Review Article

Rainwater harvesting - a safety net for water security in Ghana

ABSTRACT

Water is an important medium for many activities including water for consumptive and non-consumptive purposes. Lack of water quality and quantity does not only hampers socio-economic growth but affect agricultural productivity, sustainable development, sanitation, human health, industrial development and the ecosystem. The advent of climate change is known to affect water flow, increase dry season spells, drought and also affect reservoirs or deep groundwater wells thus worsening the precarious water situation in Africa. About 1.7 billion of the world population lives in water scarce regions and this is projected to grow to about 300% or 5 billion by 2025 especially in Africa. In Ghana, population growth, pollution of river bodies, high evapotranspiration, erratic rainfall pattern and environmental degradation among others have affected water availability and use. These challenges therefore require a deliberate water harvesting, integrated water management and conservation, water use efficiency and capacity building to withstand the dwindling trend of water resources in the country. This paper therefore seeks to draw attention to the need for policy makers, stakeholders, institutions responsible for water resources among others to consider water harvesting as a potential saviour to address the many challenges including water shortages, floods, and land degradation among others. The article was carried out through extensive review of literature, official reports and policy documents. It shows the need to adopt appropriate measures for rainwater harvesting to ensure sustainable water management and availability for all in Ghana.

Keywords: *rainwater harvesting; water security; water quality; water management; water conservation*

1.0 INTRODUCTION

Water is life and a global basic right for all. It serves as a medium for all metabolic activities and acts as a universal solvent. The importance of water in all spheres of life cannot be overemphasized. It has unique properties that promote physical, chemical and biological processes for all forms of development including soil formation [1]. Water has the ability to retain heat to modify local climatic conditions in areas near large water bodies because of its polar nature. Water is needed for domestic, industrial and agricultural activities yet water is not equally distributed in both quantity and quality. As temperature and climate varies across regions, so is water and precipitation not equally distributed evenly across the world. While some places may have more than enough water, other places will be experiencing water shortages. Water availability or shortage is therefore influenced by the hydrological cycle. The dwindling water supply and accessibility is quite obvious in the continent of Africa. According to [2] one-third of urban water supply in Africa, Latin America and the Caribbean and more than ½ in Asia are operating intermittently during periods of drought. [3] also revealed that river basins are gradually getting stressed due to water allocation for subsistence and large-scale agricultural production. It is estimated that 1.7 billion or 1/3 of the world population live in areas where there is water scarcity and this figure is projected to grow to 5 billion by 2025 due to population growth [4]. According to [5] climate change is expected to cause decline in future average water availability and increase the frequency of extreme events such as drought especially in sub-Saharan Africa. Water resources in drier climates are more sensitive to climate change due to increasing temperature which will result in high evaporation, low river flow and decline lakes and groundwater levels [6]. The rise in temperature especially in tropical climate will increase evaporation from water and soil surfaces, and transpiration from plants leading to droughts. The threat of climate change to water resources, population explosion and the quest for development especially in Africa will put much stress on water demand for economic activities as well as for irrigation purposes. According to [7] domestic and industrial water demand is projected to increase by 300% by 2025 due to an exponential increase in population and expected industrial expansion especially in Africa.

The Millennium Development Goal 7(10) on environmental sustainability required accessibility to safe drinking water and sanitation by 2015 [8] and yet the demand for water is still a big challenge for many developing countries across the world including Ghana. According to the Sustainable Development Goal (SDG) 6, every individual is to have access to safe and affordable drinking water by 2030 and that is to ensure availability and sustainable management of water and sanitation for all. In order to achieve this set goal, there will be the need especially for developing countries to double their effort in water accessibility through water harvesting and integrated water resource management at all levels of the economy. In one of the UN Water reports there is a demand for developing countries to build a climate resilient economy, adaptation and mitigation strategies to cope with the increasing population and climate variability.

This article is therefore to inform policy makers, opinion leaders, stakeholders and the general public about the importance of rainwater harvesting and integrated water resource management in the midst of climate change.

