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# AGROVOLTAICS AS AN INTERDISCIPLINARY SYSTEM FOR CLIMATE ADAPTATION IN AGRICULTURE

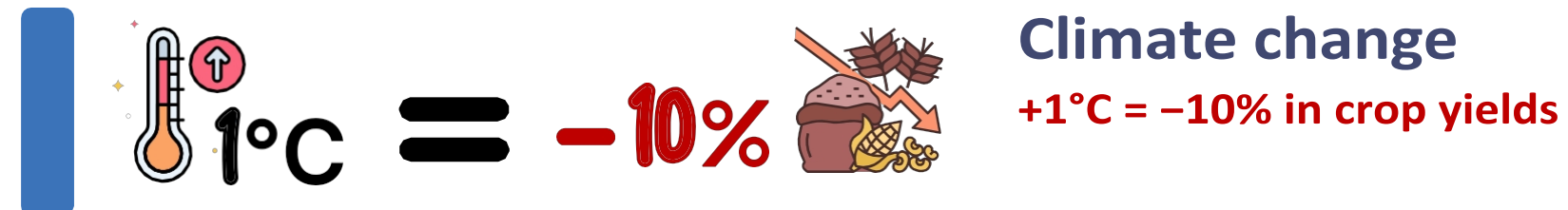
**‘Preparing Eastern Partnership countries for the European Green Deal  
(PROGRESS)’**



# GLOBAL CHALLENGES

## Why the agricultural sector needs to transition to climate-smart agriculture

Demand for food and energy is rising, whilst climate change and resource constraints are increasing the vulnerability of agricultural production.



Rising temperatures, heatwaves and weather instability are increasing risks to crop yields, water management and product quality.



### Demand for food

8.2 → 10.3 billion; +60%

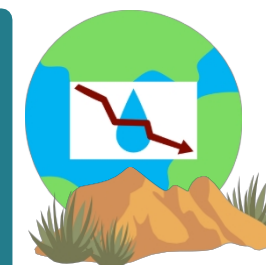
The world's population is growing, and with it the need to produce more food.



### Energy demand

40% increase → by 2050

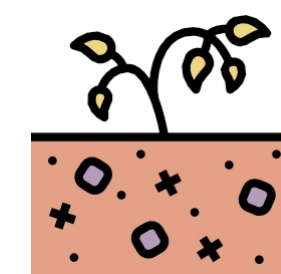
Agricultural production is increasingly dependent on energy for irrigation, cooling, storage, processing and digital systems.



### Water and soil

25% degradation; 40% shortage

Soil degradation, erosion, salinisation and water scarcity are narrowing the resource base for agricultural production.



### Yield risks

heatwaves, droughts, anomalies

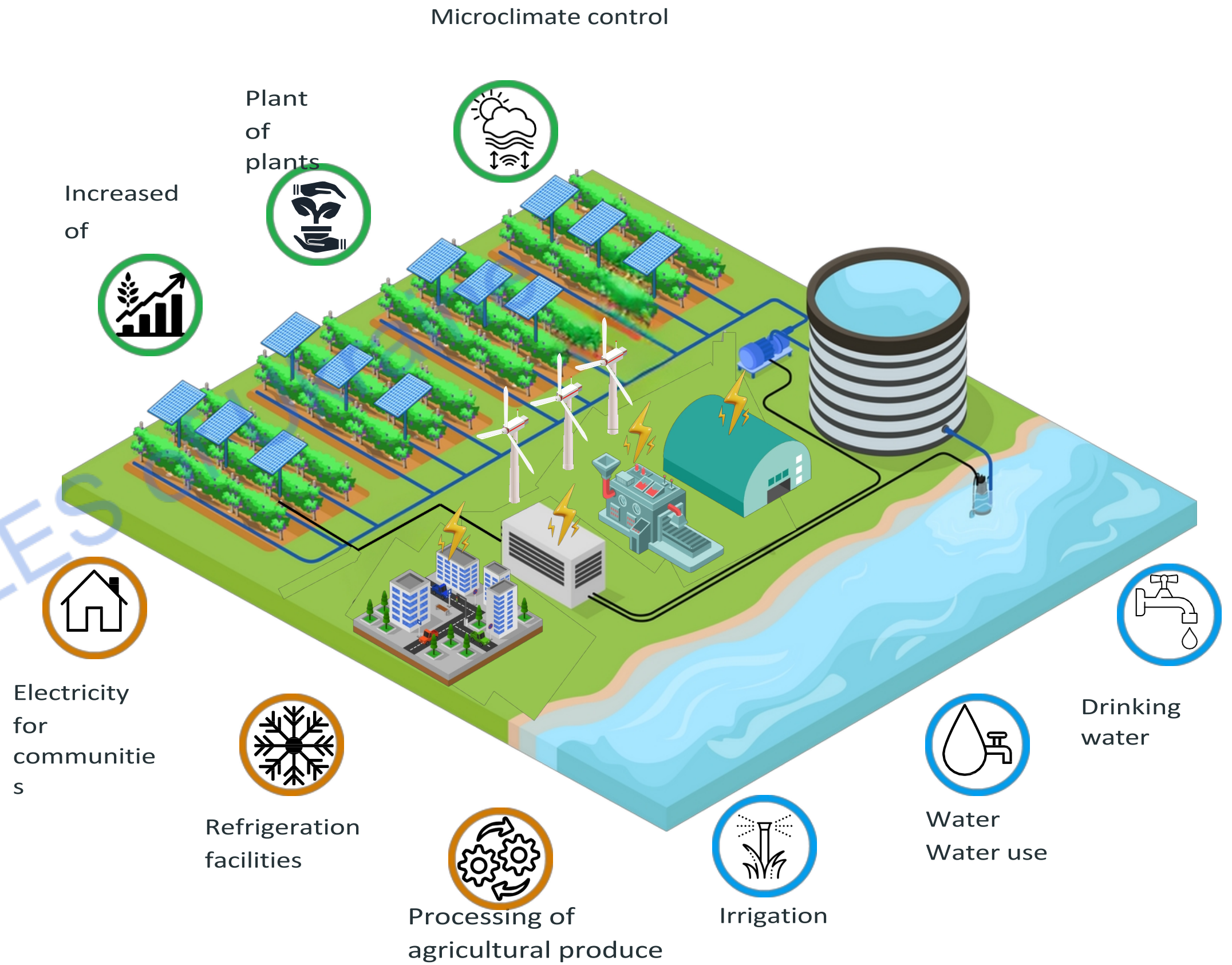
Traditional models are becoming less resilient to heatwaves, droughts, temperature fluctuations and weather anomalies.

