2024_62_Physics_JN: Impacts and benefits of agri-photovoltaics for natural environment, land productivity and resilience in a changing climate.

Supervisors: Prof Jenny Nelson (mailto:jenny.nelson@imperial.ac.uk); External: Prof Alona Armstrong, Lancaster Environment Centre, Lancaster University; Internal: Dr Bonnie Waring, Life Sciences; Dr Shivika Mittal, Grantham

Department: Department of Physics

The growing deployment of photovoltaics (PV), necessary to decarbonise energy supply, results in competition for agricultural land. One solution is the integration of PV installations with agriculture (Agri-PV), where PV modules mounted above agricultural land allow crops to grow beneath or alongside [1]. Apart from generating renewable electricity locally that can assist and decarbonize farming operations, Agri-PV can bring multiple environmental co-benefits. These include improving crop growth by shading (excess solar radiation slows plant growth in many regions), avoiding overheating and reducing water evaporation [2] as well as stabilising the crops' microclimate, and improving soil health, biodiversity and food supply. AgriPV can help provide environmental and social resilience in a changing planet where increasing temperatures and more frequent heat waves threaten the richness of soil and food supply [3]. Hence, by using Agri-PVs farmers can reduce their risk of income loss from droughts or heat waves, both by increasing the resilience of lands and by enhancing and diversifying their income from the electricity produced. These benefits are of particular relevance to rural locations in the developing world. While Agri-PV is of rapidly growing interest as a mode of PV deployment, its benefits and impacts for local ecosystems, and the dependence of these impacts on location, local climate and future climate change, have not been fully explored. From the perspective of optimum land use in a changing climate, it is also important to establish the value of Agri-PV in comparison with other potential uses of land, such as bioenergy and greenhouse gas removal [4].

This PhD project aims to address this gap through the following objectives: (1) to establish a model, based on existing knowledge of PV technology, crop growth and microclimate, of the impact of PV on crop growth and energy yield, as a function of location, crop type, local climate and projected climate; (2) to apply the model using geospatial modelling tools to establish the potential benefit of Agri-PV installations for environmental protection, food supply and low carbon energy supply, as a function of location and considering changing climate, focussing on developing regions; (3) to explore the benefit of co-locating PV with natural habitats such as peatlands, where CO2 removal by that habitat may be enhanced or restored thanks to environmental protection provided by the PV installation. The latter type of deployment offers both socio-economic and environmental benefits, since farmers may compensate income losses from agriculture with income gains in electricity generation.

Ultimately, the model applications could be used to assess the useability of Agri-PV to enable sustainable land-use transitions in a changing climate.

1. Liu et al., 2018 https://doi.org/10.1016/j.solener.2017.12.053;

2. Hassanpour et al., 2018 https://doi.org/10.1371/journal.pone.0203256;

3. Weselek et al., 2019 https://doi.org/10.1007/s13593-019-0581-3;

4. Merfort et al.,2023 https://doi.org/10.1038/s41558-023-01711-7

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