



SUSTAINABLE WATER TECHNOLOGIES FOR HOUSING REHABILITATION IN COASTAL BANGLADESH

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Abstract

Displaced communities living in housing rehabilitation projects in coastal Bangladesh often lack access to safe drinking water. Adverse climatic conditions, vulnerable geographic locations, and poor resource management make the scenario worse. Different water technologies have been inbuilt and installed in these projects, but most have proven unsustainable so far. Therefore, finding the most suitable water technology for these communities remains a key challenge in making these settlements sustainable. In this regard, the research first explores globally available water technologies that use different coastal water sources. Based on this, it seeks to identify the sustainability features of each selected water technology – suitable for the aforementioned coastal conditions. A narrative review process was used to review secondary literature and materials systematically. Relevant websites, journals, and conferences related to sustainable water supply and management were also examined. Findings suggest that sustainability parameters differ for water technologies in terms of different water sources. Rather than using a single water source-based technology, a combination based on a specific context should work better. Findings from this study can be used as a starting point for assessing the sustainability of water technologies in housing rehabilitation projects and retrofitted in possible cases.

Keywords: Sustainable Water Technologies, Housing Rehabilitation, Coastal Rural Bangladesh

Introduction

Water, an essential element of life, plays a significant role in sustainable and healthy living when its adequacy, safety, and accessibility supply of freshness is ensured. Providing safe drinking water to the world's 6.9 billion and growing population is one of the century's most significant challenges (Oelkers et al., 2011). Water scarcity and unreliable water quality are considered critical barriers to attaining the eminence of life. In 2015, the fresh drinking water crisis was identified as a significant global risk (Gude, 2017). It is predicted that by 2050, at least one in four people will suffer from recurring water shortages (Li & Yang, 2021).

Bangladesh has abundant water, with around 24,000km of rivers flowing through its fertile landscape. However, providing safe drinking water for everyone is an acute national problem, with 4 million people not

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having access to clean water (Rahman et al., 2022). Moreover, coastal areas of Bangladesh are one of the most disaster-vulnerable landscapes (Hoque et al., 2019; WB, 2018), where potable water scarcity is even worse (Hassan et al., 2022). Around 73% of people in the coastal region of Bangladesh alone are deprived of drinking water (Abedin et al., 2019; Rahman & Islam, 2018). The variously displaced rural populations remain the most vulnerable due to natural disasters and river erosion. Bangladesh government has had several rehabilitation housing programs for these displaced homeless people since 1972 (Barua et al., 2020; Barua et al., 2021), where the drinking water issues should have been resolved along with other problems as it is well addressed in the rehabilitation housing policy (PMO, 2019; 2020; 2021). In practice, however, most projects like *Asbrayan* were erected on vulnerable low-lying lands, particularly on riverbanks and in flood-prone areas (Parvin et al., 2022), where *khas* lands are primarily found, frequently without adequate disaster/hazard planning.

Contrary to initial *Asbrayan* standards, site selection and preparation often ignored the project village's geo-climatic setting and existing infrastructure (Mallick et al., 2019). The scarcity of fresh drinking water remains the most conspicuous factor in these. In contrast, resettlers also need water for additional daily usage, including bathing, washing, cultivation, sanitation, livestock farming, and more. To avail drinking water, they must depend on rainwater mostly, which is season-dependent and provides water for four to six months maximum. Other sources, such as surface water, are contaminated by the saline intrusion, while the groundwater level becomes too deep to avail. Their economic condition is too weak to avail commercially bottled water daily. Available sources are commonly well, tube-well, lake, river, canal, pond, and water containers, whichever that particular context offers. Water level depletion, saline intrusion, contamination, land scarcity, high maintenance, lack of social awareness, and high cost are the issues that make access to water very difficult (Hakim et al., 2015). In earlier projects, ponds were designed to supply drinking water. Other design solutions in these earlier projects were also removed in later stages. The government also experimented with several options, including additional rainwater collection units on community, cluster, and house levels, solar-powered purification units, etc. Ponds were limited to support all the year-round needs, and drinking water ponds require regular purifications and land. However, most technologies added later failed due to external dependency, complicated operations, and high maintenance costs (Parvin et al., 2022). Here remains the knowledge gap that requires examination of the most sustainable technologies that support groundwater recharge, contamination prevention, purification, desalinization, filtration, passive surface water source provision, affordability, easy maintenance, social awareness, and environmental friendliness.