2.0 OVERVIEW OF WATER SITUATION IN GHANA

Already African countries are constraint with financial resources to adequately provide reliable and uninterrupted water supply for domestic, industrial and agricultural purposes. The little water resources available are hardly managed appropriately due to inadequate infrastructure and logistics. Ghana as a developing country has not been able to build robust water management systems to provide adequate water for the citizenry. Water supply to various communities has been intermittent due to various challenges including drought and water pollution. The few water resources available are heavily polluted by illegal mining and poor waste management thus increasing the cost of water treatment in Ghana. According to the Ghana Water Company Limited (GWCL), Ghana requires about US$100million yearly for infrastructural development and about $717 million for urban water production coverage to about 100% across the nation by 2015. According to [9] an estimated total capital of US$15 billion is needed to develop adequate water infrastructure in sub-Saharan Africa. The population of Ghana has increased by 30.4% over the last decade and urban population has also soared tremendously and this requires adequate water to meet the increasing demand of water for various purposes. Increasing ppopulation, water quality issues, unpredictable rainfall pattern, national development and wealth of individuals will affect water availability and supply. It is already evident in Ghana that the availability of water per capita is declining due to population explosion, rapid environmental degradation, pollution of rivers bodies, draining of wetlands, increased evapotranspiration and rainfall variability [10].

It is estimated that about 1.1 million people do not have access to clean drinking water with about 5 million people most of which are in sub-Saharan Africa die annually due to both surface and ground water pollution [11]. Water, Sanitation and Hygiene play a key role in the health and nutrition of many children in Africa. Unavailability of water will precipitate socio-economic, political and environmental challenges including unsavoury competition, health challenges, conflicts, poor sanitation and food insecurity in many African countries including Ghana.

Due to the activities of illegal small scale mining (galamsey), most of the surface water bodies have been polluted extensively thus the country will soon has to rely on ground water for domestic, industrial and agricultural water supply [12]. Most river bodies in Ghana have been polluted beyond measure due to the galamsey activities and this has really become a national issue. Many communities along these river bodies have been denied of quality access to water for their domestic and agricultural activities. Many water treatment plants have already broken down and those in operation suffer high cost of maintenance due to excessive pollution of the river bodies. The only option is to provide these rural communities with boreholes which come at extra cost to these poor people. Beside the cost, many boreholes are also polluted with chemicals such as fluoride, arsenic and other heavy metals in part of Ghana including Western, Northern and Upper East regions [13]. Moreover, the continued use of the underground water is likely to affect the ground water table without a deliberate attempt to recharge the ground water through rainwater harvesting. The use of ground water will also increase the cost of water supply in the long term. The continues extraction of water from rivers, lakes and underground aquifers annually for various purposes will result in water reduction and stress particularly for irrigation [14, 15].

2.1 WATER MANAGEMENT AUTHORITIES IN GHANA

Due to the importance of water for both consumptive and non-consumptive uses in Ghana, many water related organizations have been established to address the water challenges in the country. Among the bodies established to deal with the water situation in the country are the Ministry of Water Resources, Works and Housing (MWRWH) which is mandated to formulate and coordinate policies and programmes, for systematic development of infrastructural requirement of housing, water supply, sanitation and hydrology. The Water Resources Commission (WRC) whose responsibility is to regulate, coordinate and manage water resources and water policies in the country. The Ghana Water Company Limited (GWCL) and Community Water and Sanitation Agency (CWSA) are also mandated to supply water for both urban and rural settings respectively. Ghana Irrigation Development Authority including NGOs is also required to provide dams for agricultural activities. There are other research institutions such as the Water Research Institute (WRI), Agricultural Research Stations (ARS), Hydro Services Division (HSD) whose mandates are to conduct research and gather data on water and other related resources including other numerous allied bodies which play key roles in the water sector of Ghana. A water policy is even developed by the Water Resources Commission (WRC) to ensure the protection and conservation of water resources, improve the efficiency and sustainability of water resource application for socio-economic, environmental and developmental purposes. Despite all these organizations established to address the water challenges in the country, the future of water security in the country continues to look bleak. The challenging water situation especially in the cities is a clarion call for all these organizations to develop strategies including rainwater harvesting to address the water challenges in the country. There is an urgent need for synergy among these established bodies to coordinate their activities, comprehensively plan, develop and manage all the water resources to ensure a lasting solution to the imminent water challenges in Ghana. A combination of infrastructure, advanced technology and logistics to create strong institutions in the water sector are very paramount for ensuring sustainable water resource management in the midst of climate change, water pollution and water resource degradation in Ghana.

