Learnt/ Challenges	The challenge lies in establishing an agricultural PV plant while supporting multiple cropping systems, especially given that the water's TDS (Total Dissolved Solids) levels and salinity in the specified coordinates are highly unfavorable for vegetation growth. Managing saline or brackish water conditions and mitigating their impact on crops is crucial for the success of integrated farming and solar plant development.
A Brief about the Project	The vision of this Agrivoltaics farm was to maximize power generation and manage high TDS (salinity) levels effectively by optimizing the solar tilt angle to be lower. This approach aims to enhance energy production while accommodating the challenging water quality conditions, supporting sustainable agricultural and renewable energy integration.

Figure 12. **Panel structures at the Agri PV Plant Qutabgarh – 2.4 MW**



Figure 13. **Panel structures at the Agri PV Plant Qutabgarh – 2.4 MW**



8. Talf Solar India- 2.25 MW

Table 8. Properties of 2.25MW Agrivoltaics Project by Talf Solar

Project name	2.25MW Agrivoltaics Project supplying power to Hospitals and schools
Date of commission	08-03-24
Installed capacity	2.25 MWp DC
State, city	Delhi
GPS location	https://maps.app.goo.gl/SskfqYyUV7QkK9AW6
Project Objective	Supply solar power to non-profit institutions in Delhi, helping them save on their electricity bills, and supplementing the income farmers can earn from their land, while at the same allowing the continuation of agricultural income for the farmers using spaced-out, extra high solar structures.
Ownership	Private Developer
Project developer	Talf Solar India
EPC (Engineering, Procurement, and Construction)	Handled in-house
Operation & Maintenance	Handled in-house
Research Partner	N.A.
Consumption of Power	Grid export, for ultimate use by hospitals and schools
Type of Agrivoltaics Plant	Elevated structure with extra spacing and single axis tracker.
Module Technology	Confidential
Mounting Structure	High-rise Single Axis tracker. The other requested information is confidential.
Tracking	Single Axis tracker. The other requested information is confidential.
Cleaning	Manual, once per week
Water Management	Mix of sources
Crops	Grain crops for now, other options being explored with the support of GIZ.
Farming Activity	The farmers that own the land
Lessons Learnt/ Challenges	There is very little knowledge of what crops work best in Agrivoltaics projects, that balance the requirements of the solar plant and agricultural activities. Support from agencies / universities to help in this endeavor would be welcome.
A Brief about the Project	The project was conceived in 2021; however, its implementation took far longer than anticipated due to the uncertainties caused by uncertainties in various policies.
Additional Information, if any	Talf Solar invested in spaced-out, high-rise structures despite the cost implications in order to improve the yield of agricultural activities.

Figure 14. Aerial view of the 2.25 MW plant by Talf Solar



Figure 15. Crops grown at the 2.25 MW plant by Talf Solar



9. Khare Energy Private Limited- 2 MW

Table 9. **Properties of Indra Solar Farm 2- Khargapur**

Project name	Indra Solar Farm
Date of commission	18-11-22
Installed capacity	2 MWp
State, city	Khargapur, Tikamgarh, Madhya Pradesh
GPS location	24.818603, 79.161423
Project Objective	Farmer Income Enhancement, PM KUSUM-A, Commercial and Research.
Ownership	Farmer - Mr. Navin Khare
Project developer	Khare Energy Pvt Ltd, Indore
EPC (Engineering, Procurement, and Construction)	Khare Energy Pvt Ltd, Indore
Operation & Maintenance	Khare Energy Pvt Ltd, Indore
Research Partner	Technical - Khare Energy Pvt Ltd., Indore Agricultural - Open for partnership / support
Consumption of Power	Grid Export under PM KUSUM-A at INR 3.07 Rs/unit under 25 years PPA with MP govt
Type of Agrivoltaics Plant	1. Proprietary Elevated RCC Structure for Agrivoltaics Applications by Khare Energy Pvt Ltd 2. Shadenet mounted structure 3. Semi-elevated structure for goat grazing
Module Technology	Polycrystalline, Mono-PERC Bifacial, Top-con Bifacial
Mounting Structure	Fixed Tilt, 3.5 Mtr, 20 degree Fixed Tilt, 4.5 Mtr, 25 degree Fixed Tilt, 1.5 Mtr, 23 degree
Tracking	Proposed as new test block
Cleaning	Manual, Water based, Water reused in agricultural activities
Water Management	Rainwater harvesting at farm point, drip and sprinkler irrigation, Flood irrigation
Crops	Agricultural Crops: Wheat, Barley, Sorghum, Mustard, Groundnut, Green Gram Fodder: Napier Grass Horticultural Crops: Tomato, Potato, Brinjal, Chilli, Spinach
Farming Activity	Intercropping, rotational farming, sun grazing, all three crops i.e. Rabi, Kharif and Zayad, mulching and drip irrigation, seasonal crop as well as long term fruit plantation
Lessons Learnt/ Challenges	Agrivoltaics yield parity with open-field wheat cultivation, along with 25% water savings. Results currently under review by agronomy experts for formal validation

Project name	Indra Solar Farm
A Brief about the Project	Indra Solar Farm, established by Khare Energy Pvt. Ltd. in Khargapur, Madhya Pradesh, is the state's first Agrivoltaics plant and a 16-acre live laboratory under PM-KUSUM-A. It features 3 types of modules, 4 inverter technologies, and 5 elevated structure designs, integrated with farming, horticulture, and animal husbandry. Designed for field research and scalable demonstration, it enables clean energy generation alongside crop and livestock productivity. The project is digitally monitored via Khare's Agrivoltaics SaaS and serves as a national benchmark for Agrivoltaics innovation.
Additional Information, if any	Indra Solar Farm, developed by Khare Energy Pvt. Ltd. in Khargapur, Madhya Pradesh, is a 2 MWp Agrivoltaics demonstration and research project under PM-KUSUM-A, spread across 16 acres. With a total cost of ₹9.5 Cr, it is financed through 70% bank loan and 30% farmer equity. The project features Khare Energy's proprietary elevated RCC structures, along with three types of solar modules, four inverter technologies, and five structural designs, enabling advanced performance benchmarking under real farming conditions. Integrated with multi-cropping, horticulture, and animal husbandry, it delivers dual income: ₹1.1–1.2 Cr/year from power sales and ₹10–12 lakh/year from agri-horti-livestock activities. Fully monitored through Khare's Agrivoltaics SaaS, the project offers an IRR of over 15% and a 7–8 year payback and serves as a national model for research-led, climate-smart Agrivoltaics infrastructure.



Figure 16. Aerial picture of Indra Solar Farm-2



Figure 17. Crops grown at the Indra Solar Farm-2



10. Sunseed APV Private Limited & GIZ- 1.4 MW

Table 10. Properties of Agrivoltaics Site near Parbhani, Maharashtra

Project name	Agrivoltaics plant near Parbhani
Date of commission	12-11-2022
Installed capacity DC	1.4 MWp
State, city	Manwath, Maharashtra
GPS location	19.31373, 76.45862
Type of project	Research project
Project developer	Agriculture: SunSeed APV Pvt. Ltd. and GIZ Solar: N.A.
EPC	Kanoda Energy Systems Pvt. Ltd., SunSeed APV Pvt. Ltd.
Ownership structure	N.A.
Operation & Maintenance	N.A.
Scientific partner	SunSeed APV Pvt. Ltd.
Financing structure	N.A.
Type of Agrivoltaics plant	Test field for different types: see tables below
Water management	Land graded for water harvesting and drip irrigation system
Agricultural aspects	Jai Hind Agro Farm Management
Crop cultivation	Rotational cropping, residue-free crop cultivation
Further aspects	Crop cultivation commenced in January 2023

The plant is divided into 4 sections to investigate the benefits of various APV designs.

Table 11. Properties of Agrivoltaics plant near Parbhani, Section I

APV Parbhani Section I	
Type of Agrivoltaics plant	Elevated structure with shadehouse
Area	1.6 acres
Module technology	• Polycrystalline
Mounting structure	• Overhead 3.75m • Fixed tilt 11° • Pitch 5.64m
Cleaning & water management	• Robotic dry cleaning • Fogger system & Drip irrigation system
Crops	Cherry Tomato, Capsicum, Cucumber, Betel Leaves, Turmeric, Ginger, Basil, Spinach, Methi, Coriander, Mint, Rose, Chrysanthemum, Tuberose, Hibiscus, Marigold, Watermelon, Muskmelon

Table 12. Properties of Agrivoltaics plant near Parbhani, Section II + III

APV Parbhani Section II + III	
Type of Agrivoltaics plant	Below and interspace
Area	0.8 acres and 0.8 acres
Module technology	• Mono PERC
Mounting structure	• Height: 1,75m • Fixed tilt: 11° • Test field with two pitch distances: 10m (II) and 7.5m (III)
Cleaning & water management	• Occasional wet cleaning • Drip irrigation system
Crops	Section II: musk melon, coriander, spinach, fenugreek Section III: marigold, basil

Table 13. Properties of Agrivoltaics plant near Parbhani, Section IV

APV Parbhani Section IV	
Type of Agrivoltaics plant	Interspace
Area	0.8 acres and 0.8 acres
Module technology	• Bifacial PERC
Mounting structure	• Height: 1,25m • Fixed tilt: 11° • Pitch distance: 10m
Cleaning & water management	• Occasional wet cleaning • Drip irrigation system
Crops	Watermelon

Located in the Marathwada region of Maharashtra, Western India, the Agrivoltaics farm spans over 5 acres of land and boasts a remarkable capacity of 1.4 MW. Developed as a part of the larger 50 MW solar project, this innovative facility is a collaboration between SunSeed APV, Kanoda Energy, and GIZ German Development Cooperation. The primary aim of the project is to establish a harmonious relationship between solar energy generation and agriculture while showcasing the economic viability and bankability of APV systems.

The project encompasses four distinct APV configurations, alongside an open farming area that serves as a control environment for research purposes. Notably, a standout feature of the project is a 6000m² elevated system integrated with a shade net house, where trellising vegetables thrive. The use of highly reflective shade nets not only enhances PV generation but also promotes the albedo effect. Moreover, three of the APV setups, situated at lower elevations (1.25m and 1.75m), require only slightly higher capital costs compared to conventional solar projects.

To optimize water usage, the project has implemented an advanced water management system, complete with a drip irrigation network and soil moisture sensors in each crop section. Additionally, the shading effect of the PV panels and the application of mulch contribute to reduced evapotranspiration, resulting in further water conservation.

Furthermore, the project features extensive instrumentation, serving as a platform for research and development in both crop cultivation and solar energy generation. The research conducted here will pave the way for scientific approaches to designing and adapting Agrivoltaics projects, as well as the development of cultivation strategies specific to Agrivoltaics.

Figure 18. Overview of Agrivoltaics plant near Parbhani. (Credit: GIZ)



Figure 19. Section IV (Interspace) at Agrivoltaics plant near Parbhani (Credit: GIZ)



Figure 20. Soil preparation at section III (below and interspace) at Agrivoltaics plant near Parbhani (Credit: GIZ



Figure 21. Marigold growing at section II (below and interspace) at Agrivoltaics plant near Parbhani (Credit: GIZ)



Figure 22. Soil preparation at section I (fully elevated) at Agrivoltaics plant near Parbhani (Credit: GIZ)



Figure 23. Visitors examine green capsicum at elevated section I at Agrivoltaics plant near Parbhani (Credit: GIZ)



11.Sunmaster Private Limited- 1 MW

Table 14.Properties of Sunmaster Agri PV Plant Surakpur – 1 MW

Project name	Sunmaster Agri PV Plant Surakpur
Date of commission	11-04-2025
Installed capacity	1 MWp DC
State, city	New Delhi , India
GPS location	28.620331, 76.945732
Project Objective	Research, showcasing practical applications, optimizing dual-use land, increasing farmer income, and generating energy for last-mile connectivity.
Ownership	Private Developer
Project developer	SAEV P LTD
EPC (Engineering, Procurement, and Construction)	SAEV P LTD (Sunmaster)
Operation & Maintenance	SAEV P LTD (Sunmaster)
Research Partner	N.A.
Consumption of Power	Local consumption + Export to Grid
Type of Agrivoltaics Plant	Elevated Structure 2acre/Mw
Module Technology	MONO PERC CUT CELL BIFACIAL N TYPE TOPCON
Mounting Structure	14 Degree / 4 Meter / Fixed / 40% open area
Tracking	N.A.
Cleaning	Water-based/Dry cleaning; Frequency: 15 Days
Water Management	Rainwater / Drip / Borewell
Crops	Spinach, Coriander (Cilantro), Fenugreek, Lettuce, Carrot, Turnip, Sweet potato, Ginger, Radish, Onion.
Farming Activity	Seasonal Variation / Rotational Farming
Lessons Learnt/ Challenges	The challenges included grid integration issues, the availability of electric meters, and limited land availability for project implementation.
A Brief about the Project	The vision was to power and showcase the benefits of solar Agrivoltaics systems in every village, helping them achieve energy independence. This initiative aims to demonstrate sustainable energy solutions and contribute to the vision of our Honourable PM, promoting rural empowerment, clean energy adoption, and overall development.

12. GroSolar Agrivoltaics Interspace System- 1MW

Table 15. Properties of GroSolar Agrivoltaics interspace system

Project name	GroSolar APV
Date of commission	N.A.
Installed capacity DC	7 MWp with approximately 1 MWp under Agrivoltaics use
State, city	Sindakhede, Dhule, Maharashtra
GPS location	21.17731, 74.56914
Type of project	Research
Project developer	Mr. Gulabsing Girase
EPC	Panasonic Life Solutions
Ownership structure	Gro Solar Energy
Operation & Maintenance	GroSolar Energy
Scientific partner	N.A.
Financing structure	EPC Basis
Type of Agrivoltaics plant	Interspace
Module technology	30,300 Panasonic Anchor 72 Cell 330W PV Polycrystalline Modules made in India
Mounting structure	N.A.
Tracking	Fixed tilt
Cleaning & water management	N.A.
Agricultural aspects	Loamy sand
Crops	Geranium, Guava, Lemongrass
Crop cultivation	N.A.
Further aspects	Rearing of sheep is one main aspect of this Agrivoltaics plant and the low mounting structure allows for low height crops PPA with MAHAGENCO Electricity produced is also used to power homes in nearby villages and farmer's agricultural activities



Figure 24. Geranium plants in interspace farming of GroSolar APV site (Credit: GroSolar)



Figure 25. Grazing sheep enjoying grass below the panels. (Credit: GroSolar)



13. Gujarat Industry Solar Power Limited- 1MW

Table 16. Properties of GIPCL plant near Amrol, Gujarat

Project name	Amrol Distributed Solar Power Project
Date of commission	28-04-2016
Installed capacity DC	1 MWp
State, city	Gujarat, Amrol
GPS location	22.37903, 73.05033
Type of project	Commercial
Project developer	Gujarat Industries Power Company Ltd. (GIPCL)
EPC	GIPCL & local companies
Ownership structure	GIPCL
Operation & Maintenance	GIPCL
Scientific partner	Anand Agricultural University (AAU), Dr. Mevada
Financing structure	3.44 Rs./kWh in 2019 Generated power is directly fed into rural grid (11kV rural feeder in 12km distance) Minimum T&D losses: Down from 8 - 10% to about 1% Investment: 6 Crore INR/MWp; 60,000 INR/kWp
Type of Agrivoltaics plant	Interspace / Overhead stilted hybrid
Module technology	Monofacial, polycrystalline (310Wp)
Mounting structure	• 1-3m horizontal mounting height • Different configuration of PV arrays with gaps between panels of 0 / 100 / 250mm • Cables were put around agricultural fields, resulting in • higher costs due to longer lines, partly put under the ground up to 2.5m deep
Tracking	• - 5-28° manual tilting due to season every 2 months
Cleaning & water management	• Manual cleaning with telescope cloth • Cleaning period: Each 10 days / module • Water consumption approx. 3 l / module, own borewell to get water for cleaning • Total water consumption: 200,000 litre/MWp/yr. • No rain-gutter and no rain water harvesting • Water management system installed by the company Jain Irrigation
Agricultural aspects	• Loamy sand type soil, irrigation required, tractor can go between panels and partially below panels (which may need to be tilted to low angle)
Crops	• Kharif: Groundnut, soybean, pearl millet, cotton, green gram, pigeon pea, maize, cluster bean • Rabi: chickpea, wheat, mustard, lucerne, vegetables • Summer: additionally, sesame, fodder, black gram
Crop cultivation	• More than 40 crops tested, but results not yet published

The project was commissioned by Gujarat Industries Power Company Ltd. (GIPCL), Anand Agriculture University, a university renowned in Asia for cutting-edge research, is in charge of the plant's agricultural components. The panels are installed at a height of 3m on a mounting structure. Seasonal inclination can be adjusted manually. The plant has varying inter-module and inter-array gaps to investigate the effect of different shade patterns on crop growth.

