Enhancing Climate-Resilient Sustainable Water Management (CRSWM) through Community-Based Rainwater Harvesting

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Abstract

Examining Climate-Resilient Sustainable Water Management (CRSWM) as a potential remedy for the worldwide water and sanitation crises is the goal of this study. The situation becomes more urgent as a result of climate change, which forces a switch from conventional water management systems to CRSWM, a strong strategy that guarantees resilience against climatic impacts while encouraging sustainable behaviors.

With an emphasis on the fusion of climate change adaptation, sustainable water use, and sanitation advancement, we examine the ideas and methodology of CRSWM. The study emphasizes how important it is to balance current and future water needs without sacrificing environmental or social justice.

To show the effectiveness of CRSWM, our research uses in-depth analyses of case studies from various climatic circumstances. We assess the results, difficulties, and lessons discovered via these investigations, providing guidance for regions facing comparable crises.

In order to alleviate the water and sanitation issue, this study promotes greater understanding and use of CRSWM. We argue that implementing CRSWM may significantly advance the world's water security and sanitation goals, ensuring that no one is left behind in the face of climate change.

Keywords

Sustainable; Water Management; Climate-Resilient Sustainable Water Management; sanitation advancement; world's water security

1. Introduction

Due to the growing difficulties caused by climate change and unsustainable behaviors, water security and sanitation have become crucial global concerns. The necessity of switching from traditional water management systems to cutting-edge, climate-resilient sustainable water management (CRSWM) techniques emphasizes how urgent it is to solve these concerns. This paradigm shift not only lessens the effects of climate change on water resources but also supports ethical and ecological practices.

A growing demand for water security and sanitation is being seen around the world in response to the worsening consequences of climate change, especially in areas that are susceptible to these effects. This study article focuses on the Divulapitiya area in Sri Lanka, a microcosm of the worldwide water security and sanitation dilemma, as part of a holistic effort to address these challenges. Divulapitiya, which is located in Sri Lanka's

Western Province, is representative of areas dealing with a complex interplay of manmade pressures and climate-related problems.

1.1 Divulapitiya: A Microcosm of Challenges

Divulapitiya's water dynamics are influenced by a variety of climate factors. The region experiences a tropical environment with average annual high and low temperatures of 31.69 oC and 26.26 C, respectively, which affects water supply and demand. The 337.94mm of precipitation that falls on average each year helps to maintain the delicate balance between water resources and demand. These environmental characteristics, however, also provide a backdrop for a broad range of difficulties.

With elevated iron levels and the prevalence of dangerous germs like E. coli and coliform, the quality of the water in Divulapitiya becomes a serious problem. The ecosystem and human health are both at risk from this contaminated water. Sand mining operations and industrial operations' impact on water contamination make the problem worse. The difficulty is exacerbated by inadequate access to clean drinking water, which has an impact on the local population's health. The complex web of issues with water is further complicated by the pollution that results from quarries.

1.2 CRSWM: A Pathway to Resilience

The concepts of climate-resilient sustainable water management (CRSWM) offer a viable way forward in the face of these difficulties. The CRSWM recognizes the changing nature of the environment and combines adaptation plans with improvements in sustainable water use and sanitation. It is crucial to strike a careful balance between providing for urgent water requirements and guaranteeing equity in terms of the environment and social issues. The resilience of CRSWM to climatic effects and its potential to promote long-lasting behavioral changes serve as a testament to its efficacy.

This research article will evaluate the results, difficulties, and lessons learned from the implementation of CRSWM through a review of case studies from various climatic conditions, including the Divulapitiya area. This study aims to provide direction to regions dealing with comparable water and sanitation emergencies by synthesizing lessons learned from various investigations. The study promotes wider use of CRSWM as a transformative strategy that can raise global water security and sanitation standards while maintaining fairness and resilience in the face of climate change.

