Turkish Journal of Agricultural Engineering Research

https://dergipark.org.tr/en/pub/turkager
https://doi.org/10.46592/turkager.1272864

Turk J Agr Eng Res
(TURKAGER)

ISSN: 2717-8420
2023, 4(1), 73-90

Research Article

Performance and Cost Comparison of Photovoltaic and Diesel Pumping Systems: In Central Rift Valley of Ethiopia

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Article Info

Received: 29.03.2022 **Accepted:** 29.05.2023 **Published:** 30.06.2023

ABSTRACT

Diesel pumps have extensively used for irrigation water pumping. However, this causes challenges both in terms of economic factors (fuel costs) and environmental impacts (emits air pollution). An alternative solution is using renewable energy sources. In this regard, a battery less solar PV energy system was designed and evaluated was designed and evaluated for the geographic location and metrological data of Dugda woreda, representing the central rift valley of Ethiopia. Performance testing were conducted on sunny days of April month and with time intervals of from 9:00 am to 5:00 pm, again the respective solar radiation ranges between 385.8 to 862.2 $W\,m^{-2}\ h^{-1}$*. The solar photovoltaic pumping has been evaluated with the head levels of 10, 12, 15, and 18 m. Accordingly the result showed that, PV system size can irrigate a tomato field of 0.33-0.75 ha with a mean daily water use of 8.7 and 17.4* $m^3\ day^{-1}$ *at head levels of 10 and 18 meters, respectively. After evaluation, the maximum water flow rate has been at the midday day from 12:00 am to 1:00 pm. Comparative economic evaluation of the solar-powered water pump system and diesel pump devices were done using cycle cost breakdown and the cost of water per unit volume. Thus the long term economics of water pumping using solar photovoltaic and diesel pumping systems showed a cost of 1.33* $ETB\,m^{-3}$ *and 3* $ETB\,m^{-3}$*, respectively. The result demonstrated that photovoltaic water pump systems are more affordable for the long-term services of small to medium-scale farms than gasoline water pumps.*

Keywords: *Photovoltaic, Solar radiation, Pumps, Life cycle cost*

To cite: Desta MA, Tiba GS, Issa MM and Heyi W (2023). Performance and Cost Comparison of Photovoltaic and Diesel Pumping Systems: In Central Rift Valley of Ethiopia *Turkish Journal of Agricultural Engineering Research (TURKAGER), 4(1), 73-90.* https://doi.org/10.46592/turkager.1272864

INTRODUCTION

Energy is a fundamental and essential desire of human life. It is one of the most valuable inputs in agricultural production. More than one quarter of the energy used globally is expended on food production and supply. Energy can be generated from renewable and non-renewable sources. The conventional fossil fuels cannot sustain any more in the near future because of environmental impacts and depletion of the reserves. On the other hand energy generated from renewable sources is an alternative way for sustainable, feasible and pollution free uses.

Ethiopia is endowed with many rivers and all year round abundant sunlight due to its geographical location in equator. According to recent survey, Ethiopia's annual solar potential is estimated to be over 2 trillion MW hours (Zegeye *et al.*, 2014). The potential irrigable land of the basin is only 2.64%; and the gross hydro-electric potential of the basin is found to be 800 GWh/year. The water resources of the basin have enough potential for irrigation, hydropower and domestic water supply (Hulluka *et al.*, 2023).

Because Ethiopia does not produce oil, it must rapidly develop its industrial economy to fulfill this aim. The farm segment leads the Ethiopian investment, accounting for 47.7% of the overall growth development program, with 13.3% from industries and 39% from commerce. However, farming is the most important sector, and Ethiopia practices local farming irrigation (Zegeye *et al.*, 2014).

Ethiopian has recently assessed that around 11 mega hectares is appropriate for irrigation, with groundwater accounting for 48% of the total. According to the compatibility maps and current land use data, 18% (3.74 million ha) of Ethiopia irrigated rain-fed land would be appropriate for a solar photovoltaic watering system (Otoo *et al.*, 2018).

For instance, while components like pump can last a year from 5-15, solar cells can last 20-25 years, and control panels usually have a lifespan of about seven years. Solar photovoltaic systems are highly durable. In contrast, around 20% of hand pumps was malfunctioned within less than one year after installation. They have a drawback in running high maintenance costs, unreliable fuel supply, and causes to environmental pollution (Zadi and Bamford, 2016).

A study conducted in Ethiopia for irrigation purposes of potato crops using ground water with a renewable energy of solar PV system indicated that, water pumping with solar system is better prime chance in terms of solar accessibility, carbon release control, and economic effectiveness (Nasir, 2016).On the other hand, in the Indian Himalayan region the performance of DC solar pumping showed that, a variation in pumping efficiencies and overall efficiency between directly measured and PVsyst simulated is 47.7% and 22.1%, respectively (Chandel *et al.*, 2017).

This research aims to compare the size, experimental inquiry, and economics of solar photovoltaic devices and gasoline engine pump systems in outdoor conditions in Dugda wereda, in Oromia regional state for tomato crop irrigation. This place is approximately 8 km east of Meki town and 140 km northeast of Addis Ababa.

MATERIALS and METHODS

Study Area

The Central Rift Valley (CRV) lake basin system is part of the Main Ethiopian Rift (MER) that includes four presentday enduring lakes, Zeway, Langano, Abijata, and Shalla; and a tectonically controlled endorheic basin. The study was bounded by 7° 00 ′ 56″ to 8° 28 ′ 8 ″ N latitude and 38◦ 03 ′ 38 ″ to 39◦ 24 ′ 48 ″ E longitude.

The rift valley has a wide-range socio-economic and ecology amenities. In terms of area coverage, 76.8% of its part is dominantly under rain-fed farming. Irrigated farming covers <3% of the basin. About 44% of the existing irrigated areas depend on surface water from streams. Moreover, 31% pumps uses directly from Lake Zeway, and about 25% from groundwater (Hulluka *et al.*, 2023). The overall shallow water resource of the rift valley lake basin is estimated at just over 5.6 billion m^3 $year^{-1}$ and the predicted groundwater potential of the basin is 0.1 billion m^3 $year^{-1}$.

