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Enhancing irrigation utilizing rainwater harvesting in the hilly areas of sylhet: a step toward achieving SDGS

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ABSTRACT

The study investigates the feasibility and potential of implementing rainwater harvesting (RWH) systems in the semi-mountainous region of Sylhet, Bangladesh, as a sustainable solution for water resource management. With increasing water scarcity and a heavy reliance on groundwater for irrigation, RWH presents a viable alternative that aligns with multiple Sustainable Development Goals (SDGs). Specifically, it supports SDG 6 (Clean Water and Sanitation) by providing an alternative water source, SDG 2 (Zero Hunger) by enhancing agricultural productivity, and SDG 13 (Climate Action) by promoting water conservation and resilience to climate change. The research examines two small-scale RWH systems in the Sylhet district, assessing their impact on agricultural productivity and groundwater recharge. Findings suggest that RWH can effectively support irrigation during dry periods, transforming previously uncultivated land into productive agricultural areas. By reducing dependency on groundwater, RWH contributes to sustainable water management and helps mitigate the risks of over-extraction. Despite challenges such as high initial expenses, water quality concerns, and space limitations, the study highlights the socio-economic and environmental benefits of RWH. These benefits include improved crop yields, lower irrigation costs, and increased climate resilience, directly supporting the targets of SDG 6, SDG 2, and SDG 13. The research ultimately concludes that RWH is a feasible and sustainable alternative to conventional water management methods, effectively addressing water scarcity in Sylhet's hilly regions while advancing global sustainability efforts.

INTRODUCTION

Rainwater harvesting (RWH) is a method of efficiently capturing and storing surface runoff during periods of significant rainfall, a practice that can significantly benefit agricultural activities in these hilly terrains (Helmreich and Horn, 2008) like Sylhet district. In recent years, rainwater harvesting (RWH) has gained growing recognition as a highly promising alternative resources of water, which can be used to partially offset the increasing demand of clean water globally (Bashar, 2018). Given the region's high rainfall and challenges associated with groundwater usage, rainwater harvesting emerges as a viable solution for addressing both water availability and quality issues (Alam et al., 2011).

Bangladesh is an agriculture-dependent country, where more than 16% of the national GDP depends upon agricultural production (Sarker and Prasenjit,2020), and about 80% of the total population is involved in agriculture as a profession (Rana et al.,2007). However, the country has a subtropical climate having divergent freshwater resources and the average annual rainfall varies from 5690 mm to 1110 mm from the northeast region to the west side (Choudhury et al., 2012), and about 80% of the annual rainfall occurs during the monsoon (Rana et al.,2007), but in the dry (winter and summer) season, farmers strive for water to irrigate their land and they can’t cultivate an adequate amount of land due to the water shortage. As a consequence, farmers are compelled to rely on groundwater extraction, which is not only expensive but also leads to the depletion of water resources (Vaidyanathan,1996). In the hilly terrains of Sylhet, traditional groundwater extraction methods are often costly and challenging due to the deep underground water table and stony layers (Alam et al., 2011). Rainwater harvesting can bridge this gap by providing a sustainable water supply for irrigation, crucial for agriculture and horticulture (Rainwater Harvesting for Irrigation n.d.).

Objecives

The primary goal of this study is to identify the feasibility of rainwater harvesting systems for hilly area and use the stored water for agricultural production to increase irrigated land. The study seeks to evaluate the feasibility of rainwater harvesting systems by considering the local climatic and topographic conditions. By enhancing water availability for irrigation, the study aims to reduce farmers' reliance on expensive and depleting groundwater resources. Furthermore, it promotes sustainable water management practices and the conservation of groundwater. An essential aspect of this study is to enhance farmers' knowledge and skills regarding rainwater harvesting techniques, ensuring they can effectively implement and maintain these systems. Lastly, the study will analyze the economic viability of rainwater harvesting methods compared to traditional groundwater extraction, establishing a financially sustainable model for farmers.

To meet the water demand, countries over the planet have taken rainwater harvesting as an effective alternative to water supply (Shadeed et al.,2020), (Toosi et al., 2020), (Zhang et al., 2020), also it is considered a sustainable water system where water supply is limited concerning the increasing demand (Ali et al.,2020). Rainwater is the primary natural resource of fresh water (Dhingra et al., 2019) that is usually devoid of dissolved minerals, though the quality of rainwater depends on environmental conditions (Despins et al., 2009). Here are some well-documented methods used in hilly regions, along with references for further reading:

Collecting rainwater from rooftops can be a straightforward and efficient way to gather water. The rainwater is channeled from the roof into storage systems such as tanks or underground cisterns (Mati and Bancy, 2012). This method is commonly used for domestic purposes like drinking, cooking, and irrigation (Anchan and Prasad, 2021).