**Conclusion: climate-resilient and resource-efficient agricultural models are needed, which simultaneously take into account food, energy, water and land components.**

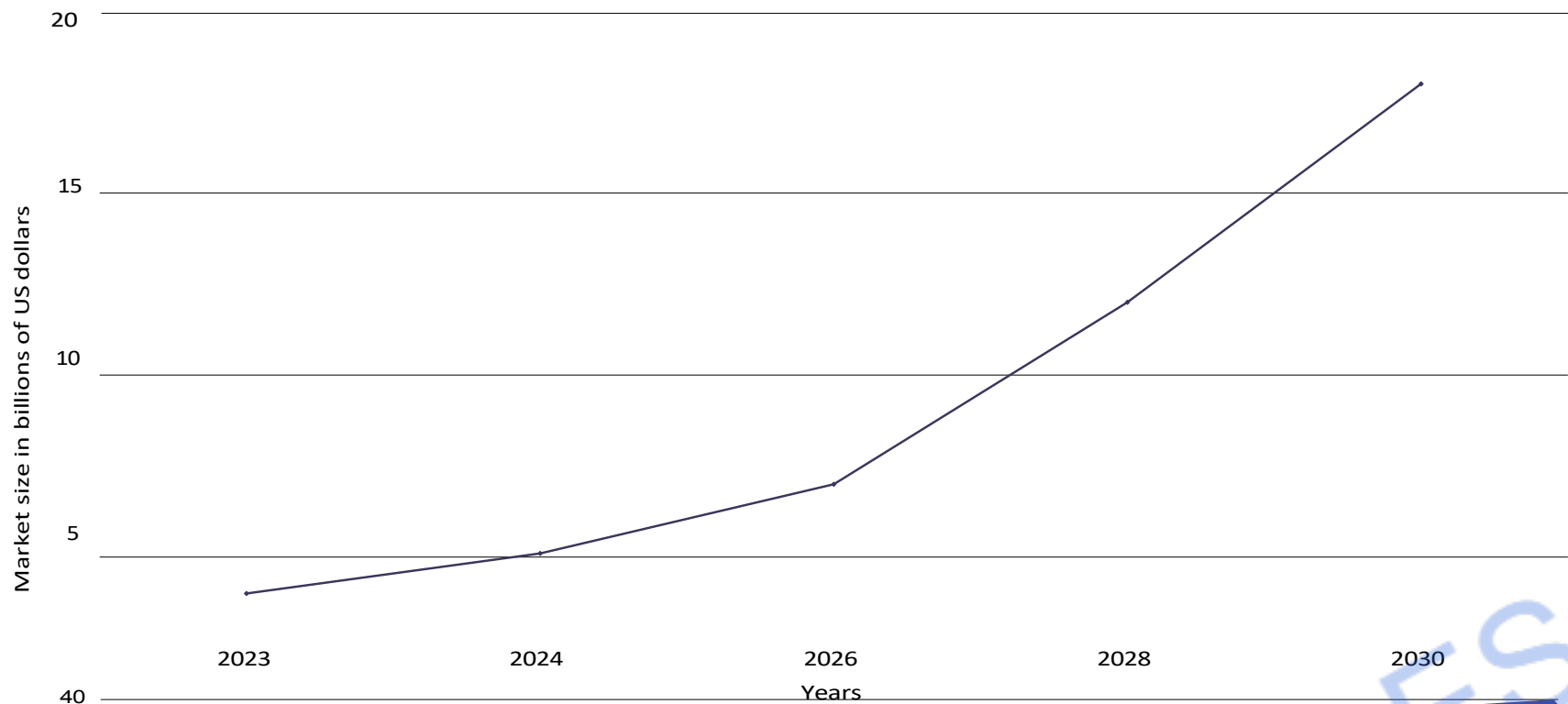