This system was designed and tested with the stated ranges of central rift valley area of Dugda wereda in specific geographical coordinates, Latitude= 8.13°N and 38.81°E, and an altitude of 1644 m.a.s.l. Ethiopia has a great daily solar potential of receiving 5000-7000 Wh m^{-2} on PV tilt surfaces (Zegeye *et al.*, 2014).

Test Condition of the System

The system was composed of a PV power generator of 150 watt power submersible helical pump PS2-100 AHRP-23S, an Apogee data acquisition system linked to a laptop, an IR thermometer temperature sensor, a hygrometer for humidity measurement, a clamp meter for measuring the current and voltage, and water flow rate directly to the plastic container. All this data has been obtained based on the maximum water requirement of the worst irrigation months (Zaki and Eskander, 1996). Accordingly, the current study is conducted between the months of February and May 2021 to evaluate the implications of pump heads on solar pump capacities.

It was tested at four pump heads of 10, 12, 15, and 18 m using a submersible pump (PS2-100 AHRP 23S) for deep good purposes. The effect of head on the operation of solar photovoltaic pumping systems was investigated and economically evaluated against the conventional diesel power system.

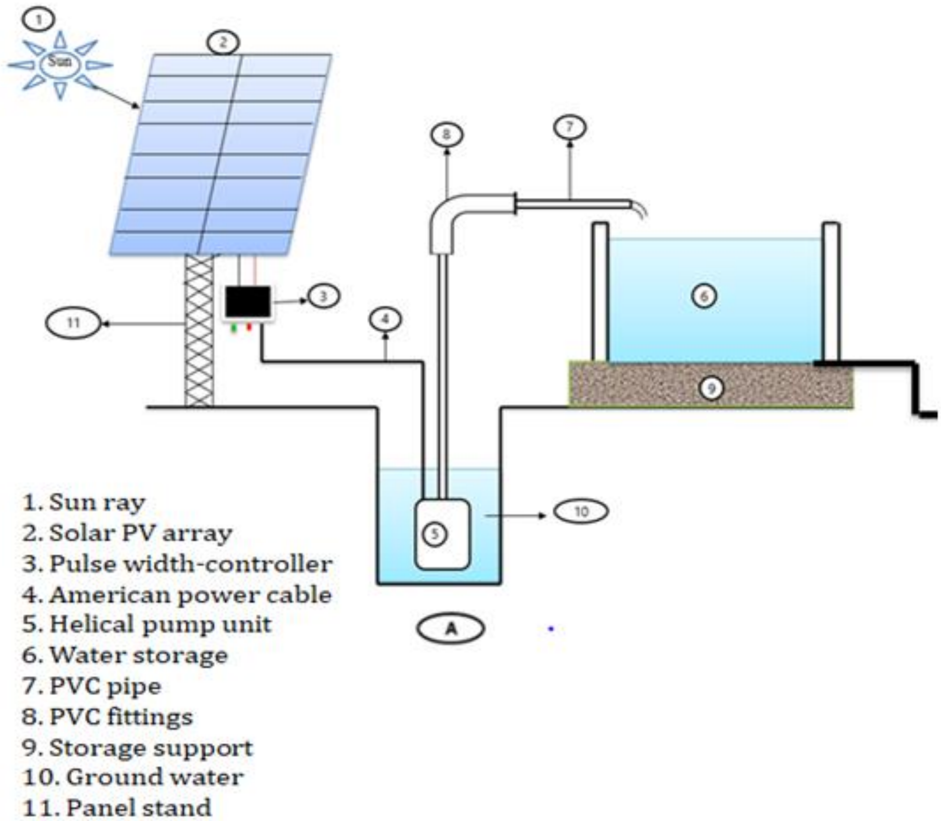

Figure 1. *Solar PV pumping system schematics.*

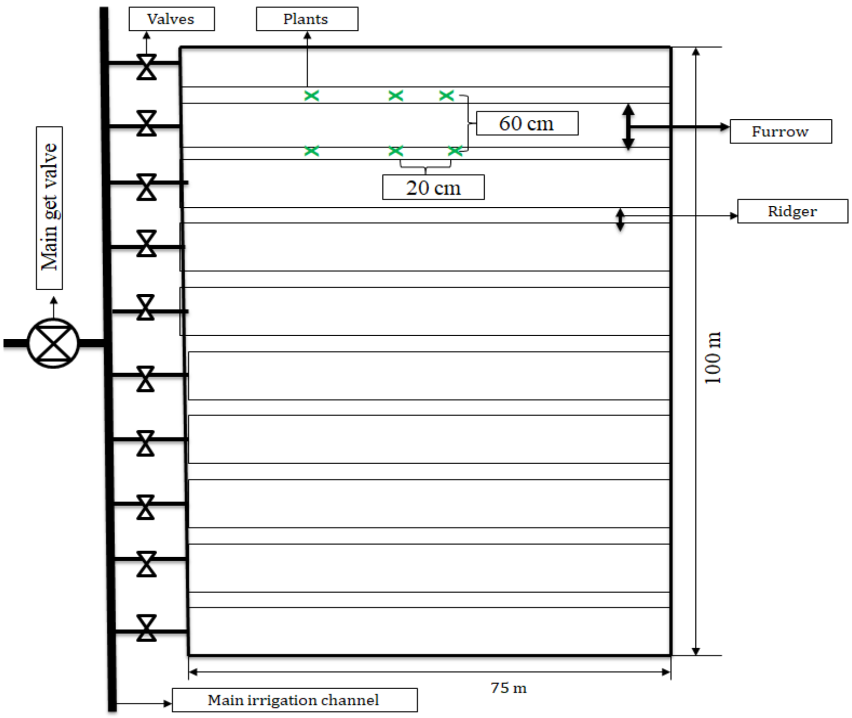

Figure 2. *Irrigation system and planting layouts.*

Figure 1 shows that solar photovoltaic water pumping system scehamtic diagrams which includes, solar panel, controller, pump, water storage, pipes with fittings, panel stand, and storage suport. Again Figure 2 describes that, the irrigation system layout as per the standards.