Contour trenches are dug along the natural contours of the hills. These trenches slow down the flow of rainwater, allowing it to infiltrate the soil (Khandelwal et al., 2019). Bunds, which are embankments, can be used in combination with contour trenches to enhance water retention (Indian Standard 2024).

Terracing involves creating step-like fields on the slopes (Khandelwal et al., 2019). This method slows down the runoff and allows the water to percolate into the soil, making it ideal for agricultural purposes (Priyanka Choudhary et al., 2024). Terraces also help in reducing soil erosion and improving crop yields (Arnáez et al., 2015).

Small check dams are constructed across streams and rivers flowing in hilly areas (Yadav and Shriram, 2014). These dams hold the rainwater, enhancing groundwater replenishment while ensuring a reliable water supply for irrigation and household needs (Indian Standard 2024).

Percolation pits are dugout pits filled with gravel and sand to facilitate groundwater recharge by allowing rainwater to percolate into the soil (Yadav and Shriram, 2014). Percolation trenches are shallow, wide trenches filled with non-specific materials to trap rainwater and promote infiltration (Khandelwal et al., 2019).

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This involves constructing ponds, lakes, or reservoirs to store rainwater. These water bodies can be used for multiple purposes, including irrigation, drinking, and recharging groundwater (Samuel and Mathew, 2008).

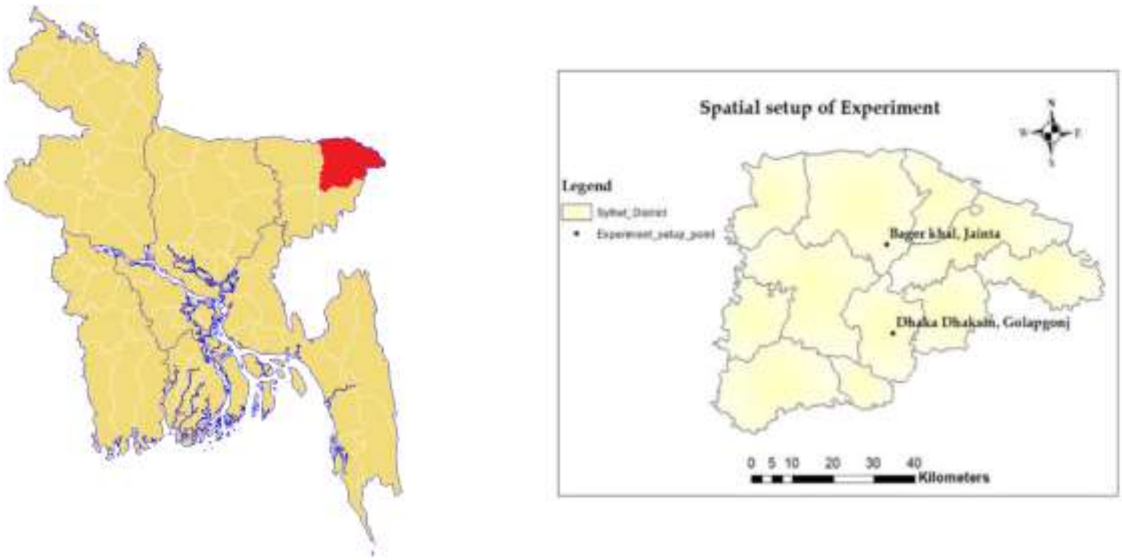
In hilly areas, micro-catchments can be particularly effective. These are small catchment areas designed to collect and store rainwater. They can be used to irrigate small plots of crops or recharge underground aquifers (Reddy and Parvatha, 2016).

Sylhet district, situated in northeastern Bangladesh, is renowned for its scenic hilly terrains, lush tea plantations, and rich biodiversity, covering an area of approximately 3452.07 square kilometers (Zafor et al., 2017). The region spans between latitudes 24°36' and 25°11' north and longitudes 91°38' and 92°30' east. Its topography features rolling hills and slopes, with elevations ranging from 10 to 50 meters (Uddin and Mukul, 2012).

The climate is characterized by a torrid monsoon, featuring predominantly hot and humid summers, and relatively cool winters (Zafor et al., 2017). The rainy season, stretching from April to October, is characterized by hot and humid conditions with very heavy rainfall. The short dry season from November to February is very warm and generally clear. The annual average highest temperatures are around 23˚C (August-October), while the average lowest temperature is 7˚C (January). The study area experiences relatively higher rainfall and lower temperatures compared to the country's annual averages. About 80% of the annual average precipitation, which is 3,334 mm, falls between May and September (Zafor et al., 2017).

