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The Use of Solar Energy in the Development of Vegetable Cultivation in Iraq (article review)

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Abstract: The agricultural systems in Iraq face severe environmental and economic challenges with the most severe being water scarcity and price of conventional energy. Under this situation, the use of solar energy in agriculture is a massive potential of improving vegetable yields and reducing the impacts of environmental imprint hence contributing to food security in Iraq. Despite a few obstacles, such as research and technological advancement, the possibility of accelerating the process of application of this technology with the necessary form of government patronage is enormous. In 2020, a Journal of Cleaner Production study stated that in countries with highly adverse climates, solar energy and other clean technologies could help to increase the productivity of agriculture, and reduce environmental impact. Iraq is among such countries that are facing the problem of harsh climates, including water scarcity and increased price of conventional energy. In 2020, a Journal of Cleaner Production study stated that in countries with highly adverse climates, solar energy and other clean technologies could help to increase the productivity of agriculture, and reduce environmental impact. Iraq is among such countries that are facing the problem of harsh climates, including water scarcity and increased price of conventional energy. Therefore, solar is not only an opportunity to the environment, but also an economic one. The solution to the environmental crisis and economic crisis of the most important sphere of the agricultural industry, and in particular vegetable farming, is the solar energy. The use of solar energy in Iraq agricultural production is an important move on the way of sustainable agricultural development. When best practices are implemented, i.e. evaluating the need of energy, choosing the right solar panels, installing them, and operating these panels, and implementing solar energy to store and irrigate their farms, farmers can be more productive with the less conventional energy cost. These measures do not only increase the agricultural output but also preserve the environment and ensure food security in nations.

Key words: Solar energy, Sustainable agriculture, Water scarcity, Food security, Iraq

Introduction

Agriculture is one of the most active sectors that form the basis of the economy in Iraq. The average daily means of one of the high-solar-irradiance countries is 5.5 to 6.5 kW/m 2. Solar energy is an option and an appropriate alternative to ensure that the agricultural sector is sustainable and food security is achieved without necessarily fully depending on the traditional resources in order to generate quality crops. The use of solar power in vegetable production represents an effective solution to the issues related to costs and productivity. It has been an appropriate means to boost the performance of agriculture with lower costs of production and attaining agricultural sustainability in Iraq—specifically in vegetable production **(Mohammed and Khalid, 2022; Al-Hadithi *et al.*, 2023).** Secondly, food production on an extensive level is facilitated through agricultural activities and offers jobs to millions of workers. The industry is, however, plagued with numerous issues such as lack of water, increased temperatures, and the application of fossil fuel power, all of which will escalate the price of agricultural production. Integration has been necessary here to support increased productivity among farms with lower costs and high sustainability—particularly in vegetable produce. The agricultural power system in Iraq remains primarily reliant on fossil fuels, which inflates costs and widens environmental problems **(Zhang *et al.*, 2021).**

The Fundamentals of Solar Energy in Agriculture

The use of solar power can power pumps, illumination, and enable the operation of irrigation and air conditioning systems. The use of solar power reduces long-term costs because the maintenance costs of solar panels are relatively cheaper compared to other traditional sources of power. The use of solar power reduces dependence on traditional sources of power and aids the protection of the environment. Since the farmers are facing more and more problems with fewer sources of power and more costs of operations, the application of solar power has become an ideal solution to deliver electricity in an efficient and pollution-free way. Solar panel systems are used extensively to generate power to utilize the pump, irrigation system and lights in the farms. Consistent with the work of **El Chaar and Lamont (2011)**, tapping the sun to power agricultural systems not only obviates the use of fossil fuels, but also reduces operation costs in the long run. The most prevalent application of the use of solar power in agricultural production includes solar-powered irrigation systems that provide an alternative to fuel shortages and dependency on the power grid. **Calogero (2004)** states that irrigation systems utilizing the power of the sun have the capability to make water utilization more efficient, especially around water-scarce regions. Iraq, being among the water-scarce nations, would greatly benefit from these systems. Solar power is equally significant in driving agricultural refrigeration equipment used in the preservation of quality in the produce once the harvest has been realized, especially in cold storage units. **Duffy and Beckman (2013)** observe that the sun can power refrigeration and storage units that reduce losses following harvest and enhance produce quality. In Iraq, the state has begun adopting the use of the sun in agriculture by introducing initiatives to support food security and reduce the use of conventional sources of power. According to the Iraqi Ministry of Agriculture, there are several projects undertaken to provide subsidized solar power systems to the farmer population to promote the use of renewable power. In addition to its financial importance, solar power also reduces environmental impact by reducing carbon emissions—a reality more and more on everyone's mind with rising climate dynamics. Collectively, solar power offers efficient and sustainable options to Iraq's agricultural sector towards increased productivity and lower costs and conservation of nature, according to the International Energy Agency (IEA).

