DROPS TO WATTS: RAINWATER HARVESTING SYSTEM FOR IOT BASED MONITORING USING ESP32

A Project
Presented to the Faculty of the
Computer Studies Department
College of Science
Technological University of the Philippines
Ayala Boulevard, Manila

by:

Angela A. Concepcion

Desiree A. Dumaguing

Glen B. Mataya

Eisen Lois E. Moises

In Partial Fulfillment
Of the Requirements for the Degree
Bachelor of Science in Information Technology

June 2024

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Ayala Blvd., Ermita, Manila, 1000, Philippines | Tel No. +632-5301-3001 local 608 Fax No. +632-8521-4063 | Email: cos@tup.edu.ph | Website: www.tup.edu.ph	Index No.	TUPM-F-COS-16-TAU
	Revision No.	00
THESIS APPROVAL SHEET FOR THE UNDERGRADUATE PROGRAMS OF THE COS	Date	07012022
	Page	1 / 1

This thesis hereto entitled:

DROPS TO WATTS: RAINWATER HARVESTING SYSTEM FOR IOT BASED MONITORING USING ESP32

prepared and submitted by **ANGELA A. CONCEPCION, DESIREE A. DUMAGUING, GLEN B. MATAYA, EISEN LOIS E. MOISES** in partial fulfillment of the requirements for the degree **BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY** has been examined and is recommended for approval and acceptance.

PROF. DARWIN C. VAGAS
Adviser

Approved by the Committee on Oral Examination with a grade of **PASSED** on MAY 31, 2024.

PROF. MAY M. GARCIA
Chairman

PROF. ARIEL L. TOMAGAN
Member

PROF. EDWARD N. CRUZ
Member

PROF. DOLORES L MONTESINES
Department Head

Accepted in partial fulfillment of the requirements for the degree **BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY**

Date: ____________

DR. JOSHUA T. SORIANO
Acting Dean

Transaction ID	TUPM-COS-TAU-ELS-07012022 -0258PM
Signature	

Transaction ID Legend: TUPX-AAA (Office Code)-BBB (Type of Transaction)-CCC (Initial of employee)-MMDDDYYYY (month day year)-HHMMAM/PM (hourminutesAM/PM)

ACKNOWLEDGMENT

We would like to express our sincere gratitude and appreciation to all those who have contributed to this research. Your support, guidance, and involvement have been invaluable, and we are truly grateful for your contributions.

First and foremost, we would like to express our sincere gratitude and admiration to Professor Darwin C. Vargas, our thoughtful, trustworthy, and understanding Thesis Advisor, who offered direction and inspiration during the study project. To Professor May M. Garcia, our Capstone and Research 1 Advisor, as well. Having these respected professors as our capstone advisers has been a true blessing; Their mentorship, financial support, encouragement, collaboration, and feedback have played a significant role in the success of this research, and we are immensely grateful for their involvement.

We would also like to express our heartfelt appreciation and gratitude to our parents for their financial support and unwavering belief that served as a constant source of motivation and inspiration. If it is not for their support this project will not be possible.

To our friends and colleagues, especially our “Mito Family” the motivation and unwavering emotional and mental support have created a sense of solidarity. Their unselfish help and collaboration while still focusing on their project helped finish this research.

Once again, we extend our heartfelt gratitude to everyone who has contributed to our research. Your presence and support have been a huge help for the success of this project, and we are honored to have had the opportunity to work with you.

ABSTRACT

Increased global demand for clean power generation, pollution and lack of water resources have spurred scientific community into coming up with advanced solutions in form of technologies. This study developed a rainwater harvesting system with IoT-based monitoring system utilizing ESP32 microcontroller for the purpose of maximizing the storage of rainwater while also using turbine technology to generate electricity. The main purpose of this study was to establish a monitoring system which can acquire data in Realtime and to assess the potential of the developed monitoring system to produce renewable energy. The management of data was done through Blynk IoT platform, while the dashboard was user-friendly, allowing one to monitor the performance of the prototype. Technologically, the merging of Blynk IoT platform helped in the effective management of operations. These findings suggested enhanced data monitoring and efficiency within water storage structures. User feedback pointed to its efficiency and simplicity in utilizing the system, therefore it can be concluded that the system has high applicability in the real world. It also highlighted the fact that the Rainwater Harvesting System not only enhances the utilization of water but also helps in the generation of renewable energy. The speed of turbine depends on the pressure of the water that is supplied from the storage tank where only 70 liters of water out of 110 liters is discharged per cycle and is effectively utilized by the turbine. The study also suggested the use of lithium batteries instead of lead-acid batteries to facilitate interconnection with a Battery Management System (BMS) and balancer; thus, improving the system efficiency and safety. Besides, the use of sensors for the purpose of automated control is recommended for enhancing the possibilities of the system. These findings highlighted the possibility of adopting IoT with rainwater in renewable energy to make the necessary progress for further real-world applications.

TABLE OF CONTENTS

		Page
TITLE PAGE		i
APPROVAL SHEET		ii
ACKNOWLEDGEMENT		iii
ABSTRACT		iv
TABLE OF CONTENTS		v
LIST OF TABLES		vi
LIST OF FIGURES		vii
LIST OF APPENDICES		viii
Chapter 1.	**THE PROBLEM AND ITS SETTING**	**1**
	Introduction	1
	Background of the Study	3
	Objectives of the Study	6
	Scope and Limitations of the Study	7
Chapter 2.	**CONCEPTUAL FRAMEWORK**	**9**
	Review of Related Literature	9
	Related Studies	39
	Conceptual Model of the Study	43
	Operational Definition of Terms	47
Chapter 4.	**RESULTS AND DISCUSSION**	
	Project Description	66
	Project Structure	66

	Project Capabilities and Limitations	74
	Test Results	75
	Evaluation Results	77
Chapter 5.	**SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS**	
	Summary of Findings	80
	Conclusions	82
	Recommendations	84
References		85
Appendices		90
Researchers’ Profile		120

LIST OF APPENDICES

Appendix		Page
A.	Evaluation Form	90
B.	Survey Questionnaire	93
C.	Results of Survey	99
D.	Evaluation Results	113
E.	Sample Answered Evaluation Sheet	114
F.	Documentation	121
G.	Thesis Grammarian Certification	123
H.	Certification of Similarity Index Using Turnitin	124

LIST OF TABLES

Table		Page
1	Computation for Pressure	51
2	Tested Devices	52
3	Functionality Test	65
4	Likert Scale: Numerical Rating and its Descriptive Interpretation	67
5	Functionality Test Result of the Rainwater Harvesting System	78
6	Evaluation Result	81

LIST OF FIGURES

Figure		Page
1	Conceptual Model of the Study	43
2	System Architecture of Drops to Watts	48
3	Electrical Flow of Drops to Watts	49
4	Prototype Design	50
5	Flowchart of IoT Based Rainwater Harvesting for Renewable Energy and Utility Water Management's Main Process	54
6	Predefined Process for Rainwater Filtering	55
7	Predefined Process for Flowing Water in the Turbine	56
8	Predefined Process of Battery Charge Control	57
9	Prototyping Method Model	59
10	Filter	67
11	Catch Basin 1	68
12	Turbine	68
13	Catch Basin 2	69
14	Charge Controller	69
15	Inverter	70
16	Battery	70
17	Outlet	71
18	ESP32 Microcontroller	71
19	Login Form	73
20	Blynk Application and Dashboard	73

21 Notification System 73

Chapter 1

THE PROBLEM AND ITS SETTING

Introduction

In the quest to find new ways to harness renewable energy and provide sufficient access to water, the confluence of these critical issues has sparked the creation of groundbreaking technology. These developments not only aim to meet the growing demand for renewable energy generation on a worldwide scale but also address urgent problems related to pollution and water scarcity. Among these innovative approaches, the combination of rainwater harvesting with turbine technology stands out as a potential method to achieve two crucial objectives: sustainable energy production and the provision of usable utility water for people.

Conventional techniques for producing energy and providing water can exacerbate socioeconomic inequities, deplete valuable resources, and harm the environment. The increasing problem of water shortages, driven by factors such as population expansion, urbanization, and pollution, was compounded by the significant contribution of fossil fuel-based energy systems to greenhouse gas emissions and climate change. In response to these challenges, researchers and engineers focused on cutting-edge technologies that could address both energy and water sustainability simultaneously, underlining the urgent need for sustainable solutions.

IoT Based Rainwater Harvesting System evaluated the concept of utilizing rainwater as a valuable resource for domestic utility purposes to ensure that everyone has access to water—a basic human need—while also generating sustainable power using advanced turbine technology. Ingenious turbine designs can fully exploit the benefits of this commonly underutilized resource by collecting and utilizing rainwater directly where it falls. These groundbreaking innovations transform rain into a clean, renewable energy source by efficiently harnessing the kinetic energy created by rainwater runoff, aiming to translate local water shortage issues into flexible water resources.

Incorporating Blynk IoT, an advanced Internet of Things (IoT) platform, into this innovative ecosystem enhances the project's capacity for data monitoring, device management, and analytics. Blynk IoT's integration facilitates a more sophisticated approach to tracking energy production and water usage efficiency, optimizing resource allocation, and improving the overall system's sustainability and impact. This IoT platform's capabilities are crucial for overcoming obstacles in effectively combining turbine technology and rainwater collection, providing a comprehensive solution for efficiently converting rainwater into electricity across various flow rates and intensities. Moreover, Blynk IoT supported system efficiencies by enabling precise monitoring of environmental conditions, thereby sustaining water quality without compromising system performance.

The integration of IoT into this study highlights the potential and likelihood of such integrated systems being widely adopted, aiming to enhance people's quality of life globally through a detailed analysis that considers economic viability, scalability, and environmental impact. By leveraging IoT technology, this research endeavors to push the boundaries of what is possible in the realms of sustainable energy production and responsible water management, charting a course toward a more sustainable and equitable future.

Background of the study

The world's expanding demand for energy, along with the depletion of fossil fuels and the environmental issues they generated, needed a rapid change to renewable energy sources. Technological developments enabled the development of innovative methods for renewable energy generation, storage, and transmission. Considering the rapidly expanding opportunity for the Internet of Things (IoT) to revolutionize a wide range of fields, this study focused on innovative turbine technology that worked with ESP32 microcontroller to harvest rainfall for renewable power while optimizing consumption of water.

According to Orion Australia (2022), renewable energy is used in generating power from natural processes; it is currently being utilized to meet the ever-increasing demand for energy worldwide. Brownouts are still prevalent, and power restoration might have been delayed, making dependable energy sources crucial for economies, powering technology, transportation, lighting, and household needs (Owusu & Sarkodie, 2016). However, the Philippines frequently experiences bad weather due to its tropical position and the existence of the southwest monsoon. The frequency and severity of the nation's heavy rainfall events were both increasing and caused by climate change. For those who live in rural or distant places, where it might have been difficult for them to obtain basic services and supplies, these effects could have been more severe. Frequent rains also result in food shortages, financial losses, and population displacement (Novio, 2022).

The Philippines has limited access to both water and power due to its vulnerability to disasters, aged infrastructure, and rising urban demand. It also has challenges in utilizing renewable resources and reducing environmental damage. According to Tan (2020), 9 million out of 101 million lacked access to dependable and clean water sources. From people living in rural regions to those residing in Metro Manila, the country's capital, everyone is affected by the issue of an inconsistent and poor-quality water supply. Taniguchi (2019) stated that the Philippines experiences high prices, harm to the environment, and disparities in access between urban and rural areas because of its dependence on coal for energy.

In business environments, dependable backup power is not just handy—it is necessary to ensure operational continuity in the event of power outages or natural disasters, which could have been vital to sustaining profitability. Among the several backup power options, lead-acid batteries have been shown to be a dependable and affordable option. Knowing that lead-acid batteries could generate strong bursts of power, they are well suited for applications that require abrupt, considerable power surges, such as starting motors or powering essential equipment. Lead-acid batteries are being integrated by businesses with renewable energy sources, such as solar and wind, to produce sustainable backup power and lessen dependency on the grid (Space Light Power, 2023).

The Internet of Things (IoT) has emerged as a fast-rising organization, with an opportunity to provide considerable socioeconomic advantages to developing and emerging countries (Hosny et al., 2022). The Internet of Things has an important role in the field of renewable energy since technology uses sensors to track the operation of renewable energy sources. IoT also makes it easier to integrate renewable energy into the larger power grid by controlling electricity flow between renewable energy sources and the electrical system to increase reliability and effectiveness. Noor and Hassan (2019) pointed out that advances in networking technology, system availability, and computer systems involving Arduino and ESP32 microcontroller, among others, accelerated the growth of the IoT.

Hydroelectric electricity is generated through the kinetic energy of falling water. Water falling from a certain height given out some amount of energy depending on the speed at which it flowed (Water Science School, 2018). Using turbines as generators of power in areas having substantial rainfall amounts, as an example of enhanced electricity resources of renewable nature is possible (Carter et al.). The innovative technology enhances the collection of rainwater, making it more sustainable and efficient with less water usage and a reduced possibility of flooding. Rainfall generation helps reduce the reliance on fossil fuels for electricity; it enhances the productivity and sustainability of rainwater harvesting.

This study developed an innovative technology for producing electricity from rainfall while also reusing the collected water for utility purposes through the implementation of Internet of Things (IoT) technologies and turbine technology while working with ESP32 microcontroller. This developing technology has the potential to have an important impact in the field of renewable energy by decreasing the dependency on fossil fuels while also improving the quality of everyday life in communities with limited access to electrical power. The paper addressed the technology’s concept, design, and prospective applications, focusing on its sustainability and advantages for both energy and water management utility.

Objectives of the Study

The study aimed to develop a functional prototype that uses rainwater and a water turbine to produce electricity for basic appliances, emergency use, and non-potable water for utility use. By implementing the prototype, significant reductions in electricity and water consumption were achieved, resulting in cost savings for households.

Specifically, it aimed to:

1. Design the prototype with the following features:
    a. Prototype functionalities involve the following:
        - Filtering leaves and dust from the gutter
        - Converting mechanical energy into electricity
        - Produce electricity for emergency purposes
        - Can store water for utility use
    b. ESP32 involves the following:
        - Track the energy produced by the turbine
        - Track the battery percentage
        - Track the energy consumption
        - Sends the data to the IOT application
2. Create the prototype by using ESP32 microcontroller, Lead Acid Battery 12V 100ah, 12V Water Turbine, Blynk IoT Application
3. Test and improve the prototype based on the functional suitability and usability of prototype functionalities.
4. Utilize TUP Evaluation Instrument to assess the prototype is level of acceptability.

Scope and Limitations of the Study

This study focused on designing, developing, and evaluating a prototype that combines rainwater harvesting with turbine technology to address energy and water scarcity in communities lacking conventional resources. The prototype aimed to provide sustainable electricity and non-potable water using specified hardware and a software IoT platform for monitoring, which was Blynk. The scope included the design and development of a functional prototype that integrated rainwater collection and turbine technology. The prototype could store up to 110 liters of water for utility use, suitable for applications such as irrigation, flushing toilets, and other non-potable purposes. The Blynk IoT platform facilitated real-time monitoring of the prototype. Rigorous testing and data analysis were conducted to refine and optimize the prototype's performance. Finally, a thorough evaluation assessed the effectiveness of the prototype in generating electricity and providing non-potable water.

The prototype was designed with functionalities such as filtering leaves and dust from the gutter, ensuring that the collected rainwater was clean and free from large debris. This was crucial for maintaining the functionality of the water turbine and the overall system. The prototype also included converting mechanical energy into electricity via a 12V water turbine, harnessing the kinetic energy from the flowing water to generate electricity. This feature was essential for providing a renewable energy source, especially for emergency use. Producing electricity for emergency purposes meant that the generated electricity was primarily intended for low-energy applications like basic lighting and small appliances, serving as a backup power source in critical times. Storing water for utility use was achieved with the system’s ability to hold up to 110 liters of water, making it suitable for non-potable applications like irrigation and toilet flushing, addressing water scarcity by providing an alternative water source.

The ESP32 microcontroller tracked the energy produced by the turbine, battery percentage, and energy consumption, sending this data to the IoT application. This tracking and transmission ensured users could monitor the system's performance and make informed decisions. The IoT application displayed the energy produced by the turbine, battery voltage, battery percentage, and energy consumption, also providing user notifications and battery level updates, facilitating effective management of the system. The materials used in the prototype included the ESP32 microcontroller, a Lead Acid Battery 12V 100ah, a 12V Water Turbine, and the Blynk IoT Application.

Despite its focused approach, the study acknowledged several limitations. A comprehensive economic analysis, including production costs and revenue streams, was beyond the scope of this study. This omission meant that the financial feasibility of large-scale implementation remained unassessed. The scalability of the technology to larger applications, such as increased turbine capacity and power distribution infrastructure, was not addressed, limiting the understanding of how the system might perform in more extensive setups. Detailed environmental assessments on local ecosystems, water quality, and sustainability were also excluded from the study, indicating that the prototype's broader environmental implications were not thoroughly evaluated. The ESP32 microcontroller, which was integral to the prototype's monitoring system, involved limitations such as the dependency on the IoT application for data tracking and real-time monitoring, which might not be ideal in areas with limited internet connectivity or technical support.

The prototype was designed for small-scale applications, potentially limiting its suitability for larger populations or households. This limitation meant that its effectiveness for larger populations or households with higher energy demands might be restricted. Reliance on rainwater collection posed challenges in regions with minimal rainfall, necessitating alternative water sources during dry periods. Additionally, the electricity generated might have been insufficient for high-energy demand households, restricting the prototype's application to basic lighting and small appliances. The capacity to store water for utility use also depended on the size of the storage system, which was designed to hold a specific number of liters, suitable for uses such as irrigation, flushing toilets, or other non-potable applications.

Despite these limitations, this study hopes to make significant contributions to the field of renewable energy by exploring an innovative, sustainable approach to generating electricity and providing non-potable water. The evaluation emphasized its strengths in usability, aesthetics, and safety, reinforcing its suitability for its intended purpose. Overall, this study underscored the importance of innovative approaches in renewable energy to address critical challenges faced by communities lacking conventional resources. The prototype's combination of functionalities, including effective filtering, energy generation, and water storage, demonstrated a comprehensive approach to addressing these challenges.

Chapter 2

CONCEPTUAL FRAMEWORK

This chapter presents a review of literature and studies relevant to the study. It includes the conceptual framework and operational definition of terms.

Review of Related Literature

This section presents key concepts and ideas on the topic of the study. It includes discussions on climate change, water waste, electricity shortage, rainwater collection, water filter, renewable energy, water turbine, inverter, charge controllers, lead acid battery, ESP32 microcontroller, Iot, floater, and flapper.

Climate Change and its Effects

The Philippines experiences a tropical maritime climate characterized by high temperatures and abundant rainfall. This section initially explores the key features of this climate, which is heavily influenced by the alternating Amihan and Habagat monsoons, resulting in distinct rainy season patterns across different regions. The islands are frequently subjected to powerful typhoons originating from the western Pacific, although the severity of these storms varies from year to year, depending on broader atmospheric conditions and the presence or absence of phenomena like El Nino or La Nina. Even when typhoons did not make direct landfall in the Philippines, they can still bring substantial rainfall and contribute to flooding by intensifying the habagat southwest monsoon. Local factors can also influence precipitation patterns on various spatial and temporal scales. Despite being predominantly rainy, the country can experience episodes of drought, posing challenges for agriculture, particularly rice cultivation.

Climate change stands out as a significant driver of change in the intricate interplay of elements that affect rainfall patterns in the Philippines. Typhoons and excessive precipitation are just two examples of severe weather occurrences that have become more frequent and intense as a result of global climate change, according to studies (Mendelsohn et al., 2012). In addition, the Philippines' distinct topography and geographic location contribute to the high degree of rainfall unpredictability. It has been established that the El Nio and La Nia phenomena have a significant impact, causing periods of drought and heavy rainfall (Natividad et al., 2016). Research has also looked at long-term rainfall trends in different locations, indicating spatial variances where some places see increases in rainfall while others see decreases, creating difficulties for the management of water resources and agriculture (Monsanto & Eugenio, 2019).

The Philippines is particularly vulnerable to tropical cyclones, which frequently bring with them severe thunderstorms and flooding (Nilo et al., 2013). Tropical cyclones play a significant impact in determining rainfall patterns. Cities' rainfall difficulties are made worse by urbanization, as greater rainfall volume and decreased infiltration contribute to flooding issues. Due to the direct effects of rainfall variability on agriculture, a crucial industry in the Philippines, research has been conducted to examine the relationship between rainfall patterns and agricultural productivity and the adoption of climate-resilient techniques (Lobell et al., 2019).

Planning for adaptation has benefited from the ability to predict future rainfall patterns in the Philippines thanks to climate modeling (Cruz et al., 2019). Strategies for managing water resources have been created to ensure sustainable resource use, taking into account shifting rainfall patterns and rising water demand (Soriano & Mallari, 2017). In addition, remote sensing technology, such as satellite data and rainfall gauges, is essential for early warning and real-time monitoring of extreme weather occurrences (Tapiador et al., 2019). Last but not least, community-based adaptation techniques that are grounded in local knowledge and practices have become more important for assisting communities in overcoming the difficulties brought on by changing rainfall patterns and extreme weather events (Lasco et al., 2014).

Climate change impact on water resources

Global hydrological cycles are changing, and one of the main factors behind this change is climate change. The dynamics of snowpack, rainfall timing, and rainfall intensity are all changing noticeably as a result of the increased global temperatures brought on by climate change. These changes have a direct impact on the distribution and availability of water resources, creating significant problems for areas all over the world (IPCC, 2014). Additionally, research shows that droughts are becoming more frequent and more severe as a result of decreased precipitation and higher evaporation, which is another way that climate change has exacerbated water scarcity in many locations. The availability of water as a whole is being impacted by these conditions, which are hurting both surface water bodies and groundwater reserves (Wang et al., N.D.).

Climate change has accelerated glacial retreat in mountainous areas with glaciers because of rising temperatures. According to Bolch et al. (2019), this phenomenon is changing the timing and volume of glacier-fed river runoff, which has an impact on the number of freshwater resources available downstream. In addition, salty intrusion into freshwater aquifers and estuaries in coastal areas is being brought on by rising sea levels as a result of climate change. Particularly in low-lying coastal areas, this intrusion poses a serious danger to the quality and accessibility of drinking water (Ericson et al., N.D.).