Figure 26. GIPCL's Amrol plant (Credit: NSEFI)



Figure 27. Aerial view of GIPCL's Amrol plant (Credit: GIPCL)



GIPCL built and operates this plant with assistance from Navsari Agricultural University. It is a scale model of the GIPCL factory at Amrol, Anand. It is located at 21.41111, 73.12264

Figure 28. View of GIPCL's Vastan plant (Credit: GIPCL)



Figure 29. Harvesting at GIPCL's Vastan plant (Credit: GIPCL)



14. Gujarat State Electricity Company Limited- Harsha Abakus- 1MW

Table 17.Properties of Harsha Abakus plant near Sikka, Gujarat

Project name	1MW GSECL STPS Solar
Date of commission	02-05-2016
Installed capacity DC	1054 kWp
State, city	Gujarat, District Jamnagar, Sikka
GPS location	22.42277, 69.84348
Type of project	Commercial
Project developer	GSECL
EPC	Harsha Abakus
Ownership structure	Gujarat State Electricity Company Limited (GSECL) (Govt.)
Operation & Maintenance	Harsha Abakus
Scientific partner	Gantar NGO
Financing structure	• PPA with Gujarat Urja Vikas Nigam Limited (GUVNL) at Rs. • 3.22/kWh (20 yrs.), progressively raised by 0.05 INR/kWh • Investment: 5.75 Cr. INR/MWp; 57,500 INR/kWp • OPEX: Approx. 700 INR/kWp/yr
Type of Agrivoltaics plant	Interspace / Overhead Hybrid
Module technology	Monofacial, polycrystalline (310Wp)
Mounting structure	• Elevation height 3m • Cabling underground below tillage depth • 4.5 acre/MWp, 549 kWp/ha • Testing of different gaps between modules: 25 / 150 / 250mm
Tracking	• Manual single-axis tracking with seasonal tilt: 0,10° & 25° • Tilting angle possible above 85°
Cleaning & water management	• Proximity to a cement-producing industry (sticky sediment) • Manually cleaning with a stand, dry cleaning is not an option • 2-5 litres of water needed per module (every 7-8 days) • Rainwater harvesting found not cost efficient
Agricultural aspects	• Gritty, sandy soil • Plough/harrow must be lifted where AC cables are relocated (only once a season) • Pipes for drip irrigation • $5m^3$ & $22m^3$ tank for cleaning & drip irrigation
Crops	• Lady fingers, bottle gourd, coriander, cluster beans • Winter: Tomato, cucumber, ladyfingers, zucchini, chili • Summer: Moong dal
Crop cultivation	• No research has been done on the shading effects of APV setups on different crops and respective yields • Agriculture between rows, not below panels • Crops higher than 5-6ft cannot be grown

Project name	1MW GSECL STPS Solar
Further aspects	Challenges: • Cleaning • The structure is too high for efficient cleaning. • Water falling on the crops with force and the stand used for cleaning may damage flowers and crops • Water comes from the public network grid pipeline. • Tilting on segment of 20 panels each requires ~10 people • Proper maintenance of the drip irrigation system

The project is situated near Sikka in the Jamnagar district of Gujarat. The region experiences fluctuating seasonal temperatures ranging from 21°C and 35°C, with an average annual rainfall of 744mm. Although the sandy and gritty soil is suitable for certain crops, the site has never been utilized for agricultural purposes before. The project has been developed on land owned by Gujarat State Electricity Company Limited (GSECL), a state-owned utility.

The modules are mounted on a 3m steel structure, allowing for limited cultivation of crops through manual farming practices. Farming can be carried out between the module rows and directly below the PV modules. In the past 2.5 years, the project managed to successfully grow crops such as lady fingers, calabash (bottle gourd), coriander, and cluster beans in the summer season. Winter crops included tomatoes, cucumbers, zucchinis, and chillies. The responsibility for maintaining and planning the crops was assigned to an undisclosed private agriculture research organization.

The cabling system within the plant is fully underground, enabling regular ploughing of the field. Pipes are laid throughout the field for irrigation purposes, employing a drip irrigation-like system with pores for efficient watering of the crops. These pipes are connected to a central water tank with a volume of 22m3. During ploughing and seed sowing, the network of micro-irrigation pipes needs to be lifted, causing disruptions.

Due to the close proximity to a cement-producing industry, frequent cleaning of the modules is necessary. Dry cleaning has proven ineffective; thus a separate pipe connected to a 5m3 water tank on-site is used for manual cleaning of each array every 7- 8 days. According to data provided by Harsha Abakus, each cleaning consumes 2- 5 litres of water [14].

The power generated by the project is sold to Gujarat Urja Vikas Nigam Limited through a PPA with an incremental tariff structure spanning 20 years.

Figure 30. Panel view Gujarat State Electricity Company Limited- 1MW- Jamnagar



15. Gujarat State Electricity Company Limited – Harsha Abakus- 1MW

Table 18. Properties of Hasha Abakus plant near Pandharo, Gujarat

Project name	1 MW Agri Base Solar Power Plant
Date of commission	02-05-2016
Installed capacity DC	1054 kWp
State, city	Gujarat, District Kutch, Pandhro
GPS location	23.66482, 68.77906
Type of project	Commercial
Project developer	Harsha Abakus
EPC	Harsha Abakus
Ownership structure	Government-owned: Gujarat State Electricity Company Limited (GSECL)
Operation & Maintenance	Harsha Abakus
Scientific partner	Gantar NGO
Financing structure	PPA with Paschim Gujarat Vij Company Limited (PGVCL) at Rs. 3.22/kWh (20 yrs.)
Type of Agrivoltaics plant	Interspace / Overhead hybrid
Module technology	Monofacial, polycrystalline (310Wp)
Mounting structure	Sister plant to Sikka
Tracking	Sister plant to Sikka
Cleaning & water management	Netafim drip irrigation
Agricultural aspects	Rocky land without sufficient nutrients
Crops	• Vegetable: Brinjal, cluster beans, coriander, ladyfinger, bottle gourd • Pulses: Green gram, sesame, split black gram, zucchini, peas
Crop cultivation	• Average crop height of 3-6ft. • Crops grown in summer and winter
Further aspects	• Challenges include cleaning through the network grid pipeline, theft of solar panels, and a structure height too high for easy cleaning

Pandhro, a village situated in the mining-dominated Kutch district, grapples with an arid climate characterised by temperatures ranging from 15°C to 27°C. The region receives meager annual rainfall, with precipitation levels averaging between 355 -375mm per annum. The project at Pandhro mirrors the 1MW Sikka plant developed by Harsha Abakus. In this instance, the PPA has been established with Paschim Gujarat Vidyut Company Limited (PGVCL). The mounting structure, PV design, operational attributes, and crop patterns remain consistent with the Sikka project.

Figure 31. **Harsha Abakus 1MW Panandharo plant (Credit: Hasha Abakus)**



16. Abellon Clean Energy Limited- 1 MW

Table 19. Properties of Abellon Energy plant

Project name	Abellon Energy plant in Aravalli District, Gujarat - 1 MW
Date of commission	28-01-2012
Installed capacity DC	3 MWp, with 1 MWp under AgriPV
State, city	Gujarat, District Aravali, Sardoi, Modasa Taluka
GPS location	23.55983, 73.28684
Type of project	Commercial
Project developer	Abellon Clean Energy Ltd, Ahmedabad
EPC	N.A.
Ownership structure	
Operation & Maintenance	N.A.
Scientific partner	N.A.
Financing structure	FiT (2015, 2016, 2017) of 0.23 USD/kWp, Gujarat Solar Policy
Type of Agrivoltaics plant	Interspace
Module technology	Poly crystalline 230W, 240W, 280W
Mounting structure	• 7.08 ha; 423 kWp/ha. • Conventional ground mounted PV design
Tracking	N.A.
Cleaning & water management	• Manual cleaning • Water used for cleaning modules irrigating the plants • Cotton fibre is used to keep moisture on the ground
Agricultural aspects	Rocky soil, porous, less retention capacity
Crops	• Vegetables: bottle gourd, lady finger • Fruits: watermelon • Spices: turmeric, ginger, chili
Crop cultivation	N.A.
Further aspects	• Henna plants encircling the solar plant as secondary wind braking barrier

Located in the semi-arid climate of the Aravalli mountain range foothills, this plant benefits from its position in the tropic of cancer, enjoying ample sunlight. The temperature ranges from 15°C to 45°C. With an average annual rainfall of 690mm in Modasa taluka, Aravalli district, the region receives a sufficient amount of precipitation. The soil, though rocky and porous with low retention capacity, is not well-suited for cereal crop cultivation. In this plant, module cleaning is carried out manually, with the water used for cleansing directly irrigating the interspace cropping area. As an additional measure, henna plants surround the solar plant, acting as a secondary wind braking barrier.

Figure 32. **Interface farming at Abellon Energy plant (Credit: Abellon Energy)**



Figure 33. **Cleaning of Solar PV'**





17. Sunseed Private Limited, Kanoda Energy and GIZ- 500kW

Table 20. Properties of Agrivoltaics plant near Nashik

Project name	Agrivoltaics plant near Nashik
Date of commission	08-2023
Installed capacity DC	250 kWp (later 500 kWp)
State, city	Sahyadri Farms, Nashik, Maharashtra
GPS location	20.16144, 73.8791
Type of project	Research
Project developer	Sunseed APV, Kanoda Energy and GIZ
EPC	WRS
Ownership structure	Sahyadri Farms
Operation & Maintenance	Farming operations: Sahyadri Farms Technical O&M: WRS
Scientific partner	SunSeed APV and GIZ
Financing structure	N.A.
Type of Agrivoltaics plant	Fully elevated single axis tracking
Module technology	Bifacial
Mounting structure	Scorpius & SunSeed APV single axis tracker
Tracking	Yes
Cleaning & water management	Robotic
Agricultural aspects	Research field
Crops	Grapes, oranges, raspberry, tomato, strawberry
Crop cultivation	Orchards
Further aspects	N.A.

Figure 34. Lemon plantation under elevated solar PV (Credit: GIZ)



18. Mahindra Susten- 400kW

Table 21. Properties of Mahindra Susten plant

Project name	Clean Solar Private Limited, Tandur
Date of commission	2016
Installed capacity DC	36.6 MWp (~400kW with Agrivoltaics)
State, city	Telangana, District Tandur, Gingurthy Village
GPS location	17.36825, 77.54105
Type of project	Commercial, partly research
Project developer	Mahindra Susten, in-house development
EPC	Private PPA
Ownership structure	Mahindra Teqo
Operation & Maintenance	Kancor Mane, an Indo-French Spice producing company, CII
Scientific partner	N.A.
Financing structure	Economic assumptions: • 18,000 INR/MWp/yr weeding costs • 1.5 to 2 lakh INR/ha gross income through lemon grass oil
Type of Agrivoltaics plant	interspace
Module technology	Thin film (170Wp) Mono-/ Policy-crystalline (310Wp; 315Wp) SAT & Fixed Tilt Combined
Mounting structure	Conventional ground-mounted PV design
Tracking	N.A.
Cleaning & water management	• Manual cleaning • 2.5 Ltr/Panel • Fortnightly Wet Cleaning • Rain gutter/ drainage system is possible as the area has lots of natural drains • Water harvesting for cleaning water is possible, but not a lot of rain
Agricultural aspects	• Loamy soil, sandy loam, sandy clay loam • Tractor way is free between rows
Crops	• Main crop: lemon grass • Other crops: annatto dye, brinjals, lady finger, green chilies, onions
Crop cultivation	• 2 to 3 ft • Round-the-year harvest • 60 to 70 litres of lemon grass crude oil • Less soil erosion • 1 acre cultivated • Lemon grass requires minimal water, suitable for rainfed conditions
Further aspects	N.A.

Figure 35. **Mahindra Susten plant at Tandur with seedlings planted (Credit: Mahindra Susten)**



Figure 36. **Mahindra Susten plant at Tandur with lemon grass (Credit: Mahindra Susten)**



19. Jain Irrigation- 290 kW

Table 22. Properties of Jain Irrigation Banana Pilot

Project name	Jain Irrigation Banana Pilot
Date of commission	2014
Installed capacity DC	14.4 kWp
State, city	Jalgaon, Maharashtra
GPS location	20.99146, 75.50704
Type of project	Research
Project developer	Jain Irrigation, in-house development
EPC	N.A.
Ownership structure	Jain Irrigation
Operation & Maintenance	Jain Irrigation
Scientific partner	Jain Irrigation
Financing structure	Internal funding
Type of Agrivoltaics plant	Overhead stilted
Module technology	• In-house production • 240W panel, polycrystalline
Mounting structure	• Mounting structure design nearly allows 95% use of land area below panels • >5m height, 500m^2; 288 kWp/ha • Machinery operated below modules
Tracking	• Single axis
Cleaning & water management	• Manual
Agricultural aspects	• Black fertile soil
Crops	• Banana • Experimentation with maize in 2014
Crop cultivation	• Reported yield impacts: 14-34.5 ton/acre (+140%) bananas; water use (-) 55% • Crop height: 4 – 5m

Figure 37. 14.4 kW Agrivoltaics structure with banana (Credit: Jain Irrigation)



Table 23. Properties of Jain Irrigation Rice Pilot

Project name	Jain Irrigation Rice Pilot
Date of commission	2014
Installed capacity DC	9.6 kWp
State, city	Jalgaon, Maharashtra
GPS location	20.99146, 75.50727
Type of project	Research
Project developer	Jain Irrigation, in-house development
EPC	N.A.
Ownership structure	Jain Irrigation
Operation & Maintenance	Jain Irrigation
Scientific partner	Jain Irrigation
Financing structure	Internal funding
Type of Agrivoltaics plant	Overhead stilted
Module technology	• In-house production • 240W panel, polycrystalline
Mounting structure	• 3m height, 105m2 area; 533 kWp/ha • Machinery operated below modules
Tracking	• Fixed tilt
Cleaning & water management	• Drip irrigation installed • Manual cleaning of panels
Agricultural aspects	• Black fertile soil
Crops	• Rice
Crop cultivation	• 3.1 – 3.8 ton/acre (+22.5%) rice; water use (-) 33.7% • Crop height: 1 – 1.8m
Further aspects	N.A.