It calls for identifying water technologies best suited for housing rehabilitation in coastal Bangladesh. The research first explores available water technologies that use different coastal water sources. Based on this, it seeks to identify the sustainability features embedded in the selected water technologies for practical use.

Materials and Method

The most popular approaches to reviewing scholarly articles include narrative, scoping, and systematic reviews (Davis et al. 2009; Arksey & Malley 2005). A narrative review was used for this study. This review technique incorporates scholarly literature, just like prior review processes.

This study used several criteria to decide if a scholarly publication qualifies. Only articles from trusted journals on water supply management with peer-reviewed were considered. A three-stage procedure was used for this. First, "sustainable water technology" was identified in terms of rain gardens, rainwater collection systems, water purification methods in coastal seas, clean drinking water sources, etc. In addition, expressions such as sustainable water supply, low-cost water supply systems, cost-effective and affordable water supply, rural water supply, wastewater management, surface water purification, desalination and water filtration techniques, low-cost water management, nature-based solution for water purification, point source water management, rain gardens, rainwater harvesting techniques, rainwater collection systems, solar systems for water purification, fog water collection, fog water management, low-cost water supply for housing, etc., were used for identifying the most relevant research articles and websites for the review process.

Since it contains hundreds of journals from different categories, the Scimago platform was primarily used. After outlining the articles, the journals' scopes, SJR, and H index concerning Water Supply Technology Studies were used. Several articles on sustainable water technologies were evaluated within various journal types (Figure 1). The total number of publications on water technology was assessed in addition to the initial count. The first phase reviewed the titles, abstracts, and keywords of all articles published in these publications. The initial review process considered fifty scientific publications, websites, and conference papers. Other sustainable water technologies from non-academic sources, nature-based solutions, and indigenous practices in various communities were evaluated in addition to the scholarly sources. Non-scholarly sources include websites and obtaining information from other online sites.

For evaluating the outcome of selected research articles, water technologies related to Groundwater, Surface Water, Rain Water, and Fog Water were reviewed narratively in terms of installation, operation, and maintenance. Finally, the sustainability features were evaluated for each type of water technology.

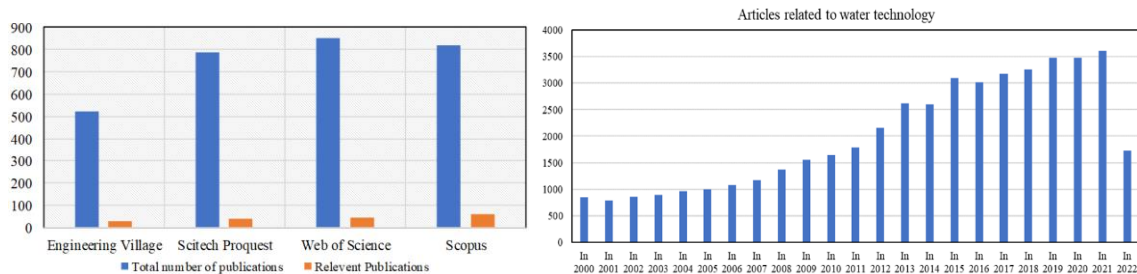


Figure 1. (a) Total number of publications and relevant publications related to water technology in 50 journals. (b) Articles related to water technology in the last 20 years.

Understanding sustainable water technology

Sustainable water technology combines intricate traditional and modern elements resembling natural processes. It offers up-to-date and upcoming technological research, development, and applications to ensure everyone has access to water. Applications of nanotechnology, biotechnology, information technology, and environmentally and human health-friendly procedures and goods that conserve resources like water and energy are examples of sustainable water technologies.

