Microclimate Management with Agrivoltaics Technology

Richmond Kuleape[1, 2] , Matthew Berwind [2] , Brendon Bingwa [2] , Max Trommsdorff[1, 2] , Anna Heimsath[2] , Martine van der Ploeg[3] , Werner Platzer[1, 2] , Dierk Bauknecht[1]

Agrivoltaics modifies the microclimate on the farm for solar PV and crop production

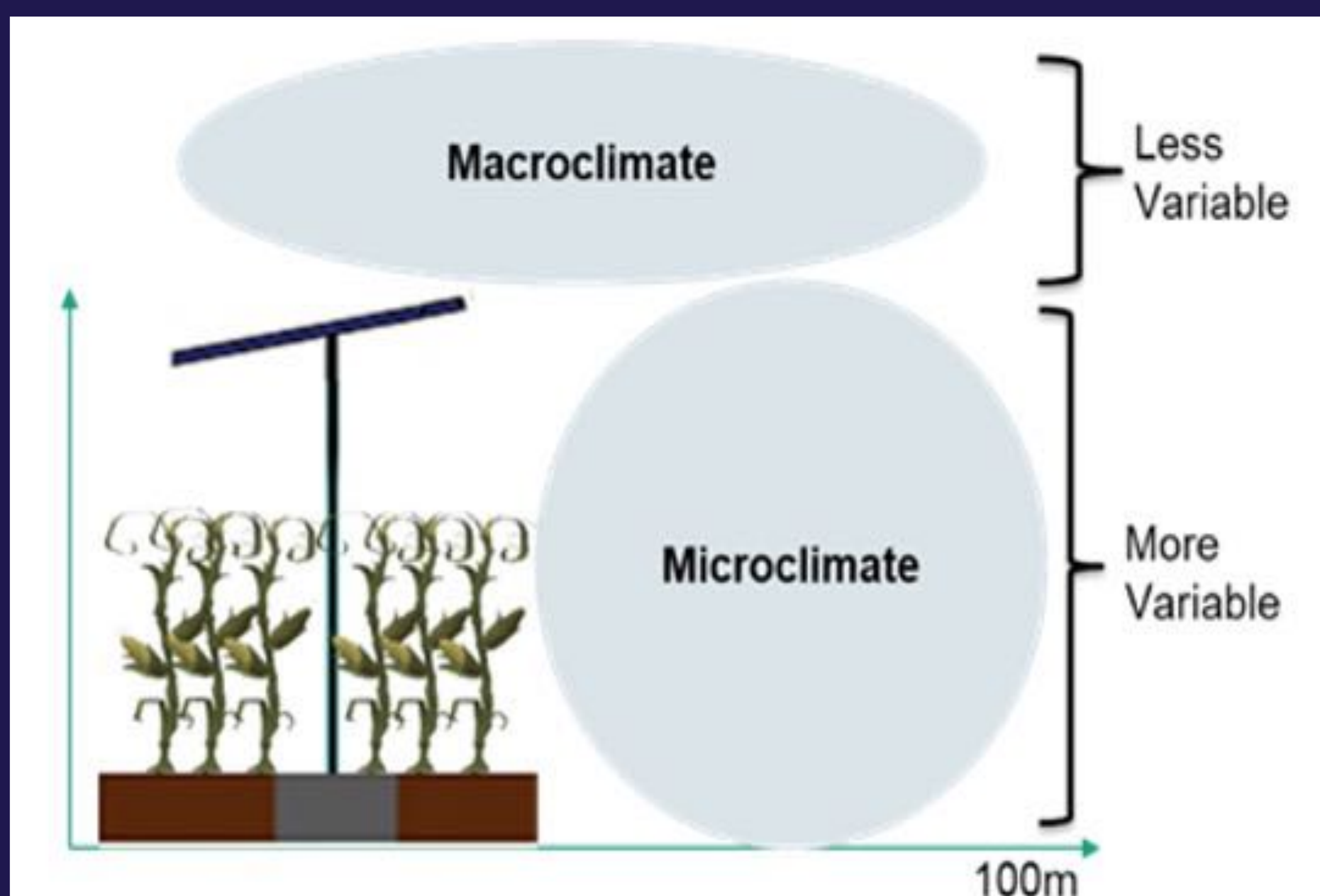

Figure 2: Classification Agrivoltaics Microclimate

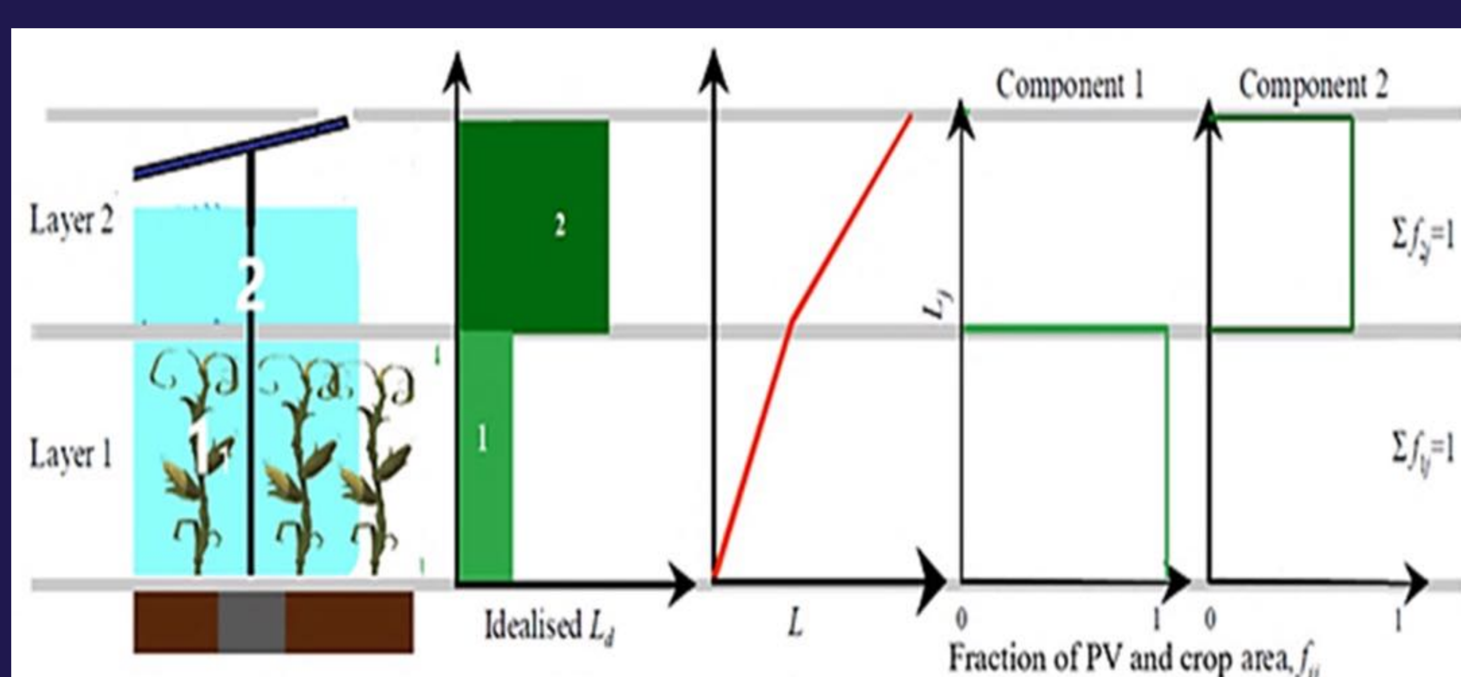

Figure 3: Flowchart to Assess Open Agrivoltaics Microclimate

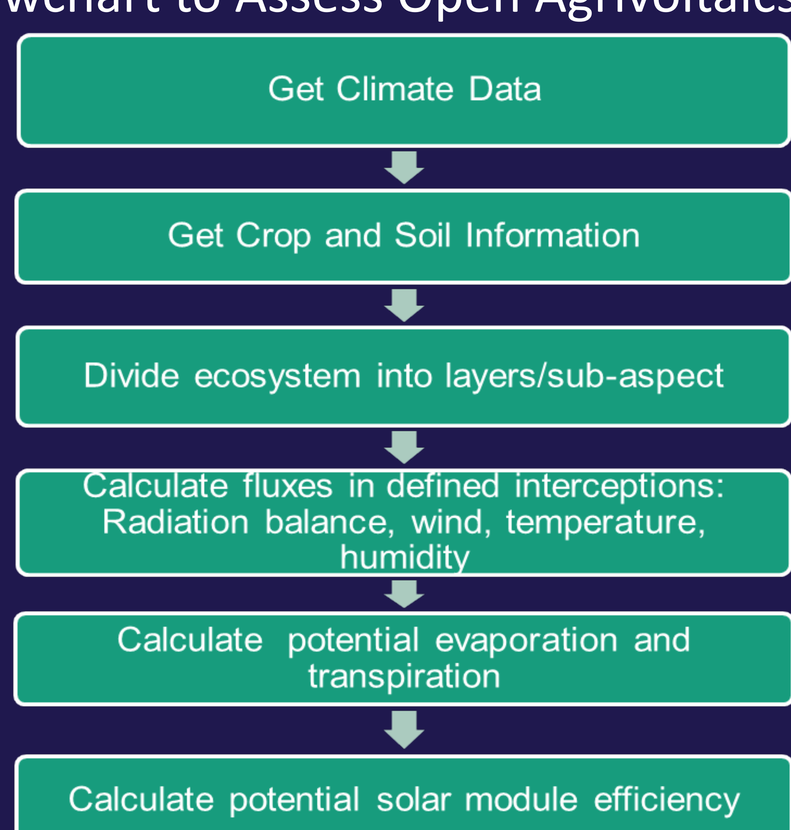

Figure 4: Flowchart to Assess Open Agrivoltaics Microclimate

Background information (Richmond Kuleape, 2023)

Download the poster

Center for Renewable Energy
Albert-Ludwigs-Universität Freiburg

universität freiburg

Fraunhofer ISE

Stipendiat*innen des Evangelischen Studienwerks Villigst

Introduction

- Experienced and projected increase of extreme climate and weather events globally has required us to rethink our water, energy food system. This drastic shift in climate is affecting crop production and causing damage. This climate issue requires triggering adaptive solutions such as Agrivoltaics (AV) [1–3].

