



Review Article

A Review on Rainwater Harvesting in Sri Lanka

Vikneshwaran Vijitha^{1*}, Seeralakandapalan Sayanthan¹ and Thushyanthy Mikunthan²

¹Department of Biosystems Technology, Faculty of Technology, University of Jaffna, Sri Lanka

²Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna, Sri Lanka

Received: May 31, 2022; Revised: August 10, 2022; Accepted: August 22, 2022

Abstract: Freshwater scarcity is one of the emerging threats to human survival. There is a gap between availability and demand for freshwater due to urbanization, industrialization, overpopulation, contamination of groundwater, and unpredictable climatic conditions. Rainwater harvesting is an environmentally sound option to mitigate the water scarcity issue. Further, rainwater is a sustainable water source that can be utilized to satisfy the water demand considerably. This manuscript reviews the rainwater harvesting systems in Sri Lanka with particular emphasis on history and present status, different techniques and methods, climate change adaptation, quality and treatments, utilization of harvested water, health benefits and issues, and policy and strategies in the Sri Lankan context. Rainwater harvesting is not a new technology in Sri Lanka; it was even practiced by ancient Sri Lankans many centuries ago. Anyhow, special attention to the operation and maintenance of the rainwater harvesting systems should be paid to improve the quality of harvested water for further uses. In addition, the effectiveness of the policies related to rainwater harvesting should be ensured for the better functioning of rainwater harvesting systems all around the country.

Keywords: Climate change, Freshwater, Mitigation, Policy, Water scarcity

1. Introduction

The existence of living beings on earth depends on water sustainability, while the availability of adequate water is considered an indicator of a country's development (Weerathna and Weerasinghe, 2009). Water shortage is one of the prevalent issues experienced by several countries all around the world, which is caused by ever-growing water demand for domestic purposes, including drinking, agricultural, industrial and environmental needs (Khanal et al., 2020). The number of people under water scarcity is estimated to be three billion in 2025 worldwide (Hanjra and Qureshi, 2010). Therefore, technological solutions such as rainwater harvesting (RWH), wastewater reuse, and desalination have been proposed as acceptable ways to mitigate water scarcity to some extent (Elimelech, 2006). In addition, integrated water resource management, good water governance, and adequate water management also can be indicated as potential practices to overcome water scarcity-related issues.

RWH is an ancient technique adopted as a viable source of water globally (AbdelKhaleq and Alhaj Ahmed, 2007). It is one of the feasible methods to recover the natural hydrologic cycle and achieve sustainable urban development (Julius et al., 2013). Sri Lanka is blessed with a bi-modal rainfall pattern and receives an average of 1,750 mm of rain annually (Sivakumar, 2021). Anyhow, significant rainwater finds its way to the sea via runoff. Even though Sri Lanka is categorized as a country with either little or no water or moderate water scarcity, a mismatch between availability and demand for freshwa-

ter exists notably in the dry zone of Sri Lanka. Further, there is a possibility of experiencing water scarcity in the near future due to the factors like rapid growth of population, limitation in water resources, and climate change (Ariyananda, 2010). Therefore, RWH can be practiced as a reliable alternative to overcome the issues related to water scarcity.

Statistically, around 34% of Sri Lankans use pipe-borne water, whereas the rest of the population depends on local sources, including rainwater harvesting tanks (De Silva and Ariyananda, 2020). Districts in the dry zone such as Vavuniya, Mannar, Mullaitivu, Jaffna, and Kilinochchi (Northern Province), Polonnaruwa, and Anuradhapura (North Central Province), Puttalam (North Western Province), and Batticaloa (Eastern Province) depend around 90% on groundwater supply (Panabokke and Perera, 2005). Anyhow, agricultural activities and contamination due to industrial wastage cause tremendous pressure on groundwater in terms of quantity and quality. In addition, the per capita availability of water is estimated to decline from 2,400 m³ to 1,800 m³ in 2025 (Amarasinghe et al., 1999), which will create many challenges for water sector-related policymakers and stakeholders to meet the Millennium Development Goal of "Water for All" by 2025. It forces the relevant authorities to be concerned about environmentally sound and feasible ways to satisfy the future water demand.