Different definitions suggested by various authors in terms of sustainable water management, sustainable water supply, water purification, and sustainable water usage are provided in Table 1.

Table 1. Relevant Definitions to understand of sustainability of water technology

Authors	Definitions
(Dubber & Gray, 2010)	Water sustainability refers to ensuring that water is used to satisfy present-day socio-economic ecological, and future demands.
(Esmailion et al., 2021)	Utilizing water in a way that satisfies present ecological, social, and economic requirements without jeopardizing future abilities is known as sustainable water management.
(Harmancioglu, 2013)	Sustainable water supply requires the identification of reliable and resilient responses to various human water needs that do not deplete water supplies or the local economy and have no long-term negative impact on the environment.
(Wilderer, 2004)	The accessibility of fresh drinkable water for human consumption and agricultural and industrial activities is called water sustainability.

(Scholz, 2013) From the planning perspective, sustainable water usage entails guaranteeing enough supplies of fresh, clean water for present and future generations and the environment. It addresses all watershed waters, including stormwater, transmitted as surface water in rivers, creeks, reservoirs, dams and subsurface water resources.



Figure 2. Word cloud of Relevant keywords to understand of sustainability of water technology.

The most popular search terms for this review paper and several research articles are represented graphically in Figure 2. A glimpse of the water technologies discussed in this article is also provided using a word cloud.

Sustainable water technology also offers the right amount and quality of water to satisfy a particular demand without jeopardizing its future potential. Although water systems in the context of sustainable development might not involve water usage, they do include those where it has historically been necessary.

For this study, we concluded that sustainable water technology is a system, method, or device that receives, purifies, stores, and supplies potable, locally acceptable, and environmentally friendly water.

Review of Available Water Technologies

Water technologies that use surface water

Household sand filter

The HSF (Household sand filter) is generally made of the dimensions of the inner diameter of the pipe, which was 15 cm; length of 90 cm; and wall thickness of 3.7 cm with 10 cm plain cement.

A Household sand filter is (HSF) low cost and used to treat low-quality water for drinking purposes (Mande et al., 2018; Hossain et al., 2022). The performance of HSF is pretty good in terms of water supply and maintenance. It can purify river, pond, and lake water, and the device or the materials of manual design could be found in local and regional markets.

It can purify 1 to 3 L of water per hour, and the maintenance cost is relatively low - about BDT 500 per 6 months.

Ceramic silver pot filter

Using a ceramic silver pot filter, (Rivera-Sánchez, et al. 2020) researched low-cost technology to clean water at the household scale. The filter element in CSF is designed like a pot and put in a plastic container. The filter works as a sieve since the clay makes it porous. These tiny pores are large enough to allow water to seep through but small enough to trap bacteria and other contaminants.

The measured flow rate in this system is 1 to 3 L/hr. The filter element is shot in once it has assumed its shape. Sawdust is burned in a kiln to create a porous substance. The filter component is infused with a Colloidal silver solution for purported disinfection. Pathogens were shown to be 95–98% of the murdered using a ceramic pot filter and silver (Wastewater Treatment Systems 2004).

The filter or the essential components of the filter can be found in regional-level markets. It takes BDT 1,500 to 2,000 for installation, and the maintenance cost might take BDT 500 after 2/3 months.

Solar thermal MED (Multi-Effect Distillation)

MED (multi-effect distillation) systems are compatible with solar thermal desalination. A MED unit connected to a pond with a 30,000-40,000 m² surface area may generate 100,000 tons of distilled water annually for a price equivalent to that of traditional desalination systems (Qiblawey & Banat, 2008).

MED is very helpful for coastal communities because it can purify sea water and the materials can be collected at regional and national markets. The construction cost for solar thermal MED is BDT 5,000 and can purify 4550 m³ of water daily. The maintenance of the MED system is a little complicated and costly. It might take up to BDT 1,000 per month.