2. Literature Review

Sanitation and water security are essential elements of sustainable development and are essential to economic success, social fairness, and public health. Climate change-related difficulties heighten the need for creative water management strategies that can adapt to shifting circumstances while preserving the health of populations and ecosystems. Climate-resilient sustainable water management (CRSWM), which combines climate adaptation with sustainable practices to address the complex interactions between climate change, water resources, and societal requirements, emerges as a strategic framework in this environment.

2.1 CRSWM: A Paradigm for Climate-Resilient Water Management

The CRSWM emphasizes the significance of anticipating and controlling changes in water supply and quality brought on by the climate. CRSWM incorporates measures for coping with climate change that increase the adaptability of water systems, building on the

overarching concepts of integrated water resources management (IWRM). This is accomplished through increasing the effectiveness of water consumption, varying the sources of water, and putting in place infrastructure that can survive severe weather conditions. CRSWM improves the sustainability and dependability of water services while also defending water resources against the effects of climate change.

In order to ensure the availability and sustainable management of water and sanitation for all, or SDG 6, CRSWM plays a critical role in reaching the goal, according to recent research. In several domains, the application of CRSWM techniques has yielded encouraging outcomes. The effectiveness of CRSWM techniques in reducing water shortages, improving water quality, and guaranteeing equal access to clean water has been shown in case studies from regions with a range of climatic circumstances.

2.2 Local Context: Water Challenges in Divulapitiya Area

The complex water issues that exist around the world are best shown by the Divulapitiya region of Sri Lanka. The presence of microorganisms like E. coli and coliform as well as lowered water quality due to increased iron levels are some of these difficulties. Water supplies are further degraded by sand mining and industrial pollution, which has an impact on both human populations and aquatic ecosystems. These problems are made worse by the scarcity of clean drinking water, which has a negative impact on one's health and quality of life.

2.3 Integrated Approaches to Water Security and Sanitation

The need for integrated strategies to handle water security and sanitation holistically is stressed by academic research. The CRSWM acknowledges the interconnectedness of water systems, human communities, and the environment as an integrated approach. Integrated water management can offer comprehensive solutions that are both flexible to changing conditions and long-term sustainable when used in conjunction with climate adaptation measures.

2.4 Knowledge Gaps and Research Opportunities

Despite the promise of CRSWM being highlighted in the literature, there remain information gaps that demand further investigation. Future studies should focus on understanding the socioeconomic effects of CRSWM deployment, as well as its scalability and replicability in other contexts. The development of comprehensive policies that take into account the social, economic, and environmental aspects of water security and sanitation also requires interdisciplinary teamwork.

2.5 Conclusion - Literature Review

A growing understanding of the significance of CRSWM as a response to the global water security and sanitation issues caused by climate change is evident from the literature assessment. While the water issues in Divulapitiya are universal, CRSWM offers a ray of hope by fusing sustainability with climate adaptation, offering a model for resilient and equitable water management. In the parts that follow, this research study will go into great detail about how CRSWM implementation is done, looking at case studies and suggesting tactics to improve water security and sanitation in Divulapitiya and comparable areas.

3. Materials and Methods

3.1 Survey Methodology

A survey was given to a representative sample of 20 people in order to examine the problems

with water security and sanitation in the Divulapitiya area. The sample was chosen to represent the demographic diversity of the local population by including a wide variety of ages, educational attainment levels, and occupations. Data on participants' water sources, water sufficiency, water storage habits, and attitudes toward rainwater collecting were all intended to be gathered by the survey's design.