Figure 38. 9.6 kW Agrivoltaics system with rice (Credit: Jain Irrigation)



Table 24. Properties of Jain Irrigation Okra/Cotton Pilot

Project name	Jain Irrigation Okra/Cotton Pilot
Date of commission	2014
Installed capacity DC	50.4 kWp
State, city	Jalgaon, Maharashtra
GPS location	20.99245, 75.510641
Type of project	Research
Project developer	Jain Irrigation, in-house development
EPC	N.A.
Ownership structure	Jain Irrigation
Operation & Maintenance	Jain Irrigation
Scientific partner	Jain Irrigation
Financing structure	Internal funding
Type of Agrivoltaics plant	Overhead stilted
Module technology	• In-house production • 240W panel, polycrystalline
Mounting structure	• Single column
Tracking	• Dual axis
Cleaning & water management	• Manual • Drip irrigation
Agricultural aspects	• Black fertile soil • Tractor to be operated below the panels
Crops	• Cotton and okra
Crop cultivation	N.A.
Further aspects	N.A.

Figure 39. Agrivoltaics with 2-axis tracking and drip irrigation (Credit: Jain Irrigation)



Table 25. Properties of Jain Irrigation Turmeric/Ginger/Mint Pilot

Project name	Jain Irrigation – Tumeric/Ginger/Mint Pilot
Installed capacity DC	19.3 kWp 482.5 kWp/ha
GPS location	20.93792, 75.56204
Type of Agrivoltaics plant	Stilted 1.7 – 2.5m
Module technology	Semi-transparent glass-glass modules
Mounting structure	• Stilted 1.7 – 2.5m • Almost full shade on area of 400m²
Tracking	Fixed
Cleaning & water management	• Cleaning done by sprinkler system • Cleaning water is descaled to prevent chalk stains on panels
Crops	Turmeric, ginger, mint

Figure 40. 13.9 kW Agrivoltaics system with turmeric (Credit: Jain Irrigation)



Table 26. Properties of Jain Irrigation Greenhouse PV Pilot

Project name	Jain Irrigation Greenhouse-PV Pilot
Date of commission	N.A.
Installed capacity DC	200 kWp
State, city	Jalgaon, Maharashtra
Type of project	Research
Project developer	Jain Irrigation, in-house development
EPC	N.A.

Project name	Jain Irrigation Greenhouse-PV Pilot
Ownership structure	Jain Irrigation
Operation & Maintenance	Jain Irrigation
Scientific partner	Jain Irrigation
Financing structure	N.A.
Type of Agrivoltaics plant	Greenhouse
Module technology	Transparent Building Integrated Photovoltaic Modules (BIPV), 260Wp per Panel
Mounting structure	• 1100m² Greenhouse • Rooftop fully covered by PV modules
Tracking	• Fixed
Cleaning & water management	Irrigation system
Agricultural aspects	Additional LED lighting
Crops	Banana
Crop cultivation	Suitable for raising seedlings
Further aspects	N.A.

Figure 41. Jain Irrigation Greenhouse PV with Building Integrated Photovoltaic Modules (Credit: Jain Irrigation)

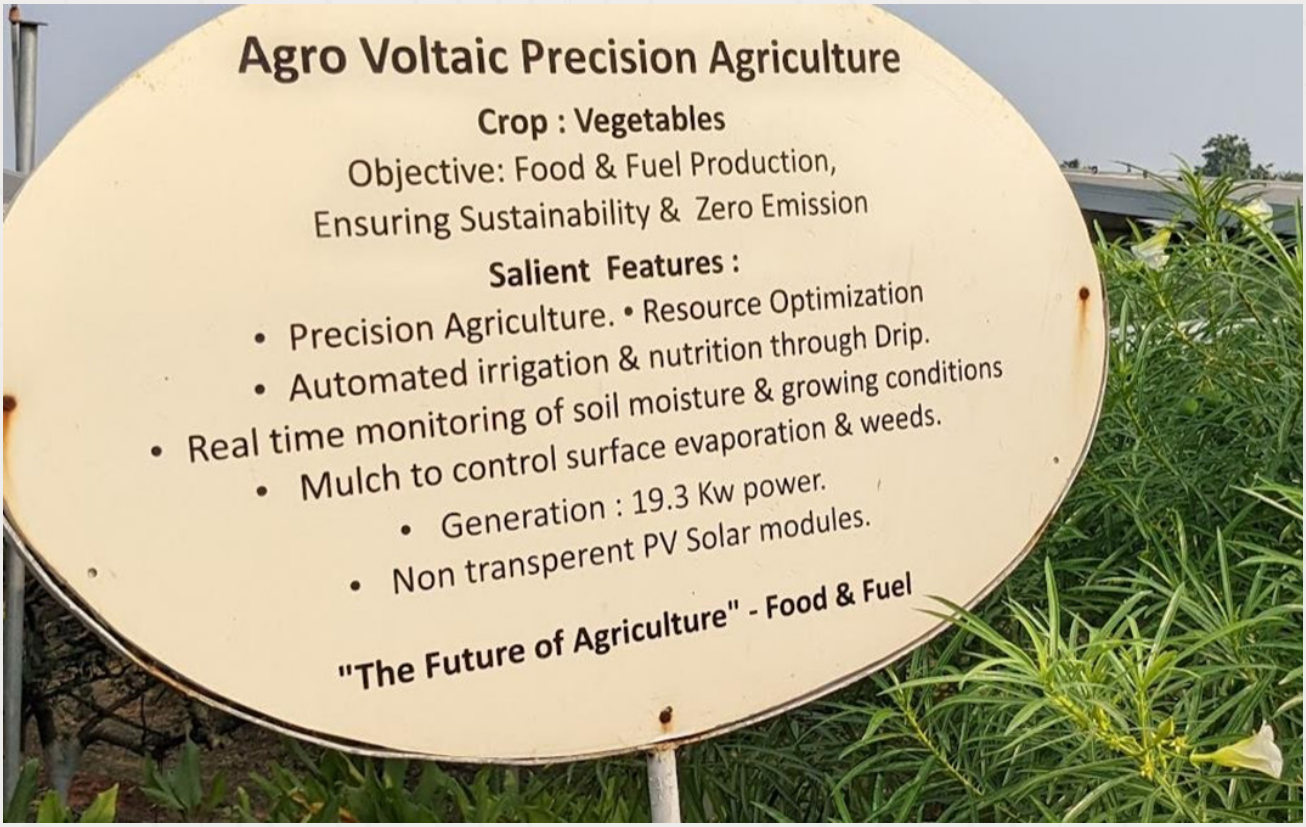


Figure 42. Information board at Jain Irrigation (Credit: Jain Irrigation)

Jain Irrigation Systems Limited (JISL) is an innovative water management company based in Jalgaon, India with a strong focus on farmers. Since 2012 [8], JISL has been actively exploring Agrivoltaics, a technique that combines agriculture and solar power. Dr. Bhavarlal Jain, founder of JISL, pioneered Agrivoltaics installations at their R&D farm, Tissue Culture Park, primarily to power agriculture pumps.

One of their successful experiments involved a 14.4kW Agrivoltaics structure covering a 600m2 area, where bananas were cultivated. In 2018, JISL expanded their research to include maize cultivation under the same structure. Another impressive initiative combined solar photovoltaics, drip irrigation, and low greenhouse gas-emission rice cultivation in a neighbouring plant. A third Agrivoltaics plant, equipped with drip irrigation, located 400m away, focused on cotton and okra production.

In addition to Agrivoltaics, JISL is actively working on a cutting-edge PV greenhouse concept. This concept involves fully covering the rooftop with PV modules while providing supplementary LED lighting. The goal of this innovative approach is to significantly reduce the hardening time of banana seedlings, optimizing their growth process.



20. Farmer (Owned)– 250 kW

Table 27. Properties of Agrivoltaics plant at Jahu, Himachal Pradesh

Project name	Sandhwani Solar Power Plant
Date of commission	N.A.
Installed capacity DC	250 kWp
State, city	Jahu, Himachal Pradesh
GPS location	31.57869, 76.73662
Type of project	Commercial
Project developer	Farmer himself
EPC	N.A.
Ownership structure	Individual Farmer
Operation & Maintenance	Voltaics Agro Pvt Ltd.
Scientific partner	N.A.
Financing structure	PPA with Himurja at a rate of 3.75 INR-/ for 25 years Total cost of PV structure: 1.1 crore, including non-AC storeroom
Type of Agrivoltaics plant	• Interspace (primarily) • Some cultivation underneath panels
Module technology	• Monofacial / polycrystalline
Mounting structure	• 2.2m Elevation of panels • Panel rows with 2m interspace, 4m between the structure base • Cable underground for tillage purposes
Tracking	• Seasonal tilt (manual), following summer and winter solstices
Cleaning & water management	• Manual • Profitable climate: air generally clean and pollution free
Agricultural aspects	• Sandy loam • Low acidity
Crops	• Eggplant, cabbage, onion, chilly and ladyfinger (for seed)
Crop cultivation	• Cultivation of most crops as interspace Agrivoltaics • Some crops (incl. turmeric) cultivated underneath PV modules
Further aspects	• Agrivoltaics plant across a total of 1.5 acres land

Nestled beneath the majestic Dhauladhar range, the Agrivoltaics site enjoys a picturesque location. With an average annual rainfall of approximately 1,411mm, the area experiences abundant precipitation. To ensure the protection of the fields and crops, meticulous attention must be given to the design and implementation of structures and effective water management strategies.

Figure 43. 2.2m elevated Panels in Juhu, Himachal Pradesh



Figure 44. Agrivoltaics system near Jahu, Himachal Pradesh (Credit: Gramin Vikas Trust)



21. Dayalbagh Agriculture University- 200 kW-

Table 28. Properties of plant at Dayalbagh Agriculture University

Project name3	Dayalbagh Agriculture University plant in Agra, Uttar Pradesh - 200 kW
Date of commission	26-01-2020
Installed capacity DC	200 kWp
State, city	Uttar Pradesh, Agra
GPS location	27.22671, 78.01072
Type of project	Research
Project developer	Dayalbagh Educational Institute (DIE), Faculty of Engineering
EPC	Dayalbagh Educational Institute
Ownership structure	Dayalbagh Educational Institute Research & Development project sponsored by Department of Science and Technology (DST) Mission Innovation
Operation & Maintenance	Dayalbagh Educational Institute
Scientific partner	Dayalbagh Educational Institute (Deemed University)
Financing structure	• No power purchase agreement with any DISCOM, electricity has been utilized in the institute premises and nearby facilities (self consumption) • Project investment: 3 cr. INR (150,000 INR/kWp), payback time of 7 years is claimed
Type of Agrivoltaics plant	Single column
Module technology	• Semi-transparent glass modules, monocrystalline • 50% of modules with transparent tedlar sheet, 50% regular • Towers with monofacial panels only, towers with transparent panels only, towers with mixed panels in checkerboard pattern • Space between modules helps mitigate storms
Mounting structure	• 18ft elevation height • 19 towers each with 50 modules • Current weight: about 3.5 tons per column. Research ongoing to significantly reduce weight
Tracking	• Single axis tracking, azimuth tracking claimed to increase yield by up to 20% • Storms used to damage gearboxes, which could successfully be mitigated by additional mechanical locks
Cleaning & water management	• R&D in progress - variable pressure sprinkler system • Before that, manual cleaning with a ladder, every 15 days
Agricultural aspects	• Deep loamy soils • Ploughing can be easily done in this plant with tractor

Project name3	Dayalbagh Agriculture University plant in Agra, Uttar Pradesh - 200 kW
Crops	• Grams, brinjal, tomato, wheat, spinach, cauliflower, carrot, gourds • Crop sizes should not exceed 8ft
Crop cultivation	• Drip irrigation for all vegetables, STP water for grams (roughly 50-50%) • Crop yields reported to be unchanged • Tillage of 1 - 2ft, cables laid below 3ft • Sheets and mulching are applied for further water savings

Agra, situated on the banks of river Yamuna in Uttar Pradesh, is globally renowned for the Taj Mahal monument. The region experiences a semi-arid climate with temperatures ranging from

18.6°C to 44.6°C. It receives an average annual rainfall of 736.3mm, contributing to the fertile deep loamy soil.

Dayalbagh University is an esteemed agricultural technical university with a thriving cow breeding economy. The university manages over 1100 cattle, primarily for milk and manure production. Grazing provides their sustenance, and the dung is dried and used as fertilizer on the fields. Covering an extensive area of 1200 acres, the university conducts innovative research and development activities. Their cow-based fertilizer has proven to enhance soil health and biodiversity, creating a favourable environment for earthworms.

Within the university's premises, a research facility is dedicated to Agrivoltaics, located on previously utilized fodder land. Students engage in agricultural activities regularly, either as part of their coursework or through voluntary participation. The mounting structure of 18ft height, along with ample spacing between the poles, allows for ploughing using heavy machinery.

In addition to Agrivoltaics, the university excels in research on mobile photovoltaic systems, which have practical applications in disaster-stricken areas. The Mitsubishi Innovation Prize was awarded to the researchers for their contributions in this field. Furthermore, the university focuses on developing electrified downstream processing machines, such as press-drying and threshing equipment, as an eco-friendly alternative to diesel-powered machinery commonly associated with tractor engines.

Figure 45. Dayalbagh Agriculture University APV plant (Credit: DAU)



Figure 46. **Dayalbagh Agriculture University APV plant (Credit: DAU)**



Figure 47. **Dayalbagh Agriculture University APV plant with different arrangement (Credit: DAU)**



22. AgriVolta – 200 kW

AgriVolta- New Tehri, Uttarakhand- 200 kW Table 29. Properties of AgriVolta - New Tehri, Uttarakhand, 200 kW

Project name	AgriVolta - New Tehri, Uttarakhand, 200 kW
Date of commission	01-06-2025
Installed capacity	200kW
State, city	Garh, Chamba, New Tehri, Uttarakhand
GPS location	30.340511, 78.446482
Project Objective	Dual-use Land Optimization
Ownership	Private Developer
Project developer	Agrivolta
EPC (Engineering, Procurement, and Construction)	Tridev Urja
Operation & Maintenance	Agrivolta
Research Partner	Center for Aromatic Plants, Selaqui
Consumption of Power	Grid Connected through 25 yearlong PPA
Type of Agrivoltaics Plant	Elevated Panels, four pole setup
Module Technology	n Type top con Bifacial
Mounting Structure	Fixed Tilt
Tracking	Single Axis
Cleaning	Manual
Water Management	Surface irrigation through sprinklers
Crops	Rosemary and Geranium
Farming Activity	Perennial Crops that grow up to 4 ft are selected that perform well in low light conditions. These herbs are cultivated for their leaves. These leaves are steam distilled to extract hydrosol and essential oils.
Lessons Learnt/ Challenges	The primary hurdle during commissioning was the scarcity of reliable, project-specific information. A technical training program at the National Institute of Solar Energy proved invaluable in bringing the plant online. The next challenge is to secure contracts and tenders that will allow this pilot to be replicated and scaled across additional sites.
A Brief about the Project	Agrivolta is a pioneering agro-voltaic project based in Tehri, Uttarakhand, combining sustainable rosemary cultivation with solar energy generation. The project spans 2.5 acres and focuses on producing high-quality rosemary hydrosol and essential oil through wood-fired distillation, while a 200kW grid-connected solar plant ensures clean energy supply and a stable secondary income. Agrivolta's goal is to demonstrate a replicable model of integrated farming and energy production—enhancing rural livelihoods while promoting climate resilience and efficient land use.
Additional Information	One acre carries the 200 kW solar array and another grows rosemary beneath the panels, creating 1.5 acres of overlapping productivity. Solar-powered drip irrigation and on-site wood-fired distillation showcase Agrivolta's low-carbon, resource-smart model, with the balance of the 2.5-acre site slated for phased expansion.