Solar energy is converted to heat and electricity to purify water, where highly expert and technician support is required. The primary installation cost is high. It is neither environmentally friendly nor human-inclusive.

Solar thermal RO (Reverse osmosis)

The solar thermal system is a popular process in many countries, including a solar collector used for heat absorption (Esmacilion et al., 2021)). The solar power is turned into heat energy, which is transferred to fluid moving through the absorbent. Additionally, the use of solar thermal-powered purification is limited to regions with significant exposure to sunlight and requires a sizable operational area (Leijon et al., 2018; Wagner & Rubin, 2014).

The System was primarily created for 20 families without access to fresh water. Two hundred litres of daily water will be needed to give one evening light to each family. The system will create 40 litres per hour and run for 5 hours daily. Twenty-four watts per hour are required for the purifier to function. Each family's daily electricity usage is 5 watts per hour. Every day, the purifier runs for five hours, with a four-hour backup from the light. The daily energy requirement is 520 watts.

The essential components for preparing solar thermal RO process could be found in the regional market and cost up to BDT 4,000. Research suggests it can purify up to 240 m³ of water per day and the maintenance cost is about BDT 2,000 per month.

Integrated anaerobic-aerobic fluidized bed reactor

A cylindrical fluidized bed with pulverized pumice-stone is used as the support material for microorganisms (Fdez-Polanco et al., 1994). Four cylindrical fine bubble membrane diffusers perform it. It offers excellent stability despite variations in organic load and delivers a short startup time for the operation. This process removes organic carbon and nitrogen from municipal and industrial wastewater (Gutterer et al., 2005).

The process is appropriate for purifying surface water, including that in ponds, rivers, and lakes. The technology may be used locally and has cheap installation and maintenance costs.

Anaerobic-aerobic fixed film bioreactor (FFB)

For aerobic treatment, two fixed-film bioreactors with a medium arrangement and recirculating system were employed in sequence (Del Pozo et al., 2003). Due to the employment of immobilized cells on the surface of the medium, the system is less susceptible to environmental variations and has a faster growth rate. This bioreactor can eliminate oil and grease from wastewater.

Small wastewater treatment systems can serve less than 50-person equivalents. This system can purify around 1,000 m³ of wastewater flows per day. It is a low-cost technology that can be used locally and constructed quickly.

Brackish Water Reverse Osmosis (BWRO) System Design

The drinking water shortage in Bangladeshi coastal districts may be helped by brackish water reverse osmosis (RO) technology. The reverse osmosis system is a more technologically advanced and financially viable drinking water source.

RO is a procedure that uses a different mechanism than distillation, electrochemical treatment, or activated carbon to extract salts and soluble organic material from brackish water. The pressurized feedwater flows across a membrane surface, with a portion of the feed permeating the membrane. A BWRO system supplies 200 litres of drinkable water per day for 20 families. The system recovery rate is 60%, so the raw feed water is 66.67 L/hr. Feed pressure is 120 PSI, and array recovery is 8% (Shamsuzzoha et al., 2018).

This process is relatively costly, but for community-level supply and long-term performance, BWRO is convenient. The construction materials for BWRO might not be found in the local market.

Water technologies that use groundwater recharge

These technologies are applied to enhance the amount of water held underground and improve the overall quality through natural absorption mechanisms, surface water from shallow aquifers is refilled artificially (Balke et al., 2004).

Pre-filtration

Firstly water is filtered before being recharged artificially with groundwater. It occurs in small, impermeable basins, such as those formed of concrete, filled with a layer of gravel and sand roughly one meter thick to act as a filter.

Water fills over a cascade and cascades through the filter layer to a collection pipe on the other side of the basin. The water is then piped into slow sand filtration basins, where it seeps vertically to recharge the groundwater artificially.

The pre-filtration technique is relatively more straightforward and could be constructed locally. The maintenance cost is lower, but the construction cost is somewhat higher (Balke et al., 2004).