Advantages of Using Solar Energy in Vegetable Cultivation

Increased need for clean and green energy sources has made solar panels the solution of choice for power supply. Evidence demonstrates that using solar power in agriculture guarantees lower operating costs because after the initial installation of the solar panels, fossil fuels, which are a traditional source of energy, are replaced with a cheap and renewable supply **(El Chaar and Lamont, 2011).** According to a recent study, the use of solar energy in vegetable cultivation is able to reduce costs and increase crop quality up to 40% compared to fossil fuels **(Chen *et al.*, 2022).** Moreover, the maintenance of solar energy systems is cheaper than the outdated generators and this will save on long run money **(Duffie and Beckman, 2013).** Other than saving on costs, the other greatest advantage of solar power

is the enhancement of the efficiency of the irrigation systems. Photovoltaic systems operate high-efficient pumps to supply water to the plants accurately to meet its needs **(Kalogirou, 2004).** It has been found through empirical evidence that solar-powered irrigation systems can increase water use efficiency through 30 percent compared to traditional systems **(Jones and Ahmed, 2021).** This is particularly relevant in Iraq and other dry areas whereby the availability of water is becoming strained. As per the reports by Food and Agriculture Organization **(FAO, 2022)**, the use of solar-powered irrigation is able to increase the management of water resources and avert wastage to a level of 30 percent, not to even mention the decrease in carbon dioxide emission to 50 percent with respect to the conventional fuels. Solar power is thus a green and clean energy supply to be applied in vegetable farming **(Wang, 2021).** This move to green energy supplies is a vital move toward making the environment sustainable and achieving the world climate goals as the world continues to become more concerned with climate change **(FAO, 2022).** Research has also revealed that solar greenhouses offer optimal conditions in which plants grow hence encouraging the maximization of outputs **(Muller *et al.*, 2022).** One of the most visible agricultural uses of solar energy is greenhouses that can be equipped to operate heating and cooling units and allow vegetable cultivation during the entire year **(Duffie and Beckman, 2013).** Tactically, the solar power as a way of reducing dependence on the traditional power grids gives the farmers greater control on having a constant and sustainable power source regardless of the frequent unstable power supply. This aspect enhances the strength of agriculture in rural settings where there is a poor or lack of power infrastructures **(Ministry of Agriculture – Iraq, 2023).** Due to advancements in new agricultural technologies, it is now possible to combine solar power with smart irrigation management and artificial intelligence for measuring the needs of the crops and maximizing water and energy efficiency. This technological advancement enhances the efficiency of the farm and maximizes resource efficiency and therefore solar energy is a strategic choice to achieve food security **(FAO, 2022).**

Iraq's Climatic Challenges and Solar Energy Solutions

Just like the case of most of the other countries in the arid and semi-arid countries, Iraq also has significant climatic problems that are threatening its environmental sustainability. Climate change is also impacting the natural resources of Iraq like water resources and agricultural land adversely, along with rising temperatures that are unsustainable at certain periods of the year. In relation to this, solar energy is one of the alternatives that can address the above issues not only as clean energy but also as an adaptation measure for climate **(Iraqi Ministry of Environment, 2020)**. The main challenge Iraq is currently facing is the drastic increase in temperature at night. Summer temperatures exceeding 50°C in many areas put a tremendous amount of pressure on the nationwide network and result in power outages even in satellite or rural communities. This is complemented by a water shortage induced by diminished river inflows—particularly from the Tigris and the Euphrates—by upstream water management by the neighboring nations. Both rivers have very important functions for agriculture and source of water in Iraq. In addition, the low investments of the country in dam plants have intensified agriculture crises as well as national food insecurity **(FAO, 2018).** Desertification also increases in south and western parts of Iraq as one of the main characteristics of the crisis. Those regions are also devastated by improper cultivation and over exploitation of water. Along with that, industrial activities cause air pollution as a result of burning fuels, which further contributes to the intensification of the climate change by producing more greenhouse gases and raising global warming levels in the area. All these are a risky way of life to human health and the conservation of natural resources in Iraq **(Iraqi Ministry of Environment, 2020; World Health Organization [WHO], 2021)**. Under such circumstances, solar power stands out as a cost-effective and renewable option, not only to limiting the emissions and taking off the strain in the grid but also to enabling agriculture and climate reliability.