- Age Distribution: Participants were categorized into five age groups to represent the demographic distribution in the region: 18-25 years (15%), 26-35 years (25%), 36-45 years (20%), 46-55 years (15%), and above 56 years (25%).
- Education Levels: Education levels were classified into five categories: just completed primary education (15%), secondary education (55%), undergraduate (10%), graduated (10%), and postgraduate (10%).
- Occupation: Participants' occupations were divided into four categories: not employed (15%), self-employed (10%), government sector jobs (20%), and private sector jobs (55%).
- Water Supply Sources: Participants were asked about their primary water supply sources, with options including water board supply (10%), private wells (30%), and Community-Based Organization supply (60%).
- Water Sufficiency: Participants' perceptions of water sufficiency were recorded, with 65% reporting water insufficiency and 35% reporting sufficiency.
- Water Storage Practices: Data was collected on whether participants stored water at home, with 30% not storing water and 70% storing water.
- Rainwater Harvesting: Participants were asked whether they gathered rainwater, with 15% indicating that they did, and 85% not practicing rainwater harvesting.
- Perceptions of Rainwater: Data was collected on participants' perceptions of rainwater's potential to fulfill their water needs, with 15% expressing doubt and 85% having confidence in rainwater's efficacy.
- Awareness of Climate Resilience: All participants indicated that they believed climate change was directly linked to water-related challenges.
- Rainwater Harvesting Challenges and Resources: Participants were questioned about the challenges and resources related to rainwater harvesting in their region.

3.2 Proposed Rainwater Harvesting System

Based on the survey findings, it is evident that the Divulapitiya area could benefit significantly from implementing a rainwater harvesting system. The following methodology outlines a feasible approach to address water scarcity:

Gathering Rainwater: The rooftops of residential structures will be equipped with a rainwater collection system. The components of this system will be a chain-like network of pipes and barrels. Water will flow into the next barrel as the first one fills, providing effective water collection. The system will be built to keep bugs and mosquitoes out and will employ cotton fabric filters to clear the roof of trash.

Filtering Rainwater: A simple and natural filtering method will be employed, utilizing gravel, charcoal, and sand filters. After filtration, the harvested rainwater can be used for various sanitation needs. The filtered water

should be boiled or treated with a few drops of lime to convert it into alkaline water.

Estimation of Water Yield: Based on the typical annual rainfall in the Divulapitiya region, the anticipated water yield from this rainwater collection system will be determined. Three barrels of water, or roughly 300 liters of water, can be gathered from an average home roof, according to estimates. This water can supply drinking water for 20 days based on an expected daily consumption of 15 liters for a family of four.

Maintenance: To enhance water collecting effectiveness, it will be crucial to keep gutters and downspouts clear and clean. It will be suggested to do routine cleaning and maintenance to avoid contamination and obstructions.