The need for the official body to be concerned about rainwater harvesting in Sri Lanka was fulfilled in 1996 by forming the Lanka Rain Water Harvesting Forum



(LRWHF). It was established to foster, disseminate and research the potential of using rainwater as a widely accepted reliable option for domestic water supply (Ariyananda, 1999). Roof RWH was promoted twenty-four years ago in Sri Lanka to satisfy drinking water demand. Later it was also considered for institutional and agricultural demand (Dissanayake and Padmi, 2019). Lots of projects have been completed by LRWHF in several places, including in Karachchi and Pachchilaipalli divisional secretariat divisions in Kilinochchi district, Northern Sri Lanka, with the objectives to make aware the beneficiaries and build capacity in rainwater harvesting and groundwater recharging technology shows their involvement in diminishing the water scarcity issues (Thusyanthini et al., 2021). Anyhow, failure in planning for the operation and maintenance of rainwater harvesting systems (RWHS) may limit the sustainability of such projects.

2. History and Present Status of RWH

Sri Lanka has an extensive history of rainwater collection in rural villages. Sri Lankans practiced informal collection of rainwater from the rooftops for many centuries. The Sigiriya fortress complex's sophisticated rainwater-cum-reservoir system in the 5th century can be the best evidence of the long history of rainwater harvesting in Sri Lanka (Ariyananda, 1999). In traditional RWH, the water is collected from tree trunks into barrels or small brick tanks for domestic use using coconut or banana leaves (Thusyanthini et al., 2021).

The RWH has become essential for sustainable water management (Ward et al., 2012). When considering the 21st century, rainwater harvesting has become popular as it possesses the benefits like low cost, simple design, and easy maintenance. Further, numerous water supply projects with foreign funding and the dissemination of technological knowledge by LRWHF can be indicated as the reason for adopting rainwater harvesting in rural areas (Ariyananda, 2001a). The efforts of LRWHF under several projects made the construction of over 42,000 domestic rainwater harvesting systems possible and brought immense benefits to communities (Dissanayake and Padmi, 2019).

3. Techniques and Methods of RWH System

There are two different techniques in RWH, namely rooftop harvesting and runoff harvesting. The rooftop harvesting technique focuses on the collection of water for domestic use. This technique is being practiced in households, schools, government institutions, and factories in Sri Lanka. In order to maintain the quality and quantity of harvested water, different components are incorporated into this system. The major components are the catchment area, delivery system, and storage tank. When RWH intends for drinking purposes, special consideration should be given to roofing materials.

Further, the storage tank is designed based on roof size,

rainfall data, number of users, and their daily water requirements (Sayanthan et al., 2017). Weerathna and Weerasinghe (2009) have stated in a guide as the estimation of the total catchment area is needed to find out the quantity of water that can be harvested. In addition, the rainfall data from a nearby station and the runoff coefficient should be taken into consideration. The runoff harvesting technique is preferable for agriculture, where the rainwater is collected from runoff catchment areas. It is an ideal way to recharge the groundwater in urban areas by directing the runoff water from driveways, landscapes, open fields, parks, roads and pavements, and other open areas of the environment to pits (Balasuriya and Arachchige, 2021).

Sri Lankans practice four different methods of RWH.

Method 1: Traditional Rainwater Harvesting Method This method is practiced at the household level to increase water availability where rainwater is collected directly without unique structures. This method is rarely practiced or not in use (Ariyabandu, 1999a).

Method 2: Conventional Rainwater Harvesting Method Many Sri Lankan houses in rural areas are of bi-segmented type. The roofs of both segments taper towards one side, forming a large catchment area for RWH. In this method, an improved gutter directs the harvested rainwater to an open tank which is made below the gutter terminal (Ariyananda, 1999).

