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Application of solar energy technology in agricultural farming for sustainable development: A review article

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Abstract Solar energy technology has become a solution for crop drying, greenhouse gas heating, water pump systems for crop production, livestock and small-scale irrigation and it is decreasing the amount for non-renewable sources of energy and increasing demand for renewable alternative sustainable energy as solar energy. There are many benefits for using alternative energy as solar energy technology in agricultural farming. It is cost effective and economical too and at the same time it can solve the problem of the Co_2 emission, which is responsible for globalclimate change. The researchers and academicians are finding ways for a sustainable alternative renewable energy, paying attention to efficient environmental management. By replacing conventional fossil fuels with renewable solar energy in agricultural farming, emission of CO_2 can be reduced and this will help to control global warming and save environment. Unlike fossil fuel, solar energy does not release greenhouse gases in the atmosphere and they are also cheap, free, abundant and cost effective which makes it a good option for sustainable agricultural farming.

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

Introduction

Nowadays global temperature in the earth's natural environment is increasing day by day resulting due to global changes in the climatic conditions and these changes have affected the weather conditions severely, resulting to damage in agricultural products and ecosystem, thereby threatening the future sustainability of agricultural systems. One of the main causes of this global challenges is due to industrialization in all matters even in agriculture and its increasing non-renewable energy consumption. This has instigated academicians, researchers and policy makers to use alternative renewable sources of energy (World Farmers' Organisation, 2017).

Mankind and other living beings on earth have to rely on agriculture for producing food and other survival necessities. However, agricultural

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operational activity is a long process and electrical energy, petrol, diesel etc. are used in its operations, which causes global warming from prolonged greenhousegas emissions. About three decades ago, energy was cheap and available in large amount but today it is gradually decreasing with increasing consumption and there is a growing fear of it to be finished in the coming century (Ahamed *et al.,* 2011). So, researchers and academicians are finding ways for an alternative energy, paying attention to energy management, policies and at the same time save the environment (Saidur, 2010; UN, 2006). The alternative energy is renewable energy in the form of energy from the sun, also called as solar energy. By replacing conventional fossil fuels with renewables energy, emission of carbon dioxide in the atmosphere can be reduced and this will help to control CO_2 emissions (Svejkovsky, 2006).

On the other hand, electrical energy which is non-renewable, obtained from coal, oil, natural gas emits CO_2 or greenhouse gas in the atmosphere and thus causing impact to global environmental change. (Svejkovsky, 2006). This made scientists to look for using solar energy, a renewable energy, which can help in maintaining a clean environment, free from carbon dioxide emission (Behera *et al*., 2015).

Agricultural practices in developing countries needs to be reformed (Afsharzade *et al.,* 2016) as there is global belief that practicing sustainable agricultural practices will help to save the available natural resources from extinction (SSNC, 1999). It is therefore, important to take essential measures by policy maker and the governments to initiate public policies that retard the environmental impact of development through efficient environmental and natural resource management by making farmers to adopt sustainable agricultural practices (Broadbent, 1998). However, implementing sustainable agriculture practices has many problems, caused by several factors, since many farmers continue to be dependent on conventional energy sources as electricity, and energy obtained from renewable source is rarely used in practice (Corré *et al.,* 2003). However, since agriculture-related activities emit lots of greenhouse gas emissions, farmers need to switch to ecologically and productive sustainable agricultural practices as organic farming by application of alternative energy technology to reduce the food insecurity, climate change and degradation in ecosystem (Bellarby *et al.,* 2008; Niggli *et al.,* 2009; Smith *et al.,* 2007). Using renewable solar energy sources can offset global environmental problems while reducing farmers' dependence on non-renewable energy sources. There are many benefits in terms of environment, health as well as cost, because solar energy is free and it has no emissions. Thus, using energy technology in agricultural farming helps to improve public health with less pollution and good yield of organic harvest. This organic harvest saves

