



FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF AGRICULTURAL MECHANISATION AND IRRIGATION

ENGINEERING

FINAL YEAR PROJECT REPORT

**DESIGN AND CONSTRUCTION OF A HYBRID PEDAL AND ENGINE-POWERED
WATER PUMPING SYSTEM.**

CASE STUDY: PAJWENDA VILLAGE, TORORO DISTRICT. BY

S/N	NAME	REG No	CONTACT	EMAIL
01	ABUZEKU BRIAN	BU/UG/2019/0034	0778368728	abuzekubrian@gmail.com
02	NAFULA ALEXANDRINE	BU/UP/2019/0981	0784339836	alexandrinevanessa187@gmail.com
03	MUJOMBA PAUL BARASA	BU/UP/2019/2872	0772578851	mujomba.brian@gmail.com

SUPERVISOR: Prof. Titus B.

*A final year project report submitted to the Department of Agricultural Mechanization
and*

*Irrigation Engineering as a partial fulfillment of the requirement for the award of a
bachelor's degree of Science in Agricultural Mechanization and Irrigation Engineering.*

ABSTRACT

Irrigation refers to the process of providing controlled amounts of water to a specific land area to aid in the growth of lawns, landscaping plants, and crops. Irrigation has attained increasing importance over the world because of the growing demand for food by a rapidly growing world population. Water pumps are currently vital tools for farmers, especially for those who live in regions with little or no rainfall. Diesel, solar, and electric water pumps are the most often used. An electric pump operates under the theory that electrical energy is transformed into mechanical energy, which is then used to transport fluid from one place to another. The pumping system takes water from open wells, bore wells, streams, ponds, canals, etc. (W. Kiprono & Ibáñez Llario, 2020).

The existing diesel and petrol pumps for irrigation would solve this problem but they are not affordable to most farmers in terms of initial purchase and maintenance. Solar and electric pumps are however not well adopted due to uneven electricity distribution and higher initial costs for solar systems. The major purpose of this study was to design a hybrid pedal and engine-powered water pumping system that enables local small-scale farmers to irrigate their gardens in different locations at reduced costs, and increase crop yield, and food production.

The study therefore entails analysis of design requirements for a hybrid pedal and engine powered water pumping system, fabrication, and assembly of every part of a hybrid pedal and engine powered water pump for small to medium size farmers, carrying out cost benefit analysis of the system.

DECLARATION

We MUJOMBA PAUL BARASA, ABUZEKU BRIAN AND NAFULA ALEXANDRINE solemnly declare that this final year project report was prepared out of our own endless efforts and it has never been presented to any institution of higher learning for any award.

MUJOMBA PAUL BARASA BU/UP/2019/2872

Signature

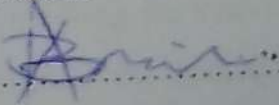


Date

11th.10.2023

ABUZEKU BRIAN BU/UG/2019/0034

Signature

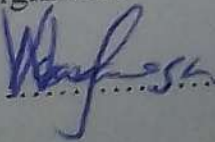


Date

11th / Oct / 2023

NAFULA ALEXANDRINE BU/UP/2019/0981

Signature



Date

11th / 10 / 23

ACKNOWLEDGEMENT

We would like to first acknowledge God's hand of protection and provision throughout the implementation process of our project. We also thank Him for the unity, love, strength, resilience and determination that He has given us to always move on with the project work rather than abandoning it.

We extend our gratitude to our supervisor professor Titus B Watmon for the continual support given to us and more so for funding our project. We pray that may the lord always provide for you and your family.

To the parents, we thank you for being there for us throughout. You have been a strong pillar in our success because of the financial muscle that you provided whenever need arose. May the almighty Lord who never sleeps grant what your hearts desire

We also express our appreciation to the department of Agricultural Mechanization and Irrigation Engineering for standing with us throughout this struggle. In this, we would like to recognize the efforts of the project coordinator Mr. Ambrose Ashabahebwa, head of department Mr. Eriau Emmanuel and other departmental staffs.

APPROVAL

This Final Year Project Report has been prepared and compiled by Mujomba Paul Barasa, Abuzeku Brian and Nafula Alexandrine. It is therefore submitted to be approved by;

APPROVAL

This Final Year Project Report has been prepared and compiled by Mujomba Paul Barasa, Abuzeku Brian and Nafula Alexandrine. It is therefore submitted to be approved by.