Method 3: Informal Rainwater Harvesting Method The capacity of the storage structure (200-liter barrels) in this method is lesser than conventional RWHS. This method contributes to the water security of households and is accepted as the standard method applied in the rural areas of Sri Lanka (Balasuriya and Arachchige, 2021).

Method 4: Institutional Rainwater Harvesting Method This method also improves household water security in remote areas of Sri Lanka. It started with the Community Water Supply and Sanitation Project (CWSSP) and was supported by NGOs and Provincial authorities. Compared to the rest of the methods, the capacity of this system is more extensive as it uses two basic systems, each with 5,000-liter storage tanks (Hapugoda, 1995).

4. RWH as a Climate Change Adaptation Measure

Extreme climate events are the results of global weather change. Along with the rapid increase in population, industrialization, and urbanization, climate change plays a decisive role in meeting the water demand and supply (Elmahdi et al., 2009). Many regions worldwide have accepted RWH as a reliable technique to reduce the detrimental effects of climate change on water supply (Mohammed et al., 2007). The reliability of RWHS depends on factors like the rainfall pattern and the dry period duration, which would differ according to the change in the climate (Khanal et al., 2020).

Jackson et al. (2001) stated some reasons for adopting rainwater harvesting systems to cope with increasing water demand besides the global weather changes. Those reasons are lack of clean drinking water and basic sanitation, increasing pressure on freshwater accessibility due to the rapid growth of population, and intensification of the earth's hydrological cycle because of climate change in the next 100 years. Schewe et al. (2014) have also investigated and discussed climate change's negative impact on water scarcity.

Developing countries are highly likely to experience climate change's negative impacts (Khanal, 2020). Climatic change has affected different sectors in Sri Lanka as well. Lo and Koralegedara et al. (2015) predicted that there is a chance of more rainfall in Sri Lanka because of climate change towards the end of this century (2080–2099), with more impact on residential RWHS compared to nonresidential systems. According to the study by De Silva (2014) in the central hills of Sri Lanka, the annual average rainfall is predicted to increase by 12% in the study area (Ratnapura, Nuwara Eliya, and Kandy) in 2050 compared to the baseline (1961-1990). In addition, annual runoff is also predicted to increase; it is almost 100% in Kandy compared to the baseline.

Likewise, the annual average temperature is predicted to rise by 1.7°C, 1.1°C, and 1.5°C in Ratnapura, Nuwara Eliya, and Kandy, respectively, in 2050. Further, De Silva (2014) has suggested some adaptation measures with a particular focus on rainwater harvesting in various ways, like storing the excess runoff water when the water demand is low and promoting community-based projects to collect and store the excess runoff by runoff collection tanks for home gardening and other purposes. On the other hand, maintenance of rainwater harvesting systems to collect roof water during the rainy season can be adopted for drinking purposes.

5. Quality and treatments of harvested rainwater

Water quality is essential as it directly correlates with people's health. The harvested rainwater does not need sophisticated treatment units as it is free from most contaminants (Sturm et al., 2014). Though rainwater is comparatively free from impurities, its quality can be altered during harvesting, storage, and household use (Khanal et al., 2020). The bacteriological quality of rainwater collected from ground catchments is inferior. In contrast, the rainwater collected from an adequately maintained rooftop catchment is suitable for drinking purposes when it is equipped with covered storage tanks. The quality of captured rainwater will be optimum if the rooftop is clean and impervious. In addition, using non-toxic materials for constructing the system and locating it away from over-hanging trees help to ensure better water quality (Rana, 2005). Initially, Sri Lankans showed considerable resistance to RWH, which was reduced later through the demonstration and awareness programs. People were reluctant to use the rainwater for drinking due to water contamination as the rainwater

tanks were constructed without a filter. This issue was solved by designing the system with gravel and charcoal filters. However, only 10% of households use rainwater for drinking due to the influence of perception of water quality and taste (Ariyabandu, 1999b).