One of the most important factors in preparing for climate change is the interconnection of the water, energy, and food systems. In-depth research has been done on the complex connections between these sectors and integrated approaches have been suggested to provide sustainable resource management in a future with changing climates (Wichelns, 2018). Finally, it is important to consider the social and economic effects of climate change on water resources, especially for disadvantaged groups. The necessity for inclusive and equitable water resource management strategies has been highlighted by research on the equity and justice aspects of water allocation and access in the context of climate-related challenges (Mehta et al., 2019). In conclusion, the extensive effects of climate change on water resources necessitate thorough research and policy action to protect these vital resources for ecosystems, communities, and economies around the world.

Water Waste

One of the planet's most valuable and necessary resources, water is essential for maintaining life and forming the environment. Its importance extends well beyond simply filling of the thirst because water is an essential part of energy generation, agriculture, industry, and numerous other facets of human existence. The use of water has been a pillar of human growth and progress, from the oldest civilizations that lived beside rivers to contemporary cities that survive on water infrastructure. Indeed, water is essential to everyday life, the environment, and the welfare of the entire world. Therefore, it is important to emphasize the necessity for careful and sustainable management of this priceless resource (Kılıç, 2020).

Kammeyer (2023) stated that the global community is now dealing with a wide variety of water problems due to poor water management and rising demands on the world's water supplies. While billions of gallons of untreated sewage and wastewater are continuously thrown into the environment, severely polluting the water supply, millions of people suffer from the urgent lack of safe, dependable water sources. The desiccation of rivers and the conversion of once-thriving lakes into dry wastelands are the results of unsustainable water extraction. The urgency of fixing the insecure water systems is increased further by the growing implications of climate change, which are increasing these already-existing water concerns.

Water waste is a pressing problem of this time, putting at risk the supply of this limited and important resource for both environmental and human demands. Water resources need to be managed responsibly because of the effects of population increase and climate change on water shortage. This waste not only exhausts the freshwater supplies but also places an unneeded burden on the energy sources utilized for water treatment and delivery.

Cariaso (2013) mentioned that when calling for regulations on the operation of swimming pools, golf courses, and car washes, DILG notes that families are the main sources of water waste. Since most of these facilities recycle and purify their water, the review found that water waste from swimming pools, car washes, and water recreation facilities was not very substantial. It shows that households' excessive water use resulted in increased consumption. This year, the LWUA reported spiking water wastage of 30 percent, which is 10 percent higher than the world average for water wastage (Romero, 2023).

The effects of water waste on the environment and human society are extensive and negative. When people waste this valuable resource, the community makes a number of urgent problems worse such as resource depletion, environmental damage, energy consumption, increased costs, food security and the like. According to the World Health Organization (2019), the water shortage in the country could threaten sustainable development and health. People are frequently compelled to rely on drinking water sources that might not be safe when there is a lack of water. In order to address such issues, techniques like the implementation of enhanced rainwater collection systems and cutting-edge desalination technologies in conjunction with renewable energy sources can be utilized. In light of these effects, it is crucial for people, communities, and governments to prioritize water conservation and embrace sustainable practices in order to guarantee a safe and healthy future for everyone's access to water.

A report by Houston Water Solutions (2023) highlighted the importance of water conservation for sustainability that water conservation is a vital part of sustainability and has several advantages. Ensuring that there is enough water in rivers, lakes, and wetlands to sustain a variety of animal and plant species, protects biodiversity and aids in the preservation of ecosystems and natural environments. Water conservation also lowers the energy needed to process and distribute clean water, reducing carbon emissions and improving environmental sustainability. Additionally, it is essential to reduce the consequences of droughts by ensuring enough supplies through techniques like rainwater collection and wastewater recycling, especially in areas vulnerable to water shortages brought on by climate change or resource exploitation. The addition of fair pricing mechanisms and the priority of ecosystem-based initiatives, such as watershed protection, further ensures the achievement of equal access to clean water while safeguarding natural ecosystems. Governments, NGOs, and communities must work together in order to create a sustainable and resilient water future for future generations.

Electricity Shortage

One article by Faridzad et al. (2022) stated that modern economies rely heavily on electricity as a source of energy for everything from homes and industries to advanced technologies. However, the lack of energy has become a significant global issue, with numerous disruptions in the supply of electricity having a substantial impact on several economic sectors. For example, a shortage of electricity in one industry sector can indirectly increase production costs in other industries, which could lead to higher prices for goods and services across the economy. This can have a ripple effect on the economy, leading to lower investment, job losses, and slower economic growth.

The soci-economic effects of unreliable power supply in the Philippines are significant and far reaching, affecting both individuals, enterprises big or small. Although it has improved, power outages are still very common due to problems like increasing consumer demands and ageing infrastructure. Such an attack could lead to catastrophic effects on both companies and customers, especially within areas of power dependent sector. In order to address this, the government must invest in more generation capacity, grid modernization, and increased energy. Investing in renewable energy will reduce the dependency on fossil fuels and enhance the grid. Consumers can also play a role through the use of energy-efficient equipment and saving energy (Francisco, 2022).

Thelwell (2020) emphasized that electricity supply in developing countries like the Philippines is unreliable and inconsistent, especially in rural regions. For those trying to live their everyday lives and build a stable local economy, this causes a serious problem. Brownouts, which are accidental or intentional decreases in the amount of power that an electrical grid produces, occur for up to 30% of Filipinos. Brownouts may have a significant negative effect on people's lives and those who rely on a rural economy.

Although renewable energy sources that are intermittent like wind, solar, and waterpower can contribute to decarbonization efforts, they are significantly different from conventional power plants that can scale or reduce output to meet demand. The power generating system faces additional difficulties as the amount of renewable energy rises, endangering dependability and reducing the case for decarbonization. In response to customer demand for renewable energy to power their homes and businesses, distributed energy resources (DERs), such as rooftop solar panels and battery storage systems, are becoming more and more common (Erdiwansyah et al., 2021).

One of the renewable energy sources that can help with the shortage is hydropower. An established, eco-friendly renewable energy source called hydropower uses the potential energy of falling water to create electricity. Considering that it is a clean and dependable source of power, it is regarded as the most developed and environmentally friendly renewable energy supply. Hydropower facilities are a sustainable investment since they may last for decades. By turning a turbine with the potential energy of falling water, hydropower facilities produce electricity. The generator, which the turbine is attached to, transforms the mechanical energy of the turbine into electrical energy. The water supply for hydropower comes from the water cycle, which depends on solar energy (Kamran, 2021).

Rainwater Collection

Water shortages are a problem in many nations worldwide. To combat the water deficit, water usage can be optimized and conserved as a natural resource. Utilizing the water cycle to generate electricity on rainy days is one way to enhance the use of renewable energy (Nield, 2020). According to Fearon (2020), by collecting and funneling rainfall to power tiny turbines, raindrop energy generation has previously been used as a type of microgeneration to power homes and small water purifying systems. Utilizing piezoelectric materials is an alternate method of producing power from rain. Utilizing the kinetic energy created when raindrops strike the surface, these materials can generate electrical energy. Surface charge builds up as raindrops hit the device, and when water spreads to connect the two electrodes, it discharges this charge, converting kinetic energy into electrical energy. Comparing this technology to comparable devices, it exhibits hundreds of times higher power density and energy conversion efficiency (Lam, 2022).

Aside from generating electricity energy, rainwater is the source of water supply for non-potable and potable use. Rainwater collection, also referred to as rainwater harvesting, is the process of catching and storing rainwater that accumulates on roofs, other surfaces, or catchment areas for later use. Rainwater harvesting systems were recognized by the Federal Energy Management Program (FEMP) as an alternative water technology applicable to federal buildings, is commercially accessible, and may reduce freshwater use.

According to Britannica, simple rain barrels to complicated constructions with pumps, tanks, and purifying systems are all examples of rainwater gathering systems. The non-potable water can be filtered for use as drinking water and utilized to irrigate lawns, wash automobiles, wash clothes, and flush toilets.

Rainfall combines with both soluble and insoluble components from the surfaces it rains on, and as it descends through the atmosphere, it picks up dust and pollutants. Plants, fungus, and other organic items may be contaminants, as well as inorganic elements like dissolved minerals, metals, chemicals, or paints that are water soluble. Rainwater collected from filthy surface runoffs is not acceptable for drinking or cooking, even though it doesn't require a high level of cleanliness for garden or agricultural purposes. The water quality in the rainwater storage tank can be improved by separating the first flush of rainfall from the roof, gutters, and other collection surfaces.

Water Filter

Clean and safe potable water is necessary for health. To make sure water is healthy, it needs to be filtered and purified. These filters remove things like unwanted particles, chemicals, and other stuff from the water. As stated by Simon and Allen (2023), there are different water filters: Activated Alumina, Alkaline and Water Ionizers, Carbon Block and Activated Carbon, Ceramic Filters, Distillation, Reverse Osmosis, Sand and Sediment Mesh and Ultraviolet Light. Not every water filtration method can remove all contaminants and completely purify the water.

A first-flush diverter helps keep one's system clean by letting dirt, leaves, and any poop that gathers on the roof and in the gutters between rain to be washed away right when one starts collecting water. The concept of the first flush in rainwater harvesting systems is an essential component of quality control, with its historical roots in traditional practices. Understanding the variability of the first flush volume due to environmental parameters is a critical aspect of system design. By recognizing the sources of contaminants, especially those originating from the roof surface, and adapting the first flush volume accordingly, rainwater harvesting systems can be optimized to ensure that collected water meets the desired quality standards (Charlebois, 2021).

From the study of Jamal et al (2023), to address the freshwater shortage in a megacity like Dhaka, Bangladesh, the first-flush in rainwater harvesting system was successfully constructed utilizing materials that were readily available. The study's successful conclusion is the provision of good water that is suited for almost every usage. The collected rainwater will not be contaminated by dust, trash, or animal droppings. Additionally, the automatic collection surface would not need to be cleaned on a regular basis, and using this method will allow rainwater to be collected and stored in a healthy and secure manner.

The debris, animal droppings and leaves can get stuck on the downspout and block the water from flowing. To avoid blocking the water from flowing, a leaf filter will be used. According to IBEX Roof (2023), leaf filters are devices that are designed to be mounted on the gutter system to block leaves, twigs, and other debris from getting inside and causing blockages. It is made from strong uPVC material that won't bend or wear out. Also, they have a built-in slope, which means the gutter protection is put at just the right angle to let leaves and stuff slide off easily (Zilinsky, 2020).

Renewable Energy

Renewable energy sources offer a beacon of hope in the fight against climate change, as explored by Panwar et al. (n.d.). These clean technologies harness the sun's immense power, captured in various forms like heat and light, to create sustainable energy streams such as wind, biomass, and geothermal. This shift from traditional energy sources promises significant reductions in carbon emissions, a crucial step towards mitigating global warming.

The journey towards a renewable future, however, is not without its challenges, as Ang et al. (2022) stated. Renewable sources like solar and wind are intermittent, meaning their production fluctuates. Integrating these sources with existing grid infrastructure and dealing with their inherent uncertainty pose significant obstacles. Additionally, the initial costs associated with renewable energy technologies can be high.

Despite these hurdles, the path forward remains clear. Advancements in grid technology and energy storage solutions, as emphasized by Ang et al. (2022), offer promising avenues for overcoming these challenges. Strong government policies and incentives are crucial for making renewable energy commercially viable. Continuous research and development efforts are essential to improve performance and reduce costs.

Rainwater harvesting, an aged-old strategy of preserving water is harvested by collecting and holding the rainfall that would penetrate into the soil (Ha & Schleiger, 2022).

Rainwater harvesting has gained renewed popularity lately as the concern of climate change and water scarcity becomes more pressing. Another way to enhance the efficiency and sustainability of rainwater harvesting is by employing advanced turbine technology (Ali & Sang, 2022). Electricity can also be produced by using the kinetic energy of flowing water through turbines. The electricity generated by the solar panel system might be utilized to power households or enterprises directly or operate pumps or any other equipment which collects, store or deliver rainfall or surface water.

The Philippines, a nation frequently battered by natural disasters and increasingly vulnerable to climate change, offers a compelling case study for embracing renewable energy. Viña et al. (2018) documented the devastating impact of natural disasters like Typhoon Haiyan, a grim reminder of the urgency to address climate change. Holden and Marshall (2018) warned of a future with more frequent and intense storms due to rising global temperatures. These environmental issues, as observed by Crost et al. (2018), can even exacerbate social conflicts.

The Philippine government, in a bold move, signed the Paris Agreement in 2017, pledging a significant reduction in national emissions. This commitment reflects a strong stance against climate change, as noted by Crost et al. (2018). However, the country faces a dilemma. As Mondal, Viña, and others pointed out, rapid development necessitates a growing energy demand. Shockingly, a significant portion of the population still lacks access to reliable electricity.

The Philippines must strive for a sustainable energy future, generating more power through environmentally friendly means. This approach not only addresses the growing energy needs of the nation but also helps preserve its precious environment and contributes to the global fight against climate change. By embracing renewable energy solutions and overcoming the associated challenges, the Philippines can secure a brighter future for its citizens and the planet.

Law in the Philippines about Renewable Energy Sources

A green energy revolution has come to the nation, courtesy to Republic Act No. 9513 which is the Philippine Renewable Energy Act of 2008. It motivates us to switch to a variety of renewable energy sources, such as hydropower, wind, and solar energy, lessening the dependency on harmful fuels. Incentives like the Feed-in Tariff (FIT) System are also provided by this law to those that produce green energy. And it's not only for big businesses; it also extends an invitation to nearby communities to join the transition to renewable energy. However, the ultimate goal is to provide the Philippines a future that is cleaner, brighter, and more sustainable.

Turbine

Recent years have seen a substantial increase in interest in the study and development of micro-hydro turbine systems to produce small amounts of power. This innovation concentrates on using rainwater runoff from rooftops as opposed to conventional hydropower systems, which rely on high head water pipes to convert mechanical energy from flowing water into electrical energy, which is known as "hydropower" or "hydroelectricity."

12V Water Turbine

12V water turbines harness the kinetic energy of flowing water to generate electricity. They are small, portable, and relatively inexpensive to make, making them a promising technology for off-grid and remote locations. The key components of a 12V water turbine include an impeller, a generator, and a housing. The impeller converts the kinetic energy of the water stream into rotational motion, which is then transferred to the generator. The generator converts the rotational motion into electrical energy, producing direct current (DC) electricity at a voltage of approximately 12V (Power Turbines, 2023).

The performance of a 12V water turbine is influenced by several factors, including water flow rate, head pressure, impeller design, and generator design. Water flow rate directly impacts the amount of kinetic energy available for conversion, and higher flow rates generally lead to increased power output. Head pressure, the difference in water pressure between the intake and outlet of the turbine, determines the amount of energy that can be extracted per unit of water, and higher head pressures generally result in improved efficiency. Impeller and generator design play crucial roles in optimizing energy transfer efficiency, and their design considerations significantly impact the overall performance of the turbine (Water Network, 2022).

12V water turbines offer a viable and sustainable solution for generating electricity from flowing water, particularly in small-scale applications. Understanding the components, processes, and factors influencing performance is essential for optimizing the utilization of these renewable energy sources.

Inverter

Static converter class includes inverters as one of its main pieces. For a load to obtain its desired output from the system, converters adjust input electrical characteristics like voltage and frequency. Particularly, the inverters transform DC into AC. Electrical engines and industrial automation are venues for their implementation. Through this, these devices efficiently manage and regulate electrical energy based on different operating needs (Tumino, 2020). According to the article “What Is the Inverter and How It Works” (2023), inverters are smart electrical devices that change direct current electricity into alternating current power, which is what we use most of the time. Converting DC electricity from a battery or solar panel into AC power suitable for operating various devices and equipment, it is a useful tool. The size and capacity of converters vary based on the intended uses. These can range from very large ones that are fully integrated into the power distribution of households, businesses, and industries, to small, portable ones that can be used with personal, portable electronic gadgets or as devices for low loads. The kind and design of the converter can affect the output's efficiency and quality.

Lead-Acid Battery

According to Kataronka (2022), lead-acid batteries are the most extensively utilized and traditional rechargeable electrochemical devices in a wide range of applications, such as backup systems for telecommunications, cars, and UPS systems. Since around 1890, lead-acid batteries have been used commercially for a variety of stationery and mobile applications. These include emergency power supply systems, standalone photovoltaic systems, battery systems for reducing wind power output fluctuations, and vehicle starter batteries. Additionally, pure lead or lead alloys are used to make the majority of lead-acid battery grids. Composite grids, including a copper core electroplated with a layer of tin and lead, have been used in certain batteries. Lead-coated copper composite materials have been used for negative grids in large grids for submarines or traction batteries (Prengaman, 2017).

According to JYC Battery (2023), the characteristics and performance of lead-acid battery are based on this: Nominal voltage (2V, 6V, or 12V) of lead-acid batteries indicates the average voltage throughout charging and discharging. Their capacity varies from tens to several hundred ampere-hours (Ah), measured in Ah. These batteries have a cycle life of several hundred to a thousand cycles and a low self-discharge rate of 1-3 percent per month. Their high charge efficiency (80–95%) allows them to recover a substantial portion of the energy used when charging. Performance is impacted by temperature, and battery reaction time is enhanced when internal resistance is reduced. Lead-acid batteries are typically safe to use under normal circumstances, but it's still important to avoid overloading, overcharging, and over-discharging to avoid any potential dangers or harm. As mentioned by Kataronka (2022), temperature, depth of discharge, energy density, power density, efficiency, self-discharge, and cycle life are some of the factors that affect lead-acid battery performance.

As highlighted by Lencwe, Chowdhury, and Olwal (2020), flooded/vented LABs provide several advantages, such as the ability to carry them easily and without the need for extra water or acid leakage. Additionally, at 25°C, they need fewer overcharges and exhibit little occurrence of acid stratification. These LABs have significant top-of-charge voltage changes, necessitate careful charging and temperature management, and require amplified over-charging at high temperatures. Moreover, because of their low cost, excellent round-trip efficiency, and simplicity of installation, lead-acid batteries are frequently utilized in households. These batteries are frequently used in backup systems for different home applications, emergency power supply systems, and standalone systems with photovoltaic (PV) panels. They have cycle efficiency levels of about 80% to 90% and a normal service life of 6 to 15 years. Lead-acid batteries are also a good choice for home energy storage needs because of their excellent recyclability, easy charging technique, and attractive cost/performance ratio (Kataronka, 2022).

In the article “Electrochemical Energy Storage”, it was mentioned that the lead-acid battery uses a reversible electrochemical mechanism using PbO2 and Pb to store electrical potential. This happens when sulfuric acid and lead dioxide combine chemically to form lead sulfate (PbSO4), which releases electrical energy into the circuit when the batteries are depleted. But when charging with an external electrical current, all that has to be done is reverse the process by gathering electrical energy, which turns lead sulfate back into lead dioxide and sulfuric acid. Lead acid's ability to function as a tool for energy transmission and a type of storage is due to their frequent conversion between various chemical states.

Charge Controller

In a hydro system, the role of a charge controller is akin to activating a load to absorb any surplus energy. According to Ahmed (N.D), charge controllers are essential in battery-based hydro systems to avoid battery overcharging. These controllers typically redirect surplus energy to a secondary load, like an air or water heater. Unlike solar-electric controllers, a micro-hydro system controller does not disconnect the turbine from the batteries. This situation has the potential to generate voltages that exceed the tolerances of certain components or lead to turbine overspeed, which could result in hazardous and destructive voltage spikes. To address this, a load-control governor is employed to oversee the system's voltage or frequency, ensuring that the generator maintains the appropriate load. It manages the activation and deactivation of dump-load capacity as the load profile shifts, or it may physically redirect water away from the turbine runner.

Types of Charge Controllers

Solar energy, known for its versatility and wide-ranging applications, has become a leading renewable resource. According to Sridhar Acharya and Aithal (n.d.), solar energy's ability to supply from a few watts to several megawatts makes it suitable for both households and large industries. Typically, solar energy is used as a supplementary source, stored in batteries, and regulated by inverters. The standards for energy storage range from 12V to 240V DC, highlighting its adaptability in diverse sectors.

One of the primary reasons to choose MPPT over PWM charge controllers is their superior efficiency in energy conversion. MPPT controllers are designed to extract the maximum possible power from solar panels by continuously tracking the maximum power point (MPP) of the panel. This capability allows MPPT controllers to adjust the input voltage and current dynamically, ensuring that the solar panels operate at their optimal efficiency. In contrast, PWM controllers use a simpler method of adjusting the pulse width of the incoming energy based on the current battery voltage. While this method is effective, it does not optimize the energy conversion as precisely as MPPT technology. Consequently, MPPT controllers can achieve efficiency levels up to 30% higher than PWM controllers, particularly under varying weather conditions and when the solar panel voltage is significantly higher than the battery voltage.

MPPT charge controllers excel in varying environmental conditions, making them more suitable for regions with fluctuating weather. The ability of MPPT controllers to adjust the input parameters dynamically means that they can maximize energy capture even during cloudy or partially shaded conditions. This adaptability ensures a more consistent and reliable energy supply, which is particularly important for larger systems with higher power requirements. In comparison, PWM controllers, which rely on a fixed modulation technique, may not perform as efficiently in such conditions, potentially leading to reduced energy harvest and less reliable performance.

Effective battery management is crucial for the longevity and reliability of solar energy systems. MPPT controllers offer more precise management of energy flow to the battery, ensuring that the battery is charged optimally and not overcharged. This precise control helps in extending the lifespan of the battery by preventing the damage that can be caused by overcharging or excessive discharge. While PWM controllers also regulate the flow of energy to prevent overcharging, their simpler mechanism does not offer the same level of precision as MPPT controllers. The enhanced battery management provided by MPPT controllers is especially beneficial in larger systems where battery life and reliability are critical.

Although MPPT controllers are generally more expensive than PWM controllers, their higher efficiency and better performance in varying conditions make them more cost-effective in the long run, especially for larger systems. The increased energy harvest and improved battery management translate into lower operational costs and less frequent battery replacements. For large-scale solar installations, the investment in MPPT technology can result in significant savings over time due to the enhanced performance and durability of the system. In contrast, PWM controllers, with their lower initial cost, may be more suitable for smaller, less demanding systems where the benefits of MPPT technology are not as critical.

SRNE's MPPT charge controllers, are designed to optimize solar energy capture and ensure efficient operation across various applications. These controllers support simultaneous full-power charging and discharging, compatible with various battery types, and include temperature compensation to enhance charging efficiency and battery lifespan. They also feature numerous load operating modes and comprehensive safety protections, making them reliable in diverse environments. Additionally, SRNE controllers offer historical data storage and multiple communication protocols, further enhancing their reliability and efficiency.

