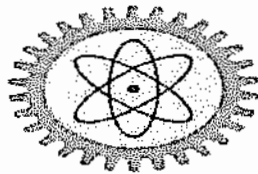


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**BUSITEMA  
UNIVERSITY**  
*Pursuing Excellence*

**FACULTY OF ENGINEERING**

**DEPARTMENT OF AGRICULTURAL MECHANISATION AND  
IRRIGATION ENGINEERING**

**DESIGN AND SIMULATION OF AN AUTOMATED SOLAR  
POWERED DRIP IRRIGATION SYSTEM FOR TOMATOES AT  
BUSITEMA**

**FINAL YEAR PROJECT REPORT**

**BY**

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bachelor's degree in Agricultural Mechanization and Irrigation engineering

**MAY 2016**



### APPROVAL

This project proposal report has been submitted to the Faculty of Engineering for examination with approval of my supervisors.

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**DECLARATION**

I TILANDEKULA JOSEPH hereby declare that this project Report is original and has not been presented to any institution of higher learning for any academic award.

Signature:  ..... Date: 25 / 05 / 2016



### APPROVAL

This project proposal report has been submitted to the Faculty of Engineering for examination with approval of my supervisors.

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## **DEDICATION**

This proposal is dedicated to my beloved parents Mr. Ssendegeya William & Mrs. Nansamba Ruth Ssendegeya in appreciation for their care and great support provided to me since childhood which have indeed made me what I am today.

## **ACKNOWLEDGEMENTS**

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## LIST OF ABBREVIATIONS

GDP- Gross Domestic Product

GPS- Global Positioning System

PV- Photovoltaic

lps- Litres per second

Ec- Electrical conductivity

DC- Direct current

Kc- Crop factor

gpm- gallons per minute

FAO- Food and Agriculture organization

PVC- Polyvinyl chloride

ET<sub>o</sub>- Reference Evapotranspiration

ET<sub>c</sub>- Crop water requirements

P<sup>H</sup>- Potential of Hydrogen

C- Carbon

OM- Organic matter

AGRA- Alliance for Green Revolution in Africa

MWE- Ministry of water and Environment,

MAAIF- Ministry of Agriculture Animal Industry and Fisheries

P- phosphorous

## ABSTRACT

Agriculture is the major economic activity in Uganda employing 65% of the total population. Majority of Ugandans practice rain fed agriculture despite the fact that since 1970, the rain fall trend is unreliable with increasing prolonged droughts. Only 14,420 ha is equipped for formal irrigation and Estimates of Uganda's spatial potential for improved irrigation vary from 170,000 ha to over 560,000, whereas the total potential arable area is 4,400,000 ha. The few irrigation schemes in place are faced with problems such as; poor management, higher maintenance and operational cost and others are manual hence requiring a lot of energy. The purpose of the study was to develop an automated solar powered drip irrigation system that would utilize the abundant sunshine in Busitema to power an irrigation system for tomatoes with the purpose of reducing poverty levels, food scarcity and malnutrition. Since the intensity of solar radiation is complementary to the water demanded by the crop, solar energy is available at the site, cheap in the long run due to low maintenance and operating costs, environmental friendly and a renewable energy. Automation saves time since there is no need for supervision, saves water and energy since watering is done only when there is need, reduces labour demand. The project involved collecting climatic data, soil data, crop data, water supply data and topographical data using methods such as oral interviews, laboratory analysis and using a GPS, drip irrigation designing, pump selection, solar sizing, economic analysis and simulation.

Economic analysis on the project was carried out for a period of 10 years on the automated PV solar powered system in comparison with PV solar powered without automation and diesel pump irrigation systems. The accumulated total costs were \$17540.75, \$13704.377, \$14638.4 for diesel pumped, PV without automation and automated PV solar powered irrigation systems respectively. From the three alternatives, it is seen that PV solar powered without automation has the least expense for the life span of the project but PV solar powered with automation is considered to be the best because of other advantages such as; saving water, energy, and reduced labour demand since watering is done only when there is need.

## REFERENCES

- Ashraf, M. (2012). Design of Drip Irrigation System.
- Bankston, J. D., & Baker, F. E. (1994). Selecting the Proper Pump, (372).
- Clark, G. A., Stanley, C. D., & Csizinszky, A. A. (1993). Water Requirements and Crop Coefficients for Tomato Production in Southwest Florida, 73.
- Dhane, B. S., Kedare, S., Dhane, S. S., Embedded, M. T., Cmrct, S., Embedded, M. T., & Design, V. (2014). Modern solar powered irrigation ssystem by using arm, 20–25.
- FRENKEN, A. p. S. and K. (2001). *Irrigation Manual* (Vol. III).
- Goffau, M. De, Hilmi, M., & Dam, B. Van. (2005). *Cultivation of tomato*.
- Goodwill, D. P. S. &Dr I. M. (2008). Section 1 : Fluid Flow in Pipes, (January), 1–30.
- Helikson, H. J., Haman, D. Z., & Baird, C. D. (1991). Pumping Water for Irrigation Using Solar Energy I, (November), 1–9.
- Ibrahim, D. (2008). *Advanced PIC microcontroller projects in c*.
- M.Abu-Aligah. (2011). Design of Photovoltaic Water Pumping System and Compare it with Diesel Powered Pump, 5(3), 273–280.
- merkley & Allen. (2007). sprinkle and trickle irrigation lecture notes, (BIE5110/6110), 1–315.
- Narale, E. P. D., Rathore, N. S., & Kothari, S. (2013). Study of Solar PV Water Pumping System for Irrigation of Horticulture Crops ., 2(12), 54–60.
- Pereira, L. S., & Allen, R. G. (1990). 5 5.1.1, (mm), 213–544.
- Phocades, A. (2000). Technical handbook on pressurized irrigation techniques.
- Report, F. (2011). Republic of uganda ministry of water and environment a national irrigation. *MWE*, (November).
- Shively, G., & Hao, J. (2012). A Review of Agriculture , Food Security and Human Nutrition Issues in Uganda, 1–42.
- UGANDA BUREAU OF STATISTICS STATISTICAL ABSTRACT. (2014). *U*.