Figure 3. *Photographs during experiemntal testing.*

As shown in Figure 3, each photograph indicates overall system installation, submersible pump testing, and measuremts tools taken during experiemt test. And, Figure 4 shows that, different measuring instruments used during data collection such as; a. Apogee instrument for measuring solar intensity b. clamp meter for measuring V and I c. IR-thermometer for measuring temperature d. hygrometer used to measure humidity.

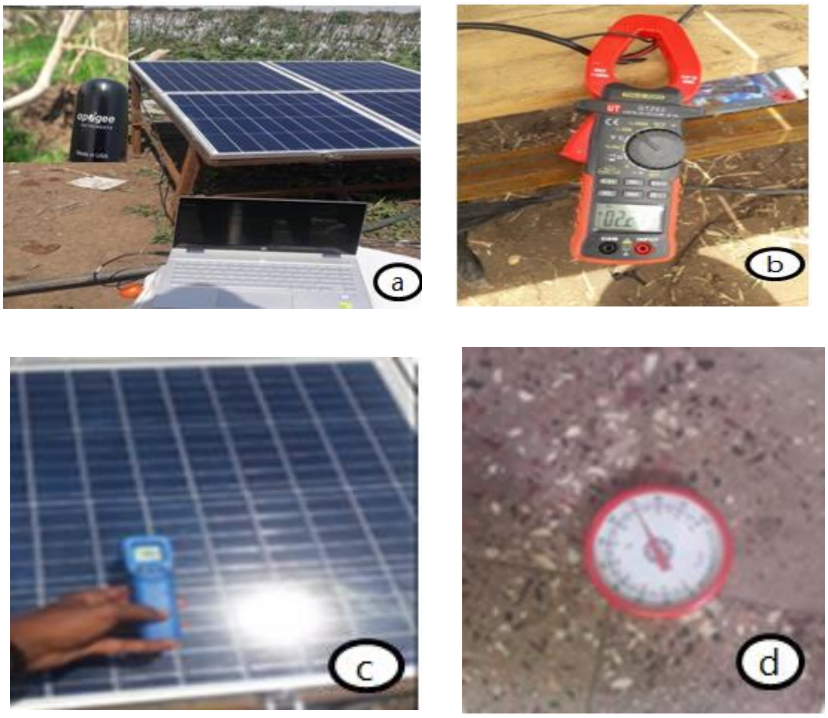

Figure 4*. Instruments used during data records.*

Determining the Maximum Crop Water Requirement

To determine the maximum water requirement, one has to be prior to calculate evapotranspiration (ET_o). If it is in the extreme climatic condition of the Blaney-Criddle method, estimated as 52% (inaccurate, dry, and sunny areas), it is assumed to be 40% for humid areas.

$$ET_o = p\,(0.46T_{mean} + 8) \quad (1)$$

$$ET_c = K_c \times ET_o \quad (2)$$

$$ET_c = 5.75 \text{ mm day}^{-1}$$

Through this, the eventual water requirements for the specific crop will be calculated using Equation 3.

$$W_r = \frac{\text{crop area} \times ET_c \times W_c}{E_u} \quad (3)$$

$$W_r = 17.4\, m^3 \cdot \text{day}^{-1}$$

Where,

ET_o, Evapotranspiration, mm day^{-1}, T_{mean}, daily average temperature, 23.9°C p, average of day fraction of yearly period in hours taken as 28% for latitude angle of 8.13° for the specific Equation 1 the value for ET_o was about 5 mm day^{-1}, W_r, Irrigation demand of water, m^3 day^{-1}, irrigated space, m^2, K_c, coefficient of a specific crop, ET_c, evapotranspiration, mm day^{-1}, Wc, percentage of wetted space, E_u, uniformity emission.

According to Foster *et al.* (2001), the percentage of wetted area is assumed be depending on the crop type; and the percentage of uniformity emission (Gouws and Lukhwareni, 2012).

Irrigation scheduling

The basic thing of an irrigation system is just scheduling before water deficiency arises. This will control when and how much water is applied. This depends on the water holding capacity of the loam soil type, with an average value of about 80 mm m^{-1} (Nasir, 2016).

The maximum irrigation interval of tomato crops can be determined using Maughan *et al.* (2015). Accordingly, the average root depth (Villalobos and Fereres, 2016) and is calculated at about three days.

$$\textit{Maximum irrigation interval} = \frac{H_w \times D_r \times D_a}{ET_c} \quad (4)$$

The Design of Flow Rate

According to the specific location obtained by inserting into CROPWAT software, the reasonable peak daily sun hours of the month was about eight hour per day. The discharge flow rate can be obtained as follows,

$$Q = \frac{W_r}{n_{PSH}} \quad (5)$$

Q=2 $\cdot$ 175 $m^3\ h^{-1}$

Where,

W_r, Water absorption capacity, mm m^{-1}, D_r, D_a, acceptable depletion for tomato crops the percentage of permissible allowable depletion available moisture in the soil with insignificant yield (Morales *et al.*, 2010).

Q, discharge rate, $m^3\ h^{-1}$, n_{PSH}, Net peak sun hours, hour

Determination of Hydraulic Energy

The hydrualic energy at the outlet of the pump could be calculated using (Gouws and Lukhwareni, 2012).

$$P_h = \frac{\rho \times g \times W_r \times H}{3.6 \times 10^6 (J \cdot kWh^{-1})} \quad (6)$$

$$\eta_{pm} = \frac{P_h}{P_{EL}} \quad (7)$$

Pel, is motor power

Ph, hydraulic power required (kWh day^{-1}), W_r, water demand, m^3 day^{-1}, *H*, dynamic head, in meter, ρ, water density, 1000 kg day^{-1}, g, gravity, $m\ s^{-2}$.

Again calculating the power motor for the pump by considering the normal working condition of pump to be 0.57 (Nasir, 2016).

Solar PV Power Requirements

In determining the better possible tilt angle of a PV panel, which would be a non-adjustable PV panel and to collect the greatest year-round solar radiation energy, it should be inclined on the way to the southern side similar to the latitude axis in order to obtain the most year-round solar radiation energy (Sass *et al.*, 2020).