MPPT charge controllers provide several advantages over PWM controllers, including higher efficiency, better performance in varying conditions, improved battery management, and greater suitability for large systems. While the initial cost of MPPT controllers is higher, the long-term benefits in terms of energy harvest, system reliability, and cost savings make them the preferred choice for many solar energy applications. SRNE's MPPT charge controllers, with their advanced features and reliable performance, exemplify why investing in MPPT technology is a wise decision for optimizing solar energy systems, ensuring maximum return on investment and sustainable energy management.

ESP32 Microcontroller

The Internet of Things (IoT) has revolutionized the way people interact with the world around them. From smart homes to connected wearables, the ability to connect everyday devices to the internet has opened doors to a future brimming with innovation. At the heart of many IoT projects lies a powerful yet affordable workhorse - the ESP32.

Capabilities of ESP32 Microcontroller

Tailored for the burgeoning Internet of Things (IoT) landscape, the ESP32 microcontroller carves a niche with its comprehensive feature set. At its core lies integrated Wi-Fi connectivity, eliminating the need for external components and enabling seamless connection to wireless networks. This opens doors for data transmission and reception over the internet, empowering remote control and real-time data collection from deployed devices in IoT applications. Imagine a scenario where an ESP32-powered system facilitates remote monitoring and control of home appliances or transmits sensor data from a remote location for centralized analysis.

Beyond mere Wi-Fi connectivity, the ESP32 boasts a robust microcontroller core that serves as the execution platform for user-defined programs. This empowers developers to implement complex calculations for analyzing sensor data or controlling external devices based on programmed logic. While processing power and memory may vary across different ESP32 module variants, they generally offer sufficient resources to tackle a broad spectrum of IoT projects.

Furthermore, the ESP32 bridges the gap between the physical world and the realm of the microcontroller through General Purpose Input/Output (GPIO) pins. These pins function as programmable electrical switches, allowing developers to connect various sensors and actuators. Temperature sensors or light detectors can be interfaced with these pins, enabling the system to gather real-time environmental data. Conversely, actuators like LEDs or motors can be connected to exert control over physical components based on program logic. This feature set paves the way for sophisticated IoT projects, such as smart irrigation systems that adjust watering schedules based on real-time temperature readings.

Specific ESP32 module iterations go a step further by incorporating an Analog-to-Digital Converter (ADC). This crucial component acts as a bridge between analog signals, commonly encountered in sensor outputs like voltage readings, and the digital domain that the ESP32 operates in. By converting these analog signals into digital values, the ADC facilitates the connection of analog sensors to the system. This capability expands the potential applications for ESP32-based projects, particularly those requiring the measurement of continuous variables such as temperature, light intensity, or sound levels.

Finally, the ESP32 provides serial communication capabilities, establishing a vital link between the development computer and the microcontroller. This interface allows developers to program the ESP32 by uploading code using the computer's serial port. Additionally, serial communication facilitates real-time monitoring of the ESP32's behavior, enabling efficient debugging and troubleshooting during the development process. This feature serves as a crucial bridge for developers, allowing them to interact with and refine their IoT creations.

In essence, the ESP32's comprehensive feature set, encompassing integrated Wi-Fi connectivity, a microcontroller core, GPIO pins, an optional ADC, and serial communication, positions it as a feature-rich solution for diverse IoT applications. This unique combination empowers developers to create versatile and interactive IoT projects, seamlessly bridging the gap between the physical world and the vast potential of the internet.

Benefits of ESP32 Mod

By integrating Wi-Fi connectivity, a powerful microcontroller core, GPIO pins, an optional ADC, and serial communication, ESP32 offers a feature-rich solution for developers in the IoT domain, streamlining development processes, enabling remote control and data collection, facilitating powerful processing and real-time interaction with the physical world through sensors and actuators, expanding sensor integration capabilities for a wider range of applications, and simplifying development and debugging for efficient project creation.

Application of ESP32 in Internet of Things

The Internet of Things (IoT) is a transformative technology that connects devices and sensors to the internet, enabling data collection and transmission without human intervention. Common IoT devices include smartwatches, smart TVs, smart appliances, and smart speakers. IoT has significant impacts across various industries, particularly in building automation.

The ESP32 microcontroller, originally designed for educational purposes, is now pivotal in IoT development due to its affordability, versatility, and ability to enable rapid prototyping. This microcontroller features General-Purpose Input/Output (GPIO) pins that facilitate connections to external electronic devices, essential for IoT applications. By connecting these GPIO pins to sensors using jumper wires or ribbon cables, the ESP32 can interface with a variety of sensors, making it a powerful tool for IoT development.

The ESP32 microcontroller offers a compelling solution for specific IoT use cases due to its affordability and compact size, making it ideal for localized data collection and transmission. With the ability to run custom code and connect to the cloud, the ESP32 can be programmed to gather data from nearby sensors and transmit it to designated destinations, streamlining data collection processes for various applications. This makes a critical a critical component in the evolution and implementation of IoT technology.

Programming Languages

ESP32 microcontroller was developed to make computing more accessible to everyone; it is reasonably priced. It also serves as a gentle introduction to physical computing because sensors, actuators, and other devices can be quickly and easily connected to it using the convenient General Purpose Input Output (GPIO) connector. A lot of individuals now have access to physical computing and programming thanks to the

ESP32 microcontroller because it is reasonably priced and almost anyone can get started by simply connecting it to a computer with the use of a USB port. Arduino C/C++ is a fundamental component of the programming environment on the ESP32 microcontroller and is a high-level language which is simple to get started with.

According to Shinde (2023), to interact with sensors, actuators, and other connected devices, microcontroller boards like the Arduino Uno are programmed using the Arduino programming language. In fact, the language is based on C++ and was created to be simple enough for non-programmers and beginners to use. In addition, it's frequently employed in tasks related to robotics, home automation, and Internet of Things (IoT) applications.

The importance of using Arduino C/C++ with the ESP32 microcontroller for coding and automation lies in its versatility and accessibility. Arduino C/C++'s user-friendly syntax and extensive educational resources make it an ideal choice for teaching programming concepts to students of all ages, aligning perfectly with the ESP32 microcontroller's educational mission. Additionally, Arduino C/C++'s vast community support and libraries simplify the development of DIY electronics and IoT projects. Whether creating weather stations, home automation systems, or robotics, Arduino C/C++'s compatibility with the ESP32 microcontroller GPIO pins enables seamless interaction with external hardware, making it a powerful tool for automation and control in various applications.

Arduino C/C++'s versatility and extensive libraries empower developers to embark on diverse projects, ranging from web development to robotics, and its compatibility with the ESP32 microcontroller expands these possibilities. In the realm of web development, frameworks, and libraries for the ESP32 microcontroller enable the building of dynamic websites and web applications, making it a top choice for developers. On the data science front, the ESP32 microcontroller's capabilities support efficient data analysis. When it comes to IoT and robotics, Arduino C/C++'s simplicity and extensive community support make it a preferred language for controlling devices and sensors, bringing projects to life. Arduino C/C++ serves as a unifying language, seamlessly transitioning between these domains, and with the ESP32 microcontroller, it enhances the potential for hands-on learning and innovative applications across a wide spectrum of projects. Whether you're coding a web app, analyzing data, or programming a robot, Arduino C/C++'s adaptability fosters creativity and innovation in diverse fields. Although Python can also be used on an ESP32 microcontroller, due to the ESP32 microcontroller's capabilities and typical project requirements, Arduino C/C++ is often the more popular option for many projects.

Internet of Things

The Internet of Things (IoT) is rapidly reshaping the world into a hyper-connected environment. Everyday objects, from common household appliances to sophisticated wearables, are now being equipped with sensors and software, enabling them to collect, exchange, and analyze data (Morgan, 2020). This essay explored the fundamental concepts of IoT, its operational foundation in Machine-to-Machine (M2M) communication, and the vast potential applications it offers across various sectors. The influx of data generated by IoT devices presents both opportunities and challenges that need to be addressed for its secure and sustainable development.

At its core, IoT leverages Machine-to-Machine (M2M) communication, a standardized method that allows devices to exchange information autonomously (Gazis, 2021). This interconnected network generates massive volumes of data, often referred to as "Big Data." This data offers a more granular and real-time view of our surroundings and can be categorized as BOLD (Big, Open, and Linked Data) (Dwivedi et al., 2017).

The "Big" aspect of BOLD refers to the sheer volume of data collected by IoT devices. This data is frequently more detailed and accurate than information obtained from traditional sources, providing valuable insights (Kaisler et al., 2013). However, managing and analyzing this vast amount of data can be complex (Dwivedi et al., 2017).

The "Open" aspect signifies the potential to share and reuse data across different applications. This fosters innovation and the discovery of unforeseen benefits (Dwivedi et al., 2017). However, this openness necessitates robust security measures to protect sensitive information (Fan et al., 2014; Hossain & Dwivedi, 2014; Hummen et al., 2012; Skarmeta et al., 2014).

Finally, the "Linked" aspect allows for the seamless merging of data from diverse sources, including traditional datasets and real-time IoT data. This interconnectedness fosters a holistic understanding and empowers more informed decision-making (Dwivedi et al., 2017). However, it raises concerns about privacy, requiring careful consideration (Skarmeta et al., 2014).

The potential applications of IoT are boundless. In homes, it can automate tasks and improve energy efficiency. In cities, it can optimize traffic flow, enhance public safety, and promote resource management (Gazis, 2021). In healthcare, it can enable remote patient monitoring and improve medical equipment efficiency (Gazis, 2021). Even rainwater harvesting systems can benefit from IoT monitoring, leading to better water management and system longevity (Misoyannix, 2022).

Despite its vast potential, IoT also presents challenges. Security breaches can expose sensitive personal data, highlighting the need for robust security measures (Fan et al., n.d.). Data management necessitates developing the infrastructure and expertise to handle the influx of information (Dwivedi et al., 2017). Additionally, the lack of universal standards across devices and platforms can hinder interoperability (Gazis, 2021).

In conclusion, the Internet of Things is revolutionizing the world. By harnessing the power of interconnected devices and data analysis, a smarter, more efficient, and sustainable future can be created. However, addressing security, data management, and standardization issues is vital to ensure the secure and sustainable development of this ever-expanding IoT universe.

Application of IoT in Rainfall harvesting

According to Misoyannix (2022), IoT is used in monitoring the rainwater harvesting systems which lead to lower operation cost, better water management process among other benefits such as longer lifespan for the system's components and enhanced tranquility on the part of users IoT technology can monitor such variables as water level, water usage, and the state of filtering system components – pimps and UV lamps. With this information, one can identify problems that can be repaired instead of being very expensive ones or replaced. IoT systems may also be used to increase water use, hence extending the life of the service. By improving their dependability and cost-effectiveness, rainwater collecting systems may be used more efficiently overall. They are reasonably effective and can contribute significantly by using IoT for monitoring.

Floater

The toilet float, often referred to as a filler float or ball float, is an essential part of a toilet's refill mechanism that regulates water levels. The water level in the tank decreases during flushing, which causes the float to fall and opens a valve to allow for refilling (Brain, N.d.). The float rises with the water level and, when it reaches a certain height, triggers the fill valve's mechanism to close off and stop overflowing (Bardi, 2023). According to Lutz (2014), through an arm, the fill valve and floater are linked. Following a flush, the floater rises as the water level in the tank refilled with water. The floater stops the water flow and keeps the tank from overflowing when the water level reaches a predetermined point, triggering a mechanism in the fill valve.

Flapper

Sealing the entry to the bowl is the toilet flapper, an important disc-shaped valve in the tank. The flapper raises to allow tank water to be released for flushing. The flapper closes the entrance to allow for refilling once it is empty. Flappers may deteriorate with time and result in leaks or problems with flushing (Lutz, 2024). According to Hisaka (2024), Water remains in the tank until it is flushed through to the toilet flapper, an essential rubber seal. Under flushing, it raises and lets water flow into the bowl since it is linked to the tank valve. In preparation for the subsequent flush, the flapper reseals when the tank empties.

Related Studies

The following studies were found related to the present study:

One raindrop could power 100 tiny light bulbs. It was proven in the research of Professor Wang Zuankai, Professor Zeng Xiaocheng and Wang Zhonglin who developed a new form of droplet-based electricity generator (DEG) in year 2020. Entitled “A droplet-based electricity generator with high instantaneous power density”, the generator they developed has a structure like a field-effect transistor (FET), enabling great energy conversion efficiency, and it has instantaneous power densities that are hundreds of times higher than those of its competitors without such a structure. When a droplet comes into contact with a surface, a conventional droplet energy generator that relies on the triboelectric effect generates electricity through contact electrification and electrostatic induction.

Researchers at the Indian Institute of Technology (IIT) Delhi have created a device known as the "Liquid-solid Interface Triboelectric Nanogenerator". It was created in the year 2021. The device is designed to produce electrical energy from various sources, including water droplets, flowing water, rain, and ocean waves, by harnessing the principles of the "Triboelectric Effect" and "Electrostatic Induction". In contrast, this study used different sources to produce electrical energy through the Triboelectric Nanogenerator while the study drop to watts is uses rainwater to produce electrical energy through water turbine. Batteries can be used afterwards to store the electricity that the device produces.

The device possesses a straightforward design and is capable of producing a few Milliwatts (mW) of power, an amount adequate for energizing compact electronic gadgets such as wristwatches, digital thermometers, radio frequency transmitters, healthcare sensors, and pedometers. This technology has the ability to generate more electrical power than standard electricity producing techniques.

As the need for sustainable and dependable renewable energy sources grows, hydroelectricity presents a possible solution, as supported by the research conducted by Castro et al. (2023), This study investigated a hydropower generator prototype that was recently created and is intended to be used in rural areas. The prototype produces usable electrical power that can meet a household's demands by using the energy generated by the motion of flowing water. The Archimedes turbine, which efficiently transforms water energy into a form that can be used, is an important component of the system. The generator now converts the mechanical energy that the turbine produces into electrical energy. The system includes a monitoring system that keeps track of the generator's important components to guarantee maximum efficiency. The turbine speed, output voltage, and produced current are all monitored by this system. The turbine and generator's ability to generate the desired amount of energy is demonstrated by the combination of their computed torque and speed values, which were obtained from the data that was gathered. Moreover, two lights were successfully turned on by the researchers during testing, and the input voltage and current needed for lamp operation were shown on an LCD panel. These outcomes confirm that the prototype can produce useful electrical power.

Synthesis of Reviewed Literature and Studies

The literature review provided details on the implications of implementing renewable energies and IoT technologies in the organization. Being prone to natural disasters, Philippines needs sustainable alternatives to the traditional energy sources. Tropics, monsoons, and typhoons also shape the country's maritime climate affecting agriculture and water management. The concern over GHG emissions reduction and addressing environmental issues as pressure increases with increasing energy demand in a country like Germany. Renewable energy resource research deals with solar, wind, bio-mass, hydro, geothermal and ocean energy considering intermittent and grid infrastructure connectivity as challenges.

Practical approaches on rainwater management in Dhaka City, Bangladesh's Households use water abundantly thus polluting the environment and affecting the livelihood. The second consideration is that IoT technology review emphasizes the importance of comprehensive data and correct choices.

Filipinos must remain focused with regard to studies and actions targeted at overcoming obstacles in the use of renewable resources, especially in the preservation of water. It also emphasized important sustainability practices and policies for tackling climate impacts and making a livable planet for all.

Conceptual Model of the Study

The conceptual model of the study is depicted in Figure 1 using the Input-Process-Output Diagram. This diagram gives an overview of the flow and the whole concept of the study.

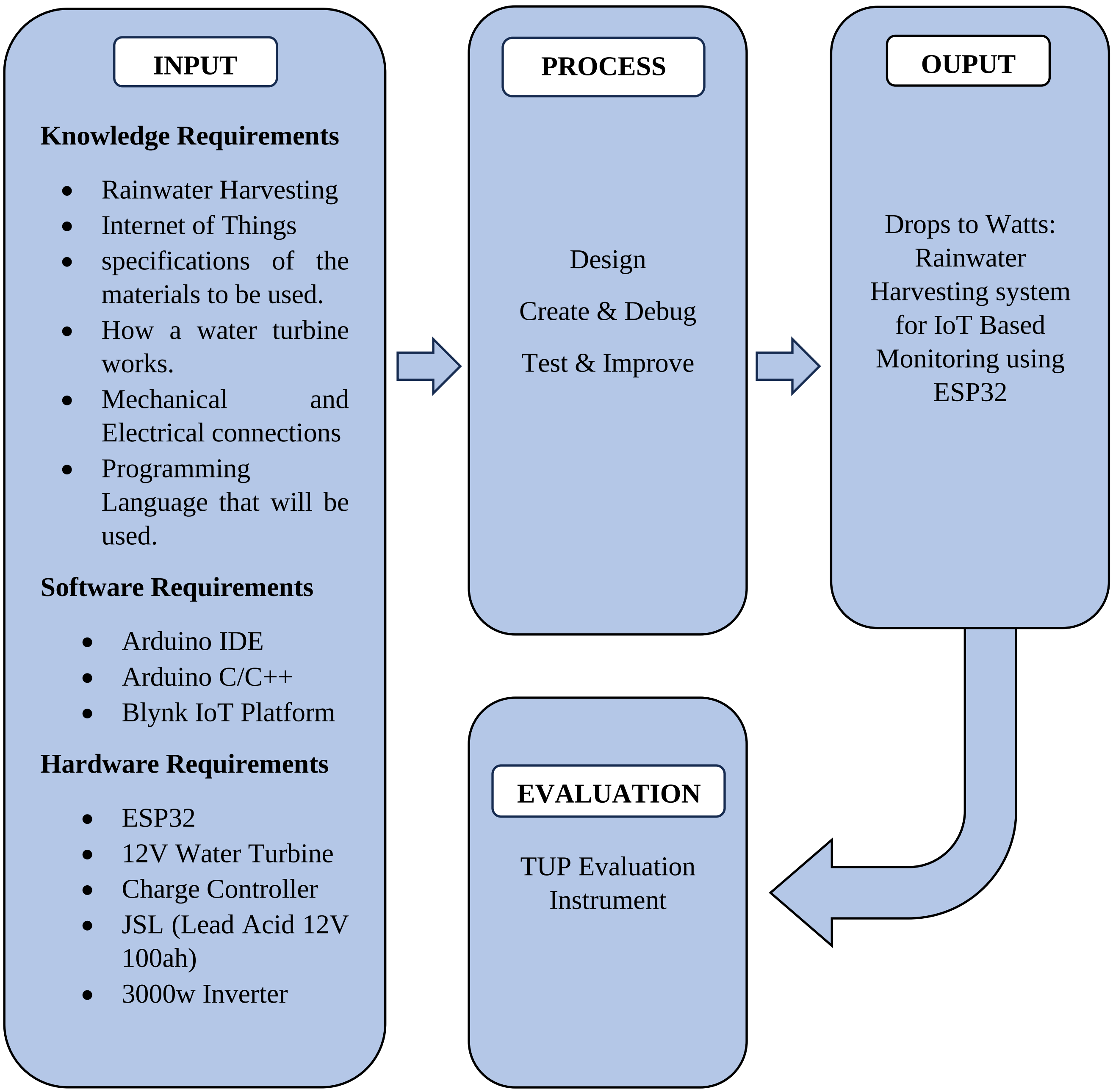


Figure 1. Conceptual Model of the Study

Figure 1 presents the conceptual model of the study using the input-process-output (IPO) model.

Input

The input block contains the knowledge, software, and hardware requirements needed to develop the system and web application for the Rainwater Harvesting System using ESP32 microcontroller.

Process

The process block includes analyzing, designing, constructing/debugging, and testing activities to develop the Arduino device and the web application for the Smart Wearable.

Design. The researchers created a sketch of the prototype and made diagram and flowcharts of the Rainwater harvesting system that is being developed. This allowed them to visually connect all the components required to power the device. This also negated the risk of doing it all over again by miscalculations.

Create & Debug. This phase is where the actual device is assembled or constructed. This is where the coding of the devices was used in every component of the ESP32 microcontroller. The researchers might encounter technical problems with the equipment, device failures, software failures, and so on. This phase also serves as the debugging phase where the device that is visually constructed will inevitably fail or show inaccurate information that the researchers needed to be addressed.

Test & improve. Once the ESP32 microcontroller has been constructed and programmed, the prototype undergoes series of testing after the development phase to improve its ability to convert rainwater-generated energy into electricity accurately. Necessary adjustments will be made to ensure the device functions correctly and reliably.

Output

The constructed Rainwater Harvesting System using ESP32 microcontroller in the output of the study. To establish acceptance, the output, especially the prototype, is subjected to evaluation.

Evaluation

The TUP evaluation Instrument was utilized for the prototype to assess the prototype's acceptability.

Operational Definition of Terms

The Following terminologies are defined for a better understanding of the study.

Catch Basin. refers to a container designed to collect rainwater from the roof.

Flush Diverter. It is a structure built at the beginning of a rainwater harvesting system to prevent the first flow of rainwater, primarily dirt on the roof, from entering the storage tank. This is given that stored rainwater is less likely to be contaminated by dust and debris.

Blyn IoT. A software application that works with the many components of a rainwater harvesting system. This software can monitor aspects such as battery level, turbine voltage, and battery temperature.

Rainwater Harvesting. refers to collection and storage of rainwater that falls on roofs for the subsequent use of the stored water in renewable energy and utility water management.

Renewable Energy. is the energy obtained from renewable sources on a human scale, such as direct sunlight, wind, or rain. A water turbine in a rainwater harvesting system may assist in transforming the mechanical energy of rainfall into electrical energy, which is another type of renewable energy.

Utility Water Management. refers to water conservation and management practices and techniques. Rainwater collection is one technique to lessen dependency on traditional water sources while also promoting sustainable water management.

Chapter 3

METHODOLOGY

This chapter entails the research methodology of the study with the following sections: project design, project development, operation and testing procedure, and evaluation procedure.

Project Design

The system architecture shown in Figure 2 illustrates the function of the prototype rainwater harvesting system. The rainwater went through filters: a leaf screen filter, a one-way funnel, and a foam filter. The container served as the catch basin wherein the rainwater was stored temporarily after the filtering process. The catch basin had a float ball mechanism that went up and was responsible for the release of water when the required water level was reached. The 12V water turbine operates when the required water level is reached. The generated electricity from the water turbine was controlled by a charge controller to protect the battery from potential damage caused by excessive charging and discharging. The battery served as storage for electricity. A 3000-watt inverter was used to convert the stored electricity, or direct current (DC), to a form suitable for household outlets, or alternating current (AC), before it was connected to the charging or outlet station. The ESP32 was responsible for connecting to the IoT platform.

