Acacia Climate Partners
LIMITED

DATA BRIEF

August 2026

## KEY FINDINGS

- U.S. agrivoltaic sites **more than doubled** from 27,000 to 62,000 acres between 2020 and November 2024, reaching 10 GW of capacity (NREL, 2024).
- The highest confirmed Land Equivalent Ratio in the peer-reviewed literature is **1.97** — achieved with lettuce at INRAE Montpellier, France.
- Jalapeño peppers at Biosphere 2 required **65% less water** under agrivoltaic panels than open-field controls (Barron-Gafford et al., 2019).
- Italy committed **EUR 1.7 billion** to agrivoltaics through its National Recovery Plan, approved by the European Commission in November 2023.
- Covering just **1% of EU agricultural land** with agrivoltaic systems would yield 944 GW of peak installed capacity, exceeding the EU's entire 2030 solar target (EC JRC, 2023).
- The only two peer-reviewed agrivoltaic systems in sub-Saharan Africa were both funded by a single **GBP 1.4 million** UKRI grant and produced positive results at both sites (Randle-Boggis et al., 2025).
- Cero Generation's Pontinia project in Italy operates at **70 MW without public subsidy**, financed by private project finance and two 10-year PPAs.

# A Technology That Has Left the Laboratory

Agrivoltaics, the co-location of solar photovoltaic generation and agricultural production on the same land, is frequently described as an emerging technology. However, the global project record does not support that characterization. The concept was formalized in a 1981 German report by Adolf Goetzberger and Armin Zastrow of the Fraunhofer Institute for Solar Energy Systems. Japan introduced the first formal commercial and regulatory framework, known as solar sharing, in 2013.

By November 2024, the United States alone had recorded nearly 600 agrivoltaic sites spanning approximately 62,000 acres and generating 10 GW of solar energy, more than double the 27,000 acres and 4.5 GW recorded in 2020 (Fall, 2024).

Globally, the agri-PV market grew from approximately 14 GW of installed capacity in 2024 to an estimated 18.4 GW by mid-2025 (SolarPower Europe, 2025).

## WHAT THE LAND PRODUCTIVITY DATA SHOW

The Land Equivalent Ratio (LER) measures how much more productive a combined agrivoltaic plot is compared with using two separate single-use parcels, one for energy and one for agriculture. An LER above 1.0 means the dual-use system produces more output per unit of land than two separate monoculture systems combined. Four peer-reviewed studies establish the confirmed global benchmark.

### Heggelbach Research Farm, Germany (Fraunhofer ISE, 2017–2021)

A 194.4 kW elevated bifacial system on a Demeter farm cooperative near Lake Constance produced a weighted average LER of 1.56 across four crops in a typical season, rising to 1.86 in the unusually hot, dry summer of 2018 when crop shade benefits were most pronounced. The system stood 5 meters above ground, enabling standard farm machinery to operate beneath it. Fraunhofer ISE described this as a land use efficiency of up to 186% compared with separate-use systems over the full monitoring period (Trommsdorff et al., 2021).

### INRAE Montpellier, France (2012–2016)

Fixed-tilt elevated panels at 2.5 meters over test plots in southern France produced LER values ranging from 1.29 for durum wheat to 1.97 for lettuce, the highest confirmed LER in the peer-reviewed literature. Shade-tolerant crops such as lettuce reach their photosynthetic saturation point well below full solar irradiance, enabling them to benefit from moderate panel shading rather than being impaired by it (Dupraz et al., 2011; Marrou et al., 2013).

### Even-Lighting System, China (USTC, 2020–2021)

A semi-transparent elevated system tested on common vegetables including lettuce, spinach, and pakchoi produced an average LER of 1.64 across vegetable types. Income per unit area was 5.14 times higher under the agrivoltaic system than under monoculture, as combined crop and electricity revenues substantially exceeded either in isolation (Zheng et al., 2021).

### Kenya and Tanzania (University of Sheffield / CIFOR-ICRAF, 2022–2023)

Two operating systems, a 62.1 kW grid-tied installation in Isinya, Kenya, and a 36.6 kW off-grid system in Morogoro, Tanzania, were monitored for twelve months. Published findings confirmed that crop survivability during a warm period was greater under the agrivoltaic system than in open-field conditions, and that land productivity was enhanced for all crops at both sites. Maize, Swiss chard, and beans were specifically reported as thriving in partial shade. Panel shading reduced

1.56–1.97

confirmed LER range across peer-reviewed studies

62,000

acres of U.S. agrivoltaic sites as of November 2024 (NREL)

643

Italian projects applied under EUR 1.7B national scheme by September 2024

**HISTORICAL GLOBAL AGRIVOLTAIC PROJECT DASHBOARD:** acacia-climate.com/sustainable-agrivoltaics

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irrigation demand, and rainwater harvesting from panel runoff further reduced irrigation needs (Randle-Boggis et al., 2025).