2.2 WATER SECURITY: SHOULD GHANAIANS BE CONCERNED?

Water plays a very important role in our socio-economic activities and without it; life will gradually grind to a halt. Water is the most important resource aside air and its availability is as important as its quality. Unfortunately, water has no substitute but its availability is gradually dwindling with time due to pollution, mismanagement, and climate change. Climate change has become a global phenomenon and has negative impacts on water resources both in quantity and quality. According to [16] climate change will affect water flow and extend dry season spells in arid and semi-arid regions which will affect the reliability of reservoirs or deep groundwater wells. Higher temperature is also observed to influence groundwater levels where the confining layer is thin resulting in drought [17].The situation is much intense in tropical regions where evapotranspiration is always especially in Sub-Saharan Africa. According to [18] he discovered that about 25% of the population in Africa is currently having extreme water stress due to drought and a projected 75-250 million and 350-600 million people in Africa will experience water stress by 2020 and 2050s respectively. Already, a decline in the annual precipitation over the years is observed in West Africa [19]. Unfortunately, most of the problems occur as a result of anthropogenic

activities such as land use change, small scale mining activities, over extraction of water resources, high rate of pollution and sedimentation loads which will not only put water supply at risk but also freshwater ecosystems in Africa [20, 21]. Many African countries over the years have been hit with severe water shortages resulting in crop failure, hunger and death of animals. Countries such as South Africa, Ethiopia, Tanzania, Chad, Benin, Indonesia, Djibouti and others have been affected with drought in one form or the other.

In Ghana, drought and water shortages have occurred in several part of the country due to water pollution and climate change. Water supply has not been consistent and water rationing programme has been the order of the day due to unavailability of water of appreciable quality. There have been concerns raised by several experts that the country is likely to import water in the next couple of years if water resources are not managed properly. Many cities across the country suffer from water shortages which affect social and economic activities. Recently, certain places in parts of Accra such as Adabraka, Asylum Down, Bubuashie and Dansoman experienced acute water shortages which resulted in the summoning of the management of Ghana Water Company Limited and the Minister for Water Resources and Sanitation by Parliament for explanation. The situation is also common in other parts of the country especially Central region and the three Northern regions. Even where water is available, supply sometimes becomes a problem due to challenges such irregular power supply to the company's sub-stations and the subsequent delay in rebooting the systems to get water flowing, old pipelines frequently breaking down or bursting due to sudden water pressure and high indebtedness from non-payment by Government (https://kuulpeeps.com/2019/03/ug-facing-water-problems-in-your-hall-here-is-why/). These and many other challenges require all stakeholders adopt strategic measures for addressing the perennial water challenges in the country including rainwater harvesting.

2.3 WATER SECURITY: A SAFETY NET FOR WATER SECURITY IN GHANA

Population growth, changes in lifestyle, water quality issues and erratic rainfall pattern will cause water stress leading to sanitation, health challenges, food security and environmental degradation especially in Africa. The construction of borehole to meet the water demand in Ghana is also faced with many challenges. Among these are intrusion of salt water into boreholes along the coastal areas, low yields and drought of some boreholes especially in the northern part of Ghana [13]. Rainwater harvesting is therefore needed to address such challenges. According to [22] rainwater harvesting has been in existence for several thousands of years since civilization and during the reign of the Roman Empire, harvested rainwater was used as a source of domestic water supply. Many arid and semi-arid countries have a long history of traditional water harvesting and storage such as "qanat" where series of underground tunnels are interconnected horizontally to collect and discharge water from a hilly source along water-bearing formations [23]. In India, they have Tankas which is also an underground storage tanks located in houses or within the courtyards for water harvesting [24].

Unfortunately, the heritage of rainwater harvesting has been abandoned while communities wander endlessly in search of water. A country like Germany does not have water problem yet almost all buildings have water harvesting guides to collect and direct harvested water to a central storage point for treatment and redistribution. Research has shown that impoundment of small-scale runoff and improved soil conservation practices could boost agricultural production in Africa in view of the present and future climate variability [25]. It is

therefore imperative that government provides the needed infrastructure to encourage and enhance rain water harvesting due to the dwindling water resources, water pollution, population growth and climate change. Water harvesting should be part of all building codes and form an integral part of the Ghana water policy. For a start, all public buildings in schools, ministries, hospitals and other institutions should be provided with water harvesting facilities. This should further be extended to private developments which will ease the pressure on the public water supply systems. The harvested water in such places could be used in cleaning, flushing of toilets and handwashing.