Determine the required solar array peak power produced using the relation of the average solar radiation based on incident solar radiance at STC, A.M 1.5, cell temperature 25ºC, and with a panel area of 1.3 m^2 (Elrefai *et al.*, 2016).

$$P_{PV} = \frac{P_h}{F * G} \times 1000\ W\ m^{-2} \quad (8)$$

$$\eta_{PV} = \frac{P_{PV}}{G \times A_{array}} \quad (9)$$

Where,

η_{PV}, solar module efficiency, A_{array}, area of solar panel, m^2.

P_{PV}, peak solar power produced, watt, *F*, percetage of mismatch factor (0.8), *G*, average monthly solar radiation based on worst moth of irrigation 5.33 kWh m^{-2} day^{-1}. Calculating the solar PV panel efficiency using the formula (Osaretin, 2016).

η_{pm} , Motor pump efficiency, P_{EL}, electrical power produced from the panel, W.

Table 1. *PV panel and pump specifications.*

Specifications	
1. Solar panels	**PV Panel: OPES 36CPdef**
Modules, number	**4**
Total ultimate produced power, watt	200
Open voltage, voltage	45.22
Nominal volt, V_{mc}	36.66
Short current, I_{sc}, ampere	2.94
Open circuit current, I_{mp}, ampere	2.73
2. Pump	PS2-100 AHRP-23S
The maximum head, m	18
Flow rate, $m^3\ h^{-1}$	2.8
The aximum pump efficiency, %	57

Table 1 shows that the overall specifications of photovolatic panel and submersible pumps. It is as per the manufacturers manual of power rated, open & nominal voltage, short & open circuits, maximum head, pump efficiency, and flow rate.

Statistical Analysis

Statistical computing (ANOVA) and graphics were performed using open-source integrated development environment for R-4.0.2 programming language software. When the treatment effects were found significant, the least significance difference test was performed to assess the difference among the treatments at 5% significance.

RESULTS and DISCUSSION

The amount of discharged water is primarily determined by the pumping head and the hourly radiation from the sun. Evaluations of solar photovoltaic systems at various heads and irradiations have been conducted using the obtained experimental results and optimized photovoltaic module array. There are various characteristics that determine the performance of the solar photovoltaic pump system, but the most essential are heads, discharge rate, peak power, and solar radiation.

The following data shows; the measured hourly solar radiation (directly measured using Apogee instrument) from 9:00 am to 5:00 pm, and designates that there have been no significant variations between the sample days of April month.

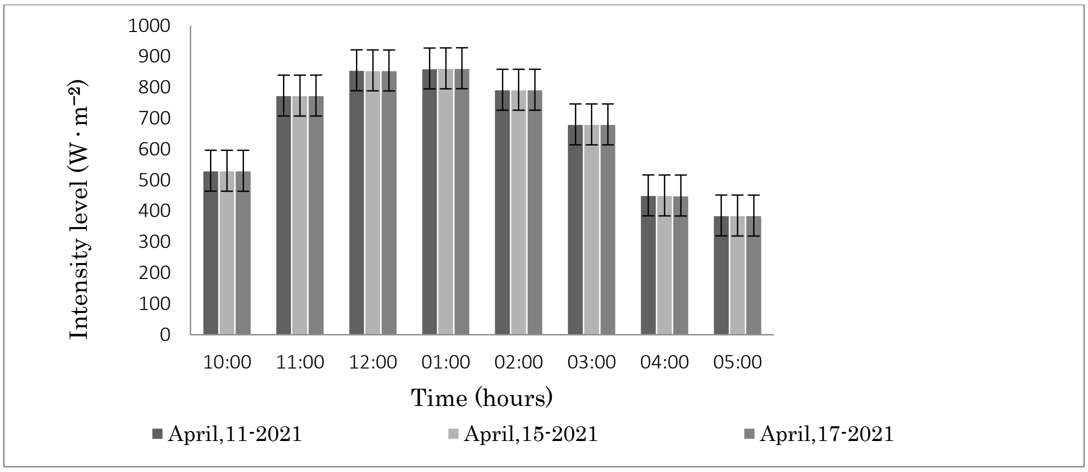

Figure 5. *Average hourly solar radiation for different sample days.*

Figure 5 shows that, data has been taken for different three days with in the maximum crop demand months. Accordingly, there no significance variation in solar intensity of different days but, it has much more variation in between hours. The maximum peak power produced (solar intensity produced) was in the mid-day time of 12:00 am to 1:00 pm and the solar intensity level ranges from 855 to 862 $W\,m^{-2}$ respectively. Again, the minimum solar intensity was in the late after-noon at 5:00 pm is about 385.7 $W\,m^{-2}$ and in the morning time the mean hourly solar irradiance was measured about 530 $W\,m^{-2}$.

PVsyst Simulated Analysis of Photovoltaic Panel

The specific site data recorded using the, PVsyst 7.1 system energy tool were used to generate a simulation report for the specific photovoltaic array illustrated in Figure 6 using parallel and series adjacent connections (2S*2P).To produce a single solar module with a power variation from 19 watt to 100 watt power, the current (I) and voltage (V) will occurred due to variation of incident irradiations.