Solar Energy Solutions to Address Climate Challenges and Its Role in Sustainable Agriculture

With respect to the deplorable environmental issues as discussed above, solar energy is one of the best that Iraq ought to rely heavily on. The solar irradiance in Iraq is of high quality during the entire calendar year and thus, one of the best countries to produce solar energy. Solar energy, on the basis of renewable energy, can be harnessed for production of electricity in rural and city areas as well as in each agricultural region, easing the load from the national grid, which cannot keep up with the needs. Solar energy is also a great option for slowing down the consumption of fossil fuels, which have a major role

in causing environmental pollution and greenhouse gas emissions **(Iraq Energy Research Center, 2022)**. Solar energy can also be used for desalination of water in arid regions in order to provide drinking water and agricultural water at a lower expense than conventional technology. Solar-powered desalination facilities have been shown through research to be effective and economical, particularly in nations like Iraq that have a desperate demand for sustainable alternatives for tackling aspects of scarcity of water challenges **(Journal of Environmental Engineering Science, 2021)**. One of the most effective uses of solar energy in Iraq is that it aids crop production. Solar energy can be used in modern irrigation schemes that conserve more water than conventional schemes. With the available shortage of water in Iraq, the use of solar energy for irrigation of cultivable land will go a great way towards increasing the production of crops without placing further strain on the resources. It also aids in proper control of the water and minimizes consumption of the water. Iraq will hence increase food security and mitigate the effects of climatic change by embracing solar-powered farming. The shift to renewable energy is a strategic move towards the enhancement of a sustainable and resilient farming sector further.

Vegetables Crops Produced with Solar Energy Irrigation in Iraq

Iraqi farmers are seeing tremendous improvement in farm production of many varieties of vegetables under solar-powered farming. In the past, the technology was trending in the Nineveh Governorate, specifically the area around Rabia, where they have now started using solar-based farming technologies. The applications have enhanced productivity and reduced expenditure, with enhanced food supply security as a result. Tomato, cucumber, eggplant and pepper are among the vegetables that benefit the most from solar energy. Reducing operational costs is one of the major solar energy advantages in agriculture. Solar energy represents the optimal solution to increasing the productivity of agriculture as a renewable resource and one of the most readily available resources in Iraq, as Iraq has sunlight that covers almost the whole year. Further, solar energy also helps in improving the quality of vegetables in a wide range, as it does not deplete the soil as well as water resources and therefore helps in the long-term use of sustainable agriculture. Replacing conventional power sources with solar power can result to significant savings on production costs of farmers. Furthermore, this shift contributes to the preservation of the environment through the reduction of climate-altering, harmful emissions. Solar power in agriculture increases production efficiency and environmental sustainability but as a Renewable and **Sustainable Energy Reviews (2019) report explains**, an enormous amount of energy, approximately 20 per cent of global energy use, is necessary to sustain the farming systems already in place and productivity is predicted to increase by another 50–80 per cent globally by 2050. Cultivation of crops by solar technology creates new horizons for agriculture in Iraq. This technology is both the answer to the environmental question and an opportunity for a new ecosystem. **Research published in the Journal of Cleaner Production (2020)** found that solar power in agricultural systems improves the cost of production and living standard of agricultural regions **(Rakan *et al.*, 2020)**. Solar energies do not just generate renewables, but also an alternative solution to progressive sustainable agriculture and environmental delivery with minimum point of contact in a clean way. After conducting two reports in 2018, the Food and Agriculture Organization of the United Nations **(FAO, 2018)** concluded that in order to achieve the vision of development in Iraq sustainably, the potential of renewable energy needs to be exploited.

The project has had an impact on the population in Iraq

Using solar power on agricultural patterns in Iraq is considered a giant leap in improving the environmental and economic situation in Iraq. Through the use of this technology, agriculture can benefit from a qualitative leap by the fact that it has been suffering many problems. The facility of using solar energy will minimize the cost and quality & quantity of production as well as the life of the surrounding society of the people in positive way. Indeed, solar energy can improve agricultural efficiency and reduce business costs **(Siddiqui and Ahmad, 2019).** Thirdly, the effect of the project on society around us is double-sided. To begin with, the shift to renewable and clean energy is a big step toward environmental changes. It contributes to more reduction in the use of conventional dirty powers which leads to resources conservation and reduces the stress on the environment **(Mohammad and Othman, 2020).** Second, these projects will expand the number of jobs in agriculture. This will facilitate the reduction in the levels of overall unemployment in the rural society and the rise in the pise of kiar of economy. The effect on the economy is also enriching the economy at the local levels by the addition

of more agriculture and the creation of new markets of agricultural produce. The standard living of agrarian dependent populations will rise due to the productivity enhancement and costs reduction, **FAO (2018)** Further, the use of renewable energy for agricultural sector is among the sustainability of the development sector in agriculture. This will lower the production cost and raise the competitive ability of the Iraqi agricultural products in the foreign and home markets. Usually, it would be good for the national economy because it boosts the agricultural sector and creates new jobs.

