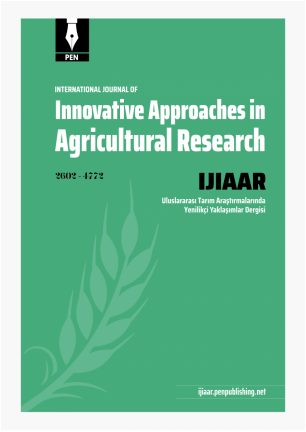


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Review article

# Renewable Energy Applications for Sustainable Agricultural Systems

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**Abstract**

Sustainable agriculture means meeting current food needs without compromising the ability of current or future generations to meet their own needs. Energy is the most important tool for sustainable agricultural development and growth. The agri-food chain accounts for around 30 % of the global energy demand. The agricultural sector is currently heavily dependent on the use of fossil fuels. The use of fossil fuels in agriculture leads to an increase in greenhouse gas (GHG) emissions in the sector. The total GHG emissions from the agri-food chain account for more than 30 % of global GHG emissions per year. Emissions from energy used in agricultural activities consist primarily of CO2, CH4, and N2O. Current fossil fuel-based energy generation needs to be shifted to renewable energy such as solar, biomass, wind, and geothermal to mitigate climate change and reduce GHG emissions. There are a variety of energy-related mitigation and adaptation opportunities in agriculture. Improvements will be made by enhancing access to electricity, making more efficient use of resources, and increasing the use of renewable energy sources in agriculture. This would have the dual advantage of providing renewable energy inputs to agriculture, thereby increasing productivity, economic and social sustainability, and reducing climate change commitments. This paper details the role of renewable energy in agriculture by linking sustainability aspects.

**Keywords:** Renewable energy, agriculture, sustainability, climate change, energy

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## INTRODUCTION

Energy provides one of the basic human needs. The sources of energy can be categorized as non-renewable (fossil) and renewable energy sources. Fossil energy sources include coal, oil, and natural gas while renewable energy resources include solar, wind, geothermal, biomass, hydropower, tidal, and wave power.

Total world primary energy supply (TPES) increased more than 2.5 times between 1971 and 2018 and reached 14,428 Mtoe (IEA, 2019). In this year, the global energy demand was met largely by fossil fuels with oil providing 31.5 %, coal 26.9 %, and natural gas 22.8 % of the world's primary energy supply. These are followed by combustible renewables and wastes (9.5 %), nuclear (4.9 %), hydropower (2.5 %), and wind, geothermal and solar (2.1 %) (IEA, 2019). Fossil energy resources play a crucial role in meeting the growing energy demand worldwide. However, renewable energy is becoming an essential source of energy generation, and its role will grow in the future, particularly as a result of climate change issues and the finite nature of fossil resources. Hydropower is the only domestic energy resource for several countries. At present, the role of hydropower in the generation of electricity is significantly greater than other renewable resources. Solar energy usage is increasing worldwide, which is generally a domestic energy source. Wind technology has been improved step by step since the early 1970s. As a result of that, wind energy will be more important in the future for meeting the energy demand of the world. Biomass accounts for more than 20 % of the total energy supply, particularly in developing countries. Most of the biomass used in these countries is intended to meet the demand for cooking and heating. The world has a vast potential for geothermal energy that can be used for direct use and generation of electricity (Better, 2013; Chel & Kaushik, 2011).

Energy has always been crucial to agriculture. Agriculture activities in many countries tend to focus mainly on animal and human resources. Insufficient electrical and mechanical energy is supplied to agriculture and therefore the potential improvement of agricultural productivity through the implementation of modern power generation is not realized (FAO, 2016). Energy use in agriculture is generally classified as either direct or indirect. Direct energy used in agriculture refers to the energy consumed directly in agricultural activities such as farm machinery, trucks, installations, harvesting, irrigation, drying, storage, and marketing. Indirect energy used in agriculture refers to the energy used in the manufacture and chemical supplies used in the processing of fertilizers, pesticides, and other agricultural chemicals. Neither indirect nor direct energy accounts for the solar energy required for photosynthesis (Schnepf, 2004).

Agriculture and food systems account for about one-third of the world's total final energy demand (Nguyen et al., 2015). Agriculture is the primary emitter of greenhouse gas (GHG) emissions mainly carbon dioxide ($CO_2$) in the global agri-food system. Agriculture contributes directly to between 10 % and 15 % of global GHG emissions. Adding emissions from deforestation and land-use changes to

animal feed production increases by up to 30%. Agricultural GHG emissions also consist of non-$CO_2$ gases, namely methane ($CH_4$) and nitrous oxide ($N_2O$), produced through the production and management of crops and livestock, which together account for about 22 % of global emissions (Andreas Gattinger, 2011; Francesco N. Tubiello, 2016). Sustainable agriculture is one of the primary objectives of the agricultural sector and this priority will only be achieved by shifting farming practices from fossil energy to renewable energy. Adopting new strategies for energy conservation, investing in renewable technologies, and improving energy efficiency in the sector will help reduce energy costs and emissions and increase production (FAO, 2011).