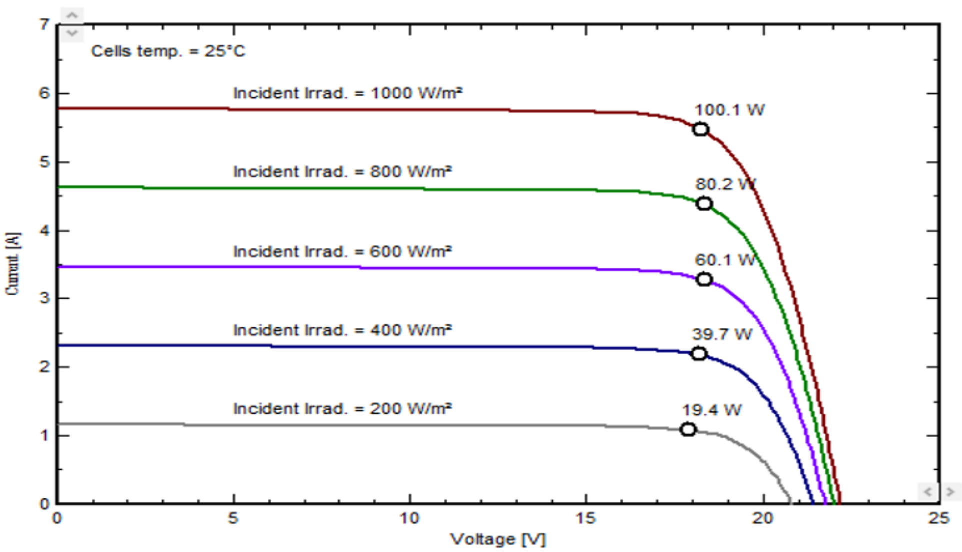

Figure 6. *I-V characteristics curves with different irradiance levels.*

Figure 6 I-V model curve shows for a constant cell temprature of 25°C, at varioussolar irradiation levels the short circuit current increases in propartion to the solar incident while open circuit voltage logarithmitically with solar radiation.As long as curved portions in the figure show that the I-V does not intercect the short circuti current is proportional to incident irradiation. On the other hand, if the incident irradiance is assumed to be persistent spectral scatterings the short ciruit current can be used as extent to incident irradiations.

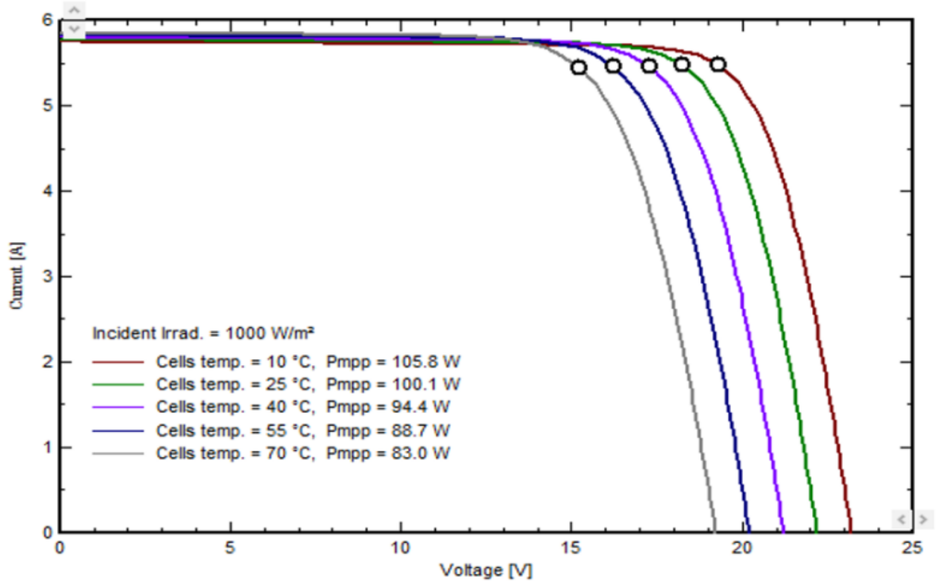

***Figure** 7. I-V characteristics curves at different temperature.*

I-V characteristics curves both for incident irradiance and temperatures were showed in Figure 7. It has been perceived that the temperature linearly decreased the produced voltage as compared to current. Subsequently, the maximum power point of photovoltaic module decreases as the voltage decreases with a constant solar irradiance. Though, the effect of temperature is lesser on short circuit current but upturns with increase in incident solar irradiance.

Figure 8 illustrated those P-V curve features for different solar irradiances at fixed cell temperature of 25ºCs. It was founded that, as increase in solar irradiance and open circuit voltage the power also increases.

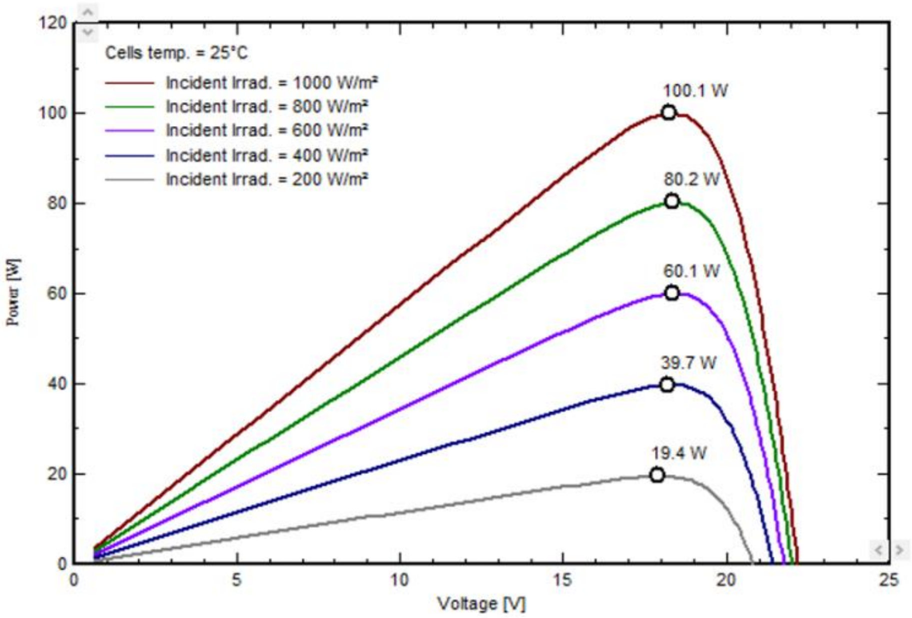

Figure 8. *P-V characteristics curve at different set of incident radiations.*

Effects of Solar Radiation

In practical situations, it is difficult to obtain 1000 W m^{-2}, as a result, research is required to determine the most effective pumping operations for specific levels of radiation.

According to the experiment test results, the solar radiation is dynamically affected by the time of each hour. The correlation model indicated that solar radiation significantly affected the flow rate at each different head level (P<0.05). The best-fit equation of each level head is presented here in Figure 9. It can be seen that the pump discharge rates rise exponentially with the rising solar radiation. It could be concluded that, at the same level of irradiance the flow rate decreases with increasing each head levels.