Promoting Investment in Solar Energy

For all these purposes to be met, Iraq must boost investment in the solar energy sector in both private and public sectors. Incentives in terms of soft loans and tax holidays to investors play an important role in efficient implementation of such projects. In addition to this, cooperation with neighboring countries with vast experience in this field, such as the United Arab Emirates and Saudi Arabia, will ensure knowledge and technological transfer for achievement in such projects **(Food and Agriculture Organization of the United Nations [FAO 2018]; Iraq Energy Research Center, 2022).**

Recommendations for Farmers Interested in Using Solar Energy in Iraq

First: Accurately Assessing Needs

Farmers must closely monitor their energy demands because energy demands vary depending on land area as well as the type of plants being cultivated. Literature shows that establishing energy demands for irrigation pumps and storage units is an initial step before establishing solar energy projects. Therefore, close monitoring of land used in agriculture as well as in terms of water demands is essential in determining system size for solar **(Peh, 2020).**

Second: Utilizing Solar Energy for Irrigation and Water Storage

Solar energy is mostly applied in agriculture through irrigation systems. Solar pumps may be used to pump up waters in rivers or wells to supply crops with water. Research has established that solar energy application in agriculture leads to a high level of water-use efficiency and less expenditure on energy. Water storage can also be done using solar energy and this reduces the operation cost in the long run and also enhances the irrigation efficiency especially in the areas where water is limited **(Peh, 2020).**

Third: Integration with Modern Agricultural Technology

Solar energy along with the latest agricultural technologies, e.g. hydroponics or smart farming, can make the combination very efficient in terms of water and energy usage. This type of integration has been confirmed to be able to boost agricultural productivity in sustainable manner **(Mousa, 2021)**.

Cost and Economic Return of Greenhouse Projects Powered by Solar Energy

Survey on initial investment, monthly savings, and pay-off period was thus carried out. Initial investment encompasses the cost of storage, solar panels, and irrigation pumps. Findings are monthly savings up to 30% of initial investment and pay-off period to be 3-5 years based on the cost of a project. The cost of a single solar panel is on average 125,000 Iraqi dinars. Six solar panels are effective to supply 10-ampere power supply that is adequate to supply big fans and water pumps and for management of temperature and humidity for greenhouses. Nevertheless, supply of other electric devices necessitates an inverter which converts 24-volt direct current (DC) from solar panels to 220-volt alternating current (AC) to be used within operating needs. From company reports involved in installation of the system of solar energy, this system is low-cost to operate and maintain compared to conventional energy sources and hence its economic feasibility for the future period is better—specifically for areas where supply of electricity is constrained or consumption of fuel for use of the generators is high-cost.

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استخدام الطاقة الشمسية في تطوير زراعة الخضراوات في العراق (مقاله مرجعية)

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الخلاصة

تواجه الزراعية في العراق تحديات بيئية واقتصادية شديدة، أبرزها قلة المياه وارتفاع تكلفة الطاقة وان استخدام الطاقة الشمسية تعد وسيلة فعالة وامنة لزيادة الإنتاج الزراعي والحفاظ على البيئة (استدامة زراعية) وبالتالي تحقيق الأمن الغذائي في العراق. بالرغم من بعض التحديات ومنها استخدام التكنلوجيا الحديثة وزيادة الاهتمام بالأبحاث العلمية ونظم الذكاء الاصطناعي لزيادة تطوير الزراعية باستخدام الطاقة الشمسية وهذا الإمكانيات تحتاج الى الدعم الحكومي. وهناك العديد من الدراسات ومنها دراسة نشرتها مجلة Journal of Cleaner Production عام 2020، أُشير إلى أن الدول ذات المناخات المتغير يمكن أن تستفيد من الطاقة الشمسية لزيادة الإنتاج الزراعة وتقليل الأثر البيئي الضارة من استخدام الطاقة التقليدية. ويعد العراق من هذه الدول التي تواجه ظروفًا مناخية قاسية وكذلك قلة المياه وارتفاع تكلفة الطاقة. وان استخدام الطاقة الشمسية تعد فرصة بيئية واقتصادية في الوقت نفسه لأنها تمثل حلاً للأزمات البيئية والاقتصادية في زراعة الخضروات. ويعتبر استخدام الطاقة الشمسية في الإنتاج الزراعي العراقي خطوة مهمة نحو تحقيق التنمية الزراعية المستدامة النظيفة للبيئة. وعند البدء باستخدام الطاقة يجب مثل اختيار الألواح الشمسية المناسبة من حيث التركيب والتشغيل لاستخدامها في التخزين والري ويمكن للمزارعين زيادة إنتاجيتهم بتكلفة أقل من الطاقة التقليدية وكذلك الحفاظ على البيئة وضمان الأمن الغذائي للدول.

الكلمات المفتاحية: الطاقة الشمسية، الزراعة المستدامة، قلة المياه، الأمن الغذائي، العراق.