# AGROVOLTAICS



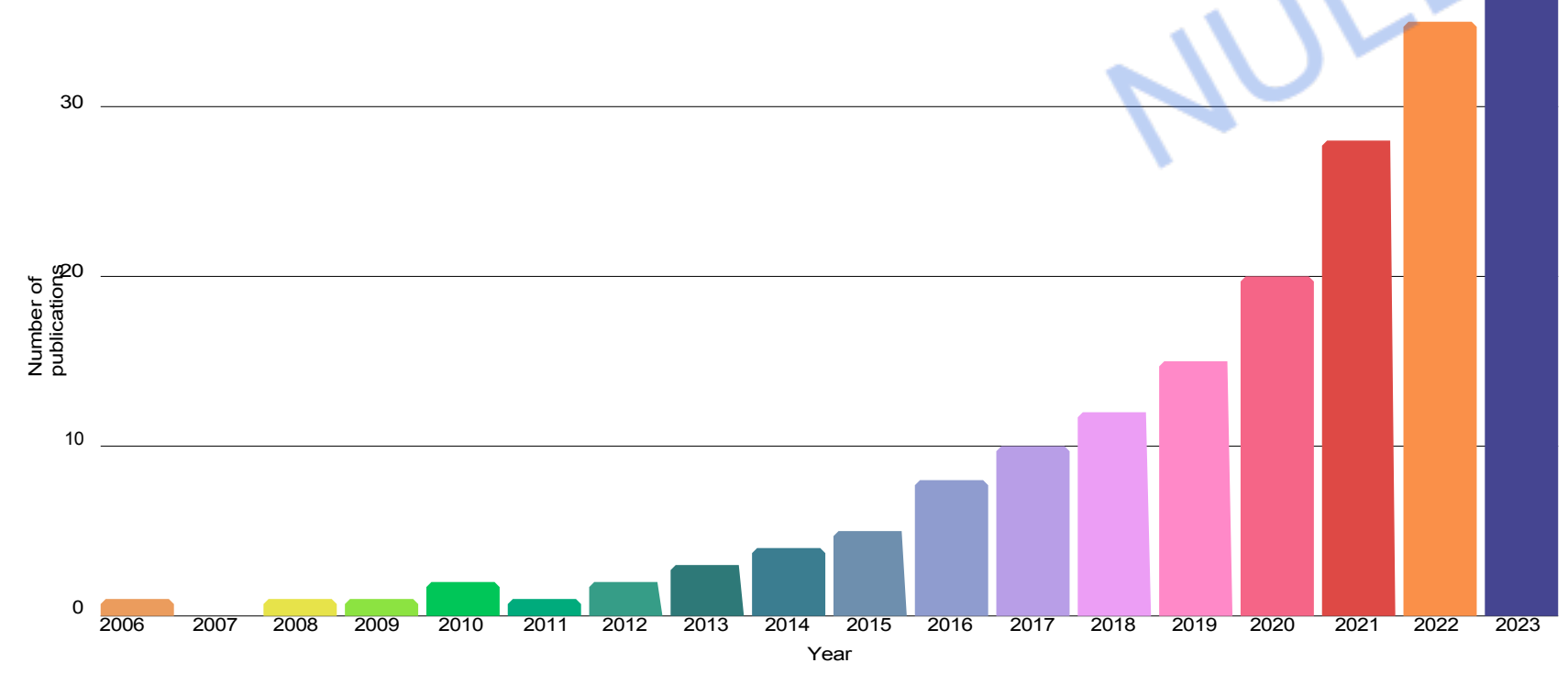
**Agrioltaics is a form of sustainable land use, which enables combining farming and agricultural electricity without sacrificing the main function of the land as agricultural land.**