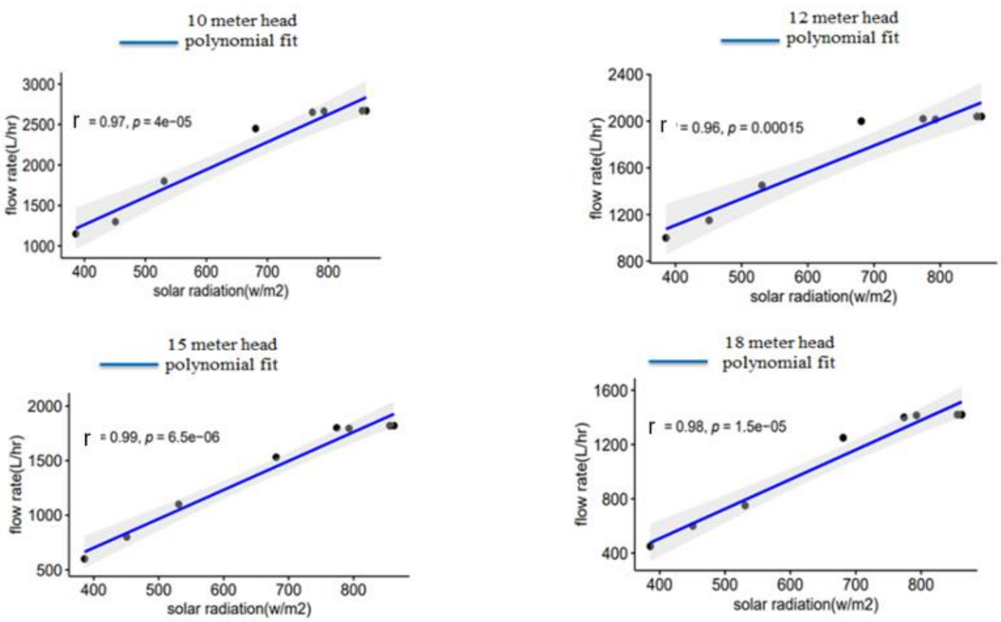

Figure 9. *Discharge versus solar radiation at different head levels.*

The data collected from the field experiment test of Table 2 showed that, the flow rate in each group also varied significantly in dependent with solar intensity. Also, the flow rate of the pump at different levels of head varies when the solar radiation varies from 385.8-862.2 W m^{-2}. The minimum and maximum flow rate obtained at 10 m head is 1150 and 2670 L h^{-1} with the respective solar intensity of 385.8 and 862.2 W m^{-2}.

Table 2. *Discharge of solar pump system at various heads and solar radiations.*

Head level (m)	Discharge flow (L h^{-1}) At 385.8 (W m^{-2})	Discharge flow (L h^{-1}) At 862.2 (W m^{-2})
10	1150	2670
12	1000	2040
15	600	1820
18	450	1420

Effects of Time on Hourly Solar Radiation

Figure 10 shows that, the hourly solar radiation produced by the PV array versus time, where the input power to the pump has gained a minimum level in the morning and afternoon time and a maximum result at the mid-day time, similar result to that of power vs. time.

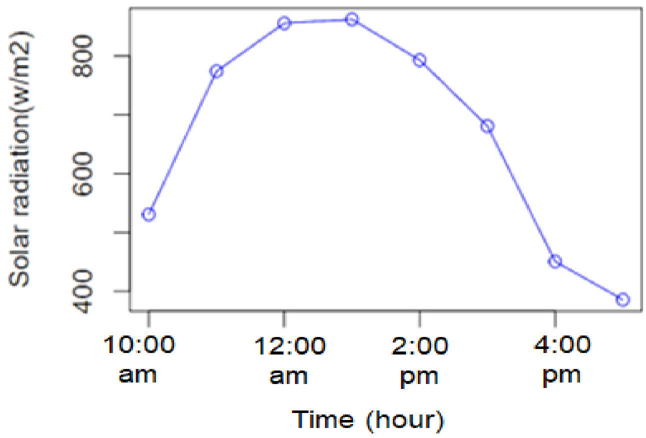

Figure 10. *Panel output power obtained on an hourly basis.*

Visualize the best fit equation and correlation effects between different heads on flow rate, the pump efficiency, and total system efficiency.

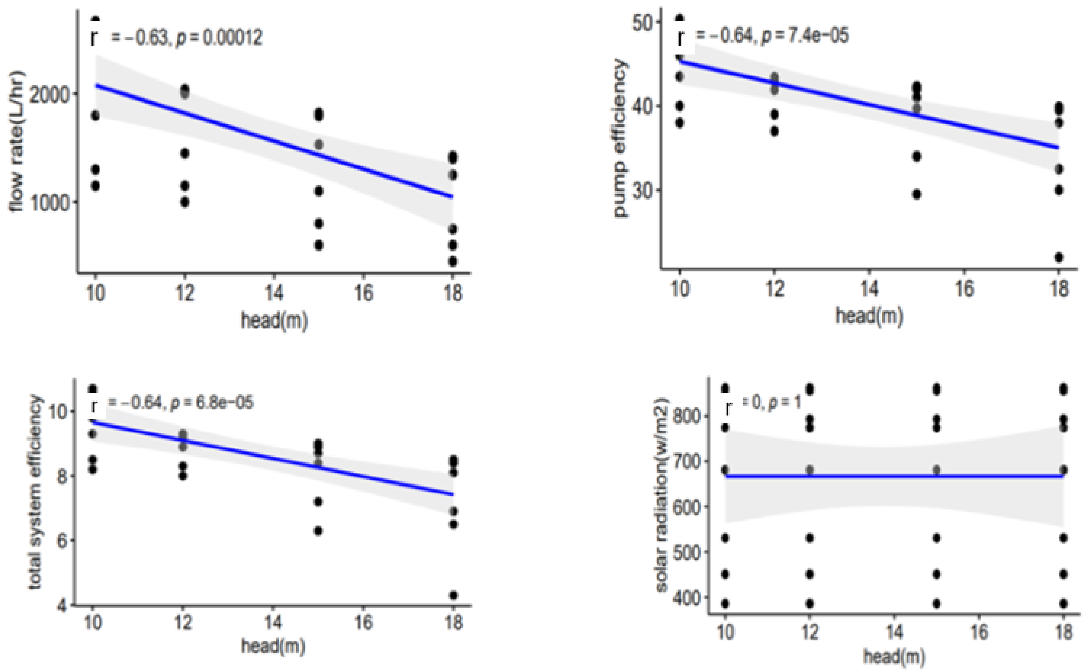

Figure 11. *Correlation effects of head in various dependent variables.*

The pump power varies every hour of the day. It increases during the morning hours, rapidly peaks in the middle of the day, and rapidly declines in the late afternoon. The pump and overall system performance are reduced for all pump head.