The geomorphology of this study area is intricate due to the presence of the Khasi and Jaintha hills, as well as small hillocks along the border of the Plio-Miocene age (Dutta et al., 2015). In different parts of Sylhet, there are limestone deposits from the Oligo-Miocene age found beneath the ocean. These deposits became more clay-rich, as indicated by the Kopili Formation (Mukherjee et al., 2009).

From a hydrological perspective, the study area located in the Sylhet basin, near the convergence of the Eurasian, Indian, and Burma tectonic plates, is a sub-basin within the Bengal Basin that is significantly influenced by tectonic activity (Zafor et al., 2016). The basin is underlain by a thick succession of marine, deltaic, and fluvial deposits, reaching up to 20 kilometers in depth, and dating from the Eocene era to the present (Sincavage et al., 2018) is representing the location of the study area in Bangladesh map.



(a) Map of Bangladesh (b) Spatial location of rainwater harvested reservoir

Figure 1: The location of the study area in Bangladesh map

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METHOD

To store rainwater for agricultural crop production in the hilly region of Sylhet district, in this research, we excavated two small reservoirs at two different locations and by following a suitable size according to farmer's water requirement, both reservoirs were built at the bottom of hills so that the rainwater can easily be stored to the reservoir through hill-slope runoff. We prepared the water reservoir at the end of the rainy season (end of August). After completing the excavation of the rainwater tank, we placed polythene on the entire reservoir surface to limit the seepage and percolation loss. Then we allowed storing rainwater into the reservoir until the dry season. At the start of the dry season, we placed a polythene sheet above the water surface to mitigate the evaporation loss. The first reservoir was built at Dhaka Dhaksin, Golapganj with the dimensions of 14 feet×9 feet× 3 feet, and the reservoir at Bager Khal, Jointapur was constructed with the dimensions of 15 feet×8 feet×3 feet. The pictures below depict the harvested water condition.

Figure 2: Polythene placed rainwater harvesting tank of Jointapur

Figure 3: Stored rainwater at Dhaka Dhaksin, Golapganj

RESULTS AND DISCUSSIONS

The total stored water and cultivated area, and research field are shown in Table 1 and Table 2, respectively. Data was collected as the name of different cultivated crops, annual rainfall of Sylhet district, amount of harvested water, cultivated area, irrigated land of Sylhet district, crop water requirement, irrigation interval, and GIS data for preparing a Geographic Information Map.

Table 1: Total stored water and cultivated area in two locations

Sample Name	Dimension (Length*Weight*Height) ft	Harvested volume of water, cft	Cultivated Area, ft^2	Cultivated Area, ha
Dhaka Dhaksin	14 ft * 9 ft * 3 ft	378 ft^3	8000 ft^2	0.074
Bager Khal	15 ft * 8 ft * 3 ft	360 ft^3	13770 ft^2	0.127
Sample Name	Dimension (Length*Weight*Height) ft	Harvested volume of water, cft	Cultivated Area, ft^2	Cultivated Area, ha
Dhaka Dhaksin	14 ft * 9 ft * 3 ft	378 ft^3	8000 ft^2	0.074

Table 2: Cultivated crops in two research fields

Crop Name	Field Name	Crop Water requirement, mm	Total planting time (days)	Irrigation interval
Bean	Dhaka Dhaksin	40	80	3 days
Tomato	Dhaka Dhaksin	40	120	2 days
Cucumber	Dhaka Dhaksin	60	130	3 days
Brinjal	Dhaka Dhaksin	50	140	3 days
Chili	Dhaka Dhaksin	40	120	2 days
Coriander	Dhaka Dhaksin	20	45	3 days
Red Spinach	Dhaka Dhaksin	20	60	2 days
Mustard Green	Dhaka Dhaksin	25	80	2 days
Tomato	Bagerkhal	40	120	3 days
Cucumber	Bagerkhal	60	130	5 days
Pumpkin	Bagerkhal	50	150	7 days

Variability and Explanation of Statistical Trends

In order to achieve the objectives of this study, monthly rainfall data for the last 20 years was collected from Bangladesh Meteorological Station (BMD) to justify the rainwater harvesting potentiality, and data on the total irrigated areas of the Sylhet district was collected from the Department of Agricultural Extension (DAE, Sylhet). All those data were analyzed to make a relationship for evaluating the potentiality of rainwater harvesting in the hilly region of Sylhet district.
Monthly Rainfall Variability of Dhaka District

