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RESEARCH ARTICLE

Solar Energy for Agriculture

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ABSTRACT

Sustainable development, especially in the fields of agriculture and environmental preservation, depends heavily on solar energy. Making the switch to solar energy sources provides tremendous promise for meeting energy demands while reducing adverse environmental effects as the world's population rises and environmental problems worsen. Solar energy has the potential to significantly improve energy efficiency, lower carbon footprints, and foster climate change resilience in the context of agriculture and the environment. The chapter will discuss thoroughly about the impact of solar energy on both sustainable agriculture and the environment. Benefits of solar energy application will be described in detail in this chapter.

Key words: Irrigation, machineries, solar energy, sustainability

INTRODUCTION

Solar energy is considered the most rich energy source of renewable energy. There are several ways to use solar radiation for generating energy and they generate either thermal energy or electrical energy. Photovoltaic (PV) cells which are made up of semiconductor materials directly convert sunlight into electricity. Through the use of solar thermal technology, heat from the sun is either directly used or transformed into energy (Turkmen, 2020). Since the dawn of humanity, solar energy has been widely used for residential, agricultural, and agro-industrial purposes.

Solar-powered Irrigation

Irrigation system developed based on solar power required low maintenance and are also environment friendly. The system is made up of components such as pumping units, pump controllers, and PV modules (Ashraf and Jamil, 2022). Solar-powered irrigation system is very cost effective and solution for the energy needs of Indian farmer. Benefit cost ratio of the solar powered system user is 1.31 and for diesel power system user 1.096 (Harishankar *et al.*, 2014). More than one million carbon emissions from agricultural sources can be avoided by replacing 50% of the diesel-powered irrigation systems with solar power system (Rana *et al.*, 2021). A gravity-fed type micro-irrigation system was developed to achieve the holistic utilization of water resources at the research farm of Central Research Institute for Dryland Agriculture, Hyderabad. The hydraulic research of the various drip irrigation system components was used to determine the flow parameters that were taken into consideration when designing the system. The system that was created in this way can supply consistent emitter discharge across the 18 m × 6 m plot (Kumar *et al.*, 2015).

Solar-assisted Drying

Replacing traditional energy sources with solar dryers can significantly lower post-harvest losses and carbon emissions in rural areas. Using sun drying for fruits, vegetables, and other crops has potential in terms of energy savings and quality.

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Around the world, several types of solar dryers with varying levels of technological performance have been devised and produced (Prasad *et al.*, 2024).

Solar-powered Tractors

In tropical areas with a reliable, affordable power source in the shape of a PV plant, the concept of an electrical tractor with an interchangeable battery pack is already a scientifically and economically viable choice. The most significant conclusion is that, in tropical regions, electrical energy generated by a solar device would not only maintain electric tractor operation but also potentially lead to the investment's recovery and give the semi-arid family farmer more revenue (Sutar and Butale, 2020). The practical use of these sustainable devices can be facilitated by more technological advancements, cost reductions, and obtaining government incentives. (Gorjian *et al.*, 2021).

Solar-powered Agricultural Robots

Solar-powered agricultural robots are designed for multipurpose work like sowing, weeding, and pesticide spraying. The operations are performed using an Android app. No direct contact with human is needed as instructions are given using Bluetooth and thus safety of operator is ensured. It reduces labor cost and also saves time of the farmer (Ranjitha *et al.*, 2019). The use of solar-powered robots reduces operation time by 49% and the rate of interference with obstacles by 26% during sowing and harvesting compare to simple controller (Otani *et al.*, 2022).

Greenhouse Heating Using Solar Energy

The main drawback of greenhouses is the high energy demand in a limited space. Integration of solar energy technologies with green house improved the performances of cultivated crop, especially in moderate climate conditions. These solar technologies enhanced crop yield and quality with sustainable and environmentally friendly energy production. However the PV modules installed on greenhouse roofs or walls created shade that cause shading and sometime impacts the growth of cultivated crops inside (Kant *et al.*, 2022). A well-designed solar-heated winter greenhouse with little to no additional heat can successfully and affordably grow a range of cold-hardy species, such as vegetables, salad crops, restaurant garnishes, and fresh cut flowers. Although summer harvests may be preserved by canning and drying but a fresh vegetable required for healthy diet in winter month (Gorjian *et al.*, 2011).

CONCLUSION

Solar energy is considered the most rich energy source of renewable energy. Sustainable development, especially in the fields of agriculture and environmental preservation, depends heavily on solar energy. The application of solar energy for irrigation, drying, agricultural machineries, and agricultural structures makes it essential for a sustainable agriculture environment. However, more research is required in the future to make it more cost-effective for rural farmers.

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