Figure 48. AgriVolta - New Tehri, Uttarakhand, 200 kW



Figure 49. Agrivolta- Panel View



23. Krishi Vigyan Kendra (NHRDF)- 110 kW

Table 30. Properties of project at Krishi Vigyan Kendra (NHRDF) Ujwa

Project name	Krishi Vigyan Kendra Ujwa Solar Farm
Date of commission	02-2021
Installed capacity DC	110 kWp
State, city	Ujwa, Delhi
GPS location	28.57134, 76.89579
Type of project	Research
Project developer	Krishi Vigyan Kendra (KVK) under National Horticultural Research and Development Foundation (NHRDF), Ujwa, New Delhi
EPC	Oakridge Energy Pvt. Ltd. Noida
Ownership structure	Land and farming by Krishi Vigyan Kendra, Ujwa, New Delhi Agrivoltaics plant owned by Oakridge Rooftops Pvt Ltd.
Operation & Maintenance	Oakridge Rooftops Pvt Ltd.
Scientific partner	Solar Department, Department of Power, Govt of NCT Delhi and ICAR- ATARI, Zone-II, Jodhpur
Financing structure	30% equity and 70% debt financing through IREDA rooftop credit line backed by German Development Bank KFW
Type of Agrivoltaics plant	Elevated structure with provision for limited agriculture underneath
Module technology	335 Wp poly crystalline solar panels
Mounting structure	• Hot dipped galvanized steel structure • 3.5m elevation height at 15° tilt
Tracking	Fixed tilt
Cleaning & water management	• Local water tank made available for cleaning water supply. Rainwater gutters ensure that the cleaning water drains to an underground tank for reutilisation of water. • Every 10 days the modules are cleaned with a 1600 W, 90 to 130 bar pressure water washer. • A drip irrigation system for the entire Agrivoltaics plant has been implemented. • Soil moisture was observed to be much better with significant irrigation water savings
Distribution of power	• The facility is connected to the public grid of BSES Delhi with group metering • Power utilised by National Agricultural Co-operative Marketing Federation of India Ltd. (NAFED), National Horticultural Research and Development Foundation (NHRDF), Krishi Vigyan Kendra (KVK) at ratio of 70:20:10 at a tariff of INR 3.13 / kWh.
Agricultural aspects	• Located in agroclimatic zone VI trans-gangatic plains region with annual rainfall of 420-780mm. • Temperature variation from 2°C-47°C. Soil with PH of 8.5 and above
Crops	Okra, tomato, brinjal, capsicum, leafy vegetables, root vegetables and cole crops planned
Crop cultivation	• Mulching and sheets are applied.

A 110kWp Agrivoltaics solar farm demonstration unit has been successfully installed on a 2000m2 area in Krishi Vigyan Kendra (NHRDF), Ujwa, New Delhi. This pilot project is part of the Mukhyamantri Kisan Aay Badhotri Solar Yojana scheme of GNCT, Delhi. Under this scheme, entities are allowed to set up photovoltaic power plants on agricultural land, utilizing up to one third of the farmland, which can be rented out to the solar power plant owner. The minimum structure height of 3.5m ensures convenient passage for tractors and other farming equipment. The funding for this unit has been fully provided by Delhi Transco Limited, Delhi, as part of their Corporate Social Responsibility (CSR), along with support from the NABARD fund, regional office, Delhi. The primary objective of this demonstration unit is to preserve and enhance the green belt surrounding Delhi by cultivating horticultural crops and encouraging the retention of agricultural land.

Figure 50. **Aerial view on Krishi Vigyan Kendra pilot with water gutter before cultivation (Credit: KVK Ujwa)**



Figure 51. **Krishi Vigyan Kendra pilot after cultivation (Credit: KVK Ujwa)**



Figure 52. **Krishi Vigyan Kendra pilot after cultivation (Credit: KVK Ujwa)**



24. National Institute Solar Energy- 100 kW

Table 31. Properties of NISE plant near Gurgaon, Haryana

Project name	National Institute Solar Energy
Date of commission	N.A.
Installed capacity DC	100 kWp
State, city	Gurugram, India
GPS location	28.42754, 77.16071
Type of project	Research
Project developer	National Institute of Solar Energy (NISE)
EPC	N.A.
Ownership structure	National Institute of Solar Energy (NISE)
Operation & Maintenance	N.A.
Scientific partner	N.A.
Financing structure	N.A.
Type of Agrivoltaics plant	Interspace
Module technology	N.A.
Mounting structure	N.A.
Tracking	Fixed
Cleaning & water management	N.A.
Agricultural aspects	Loamy sand
Crops	Tomato, chili, flowers, Kufri Lima potato
Crop cultivation	N.A.

NISE has conducted successful experiments in cultivating tomatoes, chilies, and flowers in the space between and beneath solar arrays at ground-mounted PV plants. Additionally, NISE has procured and overseen the construction of a vertical PV pilot plant featuring bifacial modules, in collaboration with Adani Solar (see below).

Figure 53. Experimental agriculture at NISE (Credit: NSEFI)



25. Central Arid Zone Research Institute- 100 kW

Table 32. Properties of CAZRI plants in Jodhpur

Project name	CAZRI plants in Jodhpur
Date of Commission	12.08.2017
Installed capacity DC	105 kWp
State, City	Rajasthan, Jodhpur
GPS Location	26.25793, 72.99297
Type of Project	Research
Project Developer	Central Arid Zone Research Institute (CAZRI)
EPC	N.A.
Ownership structure	Government-owned, CAZRI Institute
Operation & Maintenance	CAZRI Institute
Scientific partner	CAZRI Institute
Financing Structure	Economic assumptions (2019): • 500 kWp/ha • Capex of 2.25 Cr. INR (50,000 INR/kWp) • Net income crops: 80,000 INR/ha/yr • FiT of 4 INR/kWh
Type of Agrivoltaics Plant	Interspace
Module technology	Monofacial (260Wp), 1.64m to 0.992m
Mounting structure	• Latitude angle considered as tilt angle in this project (26° at Jodhpur) • Height: » Array 1: 1.22m » Array 2: 1.94m » Array 3: 2.66m • Interspace: » Arrays of 1-row PV module and 3m interspace » Arrays of 2-row PV modules and 6m interspace » Arrays of 3-row PV modules and 9m interspace • Ploughing can be easily possible in 2 cases, while in one case it has to be done manually • Total system cost of (105 kW/INR 60 lakh) -> 57,142 INR/kWp
Tracking	Fixed with no tracking as well as single axis tracking
Cleaning & Water Management	• Rainwater harvesting system from surface of PV- modules • Harvest rainwater annually approx. 1.5 lakh litres, stored in a 100 m3 water tank • Efficiency rainwater harvesting system 70 - 80%
Agricultural aspects	Sandy and loamy
Crops	• Mungbean, mothbean, clusterbean, isabgol, cumin, chickpea • Aloe vera, sonamukhi, sankhpuspi, chili, cabbage, onion, garlic
Crop Cultivation	49% land area can be used for agriculture, Land Equivalent Ratio (LER) of about 1.41

Situated in Jodhpur, this Agrivoltaics plant finds itself in an arid climate with meagre prospects. The region experiences an average irradiance on horizontal surface of 6.11 kWh/m2/day, the region has cloud-free skies for nearly 300 days each year. The temperature range spans from a chilling 9.6°C to a scorching 41.4°C.

The plant's layout boasts three different patterns, featuring PV arrays with varying rows and significant interspaces of 3m, 6m, and 9m, allowing the use of heavy machinery. The plant's design includes a rainwater harvesting system based on duct pipes attached to the PV-modules bottom edge. This facilitates the harvesting of up 1.5 lakh litres of rainwater annually. The collected water serves the dual purpose of cleansing the module surfaces and serving as irrigation. A storage tank of 100m3 is present, for holding water during the rabi season. This project effectively utilizes 49% of available land that would otherwise remain unused, transforming it into productive agricultural land. The project demonstrates a remarkable land equivalent ratio of 1.41, indicating efficient use of the cultivated area.

Table 33. Effects on yield of different crops as examined in interspacing area at CAZRI Jodhpur plants

Crop category	Interspacing (crops)	Yield affection by
Kharif	Mungbean (*Vigna radiata*), moth bean (*Vigna aconitifolia*), clusterbean (*Cyamopsis tetragonoloba*)	Growth and yield of mungbean (*vigna radiata*) was not affected by the shade of PV module, whereas rest two are affected
Rabi	Isabgol (*Plantago ovato)*, cumin (*Cuminum cyminum*), chickpea (*Cicer arietinum*)	Growth and yield of isabgol (*plantago ovata*) and Cumin (*cuminum cyminum*) are significantly affected by shade of PV module
Medicinal plants	Aloevera (*Aloe vera*), sonamukhi (*Cassia angustifolia*), sankhpuspi (*Convolvulus pluricaulis*)	Performance of medicinal crops were superior in the interspace area than over control.
Vegetables	Chilli (*Capsicum annum*), cabbage (*Brassica oleracea var. capitat*), onion (*Allium cepa*), garlic (*Allium sativum*)	Growth and yield of solanum melongena was significantly affected by the shade of the PV module.

When examining the economic aspects of the project, it is evident that revenue generated from electricity generation surpasses that from agricultural production. databased on available data, mung beans during the kharif season generate INR 8,235 in income, while Isabgol in rabi season yields revenues of INR 23,339

Figure 54. Agrivoltaics at CAZRI (Credit: CAZRI)



Figure 55.Agrivoltaics system with rain gutter at CAZRI (Credit: CAZRI)





26. IIT Guwahati, IndiaHub- 50 kW

Table 34. Properties of 50KW- Hailakandi Agrivoltaics project, Assam

Project name	Hailakandi Agrivoltaics project
Date of commission	25-05-25
Installed capacity	50kw
State, city	Hailakandi Assam
GPS location	24.689078, 92.566437
Project Objective	This is a demonstration project by IIT Guwahati to off-set energy to tea processing unit based in SS college campus
Ownership	Hailakandi farmer organization
Project developer	IIT Guwahati
EPC (Engineering, Procurement, and Construction)	Indiahub E Governance Private Limited
Operation & Maintenance	Hailakandi FPO
Research Partner	SART, IIT Guwahati
Consumption of Power	Net-metering
Type of Agrivoltaics Plant	Elevated structure
Module Technology	Mono PERC
Mounting Structure	Fixed tilt
Tracking	Stable
Cleaning	Manual
Water Management	Siplinker
Crops	Ashwagndha, Rossele, Tulsi
Farming Activity	Managed by Hailakandi FPO and blended with Tea at tea processing unit
Lessons Learnt/ Challenges	Agrivoltaics can help farmers through cultivation of medicinal plants with PV mount structures to protect from rain
A Brief about the Project	The 50 kW Agrivoltaics Plant established in Hailakandi, Assam, is a pioneering initiative undertaken by the School of Agro and Rural Technology (SART), IIT Guwahati, with financial support from the HDFC Parivartan. This project is conceptualised and executed with the help of India Hub Pvt. Ltd. to showcase renewable solar power generation in combination with sustainable agriculture along with promotion of livelihood of the local community in one of the Aspirational Districts of Assam. This would work as a field level model of Agrivoltaics projects in the northeast region of the country. The overarching objective of this Agrivoltaics system is to promote dual land utilisation, wherein the same parcel of land is used simultaneously for solar energy generation and cultivation of high-value herbal and medicinal crops. This approach enhances land productivity, promotes climate-smart agriculture, reduces carbon footprints, and provides a sustainable livelihood model for rural communities. Another key component of this innovative initiative is the establishment of a herbal tea blending unit at SS College, Hailakandi. This unit is strategically designed to process tea blended with medicinal herbs, such as Rosella and Ashwagandha, cultivated directly beneath the project's solar panels.
Additional Information, if any	

Figure 56. **Panel structures of the 50KW- Hailakandi Agrivoltaics project, Assam**



Figure 57. **Panel structures of the 50KW- Hailakandi Agrivoltaics project, Assam**



27. Odisha University of Agriculture and Technology- 40kW

Table 35. Properties of 40Kwp plant of Odisha University of Agriculture and Technology

Project name	Odisha University of Agriculture and Technology
Date of commission	04-24
Installed capacity	40Kwp
State, city	Bhubaneswar, Odisha
GPS location	Lat 20.278231 , Long 85.787494
Project Objective	Research & Demonstration
Ownership	Government University
Project developer	M/s Prithvi Enterprise, Bhubaneswar with support of the University
EPC (Engineering, Procurement, and Construction)	M/s Prithvi Enterprise, Bhubaneswar with support of the University
Operation & Maintenance	Plasticulture centre, Department of Fruits and Vegetable
Research Partner	Odisha University of Agriculture and Technology
Consumption of Power	Grid export
Type of Agrivoltaics Plant	Elevated structure
Module Technology	Mono PERC
Mounting Structure	Fixed Tilt
Tracking	Single axis
Cleaning	Water based cleaning
Water Management	Bore well with drip
Crops	Pineapples & Dragon fruits and in summer season leafy vegetables
Farming Activity	University
Lessons Learnt/ Challenges	Any shade bearing crops can be grown
A Brief about the Project	The project is funded bt BEE, Govt of India through Odisha state nodal agency
Additional Information, if any	Demonstration of model at different height like

Figure 58. **Panel structures of the 40Kwp plant of Odisha University of Agriculture and Technology**



Figure 59.**Interspace cropping at the 40Kwp plant of Odisha University of Agriculture and Technology**



28. Farmer (Owned)- 30 kW

Table 36.Properties of Fish-pond Agrivoltaics system

Project name	Fish Pond Agrivoltaics
Date of commission	N.A.
Installed capacity DC	30 kW installed with interspace fish pond Total site capacity of 1MW
State, city	Bhaloji, Rajasthan
GPS location	27.64157, 76.15659
Type of project	Commercial
Project developer	Independent Farmer
EPC	N.A.
Ownership structure	Private
Operation & Maintenance	N.A.
Scientific partner	N.A.
Financing structure	N.A.
Type of Agrivoltaics plant	N.A.
Module technology	N.A.
Mounting structure	N.A. .
Tracking	Fixed tilt
Cleaning & water management	Manual cleaning
Agricultural aspects	Fish farming, no further known agricultural activities
Crops	N.A.
Crop cultivation	N.A.
Further aspects	Maintenance challenges and irregular power supply

Figure 60. Fish Pond set-up underneath PV-modules (Credit: Down to Earth)



29. Tata-Cornell Institute Jain Irrigation Systems Limited and NGO PRAN- 20 kW

Table 37. Properties of Tata-Cornell Institute Community-Based Agrivoltaics Model

Project name	Tata-Cornell Institute Community-Based Agrivoltaics Model
Date of commission	20-04-2025
Installed capacity	20kW
State, city	Bihar, Nawada (Sherghati block)
GPS location	24.542658°, 84.764220°
Project Objective	The primary objective of the project was to co-produce food and energy on small farms to improve livelihood opportunities, reduce greenhouse gas emissions and provide conceptual proof of the scalability of smallholder Agrivoltaics in India. Specifically, the project aimed 1. To demonstrate the feasibility of group-based ownership of an Agrivoltaics site; 2. To reduce GHG emissions from agriculture using solar power for irrigation, promoting crop diversification away from rice); 3. To enhance farm income by diversifying out of rice to higher value horticulture crops 4. To demonstrate the feasibility of growing crops under solar panels; 5. To demonstrate that the solar power produced on agricultural land can be effectively utilized for agricultural production and non-agricultural purposes 6. To promote sustainable water and fertilizer management by integrating drip and sprinkler irrigation and fertigation systems.
Ownership	Agrivoltaics Producer Group of Nawada
Project developer	Tata-Cornell Institute, Jain Irrigation Systems Ltd., NGO PRAN
EPC (Engineering, Procurement, and Construction)	Jain Irrigation Systems Ltd.
Operation & Maintenance	Agrivoltaics Producer Group of Nawada
Research Partner	Tata-Cornell Institute, Cornell University (USA)
Consumption of Power	Irrigation (3 pumps), wheat mill
Type of Agrivoltaics Plant	Elevated structure (Single Pole Ground Mounted Manual Tracker)
Module Technology	Mono PERC
Mounting Structure	Single pole with manual adjustable tilt angle at 20, 25, 35 degrees
Tracking	Single axis from north to south
Cleaning	Manual cleaning; Water-based
Water Management	Water for irrigation is primarily sourced from an 80ft deep borewell. There is a backup borewell, 30ft deep. Water from the two borewells is discharged into a retention tank. Two pumps are placed into the retention tank - one to supply water to the plots through drip irrigation and another to supply water to the plots through sprinkler irrigation. Drip and sprinkler irrigation systems cover the area cultivated by the group members (8 acres).

