

A Decision-Making Framework for Agrivoltaics: Developing a Comprehensive Crop Suitability Matrix

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1. Background and Context

Agrivoltaics (Agri-PV, the integration of photovoltaic systems with agricultural practices) aims to promote dual land use and enhance both crop productivity and electricity generation. This not only promotes sustainable development but also boosts the next generation of farming practices. Since Agri-PV is planned to integrate with crops, it is important to assess the suitability of Agri-PV technology for the area beneath the panels. The success of agrivoltaic systems depends on selecting crops that can grow under the altered microclimatic conditions created by PV panel shading. Reduced sunlight, lower temperatures, and changes in soil moisture can all affect crop productivity and growth. Regional differences in climate, crop types, and irradiation conditions further influence the process. Hence, there is a need to develop a common understanding of the suitability of Agri-PV systems for different crops. However, no such research is currently available. At the same time, there is an urgent need to address these important challenges. The lack of a decisive framework poses a significant challenge for Agri-PV development. Given the pressing need, the described research aims to develop a comprehensive crop suitability matrix for agrivoltaic systems, offering a systematic framework based on real-world case studies. This matrix can serve as a guide for farmers, policymakers, and energy planners in selecting or designing Agri-PV systems.

2. Research Methodology

The research methodology for the presented work is shown in Figure 1. This study analyzed more than 150 peer-reviewed publications and case studies in order to create a crop suitability matrix for Agri-PV systems. Through the consideration of multiple contributing aspects, including crop development under shaded conditions, shade tolerance, yield potential, and economic feasibility, this systematic review and meta-analysis assists in the understanding of how various crop types interact with Agri-PV systems. Real-world case studies from different countries and locations provided support and validation for the findings.

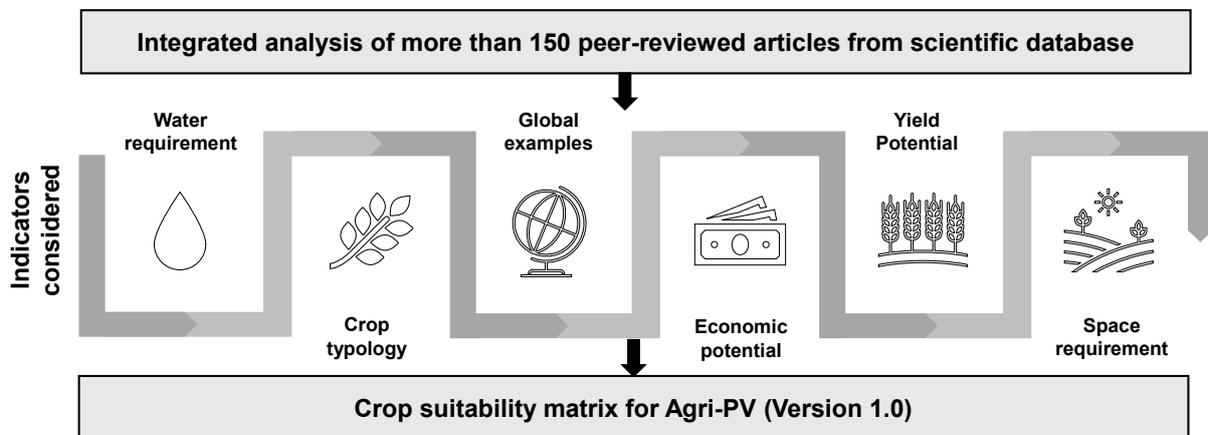


Figure 1. Research methodology for developing a crop suitability matrix

The resulting matrix provides a comprehensive and interdisciplinary insight, incorporating technical, agronomic, and economic factors. At the same time, these interdisciplinary results have been converted into a straightforward decision-making tool for Agri-PV selection based on various crop typologies. This is much needed to address a crucial challenge faced by stakeholders, including farmers, policymakers, and non-engineers.

3. Results

This article presents the Agri-PV suitability matrix as shown in Figure 2. It represents the preliminary version 1.0. This matrix provides insights into shade tolerance, water requirements, and yield/economic potential for major crop types. Through an intensive study of real-life examples from scientific databases, the values are ranked from low to high. For instance, crops with higher shade tolerance are more suitable for Agri-PV installations, as they can grow well under reduced sunlight conditions. Meanwhile, crops that require less land, such as fruits, herbs, and vegetables, offer significant economic potential and high yield when combined with Agri-PV systems. Since Agri-PV systems usually do not cover complete fields, this is crucial from an economic standpoint. However, because of their higher light requirements and larger acreage requirements, large-area crops like cereals and fiber crops, which often have lower shadow tolerance, are less suited for Agri-PV systems. This comparison emphasizes how crucial it is to choose high-value, space-efficient crops in order to optimize Agri-PV's advantages.

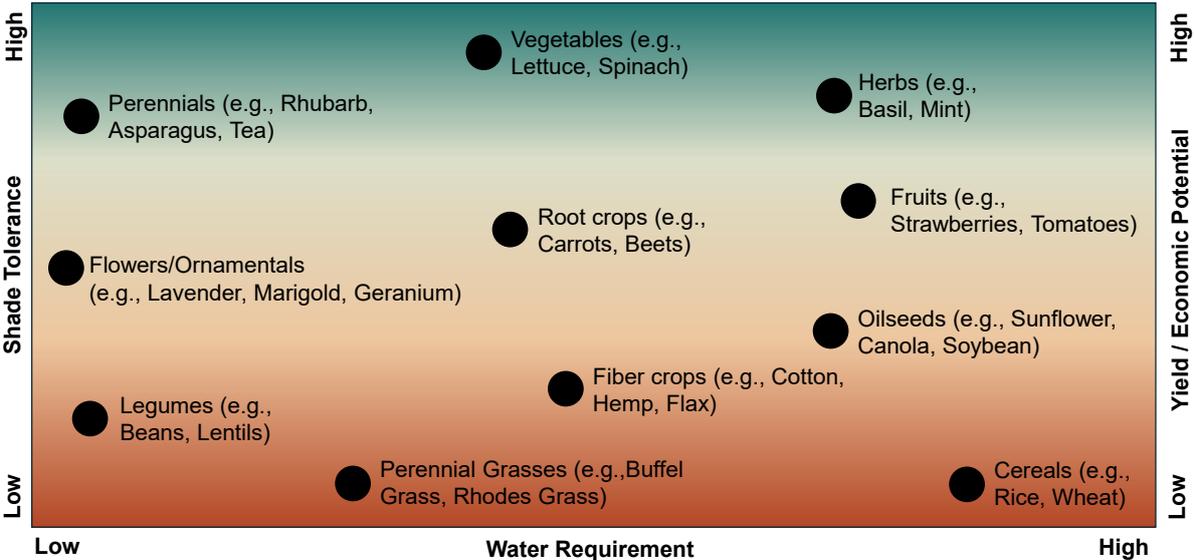


Figure 2. Crop suitability matrix for Agri-PV systems (Version 1.0)

4. Conclusion

By facilitating the dual-purpose integration of solar energy production with agriculture, this combination aids in land use optimization. A preliminary crop compatibility matrix for agrivoltaic systems is presented in this study, providing a fundamental tool to direct crop selection based on important variables like water requirements, growth cycles, and shade tolerance. The matrix facilitates well-informed decision-making by combining lessons from multiple case studies, maximizing energy production and agriculture produce. This matrix will be updated frequently to incorporate new characteristics and enhance its accuracy as agrivoltaics develop, guaranteeing that it stays applicable and relevant in a variety of climatic and agricultural contexts.