## RENEWABLE ENERGY USE IN AGRICULTURE

Sustainability issues in agricultural systems focus on the need to implement technologies and methods that do not adversely affect environmental products and services, are affordable and efficient for farmers, and contribute to increased food production (Pretty, 2008). Non-renewable energy sources are used by the agricultural industry for the operation of machinery and equipment, for the heating or cooling of buildings and on-farm lighting, and indirectly for fertilizers, industrial equipment, and off-farm chemicals that adversely affect the natural environment (Aydoğan & Vardar, 2020). The use of renewable resources can mitigate such environmental damage. A key point for improving the sustainability of the agricultural sector is finding more efficient ways to generate energy and make it available to farmers. The use of low carbon and clean energy technologies to replace fossil fuels in agriculture is one approach to achieving this (R. Sims, 2015). Increased deployment and use of renewable energy in agriculture will help improve access to energy, reduce dependence on fossil fuels in the sector, diversify farms, and help achieve sustainable development goals.

There are a variety of applications for the use of renewable energy in agricultural systems, including the generation of electricity for a variety of agricultural works: pumping water for irrigation, livestock, or domestic use; lighting farm buildings; power generation activities, and other uses. These types of renewable energy include solar, wind, biomass, and geothermal power (Ali et al., 2012). The use of these renewable energy sources in agriculture is described in more detail in the following sections.

### Solar Power

Solar radiation can be used in many ways to generate energy such as heating buildings and water, electricity generation. Solar technologies provide either electrical or thermal energy. Photovoltaic (PV) cells directly convert sunlight into electricity. PV modules are made of semiconductor materials that directly convert solar radiation into electricity. Solar thermal technology absorbs heat from the sun and either directly uses it for space and water heating or converts it to energy (Muller, 2009).

Solar energy is significant in agriculture in a variety of ways, including increasing self-reliance, saving resources, and avoiding pollution. Solar energy reduces energy use and therefore reduces costs

(UCS, 2008). Solar electrical devices are used for agriculture to provide heating, battery charging, small engines, water pumps, solar greenhouse and underfloor heating, and electric fences with electricity (Chel & Kaushik, 2011). Water for irrigation purposes may be drawn either from the surface of rivers or from aquifers. Energy needs may vary depending on the vertical and horizontal distances the water travels. Globally, irrigation pumps use approximately 62 TWh of energy a year which is equal to the total energy consumption in Singapore in 2014 (IRENA, 2016). Solar energy has a tremendous capacity for solar irrigation and can be used to pump water for livestock and crops. Solar-based systems will provide efficient, cost-effective, and environmentally friendly electricity to decentralized irrigation facilities (IRENA, 2016). Drying food reduces moisture so that the commodity can be processed for a long time and protected from corruption. Solar-drying technology extracts vegetables and fruit under sanitary conditions in compliance with the requirements. It saves energy, time, takes up less space, improves product quality and process efficiency, and protects the environment (Torshizi et al., 2017). Greenhouses offer opportunities in cold regions to produce food and horticultural goods close to the consumer, eliminating transportation costs and fuels. Several forms of passive solar systems are used for greenhouse heating purposes (Gorjian et al., 2011). Solar water heaters make hot water available to farms. The sunlight will be used for heating houses and farms. PV solar panels are also be used to produce energy using sunlight (Torshizi et al., 2017).

As an emerging industry, the number of solar energy installations is expected to increase in order to increase solar cell efficiency and reduce costs (Chel & Kaushik, 2011; Fischer et al., 2006)**.**

**Wind Power**

A wind turbine converts the power of moving air into electricity by using the kinetic energy of moving air to rotate the blades of the turbine that are connected to a generator (Laverdure, 2009). Electricity can be generated from onshore and offshore wind turbines.

Turbines used to generate wind power may supply a significant portion of the farm's total energy requirements, although they must be situated in high wind areas and usually need at least one acre of land to provide enough electricity. Wind turbines can be used to operate agricultural machines, generators, and air conditioners. Millstones have been used to grind dried grains including wheat, barley, and maize for the production of food or flour. Over several years wind power has been used to produce electricity through grain milling and pumping water. In recent times, wind turbines are used to generate electricity (NEF, 2020). Small wind systems can support agriculture in traditional ways, such as pumping water or grinding grain using mechanical energy (Chel & Kaushik, 2011).

While technical advances continue to enhance wind energy's economic performance, agricultural farmers are expected to expand their use of wind power to lower electricity prices and become more self-sufficient in resources (Fischer et al., 2006).