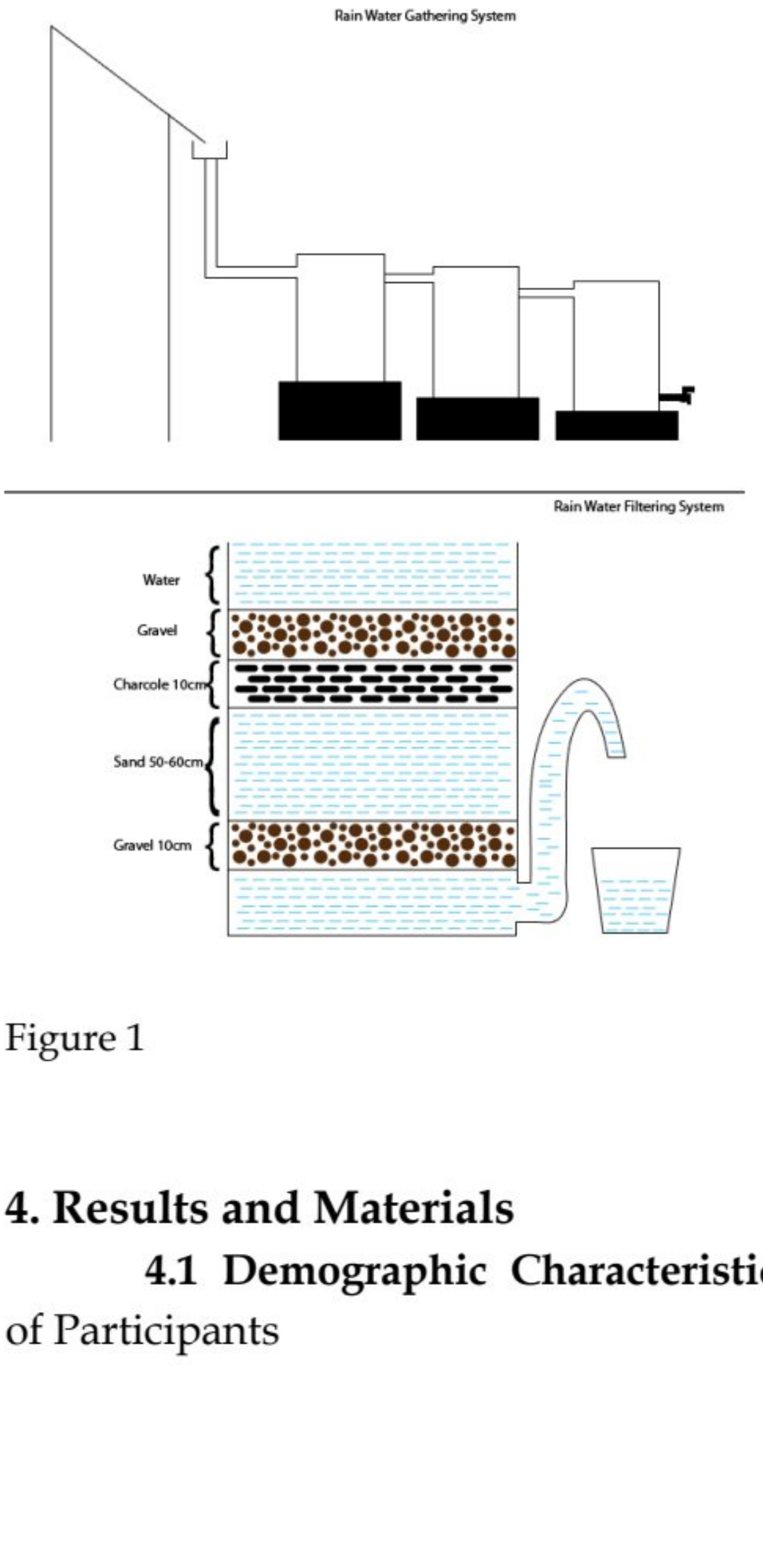

Figure 1

4. Results and Materials

4.1 Demographic Characteristics of Participants

To provide an overview of the survey participants, we categorized them based on age, education level, and occupation. The following table summarizes the demographic distribution:

Demographic Category	Percentage
Age	
18-25 years	15%
26-35 years	25%
36-45 years	20%
46-55 years	15%
Above 56 years	25%
Education Level	
Completed primary	15%
Secondary	55%
Undergraduate	10%
Graduated	10%
Postgraduate	10%
Occupation	
Not employed	15%
Self-employed	10%
Government jobs	20%
Private sector jobs	55%

Table 1

4.2 Water Supply Sources

Participants were asked about their primary water supply sources, revealing a diversified range of sources:

Water Supply Source	Percentage
Water board supply	60%
Private wells	10%

Community-Based Organization (CBO)	30%

Table 2

4.3 Water Sufficiency and Storage

Perceptions of water sufficiency and water storage practices among participants were as follows:

- 65% of participants reported that water was insufficient for their needs.
- 30% of participants did not store water at home, while 70% stored water.
- 15% of participants gathered rainwater.
- 85% of participants did not engage in rainwater harvesting.
- Of those who harvested rainwater, 85% believed it could fulfill their needs.

4.4 Awareness of Climate Resilience

All participants demonstrated awareness that climate change was directly linked to water-related challenges in their region.

4.5 Challenges and Resources for Rainwater Harvesting

Participants were asked about their views on the challenges and resources related to rainwater harvesting:

- 5% cited the high cost of gathering and filtering rainwater as a challenge.
- 10% considered the cost of rainwater gathering to be a significant obstacle.
- 15% were unsure about the challenges.
- 70% did not provide an answer.
- 15% of participants had some ideas regarding resources and support mechanisms for rainwater harvesting.
- 85% did not provide an answer.

