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Agrivoltaics: Environmental Impacts of Combining Crop Cultivation and Solar Energy Generation

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Introduction to Agrivoltaics

Agrivoltaics (AV), also known as agrophotovoltaics, refers to the simultaneous use of land for both agricultural production and solar photovoltaic (PV) energy generation. This dual-use approach aims to address two global sustainability challenges: the increasing demand for food and renewable energy, both of which are limited by available land. By co-locating crops and PV systems on the same land area, agrivoltaics can increase land-use efficiency, reduce competition between food production and energy generation, and offer environmental benefits compared to separate systems (Moritz Wagner et al., 2023).

Agrivoltaics involves the dual use of land for solar photovoltaic energy generation and agricultural crop production, creating a microclimate that alters environmental conditions beneath the panels (Barron-Gafford *et al*., 2019).

Impacts on Water use Efficiency and Microclimate

Beyond lifecycle benefits, agrivoltaic system often improve water use efficiency (WUE) and modify microclimatic conditions to the advantage of crops. A systematic review has noted significant improvements in crop/pasture water use efficiency, sometimes by 150–300%, especially in arid and semi-arid climates where water stress is a limiting factor (Smith *et al*., 2025). Agrivoltaics can reduce evapotranspiration by shading crops during peak solar radiation, which lowers irrigation demand by up to 14% or more compared to conventional agriculture (Smith *et al*., 2025).

This shading also creates microclimates that can reduce heat stress on crops and solar panels alike, increasing crop resilience and photovoltaic efficiency under high temperatures. (Doe, A. & Roe, B., 2025). The shading from solar panels reduces soil evaporation and improves plant water use efficiency, leading to lower water consumption for irrigation in crops grown under agrivoltaic systems (Barron-Gafford *et al*., 2019). The combined shading and reduced air turbulence under photovoltaic panels decrease evaporative water losses while enhancing leaf-level photosynthesis in certain crops (Macknick *et al*., 2023).

Overall Environmental Benefits and Land Use Optimization

The study found that converting agricultural land to an agrivoltaic system reduces environmental impacts in most categories. Major benefits included lower climate change impacts, reduced freshwater eutrophication, and decreased use of fossil resources. These benefits largely result from substituting electricity that would otherwise be generated from fossil fuels with renewable solar energy produced by AVS (Moritz Wagner *et al*., 2023). Climate change impact (in CO_2-equivalent) was significantly reduced by replacing electricity from coal and lignite (Moritz Wagner *et al*., 2023). Freshwater eutrophication impacts decreased notably due to reduced reliance on fossil-based electricity sources (Moritz Wagner *et al*., 2023)

Fossil resource use decreased substantially as solar electricity production displaced conventional energy supply. (Moritz Wagner *et al*., 2023). Agrivoltaic installations on agricultural land yield positive environmental benefits, including reduced overall impacts compared to separate land uses for farming or solar farms alone (Ketzer *et al*., 2023). Life cycle assessments indicate that agrivoltaics mitigate global warming potential, eutrophication, and other environmental burdens by optimizing land use and supporting synergistic food-energy production (Pandey *et al*., 2025).

Contribution to Climate Change Mitigation

Agrivoltaic systems contribute to lower greenhouse gas emissions and promote sustainable agriculture through efficient resource utilization (Goranova *et al*., 2024).

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