**International Journal of Sustainable Energy and Environmental Research**
*2021 Vol. 10, No. 1, pp. 17-28.*
*ISSN(e): 2306-6253*
*ISSN(p): 2312-5764*
*DOI: 10.18488/journal.13.2021.101.17.28*


# SOLAR POWERED AUTOMATED IRRIGATION SYSTEM IN RURAL AREA AND THEIR SOCIO ECONOMIC AND ENVIRONMENTAL IMPACT

**Muhammad Tamoor**[1+]
**Paris ZakaUllah**[2]
**Mehwish Mobeen**[3]
**Muhammad Ans Zaka**[4]

[1]*PhD Scholar, Department of Electrical Engineering, GC University Faisalabad, Pakistan.*
[1]*Email: tamoor_uog@yahoo.com Tel: +92-344-4644644*
[2,3]*Department of Sociology, GC University, Faisalabad, Pakistan.*
[2]*Email: paris.zaka@yahoo.com Tel: +92-335-0500236*
[3]*Email: mehwishmobeen456@gmail.com Tel: +92-312-4644644*
[4]*MS Environmental Engineering (Scholar), University of Agriculture, Faisalabad, Pakistan.*
[4]*Email: ans.zaka443@gmail.com Tel: +92-308-7000791*


*(+ Corresponding author)*

**Article History**
Received: 19 October 2020
Revised: 4 January 2021
Accepted: 26 January 2021
Published: 15 February 2021

**Keywords**
Solar system
Variable frequency drive
Conventional energy
Energy saving
Drip irrigation system
Environmental impact
Social status.

## *ABSTRACT*

One of the most important solutions for the climate change crisis is the development of renewable energy sources like photovoltaic energy. This study is conducted to explore the socio economic and environmental impact of using solar powered automated drip irrigation system on drip owners of Faisalabad division. Drip irrigation technology takes into account innovations in the agricultural sector and their acceptance on behalf of farmers due to various factors of its particular adjustment goes back to social, economic and climatic conditions. Solar powered drip irrigation system is a micro irrigation system that saves water ($H_2O$) and nutrients by allowing water to slowly drip to the roots of plants and minimize water evaporation by using indigenous resources like photovoltaic energy. This study focused on powered automated drip irrigation methods that have a significant impact on resource savings like saving in energy, labour cost and less use of water, improve crop yields and farmer profit that help to improve life of the rural areas. A sample of 48 respondents was selected conveniently from the Faisalabad division. Respondents were solar drip adopter. Descriptive and inferential statistical techniques were applied for data analysis to check the impact of solar drip irrigation on farmer. It was found that majority of solar drip owners are highly agreed to have change in their social status and self-reliance that are 39.58% and 72.92%. Using solar drip systems 79.17% farmers improve their product quality. This indicates that most solar drip owners have high socio-economic and environmental impact.

**Contribution/Originality:** The study explained the designing procedure of PV system for 7.460 kW electric motor installed at automated drip irrigation system. To design PV system, PV array factor of 1.35 is used. Descriptive and inferential statistical techniques were applied for data analysis to check the impact of solar powered automated drip irrigation.

## 1. INTRODUCTION

Energy plays a very important role in the progress of a country and must be conserved in the most effective way. Energy produced from different fuels in the most environmentally friendly way and effectively conserved. The use of renewable energy technologies has grown steadily to meet demand. However, renewable energy systems have some disadvantages, such as poor reliability and lean nature. More than 60% of total population lives in rural areas far from the national grid. Installation and distribution costs of energy in rural areas are much higher. As the demand for energy increases, we need to develop non- conventional methods for energy generation.

In 2013, 13.49% of the world's total primary energy produce from renewable sources, including PV, wind and hydropower. The transition to renewable resources has socio, economic and environmental benefits for developing countries. Countries that depend on agriculture like Pakistan need adequate and sustainable water resources to support crop yields and productivity. Farmers in Pakistan rely on conventional techniques, such as diesel or electric pumps for irrigation, which is expensive to maintain and environmentally harmful (World Energy Outlook, 2013).

