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Water security in sub-Saharan Africa: understanding the status of Sustainable Development Goal 6 (SDG6)

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Abstract

The world is nearing the 2030 target-year by which sustainable development goals (SDGs) should be achieved. While other developing regions seem to be making progress towards achieving SDG6, sub-Saharan Africa (SSA) is lagging behind significantly, particularly with regard to access to water supply and sanitation (WSS). As a result, most studies evaluating progress towards the achievement of water security SDGs in SSA have focused on WSS while the rest of the SDG6 targets have received scant attention, often using fragmented or incomplete evidence. Here, we fill this knowledge gap by conducting a comprehensive assessment of the status of SDG6 in all 48 countries in SSA. We provide a review of the progress made, the challenges affecting each SDG6 target and examine the different political, socioeconomic, and environmental factors with potential to undermine the achievement of SDG6 in the region. Our review clearly demonstrates that it is likely that most countries may not achieve water security by 2030. The complex nature of the challenges and factors impeding the achievement of water security in SSA outlined here suggests that a holistic intervention involving local, national, and international stakeholders and the research community is urgently needed to address SDG6 if the 2030 target date is to be met. Approaches to enhance water security may equally consider: (i) underpinning peace and security in SSA and (ii) the commitment of more financial resources by donors particularly during this period of COVID-19 pandemic.

Keywords: SDG6 assessment; water insecurity; water governance; urbanization and population growth; conflict and migration; climate change

1 INTRODUCTION

Water is essential for life as it plays a crucial role in the provision of food, energy, health, ecosystem services and environmental sustainability. Water is therefore at the centre of socio-economic development (Wheeler, Xu, & Zuo, 2020). However, the unsustainable management of water resources in many regions has led to numerous environmental challenges related to water, which have been exacerbated by population growth, climate change and economic development (Cosgrove & Loucks, 2015). Some of these challenges include water scarcity, increased pollution of water bodies, depletion of surface water and groundwater resources leading to the degradation of ecosystems, loss of habitat and extinction of many species that depend on water resources (Hogeboom, 2020). The World Economic Forum has consistently ranked water crisis as one of the top global risks in terms of impact. Due to the many water related challenges facing humanity, the United Nations General Assembly (UNGA) adopted the sustainable development goals (SDGs) in 2015 with water security SDG6 (*ensure availability and sustainable management of water and sanitation for all*) as one of the key goals (Le Blanc, 2015).

Unlike the Millennium Development Goals (MDGs), the scope of the SDGs was enlarged with a multidimensional view. As such, the number of targets under the water security goal were enlarged to go beyond water supply and sanitation (target 6.1 and 6.2) to consider water quality and wastewater (target 6.3), water use and efficiency (target 6.4), integrated water resources management (IWRM) (target 6.5), ecosystems (target 6.6) and an enabling environment (targets 6.a and 6.b). Proponents of the SDGs argue that achieving SDG6 may bring multiple benefits to society because this goal offers the highest potential synergies for attaining other goals particularly SDG1 (no poverty), SDG2 (no hunger), SDG3 (good health), SDG7 (renewable energy), SDG14 (life below water) and SDG15 (life on land) (Pradhan, Costa, Rybski, Lucht, & Kropp, 2017; Taka et al., 2021).

Compared to the rest of the world, SSA still faces substantial water security challenges particularly access to water supply and sanitation (WSS). This may explain why many studies addressing SDG6 in SSA have focussed mostly on access to WSS (Jiménez, Jawara, LeDeunff, Naylor, & Scharp, 2017; Nhamo, Nhemachena, & Nhamo, 2019). Whilst interest has been directed towards targets 6.1 and 6.2 mostly due to the disease burden and socioeconomic impact associated with poor water and sanitation (Fuente, Allaire, Jeuland, & Whittington, 2020), the remaining targets have so far received scant attention, and evidence on their status remains fragmented. There is an urgent need for a comprehensive evaluation of the status of SDG6 in SSA as we are less than ten years away from the 2030 target. Such a generic assessment would be both an extremely timely and valuable contribution to this debate and would act to outline progress made by countries in the region. It will also highlight areas where countries need additional support to attain specific targets or sustain the progress made, identify contextual barriers to achieving specific targets and highlight knowledge gaps to guide future research directions.