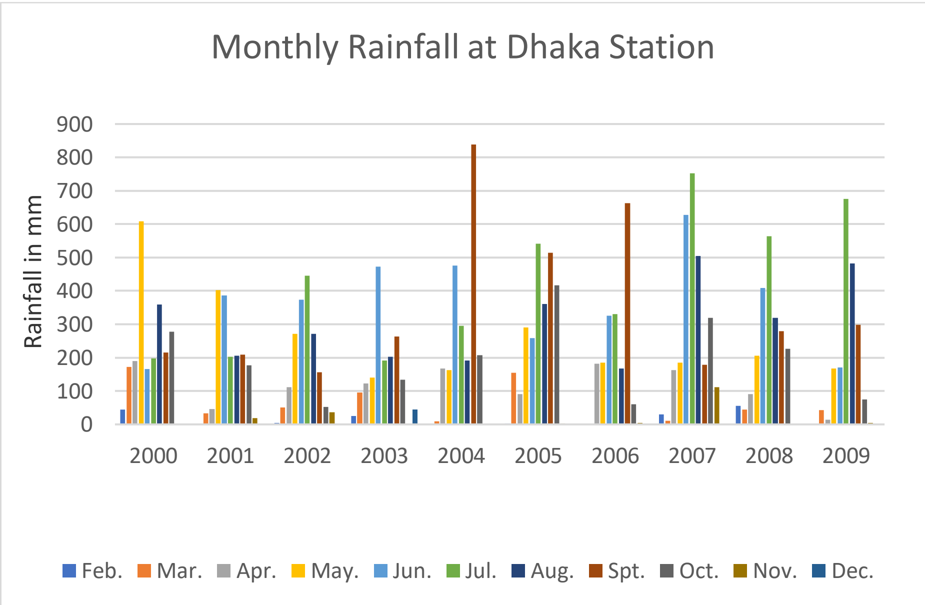

Figure 4: Monthly rainfall variability of Dhaka district (2000-2009)

Figure 4 illustrates the monthly rainfall variability over 10 years from 2000 to 2009 at Dhaka Station. It is calculated that a total amount of 2134.4 mm of rainfall occurred, with an average of 2134.4mm per year. The months of April-October exhibited a significant increase in rainfall, maintaining an average of 95.04%, covering the Summer, Rainy, and Autumn seasons of Bangladesh. In contrast, from November to March, the average rainfall was notably lower at 4.96%.

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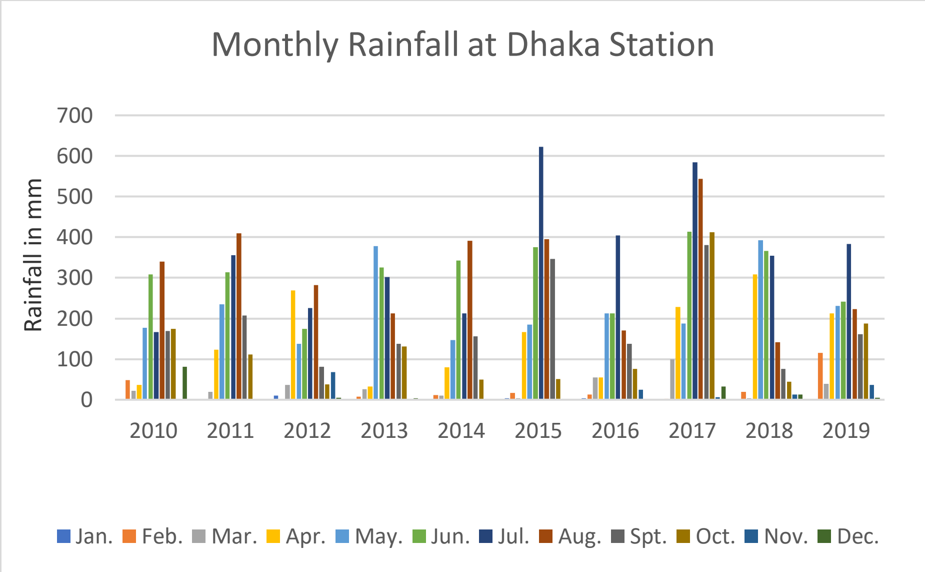

Figure 5. Monthly rainfall variability of Dhaka district (2010-2019)

Figure 5 presents the monthly rainfall variations at Dhaka Station over a decade from 2010 to 2019. The total recorded rainfall during this period amounted to 1757.5 mm, averaging 94.92% annually. A significant rise in rainfall was observed between April and October, with an average of 94.922%, encompassing the Summer, Rainy, and Autumn seasons in Bangladesh. In contrast, the months from November to March experienced considerably lower rainfall, averaging 5.08%.

From the rainfall variability trend over the last 20 years, a clear pattern emerges: minimal rainfall occurred between November and March, averaging 5.019%, while a substantial amount of rainfall was recorded in Dhaka from April to October, with an average of 94.98%.This trend highlights the strong influence of monsoons in Dhaka's climate. Monthly Rainfall Variability of Dhaka District presented in figure 6.