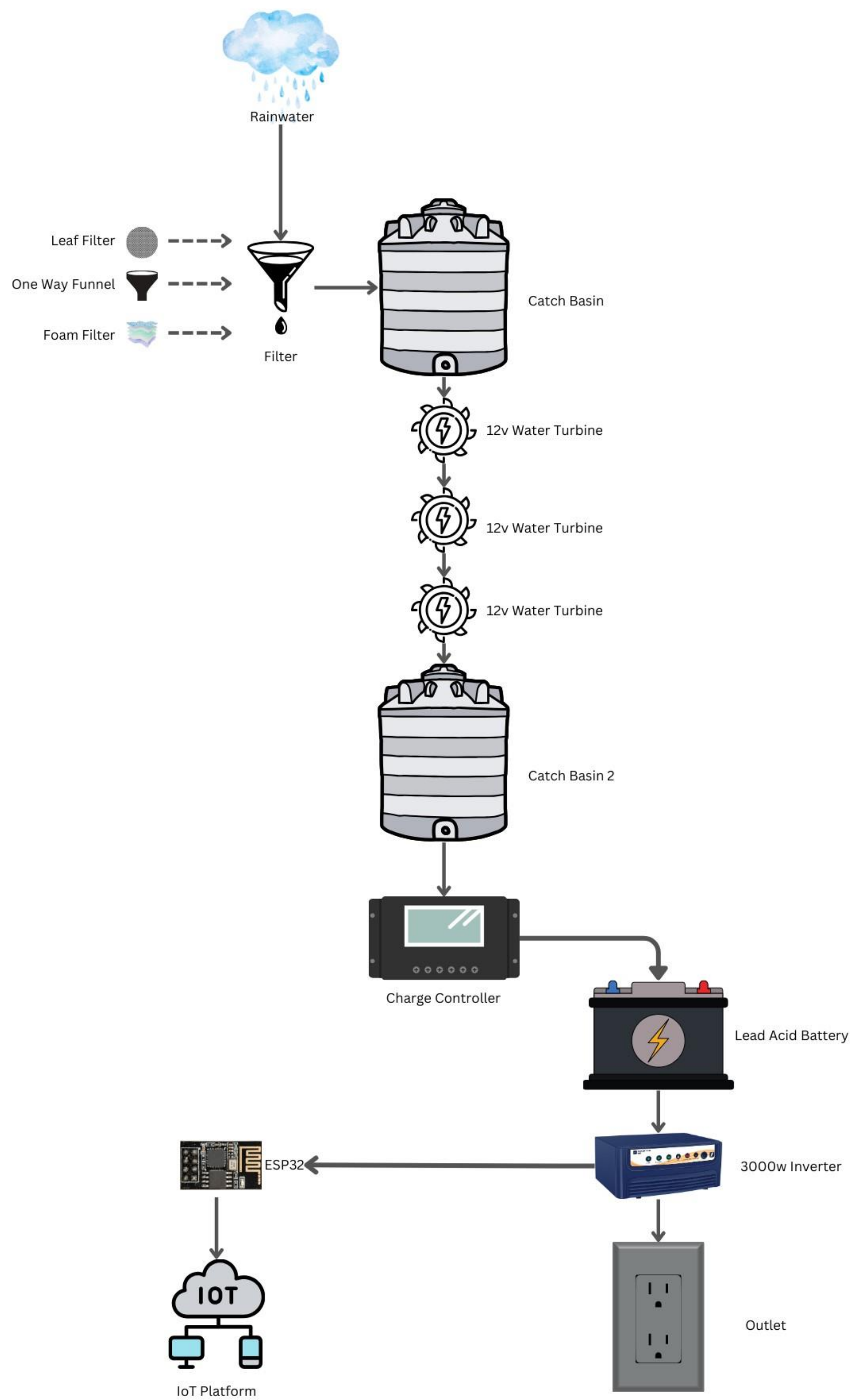


Figure 2. System Architecture of Drop to Watts

Electrical Flow of the Prototype

The diagram illustrated the electrical flow in the "Drops to Watts" rainwater harvesting system, which integrated IoT for monitoring. The process began with turbines that converted the kinetic energy from falling rainwater into electrical energy. This generated electricity was then directed to a charge controller, which regulated the voltage and current to ensure safe and efficient battery charging. The charge controller fed the regulated power into a battery, where it was stored for future use. Connected to the battery was an inverter that converted the stored DC (direct current) power into AC (alternating current) power, which was the standard form of electricity used by most household appliances. Finally, the AC power from the inverter was delivered to a power outlet, making it available for everyday use and emergency use.

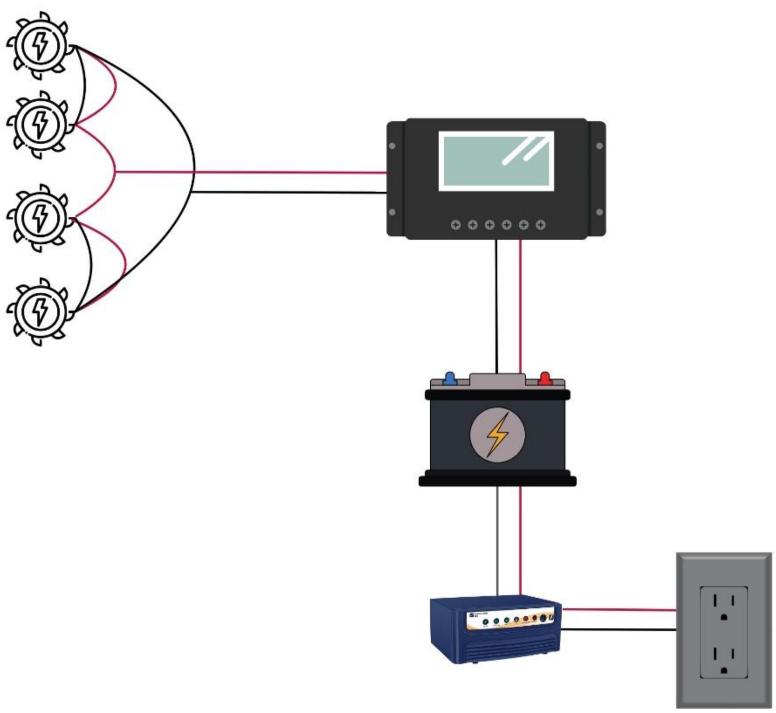


Figure 3. Electrical Flow of Drops to watts

Prototype Design

The prototype design illustrates the prototype setup for a lead-acid battery. The design includes a 12V lead-acid battery securely mounted on a horizontal platform, with protective panels on two sides to ensure stability and safety. Adjacent to the battery, a charge controller was installed, which features a digital display for monitoring battery parameters and a set of standard electrical outlets for external connections. This setup is designed to facilitate the efficient charging and discharging of the battery, ensuring optimal performance and reliability in various applications. The prototype plays a crucial role in creating a reliable and user-friendly Monitoring system.

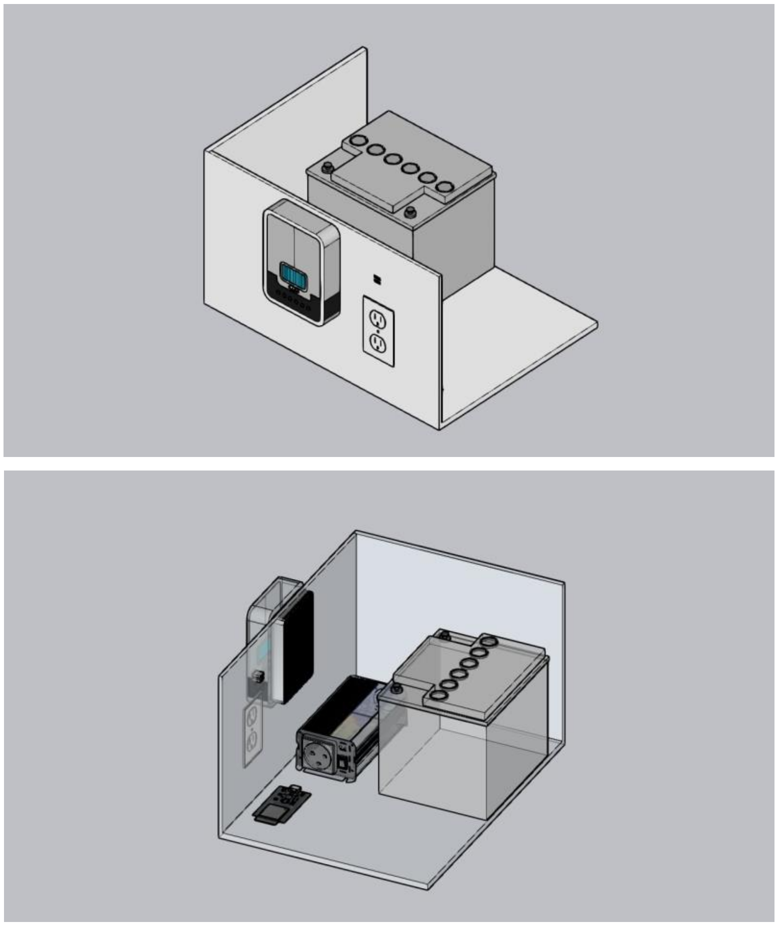


Figure 4. Prototype Design

Computation

i. Computation for Pressure that the prototype produces:

In this section, the pressure was determined using the hydrostatic pressure formula:

Table 1. *Computation for Pressure*

$P = P.g.h$
Where: $P = pressure\ in\ Pascals\ (Pa)$ $\rho = density\ of\ water\ due\ to\ gravity = 1000 kg/m^3$ $g = acceleration\ due\ to\ gravity = 9.81 m/s^2$ $h = height\ (head) in\ meters = 1.8288\ meters$
$P = \frac{1000kg}{m^3} \cdot \frac{9.81m}{s^2} \cdot 1.8288m$ $P \approx 1000 \cdot \frac{9.81m}{s^2} \cdot 1.8288$ $P \approx 17942.93\ Pascals (Pa)$
Conclusion: The pressure of the prototype from the base of a 6-foot head of water is approximately **17943 Pascals** or **17.9 kilo Pascals.**

ii. List of tested Devices

Listed in this section are the basic appliances and devices that were tested on the prototype and hours the devices will take to discharge the battery.

Table 2. *Tested Devices*

Using this Formula:

$$Total\ Energy = Battery\ Capacity\ (100Ah) \times Battery\ Voltage\ (V)$$

$$Time = \frac{Total\ Energy\ (Wh)}{Power\ Consumption\ (W)}$$

Appliances/Device	Wattage	Hours to Discharge
Cellphone	24W	50 Hours
Laptop	150W	8 Hours
Clip Fan	30W	40 Hours
Desk fan	50W	24 Hours
Light	10W	120 Hours

Program Coding

The development of Rainwater Harvesting System followed a systematic process that integrated hardware and software components to address energy and water scarcity. The system used the Blynk IoT platform for real-time monitoring and control, with Wi-Fi credentials to connect the system to the internet. During setup, serial communication was initialized for debugging and for Modbus protocol, which facilitated communication with the charge controller. The system periodically requests data from the charge controller, stores this data, and processes it. This data include data metrics like temperature, battery charge, voltage, and turbine voltage, which are then sent to Blynk IoT platform for visualization.

The prototype employs a state machine to manage its operations, transitioning between states of waiting, querying the charge controller, and transmitting data. The data collected from the charge controller is serialized to JSON format for easy handling and used to update the Blynk platform in real-time. This comprehensive approach, combining hardware interfacing with software monitoring, ensures the prototype operates efficiently, providing a sustainable solution for generating electricity and utilized stored rainwater.

Flowchart

The flowchart shown in the figure below displays the main function of the system. The system starts to collect rainwater. After collecting rainwater, it goes down to the filtering section of the prototype. After filtering the rainwater, the rainwater was collected in the basin. After getting collected, the water continues flowing to proceed to the process of spinning the turbine. While the turbine spins, the system regulates the voltage and current of the turbine. After regulating the voltage and current of the system, the battery gets charged. An inverter converts the charged battery's direct current (DC) to alternating current (AC). Since the battery is being charged, next, the data gathered that was monitored is displayed in the IoT platform.

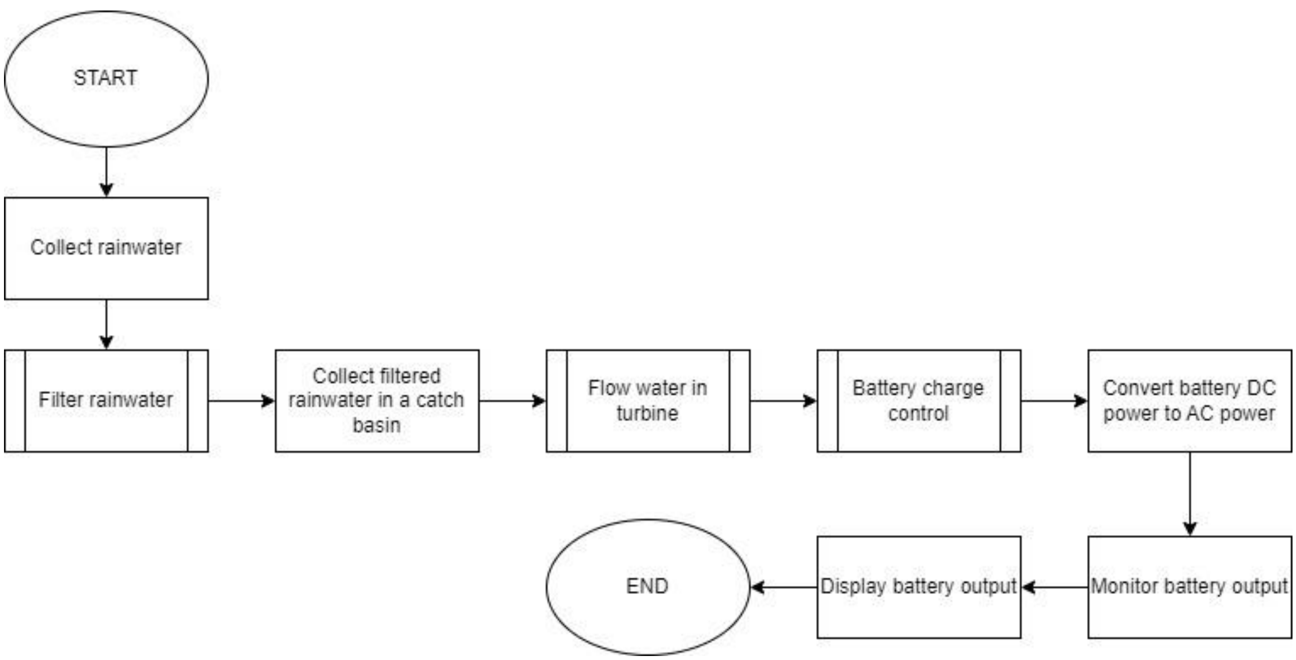


Figure 5. Flowchart of IoT Based Rainwater Harvesting for Renewable Energy and Utility Water Management's Main Process

Predefined Process for Rainwater Filtering

The predefined process for filtering rainwater involves several thorough steps. Initially, the rainwater is filtered through a leaf or a screen filter to remove large debris such as leaves and twigs. It then flows through a one-way funnel to ensure smooth and controlled passage, preventing backflow. Next, the water undergoes further purification through a foam filter, which removes smaller particles and contaminants. This comprehensive filtration process concludes with clear, filtered rainwater that is collected and is ready for utility use, ensuring high-quality and safe water for various applications.

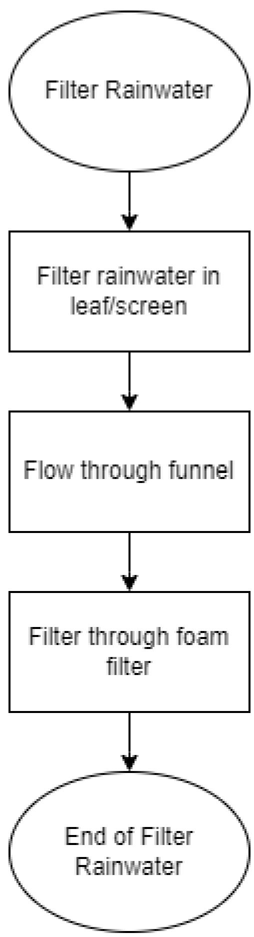


Figure 6. Predefined Process for Rainwater Filtering

Predefined Process for Flowing Water in the Turbine

Next to the filtration process is another predefined process where the turbine plays a crucial role. After the rainwater is filtered, it flows into the turbine system. Initially, the rainwater enters the inlet pipe, propelled by the force of its flow. This force initiates the primary function of the turbine, causing it to spin. As the turbine spins, it converts its mechanical energy into electrical energy, which is then directed through the motor, harnessing the power of the flowing water for practical use.

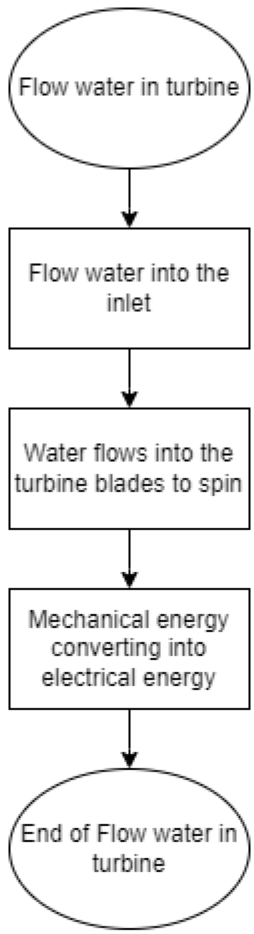


Figure 7. Predefined Process for Flowing Water in the Turbine

Predefined Process of Battery Charge Control

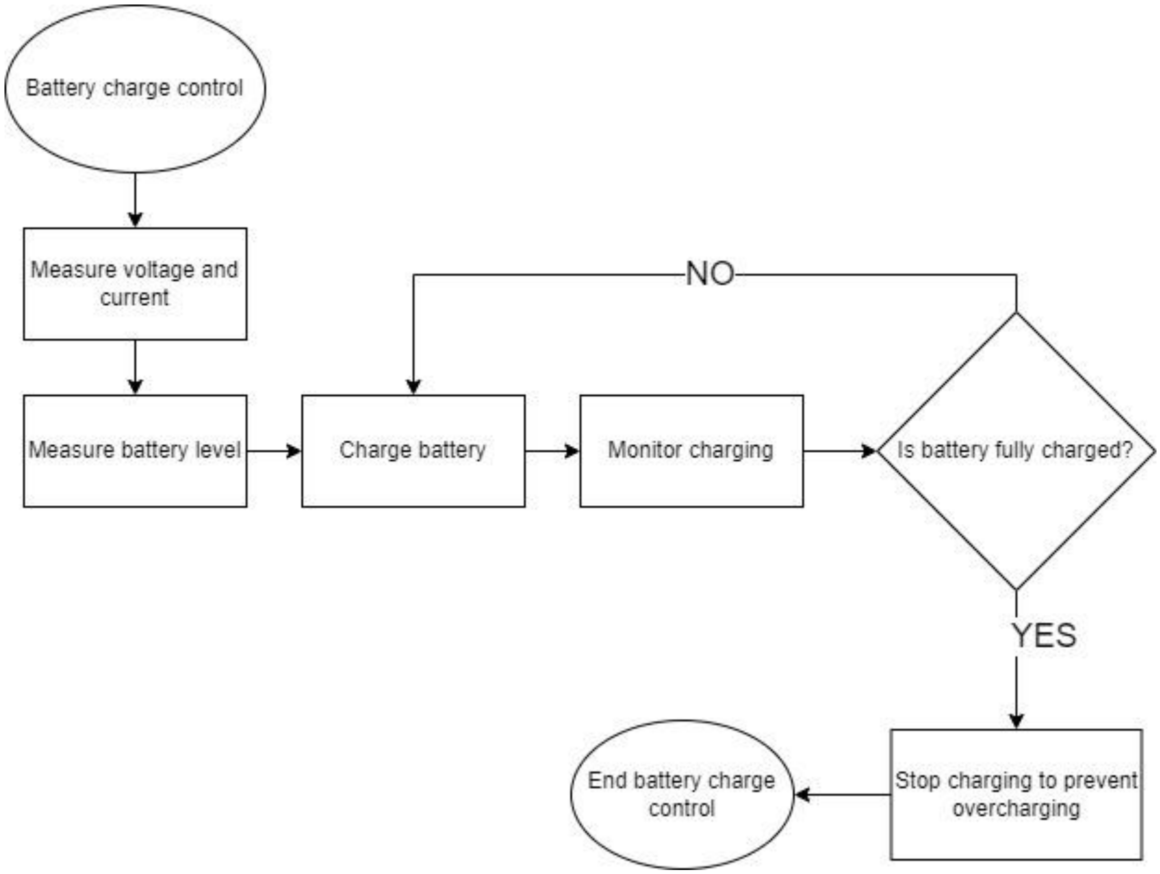


Figure 8. Predefined Process of Battery Charge Control

The predefined process for controlling battery charging continuously strives to optimize the battery's health. It begins by initiating the battery charge control. The system measures the voltage and current of the battery to determine its current state. Based on these measurements, the system assesses the battery's charge level.

If the battery was not fully charged, the system initiates the charging process. During charging, the system continuously monitors the process to ensure it proceeded correctly. The system then checks if the battery had reached its full charge capacity.

The loop continues until the battery becomes fully charged. Once that happens, the system stops the charging process to prevent overcharging, which could damage the battery. Finally, the battery charge control process ends, completing its cycle. This ensures that the battery charged efficiently while preventing overcharging, maintaining the battery’s health and longevity.

Project Development

The focus of this project was to develop an innovative rainwater harvesting system that effectively combined the development of renewable energy with water conservation. The system utilized an ESP32 for data transmission between IoT Platform and the Charge Controller. The project followed a structured prototyping methodology with six key phases: requirements analysis, design, build prototype, refine prototype, evaluate the prototype, and deployment. It was comprised of two parts—the hardware requirement and software requirement.

Prototyping Method Model

The development of the rainwater harvesting system followed the prototyping method shown in Figure 9 to improve the quality of the system that would be aligned with the user's needs. In addition, it was a useful strategy to reduce risks and improve the quality of the system. The setting up of the prototype consisted of the elements that were followed to develop the IoT-based rainwater harvesting system.