Table 3. *Mean and level of significance of dependent variables at various heads.*

Head (m)	Mean flow rate ($L\ h^{-1}$)	Mean pump efficiency (%)	Mean of total system efficiency (%)
10	2169.38^{a}	46.04^{a}	9.8^{a}
12	1714.38^{ab}	41.59^{ab}	8.89^{ab}
15	1408.13^{bc}	39.10^{bc}	$8.3b^{c}$
18	1088.13^{c}	35.16^{c}	7.45^{c}

Means results by the similar words superscript were not predominantly affected and alpha level=0.05, and letters “a, ab, bc, and c” indicate that the level of average mean followed by the same letters is not significantly different.

The working time significantly affects the overall capacity of the photovoltaic pump. As mentioned in Table 3 above, the data collected and analyzed using ANOVA for the mean and significance effects. Table 3 shows that, the mean pump efficiency and total system efficiency operating at 10 m head were 46.04% and 9.8% respectively. Again, at 10 meter head, the mean hourly flow rate was obtained 2169.38 $L\ h^{-1}$. The reason for the lower pump efficiency at 18 m head is due to the lower underutilization of limited power produced by the solar photovoltaic array.

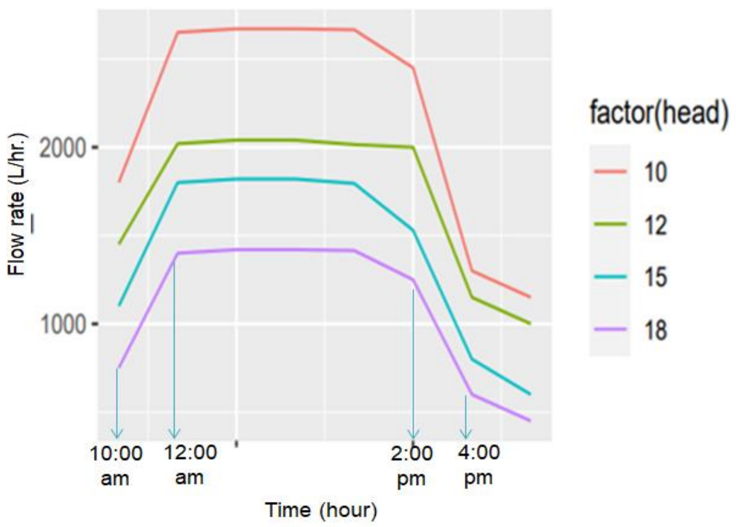

Figure 12. *Flow rate variation on an hourly basis at varying head.*

From the experiment test result obtained, for different pumping heads and pumping time, the result shows there was a variation in flow rate. Figure 12 illustrated that, the flow rate increases gradually somehow remains constant during midday as well as rapidly decline later after 3:00 pm. This result shows that, the flow rate decreases with increasing in pumping head proportionally.

Economic Comparisons Between Photovoltaic and Diesel Pumps

For this analysis, it should achieve an economic evaluation and compare solar PV with existing diesel-pumping system technology for the feasibility study. The economic evaluation is accompanied by investment cost, lifetime cycle cost, energy cost, as well as consistent profitability per the determined volume of water.

The assessment for diesel-pumping system information is gathered from the end users/ farmer field. The 6.7 Hp power diesel pump was tested within eight operating hours per day, and its initial cost with its component was (ETB) 26000. Obtained from the field-test result, the diesel pump has a fuel consumption of 0.8 L h^{-1}, and its volume of water pumping capacity is about 6 m^3 h^{-1}.

The following mathematical equation can be used to determine lifecycle expense analysis (Maughan *et al.*, 2015).

$$LCC=CC+MC+EC+RC-SC \tag{10}$$

Where;

CC stands for initial cost, *MC* stands for cost of maintenance, *EC* stands for fuel costs, *RC* stands for replacement value, and *SC* stands for recovery cost.

The following major assumption factors have been considered to be needed for an optimum cost analysis of the photovoltaic water pumping system using (Narale *et al.*, 2013) and (Park, 2013).

- The operating life of the PV panel and solar pump has been considered twenty and ten-years, respectively.

- The operational cost for a solar photovoltaic pump system is supposed to 0.1% of its investment across a year.
- The operational cost for the engine generator is supposed to 10% of the investment charge.
- The recovery price a solar pump is 5% of its overall original procuring charge.
- The specific area-based accessibility of sunlight days was measured to be 2920 h per year.
- The repairing charge of engines is expected to be 10% of the overall investment charge in year
- The recovery charge of diesel pumping was presumed to be 20% of its investment value, and it is replaced every 10 years.

According to Girma *et al.* (2015) financial comparisons were made between solar photovoltaic and diesel pumping systems for ground water use of 20 years life cycle. It was analyzed using life cycle cost analysis in different areas of Siadberand Wayu in Amhara, Wolmera in Oromia, and Enderta in Tigray regions. The findings, using life cycle cost analysis for solar photovoltaic and diesel generator pump systems were \$ 1295.66 and \$ 7812 respectively. Again, the cost of pumped water (\$ m^{-3}) were 0.1, 0.16, & 0.16 and 0.2, 0.23, and 0.27 for each respective regions of pumping systems. Based on the variation of life cycle cost comparisons made, PV water pumping was economically feasible than diesel pumping system.