3.0 WATER HARVESTING – WHAT PERTAINS IN OTHER NATIONS

Water is linked to development and has no substitute economically for all countries. The availability of water can also dwindle due to pollution and mismanagement. Water harvesting is being practiced in both developed and developing countries as a mitigation measure to address the dwindling water resources in those countries. Many of the once large river bodies are running down due to climate change. Advanced countries such as Japan, Germany, UK, USA, and Australia among others have been practicing rainwater harvesting over years. In Japan, over 750 private and public buildings have introduced rainwater collection and utilization systems in the city of Tokyo. In Germany, roof top rainwater harvesting is mandatory and being encouraged through subsidies and grants by the city authorities. In certain part of the country, rainwater harvesting is incorporated into large scale urban redevelopment to control urban flooding, provide water for both consumptive and non-consumptive purposes and create a better microclimate environment within the cities. In UK, the government is promoting rainwater harvesting especially in commercial sectors by providing financial incentives and tax holidays to encourage sustainable water harvesting and application. The other sectors are also encouraged to employ harvested rainwater for non-potable uses such as flushing toilets, washing clothes, watering garden and washing of cars, etc. due to high water prices. This situation is similar in other countries such as Australia, Canada, China and the USA. In Texas, USA, rainwater harvesting is being promoted in all residential, commercial, and industrial buildings through offering various incentives such as giving discounts on purchasing rain barrels or providing rebates for water-storage facilities. In the US, legislation has been passed in states such as North Carolina, Ohio, Virginia, Washington and Illinois to regulate the practice of rainwater harvesting [26].

In the Middle East and Asia, rainwater harvesting has been practiced since time immemorial from rooftops using different forms of cisterns for water storage. The Yerebatan Saray in Istanbul, Turkey, is probably the largest cistern in the Mediterranean region, capable of storing about 80 000 m3 of water (Bamatraf, 1994 cited in [27]. Rainwater harvesting has also been made mandatory in certain cities in India for all new building to address water challenges and encourage water conservation [28].

In Africa, rainwater harvesting is also practiced in some countries such as Botswana, Togo, Mali, Malawi, South Africa, Namibia, Zimbabwe, Mozambique, Sierra Leone, and Tanzania to mitigate the water crises in those countries [29]. Unfortunately, the practice of rainwater harvesting has not really gain much attention in Africa especially in Ghana due to many reasons such as poverty, inadequate knowledge about the system and the lack of political

will. Rainwater harvesting is very important as the primary source of water for consumption since secondary sources such as rivers, dams, streams, lakes, underground water may suffer from chemical contamination such arsenic and fluoride and require high cost of treatment. Rain water harvesting can reduce the cost of urban water supply. As the cities expand, the water company has to increase piping lines, increase booster pumps, etc. to provide water for the populace at a very high cost [27].

4.0 WATER HARVESTING – AN IMPORTANT RESOURCE FOR ECONOMIC GROWTH

Water harvesting has varied advantages in addressing socio-economic challenges. Water helps in addressing sanitation and health challenges thus an important resource when properly managed. Among the most important applications of harvested water are:

4.1 Storage for domestic uses: Water from rooftops can be collected and used for household chores such as washing, cleaning, flushing of toilets and sometime for drinking. The water supply companies can also harvest water for storage at central points which can be treated and supplied to communities nearby during the lean season. Water shortages in both rural and urban communities is really a big challenge as it forces many people especially women to travel long distances for water. According to [7] domestic and industrial water demand is projected to increase by 300% by 2025 due to an exponential increase in population and expected industrial expansion especially in Africa. People in the cities also rely on tanker services for water supply whose quality cannot be guaranteed. Water pollution has also worsened the water situation in many communities thus water harvesting becomes an indispensable option for water security in our communities.

4.2 Water for agriculture: Water can also be harvested for irrigation purposes for crop intensification and yield. In Ghana, irrigation facilities are few and many farmers therefore rely on the rainfall for their farming activities. It is estimated that rain-fed agriculture is practiced on 80% of the arable land by small holder farmers and due to climate change and climate variability, rain-fed agriculture cannot be relied upon for food production to feed the growing population. These small holder farmers manage over 80% of the world's estimated 500 million small farms and provide over 80% of the food consumed in a large part of the developing world [9]. It is estimated that 75 million hectares of land suitable for rain-fed agriculture presently will be lost by 2080 in Sub-Saharan Africa due to climate change [30]. Rainwater harvesting can be a source of water for these small holder farmers to remain in business all year round.

4.3 Water harvesting for industry: Water can also be harvested for industrial use for cooling, material processing and cleaning. Water is also needed in food and meat processing facilities which use large amount of water. The processing companies use water for washing fruits, slaughtering animals, for cleaning the facilities and processing of products into finished goods. Harvested water can also be used for other purposes which will help improve sanitation, environmental sustainability and health problems such as cholera and diarrhoea. The importance of harvested water cannot therefore be overemphasized.

4.4 Surface and groundwater recharge: Surface water bodies such as rivers, lakes and streams as well as groundwater get their sources from rainfall. Diversion of storm water and

runoff into such water bodies and groundwater recharge zones will enhance water availability. The water can also be diverted into large artificially constructed dams within and outside the cities. Artificial dams with in cities can help improve the micro-climate, serve as beach and recreational centres if properly designed. The harvested water can be used for irrigation of lawns, backyard gardens, peri-urban agriculture among others. The perennial floods that occur in cities leading to the loss of lives and properties can be reduced when storm water and runoffs are harvested.