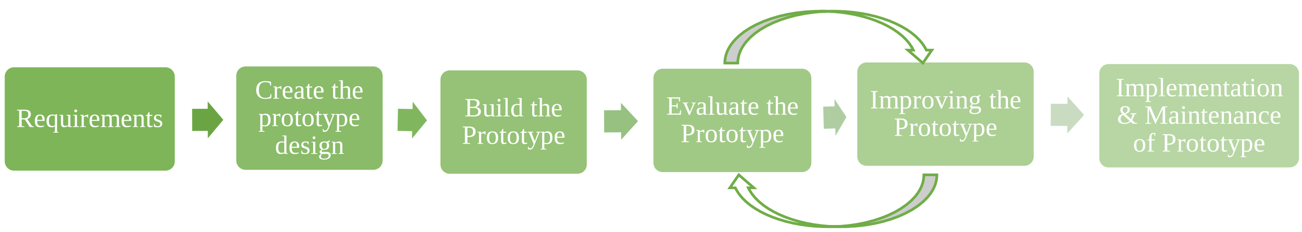


Figure 9. Prototyping Method Model

The IoT-based rainwater harvesting system was developed using a Prototyping Method Model to address user demands and enhance overall system quality. First, the requirements were gathered, focusing on needs such as the materials for building the prototype foundation, including an ESP32 microcontroller, a 12V water turbine, a charge controller, a JSL (Lead Acid 12V 100Ah) battery, and a 3000W inverter. Based on these requirements, the prototype design was created, including the foundation of the prototype, the flow of water, the wiring of the turbine, an IoT module, and an IoT application interface. The prototype was then built by combining these components to produce a prototype and the IoT application. The evaluation of the prototype involved testing to ensure that it is working and provides accurate data to the IoT application. Additionally, the researchers utilized the TUP Evaluation Instrument to assess the prototype's level of acceptability and identified areas for improvement. After testing and improving the prototype, the improved prototype was implemented in actual working environments. This prototype method reduced construction risks while improving the quality of the rainwater harvesting system.

Operation and Testing Procedures

Operation Procedure

The following procedures describe how the rainwater was processed from the gutter:

1. The prototype was installed a filter to filter the rainwater down to the extended part of the pipe and once it is filled, the contaminants flow outside the filter and the water goes inside the filter then into the basin.
2. The filtered water is directed into a catchment basin, positioned to maximize collection efficiency.

The following procedures describe how the flapper and floater operated in the rainwater harvesting system:

1. A floater was installed in the catch basin to control the water level. The floater was designed to rise with the water level.
2. When the water reachs a certain level, the floater lifts and triggers the flapper mechanism. The flapper then opens, allowing the water to flow down to the next step of the system.

The following procedures describe how the system processed rainwater from the gutter to generate the stored and usable electricity:

1. The water flows down smoothly from the basin after the floater and flapper mechanism happen into a connected pipe designed to minimize friction.
2. A strategically placed bottle within the pipe creates pressure, increasing the speed and force of the water flow.
3. The pipe with the bottle for pressurizing is connected directly to a micro-hydro turbine to optimize water flow.
4. The design of the turbine blades allows for maximum water's kinetic energy, converting it into the mechanical energy of the turbine itself.
5. The spinning turbine connected to a generator, efficiently converts mechanical energy to electrical energy.
6. Generated electricity is directed to a charge controller, regulating voltage and current generated by the turbine.
7. Regulated electricity was stored in a battery bank of deep-cycle batteries.
8. The stored DC (direct current) is converted to AC (alternating current) power using a high-efficiency inverter.
9. AC (alternating current) is distributed to electrical outlets or a power distribution panel, making it available for use.

The following procedures were followed to operate and use the monitoring system. These procedures pertain to the assessment of electric supply data for a prototype that had already been produced. These procedures encompass determining the total storage capacity of the battery, monitoring real-time battery charge levels, and tracking energy consumption.

1. The user downloaded the IoT Mobile Application of "Blynk."

2. The user must have data or internet connection.

3. The user must open the Application and log to the account.

4. After logging the correct information, one must be able to monitor the battery percentage, electric supply, battery capacity, and the energy consumption of the prototype.

5. The information could be displayed through one's mobile phone.

The following procedures describe how to utilize rainwater that was collected from the prototype and use it as utility water:

1. The overflow of the catch basin 2 is responsible for releasing the excess water from the prototype.
2. The user could easily get the utility water out of the tank using its faucet.

Testing Procedure

The system was evaluated in real-world settings with an emphasis on its usefulness and accuracy to ensure the system's high level of quality. The accuracy and functionality of the project were evaluated through the subsequent processes.

1. Checked if the filtering system separated the visible dirt that flowed with the rainwater.
2. Checked if catch basin 1 collected enough water to power the turbine.
3. Checked if the water turbine worked upon releasing the collected water in catch basin 1.
4. Checked if the energy converted into electricity using the energy converter.
5. Checked if the level of water in catch basin 2 was accurate.
6. Checked if the display system displayed the real-time battery percentage.
7. Checked if the IoT application received the correct data from the display system.
8. Checked if the IoT application notified the user.

Functionality Test

The following tests were performed to validate the prototype's performance in real-world conditions, ensuring the prototype and monitoring system met the required standards and operated efficiently.

Table 3.

Functionality Testing Procedure of the Rainwater Harvesting System

	Steps Undertaken	Expected Results
Filtering	1. Installed Leaf filter on the prototype 2. Simulated Rain with leaves and Dust 3. Observed the filtering Process	Leaves and dust are effectively filtered out, allowing only clean water to pass through.
Converting Mechanical Energy into Electricity	1. Set up the turbine in the water flow path. 2. Ensured proper mechanical connection. 3. Measured the output with a voltmeter.	Mechanical energy is converted into electrical energy, producing a measurable voltage.
Produce electricity for emergency purposes	1. Connected emergency load or Appliances 2. Measured the power supplied.	The system successfully powers the Basic and Emergency Appliances, providing a steady electrical output.
Can store water for utility use	1. Directed filtered water to a storage tank. 2. Used stored water for various utility purposes.	Water is effectively stored in the tank and is available for utility use such as irrigation or cleaning.

Table 3.1

Functionality Testing Procedure of the Monitoring System Using ESP32

	Steps Undertaken	Expected Results
Track the energy produced by the turbine	1. Connected ESP32 to the turbine's output. 2. Programmed ESP32 to measure energy production. 3. Validated readings	ESP32 accurately tracks and logs the energy produced by the turbine.
Track the battery percentage	1. Connected ESP32 to the battery Charge Controller. 2. Programmed ESP32 to measure battery voltage and calculate percentage. 3. Compared ESP32 readings with the Charge controllers reading or Multimeter.	ESP32 provides accurate and real-time battery percentage readings.
Track the energy consumption	1. Connect ESP32 to the Charge Controller. 2. Program ESP32 to measure energy consumption. 3. Validate readings with a power meter or the display in the charge controller.	ESP32 accurately tracks and logs the energy consumption of the system.
Sends the data to the IoT application	1. Connected ESP32 to Wi-Fi. 2. Programmed ESP32 to transmit data to the IoT platform. 3. Verified data reception on the IoT application.	Data from ESP32 are successfully transmitted and displayed on the IoT application in real-time.

Evaluation Procedure

Following a series of tests to validate the prototype, the project's acceptability underwent evaluation using the TUP evaluation instrument. The TUP evaluation instrument was distributed among respondents, including professionals, Information Technology students, and homeowners. The evaluation process entailed several steps:

1. The researchers provided an overview of the prototype's objectives, functions, limitations, and operational aspects to the respondents before evaluation.

2. The prototype was demonstrated and tested with the respondents.

3. Each respondent received an evaluation sheet to assess the different criteria of the prototype.

4. The evaluation sheets utilized a 4-point Likert Scale, as illustrated in the table below.

5. The collected evaluation sheets underwent processing. The data were tabulated using Microsoft Excel. The researchers presented the results via pie graphs and percentage charts to ascertain the prototype and system's success.

Table 4.

Likert Scale: Numerical Rating and Descriptive Interpretation

Numerical Rating	Descriptive Interpretation
4	Highly Acceptable
3	Very Acceptable
2	Acceptable
1	Not Acceptable

Chapter 4

RESULTS AND DISCUSSION

This chapter contains the project description, project structure, project capabilities and limitation, and results of evaluation.

Project Description

The implemented project is a combination of a rainwater harvesting system and IoT that turns mechanical energy into electricity that can power essential household appliances and is designed to be used in emergencies. The IoT serves as the monitoring and notification system. This prototype is tailored for small to medium-sized households needing a reliable backup power source during emergencies. Its goal is to supply electricity during power outages or brownouts, ensuring comfort and convenience in each home.

Project Structure

Rainwater harvesting is elaborated in two major parts: the Harvesting Prototype and the IoT Monitoring System. The Harvesting Prototype takes care of how rainwater collection and containment are done most efficiently. The IoT Monitoring System is responsible for monitoring and reporting the quantification of harvested rain at any time, while system performance and energy generation are reported in real-time. The following figures detail the processes of the Harvesting Prototype and the IoT Monitoring System such that they work in unison in the quest to optimize water collection and energy generation in specifics.

Hardware

Shown in Figure 10 is the filter catching the rainwater from the Gutter. The water from the gutter is filtered instantly by the mesh to exclude the debris, leaves, and other organisms that associate with the flow of water in case of raining. The structure of the filter was formulated so the debris easily falls in the prototype, therefore preventing the clogging of the filter.

Figure 10. Filter

Presented in Figure 11 is Catch Basin 1 that is vertically positioned for the flow of water to have greater pressure. Inside the catch basin there is a string and a ball set-up to make the Flushing process happen.

Figure 11. Catch Basin 1

Figure 12 shows the 4-turbine set up with 12V output each turbine. It was designed to make the prototype generate more electricity that can fully charge the Battery by 2-3hrs of continuously releasing of water from the Catch Basin 1.

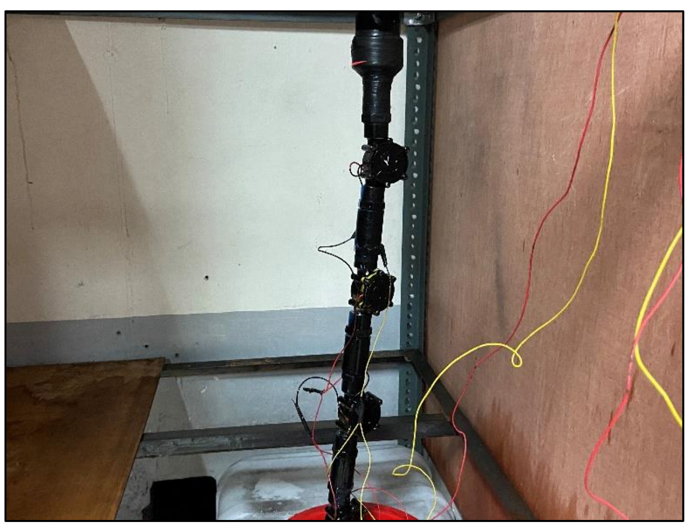


Figure 12. Turbine

In Figure 13, Catch Basin 2 is Horizontally positioned. It was designed to store the rainwater that is already processed by the turbine. Catch Basin 2 also has overflow to prevent the induction of pressure in order for the system to work continuously.

Figure 13. Catch Basin 2

Figure 14 shows the Charge Controller. It was designed to regulate the charging of battery from turbine to avoid the overcharging while producing the electricity. The Charge Controller has a screen to display current information about the battery's voltage, charging current, and amount of charge.

Figure 14. Charge Controller

Shown in Figure 15 is the Inverter that converts Direct Current to Alternating Current. It was designed to manage the conversion process, ensuring to provide an Alternating current to power appliances and devices that need AC power.

Figure 15. Inverter

Figure 16 shows the Battery. It serves as the renewable energy system's energy storage. It stores the power produced by the 12v water turbine.

Figure 16. Battery

Presented in Figure 17 is the Outlet. It was designed to supply electricity from battery goes to outlet. After that, devices and appliances can be powered by the renewable energy that has been stored.

Figure 17. Outlet

Shown in Figure 18 is the ESP32 microcontroller, an important component in the system. It served as the main microprocessor used for communicating with the other sensors and module.

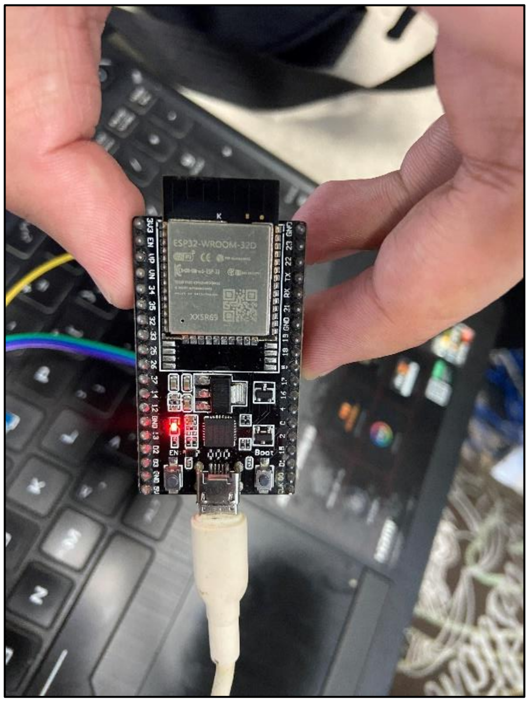


Figure 18. **ESP32 Microcontroller**

IoT Monitoring System

Login Form

Figure 19 shows the login page of Blynk application. This project utilizes only one account to access the monitoring system, this way a user can login with different devices without compromising the purpose of the system.

Blynk Application

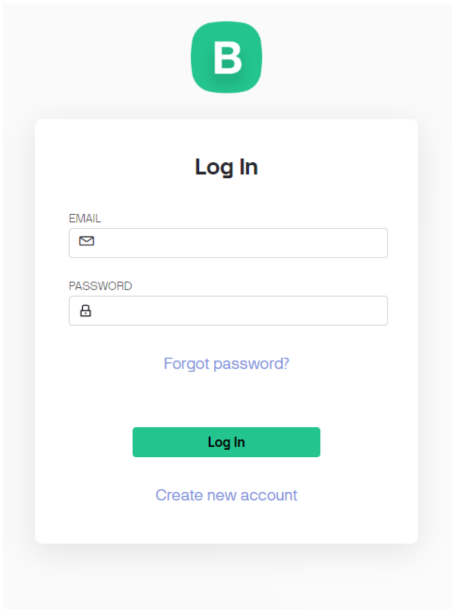
Shown in Figure 20 is the IoT Platform that was utilized for the monitoring system. The Blynk Application is capable to remotely monitor IoT devices, Customized dashboards and visualize data. This IoT Platform makes interaction with the Rainwater Harvesting system more efficient and accessible.

Dashboard

Shown in Figure 20 is the Dashboard of the monitoring system. The dashboard includes monitoring of generated power from the turbine that is currently stored in the battery, the input voltage when the turbine is working, the measure of energy consumption, and the Realtime percentage of the battery.

Notification System

Presented in Figure 21 is the Notification System offered by the IoT. This study utilized email, phone, and application notification to notify the user if the battery is already full and to prevent overcharging the battery.



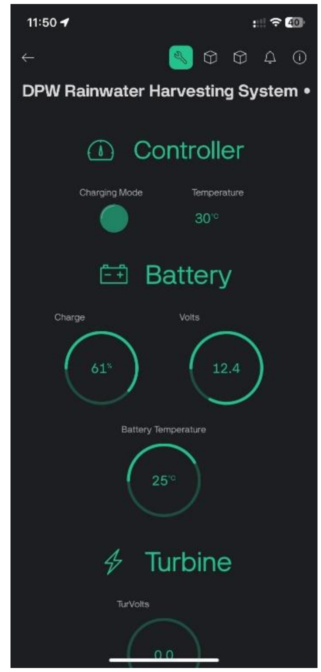


Figure 19. **Login Form**

Figure 20. **Blynk Application and Dashboard**

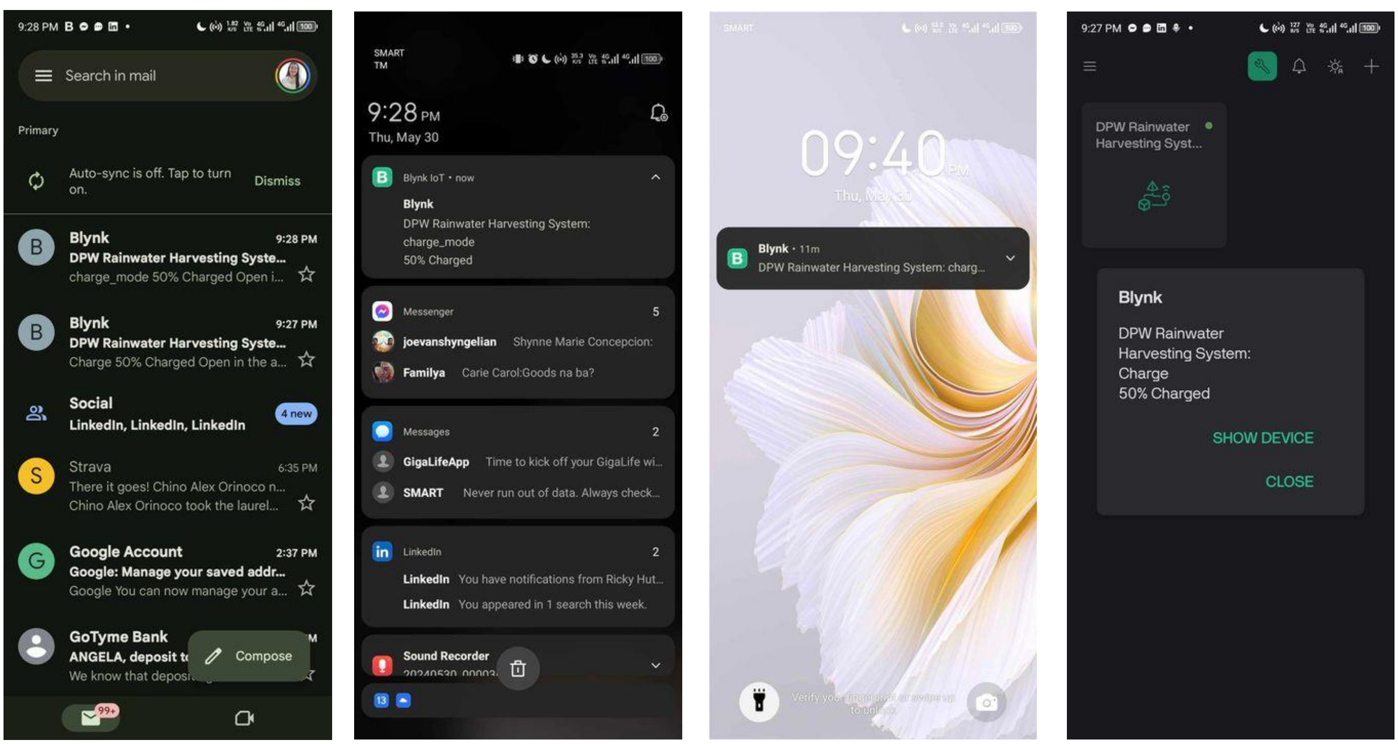


Figure 21. **Blynk Notifications**

Project Capabilities and Limitations

The following are the capabilities of the developed project including the Hardware and IoT application.

Hardware Capabilities

1. Efficiently collects and contains rainwater up to 110 liters.
2. Built with durable materials and can withstand any weather conditions to ensure longevity and effectiveness.
3. Generates up to 150 watts per one flush.
4. The turbine can generate electricity without plugging it in the power outlet.
5. The battery stores generated electricity provided by the turbine.
6. The water that is collected by catch basin 2 can be used for utility purposes.
7. The electricity that is generated by the turbine can power appliances that use maximum of 12V or 220 in AC.

IoT Capabilities

1. Can monitor the output of the turbine.
2. Can monitor the battery level.
3. Has a notification via Blynk application.

The following are the limitations of the developed project including the Hardware and Prototype.

Hardware Limitations

1. Catch basin 1 only releases the stored water when the level of rainwater makes the floater rich the top of the basin.
2. Only supports appliances that use 12V or 220 in AC.

3. The water collected cannot be used for drinking and washing the dishes.
4. The sensors should undergo regular maintenance, to ensure accurate monitoring.
5. Water turbines cannot produce electricity without the pressure of water from the Catch Basin.
6. Over time the battery degrades and requires replacement.
7. The power of microcontrollers is limited compared to powerful computers.
8. Requires adequate physical space for the prototype.

IoT Limitations

1. The monitoring system is not available offline.
2. The monitoring system has data latency.
3. The devices and sensors are limited to maintain the battery and continuous data transmission.

Test Results

The Developed IoT Monitoring system for Rainwater Harvesting was created using C/C++ Programming and Blynk IoT Platform. The test results on the functionality and performance efficiency of the Monitoring and Rainwater Harvesting System are presented in Table 5 that follows.

Table 5.

Functionality Test Result of the Rainwater Harvesting System.

Test Case	Steps Undertaken	Observed Results
Accuracy	- Used a tank to store and measure the amount of water that is needed to produce the electricity. - Used the same type of Turbine. - Used a reliable Charge controller that will process the output of the Turbine.	- The system was able to produce the amount of current to make the turbine work with pressure. - The charge controller displayed and processed the energy created by the turbine set up.
Interoperability	- Connected the Data from the charge controller using ESP32 and DB9 module. - Connected to the IoT platform using C/C++ Programming	- The monitoring system provided accurate and realtime data exchange from the prototype to the IoT Platform.
Usability	- Installed the prototype, place the prototype under the gutter of each house.	- Efficiently collected rainwater from the gutter. - The user easily monitored the output from the

	- Logged in the Acc in the IoT Platform	prototype using web and mobile phone.

Table 5. Test Case Procedure

Evaluation Results

The system was evaluated to determine its level of acceptability in terms of Functionality, Aesthetics, Workability, Durability, Economy, and Safety. The respondents consisted of 10 IT professionals, 10 Household owners, and 20 Students.

Table 6.

Summary of Respondents' Rating of the Project

Criteria	Weighted Mean	Interpretation
Functionality		
Ease of Operation	3.95	Highly Acceptable
Provision for comfort and convenience	3.88	Highly Acceptable
User Friendly	3.88	Highly Acceptable
Criterion Weighted Mean	3.90	Highly Acceptable
Aesthetics		
Color Appeal	3.68	Highly Acceptable
Attractiveness of Design	3.45	Highly Acceptable
Appropriateness of size	3.73	Highly Acceptable
Criterion Weighted Mean	3.61	Highly Acceptable
Highly Acceptable Workability		
Availability of Materials	3.90	Highly Acceptable
Availability of Technical Expertise	3.65	Highly Acceptable
Availability of tools and Machine	3.73	Highly Acceptable
Criterion Weighted Mean	3.76	Highly Acceptable
Durability		
Quality of Materials	3.66	Highly Acceptable
Quality of workmanship	3.55	Highly Acceptable
Quality of design	3.65	Highly Acceptable
Criterion Weighted Mean	3.63	Highly Acceptable
Economy		
Economy in terms of Materials needed	3.83	Highly Acceptable
Economy in terms of time/Labor	3.45	Highly Acceptable

Economy in terms in machine required	3.68	Highly Acceptable
Criterion Weighted Mean	3.65	Highly Acceptable
Safety		
Absence of Toxic/Hazardous materials	3.60	Highly Acceptable
Absence of sharp edges	3.28	Highly Acceptable
Provision for protection Devices	3.63	Highly Acceptable
Criterion Weighted Mean	3.5	Highly Acceptable
Grand Weighted Mean	**3.68**	**Highly Acceptable**

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of findings, the conclusions drawn from the findings, and the corresponding recommendations for further enhancement of the project.