*Table 1: Confirmed LER Values by Project and Crop*

| Project / Location | Primary Crop | LER Achieved |
|---|---|---|
| INRAE Montpellier, France (Marrou et al., 2013) | Lettuce | 1.97 |
| Heggelbach, Germany (Trommsdorff et al., 2021) — hot summer | Clover-grass, wheat | 1.86 |
| EAS China (Zheng et al., 2021) | Lettuce, spinach, pakchoi (avg.) | 1.64 |
| Heggelbach, Germany (Trommsdorff et al., 2021) — typical season | Clover-grass, wheat, potato, celeriac | 1.56 |
| INRAE Montpellier, France (Dupraz et al., 2011) | Durum wheat | 1.29 |

*LER > 1.0 indicates the dual-use system is more land-productive than two single-use systems combined.*

## WATER: THE CONSTRAINT AGRIVOLTAICS ADDRESSES DIRECTLY

Solar panels installed above crops reduce solar radiation reaching the soil surface, lowering soil temperature, slowing evapotranspiration, and improving moisture retention.

At the University of Arizona's Biosphere 2 facility, jalapeño peppers grown under an agrivoltaic array required 65% less water than open-field controls while achieving comparable yields. Soil moisture was 15% higher in the agrivoltaic plots. Chiltepin peppers produced three times the yield of open-field controls, and cherry tomatoes produced twice the yield, attributed to reduced heat stress (Barron-Gafford et al., 2019).

At Sun'Agri's vineyard sites in France, irrigation demand was reduced by between 12% and 70% across sites and seasons. Grape yields at Chardonnay sites reached 60% above open-field controls, Marselan 30% above, and Grenache Blanc 20% above in the 2024 growing season (pv magazine, 2024).

## COMMERCIAL-SCALE PROJECTS HAVE CONFIRMED FINANCING

### Pontinia, Italy (Cero Generation — 70 MW)

Cero Generation's Pontinia agrivoltaic project in Lazio operates at 70 MW without public subsidy. It is financed through private project finance and equity, underpinned by two 10-year virtual Power Purchase Agreements, one with Heineken and one with Philips. This structure, a subsidy-free commercial-scale agrivoltaic project with investment-grade corporate off-takers, represents the current frontier of what the private market can finance without concessional support (Cero Generation, n.d.).

### Jack's Solar Garden, Colorado, USA (1.2 MW)

A 1.2 MW community solar project in Boulder County integrates solar panels above working agricultural land structured as a community solar facility with subscriber contracts. NREL uses the site as an active agrivoltaics research location under its InSPIRE program (Fall, 2024).

## Sun'Agri, France (commercial portfolio)

Sun'Agri operates a growing portfolio of commercial agrivoltaic installations across France, financed through the RGREEN INVEST Racines platform and supported by the French Energy Regulatory Commission's competitive auction rounds. Sun'Agri's dynamic tracking systems, which adjust panel angle in real time to balance crop light requirements with energy generation, represent the most commercially mature adaptive agrivoltaic technology currently operating at scale (Sun'Agri, n.d.).

# GOVERNMENT CAPITAL IS FLOWING AT SCALE

## Italy: EUR 1.7 Billion Through the National Recovery Plan

The European Commission approved a EUR 1.7 billion Italian scheme in November 2023, partially funded through the EU Recovery and Resilience Facility, to support 1.04 GW of agrivoltaic capacity generating a minimum of 1,300 GWh per year. Agricultural producers receive investment grants covering up to 40% of eligible costs and incentive tariffs over a 20-year operational period. By September 2024, the scheme had attracted over EUR 920 million in applications from 643 projects totaling more than 1.7 GW of planned capacity, substantially oversubscribing the initial envelope (European Commission, 2023).

## France: Dedicated Competitive Auction Rounds

The French Energy Regulatory Commission organizes periodic competitive auction rounds specifically for agrivoltaic projects, awarding feed-in premiums above market electricity prices. France meets all six criteria assessed by SolarPower Europe's 2025 Agrisolar Policy Map for a comprehensive agrivoltaic regulatory framework: legal definition, land use zoning, dedicated support schemes, technical requirements, agricultural productivity standards, and environmental safeguards (SolarPower Europe, 2025).

## EU Joint Research Centre: The Land Potential Calculation

A 2023 JRC analysis calculated that applying agrivoltaic systems to just 1% of the EU's utilized agricultural area, approximately 157,600 hectares, would yield 944 GW of peak installed capacity, exceeding the EU's entire 720 GW solar target for 2030. Covering 10% of EU agricultural land would produce between 3.2 and 14.2 terawatts (European Commission Joint Research Centre, 2023).

# WHAT THE AFRICAN DATA GAP MEANS FOR FUNDERS

The published research from Kenya and Tanzania represents the totality of peer-reviewed, monitored agrivoltaic data from sub-Saharan Africa, two systems, both funded by a single UKRI Global Challenges Research Fund grant of GBP 1.4 million. Both produced positive results, with land productivity enhanced for all measured crops at both sites (Randle-Boggis et al., 2025).