# GLOBAL TREND



**Global agrivoltaics market growth forecast (Forecast, \$bn)**



**Increase in the number of scientific papers on agrivoltaics**

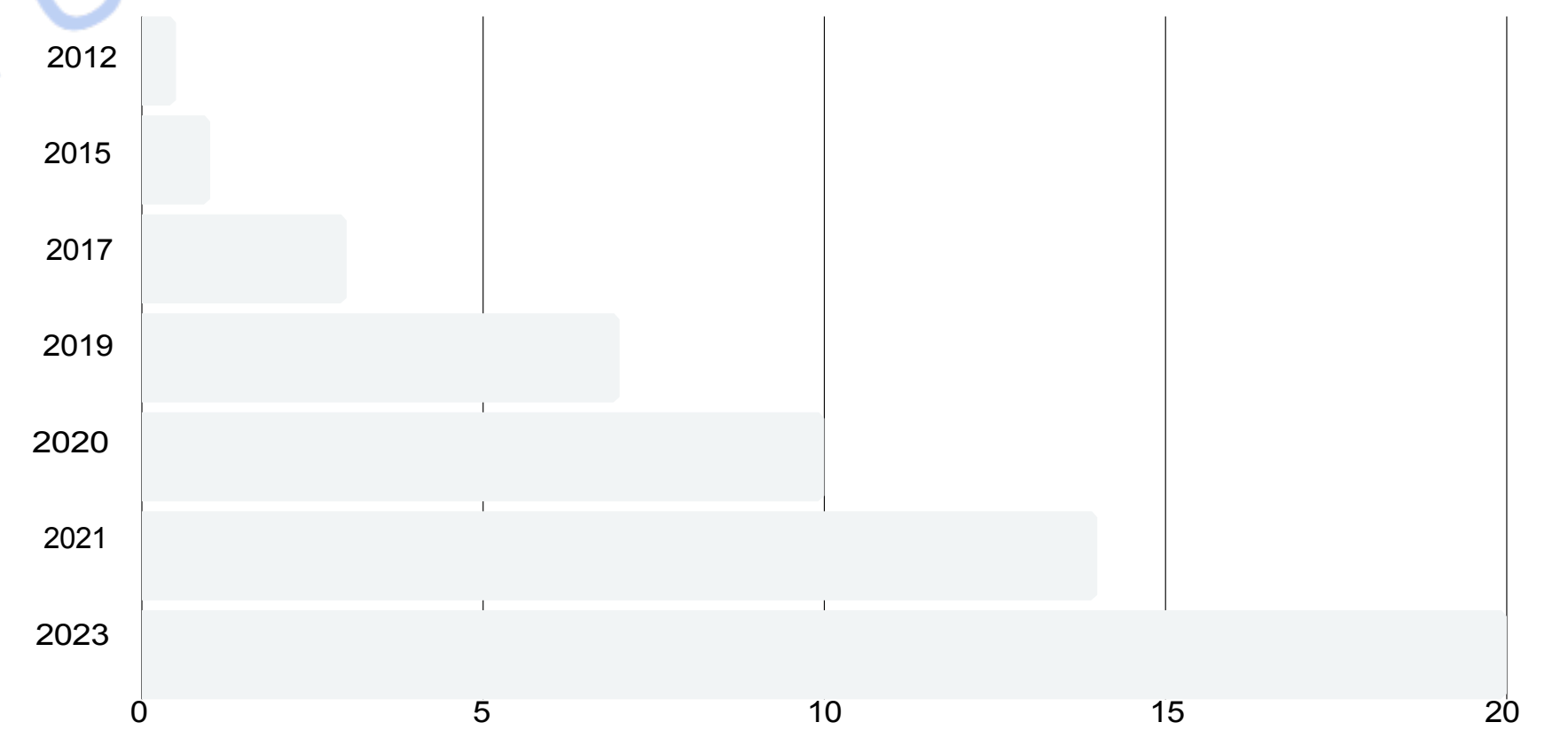
## Italy

€ **1.7** allocated to the development of agrivoltaic projects

 **81.65 BILLION UAH**

## France

**1–2 GW** of new agrivoltaic systems annually until 2026, in the context of a new legal and regulatory breakthrough.



**Global installed Agri-PV capacity, GW**



# EXAMPLES OF PROJECTS AND THEIR RESULTS



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

This project is one of the most successful examples of agrivoltaics. The project also serves as an educational and research centre and has become so popular that **it is the most visited solar power station in the country**. The success of this project helped secure a state-level law allocating **\$1 million** for further research and demonstration

Agrovoltaic projects

**1.2 MW**

Installed  
herbs and berries

capacity

**11 tonnes**

of vegetables,

annually

**5,500**

visitors to the educational

of the agrivoltaics  
centre annually

## Revitalisation of rural regions (Japan)



In Japan, agrivoltaics is seen as a strategic tool for addressing socio-economic challenges: an ageing population, the exodus of young people, and a large amount of abandoned agricultural land.

**3,474 sites**

of agrivoltaic  
systems installed

**€47.8 million**

's agrovoltaic multiplier effect  
(108.9% GRP) per community

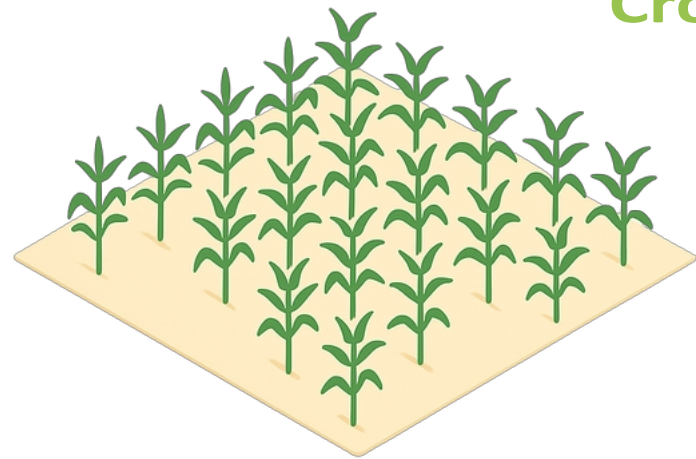
**17.8 GWh/year**

215% of the region's energy needs,  
providing energy self-sufficiency and  
income for the community

