

Fostering Sustainable Agriculture: Innovations in Smart Irrigation, AgriPV, and Rainwater Harvesting

Duygu Kuzyaka¹, Ömer Yalçın¹, Rıdvan Çelik¹, Talat Özden^{1,2}

¹Center for Solar Energy Research and Applications (ODTÜ-GÜNAM), Middle East Technical University, Ankara 06800, Türkiye

²Electrical and Electronics Engineering, Gümüşhane University, Gümüşhane, 29100, Turkey

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Presenting author email: duygu.kuzyaka@odtugunam.org

Introduction

As global concerns over environmental sustainability and food security continue to escalate, the agricultural sector faces increasing pressure to adopt innovative and sustainable practices. In this context, the integration of technology and agricultural practices has emerged as a promising avenue for fostering sustainability in agriculture. Smart irrigation systems, AgriPV (Agricultural Photovoltaics), and rainwater harvesting represent three key innovations at the forefront of this movement (Chianese et al. 2020). Smart irrigation systems utilize advanced technologies such as sensors, data analytics, and automation to optimize water usage in agriculture. By precisely monitoring soil moisture levels, weather conditions, and crop water requirements, these systems enable farmers to efficiently manage irrigation, minimize water waste, and enhance crop yields. Moreover, the implementation of smart irrigation systems contributes to the conservation of water resources and mitigates the environmental impact of agricultural activities (Khan et al. 2018). AgriPV involves the integration of solar photovoltaic panels with agricultural infrastructure, such as greenhouses or crop fields. This innovative approach not only generates renewable energy but also provides additional benefits for agricultural production such as the microclimatic conditions that benefit crop growth and also protect plants from excessive heat and UV radiation as a result of the shading provided by solar panels (Chianese et al. 2020). Rainwater harvesting is another sustainable practice that has gained traction in agriculture. By capturing and storing rainwater runoff from roofs, surfaces, or catchment areas, farmers can supplement irrigation water sources and reduce dependence on groundwater or surface water (Nema et al. 2019).

The adoption of smart irrigation systems, AgriPV, and rainwater harvesting represents a significant step towards fostering sustainability in agriculture. These innovations not only optimize resource usage and enhance agricultural productivity but also contribute to environmental conservation and resilience in the face of climate change. This study will explore the principles, benefits, and potential challenges associated with these innovative practices, highlighting their role in shaping the future of sustainable agriculture within the framework of a LivingLab integrated in Ankara, Türkiye.

Methodology

AgriPV and reference areas within the LivingLab are equipped with soil moisture and temperature sensors installed at a depth of 60 cm beneath the ground. These sensors measure both temperature and moisture levels at intervals of every 10 cm. The collected data is then transmitted to the cloud system in real time, with updates occurring every 15 minutes. Our developed control algorithm processes this data to assess the water requirements of the field. Should the field require irrigation, the control algorithm activates the solenoid valves to open and deliver water. Throughout the irrigation process, the system continues to gather data from the sensors. Once the control algorithm determines that sufficient irrigation has been administered, it instructs the solenoid valves to close, thereby completing the irrigation process. This ensures that all fields receive irrigation tailored to their specific needs, effectively reducing the risk of indiscriminate water usage.

A smart farm sensing framework, offering both qualitative and quantitative analysis, has been developed to compare the effectiveness and impact of smart irrigation systems, AgriPV, and rainwater harvesting on agricultural sustainability. This framework aims to identify patterns, trends, and best practices for integrating technology with agricultural practices.

Lastly, the findings obtained from the literature review, data collection, and comparative analysis will be synthesized to provide a comprehensive overview of the principles, benefits, and challenges associated with smart irrigation systems, AgriPV, and rainwater harvesting in sustainable agriculture. This synthesis will inform discussions regarding the role of these innovations in shaping the future of sustainable agriculture.