In assessing the status of SDG6 across SSA, the objectives of this review were to: (1) evaluate the progress made and the challenges affecting each SDG6 target in SSA, and (2) examine the different political, socioeconomic, and environmental factors with potential to undermine the achievement of SDG6 in SSA. The review is structured as follows: section two presents the review methodology. In section three, we explore the literature to highlight the progress and challenges affecting each SDG6 target. In section four we examine the different political, socioeconomic, and environmental factors with potential to undermine the progress made towards achieving SDG6 and lastly, in section five we provide the main conclusions from the review.

2 METHODS AND DATA

This paper consolidates the scant evidence on different SDG6 targets in SSA. Our overarching goal was to use a systematic review approach to provide an overview of the status of SDG6 targets by assessing progress made, identify challenges affecting each SDG6 target and highlight the different socioeconomic and environmental factors impeding or with potential to impede the achievement of SDG6.

2.1 Data search and retrieval process

In line with the objectives of the paper, we focus our systematic review exclusively on peer reviewed scientific articles. We started by searching major scientific databases including Scopus, Web of Science and Google Scholar (Bramer, Rethlefsen, Kleijnen, & Franco, 2017). To search for relevant articles, we used a combination of keywords directly related to each of the research objectives and SDG6 targets: “access AND water AND hygiene AND sanitation”, “surface water OR groundwater contamination OR pollution”, “water use efficiency OR productivity”, “financing water AND sanitation access”, “stakeholder OR community participation AND water supply”, “integrated water resources management”, “water governance AND SDG6”, “aquatic ecosystems AND sustainable development goals”, “climate impact OR climate variability AND water resources”, “transboundary water management”, “urbanization AND population growth AND water security”. This was augmented by a targeted citation search for key terms within several African countries, basins, and sub-regions (including Ethiopia, Kenya, Tanzania, Malawi, Burkina Faso, South Africa, Senegal, Sahel, West Africa, Horn of Africa) facing different water security challenges.

2.2 Screening process and paper selection

We used the following inclusion criteria to identify relevant scientific publications guided by the objectives of the paper: (1) we retained only articles that focused on SSA (2) articles published in the English language from 2010 to April 2021, (3) select only articles whose titles, abstracts and key words contained at least two of the original keywords used in the search, (4) articles addressing specific progress or challenges relating to SDG6 or any of its targets in any country, city, basin, or sub-region in SSA, (5) case studies covering individual or multiple countries or basins addressing any of the SDG6 targets because they provide relevant context to identify the different socioeconomic and environmental factors driving success or failure of SDG6 and its targets, and (6) articles that addressed any of the SDG6 targets without explicitly mentioning it as such were also examined. Out of more than 1000 articles retrieved, a quick read through the titles, abstracts and keywords reduced the number of articles to 167 that were then included in the in-depth screening. The following exclusion criteria were used: (1) articles not focusing on SSA (2) review articles were not included, (3) articles published in other languages such as French (4) articles that dealt with hydrological modelling without relating it to any of the SDG6 targets such water availability, quality, IWRM and ecosystems, and (5) articles related to SDG6 targets and health.

2.3 Paper review and analytical methods

Next, we read the key sections of the 167 flagged papers and extracted information relevant to the research objectives including the documentation of challenges affecting each SDG6 target and different political, socioeconomic, and environmental factors undermining or with potential to undermine water security in SSA. A deductive approach was applied throughout this process to allow: (1) investigation of any underlying relationships between variables, and (2) a comprehensive view of research findings from a disparate array of primary studies. The selected articles were grouped under different themes as shown in Table 1.

Table 1: Articles related to SDG6 targets.

Review item	Search theme	Number of articles
SDG6 targets	Water supply, sanitation, and hygiene	15
	Water and sanitation support	05
	Community participation in water management	09
	Water quality	22
	Water stress	15
	Water use efficiency	06
	IWRM and transboundary water management	15
	Ecosystems	12
Socioeconomic and environmental factors	Governance	20
	Conflict and migration	13
	Climate change	21
	Urbanization and population growth	14

2.3 Limitations

As with any review of this nature, there are clear subjective constraints on the selection of keywords and extraction of data from sources. Considering the scope of the paper, the number of peer-reviewed articles included here is extensive but with understandable logistic constraints. We have aimed to provide an initial outline assessment of SDG6 compliance, and it is likely that some relevant articles may have been inadvertently omitted. Similarly, we also acknowledge that the number of socioeconomic, political, and environmental factors undermining water security that we identify are not exhaustive and many other factors may not have been captured in this review. Nevertheless, the method adopted here allows us to provide the first overview of the status of SDG6 compliance within SSA.