A study conducted from May 2017 to May 2019 in the Badulla district by De Silva and Ariyananda (2020) revealed that the pH (6.5-8.5), electrical conductivity (1500 S/cm), and total soluble salts (500mg/L) in harvested rainwater were within the safe limits. The pH levels were high in the harvested rainwater due to the dissolving of cement from the newly constructed Ferro cement tank. It can be overcome by washing and flushing the tank several times. EC values were also found less in harvested rainwater compared to well water. Algal growth and mosquito breeding in the tanks can also affect the water quality. These problems can be prevented by sealing the tank tightly (Ariyananda, 2010). The presence of *Escherichia coli* (*E. coli*) is another quality-related issue. GI roofs are appropriate to ensure a lesser level of *E. coli* compared to other types of roofs as the heating of GI roofs kill the *E. coli* in the roofs (Vasudevan et al., 2001). In addition, maximum exposure to the sun and frequent cleaning reduce microbial contamination (Khanal et al., 2020).

Despite water quality concerns, some people use harvested rainwater without any treatments. According to the research done between January to February 2013 in Vavuniya district by Karthiga and Inoka (2014), 68% of the people use rainwater for drinking purposes without further purification. 27% of them practiced boiling, and only 5% of the people used the filter to purify the rainwater before drinking. Anyhow, drinking rainwater recorded no health demerits in the study area. Chlorination is also an efficient technique for treating rainwater. However, it should be done after separating the water from the tank to avoid the reaction of chlorine with the deposited organic matters in the tank (Gordon et al., 1995). A report released on 2011 stated that about 70% of the respondents in the study area have been using rainwater for drinking purposes with pretreatment. More specifically, 35%, 27%, and 8% have adopted boiling, filtering, and chlorination (Ariyananda and Aheeyer, 2011).

6. Utilization of RWH system in Sri Lanka

RWH is an easily adaptable option to mitigate water scarcity and reduce the burden on the public water supply. Though rain water is limited for drinking and cooking during the dry season, it is used for all purposes during the rainy season. RWH is a possible way to solve the drinking water problem in a district like Vavuniya, where the groundwater contains a high mineral content. It also has social and economic benefits. Sometimes the people have to transport the water from far away for their day-to-day activities. The construction of the RWH not only reduces transportation expenditure but also saves time as the people do not need to go out to collect water and

induce them to use the saved time primarily for family welfare (Karthiga and Inoka, 2014).

The construction materials for RWHS are locally available. Further, the installation and operation of RWHS are also simple, which can be done by the local people after minimum training to implement such technologies. Furthermore, the harvested rainwater can be used for farm water supplies and irrigation purposes (Mohammed et al., 2018) and could be directly reused for inferior activities like gardening, washing, and cleaning (Anchan and Prasad, 2021). In addition, it can be used in an emergency such as sudden fire incidence (Rahman et al., 2014).

The harvested rainwater acts as a water source for small-scale home gardens, facilitating the citizens of Sri Lanka to achieve food security considerably. It encourages Sri Lankans to engage in economic activities like cultivating mushrooms and running poultry and goat farms. People utilize the rainwater for toilet and washing purposes, ensuring sanitation and personal health as indirect merit (Ariyananda, 2010). When the rainwater is harvested in a bigger tank, it can be incorporated into the inland freshwater aquaculture (Sayanthan et al., 2017). Moreover, large-scale rainwater storage reduces runoff, mitigating flood events and soil erosion. Likewise, it prevents the pollutants from finding their way to water bodies (Rahman et al., 2012). Further, the minimization of runoff through RWH ensures the reduction of blockage of storm water drains (Julius et al., 2013). Also, rainwater harvesting can reduce salt accumulation in the soil, which can harm root growth (Waterfall, 2004).