Figure 1: Climate stress on Farm [2]

- Agrivoltaics (AV) potentially modifies farms environments see fig. 2. These changes are noticeable in climate variable trends [3] and are variable in the microclimatic zones.
- Here, we developing int a an AV microclimate model, which can estimate changes in radiation fluxes, water balances, and wind patterns (see Fig. 3).

Methods

- Based on the energy balance equation (eqn. 1) and Penman-Monteith concept (eqn. 2).
- $$R - ET - G - H = 0 \quad (1)$$
- $$ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)} \quad (2)$$

Where (es - ea) = air vapour pressure, and r_s/r_a = ratio of (bulk) surface and aerodynamic resistances, r a = mean air density, cp = air specific heat, γ = slope of saturated vapour pressure and temperature, and γ = psychrometric constant.

- Predicts changes in heat in layer 1 and 2 assessed in area component 1 and 2 (see fig. 3).
- Estimate evapotranspiration within an AVM.

Results and Discussion

The AVM model considers the heat flux and water balance when a solar panel is present on the farm and further quantifies the potential cooling effect, which represents the heat change and water retention through between ET, G, and H. This model currently being validated using experimental AV data in Germany and Europe.

References
[1] Barron-Gafford, G. A., Pavao-Zuckerman, M. A., Minor, R. L., Sutter, L. F., Barnett-Moreno, I., et al., "Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands," Nature Sustainability, Vol. 2, No. 9, 1 Jan. 2019, pp. 848–855.
doi: 10.1038/s41893-019-0364-5.
[2] *Building a Tool for Microclimate Management - TheWaterChannel*. (n.d.). Retrieved November 24, 2023, from
[[3] Weselek, A., Bauerle, A., Hartung, J., Zikeli, S., Lewandowski, I., et al., "Agrivoltaic system impacts on microclimate and yield of different crops within an organic crop rotation in a temperate climate," Agronomy for Sustainable Development, Vol. 41, No. 5, 1 Jan. 2021.
doi: 10.1007/s13593-021-00714-y.