Project name	Tata-Cornell Institute Community-Based Agrivoltaics Model
Crops	Kharif: Ginger, turmeric, bitter gourd, bottle gourd, banana, sugar cane; Rabi: Onion, leafy vegetables, potato, onion, banana, sugar cane; Zaid: Ginger, turmeric, bitter gourd, bottle gourd, banana, maize.
Farming Activity	Farmers who are part of the group "Agrivoltaics Producer Group of Nawada" will be conducting farming activities. One of the farmers from the group offered his land for the Agrivoltaics installation. Crops will be grown across all three seasons. Detailed cropping plan available upon request.
Lessons Learnt/ Challenges	**Group cohesion:** The model is based on a group-ownership structure comprising of small and marginal farmers. Group dynamics, enough interested farmers, effective group leadership that inspires other farmers, and effective ways to address collective action problems determine the success of groups. **Plot location:** Having adjacent plots or plots close to other members was a precondition for a project's success. Installation cost of drip irrigation, solar panels and other infrastructure are greatly affected by the proximity and fragmentation of the farms. Lack of this can lead to discontent of neighbouring farmers who are not part of the project. **Market proximity:** Agrivoltaics installation would facilitate crop diversification away from rice toward higher value crops. The proximity of markets to sell the "new" crops is often an incentive for diversification. **Local availability of inputs:** Project-related activities sometimes require inputs which are not available locally (this can range from a suitable boring machine to appropriate seed and fertilizers, and solar equipment), and this can cause delays or challenges in procurements for the project. **Technical assistance:** Since Agrivoltaics is a relatively new technology requiring technical know-how and knowledge of agronomic practices, implementation and technical support was vital.
A Brief about the Project	The Tata-Cornell Institute Community-Based Agrivoltaics Model was developed by the Tata-Cornell Institute (TCI) team with implementation support from PRAN and technical support from Jain Irrigation Systems. The project was to demonstrate the co-production of food and energy while reducing GHGs from agriculture. Additionally, the project also aims to promote sustainable water and fertilizer management practices. These goals were achieved by incorporating drip and sprinkler irrigation and fertigation technology in agricultural production. To maximize the utilization of solar power produced when irrigation was not necessary, the project integrated a wheat mill run on solar power. Community ownership of the installation is central to the project, and the long-term success of this Agrivoltaics installation depends on the group dynamics. Farmers who formed the group "Agrivoltaics Producer Group of Nawada" were consulted at every step of the process. Furthermore, the TCI and PRAN teams assisted with group formation and setting rule and regulations from engagement A rulebook that includes, but is not limited to, information about rules of engagement, pricing water and entry and exit of members. This Agrivoltaics project is part of the larger project, "Zero-Hunger, Zero-Carbon Food Systems, " led by the TCI.

Figure 61. Tata-Cornell Institute community based Agrivoltaics model (Credit: TCI)



Figure 62. Tata-Cornell Institute community based Agrivoltaics model (Credit: TCI)



30. Ruvexa Enterprises- 18 kW

Table 38. Properties of Pole-mounted Agrivoltaics by Ruvexa Enterprises

Project name	Ruvexa: Patented Pole-mounted Agrivoltaics Technology
Date of commission	21-02-2025
Installed capacity	18 kW designed capacity
State, city	New Delhi
GPS location	28.634973, 77.155359
Project Objective	To demonstrate patented Agrivoltaics technology & conduct research to determine the impact on rice-wheat and other crops
Ownership	Ruvexa Enterprises, New Delhi
Project developer	Ruvexa Enterprises, New Delhi
EPC (Engineering, Procurement, and Construction)	Ruvexa Enterprises, New Delhi
Operation & Maintenance	Ruvexa Enterprises, New Delhi
Research Partner	ICAR-IARI, Pusa, New Delhi
Consumption of Power	On-site farm
Type of Agrivoltaics Plant	Research & demonstration plant, elevated pole-mounted
Module Technology	Mono PERC, Bifacial, Twin cell 545W
Mounting Structure	Pole mounted structure with 6 panels per pole in column clusters, tilt and gap managed to reduce panel-to-panel shadow
Tracking	No trackers
Cleaning	Manual water-based as needed
Water Management	Sourced from the local water supply
Crops	Rice & wheat, future research will include other crops as well
Farming Activity	Rice & wheat cycles of farming conducted by the Department of Agronomy, IARI on a rotational basis
Lessons Learnt/ Challenges	One of the major challenges faced during installation was that the farm plot was rotated around 27 degrees counterclockwise from the ideal North-South orientation. This required careful site assessment and customized planning of panel row and column layout to optimize solar exposure. In this case, the flexibility of the elevated pole-mounted design proved advantageous. Since the structure is installed on independent poles rather than fixed frames, it was possible to orient the array to suit the site's geometry.

Project name	Ruvexa: Patented Pole-mounted Agrivoltaics Technology
A Brief about the Project	This project was set up in the Integrated Farming System (IFS) of the Department of Agronomy at ICAR IARI, New Delhi. IFS focuses on improving the productivity and sustainability of small and marginal farms through the integration of crops, livestock, and other farm components. Our Agrivoltaics system was installed in the rice-wheat section to demonstrate the patented pole-mounted design and study its effects on the crop underneath. By supplying clean energy without interrupting farming activities, this project provides an additional source of income for farmers while supporting IFS goals of promoting energy independence, circular economy and sustainable rural development.
Additional Information, if any	The plant with full designed capacity of 18 kW has been installed to simulate shading conditions, with 3 kW of solar panels and the remainder represented by structural placeholders for accurate shadow analysis on crops.

Figure 63.Pole-mounted Agrivoltaics by Ruvexa Enterprises



Figure 64.Different time durations at the Pole-mounted Agrivoltaics



31. Renkube Private Limited- 10 kW

Table 39. Properties of APV at Seed Research and Technology Centre

Project name	Agritech Innovation Pilot 2.0
Date of commission	16.11.2022
Installed capacity DC	10 kW
State, city	Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad
GPS location	17.33065, 78.41036
Type of project	Research
Project developer	Renkube Private Limited, Bangalore
EPC	N.A.
Ownership structure	N.A.
Operation & Maintenance	N.A.
Scientific partner	Seed Research and Technology Centre, Telangana State Agricultural University
Financing structure	N.A.
Type of Agrivoltaics plant	Elevated structure
Module technology	N.A.
Mounting structure	Steel structure Approx. 3.5 m Elevation of panels Approx. 3 m Pitch distance
Tracking	Fixed tilt
Cleaning & water management	N.A.
Agricultural aspects	Research field for University
Crops	Multiple, high growing crops possible
Crop cultivation	N.A.
Further aspects	Drip irrigation system Suitable for cultivation with a tractor

Figure 65. **Agrivoltaics site before cultivation (Credit: Renkube)**



Figure 66.**Agrivoltaics site after cultivation (Credit: Renkube)**





32. Amity University- 10 kW

Table 40. Properties of Agrivoltaics project at Amity University

Project name	Agrivoltaics project at Amity University
Date of commission	2017
Installed capacity DC	10 kWp
State, city	Uttar Pradesh, Gautam Buddh Nagar District, Noida
GPS location	28.54162, 77.33241
Type of project	Research
Project developer	Amity University, in-house development
EPC	N.A.
Ownership structure	Amity University Funding agency: Department of Science and Technology, Govt. of India
Operation & Maintenance	Amity University
Scientific partner	Amity University
Financing structure	Project cost 24.9 lakh INR Electricity used for self-consumption
Type of Agrivoltaics plant	Single column
Module technology	Monofacial, polycrystalline (330Wp), Canadian
Mounting structure	• Optimum tilt angle • Approximately 15 ft (4.6m) height of the mounting pole • Area: 630m^2; 159 kWp/ha
Tracking	N.A.
Cleaning & water management	• Automatic piping system for sprinkler module cleaning • Drainage system implemented • No storage of harvested water, but water harvested drops directly on the field, resulting in a reduction of irrigation needs
Agricultural aspects	• Sandy loam soil • Farmer-friendly cabling above the ground attached to the cleaning water pipes
Crops	Maize, potato, brinjal, mustard
Crop cultivation	• Nearly 90% land can be utilized for cultivation • Height of crops is practically not limited, at present up to 1m • Minimal shading impact, crop yield unchanged
Further aspects	N.A.

Noida, a well-planned city in Uttar Pradesh, boasts a temperate climate that offers favourable conditions for various activities. This region experiences minimum and maximum temperatures of of 16°C and 45°C respectively, along with an average annual rainfall of approximately 714mm. The location benefits from sandy loam soil, rich in nutrients, moisture, and humus. The project implemented on the land of Amity University showcases an innovative approach to water management. Each mounting structure is equipped with a piping system featuring cork valves, facilitating automatic cleaning of the modules. The

water used for cleaning is efficiently captured and redirected to irrigate crops, reducing overall water consumption.
The strategic height of the structures allows for the use of tractors for ploughing, streamlining agricultural operations. Moreover, manual work on the crops is not limited, ensuring flexibility in cultivation practices. The photovoltaic panels play a crucial role in the project, as they eliminate the need for grid power supply to operate the pump set. Consequently, the water requirements remain similar while reducing reliance on external energy sources. In this setup, over 95% of the land can be utilised for crop cultivation due to the limited PV capacity installed and the overhead cabling system. This efficient design maximizes the productive potential of the area while maintaining a sustainable approach to energy and water usage.

Figure 67. Plant at Amity University (Credit: NSEFI)



Figure 68. Crop and panel view at AUUP



33. Junagadh Agriculture University- 7.2 kW- Junagadh, Gujarat 2017- Vegetable Crops

Table 41. Properties of Junagadh Agriculture University plant

Project name	Junagadh Agriculture University plant
Date of commission	2017
Installed capacity DC	7.2 kWp
State, city	Gujarat, Junagadh
GPS location	21.50109, 70.44758
Type of Project	Research
Project developer	Junagadh Agriculture University
EPC	N.A.
Ownership structure	Junagadh Agriculture University
Operation & Maintenance	Junagadh Agriculture University
Scientific partner	Junagadh Agriculture University
Financing structure	Research funding
Type of Agrivoltaics plant	Overhead tilted
Module technology	• 150 Watt (0.67m X 1.47m) Poly crystalline
Mounting structure	• Elevation height: 3m • Checkered module arrangement • 7.6, 11.4m plot
Tracking	N.A.
Cleaning & water management	Manual cleaning
Agricultural aspects	• Black soils • No use of tractor as per land use and as per crop cultivation methods • Experiments with shade/insect protection nets are conducted
Crops	Tomato, capsicum, cotton
Crop cultivation	N.A.
Further aspects	• Experiments with a water pipe-based cleaning system with water harvesting by rain gutters • Local data comparing crop yield in an open field with Agrivoltaics for tomato and capsicum

A 7.52kWp capacity plant was installed at the Junagadh Agriculture University for research and development purposes. The university is located in a tropical wet and dry climate region, characterized by minimum and maximum temperatures of approximately 16°C and 38°C. The annual average rainfall in the area is about 827mm. The soil type prevalent in this region is black soil, which is highly suitable for vegetable cultivation. The crops grown in this project can be cultivated without the need for heavy machinery such as tractors for ploughing. Junagadh Agriculture University, a leader in the field of overhead stilted Agrivoltaics systems, has recommended this model to farmers in Gujarat, offering promising benefits.