Table 4. *System cost comparison using life cycle cost analysis.*

No.	Cost types (ETB)	The cost of solar PV system	The cost of diesel engine system
1	Capital cost (CC)	117780	26000
2	Maintenance cost (MC)	2332.04	52000
3	Fuel/energy cost (EC)	None	1244160
4	Replacement cost (RC)	46000	52000
5	Total cost	166112.04	1374160
	Salvage cost (SC)	5889	5200
	Life cycle cost (LCC)	172001.04	1379360

Cash Flow

It is important to consider the net present value of money as an option for worth economic comparison. Just using an economic equivalent to some present and future amount can be expressed using the following relations (Girma *et al.*, 2015).

$$F = P\,(1 + i)^N \tag{11}$$

Where,
F -Future value
P- Present value
N-years, and i-rate of interest

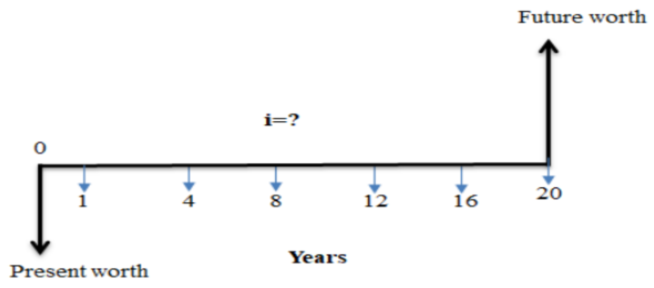

Figure 13. Cash flow diagram.

Table 4 indicates that, the solar photovoltaic pumps have higher initial investment costs than diesel pumping systems. But, other costs (maintenance, operation, and replacement) were significantly lower than those of the diesel pumping system. Additionally, there is no energy cost needed for the solar pump and the solar-driven pump has more reliability and long-term life. Diesel pumps have higher total cost as compared to solar photovoltaic system. From the results, about 85% of the life cycle cost for the diesel pump is fuel cost, and this shows that the pump charge in the extended life for the system is due to energy cost, unless the initial and other costs during the operation were very low. The economic comparison result between solar and diesel water pumping systems has a cost of water 1.3 (ETB) m^{-3}, and 3 (ETB) m^{-3} respectively, using life cycle cost analysis for 20 years.

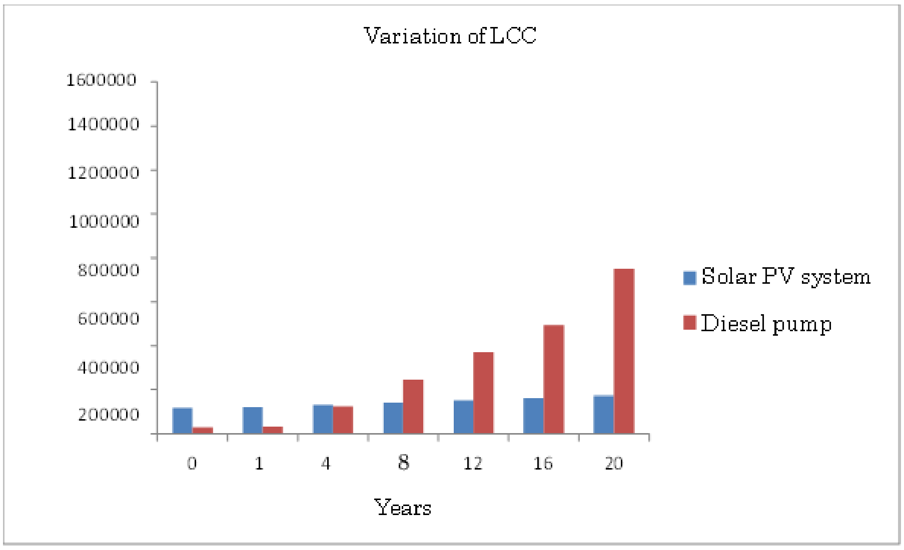

Figure 14. Variation of cash flow life cycle cost for solar photovoltaic and diesel pumps.

The Cost of Pumped Water

The cost of water pumping for both diesel and solar pumps can be calculated using the annuity technique of LCC analysis (Narale *et al.*, 2013).

$$\text{Water cost} = \frac{\text{Annual peroid series scheme}}{\text{Overall discharged water}} \quad (12)$$

By considering the total life cost of solar PV, diesel engine pumping systems were about ETB 172001.04 and 1379360, respectively. Accounting for the life cycle time of twenty years, an average twelve-month PV pump has about ETB 8600 with a monthly cost of about ETB 716.67, and the cost of pumped water (m^3) is about 1 ·3 birr m^{-3}. Also, for the diesel-pumping system, the average yearly value cost was calculated as ETB 68968, and its monthly cost is ETB of 5747.33. The cost to pump water using DP system was 3 Birr m^{-3}, which is three times as costly as a solar PV pumping system to pump a unit volume of water.

CONCLUSION

Through the performance of market-available direct-coupled solar pump systems, this pact studied the economic feasibility of the existing engine pumping system. These results have been investigated through operation in the actual and under conditions of the Dugda site. Evaluations have been conducted under four different levels of the head (10 m, 12 m, 15 m, and 18 m) on a sunny day. Heads and solar intensity at hourly bases can be determined flow rate of the solar photovoltaic pumps. The designed photovoltaic pump was accomplished by watering 0.75 hectares of tomato for eight hours with the cost of pumped water 3 ETB m^{-3}. From the evaluation results, the maximum daily water requirement was about 2.169 m^3 h^{-1} at 10 m head. If it rises to of 18 m, the average flow rate reduces to 1.088 m^3 h^{-1} with the irrigation area less than 1/3 ha of tomato farm. The best pump and total system efficiencies is in 10 m head is about 46.04% and 9.8% respectively. Hereafter, it can be decided that time has a significant influencing on solar radiation, dominantly influencing the overall efficiency of PV system. It is summarized that for locations representing central rift valley of Ethiopia, solar pump systems could size as per irradiance range 385.8-862.2 W m^{-2}. Using life cycle cost analysis with durations of twenty years, the life cycle cost of solar system was cost-ineffective than diesel-pump system. The study shows that, watering of vegetables through solar photovoltaic pump systems is a valuable again fit for extended reserves in contrast to a diesel generator. For the future, it is advantageous to model the system using internet of things for better efficient improvements. Therefore, governmental and non-governmental institutions could access to loan and create awareness about the technology.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no conflict of interest.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Maney Ayalew Desta: Investigation, formal analysis, writing original draft, and conceptualization,
Getachew Shunki Tiba: Validation, review,
Mubarek Mohammed Issa: Visualization, paper editing,
Wariso Heyi: Data collection, paper editing.

ETHICS COMMITTEE DECISION

This article does not require any ethical committee decision.

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