4.6 Proposed Rainwater Harvesting System

Based on the survey findings, it is feasible to estimate that a rainwater harvesting system could collect approximately 300 liters of water per residential roof, providing a potential 20-day supply of drinking water for a family of four.

The proposed rainwater harvesting system involves the use of interconnected barrels, a filtering system with gravel, charcoal, and sand filters, and maintenance measures to ensure the cleanliness and efficiency of the system.

5. Discussion

5.1 Demographic Distribution and Water Usage Patterns

The demographic breakdown of the survey respondents provides important information about the population heterogeneity in the Divulapitiya region. The wide range of age groups, from teenagers to seniors, reflects the complexity of water requirements at various phases of life. The majority of participants had completed their secondary education, indicating a reasonable degree of knowledge and understanding of problems relating to water.

The distribution of water supply sources shows the dependence on different sources, with a sizeable portion depending on delivery from Community-Based Organizations (CBO). The variety of available water sources emphasizes the necessity for flexible and durable water management techniques.

5.2 Water Sufficiency and Storage Practices

The survey results show that a considerable percentage of participants, or 65% of consumers, have a serious problem with not

having enough water. Additionally, 30% of people do not keep water on hand at home, which could make the problem of water shortages worse when it occurs. With 15% of participants already using it and the majority believing it can meet their water demands, rainwater harvesting emerges as a workable solution.

The survey emphasizes the value of publicity and instruction in promoting rainwater collection. The fact that a sizable portion of respondents were unclear about the difficulties and available resources in relation to rainwater harvesting suggests the necessity for information sharing and community involvement.

5.3 Proposed Rainwater Harvesting System

A realistic approach to the water issues in the Divulapitiya region is the proposed rainwater harvesting system, which is intended to collect and filter rainfall from residential roofs. A significant additional water source is provided by the estimated 300-liter output per roof, especially during dry spells.

The filtration system, which uses gravel, charcoal, and sand filters, is an easy and economical way to make sure the collected rainwater complies with sanitary requirements. The system's architecture, which includes interconnected barrels and safeguards against insects and mosquitoes, further ensures its effectiveness and security.

6. Conclusion

The study has illuminated the multifaceted challenges faced by the Divulapitiya area in terms of water security and sanitation. Climate change-induced fluctuations in water availability, coupled with compromised water quality, have created a precarious water situation for the local population.

However, the survey findings also point to promising avenues for addressing these challenges. Rainwater harvesting, when adopted and promoted effectively, can provide a resilient and sustainable solution to water scarcity. The proposed rainwater harvesting system, tailored to the specific needs of the region, offers a tangible path forward.

6.1 Implications and Recommendations

To achieve meaningful progress in enhancing water security and sanitation in the Divulapitiya area, several recommendations can be made:

- Community Education: Initiatives should be launched to raise awareness about the benefits of rainwater harvesting and provide information on low-cost implementation methods. Engaging local communities is crucial for the success of such programs.
- Policy Support: Local authorities and policymakers should consider supporting rainwater harvesting initiatives through incentives, regulations, and funding. This could facilitate the widespread adoption of these systems.
- Maintenance and Monitoring: Regular maintenance and monitoring of rainwater harvesting systems are essential to ensure their long-term effectiveness. Community involvement in upkeep is encouraged.
- Research and Development: Continuous research and development efforts should focus on improving rainwater harvesting technologies to make them more efficient, affordable, and suitable for the local context.

In conclusion, the study underscores the importance of localized and sustainable solutions in addressing global challenges such as water security and climate resilience. By leveraging the potential of rainwater harvesting and fostering a community-driven approach, the Divulapitiya area can work towards a more secure and sustainable water future, resilient to the impacts of climate change.