Bank filtration

Artificial bank filtration is drawing water from a river or lake using wells close to the water's surface (Firsch & Wichmann, 2005). The hydraulic gradient between the well's decreased groundwater and the surface water level is directed towards the well at regulated pumping rates. Thus, surface water is compelled to move into the aquifer and the well. A mixture of groundwater and surface water is extracted from the well (Zhu, 2005).

The same purification processes can be used to remove surface water. They have a horizontally positioned shaft with a diameter of 2 to 5 meters and screening strings that range in length from 10 to 50 meters. The screens may be placed beneath the river or lake. Such wells enable the extraction of vast quantities of water. It has cheap upkeep costs and is excellent for rural locations (Zhu, 2005).

Subsurface Dams

Building a subsurface dam to retain groundwater found in the silts rocks beneath an ephemeral river may be helpful in areas with dry seasons. This technique can be beneficial, particularly in small river basins where fine sand and gravel deposits are covered by bedrock that is more or less impervious at shallow depths.

Bricks or concrete can be used to erect the subsurface barrier. About 1m below the river bed level is where the highest crest of the dam should be. A delivery well must be found upstream of the subsurface dam, and infiltrating wells may be added if the liquid can be transported up from nearby locations (Balke et al., 2004).

The process is comparatively more straightforward and buildable at the local level. While building costs are often higher, upkeep costs are cheaper.

Recharge pits

Recharge pits are simple square or circular pits with weep holes spaced regularly and enclosed with a brick or stone masonry wall. Protecting the pit's top with perforated covers is possible. The filter medium should be placed at the bottom of the pit.

The catchment area, rainfall intensity, and rate of soil recharge can all be utilized to determine the volume of the pit. Depending on the thickness of the underlying strata, the pit is usually 1 to 2 meters wide and 2 to 3 meters deep. In these trenches, small houses and shallow aquifers can be refilled (Remmler & Schulte-Ebbert, 2003; Kambale, 2009).

Recharge pits are simple to create, inexpensive, and harmless to the ecology.

Water technologies that use rainwater

Roof Rain Water Harvesting (RRWH)

RRWH system consists of a storage tank and delivery systems for moving rainwater from the catchment to the appropriate storage (such as roofs or ground surfaces) (Sturm et al., 2009). Due to their durability, plastic or metal are typically used to make gutters and downpipes.

In terms of cost, roof harvesting solutions are even competitive with the public water supply (Baird et al., 2013). The corresponding prime costs are significantly lower throughout those systems' lifetimes than the private water taps' chosen benchmark. Therefore, even in places with grid supplies, it makes sense to offer RWH as a complementary water source (Benkelman et al., 2001).

Roof rainwater harvesting requires low money, can be implemented efficiently on the rooftop, and requires low maintenance costs. Installation and maintenance costs might vary according to the size and depth of the tank.

Outdoor storage tank rainwater harvesting

One of the significant types of RW is DRWH, where water is collected from sub-surface tanks and used for small-scale productive activities, home needs, and plant watering (Coombes et al., 2003). Usually, there is a limit on the amount of water; a domestic RWH system can supply per day, per week, or year, given its size, location, and operating strategy. A significant portion of the price of the DRWH system goes toward the storage tank (Morey et al., 2016).

The primary benefit of DRWH is that it provides water right at the residence, alleviating the strain of having to travel far to fetch water (Christian et al., 2016; Coombes et al., 2003).

Installing a 30 m³ homestead rainwater tank will not cost more than BDT 100,000 and can supply water to roughly 10 to 20 families (Sturm, et al., 2009; Morey et al., 2016).

Rain barrels

The rain barrels are straightforward to assemble. The Environmental Protection Agency believes that a single 208 liters rain barrel can conserve up to 4921 liters of water during summer. They are pretty simple to install. Rain barrels collect roof runoff by channelling a portion of your gutter's downspout into a nearby reservoir (Seo et al., 20120).

It is simple to maintain and simple to install in local communities. Rain barrels cost up to BDT 1,000 per unit.