In the historical period, water is an important factor in the development of lifestyle, technology and culture. In today's world, an indicator of the multilateral development of society is the existence of water. The management of this resource is one of the most important challenges for the government to provide food for growing population. The amount of water available on earth is numerous, but 96.40% of the total water is salt and not suitable for human consumption and agricultural proposals. It is also known that almost 89.0 percent of the water obtained from tube-well is used for agriculture, and the water needed to grow agricultural products is supplied using various irrigation techniques (Karami & Rezaei, 2002).

One of the biggest obstacles to agricultural progress and rural development of the country is shortage of water. Best use of the water is to increase number of agricultural products that make up a large proportion of food is considered an important task (van Rooyen, Ramshaw, Moyo, Stirzaker, & Bjornlund, 2017). The reason is that the new irrigation techniques (Solar Drip Irrigation, Sprinkler) prevents irregular waste of water and to certain extent solves the issue of water shortage. Drip irrigation is considered an agricultural innovation and must be well adapted to local, regional and technical conditions accepted by the farmer. Regarding the importance of increasing the daily use of water in Iranian agriculture, in recent years the government has made extensive investments and credits for stagnant water such as drip irrigation (Popzan, 2007).

The World Bank predicts that by 2035 0.003 billion people will be living in difficult environments due to shortage of water (Foster, 2020). In general, farmers look for irrigation methods that are most effective, with less water, labor, fertilizer and power requirements. Among the irrigation methods, solar drip irrigation systems are advanced irrigation methods to overcome various water losses problems, as well as other issues such as labour and power requirements. This method is quickly gaining importance in areas where water is scarce and high-quality crops are grown. Solar drip irrigation systems are efficient and effective technique of supplying water directly to root zone of the plant. Several studies have shown that solar drip irrigation can save around 50% to 86% of the available water (Reilly, 2004).

Recognizing the reputation of efficiency of sustainable water utilization in the agricultural sector, many demand management strategies are introduced since the late 1970s to improve the efficiency of water utilization, especially when using surface irrigation water. One of the demand management mechanisms is the use of micro-irrigation techniques like drip and sprinkler method. Data show that efficiency of water utilization has increased up-to 99% in a well-designed drip irrigation system (INCID (Indian National Committee on Irrigation and Drainage), 2014; Sivanappan, 1994).

Drip irrigation methods support to save irrigated water ($H_2O$), improve efficiency of water utilization, reduce required tillage, improve product quality, increase crop yield as well as improve the efficiency of fertilizer use (Namara, Upadhyay, & Nagar, 2005; Qureshi, Wegener, Bristow, & Harrison, 2001; Sivanappan., 2002).

Although the potential benefits of drip irrigation techniques are clear, the use of drip irrigation has not been widely promoted in different regions. The study found that the optimal policy environment for promoting micro drip irrigation system in well-irrigated area is prorate pricing of electricity, that create direct incentive for the efficient utilization of water (Kumar, 2005).

Evidence suggests that numerous researchers are tried to study the impact of micro drip irrigation system (Verma, Tsephal, & Jose, 2004) and their research show that micro-drip irrigation system produced the desired positive impact. Drip irrigation technology is proven to be technically and economically feasible, especially when agriculturalists rely on ground-water (Dhawan, 2000).

Drip irrigation is a combination of water saving and increase in crop yield increase, making it a important technology for the global challenge of crop production (Postel, 1999).

Majority of greenhouse gas emissions are caused by the use of fossil fuels. Despite high emissions, rising prices and limited resources, fossil fuels still provide for 82-86% of the world's energy, with only 14-18% using renewable sources. In long term concern is that fossil fuels are not sustainable: they will run out or be difficult to obtain due to limited resources. In the medium term, mine pollution, refining and consumption of these fuel is a global concern. This provides a theoretical basis for exploring the viability of solar energy for agriculture in Pakistan, the typical irrigation systems use large amounts of conventional energy. A photovoltaic pumping system is a suitable alternative because it supplies electricity to off-grid areas, allowing farmers to diversify their crops, increasing crop yields, enabling more efficient water use and promoting socio-economic development (Shinde & Wandre, 2015).

The use of solar pumps in rural areas of Bangladesh, where low operating and maintenance costs, ease of installation and a long service life make solar technology increasingly popular. The authors used the NPV (net present value) and the IRR (internal rate of return) of solar pump system to demonstrate its feasibility (Roy, Islam, Hasan, & Hoque, 2015).