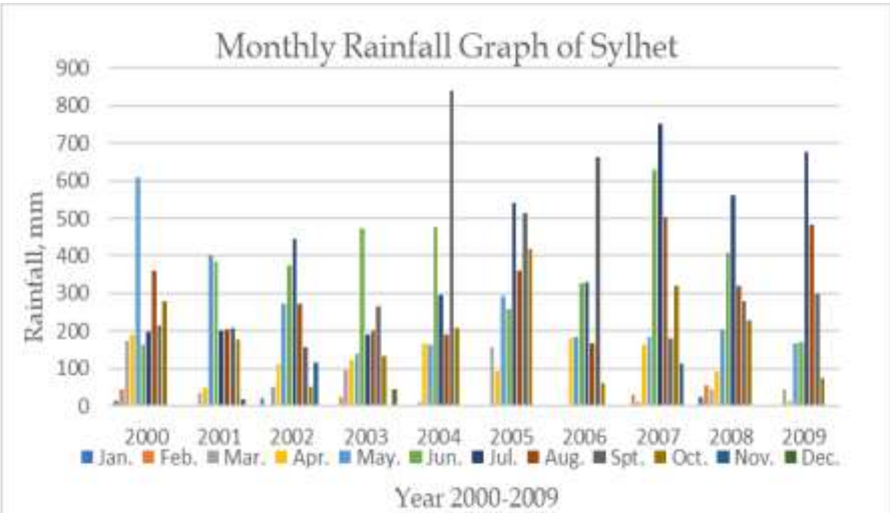

Figure 6. Monthly rainfall variability of Sylhet district (2000-2009)

The following figure (Figure 6) demonstrates the monthly rainfall variability of 10 years from 2000 to 2009 in the Sylhet districts, and it illustrates a clear trend of very low rainfall from November to March with an average of 114.1 mm and the total amount of precipitation of 1141 mm. From April, the rainfall started increasing and during May-October the rainfall showed an upheaval trend with an average of 2028.3 mm where the total amount was 20283 mm. Figure 5 illustrates the monthly rainfall pattern of the Sylhet district from 2009 to 2019. The figure depicts a clear trend of monsoon rainfall where the maximum amount of rainfall occurred in April-October and the minimum amount of rainfall occurred between November to March.

From Figure 7, it is calculated that a total amount of 16715 mm of rainfall occurred with an average of 1671.5 mm from 2010 to 2019. Here, the months of April-October maintained an average of 1849.9 mm of rainfall covering the Summer, Rainy, and Autumn seasons of Bangladesh. From November to March, there was an average of 86 mm of rainfall there. Again, a clear trend can be depicted from the above figures (rainfall variability of last 20 years) that a minimum rainfall occurred from November to March with an average of 100.05 mm and an enormous amount of rainfall occurred in Sylhet during April-October with an average of 1849.9 mm rainfall.

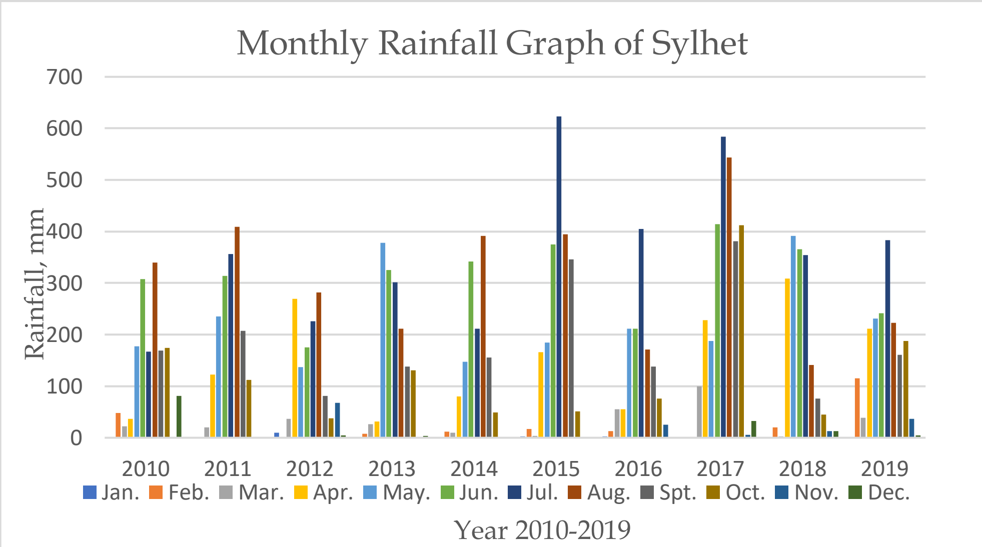

Figure 7: Monthly rainfall variability of Sylhet district (2010-2019)

Irrigated Land Variability of Sylhet District

Data on total Irrigated land, irrigated land by surface water, and irrigated land by groundwater of the last ten economic years were collected from the Department of Agricultural Extension Sylhet and analysed to get an introspective idea about irrigated land variability (Table 3).