Rainwater harvesting system in ponds

As a supplemental water source, the Rainwater Harvesting System in Ponds is more expansive and offers more opportunities. The PHS has numerous financial, environmental, and water harvesting advantages. While the PHS has good potential and should be utilized in newly developed urban areas with a rainy tropical environment, the RWH has more significant potential and may be appropriate for individuals or existing buildings (Hamdan, 2009).

In other respects, the home water demand that is addressed on a small scale by roof harvesting systems (RWHS) might also be met by pond harvesting systems (PHS), which function on a grander scale. The catchment area's runoff naturally flows to the pond reservoir, eliminating the requirement for a conveyance system at PHS. (Zabidi et al., 2020).

The system must be inexpensive, straightforward, and simple for locals to construct. Polythene and other PHS materials could be procured from regional markets.

Rain gardens

Rain gardens are a cost-effective addition to the sewer network rather than a replacement for it. A case study was used to explore the integration of rain gardens and sewage systems in Saranta Ekklisies, a neighbourhood near Thessaloniki, Greece (Basdeki et al. 2016).

At various locations within the study area, a total of five rain gardens were built. A local case suggests that a rain garden was formed in 2415 m². Another rain garden was 33 m² and was located at different street intersections. The study considered the worst rain event was predicted to occur every two years throughout a 2-year return period. The intended rain gardens effectively reduced rain runoff in the research area. Additionally, it was determined that building a rain garden would cost less than 1028.36 Bangladeshi takas per sqm (Basdeki et al., 2016; Bray et al., 2012)

Water technologies that use fog water

Fog-water collection

Following Chile's breakthrough in the middle of the 1980s, the fog-water collection started in some developing nations (Fessehaye et al., 2014). Fog collection technology is a cutting-edge technique that uses a straightforward process of surface impaction to collect wind-borne fog droplets.

A plastic mesh is physically stretched in the direction of the wind, catching fog droplets as the air travels through the mesh. On the mesh fabric, tiny fog droplets gather to form larger water droplets, trickling into an attached gutter. Gravity can then direct the collected water to a sedimentation tank, where it will eventually find its way to a home water supply and/or an irrigation system (Nahar et al., 2022).

Fog water collection is high cost, has high potential to meet the needs of the local level, and can be simply complemented at the local level. With a 40 m² collection area, a single, large fog collector can create up to 200 litres per day on aggregate all year. It may last a decade and cost between BDT 0.8 million to 1.2 million for installation.

Analysis and Discussion

Water technologies were examined under sustainability features such as Water source, Local/ Regional market availability, Portability, Low Installation cost, Low Maintenance cost, Lower Function cost per litre, Shareability, Contamination, and Nature-based aspects. Finally, discussion and suggestions were provided based on the most sustainable technologies (Tables 2 to 5).

Sustainable water technologies using surface water

The sustainability features for reviewed surface water technology include a water source, local/regional market availability, portability, low installation cost, low maintenance cost, lower function cost per litre, shareability, and contamination free.

Solar thermal MED is the costliest in terms of installation cost. But this process takes less function cost. The solar thermal med process can be suitable for community scale, and the devices are available in the regional market. The solar thermal RO installation process is less costly than the MED system. Both solar thermal MED and RO process produces some chemical components which might not be environmentally friendly. In terms of cost-effectiveness, Ceramic silver pot filters and Household sand filters are most suitable. These two processes produce fewer pollutants and are easy to construct. Also, the materials for preparing Ceramic silver pot filters and Household sand filters are available in regional markets. These filtration systems cannot reduce water salinity, but surface waters from ponds, rivers, and lakes can be purified with these devices. So, in terms of cost, maintenance, and effectiveness, sand and ceramic filters are more convenient and sustainable than other processes. In coastal zones solar powered water purification systems can be utilized because it's easier to prepare and maintain and suitable for both household and community water supply (Table 2).

Sustainable water technologies using groundwater

The sustainability of groundwater recharge systems is evaluated in table 3. Among all the systems, recharge pits are more suitable for local people because it takes lower cost, do not require a lot of space, and are simpler to construct.