Analysis of the viability of solar drip irrigation pump in India, where agriculturalists use PV energy to run the existing submersible and diesel pumps. He concluded that these solar systems are integrated with drip irrigation system, which help to save water, increase crop yields, and reduce expenditure on fertilizer and other agricultural inputs. Overall, the increase in productivity leads to increase in farmer net incomes (Honrao, 2015).

We are convinced that switching to a solar powered drip irrigation system will not only ensure reliable water supply, but also reduce irrigation costs and contribute to the energy needs for the agricultural sector without harming the environment. The main objective of this research is to know the socio economic and environmental impacts of solar drip irrigation system on solar drip adopter.

## 2. SOLAR DRIP IRRIGATION SYSTEM COMPONENTS

Here we discuss the components of solar drip irrigation system.

### *2.1. Drip Irrigation System*

The first and important step is to design the drip irrigation system, as only the number and type of plants in the field are known at the start of the design process. The irrigation system is designed based on the pressurized water requirement of the crop.

In order to design a drip irrigation system, it is important/significant to gather data about plants on agri land to determine total water demand (Kelley, Gilbertson, Sheikh, Eppinger, & Dubowsky, 2010). In order to prevent the effects of sunlight evaporation, irrigation should be carried out in the early morning (Barlow, Christy, O'leary, Riffkin, & Nuttall, 2015).

A common misconception when planning an irrigation system is that the roots of the crop grow toward water. The roots don't grow in dry soil. Plants need a large area of water so that the roots can spread and provide a solid base. There must be enough drip nozzles or emitters around the mature plant, so 45.0% to 80.0% of the canopy area must be wet (Fortier & Belt, 2019).

The number of drippers can be set based on the water requirement of each plant type. The dripper used on different sites were adjustable and adjusted to deliver the water at the flow rate of 6 LPH to 16 LPH. Therefore, Equation 1 are used to determine the number of drippers and hours of irrigation in one day.

$$Nd = \frac{V}{t \ x \ Qd} \qquad (i)$$

where

$N_d$: Number of Dripper required for each plant.

$Q_d$: Dripper flow rate (LPH).

V: Amount of Water (liters) that a Plant required.

t: Irrigation Duration (hours).

### *2.1.1. Motor and Pump*

When the experimental values of current(I)/voltage(v) or equation of the motor is known, it is easier to obtain the I-V graph. It helps to show the operating point of the system for different irradiation and ambient temperature levels.

On the selected solar drip irrigation sites, Lorentz, Hydromech, Shakti and Franklin submersible and centrifugal solar pumps are used, operate on three phase AC power as shown in Figure 1. The most important reason for choosing these pumps is that it is highly efficient and have capacity to provide water for the particular agricultural field according to crop requirement and drip design.

The power of the motor is calculated by using Equation ii.

$$Motor\ Power\ (HP) = \frac{Operating\ Discharge\ of\ Pump\ x\ Operating\ Head}{Pump\ Set\ Efficiency\ x\ 745.7\ x\ 9.8} x\ 100 \qquad (ii)$$

### *2.1.2. Filtration System*

Filtration system remove fine suspended material from water. Typical types of filters are screen filter and graded sand filter as shown in Figure 1.

### *2.1.3. Venturi*

Venturi or fertilizer tank gradually add a measured quantity of fertilizer to the water during irrigation as shown in Figure 1. This is the major benefits of drip irrigation system over many other irrigation systems.

### *2.1.4. Control Valves*

Control valve help to control pressure and discharge of water in the drip irrigation system as shown in Figure 1.

### *2.1.5. Mainline, Sub-Mains and Laterals*

Main line, sub-main lines and laterals (LDPE) supply water from the head unit of drip system to the agriculture fields. They are usually made of PE or PVC hose. Lateral generally have a diameter of 12.0-30.0 mm.

**Figure-1.** Drip System Head Unit.

### *2.2. Solar System*

#### *2.2.1. PV Array*

Solar (PV) panel absorb sun light as an energy source to produce power in the form of direct current (DC). solar cells connected in assembly to form PV modules as shown in Figure 2. PV modules in different wattages (15 to 365 watt) available in market. PV modules connected in series or parallel as shown in figure to form a PV Array that produce and supply power in residential and commercial applications. When connected in series, the voltage (V) increases, whereas in parallel connection, the current (I) increases. However, these connections can be combined in a single circuit (in series and parallel). Most common application of PV system solar pumping in agriculture sector.