7. References

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8. Attachments

Survey Results

No	Gender	Age	Educational Level	Occupation	Location	Water Supply Scheme For your Home	Water is insufficient for Consumption	What are the options you use at that times	Do you think Climate Resilient is directly related for water	Do you store and used water at home	Do you use any strategy for gather rain water	Any rain water harvesting methods in your region	Do you think rain water harvesting will help to solve water quantity problems	What are the challenges for making rain water management system in your region	What are the resources and support machanisms formaking rain water harvesting system
1	Male	46-55	Secondary Education	Self Employed	Kudagammana	CBO	Yes	Bowser Supply	Yes	No	No	Yes	Yes	The cost is high for gather rain water and filter	Tanks, Pumps, Labor
2	Male	26-35	Graduate	Government	Kelegoda	Private Well	Yes	Public Well	Yes	Yes	No	No	Yes	Cost is high for rain water gathering	Storage tanks
3	Female	Above 56	Graduate	Private	Bolagolla	Water Board	No		Yes	Yes	Yes	No	Yes	Cost is high for rain water gathering	Not answered
4	Male	26-35	Secondary Education	Private	Bolagolla	CBO	Yes	Public Well	Yes	Yes	No	No	Yes	Not answered	Not answered
5	Female	Above 56	Post Graduate	Government	Kelegoda	Private Well	No		Yes	Yes	No	No	No	Not answered	Storage tanks, Filetrs
6	Female	46-55	Secondary Education	Private	Akaragama	CBO	Yes	Bowser Supply	Yes	No	No	No	Yes	Not answered	Not answered
7	Male	26-35	Secondary Education	Private	Halgahawelawatta	CBO	Yes	Public Well	Yes	No	No	No	Yes	Not answered	Not answered
8	Female	16-25	Under Graduate	Private	Ambakotuwa	Private Well	No		Yes	Yes	No	No	Yes	Not answered	Not answered
9	Male	16-25	Primary Education	Self Employed	Godigamuwa	CBO	No		Yes	Yes	No	No	Yes	No Idea	Not answered
10	Female	36-45	Primary Education	Government	Akaragama	Private Well	Yes	Public Well	Yes	Yes	No	No	Yes	Not answered	Not answered
11	Female	Above 56	Secondary Education	Private	Kudagammana	Private Well	Yes	Public Well	Yes	Yes	No	No	Yes	Not answered	Not answered
12	Male	36-45	Secondary Education	Private	Bolagolla	CBO	Yes	Bowser Supply	Yes	No	No	No	Yes	Not answered	Not answered
13	Male	16-25	Under Graduate	No	Nawana	CBO	Yes	Bowser Supply	Yes	No	No	No	No	Not answered	Not answered
14	Male	26-35	Primary Education	No	Nawana	CBO	Yes	Public Well	Yes	Yes	No	No	Yes	No Idea	Not answered
15	Female	26-35	Secondary Education	Private	Diyagampola	Water Board	No		Yes	Yes	No	No	Yes	Not answered	Not answered
16	Female	36-45	Secondary Education	Private	Hellanuwa	CBO	No		Yes	Yes	No	No	Yes	Not answered	Not answered
17	Male	Above 56	Post Graduate	Government	Hellanuwa	CBO	No		Yes	Yes	No	No	Yes	Not answered	Not answered
18	Female	Above 56	Secondary Education	Private	Halgahawelawatta	Private Well	Yes	Public Well	Yes	Yes	No	No	No	Not answered	Not answered
19	Female	36-45	Secondary Education	No	Kelegoda	CBO	Yes	Public Well	Yes	Yes	No	No	Yes	Not answered	Not answered
20	Female	26-35	Secondary Education	Private	Pathigoda	CBO	Yes	Bowser Supply	Yes	Yes	No	No	Yes	No Idea	Not answered