**Geothermal Power**

Geothermal resources supply energy in two ways. One is the direct use of hot water or hot steam for residential heating or industrial use and another one is electricity generation (Bel, 2009). Geothermal technologies generate electrical or thermal energy. Geothermal power is ideal for small rural electricity grids, as well as for national grid applications (Fischer et al., 2006).

The heat from geothermal energy can be directly used. Geothermal fluids can be used to heat houses, cultivate greenhouses, heating water for fish farming, and pasteurize milk (Fischer et al., 2006). The most important application of geothermal energy in agriculture is greenhouse heating which is used to grow crops, fruits, and flowers on an industrial scale. Low-temperature geothermal fluids or the waste heat recovered from a geothermal plant are used as sources of energy for heating the air for drying agricultural products. Geothermal resources are used efficiently for pre-heating and heating applications (Nguyen et al., 2015).

Geothermal power has the technological and economic capacity to support the production of a variety of value-added agricultural goods in the future (Nguyen et al., 2015).

**Hydropower**

Hydropower systems operate based on a basic principle: The power of moving water turns a turbine that is connected to a generator. Hydropower plants can be classified into two main groups, namely reservoir hydropower plants, and run-of-river hydropower plants. The run-of-river hydroelectric power plants use the running water of the river to turn turbines to generate electricity. The reservoir types of hydroelectric power plants use a dam to collect and store large quantities of water. Dammed water operates a turbine that is connected to the generator (IEA, 2012; Tissot, 2009). Hydropower systems are of varying size and use.

In agriculture, hydropower is used in the following areas; electricity on the farm for pumping water for irrigation, processing, and storage of agricultural produce, and for lighting farmhouses and environment, direct use of water for irrigation from the hydropower dams, and use of dams for fish farming (Clement et al., 2018). Hydropower is a mature technology and there are many applications for use on-farm or in the food production chain. Compared with other renewable technologies, mini-hydro systems are less capital intensive.

In the future, there could be some increase in the use of mini-hydro systems that can be powered off-river without dam or water storage (R. Sims, 2015).

**Biomass**

Biomass-based energy is clean energy made usable from materials derived from biological sources. Biomass supplies arise in large quantities from a wide range of agricultural and forestry

practices as well as from food processing operations in the agri-food industry and these products are used in bioenergy, biofuels, or feedstock for biomaterials (R. Sims, 2015).

Biomass energy can be used in small-scale agriculture without any sort of further processing (Babatunde et al., 2019). The energy of most farmhouses in developing countries comes from traditional solid biomass such as wood (R. Sims, 2015). Biomass is also used for the production of biorefineries that have a wide range of applications in agriculture. The biorefinery is an industrial facility or technology that converts biomass resources into energy and other useful products (Babatunde et al., 2019). Bioenergy is produced in the form of fuel (biofuel) such as biogas, bioethanol, biodiesel, biogas, or other forms of bioenergy. Biofuels can be used directly for heating and on-site power with dedicated gas engines. In some cases, biogas is being upgraded to natural gas quality and injected into the gas grid (Clement et al., 2018; R. Sims, 2015). Biogas can be converted into alternative energy supplies that can be regenerated through agricultural production and processing operations (Weiland, 2006).

Biomass is an important technological and economic resource for renewable energy. The performance of biomass systems has continuously improved over the years and further innovations will bring down costs even more in the future (EIP-AGRI, 2019).

**Conclusion**

Since the industrial revolution, agriculture has shifted manual labor to machines. Throughout agriculture, the use of machinery and chemicals has made energy one of its main inputs. Management of energy consumption in agriculture is a global concern due to the adverse effects of greenhouse gas emissions from fossil fuels, which are generally used as an energy source for various applications in agriculture, such as water heating, irrigation, and lightning. As the world's population increases, demand for agricultural products is increasing at an exponential rate. Agriculture is therefore one of the industries that can greatly benefit from the implementation of renewable energy. Energy plays a key role in improving productivity and agricultural production systems since energy requirements are highly diverse and can be met in various ways. The use of renewable energy technologies in agriculture will not only address energy and water scarcity problems but will also ensure food security and enhance sustainable agriculture. As a result, the use of renewable energy and related technology has enormous potential to contribute to sustainable agricultural objectives and is being used in several farms, and there are many opportunities to increase their use in the future. Promoting renewable agriculture needs more government support as a basic strategy for sustainable agriculture. This will be reflected in the agricultural planning plans.

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## REFERENCES

Ali, S., Dash, N., & Pradhan, A. (2012). Role of renewable energy on agriculture. International Journal of Engineering Sciences Emerging Technologies, 4(1), 51-57.

Andreas Gattinger, J. J., Adrian Muller, Friedhelm Göltenboth and Jørgen Olesen. (2011). Mitigating Greenhouse Gases in Agriculture A challenge and opportunity for agricultural policies. Research Institute of Organic Agriculture (FiBL), Stuttgart.

