SOLAR PV POWERED MICRO IRRIGATION SYSTEMS FOR SRI LANKA – A CASE STUDY

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DECLARATION

I declare that this is my work and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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ABSTRACT

The escalating global population and diminishing natural resources have underscored the critical need for efficient water and energy management. Advancing technological solutions have become imperative to curb resource overuse and optimize utility, especially within the agricultural sector, where water and energy play pivotal roles. Contemporary agricultural practices increasingly rely on innovative technologies aimed at fostering sustainable resource management. In rural agricultural regions, where access to conventional energy infrastructure is often limited solar powered micro irrigation systems have emerged as a viable and efficient alternative for addressing these challenges, enabling judicious water and energy usage.

This research focuses on evaluating the feasibility of implementing solar photovoltaic (PV)-powered micro irrigation systems in Sri Lanka's agricultural landscape. The study primarily explores existing technological approaches documented in the literature related to solar-assisted micro irrigation. To identify the most appropriate system, qualitative data were collected through field visits and stakeholder interviews, assessing operational requirements and challenges. The investigation identified drip and sprinkler irrigation systems integrated with solar PV-powered direct current (DC) submersible pumps as the most technically suitable configurations.

A case study was conducted on a farm in Matale, located in Sri Lanka's Central Province, to assess the techno-economic viability of the selected systems. Spanning a period from 2021 to 2022, the research entailed comprehensive data collection, including solar irradiance levels, pump performance metrics, crop yield data, and economic returns. Results showed that the drip irrigation system delivered a 52.82% increase in onion yields compared to the sprinkler system (11,920 kg vs. 7,800 kg per 0.5 acre).

The economic analysis affirmed the strong financial feasibility of these systems. When subsidized, the combined irrigation setup achieved a Net Present Value (NPV) of $15,391.71, with a payback period of 3.5 years. Notably, the drip irrigation system alone yielded an NPV of $9,969.21 and a shorter payback period of 3.08 years. Operationally, the solar pumping system demonstrated 85% reliability during cultivation periods, adequately meeting irrigation demands on the majority of days. Furthermore, the Levelized Cost of Energy (LCOE) for solar pumping was calculated at $0.21/kWh, significantly lower than the $0.47/kWh cost associated with kerosene-based pumps.

The findings of this research highlight the considerable promise of solar PV-powered micro irrigation systems for Sri Lanka's small- and medium-scale agricultural enterprises, presenting a sustainable solution for resource conservation and income enhancement. The study advocates for

the prioritization of government subsidies toward drip irrigation technologies to amplify agricultural output and promote energy sustainability.

Keywords: Solar PV powered water pumping, Micro Irrigation, Sustainable solar irrigation, PV powered micro irrigation

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LIST OF ABBREVIATIONS

Abbreviation	Description
PV	Photovoltaic
DC	Direct Current
AC	Alternating Current
SWOT	Strengths, Weaknesses, Opportunities and Threats
MPPT	Maximum Power Point Tracking
SPVWPS	Solar Photovoltaic Water Pumping System
CUC	Cristiansen Uniformity Coefficient
SPV	Solar Photovoltaic
CPU	Capacity Utilization Factor
NPV	Net Present Value
CBR	Cost Benefit Ratio
IRR	Internal Rate of Return
SPVIS	Solar Photovoltaic Irrigation System
PVPS	Solar Powered Pumping System
CPU	Capacity of Utilization Factor
GHG	Green House Gasses
SPIS	Solar Powered Irrigation System
DPIS	Diesel Powered Irrigation System
SPWP	Solar Powered Water Pumping
LKR	Lanka Rupees
LCCA	Life Cycle Cost
SPDI	Solar Powered Drip Irrigation

SPMIS	Solar Powered Micro Irrigation
NPV	Net Present Value
PP	Payback Period
BCR	Benefit Cost Ratio
ROI	Return on Investment
LCOE	Levelized Cost of Energy
USD	United States Dollars
CAPEX	Initial Investment Cost (CAPEX)
DCF	Discounted Cash Flow