Supervisor

Professor Titus B Watmon

Signature

..... *T. Watmon*

Date

..... *12th October 2023*

DEDICATION

I Mujomba Paul Barasa dedicate this report to my beloved family. In this regard I recognize the tremendous support of Miss Anyenge Melda-my mother, Mr. Barasa David- my father, Miss Tamubula Angella, my wife and all other family members who successfully played the mid-field role in my academic journey.

I Abuzeku Brian dedicate this report to Nabirye Dezilanta – my mother, Abuzeku Robert- my father, Abuzeku Jordan – my brother and all other family members who continuously stood for me whenever I needed their assistance.

I Nafula Alexandria dedicate this report to Wafula Jackie Brenda- my mother, Kaihura Vincent Kabagambe- my father, Wafula Ignatius Emmanuel- my brother and all my family and friends who were strong pillars for me to lean on and eventually to achieve this great success.

ACRONYMS

AMI	Agricultural Mechanization and Irrigation Engineering
MWE	Ministry of Water and Environment
MAAIF	Ministry of Agriculture Animal Industries and Fisheries
UN	United Nations
SDGs	Sustainable Development Goals
ASABE	American Society of Agricultural and Bio systems Engineers
FAO	Food and Agricultural Organization
NIR	Net Irrigation Requirement
GIR	Gross Irrigation Requirement
NPV	Net Present Value
BCR	Benefit Cost Ratio
CWR	Crop Water Requirement
ET _o	Reference Evapotranspiration

Table of Contents

ABSTRACT	i
----------------	---

DECLARATION	ii
ACKNOWLEDGEMENT	iii
APPROVAL.....	iv
DEDICATION	v
ACRONYMS.....	vi
LIST OF FIGURES	xi
LIST OF TABLES	xii
CHAPTER ONE.....	1
1.0 INTRODUCTION	1
1.1 Background	1
1.2 Motivation.....	3
1.3 Problem Statement.....	3
1.4 Objectives	3
1.4.1 General objective;	3
1.4.2 Specific Objectives.....	3
1.5 Research questions;.....	4
1.6 Significance.....	4
1.7 Justification	4
1.8 Conceptual framework.....	5
1.9 Scope of the study	5
1.9.1 Conceptual scope.....	5
1.9.2 Time scope.....	5
1.9.3 Geographical scope	5
CHAPTER TWO.....	6
2.0 LITERATURE REVIEW.....	6
2.1 Irrigation.....	6
2.1.1 Relevance of irrigation in Uganda today.....	6
2.1.2 Increasing Population Versus Food security	6
2.1.3 Social Impact.....	7
2.1.4 Design Analysis of solid Shafts.....	7
2.1.5 Design Based on Strength	7

2.1.6 Bearing Selection	8
2.1.7 Design of the Key.....	9
2.1.8 Material Selection.	9
2.2 Pumps.....	10
2.2.1 Classification of the pumps	10
2.2.2 Major types of pumps.....	10
2.2.3 A rotary hand pump	11
2.3 Irrigation water demand.....	12
2.3.1 Crop water requirement.....	12
2.3.2 Effective Rainfall data.....	12
2.4 Specific Objective Two: To Fabrication and Assembly of a hybrid pedal and engine powered water pumping and irrigation system.....	13
2.4.1 Cutting.....	13
2.4.2 Bending	14
2.4.3 Assembling (joining of pieces).....	14
2.5 Specific objective three. Test and carryout a cost benefit analysis of the system.....	14
2.5.1 Questions addressed by the economic analysis.....	14
2.5.2 Main elements of economic analysis	14
2.5.3 Payback period	14
2.5.4 Return on investment	15
2.5.5 Net present value (NPV)	15
2.6 Life Cycle Costing	16
2.7 Gap in Knowledge	16
CHAPTER THREE	17
3.0 RESEARCH METHODOLOGY	17
3.1 Introduction	17
3.1.1 Research design.....	17
3.1.2 Research instruments.....	17
3.1.3 Data collection procedure.....	17
3.1.4 Data analysis	17
3.1.5 System design.....	17