According to De Silva (2005), RWH is an ultimate option to recharge the groundwater through percolation, which helps cope with groundwater depletion due to evaporation and over-extraction. A significant reduction in water bills is another advantage of RWH. Ariyananda et al. (2007) found a reduction in water bills in the households that use water from the RWH system for several purposes. Bill reduction of around 34% and 60% was observed for low and high-income groups in the study area of Anuradhapura, Kandy, and Negambo (Ariyananda, 2007). Though RWHS is identified as a potential solution to mitigate water scarcity in the dry zone of Sri Lanka, the concern about utilizing it for flood mitigation is comparatively less. Ranasinghe and Disanayake (2018) proved that implementing RWHS will significantly reduce the local flooding during a rain event in a Colombo DS Division and any urban area by storing excess rainwater and using it for different applications.

A report on the effectiveness of RWHS as a Domestic Water Supply revealed that a hundred percent of the respondents in Kurunegala use rainwater for drinking during dry and wet seasons. In contrast, a hundred percent of the respondents in Batticaloa use rainwater for drinking, cooking, and washing clothes only during the wet season. In contrast, none of the Mannar, Kalutara, and Ratnapura respondents use rainwater

as drinking water. Further, all the beneficiaries surveyed in Ampara, Matale, and Matara use rainwater for washing clothes. Notably, all the respondents from districts such as Matale, Matara, Batticaloa, Kalutara, Ratnapura, and Hambantota use rainwater for toilet use (Ariyananda and Aheeyer, 2011). More interestingly, a survey among thirty rainwater harvesting practitioners in Karachchi divisional secretariat division, Kilinochchi district, showed that all of them use rainwater alone for drinking purposes while using other water sources like tubewell, shallow well, neighbor's well /common well for other purposes (Thusyanthini et al., 2021).

7. Health Benefits and Issues of Using Rainwater as a Drinking Water Source

The physical and chemical standards of rainwater should be within the acceptable limits for drinking. Appropriate design and maintenance of the RWH system ensure low health risks and a significant improvement in human health (Ariyananda, 2005). A clean rooftop, efficient operation of filters, and first flush and closing of the tank to prevent mosquito breeding and algal growth ensure the good quality of harvested rainwater for further usage (Ariyananda, 2001b). Poor maintenance of the RWHS, heavy metals and other substances may lead to human health risks. As the rainwater lacks minerals, it may cause health hazards when used in the long term. Therefore it is essential to intake minerals through food or medicines. Further, it can be overcome by mixing rainwater with groundwater (Ranasinghe and Wijerathne, 2014; WHO, 2014).

The primary health-related problems identified in RWHS in Sri Lanka are the presence of dissolved contaminants and micro-organisms in the harvested water. Other essential parameters like color, turbidity, pH, and conductivity are within the recommended standards of the World Health Organization. Minor contamination such as leaves, droppings of animals, and insects can be minimized with proper cleaning procedures (Ariyananda and Aheeyer, 2011). According to the results obtained from the study of De Silva and Ariyananda (2020) in Badulla, the rainwater in the tank was suitable for Chronic Kidney Disease of unknown etiology (CKDu) patients as the TDS values were less than 100mg/L. Jayasumana et al. (2014) reported high amounts of zinc led in the Northern Province of Sri Lanka, which can lead to chronic kidney diseases.

8. Policy and Strategy in Sri Lanka

The Sri Lankan government made a national policy on rainwater harvesting in 2005 to encourage communities to control water near its source by harvesting rainwater. Later in 2009, the Legislation made rainwater-harvesting mandatory in the new building above a specific roof size in areas under municipal and urban councils (Ariyananda, 2010). The National Rainwater Policy expects to have some merits, such as reduction of storm water runoff, mitigation of localized flood damage, soil

erosion and land degradation, prevention of groundwater depletion, minimizing water stress during droughts, reduction of urban thermal pollution effects, minimizing unregulated stagnation of water over prolonged periods, causing the spread of disease and enabling broader access to additional sources of water during natural disasters such as fire, flood, and droughts. Dissanayake and Padmi (2019) reported that the policy has not given an effective framework for RWH and highlighted the inefficiency of law as it is impractical.

