Solar Powered Irrigation for Sustainable Development and Its Risk in Ethiopia

Minyahil Tanashu Toga (✉ tanashuminyahil@gmail.com)
Bahir Dar Institute of Technology

Original article

Keywords: power, irrigation, Sustainable development, risk

DOI: https://doi.org/10.21203/rs.3.rs-75607/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
Abstract

Background: In recent years, solar energy in Ethiopia has emerged as one of the cleanest, environmentally friendly, and reliable sources of energy. Energy is one of the main inputs of agriculture, especially for small scale irrigation, is becoming a focus in the agricultural water management agenda of the country Ethiopia. In this respect, Solar Powered Irrigation Systems are promoted widely in Ethiopia as the alternative to diesel-run pumps which is widely used by farmers in Ethiopia for sustainable development. These studies investigate the use of solar water pump for sustainable development and its risk in Ethiopia.

Method: The investigation is based a review, assessment of inventory reports, scientific literatures and 10 people engaged in research, development, and/or implementation of solar power irrigation system were interviewed in person, household interviews and focus group discussions

Result: Solar based Small-scale irrigation is a policy priority in Ethiopia for rural poverty alleviation and growth, as well as climate adaptation, so there is considerable scope for expansion of small scale solar-based irrigation in Ethiopia. The risk is that farmers will consume more water than they did before the introduction of solar powered irrigation water pumping and if not well managed it will cause groundwater over abstraction, leading to depletion and degradation of groundwater resources

Conclusion: Sustainable development of the country can be achieved by enhancing solar powered small scale irrigation system to boost agricultural growth by enhancing agricultural productivity, decreases post-harvest loss, increase agribusiness income generation opportunity and revenue and increase energy efficiency and associated savings within the operation of farms and agribusiness while simulating low carbon economic growth within the agricultural sector of the country. Nevertheless, it is important to note that a solar-powered irrigation system if not well managed and regulated creates the risk of supporting unsustainable water use.

Background

Climate change has become a universal threat to mankind which requires urgent action. This has seen the replacement of the Millennium Development Goals by the Sustainable Development Goals. The Sustainable Development Goals do not only target improving the social and economic life of the poor worldwide but also have additional emphasis on protecting the environment and ensuring sustainable use of resources [1]. When considering the development of the country, energy is one of the key points. Energy can be generated from renewable and non-renewable energy sources. High prices, fast depletion rate and environmental impacts of fossil fuels create problems in electricity generation through conventional energy sources. Solar powered water pumping system has emerged as a promising alternative to conventional diesel and electricity powered irrigation pumps [2].

Most of the 82.9% of the Ethiopian population living in rural areas depend on agriculture this is seen as the engine that helps to ensure food security, generate incomes, provide jobs and drive rural development.
The Government of Ethiopia places strong emphasis on agriculture, including smallholder agriculture. Investment in irrigation is a key strategic direction to accelerate economic structural transformation, it is important to note that women are responsible for about 40% of agricultural activities in Ethiopia, but has 13.4% lower productivity than men caused by endowment and structural differences. Reducing these resource and structural differences through targeted measures for equitability has the potential to boost agricultural growth. Solar Powered Irrigation Systems provide a reliable source of clean energy to the farmers to irrigate their lands [3]. Once the systems are installed, there is no cost per unit of power and thus no financial incentive for farmers to save on fuel or electricity for water pumping. This can lead to wasteful water use, over-abstraction of groundwater, and low field application efficiency. In some cases, farmers sell water to their neighbors at a profit, increasing the overall water withdrawals. Recognizing the water-related risks and addressing those from the beginning especially in the financing and design stages will be crucial to ensure the sustainable use of Solar Powered Irrigation Systems technology [4, 7]

Figure 1 shows the implementation in southern part of Ethiopia as small-scale irrigation with minimum cost can effectively build the resilience of vulnerable farming households by reducing their reliance on erratic and unpredictable rainfall. The introduction of appropriate, sustainable and successful solar powered small-scale irrigation schemes requires attention to good practice at each stage of implementation, right from planning, to construction and through to community level governance in the country.

Survey Of Literature>

In this section works related to this paper are discussed. Different reports, product information, case study, website and published papers exists solar irrigation system were conducted.