# THE DOUBLE BENEFITS OF AGROVOLTAICS

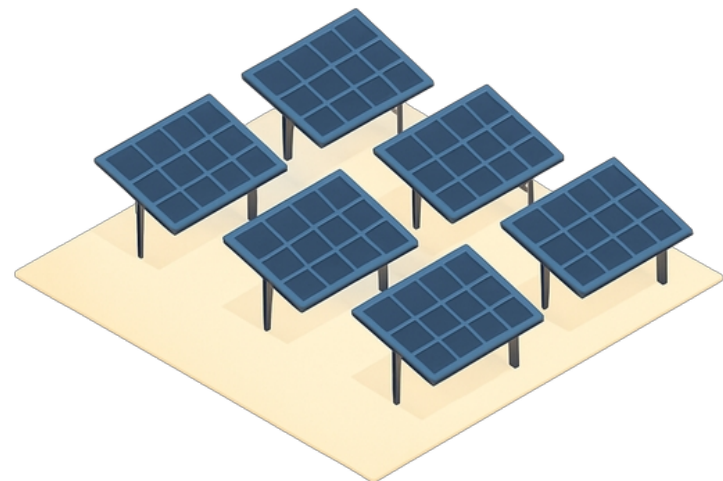
## About agri-PV

100%  
Crops



or

100%  
Solar panels



## 2 MAIN TYPES OF AGRO-PHOTOVOLTAIC SYSTEMS

### OVERHEAD AGRI-PV SYSTEMS

Growing shade-tolerant crops under solar panels.

Land use efficiency:

$$\begin{array}{c} \text{63\%} \\ \text{sun} \end{array} + \begin{array}{c} \text{90–116\%} \\ \text{crops} \end{array} = \begin{array}{c} \text{153–178\%} \\ \text{Overall efficiency} \end{array}$$

Suitable crops



Berries



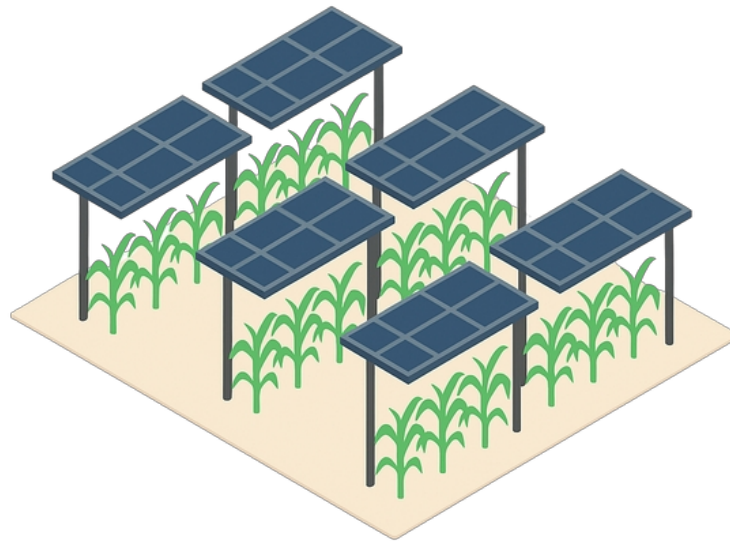
Leafy vegetables



Fruit vegetables



Fruit



### Interspaced Agri-PV

Cultivation with access for agricultural machinery.

Land use efficiency:

$$\begin{array}{c} \text{25\%} \\ \text{sun} \end{array} + \begin{array}{c} \text{83–113\%} \\ \text{cultures} \end{array} = \begin{array}{c} \text{108–123\%} \\ \text{Overall efficiency} \end{array}$$