Summary of Findings

Based on the test and evaluation results, the developed Project Drops to Watts: Rainwater Harvesting System for Iot Based Monitoring Using Esp32 could produce renewable energy from rainwater and could provide an IoT application effectively to monitor the data output from the prototype.

The system was reviewed and evaluated by a total of 40 respondents composed of Household/owners, IT professionals, and Students. The following is the summary of findings.

Functionality – The respondents' weighted mean evaluation of this criterion, which was measured in terms of ease of operation, provision for comfort and convenience, and user-friendly, received an interpretation of highly acceptable with a value of 3.90. It indicates simple controls with a user-friendly app for easy monitoring, automated collection and remote monitoring for the user’s convenience, and easy setup and interface, with clear instructions and alerts.

Aesthetics – The respondents' weighted mean evaluation of this criterion, which was measured in terms of color appeal, attractiveness of design, and attractiveness of design, received an interpretation of highly acceptable with a value of 3.61. It indicates the sleek visual of the IoT complements any setting. The rainwater collection works perfectly with its prototype.

Highly Acceptable Workability - The respondents' weighted mean evaluation of this criterion, which was measured in terms of availability of materials, availability of technical expertise, and availability of tools and machine, received an interpretation of highly acceptable with a value of 3.76. It indicates components that are easily sourced guarantee continuous operation. Common tools and general understanding are needed for installation and maintenance.

Durability - The respondents' weighted mean evaluation of this criterion, which was measured in terms of quality of materials, quality of workmanship, and quality of design, received an interpretation of highly acceptable with a value of 3.63. It indicates skilled workmanship and quality components offer the best durability and dependable performance.

Economy - The respondents' weighted mean evaluation of this criterion, which was measured in terms of Economy in terms of Materials needed, Economy in terms of time/Labor, and Economy in terms in machine required, received an interpretation of highly acceptable with a value of 3.65. It indicates cost-effective components are used, along with easy installation, minimum maintenance, and common tools.

Safety - The respondents' weighted mean evaluation of this criterion, which was measured in terms of absence of toxic/hazardous materials, absence of sharp edges, and provision for protection devices, received an interpretation of highly acceptable with a value of 3.50. It indicates that to prevent injuries, safe, non-toxic components with smooth edges should be used, and safety measures should be included for secure operation.

Conclusions

In general, the following conclusions were derived from the above findings.

1. The developed project was successfully designed with the following features:
    a. Generates electricity
    b. Stores rainwater to be used as utility water
    c. Can power basic emergency and household appliances
    d. IoT monitoring system for the following:
        i. Checks if the battery is charging
        ii. Temperature of the surroundings
        iii. Battery percentage
        iv. Current volt output of the battery
        v. Temperature of the battery
        vi. If the turbine is working, monitors the load input
        vii. Monitors the load output via DC output.
2. The project was successfully developed using the following algorithms and tools:
    a. Arduino IDE
    b. ESP32
    c. Blynk IoT Platform
3. The evaluation and tests revealed that the Prototype and IoT Based Monitoring System and usable and reliable to its user.
4. The developed project was rated as **"Highly Acceptable"** in terms of Functionality, Aesthetics, Workability, Durability, Economy, and Safety. This result suggests that

"DROPS TO WATTS" could be useful and would be reliable to use in any household.

Recommendations

The following recommendations were put forward for further enhancements of the project.

1. For future researchers, use Lithium Battery. Avoid Gel type and Lead Acid, for more flexibility in the IoT.
2. Use more sensors and apply integration.
3. Consider having the turbine 3D-printed.
4. Use more durable materials for longevity of the prototype.
5. Incorporate database on the IoT platform for tracking the power generation effectively.

REFERENCES

A Tropical Archipelago. (2023, October 8). *A Tropical Archipelago*. https://typeset.io/papers/a-tropical-archipelago-4mduh5z54e

480-289-5766 - cdn.ymaws.com. (n.d.). https://cdn.ymaws.com/www.arcsa.org/resource/resmgr/docs/arcsa_rwh_brochure_5.17.16.pdf

A Tropical Archipelago. (2023, October 8). *A Tropical Archipelago*. https://typeset.io/papers/atropical-archipelago-4mduh5z54e

Ali, S. S., & Sang, Y. (2023). Implementing rainwater harvesting systems as a novel approach for saving water and energy in flat urban areas. Sustainable Cities and Society, 89, 104304. https://doi.org/10.1016/j.scs.2022.104304

Ang, T.-Z., Salem, M., Mohamad Kamarol, Himadry Shekhar Das, Mohammad Alhuyi Nazari, & Natarajan Prabaharan. (2022). A comprehensive study of renewable energy sources: Classifications, challenges and suggestions. *Energy Strategy Reviews*, *43*, 100939. https://doi.org/10.1016/j.esr.2022.100939

Bastiaansen, R. (2022, October 17). *What is a raspberry pi used for?: TechTarget*. IT Operations. https://www.techtarget.com/searchitoperations/tip/What-is-a-Raspberry-Pi-used-for

BasuMallick, C. (2022, August 26). *Raspberry pi models and features*. Spiceworks. https://www.spiceworks.com/tech/networking/articles/what-is-raspberry-pi/

Bertheau, P., Dionisio, J., Jütte, C., & Aquino, C. (2020). Challenges for implementing renewable energy in a cooperative-driven off-grid system in the Philippines. *Environmental Innovation and Societal Transitions*, *35*, 333–345. https://doi.org/10.1016/j.eist.2019.03.002

Brain, M. (n.d.). How toilets work. HowStuffWorks. https://home.howstuffworks.com/toilet4.htm

Carter, J., Rahmani, A., Dibaj, M., & Akrami, M. (2023, February 7). Rainwater energy harvesting using micro-turbines in downpipes. MDPI. https://www.mdpi.com/1996-1073/16/4/1660

CEO Machining. (2022, February 22). *Hydro Turbine Maintenance: Hydroelectric problems and solutions*. Cutting Edge. https://ceomachining.com/hydro-turbine-maintenance/

CityU new droplet-based electricity generator: A drop of water lights up 100 small LED bulbs. City University of Hong Kong. (2020, February 6). https://www.cityu.edu.hk/media/news/2020/02/06/cityu-new-droplet-based-electricity-generator-drop-water-lights-100-small-led-bulbs

Ecoflow. (2023, August 31). What is an MPPT solar charge controller & how does it work?. EcoFlow US Blog. https://blog.ecoflow.com/us/what-is-mppt-solar-charge-controller/

Encyclopædia Britannica, inc. (n.d.). Rainwater harvesting system. Encyclopædia Britannica. https://www.britannica.com/technology/rainwater-harvesting-system

Energy Saving Trust. (2021, September 7). Use hydroelectricity to power your home - Energy Saving Trust. https//energysavingtrust.org.uk/advice/hydroelectricity/

ESP8266 Wi-Fi SOC | Espressif Systems. (n.d.). https://www.espressif.com/en/products/socs/esp8266

Fearon, R. (2020, August 31). Raindrop Electricity: Generating “Blue Energy” from rainfall. Discovery. https://www.discovery.com/science/raindrop-electricity--generating--blue-energy--from-rainfall

Gazis, A. (2021). What is IoT? The Internet of Things explained. *Academia Letters, 1003*. https://doi.org/10.20935/al1003

Giesen, E. V. (2021, August 31). Rainwater harvesting as an alternative water source. Stormwater Solutions. https://www.stormwater.com/stormwater-bmps/article/33053895/rainwater-harvesting-as-an-alternative-water-source

Groote, J. F., Morel, R., Schmaltz, J., & Watkins, A. (2021, August 19). *The Raspberry Pi and the ARM processor*. SpringerLink. https://link.springer.com/chapter/10.1007/978-3-030-68553-9_8

Hisaka, M. (2024, April 25). What Is a Toilet Flapper? How to Find It, Get It Working, and More. Angi. https://www.angi.com/articles/what-is-a-toilet-flapper.htm

Hitaltech. (2022, February 7). *Home*. Innovative uses of Raspberry Pi using the Internet of Things. https://www.hitaltech.com/en/articles/how-do-i-use-raspberry-pi-for-development-of-iot-applications/

Hosny, K., Magdi, A., Salah, A., Elkomy, O., & Lashin, N. (2022, August 25). Internet of things applications using Raspberry-Pi: a survey. International Journal of Electrical and Computer Engineering (IJECE). https://www.researchgate.net/publication/365450641_Internet_of_things_applications_using_Raspberry-Pi_a_survey

Hymel, S. (2023, June 22). *Python programming tutorial: Getting started with the raspberry pi*. Python Programming Tutorial: Getting Started with the Raspberry Pi - SparkFun Learn. https://learn.sparkfun.com/tutorials/python-programming-tutorial-getting-started-with-the-raspberry-pi/all#:~:text=Python%20is%20a%20beginner%2Dfriendly,data%20on%20the%20Raspberry%20Pi.

Jamal, S. I. M., Tarek , Y. A., Siddique, A. B., Shaikh, A. A., Debnath, S. C., Uddin , R., Ahmed , S., Akbor , A., Al-Mansur , M. A., Rez, A., Islam, T., Khan , R., Moniruzzaman, M., & Sultana , S. (2023, January). Cell press. https://www.cell.com/heliyon/pdf/S2405-8440(23)00234-7.pdf

Juillet, R. (2022, August 17). *Why use python to develop your it project?*. Bocasay. https://www.bocasay.com/web-development-benefits-python/

Lam, C. (2022, July 13). Research recap: Generating electricity from rain - sustainable waterloo region. Sustainable Waterloo Region -.

https://www.sustainablewaterlooregion.ca/2022/07/07/research-recap-generating-electricity-from-rain/

Leaf filter cost: Is it worth the investment?. IBEX Roof. (2023, October 23). https://www.ibexroof.com/leaf-filter-cost/

Lee, W.-M., & Ching, C. (2022, August 31). *Introduction to IOT using the Raspberry Pi*. CODE Online. https://www.codemag.com/article/1607071/Introduction-to-IoT-Using-the-Raspberry-Pi

Ltd, S. (n.d.). Rainwater harvesting for toilets. https://www.stormsaver.com/Rainwater-Harvesting-for-Toilets#:~:text=Rainwater%20Harvesting%20for%20Toilet%20Flushing%20is%20one%20of%20the%20quickest,bills%20whilst%20helping%20the%20environment.

Lunawat, R. (2022, April 7). Can we generate electricity from rainfall?. Science ABC. https://www.scienceabc.com/eyeopeners/can-generate-electricity-from-rainfall.html

Morgan, J. (2020). *5/4/2018 A Simple Explanation Of "The Internet Of Things" A Simple Explanation Of "The Internet Of Things."* https://course.ccs.neu.edu/cs7680su18/resources/w1/simpleExplanation.pdf

N.L. Panwar, Kaushik, S. C., & Kothari, S. (N.D.). Role of renewable energy sources in environmental protection: A review. *Renewable and Sustainable Energy Reviews, 15*, 3. https://doi.org/10.1016/j.rser.2010.11.037

Nield, D. (2020, February 10). New way to generate electricity from rain can power 100 led bulbs per drop. ScienceAlert. https://www.sciencealert.com/we-re-getting-closer-to-generating-electricity-from-raindrops

Novio, E. B. C. (2022, January 21). Climate Change and Disasters in the Philippines: Heinrich Böll Foundation: Southeast Asia Regional Office. Heinrich-Böll-Stiftung. https://th.boell.org/en/2022/01/21/climate-disasters-philippines

Official Gazette. (2020, December 16). *Republic Act No. 9513 | GOVPH*. Official Gazette of the Republic of the Philippines. https://www.officialgazette.gov.ph/2008/12/16/republic-act-no-9513/

Orion Australia. (2022, June 14). Rain Power: Reusing Harvested Rainwater To Generate Electricity. https://www.orionproducts.com.au/news/rain-power-reusing-harvested-rainwater-to-generate-electricity

Owusu, P. A., & Sarkodie, S. A. (2016). A review of renewable energy sources, sustainability issues and climate change mitigation. Cogent Engineering, 3(1), 1167990. https://doi.org/10.1080/23311916.2016.1167990

Pedamkar, P. (2023, October 10). *Raspberry pi: Exploring the versatility and potential*. EDUCBA. https://www.educba.com/what-is-raspberry-pi/?fbclid=IwAR2-L_Dh-ksM3pRtpPfHWslfLHgKcUH5fxkELng6eu1xBXBAlqTmkFVamnw

Radonic, L. (2018, June 1). When catching the rain: A cultural model approach to green infrastructure in water governance. Allen Press. https://meridian.allenpress.com/human-organization/article-abstract/77/2/172/72467/When-Catching-the-Rain-A-Cultural-Model-Approach

Renewable energy – powering a safer future. United Nations. https://www.un.org/en/climatechange/raising-ambition/renewable-energy#:~:text=Renewable%20energy%20sources%20%E2%80%93%20which%20are,or%20pollutants%20into%20the%20air.

renkeer_Admin. (2021, June 15). *Water Level Sensor | What, How, Where, Benefits, Types - Renke*. Renke. https://www.renkeer.com/water-level-sensor-definition-applications-benefits-types/#:~:text=What%20is%20a%20water%20level

Renogy Marketing Team. (2019, December 29). What is the difference between MPPT and PWM charge controllers?. Renogy United States. https://www.renogy.com/blog/what-is-the-difference-between-mppt-and-pwm-charge-controllers/

Simon, S. (2023, April 20). 8 common types of water filters and how they work. Forbes. https://www.forbes.com/home-improvement/home/types-of-water-filters/#how_to_determine_which_water_filters_are_right_for_you_section

Słyś, D., & Stec, A. (2020, January 12). Centralized or decentralized rainwater harvesting systems: A case study. MDPI. https://www.mdpi.com/2079-9276/9/1/5

Sridhar, A., & Sridhar, A. (2020, December 01). A comparative study of MPPT and PWM solar charge controller. Research Gate. https://iopscience.iop.org/article/10.1088/1742-6596/1712/1/012023/pdf

Sritram, P., & Suntivarakorn, R. (2021, November 29). *The efficiency comparison of hydro turbines for Micro Power Plant from free vortex*. MDPI. https://www.mdpi.com/1996-1073/14/23/7961

Tan, C. (2020, March 5). *Introduction to python with raspberry pi*. Little Bird Electronics Guide. https://littlebirdelectronics.com.au/guides/189/introduction-to-python-with-raspberry-pi

Tehran Times. (2023, March 04). What Is the Inverter and How It Works? https://www.tehrantimes.com/news/482555/Tavanir-holds-event-to-promote-technological-achievements-in

Tumino, P. (2020, June 8). An introduction to inverters for photovoltaic (PV) applications. Technical Articles. https://eepower.com/technical-articles/an-introduction-to-inverters-for-photovoltaic-pv-applications/#

Turbine Harvests Green Energy Even in Slow Water Currents. Energy Water Nexus. (2022, June 18). https://thewaternetwork.com/_/energywater-nexus/article-FfV/turbine-harvests-green-energy-even-in-slow-water-currents-zcbAJj_r9LrOUbB_EL2e6Q

Water Science School. (2018, June 8). Hydroelectric Power Water Use Completed. Hydroelectric Power Water Use | U.S. Geological Survey.

https://www.usgs.gov/special-topics/water-science-school/science/hydroelectric-power-water-use

Ahmed, M. (n.d., April). (PDF) Institutional Engineering and Technology (IET) a study on Hydro ... https://www.researchgate.net/publication/338541272_Institutional_Engineering_and_Technology_IET_A_STUDY_ON_HYDRO_ELECTRIC_GENERATION_IN_BANGLADESH_A_STUDY_ON_HYDRO_ELECTRIC_GENERATION_IN_BANGLADESH

Water Turbine Electric Power Generator for renevable energy. Powerturbines. (2023, November 11). https://powerturbines.eu/en/

Water-efficient technology opportunity: Rainwater Harvesting Systems. Energy.gov. (n.d.). https://www.energy.gov/femp/water-efficient-technology-opportunity-rainwater-harvesting-systems

What you need to know about toilet fill valves. Bardi. (2023, May 9). https://bardi.com/blog/what-you-need-to-know-about-toilet-fill-valves

Zilinsky, G. (2020, December 3). Docket Alarm. https://www.docketalarm.com/cases/Ohio_Southern_District_Court/2--20-cv-06229/Zilinsky_et_al_v._LeafFilter_North_LLC/1/

APPENDIX A

EVALUATION FORM

Republic of the Philippines
Technological University of the Philippines
COLLEGE OF SCIENCE
Department of Computer Studies
Ermita Manila

Name (Optional): ____ Date: ___________

What Best Describe you? Student IT Professional Household owner

DROPS TO WATTS: RAINWATER HARVESTING SYSTEM FOR IOT BASED MONITORING USING ESP32

Directions: Please evaluate the "Drop to Watts" Prototype using the given rating scale by placing a check (✓) mark under the corresponding numerical rating.

Numerical Rating	Equivalent
4	Highly Acceptable
3	Very Acceptable
2	Fairly Acceptable
1	Not Acceptable

Criteria	4	3	2	1
A. Functionality				
1. Ease of operation. Simple controls with a user-friendly app for easy monitoring.				
2. Provision for comfort and convenience Automated collection and remote monitoring for the user's convenience.				

3. User friendliness Easy setup and interface, with clear instructions and alerts.				
B. Aesthetics				
1. Color Appeal The system features a modern color palette that blends well with various environments.				
2. Attractiveness of Design Sleek and stylish design enhances the overall aesthetic of any space.				
3. Appropriateness of size The prototype design is appropriate for the rainwater collection.				
C. Workability				
1. Availability of Materials Easily sourced components ensure uninterrupted functionality.				
2. Availability of technical expertise Widespread expertise for installation and maintenance.				
3. Availability of tools and Machine Common tools and machines are needed for setup and operation.				
D. Durability				
1. Quality of Materials Built with high-grade, long-lasting materials.				
2. Quality of workmanship Expert craftsmanship ensures reliable performance.				
3. Quality of design Thoughtfully designed for maximum durability and efficiency.				
E. Economy				

1. Economy in terms of materials needed Uses cost-effective, readily available components.				
2. Economy in terms of time/labor Quick installation and minimal maintenance reduce labor costs.				
3. Economy in terms of machines required Requires standard, affordable tools for setup and operation.				
F. Safety				
1. Absence of toxic/Hazardous materials Uses safe, non-toxic components.				
2. Absence of Sharp edges Designed with smooth edges to prevent injuries.				
3. Provision for protection devices Includes safety features and protective devices for secure operation.				

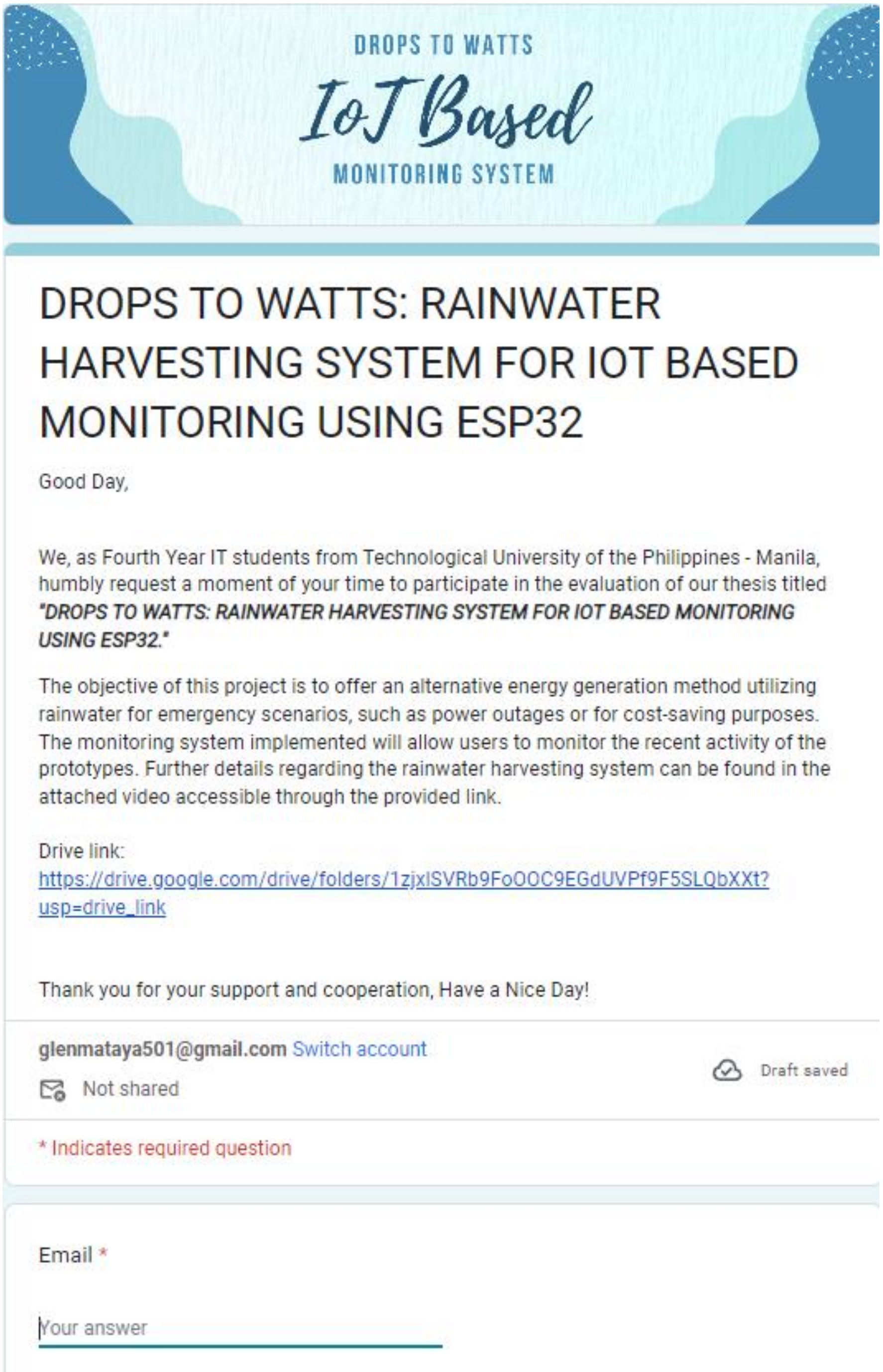
Comments and Suggestions

____

Signature

APPENDIX B

SURVEY QUESTIONNAIRE



DROPS TO WATTS: RAINWATER HARVESTING SYSTEM FOR IOT BASED MONITORING USING ESP32

Good Day,

We, as Fourth Year IT students from Technological University of the Philippines - Manila, humbly request a moment of your time to participate in the evaluation of our thesis titled ***"DROPS TO WATTS: RAINWATER HARVESTING SYSTEM FOR IOT BASED MONITORING USING ESP32."***

The objective of this project is to offer an alternative energy generation method utilizing rainwater for emergency scenarios, such as power outages or for cost-saving purposes. The monitoring system implemented will allow users to monitor the recent activity of the prototypes. Further details regarding the rainwater harvesting system can be found in the attached video accessible through the provided link.

