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A study in agriculture farming of sustainable development in solar energy in India

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Abstract:

Solar energy technology has emerged as a solution for various agricultural applications such as crop drying, greenhouse heating, water pumping systems for crop production, livestock care, and small-scale irrigation. It is reducing the dependence on non-renewable energy sources while increasing the demand for renewable and sustainable alternatives like solar energy. There are numerous benefits to using renewable energy, such as solar technology, in agriculture. It is both cost-effective and economically viable, while also addressing the issue of CO2 emissions, which contribute to global climate change. Researchers and academics are actively seeking sustainable alternatives to conventional energy, focusing on effective environmental management. By replacing traditional fossil fuels with renewable solar energy in agriculture, CO2 emissions can be reduced, thereby helping to mitigate global warming and preserve the environment. Unlike fossil fuels, solar energy does not release greenhouse gases into the atmosphere, and it is also abundant, free, and cost-effective, making it a valuable option for sustainable agricultural practices.

Keywords: solar energy, environmental management, renewable energy, sustainable

Introduction:

The demand for energy in agriculture has significantly increased to meet the needs of a growing population and the rising demand for food. Traditional energy sources are becoming insufficient and are depleting as their reserves near exhaustion. Consequently, along with advancements in agriculture, agro-researchers are focusing on the exploration and discovery of new energy sources. The sun, an inexhaustible energy source, has been producing solar energy through nuclear fusion since the birth of the solar system. Solar energy plays a crucial role in meeting energy demands. Fortunately, it offers numerous advantages that can be utilized both directly and indirectly. To ensure a sustainable future and address the increasingly severe impacts of climate change, especially global warming, developing countries are urgently transitioning from conventional energy to renewable energy sources. Solar energy is abundant, free, and non-polluting, making it one of the most competitive renewable energy options. In the agricultural sector, solar energy is harnessed in various ways for different applications. For example, its thermal properties are used for drying foodstuffs, vegetables, crops, and meat, which is a direct application of solar energy.

However, traditional solar drying is time-consuming and exposes products to potential contamination from dust, pests, and weather changes like wind and rain. In response, modern solar dryers have been developed to improve the efficiency and hygiene of solar drying. For decades, solar energy has been used in diverse ways, particularly after being converted into other forms, such as chemical and electrical energy. Significant research has been dedicated to improving solar energy conversion methods to increase its capture and utilization. The conversion of solar energy into electrical energy, or "soletrical energy," has expanded its use across various sectors. In agriculture, soletrical energy is being explored for applications such as water pumping, lighting, pesticide spraying, and operating machinery like tractors. Although the use of solar energy in agriculture is growing, more awareness and research are needed to fully harness its potential and meet future energy needs. The global temperature is steadily rising due to climate change, which has severely impacted weather patterns, agricultural production, and ecosystems, threatening the sustainability of farming systems. One of the main contributors to these global challenges is industrialization, including in agriculture, and the increased consumption of non-renewable energy. This has prompted researchers, academicians, and policymakers to seek renewable energy alternatives. Agriculture is essential for providing food and other necessities for life on Earth, but it is energy-intensive, relying on electricity, petrol, and diesel, which contribute to greenhouse gas emissions and global warming. While energy was cheap and abundant three decades ago, today it is gradually diminishing with increasing consumption, raising

concerns about its future availability. Researchers are now focusing on alternative renewable energy sources, with solar energy emerging as a promising solution. By replacing conventional fossil fuels with renewable energy, such as solar power, carbon dioxide emissions can be reduced, helping to mitigate climate change and preserve the environment for future generations.

The major determinant factors of agriculture in India are:

(1) Land forms
(2) Climate
(3) Soil types
(4) Water

Contribution of Agriculture to the National Economy:

Agriculture has been the backbone of the Indian economy. However, its share in the GDP has shown a declining trend since 1951. Despite this, agriculture still provided employment and livelihood to 63% of the population in 2001. The declining contribution of agriculture to GDP can have broader implications for other sectors of the economy, which may negatively impact society as a whole. Recognizing its significance, the Government of India has taken steps to modernize agriculture. On the other hand, non-renewable energy sources such as coal, oil, and natural gas contribute to CO2 emissions, causing global environmental changes (Svejkovsky, 2006). As a result, scientists have turned to renewable solar energy, which can help maintain a cleaner environment by reducing carbon emissions (Behera et al., 2015).