3.1.6 The rotary hand pump	17
3.1.7 Flywheel	17
3.1.8 Sprocket.....	18
3.1.9 Pulley and belt	18
3.1.10 Engine.....	18
3.1.11 Shaft.....	18
3.2 The Engineering drawing	19
3.3 System construction.....	19
3.3.1 Principal operation of a rotary hand pump.....	20
3.3.2 System block diagram	21
3.4 Specific Objective One: Analyze design requirements for a hybrid pedal and engine powered water pumping system.....	21
3.4.1 Design considerations	21
3.4.2 Availability of the materials	21
3.4.3 Marketability	22
3.4.4 Cost of production.....	22
3.4.5 Weight.....	22
3.4.6 Strength of the material	22
3.4.7 Ergonomics.....	22
3.5 THE PUMP.....	22
3.5.1 Pump selection	22
3.5.1 The Pump flow rate (Q).....	22
3.5.2 Irrigation water demand analysis	22
3.5.3 Calculation of effective rainfall.....	24
3.5.4 Total head in the pump	24
3.5.5 Velocity of flow	25
3.5.6 The required power	25
3.5.7 Determination of the pump capacity	25
3.6 CHAIN DRIVE	25
3.6.1 The gear system on a modern bicycle	26
3.6.2 Velocity ratio of chain drives.....	27

3.6.3 Length of the chain and centre distance	28
3.6.4 Factor of safety of chain drives	29
3.6.5 Speed of sprockets.....	31
3.6.6 Engine.....	31
CHAPTER FOUR	36
4.0 RESULTS AND DISCUSSIONS	36
4.1 Design of chain and sprocket system	36
4.2 Design of the flywheel	38
4.3 Engine sizing.....	38
4.4 Design of belt and pulley system	39
4.5 Design of the shaft min diameter	42
4.6 Selection of the pump	44
4.7 Pipe sizing.....	45
4.8 Testing of the machine	46
4.9 Efficiency of the machine	46
4.10 Carrying out a cost-benefit analysis of the prototype.....	47
CHAPTER FIVE	49
5.0 CONCLUSION AND RECOMMENDATIONS	49
5.1 Discussion	49
5.2 Conclusion.....	49
5.3 Summary	50
5.4 Challenges Faced	51
5.5 Recommendation to Practitioners	51
5.6 Recommendations for further studies	51
5.7 Limitations	51
APPENDIX	52
REFERENCES	54

LIST OF FIGURES

Figure 1 showing the project conceptual framework	5
Figure 2 showing various pump classifications	10
Figure 3 showing the engineering drawing	19
Figure 4 shows a photo of a rotary hand pump	20
Figure 5 showing the system block diagram.....	21
Figure 6 showing parts of the chain drive	26
Figure 7 showing the alternative gear arrangements of a sports bike	27
Figure 8 showing relationship between pitch, links and length	28
Figure 9 showing nomenclature of an open belt	32

LIST OF TABLES

Table 1 showing the recommended values of C_{bm} and C_t.....	8
Table 2 showing climate data from CLIMWAT2.0 for CROPWAT	23
Table 3 showing rainfall data for the station	24
Table 4 showing the materials used	45

CHAPTER ONE

1.0 INTRODUCTION

This chapter briefly gives the general information relevant to the design topic whilst clearly showing the problem of interest for the design. It as well shows how this study helps to reduce the problem through the fulfillment of several objectives and activities listed therein.

1.1 Background

Irrigation refers to the process of providing controlled amounts of water to a specific land area to aid in the growth of lawns, landscaping plants, and crops. Irrigation has attained increasing importance over the world because of the growing demand for food by a rapidly growing world population.

According to projections made by the United Nations in 2013, the world's population currently at 7.2 billion, will reach 9.7 billion by 2050, rising at a rate of roughly 1.14% annually. Africa's population, currently estimated at 1.1 billion, is expected to reach roughly 2.1 billion by 2050. The population of Uganda is predicted to be about 45 million, growing at an average annual rate of 3%. (Wanyama et al., 2017). Correspondingly, pressures on earth's finite natural resources, of which arable land is one, are rising in tandem with this growing human population

The majority of the world's agriculture is rain-fed, and as a result, climate change and variability, manifest as unpredictable rainfall patterns and extended dry spells. (Gitz et al., 2016). currently, Irrigation agriculture accounts for 20% of all agricultural land worldwide and generates only 40% of global food production(Transformation & Irrigation, 2017). By allowing for greater crop diversification and production intensification, irrigated agriculture is typically twice as productive per unit of land as rain fed agriculture. (Documented et al., 2022).

The total area in Uganda that is equipped for irrigation expanded from 4,000 hectares in 1971 to 11,000 hectares in 2020, expanding at an average annual rate of 2.40%.(Guanabara et al., n.d.) Despite prior attempts by the Government of Uganda (GoU) to promote irrigation through several supportive programs like the Ugift micro-scale irrigation program, and BADEA, among others, less than 1% of agricultural families in Uganda employ irrigation.(Wanyama et al., 2017).