Raising awareness regarding the importance of RWH is one of the key strategies in the National Rainwater Policy. Sri Lankan government has not remarkably invested in rainwater harvesting, and it is revealed that the contribution of the National Water Supply and Drainage Board to the rainwater harvesting system is around 10%. The balance is from the funding projects. The construction cost is a reason for the lack of usage of RWHS for domestic, commercial, and industrial purposes. Ariyananda and Aheeyer (2011) found that most domestic rainwater tanks in Sri Lanka have a capacity of 5000 liters (64.49%).

In contrast, a tank with a capacity of 8000 liters (1.63%) is being used somewhat. The average cost of the such tank is LKR 50,000 (Ariyananda and Aheeyer, 2011). Therefore funding, subsidies, or loans should be adopted to help the public establish RWHS for domestic purposes.

9. Conclusion

This paper evaluated several aspects of rainwater harvesting in Sri Lanka. The over-exploitation and contamination of groundwater raise the need to adopt environmentally sound techniques like RWH to mitigate water scarcity. Being a developing country, Sri Lanka lacks adopting sophisticated techniques like desalination and groundwater remediation to a greater extent for human consumption. Therefore adapting RWH will enhance water availability for different purposes in a cost-effective manner. According to the reviewed data, mainly rainwater's chemical and physical quality is found within the standards to be used for drinking purposes with or without simple treatments.

Further RWHS can be a reliable water source for disadvantaged groups such as poor rural communities and CKDu-affected patients. Anyhow periodic analysis of the operation and maintenance of the RWHS is required to ensure the system's efficient functioning. In addition, implementing policies and strategies related to RWH should focus on storm water management, urban green, sustainable agriculture and public services to empower the vital ecosystem and livelihood of humans in the Sri Lankan context.

References

- AbdelKhaleq, R.A. and Alhaj Ahmed, I., 2007. Rainwater harvesting in ancient civilizations in Jordan. *Water Science and Technology: Water Supply*, 7(1):85-93.
- Amarasinghe, U.A., Mutuwatta, L. and Sakthivadivel, R., 1999. *Water scarcity variations within a country: A case study of Sri Lanka* (Vol. 32). IWMI.
- Anchan, S.S. and Prasad, H.S., 2021. Feasibility of roof top rainwater harvesting potential-A case study of South Indian University. *Cleaner Engineering and Technology*, 4.
- Ariyabandu, R., 1999a. Development of Rainwater Harvesting for Domestic Water Use in Rural Sri Lanka, *Asia-Pacific Journal of Rural Development*, 9(1):1-14
- Ariyabandu R., 1999b, Water Security through Rainwater Harvesting. In: *25th WEDC Conference*, Addis Ababa, Ethiopia. pp.366-368.
- Ariyananda, T., 1999. Rain water harvesting for domestic use in Sri Lanka, In: *Proceedings of the 25th WEDC Conference*, Addis Ababa, Ethiopia. pp.369-372.
- Ariyananda, T., 2001a. Quality of Collected Rainwater from Sri Lanka. In: *Proceeding of 26th WEDC Conference*, Dhaka, Bangladesh.
- Ariyananda, T., 2001b, April. Quality of collected rainwater in relation to household water security. In: *Domestic Roof-water Harvesting Workshop*, IIT Delhi, India.
- Ariyananda, T. 2005, Recommendations for Improving Rain Water Quality. In: *XIIIth International Rain Water Catchment Systems Conference*, New Delhi, India.
- Ariyananda, T., 2007. Rain Water Harvesting for Urban Buildings in Sri Lanka, In: *Subtropical Green Building International Conference*, Taipei Taiwan.
- Ariyananda, T., 2010. Domestic rainwater harvesting as a water supply option in Sri Lanka. *Hydro Nepal: Journal of Water, Energy and Environment*, 6:27-30.
- Ariyananda, T. and Aheeyer, M.M.M., 2011. Effectiveness of rain water harvesting (RWH) systems as a domestic water supply option. *October 2011*. Available at: http://www.waterboard.lk/web/images/contents/miscellaneous/survey_of_rwh_2011.pdf.
- Balauriya, B.M.C.M. and Arachchige, U.S.P.R., 2021. Rainwater Harvesting for Drinking Purposes in Sri Lanka. *Journal of Research Technology & Engineering*, 2(3):37-46.