humanbeings from many diseases and other health impacts such as protection from cancer, lungs, and other related diseases borne from water - air pollution and climate- change (Schnepf, 2003). In order to attract more farmers, attempts are made with introduction of lost cost solar water heating health system, and to implement it, more researches are being conducted through replacing expensive metals and glass with usage of plastic materials and thus application of solar energy technology aims to boost the sustainable agricultural objectives with low cost but high productivity, in order to provide a stable source of income to the farmers (Fischer *et al.*, 2006; Peskett *et al.*, 2007;UCS, 2017). It is therefore very important to have efficient agricultural management system, that yields high quality food products, higher output with low cost investment through application of innovative farming technology, particularly in distant rural small-scale farmers (UCS, 2017). It is generally observed that farmers were the first to be affected with an increase in the cost of fuel for energy or fertlizers, which many of them could not get profit as they have to sell their products at a lower prize than their investment (Costantini and Bracceva, 2017). But, this high cost investment can be somewhat saved if they use alternative and cheap renewable solar energy technology in agicultural farming as maintenance and operations of this technology is cheaper and time saving than using engines operated by diesel engine or electricity, thus providing farmers more time to engage in other productive activities (Peskett *et al*., 2007; Schnepf, 2003). At the save time, it saves the environment from pollution and warming (Peskett *et al.*, 2007). Thus, one of the global priorities among the agricultural scientists is to replace fossil fuel energy with alternative renewable solar energy.

Solar energy for crop and grain drying

Traditionally, farmers usually spread grain, paddy, crops and fruits in the open space after harvesting, when there is bright sunlight as it is an easy and economical technique for drying. However, this traditional technique even though is simple and economical, has many disadvantages as the crops can be spoiled by insects, pests, birds, rodents, wind, rain and other weather condition. To overcome this problem, farmers use innovative solar drying equipment, made by building a solar wall in a building and this can dry the crops and grains faster and more uniformly and at the same time are protected from rain, birds, insects and other rodents (EREC, 2003; UCS 2017). The function of solar wall is to absorb heat at which air passes through the wall in the building, resulting to high indoor temperature. The indoor temperature is so high that it can be used to dry crops and grains and it is more convenient to farmers as this method of drying protects delicate food from burning or ove drying and it dries crops

faster than leaving them dry in the open space of the field. Since many farmers face economic hardships, they need to use innovative devices or technology for an efficient solution. Thus, using solar drying equipment brings many benefits to the farmers as it functions economically and efficiently, provides greater flexibility in choosing a harvest date and protects it at the time of storing from damaged caused by moisture, it can also be used for drying many kinds of crops, grains or fruits A solar drying equipment's components are a shed, tray or rack and a collector. However, there are certain factors which influences the size of the collector and the rate of airflow as material type, moisture content, presence of air humidity, and intensity of solar radiation (Schepens, 1986). Generally, solar dryer is more cost effective (NYSERDA, 2009). The The following are the benefits of using solar energy agricultural crop drying devices as:

- it is economical
- does not generate carbon dioxide or air pollution
- as the solar wall is usually made of metal, the system is long lasting
- easy to install and low cost
- it can dry crops faster and more uniformly
- this system can be adapted to various types of farms and their requirements

Figure 1 shows the different solar drying devices.

Figure 1. Solar drying devices
Source:
http://www.agriculturesolar.com/3b_drying_process_of_solar_grain_dryer.html#.WMj3bcYxU2w
http://www.daviddarling.info/encyclopedia/S/AE_solar_energy_for_crop_drying.html
http://www.ucsusa.org/clean-energy/increase-renewable-energy/solar-energyagriculture#.WMoyJsYxU2w

Solar energy for water and space heating

Solar energy can also be used for water and space heating through creating innovative popular devices as solar water heating system. Using this system is advantageous as it is is economical, pollution free and easy to operate.

It will save energy for water heating if it is used on a wide scale by most farmers. The device usually consists of a collector and storage tank, where water in collector gets heated during day time, then pumped or passed the heated water to the storage tank. Using this device can prevent carbon dioxide emission of 1.5 tonnes per year (Solar Water Heating, 2017). Solar space heating system is similar to solar water heating system except that it uses heat energy instead of hot water for heating. It is used to heat farms such as livestock and dairy operations in an enclosed building. So, using solar space heating facilities in a farm building has the ability for replacing contaminated indoor air and improves air quality. In addition, it saves cost of energy consumption as the cost of solar energy usage is less and cheaper. Solar space heating system also enables to get rid off carbon dioxide presence during hot weather in summer through increasing natural ventlilation system and this helps to purify and improve air quality for healthy and safe rearing of animals (UCS, 2017; WFE, 2002; Garg, 1987; Goedseels, 1986). (Schnepf, 2007; Svejkovsky, 2006.)