Drive link:
https://drive.google.com/drive/folders/1zjxISVRb9FoOOC9EGdUVPf9F5SLQbXXt?usp=drive_link

Thank you for your support and cooperation, Have a Nice Day!

glenmataya501@gmail.com Switch account
Not shared
Draft saved

* Indicates required question

Email *

Your answer

Respondent Information

Name (Optional)

Your answer

TUP ID Number (optional)

Your answer

Profession *

- ○ Student
- ○ IT Professional
- ○ Household owner

Functionality

Ease of operation *

Simple controls with a user-friendly app for easy monitoring.

	1	2	3	4	
Not Acceptable	◯	◯	◯	◯	Highly Acceptable

Provision for comfort and Convenience *

Automated collection and remote monitoring for the users convenience

	1	2	3	4	
Not Acceptable	◯	◯	◯	◯	Highly Acceptable

User Friendliness *

Easy setup and interface, with clear instructions and alerts.

	1	2	3	4	
Not Acceptable	◯	◯	◯	◯	Highly Acceptable

Aesthetics

Color Appeal *

The IoT features a modern color palette that blends well with various environments.

	1	2	3	4	
Not Acceptable	◯	◯	◯	◯	Highly Acceptable

Attractiveness of Design *

Sleek and stylish design enhances the overall aesthetic of any space.

	1	2	3	4	
Not Acceptable	◯	◯	◯	◯	Highly Acceptable

Appropriateness of size *

The prototype design is appropriate for the rainwater collection.

	1	2	3	4	
Not Acceptable	◯	◯	◯	◯	Highly Acceptable

Workability

Availability of Materials *
Easily sourced components ensure uninterrupted functionality.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Availability of Technical Expertise *
Widespread expertise for installation and maintenance.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Availability of tools and Machine *
Common tools and machines are needed for setup and operation.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Durability

Quality of Materials *
Built with high-grade, long-lasting materials.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Quality of workmanship *
Expert craftsmanship ensures reliable performance.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Quality of Design *
Thoughtfully designed for maximum durability and efficiency.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Economy

Economy in terms of Materials needed *
Uses cost-effective, readily available components.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Economy in terms of Time/Labor *
Quick installation and minimal maintenance reduce labor costs.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Economy in terms in machine required *
Requires standard, affordable tools for setup and operation.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Safety

Absence of toxic/Hazardous materials *
Uses safe, non-toxic components.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Absence of Sharp Edges *
Designed with smooth edges to prevent injuries.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Provision for Protection Devices *
Includes safety features and protective devices for secure operation.

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Comments and Suggestions

if you have comments and suggestions (optional)

Your answer

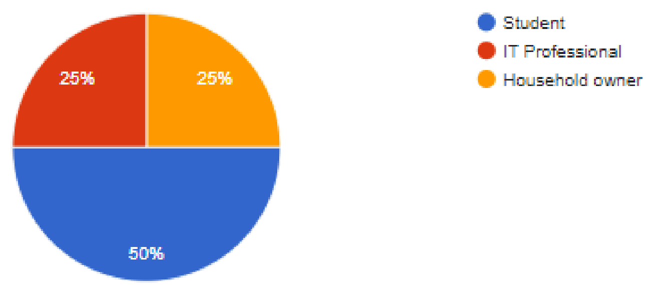
APPENDIX C

RESULTS OF SURVEY

Profession

Copy

40 responses



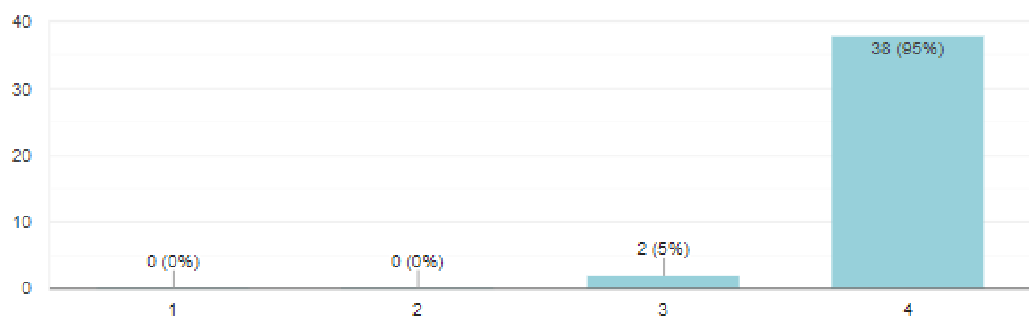
Functionality

Ease of operation

Copy

Simple controls with a user-friendly app for easy monitoring.

40 responses

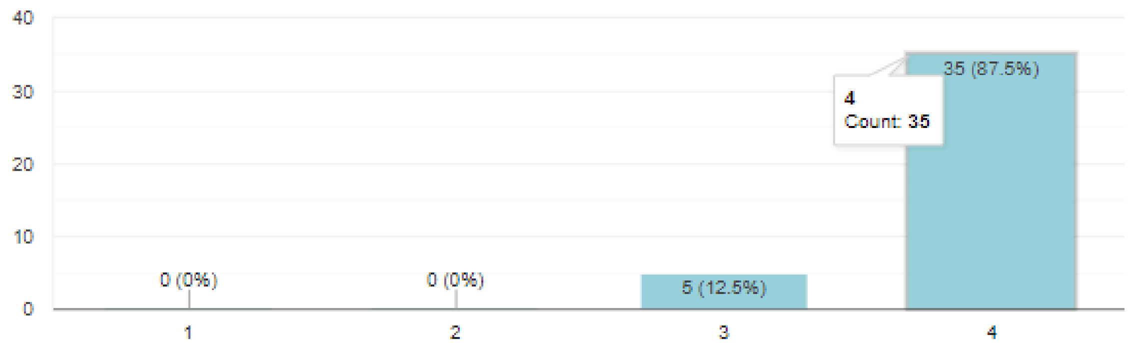


Copy

Provision for comfort and Convenience

Automated collection and remote monitoring for the users convenience

40 responses

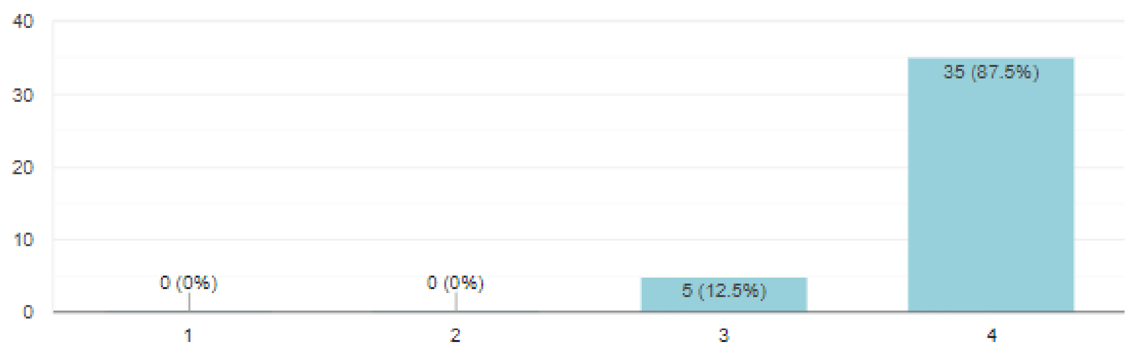


Copy

User Friendliness

Easy setup and interface, with clear instructions and alerts.

40 responses



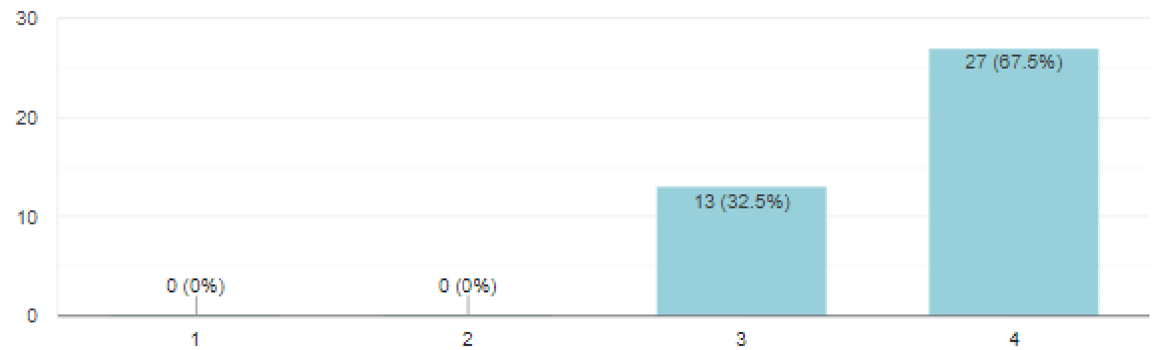
Aesthetics

Copy

Color Appeal

The IoT features a modern color palette that blends well with various environments.

40 responses

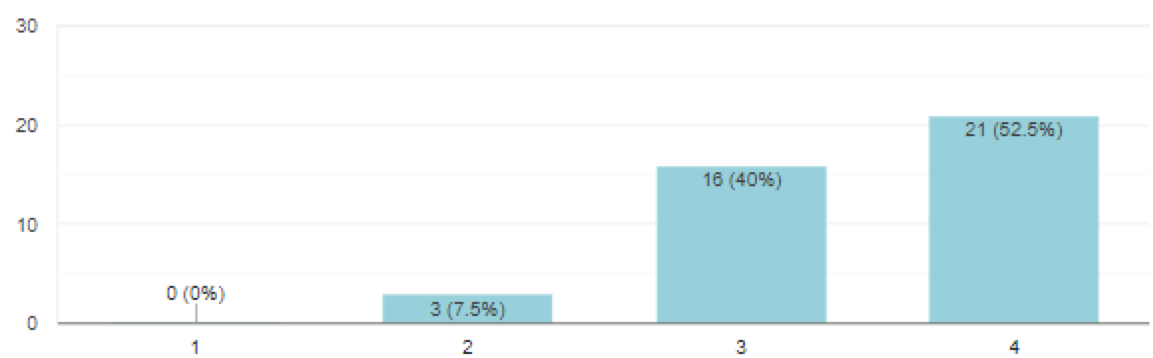


Copy

Attractiveness of Design

Sleek and stylish design enhances the overall aesthetic of any space.

40 responses

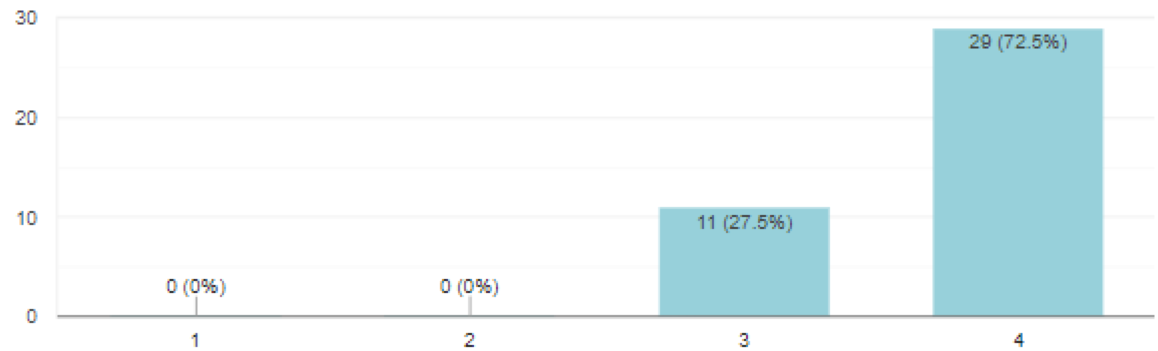


Copy

Appropriateness of size

The prototype design is appropriate for the rainwater collection.

40 responses



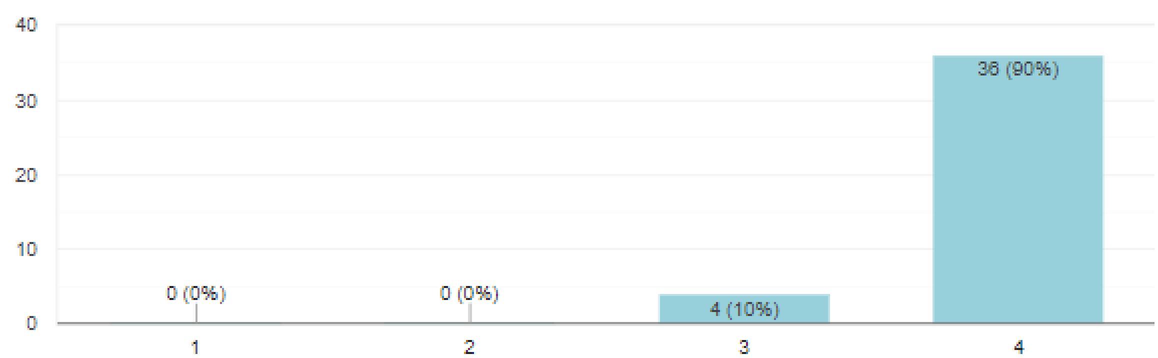
Workability

Copy

Availability of Materials

Easily sourced components ensure uninterrupted functionality.

40 responses

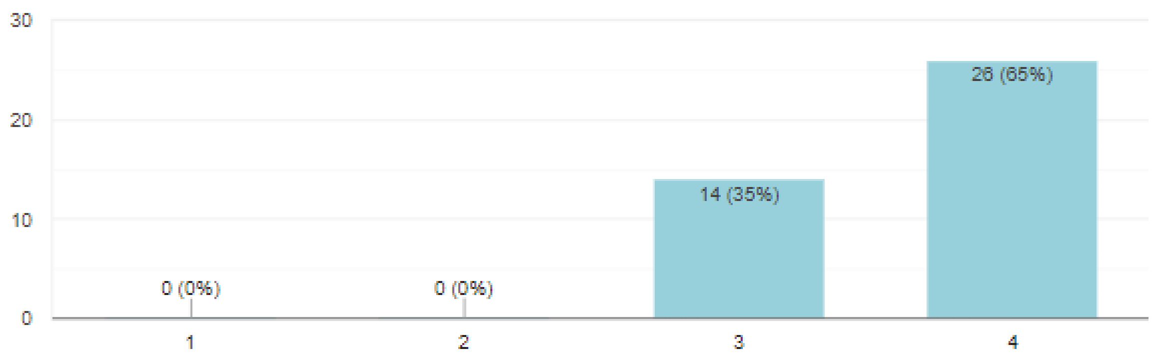


Copy

Availability of Technical Expertise

Widespread expertise for installation and maintenance.

40 responses

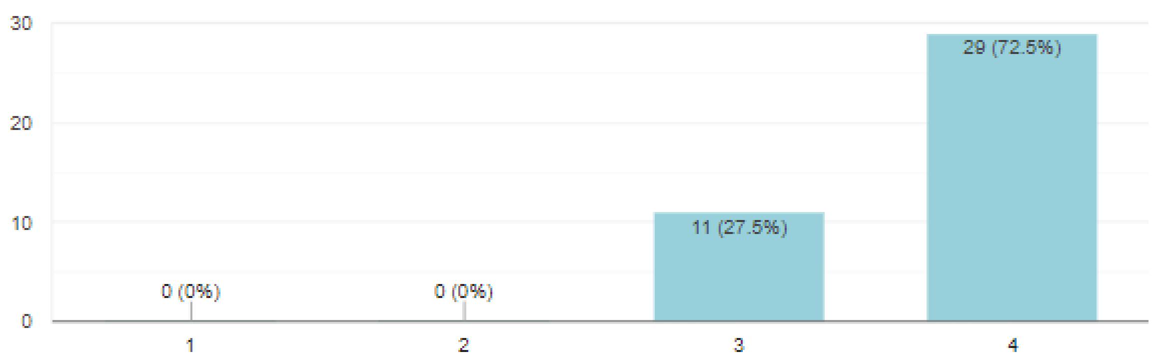


Copy

Availability of tools and Machine

Common tools and machines are needed for setup and operation.

40 responses

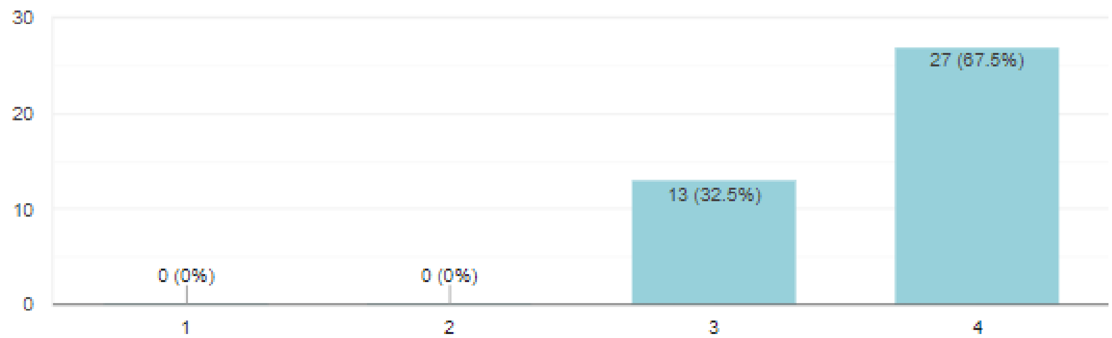


Durability

Copy

Quality of Materials
Built with high-grade, long-lasting materials.

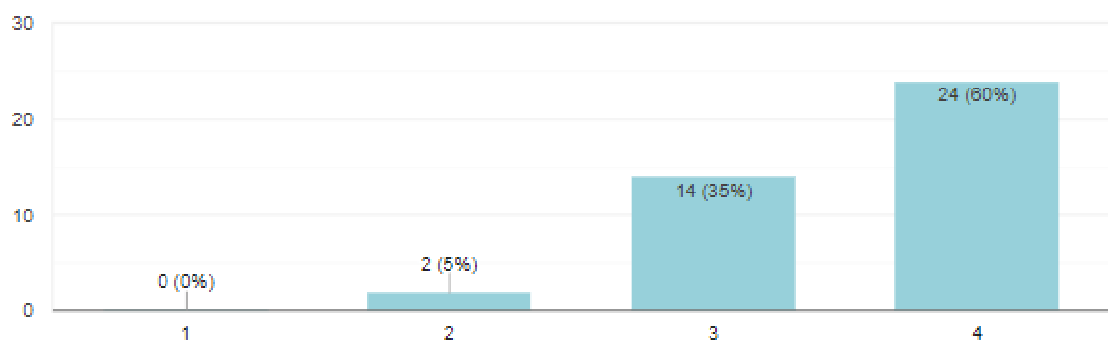
40 responses



Copy

Quality of workmanship
Expert craftsmanship ensures reliable performance.

40 responses

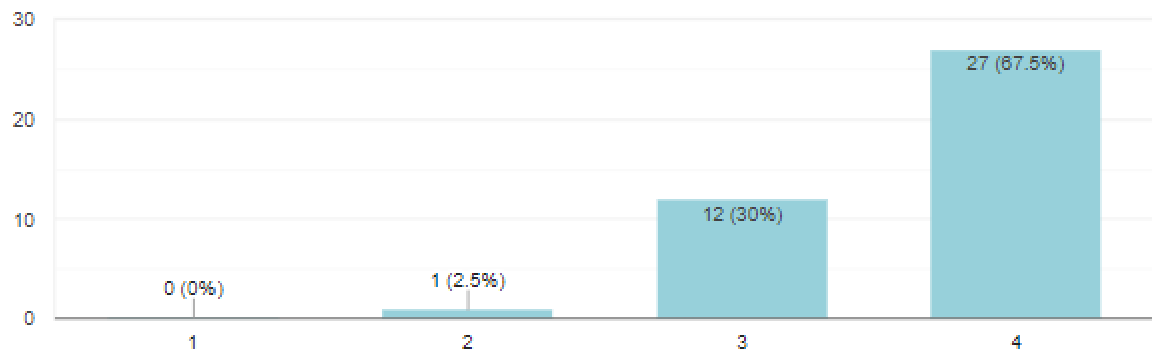


Copy

Quality of Design

Thoughtfully designed for maximum durability and efficiency.

40 responses



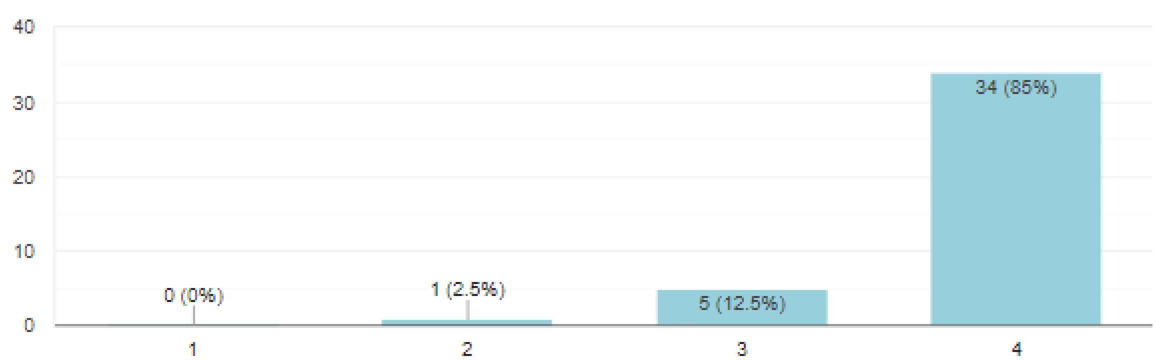
Economy

Copy

Economy in terms of Materials needed

Uses cost-effective, readily available components.