Suitable crops



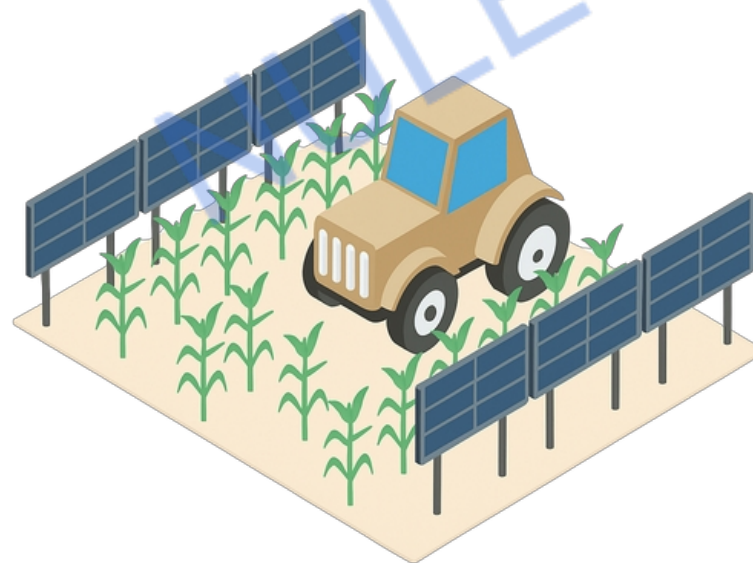
Root crops



Cereals



Forage grasses



# APPLE TREES AS A CROP FOR AGROVOLTAIC SYSTEMS



## Biological characteristics of apple trees and climatic challenges



### Light saturation of photosynthesis

Threshold  $\approx 800\text{--}1200 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  (PAR). Excessive insolation during heatwaves does not increase photosynthesis and causes light stress to the leaves.



**Flower bud formation in the previous year** Fruit bud differentiation occurs in the summer of the previous season, so the weather conditions during this period determine the following year's yield.



### Shallow root system (dwarf rootstocks)

In modern intensive orchards, dwarf rootstocks (M9, M26) are predominantly used, as they develop a shallow root system ( $\approx 80\text{--}120$  cm). This quickly leads to water stress in the event of drought or soil overheating.



### Sunburn on fruit

At an air temperature of  $+30^\circ\text{C}$  in direct sunlight, the skin of an apple heats up to  $+45\text{--}52^\circ\text{C}$ . This leads to tissue necrosis (sunburn), rendering the fruit unsuitable for storage and sale.

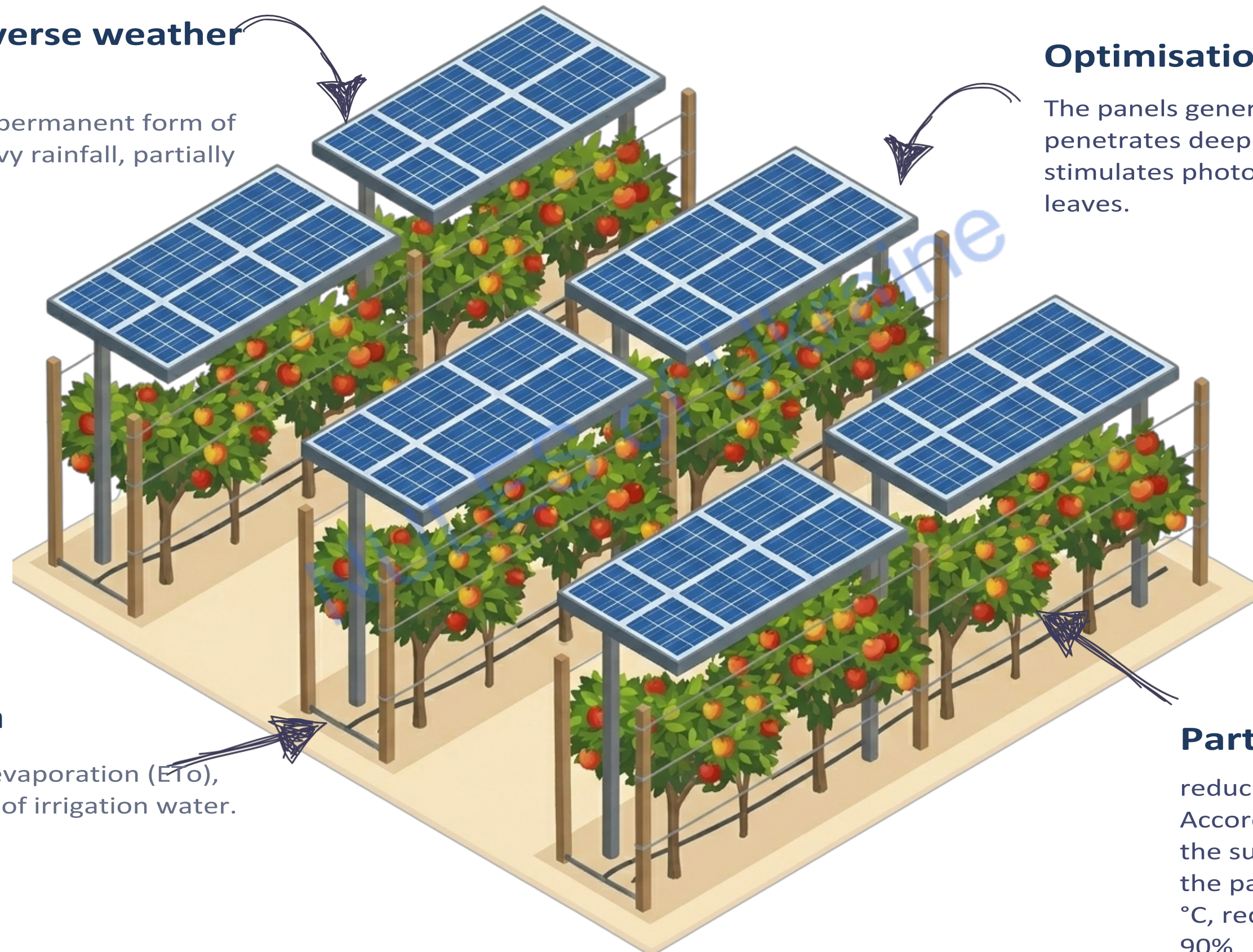
# MECHANISMS OF AGROVOLTAICS' IMPACT ON APPLE ORCHARDS

## Protection against adverse weather conditions

Panel structures can serve as a permanent form of protection against hail and heavy rainfall, partially replacing anti-hail nets.