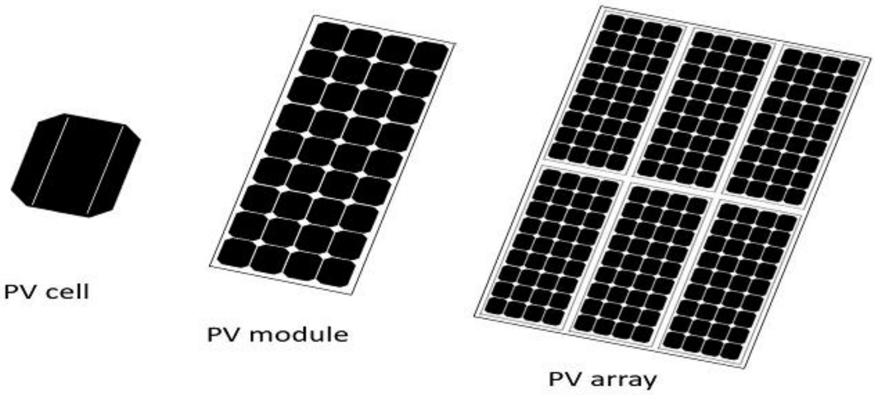


**Figure-2.** Photovoltaic (PV) Modules.

**Source:** Modified from www.samlexsolar.com

These properties were determined under standard test conditions (STC) at a cell temperature of 25.0 °C, an irradiance of 1000.0 W / $m^2$, and air mas of 1.50 spectrum (Sinovoltaics, 2016).

The size of the water pump installed on all selected sites is 7.460 kW (10 HP) as shown in Figure 3. To design PV system for 7.460 kW motor, PV array factor of 1.35 is used.

**Table-1.** PV Array Sizing.

| Motor Capacity (kW) | PV Array Design Factor | PV Array Size (kW) |
|---|---|---|
| 7.460 | 1.35 | 10.07 |
| No. of PV Modules | Number of String | VFD Size |
| 32.0 (315 Watt) | 2 | 11KW |

**Figure-3.** Installed PV System on Site.

### *2.2.2. Variable Frequency Drive*

A variable frequency drive (VFD) is a motor controller. VFD drive the motor by varying the voltage (V) and frequency (Hz) supplied to the motor as shown in Figure 4. The frequency is directly link to the RPM of the motor means higher frequency, higher RPM. If motor is not needed to run at full speed, the variable frequency drive is used to reduce the voltage (V) and frequency (Hz) to meet requirements of the motor load. In other words, as motor speed changes is needed, the VFD can simply increase or decrease the motor speed (RPM) (David & Scott, 2007).

**Figure-4.** Variable frequency drive.

## 3. METHODS

The study was conducted in Faisalabad division of Punjab province. Faisalabad division consist of four districts (Faisalabad, Toba Take Singh, Jhang and Chiniot). A total of twelve respondents from each district were selected by convenient sampling techniques, making a sample size of 48 respondents. Respondents were solar drip irrigation method adopter. The data was collected by personal interview from the selected solar drip owners through carefully constructed and pre-tested interview schedule. Three main indicators used in the survey are social impact, economic impact and environmental impact. Social impact includes change in social status, change in self reliance and improving quality of product. Economic impact includes saving in energy cost, saving in labour cost and increase in crop yield. Environmental impact includes saving of water and less use of fertilizer.

The before and after approach was followed for getting the information about the aspects selected for study. The scoring was followed for each aspect. The solar drop owner classification is achieved by dividing the number of categories in the context by the minimum and maximum observation range. To obtain overall socio economic and environmental impact, the score obtained by each aspect by an individual were summed up. The score of each aspect was added to get the socio economic and environmental impact score.

## 4. RESULTS AND DISCUSSION

### *4.1. Social Impact*

Information about change in social status after using solar drip irrigation system (is shown Table 2).