Solar energy for greenhouse heating

Solar energy for greenhouse heating reduces the need for fossil fuels for heating. Through greenhouse heating, farmers can grow many different kinds of crops even if the climate is not suitable and its development can reduce the world's food scarcity problem. In addition, it helps to cultivate all kinds of crops or fruits all through the year without regard to season. As a result, people can enjoy all kinds of food, which are available all through the year. The device helps to retain heat for using at night and even for cloudy weather conditions. The system is contsructed generally to capture sunlight in the southern side while its northern side is insulated with no windows to heat up the space for inducing higher plant growth (EREC, 2003; NYSERDA, 2009). This farming method has the ability to control temperature and use innovation to improve farming production by using materials that gets the maximum solar energy benefits. Farmers can adapt the climatic influences on farming through the use of greenhouses. For example, in cold climates, farmers can use heaters inside the greenhouses, while in the humid or dry climate, they can use fan. Another advantage of greenhouse farming is that it enables farmers to grow in vertical space, in shelves, or hanging from the ceilings and this saves the farming area (Wisegeek.com (2017). The main advantages of using this method is that it is free, less cost, clean and renewable resource. A farmer using a solar greenhouse heater will typically have much lower energy bills than someone who has a greenhouse heated by other types of greenhouse heaters. A solar greenhouse heater is also much better for the environment because the energy used by these

heaters is clean with no dangerous by-products, like carcinogens. The disadvantage is that there may not be sufficient heat on cloudy days.

Solar Photovoltaic (SPV)

SPV (Solar Photo Voltaic) techonology helps to convert solar radiation on a device into electricity with no environmental degradation (Ali *et al.*, 2012). It can be used at any time but the frequency of electricity is more when the sunlight is strong or striking directly to the Photo Voltaic component. This device can be used in the form of stored energy in battery or as direct electrical appliance, that can be used in areas with no electricity supply as the solar electricity energy. Using PV energy is cost effective as it is cheaper and the cost of maintenance is lesser than using other mode of electricity generating engine such as diesel generators, wind turbines, or batteries. In addition, the production of electricity through this system is renewable and without noise or pollution. It is very convenient to use in agriculture farm, ranches for irrigation, and for supplying water in distant places in the rural village, where there is no electric connection. So, numerous farmers rely on Solar Photo Voltaic (SPV) energy at summer time as it is a solution for livestock, crops, and small-scale irrigation (Singh and Mishra, 2015; Pauline, 2016; Chowdhury *et al.*, 1993). Batteries are not required generally for its operation. However, large pumping system may require batteries or inverters Even though the solar powered has many benefits, it has some disadvantages. One disadvantage is that the use of solar panels on irrigation plants requires a high initial investment cost. Furthermore, solar energy is not available in the evening hours, so expensive storage devices like the battery are required for the plant to run smoothly all day and batteries may need to be replaced every 3 to 5 years. Since efficiency of solar energy conversion is relatively low, the space needed for the installation is very high. Lastly, solar energy is highly dependent on atmospheric conditions. For example, energy might not be available if there is a week-long storm and cloudy days may tend to provide a lower amount of solar energy than rainy days.

Utilizing solar-powered devices in agriculture farming promotes sustainability and environmental benefits by reducing increasing consumption of fossil fuels and other conventional energy sources. Its usage is beneficial to the environmental health as it decreases the amount of CO_2 emissions. Solar energy can be used in many agricultural works such as crop watering and drying, greenhouse heating, water pumping, photovoltaics electric supply and irrigation. The article has pointed out that using solar energy technology in agricultural farming is advantageous because it is less expensive with higher

yield than using electric, or oil-based conventional energy sources and they can be used in other aspects of daily life too. As technological innovation is expanding throughout the world, agricultural and environmental scientists emphasize on renewable sustainable agriculture. Due to their efforts, application of solar energy technologies is increasingly expanding throughout the world. Global research has firmly stated that unless agriculture is practiced in a sustainable way, there is the danger of losing vital resources in the near future. Therefore, it is important for mankind to prepare and take appropriate measures to save the future world, through the adoption of public policies, using sustainable innovative agricultural practices, operations and management of natural resources, by promoting to use alternative energy as solar energy in order to reduce the social and environmental impact. Utilizing solar technologies are sustainable, economical, efficient and easily available resources. Thus, it can be concluded that application of solar energy technology in agricultural farming will help to minimize global warming and is an important aspect for sustainable environmental management and development program.

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