Agricultural practices in developing countries need to be reformed (Afsharzade et al., 2016), as there is a global belief that adopting sustainable farming methods will help preserve natural resources (SSNC, 1999). Policymakers and governments must initiate programs that mitigate the environmental impact of development through effective resource management, encouraging farmers to adopt sustainable practices (Broadbent, 1998). Despite the many benefits, implementing sustainable agriculture faces challenges, largely due to farmers' continued reliance on conventional energy sources like electricity, with renewable energy rarely used in practice (Corré et al., 2003). Agriculture emits significant greenhouse gases, so switching to sustainable practices, such as organic farming combined with alternative energy technologies, is crucial to addressing food insecurity, climate change, and ecosystem degradation (Bellarby et al., 2008; Niggli et al., 2009; Smith et al., 2007).

Impact of Globalization on Indian Agriculture:

Today, Indian farmers face significant challenges from international competition. The government's reduction in public investment in agriculture, along with decreased subsidies on fertilizers, has increased production costs. Lower import duties on agricultural products have also harmed local farmers. Many are withdrawing investments from agriculture, causing a decline in employment in the sector. Using renewable solar energy sources can alleviate global environmental challenges while reducing farmers' reliance on non-renewable energy. Solar energy offers numerous environmental, health, and economic benefits since it is free and emits no pollutants. Integrating solar technology into farming can improve public health by reducing pollution and supporting the production of organic crops, which can help protect against diseases like cancer and respiratory conditions caused by pollution (Schnepf, 2003). To encourage more farmers to adopt these technologies, efforts are being made to introduce low-cost solar water heating systems and conduct research to make these systems more affordable (Fischer et al., 2006; Peskett et al., 2007; UCS, 2017).

Innovative Applications of Solar Energy in Agriculture

1. **Solar Energy for Crop Drying**
   Traditionally, farmers have dried crops, grains, and fruits in the open air, but this method has several drawbacks, such as contamination by pests, dust, and weather conditions. Modern solar drying equipment offers a more efficient and hygienic alternative. Solar walls built into drying structures raise the internal temperature, drying crops faster while protecting them from external threats (EREC, 2003; UCS, 2017). This system is economical, long-lasting, and can be adapted to various farm conditions, making it highly beneficial for farmers.
2. **Solar Energy for Water and Space Heating**
   Solar energy can also be used to heat water and spaces on farms through innovative devices like solar water heating systems. These systems are cost-effective, pollution-free, and easy to operate, offering significant energy savings. Solar space heating is particularly useful for heating farm structures, improving air quality and reducing CO2 emissions (UCS, 2017).
3. **Solar Energy for Greenhouse Heating**
   Solar heating in greenhouses reduces the need for fossil fuels and allows farmers to grow crops year-round, regardless of external climate conditions. By capturing sunlight, solar greenhouses help maintain optimal temperatures for plant growth, even in cold weather, enhancing crop yields and reducing global food shortages (EREC, 2003; NYSERDA, 2009).
4. **Solar Photovoltaic (SPV) Technology**
   SPV technology converts solar radiation into electricity, which is essential for farms in remote areas with limited access to the grid. This renewable and cost-effective technology can power water pumps, irrigation systems, and

other agricultural machinery, reducing dependence on fossil fuels (Singh and Mishra, 2015). Although solar PV systems require a high initial investment, they offer long-term savings, especially in areas where conventional energy sources are expensive or unavailable.

Conclusion:

The use of solar energy in agriculture offers numerous benefits, including reduced greenhouse gas emissions, cost savings, and enhanced productivity. By promoting the adoption of solar technologies, policymakers can help ensure sustainable farming practices, preserving natural resources for future generations. Solar energy is a key solution to minimizing global warming and supporting sustainable agricultural and environmental management.

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