Table 3. Irrigated Land of Sylhet District (Source: DAE, Sylhet 2021)

Economic Year	Land Irrigated by Groundwater (by using deep and shallow devices), ha	Land Irrigated by Surface water, ha	Irrigated Land, ha
2010-2011	856	57262	58118
2011-2012	925	58789	59714
2012-2013	1021	60053	61074
2013-2014	1145	60965	62110
2014-2015	1321	62514	63835
2015-2016	1480	63758	65238
2016-2017	1575	66756	68331
2017-2018	1705	67530	69235
2018-2019	1820	69315	71135
2019-2020	2087	72058	74145

Figure 8 and Table 3 illustrate the total irrigated area as well as the irrigated area by groundwater with a gradual upheaval trend. In the economic year of 2010-2011, the total irrigated area was 58118 ha and a gradual incremental trend was shown to turn into a total irrigated area of 74145 ha in the economic year of 2019-2020.

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Figure 8. Total irrigated area as well as the irrigated area by groundwater with a gradual upheaval trend (2010-2020)

Above all these, there is a matter of that the farmers of this region are becoming aware of irrigation requirements and cultivating more agricultural field to secure the food demand. In the economic year of 2010-2011, the groundwater irrigated area in Sylhet was a total of 856 ha only which increased up to a total of 2087 ha from 2019 to 2020, i.e. approximately 1.5 times to a total of 2087 ha irrigated area increased by groundwater irrigation since 2010. Although it is a positive aspect of agricultural production, the above graph and table (Figure 6 and Table 3) have introduced to a concern that groundwater use for agricultural production are increasing day by day for the last 10 years, creating pressure on groundwater with a serious aquifer depletion.

Comparative Analysis of Rainfall in Dhaka and Sylhet for Rainwater Harvesting

Rainwater harvesting (RWH) is a sustainable approach to water resource management, especially in regions with distinct seasonal rainfall patterns like Dhaka and Sylhet. The analysis of rainfall data from these two regions highlights key relationships that impact the feasibility and efficiency of rainwater harvesting.

Both Dhaka and Sylhet experience a monsoon-dominated climate, with maximum rainfall occurring between April and October and minimal rainfall from November to March. However, Sylhet consistently receives a higher volume of annual rainfall compared to Dhaka, making it a more favorable region for large-scale rainwater harvesting. Also comparing the differences in annual rainfall also indicates that Sylhet has a higher potential for rainwater collection, necessitating more extensive storage infrastructure, whereas Dhaka may require additional water sources during the dry season.

Sylhet, with its high-intensity rainfall during the monsoon months, requires effective storage and runoff management to minimize water loss and maximize rainwater harvesting. Larger storage systems are needed to capture and utilize the surplus rainfall. In contrast, Dhaka, with moderate rainfall, can utilize rainwater harvesting as an additional water supply, particularly during the dry months (November–March). To address water scarcity, Dhaka can implement strategies like groundwater recharge and optimized distribution of harvested rainwater for sustainability. Both cities must also adapt infrastructure, ensuring proper filtration, collection, and storage facilities to maintain water quality and promote efficient use.

Relation Between Rainfall and Irrigated Area for Sylhet District

By analysing the rainfall data of the last twenty years (**Error! Reference source not found.** & **Error! Reference source not found.**), it is clear about the rainfall pattern of Sylhet district that an enormous amount of rainfall occurred during April-October with an average of 1849.9 mm and those moths cover summer, rainy and autumn seasons (monsoon) of Bangladesh. Where a minimum amount of rainfall occurred from November to March with an average of 100.05 mm and those months cover the late autumn, winter, and spring seasons (dry) of Bangladesh. From the analysis of an irrigated area of Sylhet district, another trend is clear that irrigating area are increasing for the last consecutive 10 years. It is a positive aspect for increasing food security but a discernible thing is groundwater irrigation also increasing simultaneously which is very pernicious for the environment where groundwater table depletion in the dry season is a pressing problem for the hilly region of Sylhet district and has available surface water resources in the monsoon season due to the extravagance rainfall. From the investigation and analysis, it also could be stated that rainwater harvesting would be a shrewd decision for a farmer who has an annual average of 1949.95 mm rainfall. It is possible to reserve an adequate amount of rainwater in the monsoon from the heavy rainfall and to utilize it according to various requirements (cultivation, household, drinking, etc.). By irrigating the stored water in the field, the farmer could be cultivated at a very low cost, a sustainable manner, and would be beneficent by getting higher economic returns.

