Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 06, Issue: 05 (SEP-OCT, 2026)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Agrivoltaics: Producing Food and Solar Energy on the Same Agricultural Land

*P. G. Gameti[1], Dr. A. R. Ninama[2] and Dr. K. V. Ram[3]
[1]Ph.D. Scholar (Plant Pathology), Department of Plant Pathology, B. A. College of Agriculture, Anand Agricultural University, Anand-388110, Gujarat, India
[2]Assistant Research scientist, Regional Research Station, Sardarkrushinagar Dantiwada Agricultural University, Bhachau, Gujarat-370140, India
[3]Assistant Professor, Department of Agronomy, Junagadh Agricultural University, Junagadh-362001, Gujarat, India
*Corresponding Author's email: gametiprincy28@gmail.com

Agrivoltaics combines solar photovoltaic (PV) electricity generation with crop production on the same land. It may address competing demands for food, energy and land while supporting farm operations and diversifying income. Crop responses depend on shading, panel design, climate, irrigation and crop physiology. This article outlines agrivoltaic systems, benefits, limitations and opportunities for India, particularly Gujarat. Successful implementation requires site-specific design and evaluation of agricultural and energy outputs.

Keywords: Agrivoltaics; solar photovoltaic; crop yield; microclimate; water-use efficiency; Gujarat.

Introduction

Agriculture and renewable-energy development both require land. Conventional solar parks may displace cultivation, whereas agrivoltaics—also called agrophotovoltaics or solar sharing—combines crop production and solar electricity. Panels may be elevated above crops, placed between rows or integrated into protected structures. Performance depends on panel design, shading, crop type, water and farm operations (Dupraz *et al.,* 2011; Chopdar *et al*., 2024).

How agrivoltaics works

Photovoltaic modules convert sunlight into electricity for irrigation pumps, cooling, lighting and other farm needs; surplus power may be exported where grid access and agreements permit. Crops receive sunlight through panel gaps or beneath the structures. The design challenge is to balance light for photosynthesis with electricity generation. Excessive shading can reduce crop growth and yield, while moderate shade may lower heat load in some hot environments. Outcomes must be tested against open-field controls rather than assumed (Amaducci *et al*., 2018; Asa'a *et al.,* 2024).

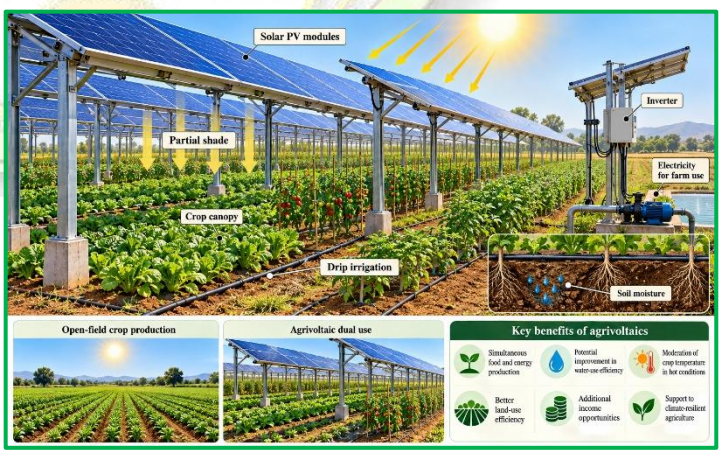


Figure 1. Conceptual illustration of an agrivoltaic system integrating PV modules, crops, irrigation and farm electricity use. The figure is illustrative and does not represent measured experimental data

Major agrivoltaic configurations

Different configurations offer trade-offs in cost, crop access, light transmission and electricity generation

Table 1. Common agrivoltaic designs and key considerations.

System	Description	Main consideration
Elevated panels	Modules mounted above crops	Higher structural cost; machinery clearance
Inter-row system	Crops grown between PV rows	Shade depends on spacing and solar angle
Greenhouse PV	Modules integrated into protected structures	Light transmission must suit the crop
Vertical bifacial	Vertical panels capture light on both sides	Orientation affects crop light and energy
Dynamic/tracking	Panel position changes over time	Added cost and maintenance

Crop growth, microclimate and water

PV panels redistribute sunlight and may alter leaf temperature, soil temperature and evaporation. Some leafy vegetables and selected horticultural crops may tolerate moderate shade, whereas light-demanding crops can lose yield if radiation becomes limiting. Partial shade may reduce heat stress in hot conditions, but its effect varies with panel coverage, wind, humidity and crop canopy. Panels can also redirect rainfall, creating uneven wet and dry zones. A systematic review reported potential improvements in water-use efficiency in some systems, alongside yield penalties where shading was excessive (Omer *et al*., 2025). Drip irrigation and soil-moisture monitoring may help manage these differences.

Crop selection

Crop choice should consider shade tolerance, crop duration, canopy height, harvest method, market demand, machinery access and irrigation needs. Potential candidates for local trials include leafy vegetables, tomato, chilli, brinjal, green gram, black gram and suitable fodder crops. These are candidates for evaluation, not universal recommendations; local trials should compare yield and quality under panels with open-field controls.

Table 2. Potential crop groups for preliminary agrivoltaic trials.