**Table-2.** Change in social status after using solar drip irrigation system.

| Serial No. | Change in Social Status (%) | Frequency | Percentage (%) |
|---|---|---|---|
| 1 | 0 – 25% | 6 | 12.50 |
| 2 | 26 – 50% | 13 | 27.09 |
| 3 | 51 – 75% | 10 | 20.83 |
| 4 | 76 – 100% | 19 | 39.58 |
| Total | | 48 | 100% |

The data in Table 2 show that by using the solar drip irrigation system, the 39.58% of respondents have their social status between 76 – 100%, followed by 27.09% of solar drip owners between 26 – 50% and 20.83% of solar drip owners between 51 – 75%. While 12.50% of solar drip owners have their social status between 0 – 25%. This indicates that the social status of the respondents improves after using solar drip irrigation system.

Information about change in self- reliance after using solar drip irrigation system (is shown Table 3).

**Table-3.** Change in self- reliance after using solar drip irrigation system.

| Serial No. | Change in Self- Reliance (%) | Frequency | Percentage (%) |
|---|---|---|---|
| 1 | 0 – 25% | 1 | 2.08 |
| 2 | 26 – 50% | 4 | 8.33 |
| 3 | 51 – 75% | 8 | 16.67 |
| 4 | 76 – 100% | 35 | 72.92 |
| Total | | 48 | 100% |

The data in Table 3 show that Majority of solar drip owners 72.92% have their self-reliance in range of 76 – 100% followed by 16.67% of solar drip owners in range of 51 – 75% and 8.33% in range of 26 – 50%. Majority of the respondents were highly satisfied by adopting solar drip irrigation system.

Information about improvement in product quality as compared to conventional irrigated product after using solar drip irrigation system (is shown Table 4).

**Table-4.** Improvement in product quality as compared to conventional irrigated product.

| | Frequency | Percentage (%) |
|---|---|---|
| Improved | 38 | 79.17 |
| Not Improved | 10 | 20.83 |
| Total | 48 | 100% |

As shown in Table 4, majority 79.17% of solar drip owners improve their product quality after using the solar drip irrigation system, but 20.83% of solar drip owners responded that their production quality didn't improve as compared to conventional irrigation system. The results show that most of respondents agreed that their products quality improve after using solar drip system.

### *4.2. Economy*

Information about energy cost in conventional irrigation system and solar drip irrigation system (is shown Table 5).

**Table-5.** Energy Cost (PKR).

| Energy Cost (PKR) | Conventional Irrigation System | | Solar Drip Irrigation System | |
|---|---|---|---|---|
| | Frequency | Percentage (%) | Frequency | Percentage (%) |
| 1 to 4000 | 2 | 4.16 | 40 | 83.33 |
| 4001 to 10000 | 27 | 56.25 | 8 | 16.67 |
| 10001 to 20000 | 19 | 39.59 | 0 | 0.00 |
| Total | 48 | 100% | 150 | 100.00 |

The data in Table 5 shows that by using conventional irrigation system, the 56.25% of farmer spend money for electricity between 4001 to 10000 Rupees followed by 39.59% of farmer spend money in between 10001 to 20000 Rupees for electricity bills or diesel fuel. After using solar drip irrigation system, the 83.33% of solar drip owners spend money for electricity charges in between 1 to 4000 Rupees followed by 16.67% of solar drip owners spend money between 4001 to 10000 Rupees. The results show that by adopting solar drip-irrigation method decrease the energy cost of farmer like electricity bill or fuel bills.

Information about labour cost in conventional irrigation system and solar drip irrigation system (is shown Table 6).

**Table-6.** Labour Cost (PKR).

| Labour Cost (PKR) | Conventional Irrigation System | | Solar Drip Irrigation System | |
|---|---|---|---|---|
| | Frequency | Percentage (%) | Frequency | Percentage (%) |
| 1 to 4000 | 0 | 0.00 | 5 | 10.42 |
| 4001 to 10000 | 22 | 45.83 | 33 | 68.75 |
| 10001 to 20000 | 26 | 54.17 | 10 | 20.83 |
| Total | 48 | 100% | 48 | 100% |

The data in Table 6 show that by using conventional irrigation system, the 54.17% of farmers spend money for labours between 10001 to 20000 Rupees followed by 45.83% of farmer spend money in between range of 4001 to 10000 Rupees for labour purpose. After using solar drip irrigation system, the 68.75% of solar drip owners spend money for labourers in between 4001 to 10000 Rupees followed by 20.83% of solar drip owners spend money between 10001 to 20000 Rupees. While 10.42% of solar drip owners spend money between 1 to 4000 Rupees in labour cost. Results indicate that this system is helpful in reducing labour cost.