Figure 69. Junagadh Agrivoltaics system (Credit: Prof. P.M. Chauhan, JAU)



Figure 70. Aerial view of Junagadh Agrivoltaics system (Credit: College of Agricultural Engineering and Technology, JAU)



Figure 71. Irrigation system at Junagadh Agriculture University site (Credit: JAU)



Figure 72. **Installed pipe system to collect cleaning water (Credit: JAU)**



34. Indian Institute of Social Welfare and Business Management- 5.22 kW

Table 42. Agrivoltaics method of Agriculture using coal-ash- Durgapur, West Bengal- 5.22 kw

Project name	Agrivoltaics method of agriculture using coal-ash
Date of commission	04-01-2025
Installed capacity	5.22 kW peak SPV with more than 5000 SFT under the pilot project area
State, city	West Bengal, Durgapur (Locality: Andal)
GPS location	23.580961, 87.200351
Project Objective	To optimize energy-food-land use: SPV and selected energy crops, vegetables and flowers with all conclusive combinations of soil-fly ash-bottom from a coal based thermal power plant
Ownership	Damodar Valley Corporation (DVC), Government of India
Project developer	Indian Institute of Social Welfare and Business Management (IISWBM)
EPC (Engineering, Procurement, and Construction)	DVC and RE-Power
Operation & Maintenance	IISWBM
Research Partner	DVC
Consumption of Power	Local grid of Durgapur Steel Thermal Power Station (DSTPS)
Type of Agrivoltaics Plant	Elevated Structure Ground Mounted
Module Technology	Mono PERC
Mounting Structure	Ground mounted and fixed tilted at an elevation of 6 feet to 8 feet, sloping south at 12 degrees
Tracking	No
Cleaning	(sprinkler) water based cleaning system
Water Management	Sprinkler based, 100% water is utilized in irrigation of the Agrivoltaics plants and vegetable
Crops	Vegetables, flowers, Spices
Farming Activity	IISWBM is responsible for conducting farming. Different energy and flowering plants and vegetable varieties have been sown as per season.
Lessons Learnt/ Challenges	Different plants need different kinds of care when grown in coal-ash. Ploughing is frequently required in coal-ash

Project name	Agrivoltaics method of agriculture using coal-ash
A Brief about the Project	We propose an innovative method to transform barren land for Agrivoltaics, combining ground-mounted solar photovoltaic (SPV) projects with agriculture directly beneath the panels. Our unique approach utilizes ash as a foundational topsoil for lands not fertile/suitable for farming. Preliminary in-situ results show promising success in cultivating edible vegetables and flowers. This model presents a sustainable framework for repurposing ash, optimizing land use, generating clean energy, and empowering local communities enhancing job, water, energy and food security. Implementing this on a large scale is expected to significantly contribute to India's development objectives and the 2070 Net Zero target.
Additional Information, if any	This project is funded by the Damodar Valley Corporation

Figure 73. Panel structure at the AGRIVOLTAICS plant at the Durgapur, West Bengal- 5.22 kw



Figure 74. Long-bean crop at the AGRIVOLTAICS plant at the Durgapur, West Bengal- 5.22 kw



35. National Institute of Solar Energy (NISE)- 5 kW

Table 43. Properties of vertical APV plant NISE near Gurgaon, Haryana

Project name	Vertically Installed Bifacial PV Modules Pilot
Date of commission	N.A.
Installed capacity DC	5 kWp
State, city	Haryana, Gwal Pahari, near Gurgaon
GPS location	28.42679, 77.15838
Type of project	Research
Project developer	National Institute of Solar Energy (NISE)
EPC	Adani Solar
Ownership structure	National Institute of Solar Energy (NISE)
Operation & Maintenance	N.A.
Scientific partner	National Institute of Solar Energy (NISE)
Financing structure	N.A.
Type of Agrivoltaics plant	Vertical Installation
Module technology	Bifacial (mono-PERC), Module BI faciality: 0.85
Mounting structure	N.A.
Tracking	No
Cleaning & water management	N.A.
Agricultural aspects	Loamy sand
Crops	N.A.
Crop cultivation	N.A.
Further aspects	Energy generated is fed into the grid

Figure 75.Vertical PV installation with bifacial modules at NISE (Credit: NSEFI)



36. Hinren Engineering Private Limited- 3 kW

Table 44. Properties of Hinren Agrivoltaics Rooftop (APVRT) System

Project name	Residential Agrivoltaics Rooftop
Date of commission	31 –10-2019
Installed capacity DC	3 kWp
State, city	Bangalore, Karnataka
GPS location	12.90890, 77.59428
Type of project	Commercial product for residential customers
Project developer	Hinren Engineering Pvt. Ltd.
EPC	Hinren Engineering Pvt. Ltd.
Ownership structure	Private
Operation & Maintenance	By system owner, Enphase Enlighten monitoring tool
Financing structure	100% equity
Type of Agrivoltaics plant	Elevated structure with provision for home gardening
Module technology	• 380Wp mono-crystalline twin peak PERC solar panels from REC Solar Make with Enphase IQ7+ micro inverters.
Mounting structure	• Galvanized steel, 2.3m elevation height with walkway to permit manual cleaning of the system • White heat seal paint was applied to cool the roof and • increase albedo effect
Tracking	• Fixed tilt
Cleaning & water management	• Automatic solar panel cleaning with water with harvested rainwater going back into a wastewater tank for filtration and reutilisation
Distribution of Power	• Net-metering with local distribution company BESCOM
Agricultural aspects	• Albedo effect from white heat seal paint applied on the floor of the roof provides extra light for the plants grown • Leaf and kitchen composters complete the nutrition cycle providing soil for the rooftop garden
Crops	• Good experience with cauliflower and tomato but also lady finger, chilly, promogrante, lemon, spinach, rosemary, bitter gourd, brinjal, beans, basil, coriander, papaya and lettuce amongst others • Ragi and rice did not grow successfully so far
Crop cultivation	To improve sunlight availability some crops must be shifted two to three times per year.
Further aspects	Considerations are made for urban Agrivoltaics e.g. as part of public parks or urban gardening.

The APVRT system offers a dual benefit of clean electricity and pesticide-free vegetables. Over the course of a year, it generated approximately 4,500 kWh of emission-free power. Out of this, 2,200 kWh were consumed by the residents, while the remaining 2,300 kWh were sold to the local DISCOM. This not only provided green electricity for nearby houses but also contributed to a sustainable energy ecosystem.

Figure 76. **Hinren Agrivoltaics rooftop system (Credit: Hinren Engineering Pvt. Ltd.)**



Figure 77.**Hinren APVRT structure and white heat seal paint (l), generation profile (r) (Credit: Hinren/Enphase**





Upcoming Projects

37. BAIF Development Research Foundation- 1.2 MW

Table 45. Demonstrating Agrivoltaics for Prospering Farmers- BAIF Campus, Pune- 1.2 MW

Project name	Demonstrating Agrivoltaics for Prospering Farmers- BAIF Campus, Pune- 1.2 MW
Date of commission	01-06-2025
Installed capacity	1280 kWh
State, city	BAIF campus, Urulikanchan, Pune Maharashtra, Karimnagar Dairy, Padmanagar, Karimnagar Telangana, BAIF campus, Lakkihalli, Hassan District, Karnataka
GPS location	18°31'18"N 74°09'18"E, 18°18'11.9"N 79°13'29.0"E 13°12'01"N 76°23'42"E
Project Objective	The following specific objectives will be met: • Demonstrate dual use of land with solar panels (i.e., Agrivoltaics) with multiple applications with cost economies. • The project will aim to use scientific knowledge to develop a package of practices that are suitable for various local crops. • Demonstrate economic viability. • Disseminate knowledge and policy recommendations at the state and national level. • Increase awareness amongst farmers, organizations, CSR partners, and govt. institutes.
Ownership	BAIF Development Research Foundation
Project developer	BAIF Development Research Foundation
EPC (Engineering, Procurement, and Construction)	1. Maxwell Solar & Wind Energy 2. Hari Govinda Enterprises 3. GCEP Solar Pvt Ltd 4. Solarth Pvt. Ltd. 5. Mruda Solar 6. Reyon Solar Pvt. Ltd.
Operation & Maintenance	BAIF is in process of training the local persons with the help of Schneider Electric Entrepreneurs Network for regular operations and maintenance of the project at all three locations.
Research Partner	Team of agronomist and solar experts from BAIF and now BAIF is looking for research partners
Consumption of Power	The power will be used for following purposes 1. Providing power to BAIF campus related activities, lab's and production facilities 2. Powering the pumps of capacity of 100 and 20 HP, 10 HP and various pumps of 5 & 7 HP mainly used for irrigation purpose 3. Powering the pumps for village level drinking water facility of capacity 5 and 12 HP 4. For charging the battery bank placed at Pune and Karnataka location for night time supply to street lamps and EV charging facility 5. During day time the power will be directly used for running the load/s such as chaff cutters, processing machines and other enterprises.
Type of Agrivoltaics Plant	1. Greenhouse-integrated (flexible and conventional PV installation) 2. Vertical PV 3. Renkube model 4. Standard with 1, 1.5, 2.1m module height lower end 5. With height of 4 meters

Project name	Demonstrating Agrivoltaics for Prospering Farmers- BAIF Campus, Pune- 1.2 MW
Module Technology	1. Topcon bifacial 2. Flexible Mono PERC 3. Mono Crystalline PERC Technology
Mounting Structure	1. Polyhouse with flexi PV 2. Vertical PV 3. Renkube model 4. Standard MMS 9.5 m pitch, 1.5m module height lower end 5. Double axis tilting - Fully Automatic Tracker for daily tracking 6. Single axis tilting – Manually - Seasonal Tilt structure with 4 tilt angles 7. Installation on Sloping roof of cattle shade 8. Standard MMS 9.5 m pitch, 1 m module height lower end 9. Standard MMS 9.5 m pitch, 2.10 m module height lower end 10. With height of 4 meters with tilt angle of 10° - with spacing 7 m in 1st & 2nd, 6 m in 2nd & 3rd, 5 m in 3rd & 4th, 11. Installation on polyhouse with conventional panels - Without actual load on polyhouse 12. Conventional solar Pump with less than 1m module height lower end
Tracking	Asun Solar Power Private Limited
Cleaning	Manual with water based cleaning
Water Management	Drip Irrigation water is sourced from river and well
Crops	Plan for crop cultivation: Aster, Bitter gourd, Brinjal, Beans, Beetroot, Cucumber, Chilli, Cauliflower, Coriander, Cabbage, Carrot, Capsicum, Chrysanthemum, Garlic, Ginger, Lettuce, Marigold, Okra, Onion, Palma Rosa, Radish, Ridge gourd, Sunflower, Sweet Corn, Spinach, Turmeric, Tomato.
Farming Activity	BAIF is having inhouse team of agricultural experts who are involved in the planning of farming activities. The crops are elected on the basis of structure type and availability of sunlight and seasonal suitability.
Lessons Learnt/ Challenges	The designing of various structures and finding suitable EPC is a major challenge, as the concept of agrivoltaics is very new in India and most of the vendors have experience of convectional ground mounted structure installation.
A Brief about the Project	The Demonstrating Agrivoltaics for Prospering Farmers project by BAIF Development Research Foundation aims to address the rising competition between land use for food and energy in rural India. As India targets 448 GW of solar energy by 2030, agrivoltaics using land simultaneously for agriculture and solar power offers a sustainable solution. **Origin:** BAIF, with decades of experience in rural development, recognized the urgent need for integrated land use that ensures both food security and renewable energy access. Agrivoltaics emerged as a promising model to achieve this, particularly in underserved farming communities. **Goals:** • Demonstrate scalable agrivoltaics systems in Maharashtra, Telangana, and Karnataka. • Develop and document best practices for crop cultivation under solar panels. • Train farmers and create green job opportunities. • Supply clean energy to rural households and agriculture. • Influence policy for national-level adoption of agrivoltaics. The project blends innovation, sustainability, and livelihood enhancement with empowering farmers by providing knowledge, energy, and income.

Project name	Demonstrating Agrivoltaics for Prospering Farmers- BAIF Campus, Pune- 1.2 MW
	Partners: Funding Parther – HSBC Software Development India Pvt. Ltd. Technology Partner – Snider Electric, Renkube, Technical Consultant – Mr. Kaustub Apte - Maxwell Solar & Wind Energy Motivator and supporter – Mr. Gulab Sing Girase – Grosolar
Additional Information, if any	In this project BAIF is also demonstrating the Climate smart village model, in which the energy requirements for agricultural operations, common needs of community and for household applications will be fulfilled with the help of renewable energy.

Figure 78. Vertical Panels at the Agrivoltaic project at BAIF Campus, Pune- 1.2 MW



Figure 79. Panels at the Agrivoltaic project at BAIF Campus, Pune- 1.2 MW





02

Comparative Performance Analysis.

Insights into Technical, Financial and Agricultural Outcomes

Technical Outcomes

Agrivoltaics system in India are deployed across three structural archetypes: low-height interspace models, medium-to-high elevated stilted systems, and vertical/track-based structures. This section compares these typologies on system architecture, module technology, cleaning and water management, and operational integration.

Parameter	Interspace/Mounted	Elevated Stilted	Vertical / Tracker
Height	1–3 m horizontal mounting(e.g. GIPCL Amrol: 1–3 m, GSECL Jamnagar: 3m)	≥ 3 m (e.g. Dayalbagh: 5.5m; Farmer owned, Juhu, Himachal Pradesh: 2.2 m; Central Arid Zone Research Institute: 1.64m)	Vertical bifacial (NISE: 5 kW pilot, BAIF Pune)
Panel Technology	Monofacial (mostly 260–310 Wp) as seen in GSECL	Semi-transparent glass modules, bifacial PERC (Jain irrigation, Dayalbagh)	Bifacial mono-PERC (bifaciality ~0.85) as seen in Sunseed APV-Parbhani, Sunmaster Pvt ltd Issapur, NISE Gurgaon, Ruvexa Enterprises.
Tracking	Fixed tilt (0°–26° seasonal manual tilt) (Sunmaster Delhi, Grosolar Dhule, Odisha University, Renkube Private Limited)	Some single-axis (Talf Solar, Parbhani, Tata-Cornell-Jain Irrigation, DAU, Odisha Agriculture University)	No tracking (vertical) or single axis only (CAZRI project/Talf solar)
Cleaning & Water Management.	Manual dry/wet cleaning; rain-gutters (Junagadh University, Abellon clean Energy)	Automated sprinkle/robotic cleaning; rainwater harvesting in some (Sunmaster, Sunseed)	Not extensively tested

Structural Elevation and Spatial Access

Interspace Systems (e.g., GIPCL Amrol, GSECL Sikka): Panels are typically mounted 1–3 meters above ground. These systems permit inter-row cultivation but restrict large equipment access and crop variety. They are cost-effective but limited in agronomic flexibility. Some projects (e.g., Abellon Energy, Harsha Abakus) report difficulty using tractors below the structures due to constrained clearances.

- Elevated Stilted Structures (e.g., Dayalbagh – 5.5m; Sunmaster Private Limited, Mundela – 3.5m): These designs allow mechanized operations, better light dispersion, and the flexibility to grow taller or more diverse crops. However, they significantly increase civil construction costs and wind load risks. Pilot projects (e.g., Sunseed APV Private Limited, Parbhani) incorporate shade-net houses over elevated structures to optimize light intensity and wind buffering.
- Vertical/Tracker-Based Systems (e.g., NISE Gurgaon, BAIF Pune, Talf Solar – Single Axis): These systems minimize land coverage and optimize east-west irradiation through bifacial modules. While land use is efficient, the complexity of tracking and potential mechanical failures necessitate higher maintenance sophistication. Vertical bifacials require precise albedo management to realize rear-side yield gains.

Module Technology and Orientation

- Legacy Systems: Use monofacial polycrystalline panels (e.g., GSECL Sikka) with capacities around 310 Wp. These systems remain common due to lower upfront costs but offer limited spectral response and no bifacial gain.
- Modern Deployments: Increasingly shift to bifacial mono-PERC or N-type TOPCon modules (e.g., Mundela, Surakpur, Indra Solar Farm), with improved yield potential from rear-side irradiance especially on high-albedo surfaces (e.g., sandy or white-reflective soil beds).
- Innovative Models: Includes semi-transparent modules (e.g., Dayalbagh) and glass-glass PV panels (e.g., Jain Irrigation Turmeric-Ginger Pilot) that aim to diffuse light more evenly, reduce crop stress, and enhance agronomic compatibility.

Cleaning Regimes and Water Integration

- Manual Cleaning (Majority): Performed weekly or twice a week, depending on dust load (e.g., Dayalbagh every 15 days; GSECL every 7–8 days using 2–5L per panel). Salinity and industrial proximity (e.g., cement industry near Sikka) aggravate maintenance challenges.
- Robotic/Semi-Automated Cleaning; Introduced in newer projects such as Parbhani and Sunmaster Mundela. These reduce labour cost and water use, though installation and maintenance costs are higher and may not suit smaller projects.
- Water Reuse Models: Best practices include integrated rainwater harvesting and reuse of panel cleaning water for irrigation (e.g., Cochin Airport, CAZRI). Parbhani uses foggers and drip systems guided by soil moisture sensors, optimizing both irrigation efficiency and panel hygiene.