Aydoğan, B., & Vardar, G. (2020). Evaluating the role of renewable energy, economic growth and agriculture on CO2 emission in E7 countries. International Journal of Sustainable Energy, 39(4), 335-348. https://doi.org/10.1080/14786451.2019.1686380

Babatunde, O., Denwigwe, I., Adedoja, O., Babatunde, D., & Gbadamosi, S. (2019). Harnessing Renewable Energy for Sustainable Agricultural Applications. International Journal of Energy Economics and Policy, 9, 308-315. https://doi.org/10.32479/ijeep.7775

Bel, F. L. (2009). Geothermal Energy Production. In Renewable Energies (pp. 261-328). https://doi.org/10.1002/9780470612002.ch9

Better. (2013). Renewable energy targets, potentials and energy demand scenarios of Turkey.

Chel, A., & Kaushik, G. (2011). Renewable energy for sustainable agriculture. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA, 2011, 31 (1), pp.91-118.

Clement, O., Akinyele, O., Oladimeji, S., & Oladipo, O. (2018). Renewable Energy Usage for Agricultural Practices: A review. 2018 International Conference of The Nigerian Institution of Agricultural Engineers, Lagos, Nigeria, September, 2018.

EIP-AGRI. (2019). Enhancing production and use of renewable energy on the farm. Brussels, Belgium.

FAO. (2011). Energy-smart food for people and climate. Technical report. Food and Agriculture Organization of the United Nations (FAO).

FAO. (2016). Energy, agriculture and climate change towards energy-smart agriculture. Technical report. Food and Agriculture Organization of the United Nations (FAO).

Fischer, J. R., Finnell, J., & Lavoie, B. (2006). Renewable Energy in Agriculture: Back to the Future? Business Choices. The Magazine of Food, Farm, and Resources Issues.

Francesco N. Tubiello, R. D. C.-G., Mirella Salvatore, Angela Piersante, Sandro Federici, Alessandro Ferrara, Simone Rossi, Alessandro Flammini, Paola Cardenas, Riccardo Biancalani, Heather Jacobs, Paulina Prasula, and Paolo Prosperi. (2016). Estimating Greenhouse Gas Emissions in Agriculture A Manual to Address Data Requirements for Developing Countries. Food and Agriculture Organization of the United Nations (FAO).

Gorjian, S., Hashjin, T., & Ghobadian, B. (2011). Solar Powered Greenhouses. 10th International Conference on Sustainable Energy Technologies on Sustainable Energy Technologies

IEA. (2012). Energy Technology Perspectives 2012: Pathways to a Clean Energy System. IEA, Paris

IRENA. (2016). Solar pumping for irrigation: Improving livelihoods and sustainability. The International Renewable Energy Agency, Abu Dhabi.

Laverdure, R. B. (2009). Wind Systems Technology. Renewable Energies (pp. 103-142). https://doi.org/10.1002/9780470612002.ch5

Muller, J. C. (2009). Photovoltaic Electricity Production. In Renewable Energies (pp. 1-23). https://doi.org/10.1002/9780470612002.ch1

NEF. (2020). Renewable Energy Technologies. National Energy Foundation. Milton Keynes, UK. http://www.nef.org.uk/knowledge-hub/other-renewable-energy/renewable-energy-technologies

Nguyen, M. V., Arason, S., Gissurarson, M., & Pálsson, P. G. (2015). Uses of geothermal energy in food and agriculture: Opportunities for developing countries. Food and Agriculture Organization of the United Nations (FAO).

Pretty, J. (2008). Agricultural sustainability: Concepts, principles and evidence. Philosophical transactions of the Royal Society of London. Series B, Biological Sciences, 363, 447-465. https://doi.org/10.1098/rstb.2007.2163

R. Sims, A. F., M. Puri, S. Bracco. (2015). Opportunities For Agri-Food Chains To Become Energy-Smart. Food and Agriculture Organization of the United Nations (FAO).

Schnepf, R. (2004). Energy Use in Agriculture: Background and Issues. CRS Report for Congress.

Tissot, R. N. (2009). Small Hydropower. In Renewable Energies (pp. 227-260). https://doi.org/10.1002/9780470612002.ch8

Torshizi, M. V., Mighani, A. (2017). The application of solar energy in agricultural systems. 3(2), 234-240.

UCS. (2008). Renewable Energy and Agriculture: A Natural Fit. Retrieved 20.07.2020 from https://www.ucsusa.org/resources/renewable-energy-and-agriculture?print=t#

Weiland, P. (2006). Biomass Digestion in Agriculture: A Successful Pathway for the Energy Production and Waste Treatment in Germany. Engineering in Life Sciences, 6, 302-309. https://doi.org/10.1002/elsc.200620128