Information about increase in crop yield by using solar drip irrigation system (is shown Table 7).

**Table-7.** Increase in Crop Production.

| Sr. No. | Increase in Crop Production (%) | Frequency | Percentage (%) |
|---|---|---|---|
| 1 | Up to 30% | 15 | 31.25 |
| 2 | 31 to 60% | 26 | 54.16 |
| 3 | Above 60% | 7 | 14.59 |
| Total | | 150 | 100.00 |

The data in Table 7 shows that majority of solar drip owners 54.16% increased their crop yield between 31 to 60 % followed by 31.25% of solar drip owners increased their crop yield up to 30%. While, 14.59% of solar drip owners increase their crop yield above 60%. It indicates that solar drip irrigation system increase crop yield.

### *4.3. Environmental Impact*

Information about saving of water by using conventional irrigation system and solar drip irrigation system (is shown Table 8).

**Table-8.** Saving of Water.

| Saving of Water (%) | Conventional Irrigation System | | Solar Drip Irrigation System | |
|---|---|---|---|---|
| | Frequency | Percentage (%) | Frequency | Percentage (%) |
| Up to 30 % | 21 | 43.75 | 1 | 2.08 |
| 31 to 60 % | 16 | 33.33 | 11 | 22.92 |
| 61 to 90 % | 9 | 18.75 | 32 | 66.67 |
| Above 90 % | 2 | 2.67 | 4 | 8.33 |
| Total | 48 | 100% | 48 | 100.00 |

The data in Table 8 shows that by conventional irrigation system, the 43.75% of farmers saves upto 30% of irrigation water followed by 33.33% of farmers save between 31-60%%. The 18.75% of farmers save irrigation water between 61-90% and 2.67% of the farmers save irrigation water above 90%. After using solar drip irrigation system, 66.67% of solar drip owners save 61-90% of irrigation water followed by 22.92% of solar drip owners save irrigation water between 31-60%. While, 2.08% solar drip owners save irrigation water up to 30% and 8.33% of the solar drip owners save irrigation water above 90%. Solar drip irrigation system is an effective method of irrigation that helps in to save water.

Information about less use of fertilizer in conventional irrigation system solar drip irrigation is shown in Table 9.

**Table-9.** Less Use of Fertilizer

| Less Use Fertilizer (kg) | Conventional Irrigation System | | Solar Drip Irrigation System | |
|---|---|---|---|---|
| | Frequency | Percentage (%) | Frequency | Percentage (%) |
| 1-10 | 0.0 | 0.0 | 29 | 60.42 |
| 11-20 | 2 | 4.17 | 10 | 20.83 |
| 21-30 | 7 | 14.58 | 8 | 16.67 |
| 31-40 | 39 | 81.25 | 1 | 2.08 |
| Total | 48 | 100% | 48 | 100% |

The data in Table 9 shows that by using of conventional irrigation system, the 81.25% of farmers use 31-40 kg of fertilizers followed by 14.58% of farmers use 21-30 kg of fertilizer. After using of solar drip irrigation system, the 60.42% of solar drip owners use 1-10 kg of fertilizers followed by 20.83% of solar drip owner use between 11-20 kg. While 16.67% of Solar drip owners use 21-30 kg and 2.08% of drip owners use 31-40 kg of fertilizers. It improves the efficiency of fertilizer used. Less amount of chemical fertilizer used in the agriculture sector beneficial for environment and health.

### *4.4. Discussion*

It can be concluded that majority of solar drip owners had their social status and self-reliance are in range of 76-100%. It is clear that most 79.17% farmers improve their product quality after using solar drip irrigation systems. Studies have shown that solar drip irrigation can achieve high economic returns and profitability. It lowers the cost of fertilizer and other agricultural inputs. The increase in productivity has led to an increase in the farmer net income. It is evident that by using conventional irrigation system, 56.25% of farmers spend money for electricity between 4001 to 10000 followed by 39.59% of farmer spend money in between 10001 to 20000. After using solar drip system, 83.33% of farmers spend money for electricity charges in between 1 to 4000 followed by 16.67% of farmer spend money in between 4001 to 10000 Rupees. Results shows that in conventional irrigation method majority of respondents 54.17% spend money for labours between 10001 to 20000 (PKR) and after using solar drip irrigation system the majority 68.75% of solar drip owner spend money between 4001 to 10000 (PKR). Agricultural experts urge the growers to use the latest technologies, including solar drip irrigation method to increase crop productivity by 30.0 to 100.0 % in addition to saving in electricity, water, fertilizers and reducing labour cost and other expenditures (Kulecho & Weatherhead, 2005).