Table 3

Survey Results Graphs

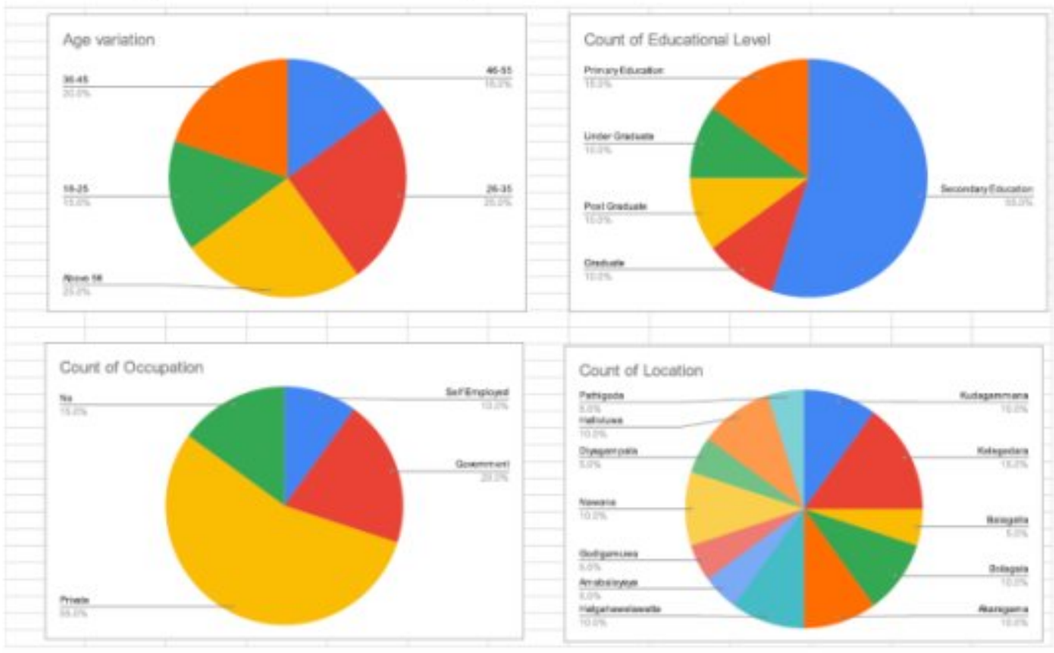
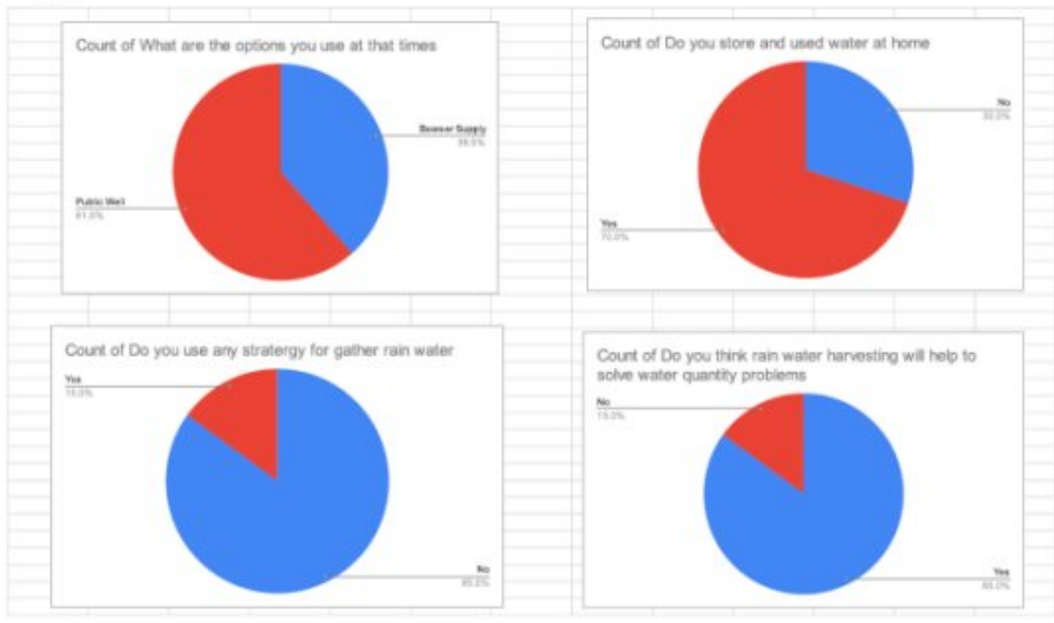