## Optimisation of light conditions

The panels generate diffuse light, which penetrates deeper into the canopy and stimulates photosynthesis in the inner leaves.



## Reduced evaporation

Partial shading reduces total evaporation ( $E_{To}$ ), saving approximately 25–30% of irrigation water.

## Partial shading

reduces overheating of fruit and leaves. According to Glasnik zaštite bilja (2025), the surface temperature of apples under the panels is reduced by approximately 3.3 °C, reducing the risk of sunscald by up to 90%

# BEST RESEARCH: THE IMPACT OF AGROVOLTAICS ON APPLE ORCHARDS

## Juillion et al., 2022 — *Scientia Horticulturae*

DOI/Link: [10.1016/j.scienta.2022.111434](https://doi.org/10.1016/j.scienta.2022.111434)

The effect of shading by panels on water regime, leaf morphophysiology and yield determinants (3 seasons).



QR

## Lopez et al., 2023 — *Acta Horticulturae (IHC2022)*

DOI/Link: [10.17660/ActaHortic.2023.1366.20](https://doi.org/10.17660/ActaHortic.2023.1366.20)

Dynamic panels as a tool for protecting orchards from climatic risks; real-time shading management.



QR

## Lopez et al., 2024 — *AgriVoltaics Conference Proceedings (World Conference 2024)*

DOI/Link: PDF

Fruit temperature ↓ by up to 3.3°C; sunburn: 13% → 2% (2022); effect of 'controlled shading'.



QR

## Vélez et al., 2025 — *Overhead AV: ripening delay (preprint)*

DOI/Link: [10.21203/rs.3.rs-5527009/v1](https://doi.org/10.21203/rs.3.rs-5527009/v1)

Ripening delay and shifts in apple ripening patterns under overhead AV; important for harvest planning.



# AGROVOLTAICS IN UKRAINE: FROM SCIENCE TO IMPLEMENTATION

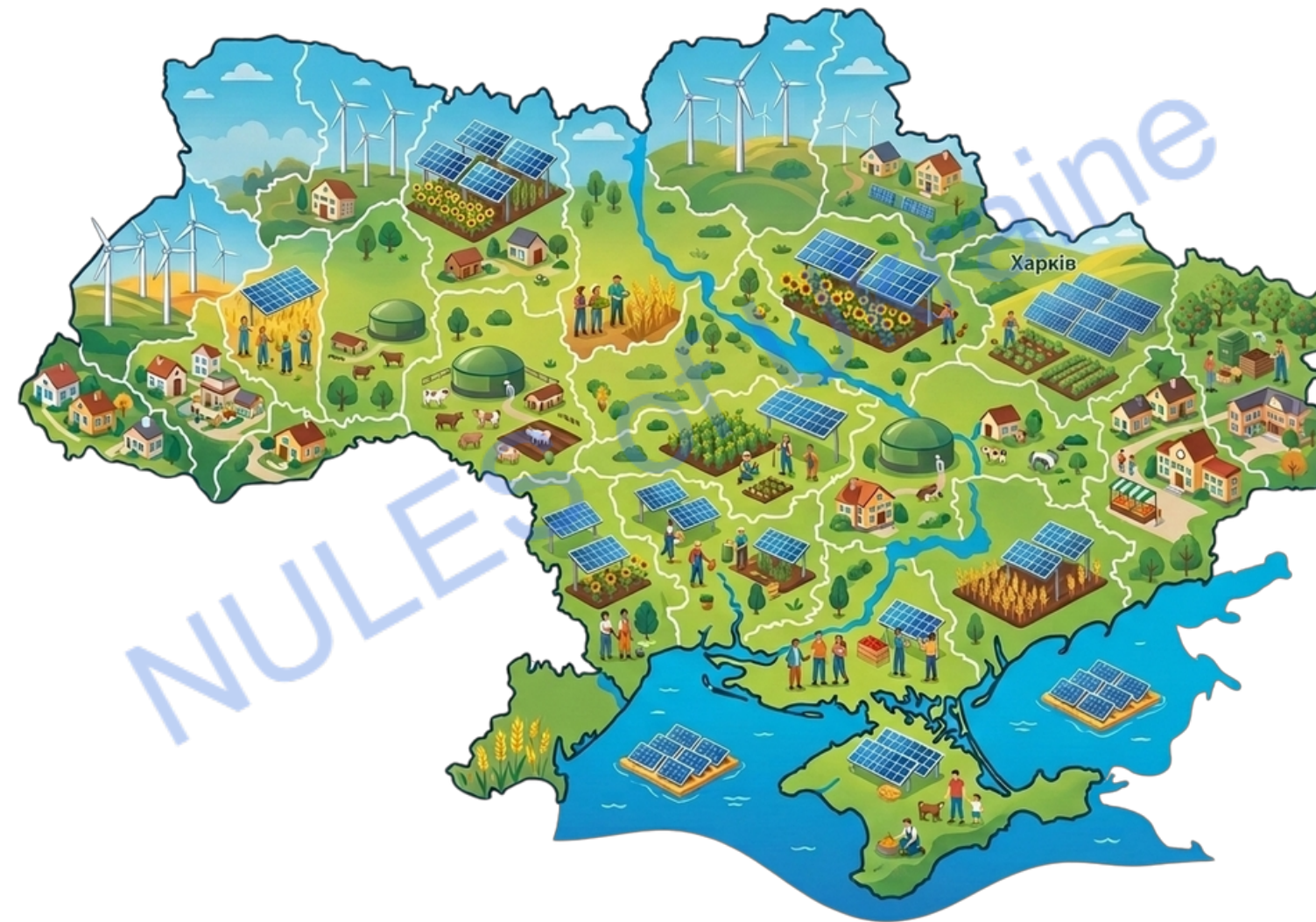
Today, agrivoltaics in Ukraine is moving from the stage of explaining the concept to the formation of its own scientific, demonstration and partnership ecosystem.