The data shows that after using solar drip system majority of system owners 54.16% increased crop yield between 31 to 60 %. Drip irrigation is a combination of water ($H_2O$) savings and increase in crop yield make it a chief technology for the global challenge of crop production (Postel, 1999). It is observed that by using conventional irrigation system, majority of farmers save up to 30% of irrigation water but after using solar drip irrigation, most of farmers save 61 to 90% irrigation water. Several studies have shown that solar drip irrigation can save around 50% to 86% of the available water. Solar drip irrigation system is efficient and effective technique of supplying water directly to root of the plant and help in to save irrigation water, improve efficiency of water utilization (Reilly, 2004). The results indicated that before using solar drip irrigation system, majority of farmers huge amount fertilizers than the farmers that used solar drip irrigation system. Drip irrigation methods support to save irrigated water ($H_2O$), improve efficiency of water utilization, reduce required tillage, improve product quality, increase crop yield as well as improve the efficiency of fertilizer use (Namara et al., 2005; Qureshi et al., 2001; Sivanappan., 2002). Overall most solar drip owners have a high socio-economic and environmental impact.

## 5. CONCLUSION

A recent study showed that the available supply of water is more than 1000.0 cubic meters per person which put Pakistan in the category of high stress county. According to statistics from the Planning and Development Department of the Federal Government of Pakistan, the total water availability has decreased from 298.0 $m^3$ per capita in 1996-97 to 101.0 $m^3$ per capita in 2004-05. The situation is likely to get worse, in view of the growing population, urbanization and increasing industrialization, Therefore, shortage of water is one of the biggest obstacles to agricultural progress and rural development in Pakistan. Irrigation water is known to be the most critical factor in crop production and its effective use can increase productivity Farmers have faced severe water shortages for many years, resulting in a significant reduction in agricultural productivity.

Solar drip irrigation systems have proven to be an effective and most suitable option for solving various crop production problems. Solar drip irrigation systems have significant socio-economic and environmental impacts. The adoption of this solar drip system can improve the social and economic status of the farmer. Solar drip method of irrigation improves the product quality, reduces labour expenditure, energy and other agriculture inputs and increases the efficiency of fertilizers used. It is also found that solar drip irrigation system allowing farmer diversify their crops, increase crops yields and achieve more efficient use of water. Overall, all this increased the productivity that leads to the socio economic development of farmer.

**Abbreviations**

PV Photovoltaic.

DC Direct Durrent.

AC Alternating Current.

VFD Variable Frequency Drive.

**Funding:** This study received no specific financial support.
**Competing Interests:** The authors declare that they have no competing interests.
**Acknowledgement:** All authors contributed equally to the conception and design of the study.

## REFERENCES

Barlow, K., Christy, B., O'leary, G., Riffkin, P., & Nuttall, J. (2015). Simulating the impact of extreme heat and frost events on wheat crop production: A review. *Field Crops Research*, *171*, 109-119.Available at: https://doi.org/10.1016/j.fcr.2014.11.010.

David, M. B., & Scott, K. (2007). NEMA application guide for AC adjustable speed drive systems. Retrieved from https://www.industry.usa.siemens.com/drives/us/en/electric-motor/anema-motors/specification/Documents/nema-application-guide.pdf.

Dhawan, B. (2000). Drip irrigation: Evaluating returns. *Economic and Political Weekly*, *35*(42), 3775-3780.

Fortier, J. H., & Belt, J. M. (2019). Tree irrigation: Water where roots need it. Retrieved from http://landscapeonline.com/research/article/9308.

Foster, S. (2020). Global policy overview of groundwater in urban development—a tale of 10 Cities! *Water*, *12*(2), 456.Available at: https://doi.org/10.3390/w12020456.