Structural Integration Challenges

- Projects report challenges in grid interconnection (Surakpur), insufficient electric metering infrastructure (Qutabgarh), and saline water constraints (Pandhro). Projects in difficult geographies such as Himachal (Jahu) had to contend with high rainfall and required custom structure design and anchoring.



Financial Outcomes:

Financial performance across agrivoltaics projects varies by ownership type, system size, structural form, and tariff mechanisms. The comparison spans CapEx, operational expenditure (OpEx), tariff realization, and economic return indicators.

Metric	Commercial Pilots	R&D/Academic
CapEx	₹ 57000 - 60000/kWp (GIPCL, GSECL)	₹ 50000- 150000/kWp (CAZRI, Dayalbagh)
O&M Costs	₹ 700 / kWp - yr (GSECL)	Cleaning every 10 - 15 days, manual labour
PPA Tariff / LCOE	₹ 3.22–3.44/kWh (GSECL, GIPCL)	Feed in Tariff of ₹ 4/kWh (CAZRI)
Payback Period	Commercial: 7 years (Indra Solar Farm)	Academic: 7 years (Dayalbagh)

Capital Costs and Financing Sources

- Interspace and Ground-Mounted: Typically cost ₹55,000–₹65,000/kWp. For example, GIPCL and GSECL projects were executed at ~₹57,500/kWp.
- Elevated and Advanced Pilots: Systems like Dayalbagh (₹1.5 lakh/kWp), Jain Irrigation, and Indra Solar (₹9.5 Cr for 2 MWp) reflect higher CapEx due to elevated steel infrastructure, semi-transparent panels, and research instrumentation.
- Financing Mix: Commercial plants (e.g., Indra Solar) blend 70% debt (via SBI) with 30% equity, while most research pilots are grant-funded or donor-supported (e.g., GIZ at Parbhani, Jain Irrigation self-financed).

Operational and Maintenance Costs

- O&M Range: ₹700–₹1,000/kWp annually for commercial plants. Sites in arid/dust-heavy areas (e.g., Sikka, Kutch) require frequent wet cleaning, raising both OpEx and water consumption.
- Labor Dependence: Even at R&D farms, cleaning and land prep are heavily labor-driven, which limits scalability unless semi-automation is introduced. Robotic systems at Mundela, Parbhani improve cost predictability but remain unaffordable for smallholders.

Revenue Models and Tariffs

- Commercial PPAs: PM-KUSUM-A projects like Indra Solar earn ₹3.07/kWh via 25-year PPAs with state discoms. Other Gujarat sites (GIPCL, GSECL) operate at ₹3.22–₹3.44/kWh under long-term agreements with GUVNL.
- Self-Consumption Models: Educational and institutional APV systems (e.g., Talf Solar, Dayalbagh) export to nearby hospitals or colleges. Though they reduce consumer power bills, financial data on revenue realization and repayment is unavailable.
- Dual Income Stream Potential: Indra Solar reports ₹1.1–₹1.2 Cr/year from solar, plus ₹10–12 lakh/year from agri-horti-livestock. Few other sites offer such detailed integration.

Return on Investment

- IRR Estimates: Only one site (Indra Solar) quantifies return: >15% IRR, with a 7–8-year payback, suggesting strong potential if both crop and solar revenue are optimized.
- Missing Metrics: No LCOE estimates or standardized cash-flow data is reported across other sites, especially academic ones, limiting any financial benchmarking.
- Financial Insight: Bankable APV requires convergence of long-tenure PPAs, dual-revenue models, and concessional capital. Currently, absence of FLDGs, performance-based incentives, and standard CapEx benchmarks impedes developer confidence

Project (Location)	Commission Date	Capacity (kWp)	Total CAPEX (₹ Cr)	CAPEX per kWp (₹)
GIPCL Amrol (Gujarat)	28 April 2016	1000	6.00 Cr	₹ 60,000.00
GSECL Sikka (Gujarat)	02 May 2016	1,054	6.06 Cr	₹ 57,500.00
CAZRI Jodhpur (Rajasthan)	12 August 2017	105	2.25 Cr	₹ 50,000.00
Dayalbagh University (Agra, UP)	26 January 2020	200	3.00 Cr	₹ 1,50,000.00
SunMaster Najafgarh (Delhi)	26 March 2021	2500	5.1 Cr	₹ 20,485.00+
Sunseed Parbhani	12 November 2022	1400	5.5 Cr	₹ 39,352.00
Indra Solar Farm-2 (Khargapur, MP)	18 November 2022	2000	9.50 Cr	₹ 47,500.00

The installation prices of agrivoltaics systems in India have significantly decreased over the past decade and have become far more affordable and scalable than previous prices. In 2016, initial commercial projects like GIPCL Amrol and GSECL Sikka took installation prices of ₹60,000 per kWp. Projects like SunMaster, Issapur in Delhi (₹20,485/kWp) and Sunseed, Parbhani in Maharashtra (₹39,352/kWp) illustrate that agrivoltaic technology is no longer reserved for premium R&D sites or state-owned enterprises. The 2022 Indra Solar Farm-2 in Madhya Pradesh was commissioned at ₹47,500/kWp a 20-25% drop from 2016 costs.

- This cost reduction is the result of a series of structural developments. International photovoltaic module prices fell by over 80% over the last decade due to advances in technology and economies of scale, according to the International Renewable Energy Agency (IRENA, 2023) (26). The Indian Government has played a significant importance to increase the affordability and accessibility of agrivoltaic systems with a set of targeted policy frameworks, monetary incentives, and institutional support. From lowering the costs per kWp of installation to enabling small farmers, cooperatives, and rural entrepreneurs to adopt agrivoltaics, the government has thus helped change agrivoltaics from a niche technology to a mainstream, grassroots-level solution.
- Production Linked Incentive (PLI) schemes and import replacement policies of India have increased local manufacturing capacity, lowering component and logistics costs. Waiver on Transmission Charges for interstate solar projects commissioned before June 2025 helped utilities and private developers integrate agrivoltaic generation without additional costs. (27) (28)
- Policy initiatives like PM-KUSUM have brought added financial incentives, simplified certifications, and encouraged modular, scalable agrivoltaic designs suitable for rural installation. The Central financial assistance (CFA) of up to 30% of the benchmark cost, with equal share of 30% from the state government, reduces the farmer's burden of the total CAPEX. (4)
- Today, these changes have made agrivoltaics a practical solution implemented by farmers, cooperatives, and state agencies. Today, it is not only technically viable but increasingly economically accessible, helping India move closer to its climate goals while improving land productivity and rural incomes. The cost data shows that agrivoltaics is now within the reach of the greater mass. This is a powerful and hopeful signal for development in India.

Agricultural outcomes:

- The performance across sites varies widely depending on structural design, crop choices, microclimatic variables, and institutional capacity. The evaluation of the agronomic potential of APV systems, analyzing crop performance under varied shading conditions, land-use optimization metrics, and systemic constraints that impede replication and scale

Aspect	Interspace	Under Elevated Panels	Specialized Systems
Crop Variety	Over 20 different crops (Cochin Airport)	Multiple varieties of vegetables and crops (Tata Cornell-Bihar)	Ongoing research for crops like Rice and Wheat (Jain irrigation and Ruvexa Delhi)
Yield Impact	Cumin yield was significantly affected (CAZRI)	Generally neutral to slightly improved	140% gain in banana yield (Jain Irrigation)
Water Use	Cleaning water reused or borewell; ~2,00,000 L/MWp-yr	Drip irrigation rainwater harvesting (CAZRI)	55% water savings (Jain irrigation)
Land Equivalent Ratio (LER)	Not typically assessed	LER of 1.41 observed at CAZRI (more output per hectare) -	Elevated trellis vegetable systems under testing

Across the projects surveyed, crop productivity under photovoltaic canopies has shown a wide range of responses, with success largely contingent on the alignment between crop physiology and shading intensity.

- Positive Performance of Shade-Tolerant and Semi-Tolerant Crops: A recurring pattern across elevated and vertical installations is the successful cultivation of shade-resilient crops such as:
- Leafy vegetables: spinach, fenugreek, coriander (e.g., Qutabgarh, Surakpur, Parbhani)
- Root and tuber crops: radish, beetroot, turmeric, ginger (e.g., Mundela, Jain Irrigation, CAZRI)
- Pulses and cereals: green gram, foxtail millet, kodo millet (e.g., Indra Solar, BAIF Pune)
- Fruit-bearing plants: tomato, watermelon, grapes, banana (e.g., Parbhani, Indra Solar)

Projects such as Indra Solar Farm reported wheat yields under panels that were comparable to open fields, despite 25% lower water consumption, due to moderated evapotranspiration and soil moisture retention. Similarly, Jain Irrigation observed a 140% increase in banana productivity under bifacial panel shade, attributing the gains to reduced sun stress and more stable microclimate.

Modulated Performance in Seasonal Crops: Floricultural and short-cycle vegetables such as marigold, rose, and okra have been observed to perform well in vertically aligned systems (e.g., NISE Gurgaon, BAIF Pune), but require careful orientation and microclimate regulation (e.g., additional shade nets) to avoid photo inhibition during peak summer months. Site-Specific Observations:

At Parbhani, tomato, brinjals, and watermelon performed effectively under a hybrid system combining bifacial panels with foggers and mulch, indicating the role of microclimate-enhancing interventions.

In the Himachal pilot (Jahu), which lies in a high-rainfall and high-altitude zone, climate-resilient crops like turmeric and seasonal fodder grass were prioritized. However, the excessive rainfall challenged standard agronomic practices, requiring localized R&D adaptation.

Land Productivity Outcomes

The agrivoltaics value proposition rests heavily on the principle of optimized land productivity expressed through metrics like Land Equivalent Ratio (LER) and the combined economic output per hectare.



Land Equivalent Ratio (LER): Though formalized LER monitoring remains sparse, several sites report values ranging from 1.2 to 1.4, indicating that combined yields (crop + electricity) under agrivoltaics exceed what the land would have generated from either use independently. Notable examples include:

- CAZRI Jodhpur: Achieved high LER by integrating elevated bifacial panels with vegetable crops and efficient water harvesting.
- Indra Solar: Operates a three-season cropping calendar (Rabi, Kharif, Zaid) alongside power generation, reporting full-season yield maintenance without shading penalty.
- Jain Irrigation: Reports high LER for turmeric and banana through semi-transparent modules and staggered planting cycles.

Integrated Yield Maximization: Some developers (e.g., Indra Solar, Parbhani) go beyond traditional metrics by integrating livestock (goat grazing, poultry) and value-added processing (turmeric curing, banana packaging) into the APV ecosystem, further raising per-acre income. Despite promising LER signals, few projects undertake long-term, multi-season monitoring to confirm statistical reliability. Without disaggregated data by crop, season, and shading profile, extrapolating LER to national policy or substeady side at mature.

Best Practices

Several practices observed across various projects have demonstrated benefits for efficient agrvoltaics implementation. Technical practices include elevated structures (≥3m) that enable farm machinery to be used and promote crop yields, in addition to advanced technologies, including bifacial and semi-transparent modules for enhanced light diffusion and heat stress mitigation. Integrated water solutions, which include rainwater harvesting and using recycled water from panel cleaning, help reduce irrigation requirements and operational costs, while tracking systems maximize solar output over high-irradiance zones.

Agriculture practices like choosing shade-tolerant, high-value crops such as turmeric, ginger, and aloe vera are the most supported crops in terms of low maintenance, easy value generation and increasing consumer demands, using monitoring tools such as the Land Equivalent Ratio (LER) and organic farming practices that ensure sustainability practices.

Institutional practices such as the involvement of agricultural universities help improve farming methods by using crop rotation and growing multiple types of crops. Through this approach, the system can be made more scientifically reliable, helps control pests, maintains the soil moisture content and supports income generation from energy production.

The table below provides an overview of crops cultivated in states where agrivoltaic projects have been piloted. The crop selection is based on the agroclimatic zones of these states and reflects the choices made by landowners for cultivation under solar panels.



Table 46. Suitable crops based on agroclimatic condition

Agroclimatic Region	States	Crops Cultivated in Agrivoltaic Systems	Potential Crops	Climatic Condition
Eastern Himalayan Region	Assam	Medicinal Crops: Ashwagndha, Rossele, Tulsi	Rice, potato, maize, tea and fruits (orange, pineapple, lime, lichi etc.) are the main crops.	Thick forest cover and sub-humid climate (rainfall over 200 cm; temperature July 25°C-33°C, January 11°C-24°C)
Lower Gangetic Plains Region	Bihar	Ginger, turmeric, bitter gourd, bottle gourd, banana, sugar cane;	Rice is the main crop which at times yields three successive crops in a year. Jute, maize, potato, and pulses are other important crops. Planning strategies include improvement in rice farming, horticulture (banana, mango and citrus fruits).	Temperature for July month varies from 26°C-41°C and for January month 9°C-24 0C.
Trans-Gangetic Plain Region	Delhi	The crops can be grouped based on their type. Millets include Finger Millet (Ragi), Foxtail Millet, and Kodo Millet. Leafy vegetables and root vegetables. Legumes include French Beans and Snow Peas. Tuber crops (potatoes) and bulb crops (onions). Fruit vegetables include Cherry Tomatoes and perennial or specialty crops like Asparagus (tolerates some shade) and Mushrooms.	Important crops include wheat, sugarcane, cotton, rice, gram, maize, millets, pulses, vegetables and oilseeds etc	The climate has semiarid characteristics with July month's temperature between 26°C and 42°C, January temperature ranging from 7°C to 22°C and average annual rainfall between 70 cm and 125 cm
Gujarat Plains and Hills Region	Gujarat	Winter crops include tomato, cucumber, lady finger, zucchini, and chili. Summer crops mainly consist of moong dal, bottle gourd, lady finger, and watermelon. Spices such as turmeric, ginger, and chili are grown seasonally, while crops like lady's finger, bottle gourd, coriander, and cluster beans are adaptable to multiple seasons.	Groundnut, cotton, rice, millets, oilseeds, wheat and tobacco are the main crops. It is an important oilseed producing region	It is arid a semi-arid region with average annual rainfall between 50 cm-100 cm, and monthly temperature between 26°C-42°C in July and 13°C-29°C in January

Agroclimatic Region	States	Crops Cultivated in Agrivoltaic Systems	Potential Crops	Climatic Condition
Trans-Gangetic Plains Region	Haryana	Tomato, chili, flowers, Kufri Lima potato	Important crops include wheat, sugarcane, cotton, rice, gram, maize, millets, pulses and oilseeds	The climate has semiarid characteristics with July month's temperature between 26°C and 42°C, January temperature ranging from 7°C to 22°C and average annual rainfall between 70 cm and 125 cm
Southern Plateau and Hills Region	Karnataka	Cauliflower and tomato but also lady finger, chilly, promogrante, lemon, spinach, rosemary, bitter gourd, brinjal, beans, basil, coriander, papaya and lettuce amongst others	Low value cereals and minor millets predominate. Coffee, tea, cardamom and spices are grown along the hilly slopes of Karnataka plateau	The temperature of July month lies between 26°C to 42°C, that of January month between 13°C-21°C with annual rainfall between 50 cm-100 cm
Eastern Plateau and Hills Region	Maharashtra	Vegetables: Rotational cropping, residue-free crop cultivation, Cherry Tomato, Capsicum, Cucumber, Betel Leaves, Turmeric, Ginger, Basil, Spinach, Methi, Coriander, Mint, Flowers: Rose, Chrysanthemum, Geranium, Tuberose, Hibiscus, Marigold, Fruits: Watermelon, Muskmelon, Guava, Aromatic crops: Lemongrass	Rainfed agriculture is practised growing crops like rice, millets, maize, oilseeds, ragi, gram and potato	The region enjoys 26°C-34°C of temperature in July, 10°C-27° C in January and 80 cm-150 cm of annual Rainfall
East Coast Plains and Hills Region	Odisha	Pineapples & Dragon fruits and in summer season leafy vegetables	Main crops include rice, jute, tobacco, sugarcane, maize, millets, groundnut and oilseeds. Main agricultural strategies include improvement in the cultivation of spices (pepper and cardamom)	The Climate is sub-humid maritime with May and January temperatures ranging from 26°C-32°C and 20°C-29°C and annual rainfall of 75 cm-150 cm.