- De Silva, C.S., 2014. Rainwater harvesting as an adaptation measure for the Impact of climate change on water resources in Central Hills of Sri Lanka. In: *Symposium on Mainstreaming Rainwater Harvesting as a Water Supply Option*. p.72.
- De Silva, C.S. and Ariyananda, T., 2020. Groundwater Responses to Artificial Recharge of Rainwater in Badulla District in Sri Lanka. *Journal of Dry Zone Agriculture*, 6(2).
- De Silva, S., 2005. Impact of Artificial Recharging of Groundwater with Rainwater: a Case Study in Kotewehera of Sri Lanka. In: *Lanka Rain Water Harvesting Forum, Sri Lanka*.
- Dissanayake, D.M.S.B. and Padmi R., 2019. Effectiveness of National Rainwater Policy and Strategy in Sri Lanka. In: *Proceeding of International Conference on Water Security Through Rainwater Harvesting*.
- Elmahdi, A., ElGafy, I. and Kheireldin, K., 2009. Global warming-water shortage and food security future planning interaction, system analysis approach (WBFSM). WRM2009. *Water Resource Management, Malta*, pp.9-11.
- Elimelech, M., 2006. The global challenge for adequate and safe water. *Journal of Water Supply: Research and Technology-AQUA*, 55(1):3-10.
- Gordon, G., Adam, L. and Bubnis, B., 1995. *Minimizing chlorate ion formation in drinking water when hypochlorite ion is the chlorinating agent*. AWWA Research Foundation and American Water Works Association.
- Hanjra, M.A. and Qureshi, M.E., 2010. Global water crisis and future food security in an era of climate change. *Food policy*, 35(5):365-377.
- Hapugoda, K.D., 1995. Action research study on rainwater harvesting. *Community water supply and sanitation project (CWSSP)*, Colombo, Sri Lanka.
- Jackson, R.B., Carpenter, S.R., Dahm, C.N., McKnight, D.M., Naiman, R.J., Postel, S.L. and Running, S.W., 2001. Water in a changing world. *Ecological applications*, 11(4):1027-1045.
- Jayasumana, C., Gunatilake, S. and Senanayake, P., 2014. Glyphosate, hard water and nephrotoxic metals: are they the culprits behind the epidemic of chronic kidney disease of unknown etiology in Sri Lanka?. *International journal of environmental research and public health*, 11(2):2125-2147.
- Julius, J.R., Prabhavathy, R.A. and Ravikumar, G., 2013. Rainwater harvesting - A review. *International Journal of Scientific & Engineering Research*, 4(8):276-282.
- Karthiga, K. and Inoka, N.K.P., 2014. To Assess the Socio Economic Impacts of the Rain Water Harvesting Project Implemented in Vavuniya District. In: *Symposium on Mainstreaming Rainwater Harvesting as a Water Supply Option*. pp.55-63.
- Khanal, G., 2020. Climate change adaptation undertaken by smallscale farmers in Nepal: a reference from Tinau River Basin. *Quest Journal of Management and Social Sciences*, 2(1):115-131.
- Khanal, G., Thapa, A., Devkota, N. and Paudel, U.R., 2020. A review on harvesting and harnessing rainwater: an alternative strategy to cope with drinking water scarcity. *Water Supply*, 20(8):2951-2963.
- Lo, K.F.A. and Koralegedara, S.B., 2015. Effects of climate change on urban rainwater harvesting in Colombo city, Sri Lanka. *Environments*, 2(1), pp.105-124.
- Mohammed, I.U., Ndahi, A.K., Ahmed, S.D., Hayatu, J.M. and Wude, M.O., 2018. Rainwater Harvesting For Water Supply and Integrated Development in Rural and Semi-Urban Areas. *Nigerian Research Journal of Engineering and Environmental Sciences*, 3(1):287-304
- Mohammed, T.A., Noor, M.J.M.M. and Ghazali, A.H., 2007. Study on potential uses of rainwater harvesting in urban areas. *Putrajaya Malaysia*.
- Panabokke, C.R. and Perera, A.P.G.R.L., 2005. Groundwater resources of Sri Lanka. *Water Resources Board, Colombo, Sri Lanka*, 28.
- Rahman, A., Keane, J. and Imteaz, M.A., 2012. Rainwater harvesting in Greater Sydney: Water savings, reliability and economic benefits. *Resources, Conservation and Recycling*, 61, pp.16-21.
- Rahman, S., Khan, M.T.R., Akib, S., Din, N.B.C., Biswas, S.K. and Shirazi, S.M., 2014. Sustainability of rainwater harvesting system in terms of water quality. *The Scientific World Journal*, 2014.
- Rana, S., 2005. Rain water harvesting for drinking in rural area (A case study on three villages of Paikgacha Thana in Khulna District).
- Ranasinghe, P. and Dissanayake, D.M.S.B., 2018. Rainwater Harvesting Systems as a strategy for Urban Storm Water Management.
- Ranasinghe, S. and Wijerathne, C., 2014, September. A Review on Health Benefits and Issues of Using Rainwater as a Drinking Water Source. In: *Symposium on Mainstreaming Rainwater Harvesting as a Water Supply Option*. p.85.
- Sayanthan, S., Mikunthan, T. and Prabhakaran, M., 2017. Needs and Trends of Rain Water Harvesting in Sri Lanka. *International Journal of Research Studies in Agricultural Sciences*. 3(12):42-52.
- Schewe, J., Heinke, J., Gerten, D., Haddeland, I., Arnell, N.W., Clark, D.B., Dankers, R., Eisner, S., Fekete, B.M., Colón-González, F.J. and Gosling,