Crop group	Examples for evaluation	Measurements
Leafy vegetables	Spinach, amaranth	Marketable yield and leaf quality
Fruiting vegetables	Tomato, chilli, brinjal	Flowering, fruit set and yield
Pulses	Green gram, black gram	Pod yield, maturity and biomass
Fodder crops	Suitable grasses and forage legumes	Dry matter and forage quality

Benefits and land-use efficiency

Agrivoltaics may combine food and energy production, diversify farm income, supply electricity for farm operations and moderate microclimate under suitable conditions.

Land-use efficiency can be evaluated using the **land equivalent ratio (LER)**:

$$\mathrm{LER} = \frac{Y_{\mathrm{AV}}}{Y_{\mathrm{C}}} + \frac{E_{\mathrm{AV}}}{E_{\mathrm{S}}}$$

Where:

- Y_{AV}= crop yield per unit area under agrivoltaics.
- Y_{C}= crop yield per unit area under conventional cultivation.
- E_{AV}= electricity generated per unit area under agrivoltaics.
- E_{S}= electricity generated per unit area under a comparable standalone solar installation.

An LER greater than 1 indicates that the combined land-use performance exceeds the corresponding separate land uses, provided the comparison uses appropriate reference systems and consistent boundaries. For example, an LER of 1.20 would indicate that the combined system produces the same proportional agricultural and electricity outputs that would otherwise require 20% more land under the specified separate-production comparison.

Opportunities for India and Gujarat

Agrivoltaics is relevant to India's food–energy–water challenge. Gujarat offers opportunities for trials because of its solar resources and diverse farming environments. Nevertheless, local performance depends on crop response, water availability, soil, dust, wind, panel design and economics. PM-KUSUM supports specified solar-energy and agricultural-pump initiatives, but solarizing a pump or installing a solar plant does not automatically constitute agrivoltaics: meaningful crop production must continue on the same land. Multi-season demonstrations should measure crop yield, quality, soil moisture, temperature, irrigation volume, electricity generation, labour and net returns (Medonna & Ghosh, 2025).

Constraints and future directions

Constraints include high investment, yield loss under excessive shade, machinery interference, maintenance, uneven rainfall distribution and limited long-term local data. Soil-moisture sensors, weather stations, remote sensing and automated irrigation may improve management, but their costs and reliability need assessment. Research priorities include crop-specific trials, standardized panel-design reporting, multi-season water measurements, economic analysis, and assessment of soil health and biodiversity.

Table 3. Practical framework for evaluating agrivoltaic systems.

Planning stage	Key action or measurement
Site and design	Assess climate, soil, water, crop needs, panel height and spacing
Field trial	Compare replicated agrivoltaic plots with open-field controls
Water and energy	Record soil moisture, irrigation volume and electricity output
Economic assessment	Include crop revenue, energy value, labour, maintenance and capital costs
Long-term monitoring	Track yield stability, soil health, reliability and farmer acceptance

Conclusion

Agrivoltaics offers a promising way to combine crop production and renewable electricity generation on the same land. Its success depends on balancing crop light requirements, panel configuration, irrigation, farm access, energy output and investment costs. For Gujarat and other Indian regions, crop-specific multi-season trials and transparent economic analysis are essential before large-scale adoption. The goal should be a productive and financially viable farming system—not electricity generation at the expense of agriculture.

References

1. Amaducci, S., Yin, X., & Colauzzi, M. (2018). Agrivoltaic systems to optimise land use for electric energy production. *Applied Energy*, 220, 545–561.
2. Asa'a, S., Reher, T., Rongé, J., Diels, J., Poortmans, J., Radhakrishnan, H. S., van der Heide, A., Van de Poel, B., & Daenen, M. (2024). A multidisciplinary view on agrivoltaics: Future of energy and agriculture. *Renewable and Sustainable Energy Reviews,* 200, 114515.
3. Barron-Gafford, G. A., Pavao-Zuckerman, M. A., Minor, R. L., Sutter, L. F., Barnett-Moreno, I., Blackett, D. T., Thompson, M., Dimond, K., Gerlak, A. K., & Macknick, J. E. (2019). Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands. *Nature Sustainability*, 2, 848–855.
4. Chopdar, R. K., Sengar, N., Giri, N. C., & Halliday, D. (2024). Comprehensive review on agrivoltaics with technical, environmental and societal insights. *Renewable and Sustainable Energy Reviews*, 197, Article 114416.

5. Dupraz, C., Marrou, H., Talbot, G., Dufour, L., Nogier, A., & Ferard, Y. (2011). Combining solar photovoltaic panels and food crops for optimising land use: Towards new agrivoltaic schemes. *Renewable Energy,* 36(10), 2725–2732.
6. Medonna, A., & Ghosh, A. (2025). Harvesting sun amplified: A comprehensive review of agrivoltaics and floatovoltaics with a focus on India's potential. Solar Compass, 15, 100132.
7. Ministry of New and Renewable Energy. (n.d.). Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyaan (PM-KUSUM). Government of India.
8. Omer, A. A., Li, M., Zhang, F., Hassaan, M. M. E., El Kolaly, W., Zhang, X., Lan, H., Liu, J., & Liu, W. (2025). Impacts of agrivoltaic systems on microclimate, water use efficiency, and crop yield: A systematic review. *Renewable and Sustainable Energy Reviews*, 221, 115930.