Results

As shown in Figure 1, it has been observed that, despite applying the same amount of irrigation, the soil in the AgriPV area retains water more effectively compared to the reference area which is obtained from the LivingLab in Ankara.

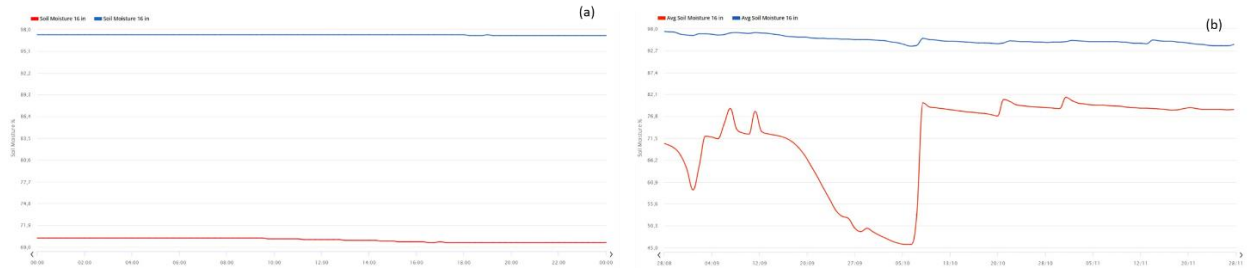


Figure 1. Comparing soil moisture values for pepper obtained from AgriPV (blue) and the reference area (red), (a) on 28 August 2023, (b) for three months starting from 28 August 2023.

As shown in Figure 1, the most dramatic difference between the soil moisture values was observed as 48% more moisture under the AgriPV system on 05 October 2023.

Figure 2 indicates the smart farm sensing system designed for the LivingLab.

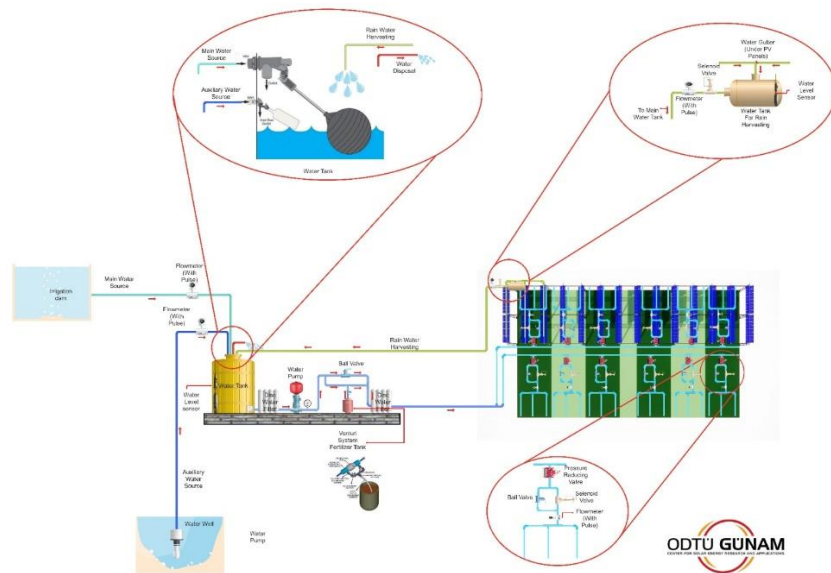


Figure 2. Schematic view of smart farm sensing design.

As shown in Figure 2, the smart farm sensing design contains various parts such as a water pump, water tank, flowmeter, filter, solenoid valve, controller, manometer, water well, ball valve, and fertilizer tank, each of which is crucial for a well-functioning smart irrigation system.

Conclusion

In summary, the integration of smart irrigation systems, AgriPV, and rainwater harvesting presents a promising pathway toward sustainable agriculture. Through advanced technologies and innovative practices, these solutions optimize resource usage, enhance productivity, and mitigate environmental impact. Moving forward, continued research, investment, and policy support are essential to realizing the full potential of these innovations and building a more resilient and sustainable agricultural future.

References

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