Crop Water Needs and Rainwater Harvesting: Dhaka vs. Sylhet

As rainwater harvesting has significantly improved crop yield in Dhaka by providing supplemental irrigation during the dry season, particularly for Boro rice, which relies heavily on irrigation (Bell et al., 2015). However, its impact would be even more pronounced in Sylhet. With its higher rainfall, Sylhet already experiences good crop yields, particularly for rice and other seasonal crops (Muttaleb et al., 2017). Rainwater harvesting in Sylhet would not only manage excess water during the monsoon but also ensure a steady supply during the dry season, further boosting crop productivity. The effectiveness of rainwater harvesting in Sylhet would be more significant, as it helps stabilize crop production throughout the year, addressing both water scarcity and excess (Islam et al., 2017).

In Dhaka, while rainwater harvesting is primarily useful for rice, vegetables and fruits, which have lower water requirements. On the other hand, Sylhet's crops, including Aman rice, jute, and tea, have higher water needs, with tea and jute in particular requiring consistent moisture throughout the year (Ali and Yusuf, 2014). Rainwater harvesting in Sylhet would provide necessary irrigation during dry spells, as well as help manage excess runoff during the monsoon. This makes it even more beneficial than in Dhaka, where it is primarily used to support dry-season crops. Overall, rainwater harvesting in Sylhet could optimize water availability for crops with higher and more consistent water demands, maximizing overall crop productivity (Abdullah et al., 2024).

Socio-Economic Output

Rainwater harvesting has a divergent socio-economic impact i.e., it can generate employment opportunities (Safari et al., 2020), significantly escalate the monthly income (Jan, 2020), and can play a great role in enhancing food security (Ngigi and S.N, 2003). In this research work, rainwater was harvested in two different places in Sylhet district for agricultural crop production and evaluated the socio-economic output. At Dhaka Dhaksin, Golapganj, the farmer was a 60 years old expatriate, who returned his home from England to spend his leisure time with his family. At the end of August 2020, he stored a total of 378 ft3 of water on the prepared reservoir and he cultivated various horticultural crops like beans, tomatoes, cucumbers, brinjal, etc. On his 0.074 ha land. He only grew those crops for the consumption purpose of his family and relatives for the first time. After harvesting once, he planted once again considering his stored water resources. At the end of the full season, the farmer estimated that the rainwater harvesting system saved his almost BDT 10000, which he had to spent for purchasing vegetables. The second location was in Bagerkhal, Jointapur, where the goal of the farmer was to make money from his cultivation. At the end of August 2020, he reserved a total of 360 ft3 of rainwater and he cultivated different horticultural crops like tomato, cucumber, pumpkin, etc. on his 0.127 ha land. Though the plan was to irrigate precisely according to crop water requirements, but he could not refute his traditional practice and sometimes he irrigated like surface flood irrigation wasting a lot amount of stored water. As he occasionally irrigated his lands with water from other sources, he estimated a total of BDT 40000 by selling those crops upon harvesting, and also about the reduced cultivation cost reduces in an enormous range compared to the other farmers. Since he sometimes irrigated his land from the other water sources, it could mitigate his cultivation cost more, if he irrigated during the full season by using his stored water.

In Sylhet, rainwater harvesting can further stabilize water availability for crops like tea, jute, and rice, leading to more consistent irrigation and increased agricultural income. It also helps mitigate flooding during the monsoon, reducing crop damage and infrastructure repair costs.

Rainwater Harvesting: A Key to Achieving Sustainable Development Goals

Rainwater harvesting is a sustainable practice that supports several Sustainable Development Goals (SDGs). By collecting and storing rainwater, communities can ensure clean water access, boost food security through improved irrigation, and enhance resilience to climate change.

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Rainwater harvesting is a crucial practice that helps achieve multiple Sustainable Development Goals (SDGs). For SDG 6: Clean Water and Sanitation, it provides a reliable source of clean water, especially in areas with groundwater contamination (Arora and Mishra, 2022). For SDG 2: Zero Hunger, it ensures a steady water supply for irrigation, improving agricultural productivity and food security (Allahyari and Poursaeed, 2020). Lastly, for SDG 13: Climate Action, it reduces groundwater strain and manages surface runoff, aiding communities in adapting to climate change and becoming more resilient to its impacts (Nandi and Swain, 2024). This multifaceted approach makes rainwater harvesting a powerful tool in promoting sustainability and resilience (SDGs 2015).