Honrao, P. (2015). Economic Viability of solar irrigation pumps for sustainable agriculture in Maharashtra:-Adoption response by farmers. *Global Journal for Research Analysis*, *4*(8), 43-47.

INCID (Indian National Committee on Irrigation and Drainage). (2014). Drip irrigation in India, New Delhi. Retrieved from https://icid.org/.

Karami, A., & Rezaei, M. K. (2002). The use of sprinkler irrigation: Issues and problems. *Journal of Agricultural Economics and Development*, *10*(37), 221-245.

Kelley, L. C., Gilbertson, E., Sheikh, A., Eppinger, S. D., & Dubowsky, S. (2010). On the feasibility of solar-powered irrigation. *Renewable and Sustainable Energy Reviews*, *14*(9), 2669-2682.

Kulecho, I., & Weatherhead, E. (2005). Reasons for smallholder farmers discontinuing with low-cost micro-irrigation: A case study from Kenya. *Irrigation and Drainage Systems*, *19*(2), 179-188.Available at: https://doi.org/10.1007/s10795-005-4419-6.

Kumar, M. D. (2005). Impact of electricity prices and volumetric water allocation on energy and groundwater demand management: Analysis from Western India. *Energy Policy*, *33*(1), 39-51.Available at: https://doi.org/10.1016/s0301-4215(03)00196-4.

Namara, Upadhyay, & Nagar, R. K. (2005). *Adoption and impacts of microirrigation technologies: Empirical results from selected localities of Maharashtra and Gujarat States of India* (Vol. 93): International Water Management Institute. Retrieved from: https://www.iwmi.cgiar.org/Publications.

Popzan, A. (2007). Economics and development of agriculture. *Periodical*, *58*(1), 151-176.

Postel, S. (1999). *Pillar of sand: Can the irrigation miracle last*. New York: WW Norton & Company.

Qureshi, M. E., Wegener, M. K., Bristow, K. L., & Harrison, S. R. (2001). Economic evaluation of alternative irrigation systems for sugarcane in the Burdekin delta in North Queensland, Australia (pp. 47-57): Water Resource Management, WIT Press. Retrived from: https://www.academia.edu/19617031/Economic_evaluation_of_alternative_irrigation_systems_for_sugarcane_in_the_Burdekin_delta_in_north_Queensland_Australia.

Reilly, J. (2004). Drip irrigation: A water conserving solution. Irrigation and green industries. The business magazine for landscape irrigation and maintenance contract. Retrived from: http://igin.com/article-218-drip-irrigationa-waterconserving-solution.html.

Roy, A., Islam, W., Hasan, S., & Hoque, S. N. (2015). Prospect of solar pumping in the northern area of Bangladesh. *American Journal of Renewable and Sustainable Energy*, *1*(4), 172-179.

Shinde, V., & Wandre, S. (2015). Solar photovoltaic water pumping system for irrigation: A review. *African Journal of Agricultural Research*, *10*(22), 2267-2273.Available at: https://doi.org/10.5897/ajar2015.9879.

Sinovoltaics. (2016). Standard test conditions (STC): Definition and problems. Retrieved from http://sinovoltaics.com/learning-center/quality/standard-testconditions-stc-definition-andproblems/

Sivanappan, R. (1994). Prospects of micro-irrigation in India. *Irrigation and Drainage Systems*, *8*(1), 49-58.Available at: https://doi.org/10.1007/bf00880798.

Sivanappan., R. K. (2002). *Strengths and weaknesses of growth of drip irrigation in India*. Paper presented at the Proceedings of the GOI Short Term Training on Micro Irrigation for Sustainable Agriculture.

van Rooyen, A. F., Ramshaw, P., Moyo, M., Stirzaker, R., & Bjornlund, H. (2017). Theory and application of agricultural innovation platforms for improved irrigation scheme management in Southern Africa. *International Journal of Water Resources Development*, *33*(5), 804-823.Available at: https://doi.org/10.1080/07900627.2017.1321530.

Verma, S., Tsephal, S., & Jose, T. (2004). Pepsee systems: Grassroots innovation under groundwater stress. *Water Policy*, *6*(4), 303-318.Available at: https://doi.org/10.2166/wp.2004.0020.

World Energy Outlook. (2013). *International energy agency*. France: IEA.