40 responses

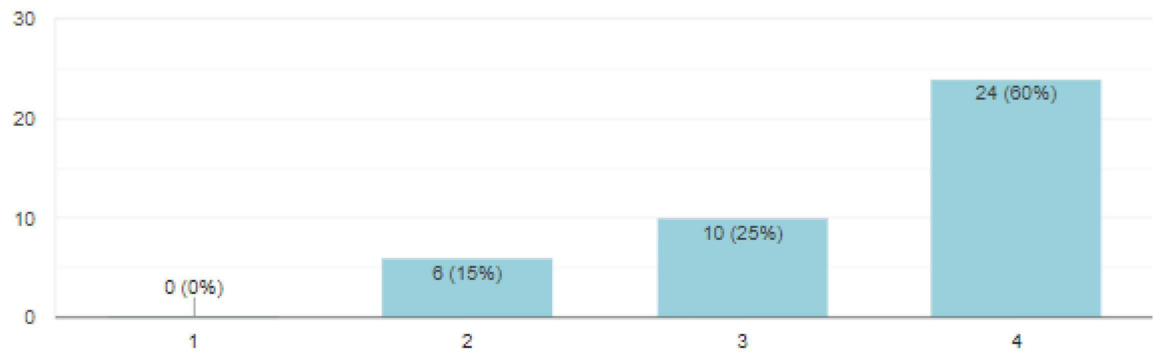


Copy

Economy in terms of Time/Labor

Quick installation and minimal maintenance reduce labor costs.

40 responses

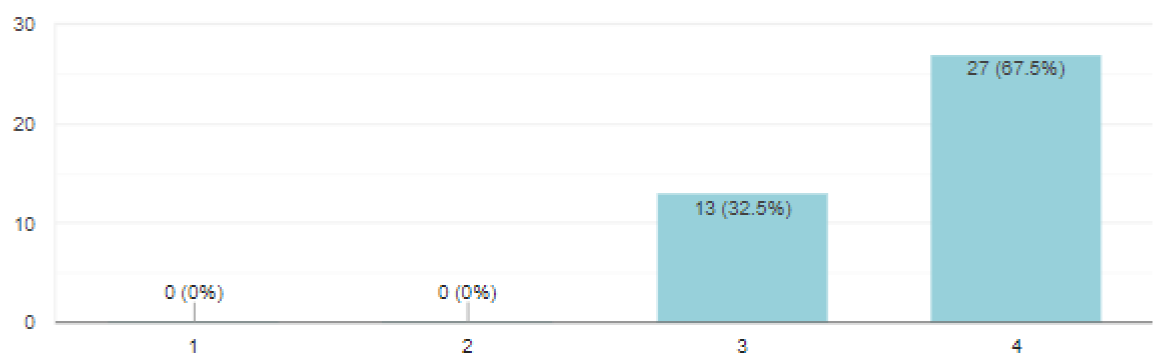


Copy

Economy in terms in machine required

Requires standard, affordable tools for setup and operation.

40 responses



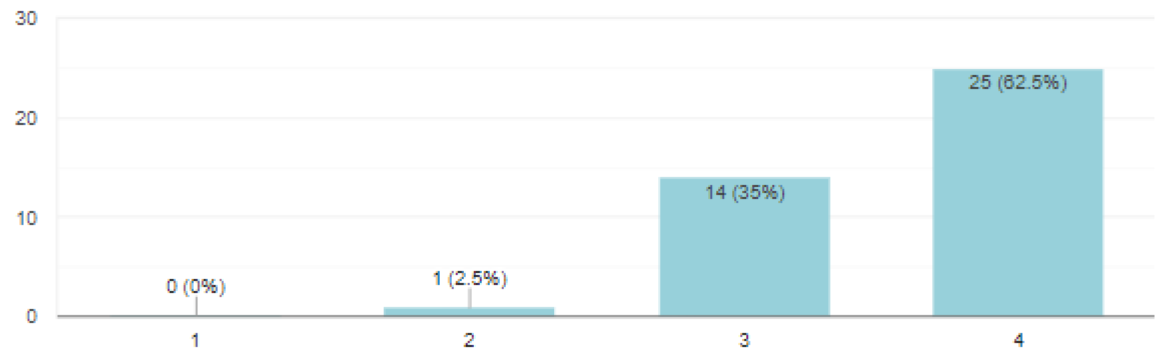
Safety

Copy

Absence of toxic/Hazardous materials

Uses safe, non-toxic components.

40 responses

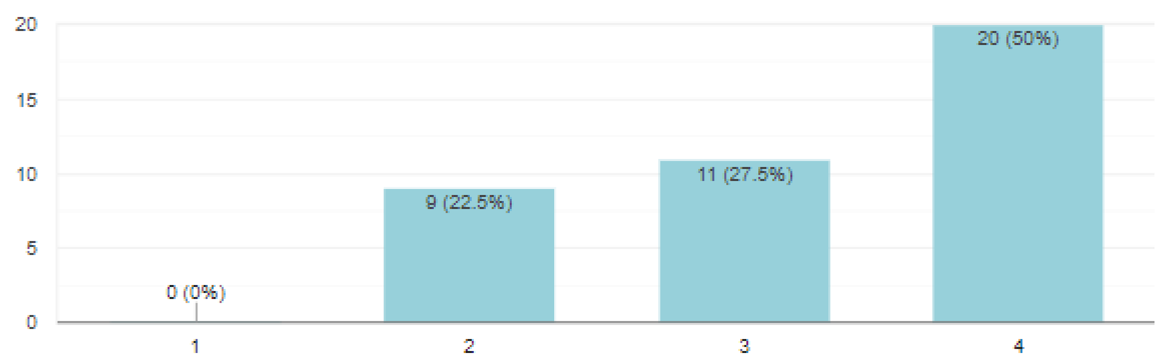


Copy

Absence of Sharp Edges

Designed with smooth edges to prevent injuries.

40 responses

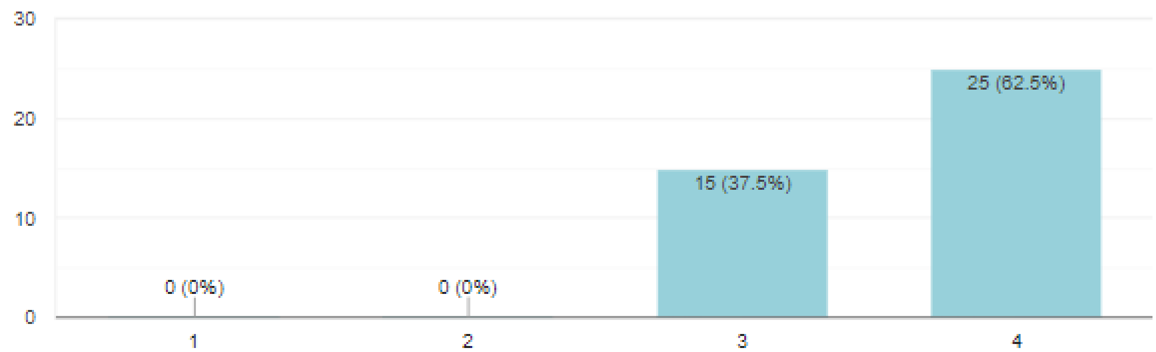


Copy

Provision for Protection Devices

Includes safety features and protective devices for secure operation.

40 responses



Comments and Suggestions

if you have comments and suggestions (optional)

6 responses

I like the system

None. Panalo sha

Goodluck much !!!!!!

the prototype was too big but good proportion for target part of the house which is the gutter

I suggest to remove the prototypes cover to expose the tank, pipes, and turbines for clearer perspective in demonstration

This project is 2 in 1, EExIT

Appendix D

EVALUATION RESULTS

Evaluation Results with Weighted Mean per Indicator, Average Mean per Criterion, and Overall Grand Mean

RESPONDENTS	FUNCTIONALITY			AESTHETICS			WORKABILITY			ECONOMY			SAFETY		
	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
IT Professional	3	3	4	4	2	3	4	4	2	3	3	4	2	2	3
IT Professional	3	4	4	4	3	4	4	3	3	4	3	3	2	3	3
IT Professional	4	4	4	4	3	3	4	3	4	4	3	4	4	2	4
IT Professional	4	3	4	4	3	4	4	3	2	4	4	3	4	3	4
IT Professional	4	3	4	3	4	4	4	3	3	4	3	4	4	4	4
IT Professional	4	4	3	3	4	4	4	3	4	4	3	4	3	4	4
IT Professional	4	4	4	3	4	3	4	3	4	3	4	4	4	4	4
IT Professional	4	4	4	4	4	4	4	3	4	4	4	3	4	2	3
IT Professional	4	4	4	3	4	4	4	3	4	4	4	4	3	3	3
IT Professional	4	4	3	4	2	3	4	4	3	4	4	4	3	4	3
Student	4	3	4	3	4	3	4	3	4	2	3	4	3	4	4
Student	4	4	4	3	4	4	4	3	4	4	3	3	4	4	4
Student	4	4	4	3	4	4	3	3	4	3	3	4	4	4	4
Student	4	4	4	4	4	4	4	3	4	4	4	4	4	2	3
Student	4	4	3	4	4	3	4	4	4	4	4	4	3	2	4
Student	4	4	4	4	2	4	4	4	4	4	3	3	3	4	3
Student	4	4	3	3	3	4	4	3	4	4	4	4	4	4	4
Student	4	3	4	3	3	4	4	4	4	4	2	4	4	4	3
Student	4	4	4	3	3	4	3	4	4	4	3	4	4	4	4
Student	4	4	3	4	4	4	4	4	4	4	2	3	4	4	4
Student	4	3	4	4	3	4	4	4	4	3	4	3	4	4	4
Student	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Student	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4
Student	3	3	3	3	4	3	3	4	4	4	4	3	4	4	4
Student	4	4	4	4	3	4	4	4	4	4	3	4	4	4	4
Student	4	4	4	3	3	4	4	3	3	4	2	3	4	3	4
Student	4	4	4	4	3	4	4	4	3	4	4	4	4	4	4
Student	4	4	4	4	3	4	4	3	4	4	4	3	3	4	4
Student	4	4	4	3	4	3	4	4	3	4	4	4	4	4	4
Student	4	4	4	3	3	3	4	3	3	3	2	4	4	4	3
Household Owner	4	4	4	4	4	3	3	4	4	4	4	3	3	4	4
Household Owner	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4
Household Owner	4	4	4	4	4	3	4	4	4	4	4	4	4	3	4
Household Owner	4	4	4	4	3	3	4	4	4	4	4	4	4	2	4
Household Owner	4	4	4	4	3	4	4	3	4	4	2	4	4	4	4
Household Owner	4	4	3	3	3	4	4	3	4	4	2	4	4	4	4
Household Owner	4	4	4	3	3	4	4	4	4	4	4	3	4	4	4
Household Owner	3	4	4	4	4	4	4	4	4	3	4	3	4	4	4
Household Owner	3	4	4	4	4	4	4	4	3	4	4	4	4	4	4
Household Owner	4	3	4	4	4	4	4	3	4	4	4	4	4	4	4
WEIGHTED MEAN PER INDICATOR	**3.95**	**3.9**	**3.88**	**3.68**	**3.45**	**3.7**	**3.9**	**3.65**	**3.73**	**3.66**	**3.55**	**3.65**	**3.83**	**3.45**	**3.68**
CRITERION WEIGHTED MEAN	**3.903333333**			**3.62**			**3.76**			**3.62**			**3.653333333**		
Overall Mean:	**3.68**														

Responses cannot be edited

DROPS TO WATTS: RAINWATER HARVESTING SYSTEM FOR IOT BASED MONITORING USING ESP32

Good Day,

We, as Fourth Year IT students from Technological University of the Philippines - Manila, humbly request a moment of your time to participate in the evaluation of our thesis titled ***"DROPS TO WATTS: RAINWATER HARVESTING SYSTEM FOR IOT BASED MONITORING USING ESP32."***

The objective of this project is to offer an alternative energy generation method utilizing rainwater for emergency scenarios, such as power outages or for cost-saving purposes. The monitoring system implemented will allow users to monitor the recent activity of the prototypes. Further details regarding the rainwater harvesting system can be found in the attached video accessible through the provided link.

Drive link: https://drive.google.com/drive/folders/1zjxlSVRb9FoOOC9EGdUVPf9F5SLQbXXt?usp=drive_link

Thank you for your support and cooperation, Have a Nice Day!

* Indicates required question

Email *

christian.dejose@gmail.com

Respondent Information

Name (Optional)

TUP ID Number (optional)

Profession *

- (●) Student
- ( ) IT Professional
- ( ) Household owner

Functionality

Ease of operation *
Simple controls with a user-friendly app for easy monitoring.

	1	2	3	4	
Not Acceptable	○	○	○	●	Highly Acceptable

Provision for comfort and Convenience *
Automated collection and remote monitoring for the users convenience

	1	2	3	4	
Not Acceptable	○	○	○	●	Highly Acceptable

User Friendliness *

Easy setup and interface, with clear instructions and alerts.

	1	2	3	4	
Not Acceptable					Highly Acceptable

Aesthetics

Color Appeal *

The IoT features a modern color palette that blends well with various environments.

	1	2	3	4	
Not Acceptable					Highly Acceptable

Attractiveness of Design *

Sleek and stylish design enhances the overall aesthetic of any space.

	1	2	3	4	
Not Acceptable					Highly Acceptable

Appropriateness of size *

The prototype design is appropriate for the rainwater collection.

	1	2	3	4	
Not Acceptable					Highly Acceptable

Workability

Availability of Materials *
Easily sourced components ensure uninterrupted functionality.

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Availability of Technical Expertise *
Widespread expertise for installation and maintenance.

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Availability of tools and Machine *
Common tools and machines are needed for setup and operation.

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Durability

Quality of Materials *
Built with high-grade, long-lasting materials.

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Quality of workmanship *
Expert craftsmanship ensures reliable performance.

	1	2	3	4	
Not Acceptable	○	○	◉	○	Highly Acceptable

Quality of Design *
Thoughtfully designed for maximum durability and efficiency.

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Economy

Economy in terms of Materials needed *
Uses cost-effective, readily available components.

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Economy in terms of Time/Labor *
Quick installation and minimal maintenance reduce labor costs.

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Economy in terms in machine required *
Requires standard, affordable tools for setup and operation.

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Safety

Absence of toxic/Hazardous materials *
Uses safe, non-toxic components.

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Absence of Sharp Edges *
Designed with smooth edges to prevent injuries.

	1	2	3	4	
Not Acceptable	○	◉	○	○	Highly Acceptable

Provision for Protection Devices *
Includes safety features and protective devices for secure operation.

	1	2	3	4	
Not Acceptable	○	○	◉	○	Highly Acceptable

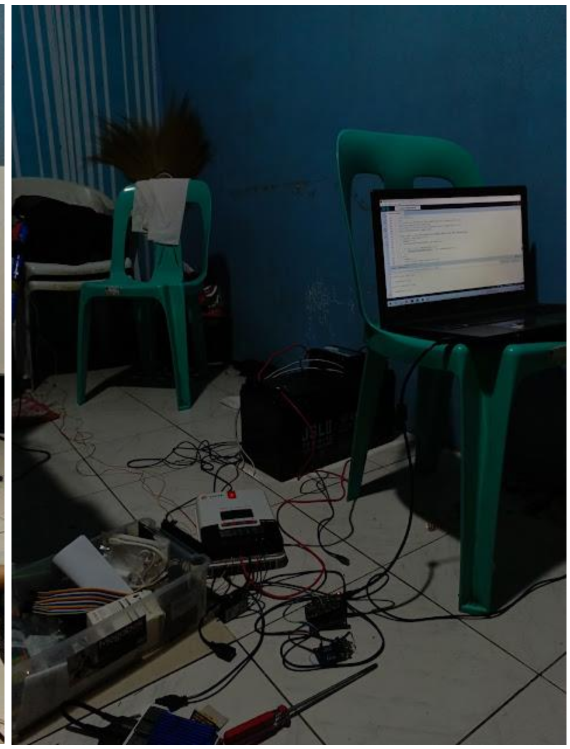
Comments and Suggestions

if you have comments and suggestions (optional)

the prototype was too big but good proportion for target part of the house which is the gutter

Appendix F

DOCUMENTATION


SRNE
12.4


Solar Charge Controller
12.4
RoHS
DPW Rainwa...
Controller
Battery
Turbine

Appendix G

THESIS GRAMMARIAN CERTIFICATION

	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Ayala Blvd., Ermita, Manila, 1000, Philippines Tel No. +632-5301-3001 local 608| Fax No. +632-8521-4063 Email: cos@tup.edu.ph | Website: www.tup.edu.ph	Index No.	REF-COS-3.5-INT-TGC
		Revision No.	00
		Effectivity Date	06132022
VAA-COS	**THESIS GRAMMARIAN CERTIFICATION**	Page	1 / 1

THESIS GRAMMARIAN CERTIFICATION

This is to certify that the thesis entitled,

DROPS TO WATTS: RAINWATER HARVESTING SYSTEM FOR IOT BASED MONITORING USING ESP32

authored by

Concepcion, Angela A.
Dumaguing, Desiree A.
Mataya, Glen B.
Moises, Eisen Lois E.

has undergone editing and proofreading by the undersigned.

This Certification is being issued upon the request of Angela A. Concepcion, Desiree A. Dumaguing, Glen B. Mataya, and Eisen Lois E. Moises for whatever purposes it may serve them.

Marilyn M. Ignacio
Prof. Marilyn M. Ignacio
Grammarian

Technological University of the Philippines

June 11, 2024
Date of Issuance

Transaction ID	
Signature	

Appendix H

CERTIFICATION OF SIMILARITY INDEX USING TURNITIN

	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Ayala Blvd., Ermita, Manila, 1000, Philippines Tel No. +632-301-3001 local 711 Email: urds@tup.edu.ph | Website: www.tup.edu.ph	Index No.	F-URD-4.1-CSI
		Issue No.	01
		Revision No.	00
		Date	07102023
VRE-URD	CERTIFICATE OF SIMILARITY INDEX USING TURNITIN	Page	1 / 1
		QAC No.	CC-07102023

This is to certify that the manuscript entitled

"DROPS TO WATTS: RAINWATER HARVESTING SYSTEM FOR IOT BASED MONITORING USING ESP32"

Authored by

Angela A. Concepcion
Desiree A. Dumaguing
Glen B. Mataya
Eisen Lois E. Moises

College of Science

has been subjected to similarity check on June 11, 2024 using Turnitin with generated similarity index of **10**%.

Processed by:

Assoc. Prof. FRANCIS A. ALFARO, Ed.D., LPT
Faculty, University Research
and Development Services

Certified correct by:

Assoc. Prof. FRANCISCO D. ESPONILLA II, Ed.D.
Director, University Research
and Development Services

Transaction ID	URD-TCERT-ELGB-10032022
Signature	

RESEARCHERS' PROFILE

Angela Concepcion

INFORMATION TECHNOLOGY STUDENT

RELATED EXPERIENCE

March 2018 - Present

Graphic and Presentation Designer

Self Employer

March 2023 - July 2023

Pioneered Pawesome integrated inventory System

System Integration and Architecture Project

January 2023 - February 2023

Quality Assurance Analyst

Advance Database System Project

EDUCATION

2020 - 2024

Technological University of the Philippines

2018 - 2020

Sapang Palay National Senior High School

Science Technology Engineering and Mathematics

2014 - 2018

Sapang Palay National High School

CONTACT

anglcncpcion@gmail.com

9753766467

Sta.Cruz IV Area D
City of San Jose del Monte,
Bulacan.

SOFTWARE SKILLS

UI/UX

Content Management Systems

Microsoft Application

Wireframes

Photo and Video editing

LANGUAGE

English

Filipino

I hereby certify that the above information is true and correct.

Signature over Printed Name

Desiree Dumaguing

INFORMATION TECHNOLOGY STUDENT

CONTACT

dsr.dmgng@gmail.com

09158291750

2060 Ipil St. Pleasantview Subdivision. Bagbaguin, Caloocan City

SOFTWARE SKILLS

UI/UX

Content Management Systems

Microsoft Application

Wireframes

Photo and Video editing

LANGUAGE

English

Filipino

RELATED EXPERIENCE

March 2024 - Present

Software Tester

On-the Job Training

August 2017 - February 2018

Visual Graphic Design

Vocational

EDUCATION

2020 - 2024

Technological University of the Philippines

Bachelor of Science in Information Technology

2018 - 2020

Our Lady of Fatima University - Main Campus

Science Technology Engineering and Mathematics

2014 - 2018

Caybiga High School

I hereby certify that the above information is true and correct.

Signature over Printed Name

Glen Mataya

INFORMATION TECHNOLOGY STUDENT

CONTACT

glenmataya501@gmail.com
9065675306
Durian St., Pembo, Taguig City

SOFTWARE SKILLS

- UI/UX
- Content Management Systems
- Microsoft Application
- Microcontroller
- Photo and Video editing

LANGUAGE

- English
- Filipino

RELATED EXPERIENCE

March 20 - Present

IT Support

On-the Job Training

March 2023 - July 2023

Pioneered Pawesome integrated inventory System

System Integration and Architecture Project

January 2023 - February 2023

Backend Developer

Advance Database System Project

EDUCATION

2020 - 2024

Technological University of the Philippines
Bachelor of Science in Information Technology

2018 - 2020

Mabini Colleges Inc.
Science Technology Engineering and Mathematics

2014 - 2018

Paracale National High School

I hereby certify that the above information is true and correct.

Signature over Printed Name

Eisen Lois Moises

INFORMATION TECHNOLOGY STUDENT

RELATED EXPERIENCE

March 2024 - Present
Computer Technical Support and Live Tech Support
On-the-job Training

March 2023 - July 2023
Pioneered Pawesome integrated inventory System
System Integration and Architecture Project

January 2023 - February 2023
Quality Assurance Analyst
Advance Database system Project

EDUCATION

2020 - 2024
Technological University of the Philippines
Bachelor of Science in Information Technology

2018 - 2020
Arellano University - Elisa Esguerra Campus
Science Technology Engineering and Mathematics

2014 - 2018
Tañong Integrated School

I hereby certify that the above information is true and correct.

Signature over Printed Name

CONTACT

eisenlois.moises01@gmail.com
9184061125
163 M. Sioson St., Brgy. Dampalit, Malabon City

SOFTWARE SKILLS

UI/UX
Content Management Systems
Microsoft Application
Wireframes
Photo and Video editing

LANGUAGE

English
Filipino