Importantly, the biophysical conditions across sub-Saharan Africa, high solar irradiance, elevated ambient temperatures, high evapotranspiration, frequent water stress, and land constraints on smallholder farms, are precisely the conditions under which the documented benefits of agrivoltaics are most pronounced.

The Randle-Boggis et al. (2025) study found that crop survivability during a warm period was greater under the agrivoltaic system than in open-field conditions, consistent with findings from Biosphere 2, where temperatures under the panels were measurably lower and soil moisture measurably higher than in open-field controls (Barron-Gafford et al., 2019).

The gap between Africa's biophysical suitability and its near-zero implementation record is a function of the availability of development capital to build the evidence


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base, not of any demonstrated technical failure. The Fraunhofer ISE APV-RESOLA project at Heggelbach ran from 2016 to 2021 with continuous monitoring across five seasons, generating the most cited agrivoltaic dataset in the world. The comparable east African dataset covers twelve months across two sites.

## THE STRUCTURE OF THE INVESTMENT OPPORTUNITY

Agrivoltaics creates three distinct revenue streams on a single land parcel: electricity sales, agricultural output, and, in an increasing number of jurisdictions, carbon credits under verified standards. In financed projects, the electricity revenue, particularly when secured under a long-term PPA with a creditworthy off-taker, forms the senior revenue layer supporting debt service. Agricultural revenue provides diversification and, in projects targeting shade-tolerant crops, has in several documented cases exceeded the agricultural revenue from the equivalent open-field plot.

Agrivoltaic systems carry a capital cost premium over conventional ground-mounted solar of approximately 20 to 35 percent, reflecting the elevated mounting structure and wider row spacing required to maintain agricultural access. This premium is offset in markets with dedicated support schemes by the agrivoltaic-specific feed-in premium or grant component. In markets without dedicated support, the agricultural revenue stream must compensate directly, which is achievable at current crop revenue levels in several African markets where open-field yields are suppressed by heat stress and water scarcity.

## VERIFIED PROJECT RECORD

*Table 2: Global Historical Agrivoltaic Project Dashboard*

| Project | Country | Capacity | Type | Key Confirmed Finding |
|---|---|---|---|---|
| APV-RESOLA Heggelbach | Germany | 194.4 kWp | Research | LER 1.56 avg.; 1.86 (2018) |
| INRAE Montpellier (Dupraz et al., 2011) | France | N/P | Research | LER 1.3–1.9 (modeled) |
| INRAE Montpellier (Marrou et al., 2013) | France | N/P | Research | LER up to 1.97 (lettuce) |
| Biosphere 2 — Univ. of Arizona | USA | N/P | Research | Peppers 3×; tomatoes 2×; water −65% |
| Jack's Solar Garden, Colorado | USA | 1,200 kWp | Commercial | NREL active research site |
| Pontinia (Cero Generation) | Italy | 70,000 kWp | Commercial | Subsidy-free; 2 × 10-yr PPAs |
| Sun'Agri vineyards | France | Portfolio | Commercial | Water −12% to −70%; yield +20% to +60% |
| EAS — USTC, China | China | N/P | Research | LER 1.64 avg.; income 5.14× mono |
| LAS Kenya (Isinya) | Kenya | 62.1 kWp | Research | Land productivity enhanced; irrigation reduced |
| SAT Tanzania (Morogoro) | Tanzania | 36.6 kWp | Research | Land productivity enhanced; off-grid electricity |
| APV-MaGa (Mali & Gambia) | West Africa | ≈450 kWp | R&D Pilot | Fraunhofer ISE led; BMBF-funded |

| | | | | |
|---|---|---|---|---|
| GGGI Ethiopia Feasibility | Ethiopia | 1–5 MW proposed | Feasibility | Workshop December 2025 |

*N/P = not publicly available. Full interactive dashboard:* acacia-climate.com/sustainable-agrivoltaics

## CONCLUSION

The global agrivoltaics evidence base is sufficient to support investment decisions. Land productivity gains confirmed in peer-reviewed literature, water savings measured in operating systems, commercial-scale transactions financed without subsidy, and sovereign capital committed at the billion-euro level, taken together these represent a technology that has moved well past the proof-of-concept stage in developed markets.

The African investment case rests on the same body of evidence, strengthened by the biophysical argument that the conditions characterizing large parts of sub-Saharan Africa are precisely the conditions under which agrivoltaic systems produce their largest documented benefits.

The current is the absence of a coordinated pipeline of bankable African agrivoltaic projects, connected to the concessional finance instruments required to bring commercial capital in behind them.

*All data in this brief are drawn from named, verifiable sources. No market projections, illustrative figures, or unattributed statistics have been included. DOIs and working URLs are provided in the Sources list.*