Rainwater harvesting systems have significant environmental benefits. They alleviate water pressure on centralized water networks, conserving valuable resources (Semaan et al., 2020) (Vialle et al., 2015). Additionally, rainwater harvesting helps reduce environmental contamination by providing an alternative water source (Vialle et al., 2015). By increasing soil permeability, these systems prevent floods, which is particularly beneficial in flood-prone areas (Angrill et al., 2011). Furthermore, rainwater harvesting enhances groundwater recharge, replenishing aquifers and improving overall water availability (Embaye et al., 2020) (Gebremeskel et al., 2018) (Negusse et al., 2013). By using surface water instead of groundwater, rainwater harvesting also reduces the pressure on underground aquifers, mitigating groundwater depletion. These environmental benefits highlight the importance of rainwater harvesting in promoting sustainable water management practices.

Challenges of RWH

Rainwater harvesting (RWH) faces several challenges (Shaidi and Vincent 2020). One significant issue is the quality of the collected water, which may contain contaminants like dust, leaves, bird droppings, and chemicals from roofing materials. This necessitates proper filtration and treatment to ensure the water is safe for use (Dauda et al., 2021). The initial cost of setting up an RWH system can be high due to the expenses associated with storage tanks, filtration systems, and plumbing modifications (Shaidi and Vincent, 2020). Regular maintenance is also crucial to keep the system functioning properly, including cleaning filters, checking for leaks, and ensuring storage tanks remain free from algae and other contaminants (Patrick et al., 2014). Additionally, finding adequate space for storage tanks can be challenging, especially in urban areas with limited space (Dauda et al., 2021). Regulatory issues may also arise, as some regions have legal and regulatory hurdles related to the installation and use of RWH systems. Lastly, a lack of public awareness and understanding about the benefits and functioning of RWH systems can hinder their adoption. By tackling these challenges, we can make rainwater harvesting a more viable and widely adopted practice.

Recommendation

Rainwater harvesting (RWH) is an eco-friendly method of capturing and storing rainfall for diverse applications, including irrigation, household use, and industrial purposes (Nandi and Gonela, 2022).

To effectively address the challenges of rainwater harvesting and promote its widespread adoption, several key recommendations and strategies can be implemented. Investing in advanced filtration and treatment technologies is essential to ensure the collected rainwater is safe for various uses, including potable purposes, along with regular maintenance and monitoring systems to maintain consistent water quality (Alim et al., 2020). Governments and organizations can offer financial assistance through subsidies, grants, or low-interest loans to reduce the initial cost of setting up RWH systems (Ssekyanzi et al., 2024). Developing compact and efficient storage solutions can help overcome space constraints, especially in urban areas, and integrating RWH systems with existing infrastructure, such as green roofs and urban gardens, can maximize the use of available space (Lepcha et al., 2024). Investing in research and development can lead to innovations in RWH technologies and practices, and collaboration between researchers, engineers, and policymakers can help address technical and regulatory challenges. Finally, engaging local communities in the planning, implementation, and maintenance of RWH systems can ensure their long-term success by fostering a sense of ownership and responsibility.

CONCLUSION

The exploitation of water resources is the threatening problem of available water resources. In contrast, the global water demand increased by 55% due to the population demand (Cardoso et al., 2020), the dearth of water became a global incident (Zhang et al., 2021) and the scarcity of water is one of the main reasons behind the indignation of people (Kahinda and Taigbenu, 2011). Thus, water is becoming a limiting factor for crop production in many developing countries around the world (Sarki et al., 2014) and rainwater harvesting has been proven as a promising sustainable water resource for those areas where has lack potable water access (Sturm et al., 2009). In this study, two small-scale rainwater harvesting systems were evaluated in the semi-mountainous hilly region of the Sylhet district. The goal was to assess the feasibility of rainwater harvesting systems in that area and increase agricultural land and irrigated land by using the stored water. In this research, a total of 738 ft3 of water was harvested in two different harvesting reservoirs and cultivated a total of 0.21 ha of fallow land. Those land turned into agricultural land by utilizing surface irrigation from the stored rainwater and both the farmers also got benefited from RWHS establishing rainwater harvesting system as a suitable alternative of water resources for agricultural production in that area. Besides, it has already been proven that rainwater harvesting systems enhance groundwater recharge, during the precise application of stored water as surface irrigation to the crop root following the crop water requirement. Irrigation usually increases the infiltration rate and influences groundwater recharge, where this research showed a way to reduce groundwater extraction for crop production by utilizing the stored water in RWHS. So, it can be concluded that the rainwater harvesting system will be a possible and sustainable alternative to managing limited water resources in the hilly region of the Sylhet district.

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