Figure 2



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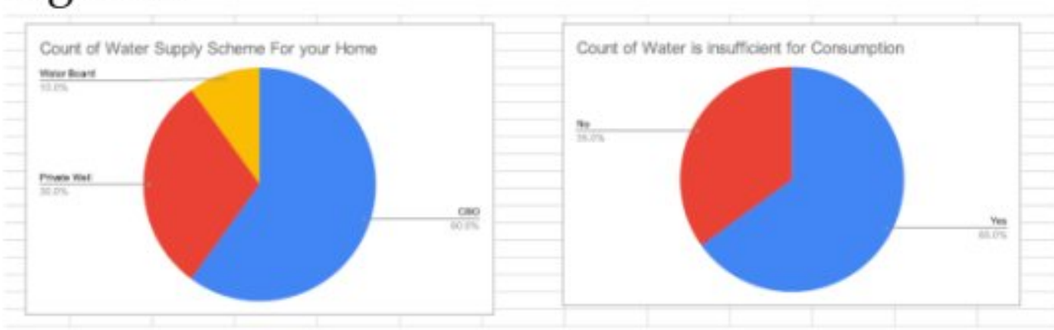

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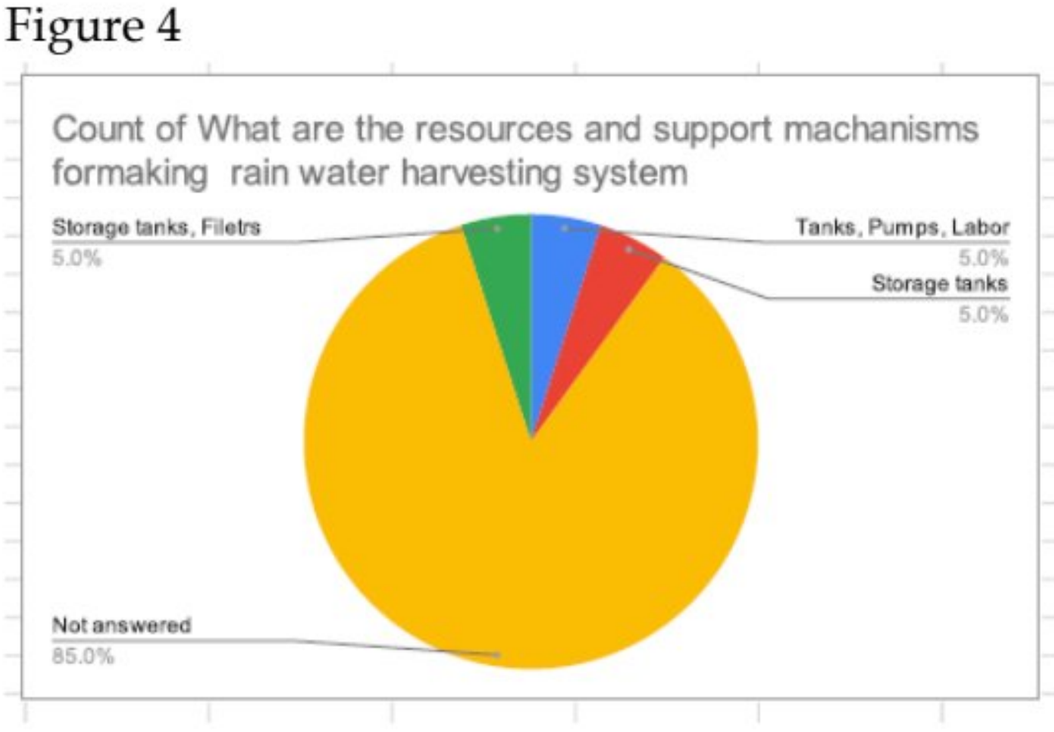

Figure 5