Agroclimatic Region	States	Crops Cultivated in Agrivoltaic Systems	Potential Crops	Climatic Condition
Southern Plateau and Hills Region	Telangana/ Andhra Pradesh	Multiple vegetable crops and Aromatic crops like Lemongrass	Low value cereals and minor millets predominate. Coffee, tea, cardamom and spices are grown along the hilly slopes of Karnataka plateau.	The temperature of July month lies between 26°C to 42°C, that of January month between 13°C-21°C with annual rainfall between 50 cm-100 cm
Western Himalayan Region	Uttarakhand	Rosemary and Geranium	Maize, wheat, potato, barley are other important crops. Temperate fruits like apple and pear etc. are produced in some parts.	Summer season is mild (July average temperature 5°C-30°C) but the winter season experiences severe cold conditions (January temperature 0°C to -4°C)
East Coast Plains and Hills Region	West Bengal	Vegetables, flowers, Spices	Rice, coconut, oilseeds, sugarcane, millets, pulses and cotton are the main crops. The region is also famous for plantation crops and spices which are raised along the hill slopes of the Ghats.	This is a humid region with annual rainfall above 200 cm and average temperatures of 26°C-32°C in July and 19°C-28°C in January.
West Coast Plains and Ghat Region	Kerala	Vegetables, including tubers and roots such as yam, mountain ginger, and turmeric; leafy and flower vegetables like cabbage and cauliflower; gourds and cucurbits such as snake gourd, bitter gourd, bottle gourd, ash gourd, blonde cucumber, and pumpkin; and other popular vegetables like long yard beans, eggplant, tomato, and okra.	Low productivity areas of paddy and millets under rained conditions should be diverted to horticultural crops like mango, banana, coconut etc.	This is a humid region with annual rainfall above 200 cm and average temperatures of 26°C-32°C in July and 19°C-28°C in January



Key Constraints

Despite multiple successful demonstrations, there is an evident absence of structured agronomic planning across most APV installations particularly outside large-scale commercial projects or research-backed pilots.

Limited Integration with Agricultural Research Institutions: Only a handful of sites report structured collaboration with Krishi Vigyan Kendras or agricultural universities. Notable partnerships include:

- GIPCL with Anand Agricultural University (AAU)
- Dayalbagh with the Department of Science and Technology (DST)
- Parbhani with Krishi Vigyan Kendra and Mahatma Phule Krishi Vidyapeeth (MPKV)
- Elsewhere, developers often rely on empirical trial-and-error, with no formal agronomic validation or crop selection matrix.

Monitoring Infrastructure Deficiency: Most pilots do not employ systematic yield monitoring systems. Instruments like soil moisture sensors, solar radiation monitors, and crop productivity dashboards are deployed only at a few sites (e.g., Indra Solar, Parbhani). Without such instrumentation, the effects of microclimate changes caused by panel shadowing cannot be scientifically measured or optimized.

Advisory and Replicability Concerns: Developers such as Talf Solar explicitly report the lack of credible, crop-wise, zone-specific agronomic guidance for agrivoltaics. In the absence of a national crop-panel compatibility matrix or APV-specific extension service protocols, the burden of adaptation falls entirely on the developer or farmer.

Problem Title	Description	Examples
High Capital Expenditure	Elevated structures cost much more than standard solar, making it unaffordable for small farmers.	Dayalbagh University: ₹1.5 lakh/kW; Amity University: ₹2.49 lakh/kW; GSECL: ₹57,000/kWp for reorientation.
Crop Yield Variability	Crop performance is inconsistent; shade-tolerant crops do well, others may not perform well, causing farmer risk.	Shade-tolerant crops (mungbean, ginger, mint) performed well; cumin, isabgul, ragi, and rice struggled at CAZRI and Jain Irrigation pilots.
Timing Conflict (Energy vs Agriculture)	O&M operations like cleaning can disrupt crop cycles and damage plants.	At Sikka site in Gujarat, crops were damaged during high-pressure solar panel cleaning.
No Dedicated APV Incentives	Lack of specific policies or funding for agrivoltaics; existing schemes don't cover dual-use costs.	PM-KUSUM supports solar on agricultural land but does not cover extra costs of dual-use systems; no capital subsidy or VGF for APV.
Limited Market Linkages	Most projects lack access to reliable buyers or supply chains, limiting farmer income from crops.	Cochin Airport succeeded in direct-to-consumer sales; most pilots lack links to mandis, cooperatives, or institutional buyers.

04 Conclusions

This report provides a comprehensive comparative performance analysis of agrivoltaics systems in India, informed by operational evidence from 37 distinct sites across 16 states. Through disaggregated evaluation of technical configurations, financial structures and agronomic outcomes, it provides a grounded and multidimensional view of agrivoltaics viability not as an abstract innovation, but as a land-energy-agriculture model already in operation.

The insights derived reflects a sector that is moving beyond proof-of-concept, yet remains institutionally unstructured. A wide spectrum of design formats from low-mounted to elevated stilt and vertical systems has evolved in silos, without technical standardization. Financial returns, while demonstrably viable in a handful of integrated commercial pilots, remain highly contingent on access to concessional capital, dual off-take arrangements, and localized agronomic support. Agronomic performance shows high potential but is undercut by the absence of structured advisory mechanisms and crop-panel interaction matrices suited to Indian conditions. Financial studies show CAPEX to range between ₹57,000–₹1,20,000 per kWp, with OPEX averaging around ₹700 per kWp per year, reflecting higher maintenance, cleaning, and irrigation requirements when compared to standard ground-mounted solar. Importantly, dual-income streams derived from energy sales and agricultural yields have begun mature, as observed in both commercial deployments and farmer-owned micro grid models.

Crucially, the report identifies a triple asymmetry that currently defines India's agrivoltaics sector:

- A design-performance asymmetry, where structural typologies are not calibrated to agro-climatic or cropping contexts;
- A financial-incentive asymmetry, where elevated systems bear higher capital costs but receive flat tariffs and undifferentiated risk coverage;
- An institutional-readiness asymmetry, wherein state and district-level actors lack the procedural guidance or fiscal instrments to support APV deployment.

To address the scale and fragmentation problems of rural financing, pilot programs should investigate:

- SPVs owned by the community: FPOs, cooperatives, or local panchayats owning agrivoltaics assets in a collective manner.
- Financing led by aggregators via FPOs/PACS: These entities serve as intermediaries to group smaller applications from farmers into larger loan proposals, thereby reducing the transaction cost per unit and administrative burden of the bank side.



Other functions of aggregators include maintenance of shared infrastructure, ensuring returns, and ensuring that maintenance agreements are complied with.So, agrivoltaics and its deployment in the diverse agroclimatic zones as well as socio-economic context of India creates uncertainties for farmers, solar developers, and potential investors. Accordingly, demonstration projects across regions in India, which consider different agricultural value chains ,stakeholder models and address key knowledge gaps, are needed. The government of India may consider tendering projects specific to Agrivoltaics while also encouraging pilot projects to sensitize stakeholders across sectors.

Typically, debt constitutes about 70% of the Agrivoltaics project capital. At commercial rates of around 8%, financing costs significantly affect project viability. With the soft-loan program or issuance of green bonds targeting around 3% interest, it can reduce expenses by 25% on debt servicing, thereby decreasing the levelized cost of energy. These capital vehicles characteristically present long duration and low-cost existence. Such traits help them ideally suit the 10–12-year course of specialized Agrivoltaics loans and entities can either underwrite them on their own or they may be guaranteed by budgetary allocations. Green bonds, in particular, attract climate-focused investors and institutional capital, providing a stable and sustainable source of funding for long-term infrastructure like Agrivoltaics. (16) (17)

The financing architecture will not succeed without demand-side readiness. To enable rural banks and farmers with knowledge of agrivoltaics as a financial opportunity, they must be made aware. Targeted campaigns should be undertaken to:

- Conduct regional-level workshops and online modules to train branch-level staff of Regional Rural Banks (RRBs), NBFCs, and cooperative banks.
- Distribute materials to farmers in vernacular languages related to the benefits, risks, and financial models of agrivoltaic
- KVKs and Panchayat-level sessions are to be utilized for ensuring the last-mile engagement.

To address these, agrivoltaics must be recognized and governed as a hybrid infrastructure asset distinct from conventional ground-mounted solar and requiring convergence between the ministries of renewable energy, agriculture, and rural development. This entails not just financial reform, but regulatory clarity, performance benchmarking, and the formal incorporation of agrivoltaics within land-use and agricultural policy frameworks. Rather than proposing abstract models, the report uses grounded, comparative evidence to build a credible foundation for policy reform and structured replication. As energy transition deepens and land-use trade-offs intensify, agrivoltaics offers a coherent pathway for decentralized solar expansion that aligns not just with carbon targets, but with agricultural productivity, rural employment, and climate resilience.



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Bibliography

1. Central Electricity Authority. 2022. National Electricity Plan 2022. Page 116. https://cea.nic.in/wp-content/uploads/irp/2022/09/DRAFT_NATIONAL_ELECTRICITY_PLAN_9_SEP_ 2022_2-1.pdf.
2. Department of New & Renewable Energy. 2020. DISCOM KUSUM Tender for Installation of Decentralized Grid Connected Ground/ Stilt Mounted Solar Based Power Plants.
3. Maximilian Vorast. 2020. AGRIVOLTAICS SCOPING INDIA & INTERNATIONAL
4. EXPERIENCES. Preliminary Report. Fraunhofer Institute for Solar Energy Systems ISE.
5. Ministry of New and Renewable Energy of India. 2019. Guidelines for Implementation of Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM) Scheme.
6. Ministry of New and Renewable Energy of India. 2020. Programme/Scheme wise Physical Progress in 2020-21 & Cumulative upto Oct, 2020. https://mnre.gov.in/the- ministry/physical-progress.
7. [Ministry of Agriculture & Farmers Welfare. (2024, August 28). Agricultural Infrastructure Fund (AIF) Scheme. Press Information Bureau. https://www.pib.gov.in/PressNoteDetails.aspx?NoteId=152061&ModuleId=3
8. Ministry of Agriculture & Farmers Welfare. (2025, February 4). PROJECTS UNDER AGRICULTURE INFRASTRUCTURE FUND. Press Information Bureau. https://www.pib.gov.in/PressReleseDetailm.aspx?PRID=2099753&utm
9. Department of Agriculture & Farmers Welfare. (n.d.). Eligible projects. National Agriculture Infra Financing Facility. https://agriinfra.dac.gov.in/Home/EligibleProjects.
10. Srivastava, A. (n.d.). Can large-scale solar energy work with agriculture? India Development Review. Retrieved June 18, 2025, from https://idronline.org/article/climate-emergency/can-large-scale-solar-energy-work-with-agriculture/
11. Ministry of New and Renewable Energy (MNRE). (2025, April 15). AgriPV: Co-locating agriculture and photovoltaics – MNRE white paper. Retrieved from https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2025/04/2025041510438064 82.pdf
12. Mercom India. (2023, December 20). Through agrivoltaics, farmers can earn dual income from crops and solar: Interview. Retrieved June 18, 2025, from https://www.mercomindia.com/through-agrivoltaics-farmers-can-earn-dual-income-from-crops-and-solar-interview
13. Reuters. (2025, June 16). Solar and wind undercut fossil fuels on cost, says Lazard energy report. https://www.reuters.com/sustainability/solar-wind-undercut-fossil-fuels-cost-says-lazard-energy-report-2025-06-16/
14. Singh, J. (2025, March 18). The role of solar in India's 500 GW renewable energy target by 2030. pv magazine India. Retrieved from https://www.pv-magazine-india.com/2025/03/18/the-role-of-solar-in-indias-500-gw-renewable-energy-target-by-2030/

15. Centre for Science & Environment (via NSEFI). (2020). Agrivoltaics in India – Overview of projects and policies [PDF]. India Agrivoltaics Alliance.
16. IEA-PVPS Task 13. (2025, March). Dual land use for agriculture and solar power production: Overview and performance of agrivoltaic systems [PDF]. IEA-PVPS.
17. IREDA. (2022). Financing norms and policies for renewable energy projects. Indian Renewable Energy Development Agency. https://www.ireda.in/
18. Ministry of Finance, Government of India. (2023, January). Framework for Sovereign Green Bonds.
19. International Renewable Energy Agency (IRENA). (2020). Renewable Power Generation Costs in 2020. https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020
20. Solar Mango. (2015, December 8). Costs for small MW-scale grid-connected power plants in India – LCOE and optimal tariff. https://www.solarmango.com/2015/
21. SaurEnergy International. (2024). India's solar O&M market: A tale of increased domination of new evolving technologies. https://www.saurenergy.com/
22. India Water Portal. (2022, May). Agri-voltaics in India: Challenges and opportunities. Retrieved from https://www.indiawaterportal.org/articles/agrivoltaics-india
23. Sharma, R., & Deshmukh, V. (2023). Techno-economic analysis of agrivoltaic systems in India. Sustainability, 15(14), Article 11059. https://doi.org/10.3390/su151411059
24. Trans India Law Associates & NSEFI. (2021). Legal aspects of agriphotovoltaics in India [PDF].
25. India Agrivoltaics Alliance. (2024). Policy and regulatory enablers for accelerating solarization of agriculture through agrivoltaics: Guidebook for policy makers (Version V1.0). National Solar Energy Federation of India (NSEFI). https://www.agrivoltaics.in/_files/ugd/0c91be_10d7b0628c4042048cc6f44e9762f0d3.pdf
26. National Solar Energy Federation of India (NSEFI) & TUeV Sued. (2021, October). Overview on Agrivoltaic Projects in India. Retrieved from https://www.nsefi.in/resources/overview-on-agrivoltaic-projects-in-india/
27. International Renewable Energy Agency. (2023). Renewable power generation costs in 2022. IRENA. Retrieved from https://www.irena.org/publications/2023/Jun/Renewable-Power-Generation-Costs-in-2022
28. Ministry of New and Renewable Energy. (2022). PLI Scheme for High Efficiency Solar PV Modules. Government of India. Retrieved from https://mnre.gov.in/img/documents/uploads/file_f-1617170730912.pdf
29. Ministry of Power. (2021, June 21). Waiver of Inter-State Transmission Charges on Transmission of the Electricity generated from Solar and Wind Sources of Energy. Government of India. Retrieved from https://powermin.gov.in/sites/default/files/webform/notices/OM_ISTS_waiver_21_06_2021.pdf



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