The sustainability features for reviewed groundwater technology include a water source, local/ regional market availability, portability, low installation cost, low maintenance cost, lower function cost per litre, and shareability.

Sustainable water technologies using rainwater

The sustainability features for reviewed rainwater technology include a water source, local/regional market availability, portability, low installation cost, low maintenance cost, lower function cost per litre, shareability, contamination, and nature-based. The sustainability features are shown in Table 4.

The many procedures connected to a rainwater harvesting system are described in Table 4. Domestic rainwater harvesting and rooftop rainwater harvesting system is relatively easy to construct and cost-effective. But PHS requires extra space and is suitable for a broader scale. Even though the only differences between both systems are their size and how the conveyance system is used, the use of RWHS to meet residential water demand has been explicitly acknowledged through the RHS application. In contrast, PHS application is still a fact of discussion.

Sustainable water technologies using fog water

The fog harvesting system is expensive in Bangladesh and cannot be used all year. So, fog eater collection system is less sustainable (Table 5).

Table 2. Sustainability features from the water technologies that use surface water

Sustainability Features	Solar thermal MED	Solar thermal RO.	Household sand filter	Ceramic silver pot filter	Integrated anaerobic-aerobic fluidized bed reactor	Brackish Water Reverse Osmosis (BWRO) System Design	Anaerobic-aerobic fixed film bioreactor (FFB)
Water source	Sea	Sea	Pond/lake/river	Pond/lake/river	Pond/lake/river	Sea	Pond/lake/river
Local/ Regional market availability	√	√	√	√	×	×	×
Portability	√	√	√	√	×	√	√
Low Installation cost	×	√	√	√	×	×	×
Low Maintenance cost	×	√	√	√	×	×	×
Lower Function cost per litre	×	√	√	√	√	√	×
Shareability	√	√	√	√	√	√	√
Contamination free	×	×	×	×	×	√	√

Table 3. Sustainability features from the water technologies that use groundwater

Sustainability Features	<i>Pre-filtration</i>	Bank filtration	Subsurface Dams	Recharge pits
Water source	River, lake, ground	River, lake, ground	ground	ground
Local/Regional market availability	√	√	√	√
Portability	√	√	√	√
Low Installation cost	×	×	×	√
Low Maintenance cost	√	√	√	√
Lower Function cost per litre	√	√	√	√
Shareability	√	√	√	√

Table 4. Sustainability features from the water technologies that use rainwater

Sustainability Features	Roof Rain Water Harvesting	Pond Rainwater Harvesting Systems	Domestic Rainwater Harvesting (DRWH)	Rain Gardens
Water source	Rain Water	Rain Water	Rain Water	Rain Water
Local/ Regional market availability	√	√	√	√
Portability	√	×	√	√
Low Installation cost	√	√	√	×
Low Maintenance cost	√	√	√	√
Lower Function cost per litre	√	√	√	√
Shareability	√	√	√	√
Nature based	×	×	×	√

Table 5. Sustainability features from the water technologies that use fog water

Sustainability Features	Fog Water Collection System
Water source	Fog
Local/ Regional market availability	√
Portability	√
Low Maintenance cost	√
Shareability	√

Water technologies related to surface water such as Brackish Water Reverse Osmosis (BWRO) System Design and Anaerobic-aerobic fixed film bioreactor (FFB) are not environment friendly whereas Solar thermal MED Solar thermal RO Household sand filter, Ceramic silver pot filter, integrated anaerobic-aerobic fluidized bed reactor causes less pollution, and they are environment friend. Among the surface water technologies, sand filters and ceramic silver pot filters are relatively cheaper and most suitable for locals because of their simplicity (Table 2). Groundwater technologies mostly require higher costs but recharge pits are reasonably affordable and easier to construct. Groundwater technologies are also sustainable regarding function and maintenance costs (table 3). Among the rainwater technologies, rain gardens are nature-based and relatively costly. They require a lot of space, whereas other systems, such as rooftops and pond rainwater harvesting, require less space (Table 4). The fog water collection system is not suitable for Bangladesh because it takes higher installation costs and requires a lot of space in the context of Bangladesh. Besides, water cannot be collected yearly (Table 5).