- S.N., 2014. Multimodel assessment of water scarcity under climate change. *Proceedings of the National Academy of Sciences*, 111(9):3245-3250.
- Sivakumar, S.S., 2021. Water Resources and Water Policy Initiatives in Sri Lanka.
- Sturm, M., Zimmermann, M., Schütz, K., Urban, W. and Hartung, H., 2009. Rainwater harvesting as an alternative water resource in rural sites in central northern Namibia. *Physics and Chemistry of the Earth, Parts A/B/C*, 34(13-16):776-785.
- Thusyanthini, R., Peramunagama, S.S.M. and De Silva, A.G.S.D., 2021. Needs of the Human Right to Safe Drinking Water in terms of Rainwater Harvesting System in Dry Zone of Sri Lanka. *International Journal of Scientific and Research Publications*, 11(3):125-131.
- Vasudevan, P., Tandon, M., Krishnan, C. and Thomas, T., 2001, September. Bacteriological quality of Water in DRWH. In: *10th Conference of the International Rainwater Catchment Systems Association*. IRCSA.
- Ward, S., Memon, F.A. and Butler, D., 2012. Performance of a large building rainwater harvesting system. *Water research*, 46(16):5127-5134.
- Waterfall, P.H., 2004. *Harvesting Rain water for landscape use*. 2nd ed. USA-Arizona: Arizona Department of Water resource. pp.13- 38.
- Weerathna, C.S. and Weerasinghe, P.A., 2009. 'Importance of rain water', Tanuja Ariyananda (ed), *Rain Water Harvesting Practitioners Guide for Sri Lanka*, 1st edn, Nugegoda, Sri Lanka. pp.12-19.
- WHO, 2014. *Guidelines for drinking-water quality*. Switzerland: World Health Organization. 4th ed.