The work indicated in entitled as “Design and Simulation of Photo-voltaic Water Pumping System for Irrigation” presents standalone PV system for irrigation application [2]. Solar PV power is more reliable for small scale irrigation for almost all parts of Ethiopia. This is due to the fact that solar energy is in phase with water demand to irrigate crops, secondly; Ethiopia has an abundant supply of solar energy throughout the year. According to the researcher using solar power system will increase rural electrification and enhancing the living standard of the community.

A paper entitled as “PV Water Pumping Systems for Agricultural Applications” [5]. The paper discus about the detail about an accurate assessment of the crop irrigation water requirement is essential for the optimal design of PV Water Pumping systems. Moreover, analyzing the effects of pumped water on the available water resources and crop productivity is essential for verifying the technical successfulness of the design. The constraint related the groundwater resource represents the main determining factor for the optimal size of solar water pumping systems. According to the paper implementation of solar water pumping system need to be assessed and strategic design must be applied for proper utilization of ground water.
A paper entitled as “Rural Water Supply Technology Selection in Achieving Sustainable Development Goal 6 in Amhara, Ethiopia” [6]. The paper presents about Social issues are significant to consider when planning a solar scheme. Social issues to be considered are land use and ownership, acceptance of the community and the willingness to pay.

A paper entitled as “Performance Study of a Solar Photovoltaic Water pump used for Irrigation at Jaipur in Rajasthan, India” [7]. The paper presents about Performance of a 5 hp Brush Less DC submersible solar photovoltaic water pump installed at Madarpura (Jhotwada) of Jaipur in Rajasthan. The simulation results vary because of number of variable such as water requirement at irrigation field site, head of water, head of pump etc. given as input.

The work indicated in entitled as “Solar Energy Harvesting for Irrigation Water Pumping System”. This paper presents the stand- alone solar water pumping system for irrigational purpose. The proposed system can be implemented with low cost controllers. This system uses conventional two-stage converter one for getting maximum power from solar array and second for the controlling the induction motor drive performance by v/f control algorithm. MPPT is achieved by perturb and observe MPP algorithm. Flow rate of pump has been controlled by controlling the motor speed by PI controller. Simulation analysis depicts that the steady state as well as dynamic state is satisfactory and both controllers are working smoothly [8].

**Methodology**

Ten people engaged in research, development and/or implementation of solar power irrigation system were interviewed in person and household interviews and focus group discussions were conducted with spring based community managed irrigation schemes. During sites visits people working with solar power irrigation system were also interviewed. This helped to put the interviews and the literature research, into perspective.

**Result And Discussion**

Perceptions and experience solar water pumping system were gathered. Experiences of Solar water pumping systems were gathered through interviews. Issues that were raised are:

- Concerns about theft, solar water pumping systems;
- The perceived inability of solar water pumping systems to supply variations in water demand;
- Sophisticated technology of solar water pumping systems with serviceability;
- Performance concerns; and
- High cost.

**The Energy Crisis and Irrigation**
Energy demand is increasing significantly nowadays due to increase in population, industrialization and transportation. The fossil fuel depletion is high with this increase in energy demand. There are sincere efforts from around the world to tap renewable sources and adopt these sources of energy for their social and economic development [9].

A large proportion of the world's traditionally irrigated land is commanded by gravity-fed water obtained by controlling the flow of rivers and providing suitable canal distribution systems. This is evidently a desirable method since there are little or no energy costs associated with distributing the water once the scheme has been completed. However, there are limits to the amount of land that can readily be commanded by gravity-fed water, and many populations and the land they require to cultivate cannot benefit from such schemes, now or in the future [10].

**Advantage of solar powered irrigation system**

In order to increasing agricultural productivity and income due to improved access to water and more efficient use of water if combined with drip or other water efficient irrigation technologies. Food security may be improved if introduction of solar powered irrigation water pumping is accompanied by changes in irrigation technologies and agricultural practices.

**Disadvantage of solar powered irrigation system**

Risk of groundwater over abstraction, leading to depletion and degradation of groundwater resources

**Risk related to Solar Powered irrigation system**

The risk is that farmers will consume more water than they did before the introduction of solar powered irrigation water pumping, by: (i) applying more water in the field overall (for example, when shifting from deficit to optimal irrigation, or simply over-irrigating); (ii) expanding the area of land under irrigation; (iii) growing higher-value, but often more water-intensive, crops; (iv) selling water to neighboring farmers and communities. This is particularly an issue in areas where groundwater resources are already overexploited and recharge rates are slow.

**Solar Powered Irrigation and Policy Measures**

The following recommendations would help ensure that investments in solar powered irrigation are equitable, poverty reducing and have sustainable impact in a variable climate.