REFERENCES

- ACODE. (2022). *Performance of DistrictLocal government councilsand the challenges toEffective service delivery*. 1–3.
- Area, I., Total, W., Eisenhauer, D. E., Martin, D. L., & Heeren, D. M. (2021). *Chapter 1 Introduction to Irrigation*. 1–9.
- Chan, C. Y., Tran, N., Pethiyagoda, S., Crissman, C. C., Sulser, T. B., & Phillips, M. J. (2019). Prospects and challenges of fish for food security in Africa. *Global Food Security*, 20, 17–25.
- Documented, D. P., Rainfed, N., & Authority, A. (2022). *Accelerating the Growth o f Rainfed*. July.
- Doering, O., & Sorensen, A. (2018). The land that shapes and sustains us. *How to Feed the World*, 46–58. <https://doi.org/10.5822/978-1-61091-885-5>
- Gitz, V., Meybeck, A., Lipper, L., Young, C., & Braatz, S. (2016). Climate change and food security: Risks and responses. In *Food and Agriculture Organization of the United Nations*. <https://doi.org/10.1080/14767058.2017.1347921>
- Guanabara, E., Ltda, K., Guanabara, E., & Ltda, K. (n.d.). *No 主観的健康感を中心とした在宅高齢者における健康関連指標に関する共分散構造分析 Title*.
- Gupta, D., Mann, S., Sood, A., & Gupta, R. K. (n.d.). *PHYTOCHEMICAL , NUTRITIONAL AND ANTIOXIDANT ACTIVITY EVALUATION OF SEEDS OF JACKFRUIT (ARTOCARPOUS HETEROLPHYLLUS LAM .)*. 336–345.
- Kašpar, M., Bližňák, V., Hulec, F., & Müller, M. (2021). High-resolution spatial analysis of the variability in the subdaily rainfall time structure. *Atmospheric Research*, 248, 105202.
- Khurmi, R. S., & Gupta, J. K. (n.d.). [A Textbook for the Students of B A TEXTBOOK OF A TEXTBOOK OF A TEXTBOOK OF A TEXTBOOK OF A TEXTBOOK OF Top. In *Engg. Services*.
- Mason-D’Croz, D., Sulser, T. B., Wiebe, K., Rosegrant, M. W., Lowder, S. K., Nin-Pratt, A., Willenbockel, D., Robinson, S., Zhu, T., & Cenacchi, N. (2019). Agricultural investments

and hunger in Africa modeling potential contributions to SDG2–Zero Hunger. *World Development*, 116, 38–53.

Moseki, O., Murray-Hudson, M., & Kashe, K. (2019). Crop water and irrigation requirements of *Jatropha curcas* L. in semi-arid conditions of Botswana: applying the CROPWAT model. *Agricultural Water Management*, 225, 105754.

MWE. (2019). *Improving Livelihoods through water for production. Episode 2. Episode 2*(September). <https://www.mwe.go.ug/library/improving-livelihoods-through-waterproduction>

Rosa, L., Chiarelli, D. D., Rulli, M. C., Dell’Angelo, J., & D’Odorico, P. (2020). Global agricultural economic water scarcity. *Science Advances*, 6(18), eaaz6031.

Transformation, A., & Irrigation, T. (2017). *MINISTRY OF AGRICULTURE , ANIMAL INDUSTRY AND FISHERIES MINISTRY OF WATER AND ENVIRONMENT. November.*

W. Kiprono, A., & Ibáñez Llario, A. (2020). Solar Pumping for Water Supply. In *Solar Pumping for Water Supply*. <https://doi.org/10.3362/9781780447810>

Wanyama, J., Ssegane, H., Kisekka, I., Komakech, A. J., Banadda, N., Zziwa, A., Ebong, T. O., Mutumba, C., Kiggundu, N., & Kayizi, R. K. (2017). *Irrigation Development in Uganda : Constraints , Lessons Learned , and Future Perspectives. 143*(1). [https://doi.org/10.1061/\(ASCE\)IR.1943-4774.0001159](https://doi.org/10.1061/(ASCE)IR.1943-4774.0001159) .

Yemata, D. (2020). *Assessment of traditional irrigation water management: the case of Shina traditional irrigation Schemes, West Gojam Zone.*