● Scientific research

● Demonstration sites

● Education and training

● Communities and land restoration



● International consortia

● R&D and certification of systems

● Policy and regulatory environment

● Communication and Conferences

**Key idea:** In the Ukrainian context, agrivoltaics is not merely a technology for growing crops beneath solar panels, but an infrastructure for science, energy, community reconstruction and new international projects.

# OUR PROJECTS AND WHERE WE ARE HEADING

Our initiatives demonstrate how agrivoltaics combines energy, science, spatial development and the circular economy.

DEMO / LIVING LAB

## Agro-energy settlement



### The essence of the initiative

The agrivoltaic settlement combines housing, work, local energy and science — serving as a model for the rehabilitation of internally displaced persons, veterans and researchers.

#### Focus

- housing and workplaces microgrid and bioenergy
- agricultural zone and experimental plot

CIRCULAR VALUE CHAIN

## The circular model of the FPV cluster



### The essence of the initiative

Floating PV generation, BSFL, aquaculture, greenhouses and biogas form a closed cycle of resources, energy and fertilisers.

#### Focus

- organic waste processing electricity and biogas
- production
- added value and community income

TESTING / SCALE-UP

## Agrovoltatics R&D centre



### The essence of the initiative

A 20–30-hectare centre for the development, testing, adaptation and certification of agrivoltaic systems tailored to Ukraine's climatic conditions.

#### Focus

- experimental plots of various types digital
- laboratory and monitoring
- certification and scaling of solutions

**Together, these three areas position Agrovoltatics as a platform: from a demonstration site to a fully-fledged model of economic and spatial development.**

# CONFERENCE 2026 AND PROCEEDINGS

## 2nd INTERNATIONAL INTERDISCIPLINARY CONFERENCE



Conference website

A platform for shaping new research topics, fostering cross-sectoral links and establishing a framework for the development of a climate-resilient agricultural sector

## PROCEEDINGS OF LAST YEAR'S CONFERENCE

- abstracts and scientific papers
- analytical conclusions
- Practical implementation case studies





# Useful links



FACEBOOK



ON THE AGRIVOLTAICS ASSOCIATION'S FACEBOOK PAGE, YOU CAN FIND ANALYTICAL REVIEWS OF LEADING RESEARCH ON AGRIVOLTAICS, AS WELL AS RECOMMENDED TOPICS FOR YOUR OWN RESEARCH



TECHNICAL AND ECONOMIC ASSESSMENT OF AGRIVOLTAIC SYSTEMS AND LIFE CYCLE



RESEARCH ON AGRIVOLTAIC BUSINESS MODELS IN INDIA



NEW ANALYTICAL TOOLS FOR ASSESSING THE ECONOMIC VIABILITY OF AGRIVOLTAICS



THE ECONOMICS OF AGRIVOLTAICS IN VITICULTURE



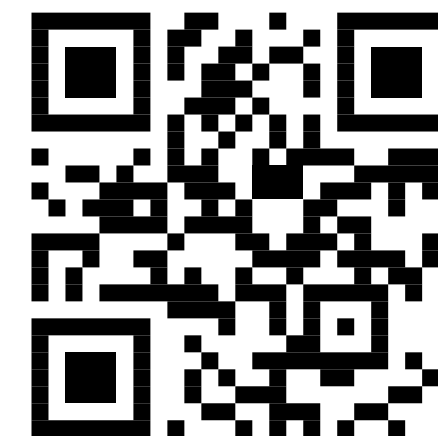
# Contact



**FACEBOOK**



**VIDEO PRESENTATION  
WEBSITE**



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