1. Assess Environmental sustainability: Assessing of the environmental sustainability of water source and weather data before irrigation development. Assessments should be made based expertise from a university.

2. Equitable management: Support the development of accountable, well-trained water user associations/ irrigation committees. These associations need ongoing support, not just one-off
training. Support should include the development of by-laws and mediation mechanisms for equitable and accountable distribution of water [10].

3. Sustainable development impacts: Making solar irrigation development is accompanied by complementary investments in market development, transport infrastructure and communications in rural areas. Without these, solar irrigation development will bring limited returns and will not generate the desired rural growth.

Conclusion

Energy being one of the main inputs of agriculture, especially for small scale irrigation, is becoming a focus in the agricultural water management agenda of the country Ethiopia. Most of the Ethiopian population living in rural areas depends on agriculture this is seen as the engine that helps to ensure food security, generate incomes, provide jobs and drive rural development. The Government of Ethiopia places strong emphasis on agriculture, including smallholder agriculture. In this respect, Cost effective solar powered small-scale irrigation can effectively build the resilience of vulnerable farming households by reducing their reliance on erratic and unpredictable rainfall. The implementation of solar powered small-scale irrigation schemes requires attention to good practice at each stage of implementation, right from planning, to construction and through to community level governance. In order to minimize risk of supporting unsustainable water use an accurate assessment of the crop irrigation water requirement is essential for the optimal design of solar powered small-scale irrigation systems. Moreover, analyzing the effects of pumped water on the available water resources and crop productivity is essential for verifying the technical successfulness of the design.

Declarations

Acknowledgment

The author of this manuscript would like to express appreciations that made contribution to this study

Funding

Not applicable

Availability of data and material

All data and material required for analysis is incorporated in the paper

Ethical approval and consent to participate

Not applicable

Consent for publication
Not applicable

**Competing interests**

The author declare that there is no competing interests

**Author details**

*Bahir Dar University, Bahir Dar Institute of Technology, Bahir Dar, Ethiopia*

Email address: tanashuminyahil@gmail.com

**References**

1. Misrak Girma ¹,*, Abebayhu Assefa ¹ and Marta Molinas ² “Feasibility study of a solar photovoltaic water pumping system for rural Ethiopia”
2. Abdulbasit Nasir. “Design and Simulation of Photo-voltaic Water Pumping System for Irrigation”. Advances in Applied Sciences. Vol. 4, No. 2, 2019, pp. 59–71. doi: 10.11648/j.aas.20190402.14
3. Likimelesh Nigussie N, Lefore P, Schmitter, Nicol A, Gender and water technologies: “Water lifting for irrigation and multiple purposes in Ethiopia”, International Water Management Institute, East Africa and Nile Basin Office, Addis Ababa, February 2017
4. Hans Hartung, Pluschke L, “The benefits and risks of solar-powered irrigation - a global overview”, FAO 2018
5. Pietro Elia Campana, PV Water Pumping Systems for Agricultural Applications, Mälardalen University Press Dissertations No. 175, 2015, Sweden
6. Kaisa, Kuismanen, Rural Water Supply Technology Selection in Achieving Sustainable Development Goal 6 in Amhara, Ethiopia, Master of Science Thesis, December 2018
7. Harjot Singh¹,a, Bharat Kumar Saxena¹,b, K. V. S. Rao¹,c, “Performance Study of a Solar Photovoltaic Water pump used for Irrigation at Jaipur in Rajasthan, India”, 2017 IEEE International Conference on Technological Advancements in Power and Energy (TAP Energy)
8. Nandikesh Pushpraj NG, Vikas G, Mulla MA, “Solar Energy Harvesting for Irrigation Water Pumping System” IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI-2017) ©2017 IEEE
9. Paramasivam DrP, “To Quantify the Impact of Energy Crisis on Irrigation” Department of Agricultural Economics Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University Coimbatore – 641 003
10. Dawit Hailu Mazengia, Ethiopian Energy Systems Potentials, Opportunities and Sustainable Utilization Uppsala, Sweden, September 2010
11. RiPPL No.3 Small-scale irrigation in the Ethiopian highlands, WaterAid Ethiopia, Kirkos Sub-city, Kebele 04, House no 620, Debrezeit Road, PO Box 4812, Addis Ababa, Ethiopia
Figures

Figure 1

Water pumping from the well using the solar pump and measuring the amount [12]