4.5 Water harvesting to reduce land degradation: Water from rooftops and hilly areas together increase the erosivity of runoff which eventually course different types of erosion. The energy inherent in running water has caused a lot of havoc to the landscape of many communities. Soil erosion occurs through soil detachment, transportation and deposition of top agricultural soils thus reducing the productivity of the soil. Rainwater harvesting is therefore very important to address the water erosion risks and safe us the cost of land restoration. The use of terracing to redirect runoff at reduced velocities for collection and ponding will help improve infiltration, reduce land degradation and make water available for various uses. The water stored in ponds can be used for construction and redevelopment purposes around the cities.

5.0 NEED FOR WATER RESOURCE MANAGEMENT AND CONSERVATION

Water quantity and quality, undoubtedly, play a pivotal role in the socio-economic development of every nation especially in Africa. Global demand for water is said to have tripled since the 1950s, while the supply of fresh water has been declining [14] and this calls for measures to improve integrated water management systems. Already, it is estimated that about 40% of the world population is under water scarce which is estimated to increase to 66% by 2015 due to increase water pollution, population growth and a changing climate. Climate change is observed to account for 22% of future water shortages in North Africa while socio-economic factors will account for 78% by 2050 [31]. Anthropogenic activities such as land use change, over extraction of water resources, high rate of pollution and sedimentation loads will cause freshwater ecosystems to be at risk in Africa [20, 21]. Despite the impact of climate change on water scarcity, certain elements such as population growth, urbanization, agricultural growth, and land use change, water pollution will be more prominent in the continent [31, 32, 33]. In Ghana, the continuous pollution of our river bodies has already caused irreparable damage to many aquatic ecosystems especially from uncontrolled mining. The benefit of a few individuals looking for gold cannot be sacrificed at the altar of many who depend of the river bodies for their survival. All the efforts to control the activities of mining in the country is therefore in the right direction. Water is life and must be treated as such. The preservation and conservation of all river bodies and dams in the country must be a priority to all Ghanaians to avert disastrous water scarcity. Even though access to safe drinking water and sanitation in Africa has improved from 56% in 1990 to 65% in 2008, there is still significant disparities among urban, rural and cities which needs attention [34].

According to [3] river basins are also gradually getting stressed due to water allocation for subsistence agriculture or large-scale cereal production. According to [6] water resources in

drier climates are more sensitive to climate change due to increasing temperature which will result in high evaporation, low river flow and decline lakes and groundwater levels. The rise in temperature especially in tropical climate will increase evaporation from water and soil surfaces, and transpiration from plants leading to droughts. African countries in tropical regions need to be more serious in preserving its water resources than those in temperate regions. Brandy and Weil [1] estimates that the potential evapotranspiration values range from more than 1500 mm/year in hot and arid areas to less than 40 mm/year in very cold regions. According to [35] there will be an increased in fresh water demands coupled with low water supply due to higher temperatures and declining rainfall affecting water quality and availability in many countries. Ghana therefore needs to adopt positive approach towards water harvesting, water use management and conservation.

6.0 CONCLUSION

Population growth, changes in lifestyle due to improved economy, development and industrial expansion will exponentially results in high water demands to meet the changing pace thus put much pressure on the existing water sources. Water pollution both surface and underground due to illegal mining, leachate from refuse dams, poor agricultural practices and uncontrolled industrial activities couple with erratic rainfall even without climate change will shrink the availability water in the system. These therefore call for rainwater harvesting, proper water management and conservation in all spheres of the economy.

Water harvesting is therefore one of the cheapest options to collect and store adequate water for domestic, agricultural and industrial uses. Water can be collected from roof tops, interception of runoffs and storm waters which could be directed to recharge pools, reservoirs to store water for the lean season. . Valleys and degraded lands by sand winners could be redesigned to serve as a buffer zone for water storage and ground water recharge. Construction of deep irrigation dams with trees planted around them and regularly dredging of old dams could help store adequate water for dry season irrigation. Rainwater harvesting must be part of all building codes and this must first start with public buildings. The government as a matter urgency should provide incentives, subsidies and technical support to organizations and individuals who are willing to harvest water especially those in the cities. These measures when properly implemented could avert floods and ensure sustainable water management to meet the needs of the present water demands without compromising the ability of future generation from meeting their own needs.

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