Conclusion

The most significant obstacles to humanity are a lack of water and inconsistent water quality. Water insecurity is caused by inadequately maintained, deteriorating, expensive, and unreliable sources that require much travel

time. Water insecurity is also a result of the existing water infrastructure's high rates of technical dysfunction. This research examined water technologies, including groundwater, surface water, rainwater, and fog water, and it provided a narrative review of the technologies' installation, use, and maintenance.

In this study, the review process was done by performing three steps. Firstly, suitable journals associated with water, water technologies, and sustainability were selected for choosing appropriate articles. Secondly, a keyword-based search was performed, and thirdly scholarly articles were reviewed. As counter the first objective of this study several globally available water technologies are reviewed that use different coastal water sources including Solar thermal MED, Solar thermal RO, Household sand filter, Ceramic silver pot filter, Integrated anaerobic-aerobic fluidized bed reactor, Brackish Water Reverse Osmosis (BWRO) System Design, and Anaerobic-aerobic fixed film bioreactor (FFB) for surface water; Pre-filtration, Bank filtration, Subsurface Dams, and Recharge pits for groundwater; Roof Rain Water Harvesting, Pond Rainwater Harvesting Systems, Domestic Rainwater Harvesting (DRWH), and Rain Gardens for rainwater and finally, Fog Water Collection System for fog water. As for the second objective of this study several sustainable features are identified from the selected water technologies which includes local/regional market availability, portability, low installation cost, low maintenance cost, lower function cost per litre, shareability, and contamination free for surface water; local/regional market availability, portability, low installation cost, low maintenance cost, lower function cost per litre, and shareability for ground water; local/regional market availability, portability, low installation cost, low maintenance cost, lower function cost per litre, shareability, contamination, and nature-based for rainwater; however, fog water collection system is discussed as unsustainable technology for the coastal housing rehabilitation communities.

Findings suggest that sustainability parameters differ for water technologies in terms of different water sources. Rather than using a single water source-based technology, a combination based on a specific context should work better.

According to the review results, Brackish Water Reverse Osmosis (BWRO) System Design and Anaerobic-Aerobic Fixed Film Bioreactor (FFB) are two surface water technologies that are found not to be eco-friendly, while the Solar-powered RO, the combined anaerobic-aerobic fluidized bed reactor, ceramic silver pot filters, and household sand filters reduce pollutants are environmentally friendly. Sand and ceramic silver pot filters are considerably less expensive surface water technologies that are best suited for locals due to their simplicity. While most groundwater solutions are more expensive, recharge pits are less costly and more straightforward to build. Technologies that use groundwater are also cost-effective in terms of operation and maintenance. Recharge pits are the most appropriate systems for the local population since they are less expensive, demand less space, and are easier to build. This study also reviewed various methods for collecting rainwater. Because homes in the research region are often clustered together and share a shared yard and pond, rainwater managing devices in the pond could be an improved on-site source for supplying water. In contrast, RWH could be able to resolve the problems with distinct families. Among the rainwater harvesting and collection techniques, rain gardens are relatively expensive, but they are nature-based and sustainable in the longer term. The fog water collection system was also evaluated, which remained unsustainable in the current context of Bangladesh.

However, evaluation of other water technologies that were not done in the current study because of various limitations should also be evaluated to make them more impactful in sustainable water technologies. Findings from this study can be used as a starting point for assessing the sustainability of water technologies in housing rehabilitation projects and retrofitted in possible cases. The outcome of this study can be implemented and tested as further research to assess the sustainability features.

Conflict of Interests

The authors declare no conflict of interest.

Author Contribution

Sheikh Serajul Hakim: Conceptualization, Supervision, Writing – review & editing, Writing – Validation, data collection, Methodology, Interpretation. Md. Azharul Islam: Writing – original draft, review & editing, Methodology, Data analysis.

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