3 WATER SECURITY CHALLENGES FACING SUB-SAHARAN AFRICA.

An overview of the different SDG6 targets indicate that water and sanitation support, water use efficiency, IWRM, transboundary water management and ecosystems have received less attention compared to the rest of the targets (Table 1). Although our review methodology follows a systematic approach making it transparent and replicable, we wish to reiterate that the results of our search should be regarded with caution because not articles identified in search could be included due to logistic constraints as highlighted earlier.

3.1 Access to drinking water and sanitation services.

Access to water supply and sanitation (WSS) remains one of the biggest challenges to water security in SSA. Previous studies have reported that most countries in SSA made substantial progress to improve access to water supply compared to sanitation services between 1990-2015 (Armah et al., 2018). Despite the remarkable progress, many countries did not achieve the MDG in WSS. Evidence suggest that several countries may still not achieve the WSS targets by 2030. While the situation for water supply may seem attainable with additional support, the sanitation target seems to be in a dire situation (Assefa, Babel, Sušnik, & Shinde, 2019).

There are equally strong spatial inequalities in access to WSS between urban and rural areas across SSA (Ellis A Adams & Smiley, 2018; Cole, Bailey, Cullis, & New, 2018). This urban-rural disparity remains a major obstacle to achieving universal coverage in access to WSS in SSA. Limited access to WSS in SSA disproportionately affects women and girls because this group is mostly responsible for collecting water for their families and engaging in reproductive roles such as caring for relatives with WSS related illnesses thereby reinforcing gender inequality and poverty (Graham, Hirai, & Kim, 2016).

Open defaecation is still widespread across SSA and the prevalence of handwashing with soap at critical times (after defecation and before eating) is still very low (Roche, Bain, & Cumming, 2017). However, a recent study covering Nigeria, Tanzania and Uganda has reported an improvement in water, hygiene and sanitation during the COVID-19 pandemic due to innovation and continuous mass sensitisation (Durodola, Nabunya, Kironde, Nevo, & Bwambale, 2020). It is widely reported that access to WSS services in schools has a positive impact on school attendance rates among adolescent girls and can enhance health and hygienic behaviour among children in SSA. However, a survey of some schools across six countries in SSA indicated a very limited access to adequate WSS facilities and soap for handwashing; with only few schools able to meet the student-to-latrine ratios for both sexes as recommended by WHO (Morgan, Bowling, Bartram, & Kayser, 2017). Other studies have suggested that intervention to enhance sanitation and hygiene practices in schools should focus on boys as there appears to be a gender dimension to hygienic behaviours – current evidence suggests that girls exhibit better hygienic behaviours than boys (Thakadu, Ngwenya, Phaladze, & Bolaane, 2018).

Some of the challenges impeding access to water supply particularly in urban areas include rapid urbanization, increasing population, expansion of informal settlements, low capital investment in water infrastructure and poor management of existing infrastructure and resources (Ellis A Adams, Sambu, & Smiley, 2019; Cobbinah, Erdiaw-Kwasie, & Amoateng, 2015). These factors contribute to overwhelm the capacity of governments to respond to increasing water demand in urban areas (Dos Santos et al., 2017). Development of sanitation services in SSA is also constrained by a lack of reliable and comparable benchmark estimates of the unit costs of sanitation infrastructure which is currently characterised by ambiguity concerning costing standards (Sainati, Zakaria, Locatelli, & Evans, 2020). Access to water supply in some communities is also constrained by the dissonance between statutory and customary institutions that regulate access to water (Gondo & Kolawole, 2020).

Access to WSS services in SSA remains a great cause for concern; particularly during this COVID-19 pandemic when access to clean water and soap for handwashing is the first line of protection against the virus. Numerous case studies have reported that a lack of access to clean water and basic hygiene facilities will substantially limit the capacity of countries in SSA to effectively combat the COVID-19 pandemic (Ekumah et al., 2020). It is possible that this pandemic will be a wake-up call to governments in SSA and donors to prioritise and step-up different sustainable financing mechanisms to increase access to WSS services in the region. Also considering that access to WSS services is a basic human right that is not being met for a large proportion of the population in SSA.

3.1.1 *Water supply and sanitation support*

Disbursements for official development assistance for water supply and sanitation (ODA-WSS) to SSA have witnessed an increasing trend since 2002, exceeding US$250 million after the adoption of SDGs in 2015 (Figure 1).

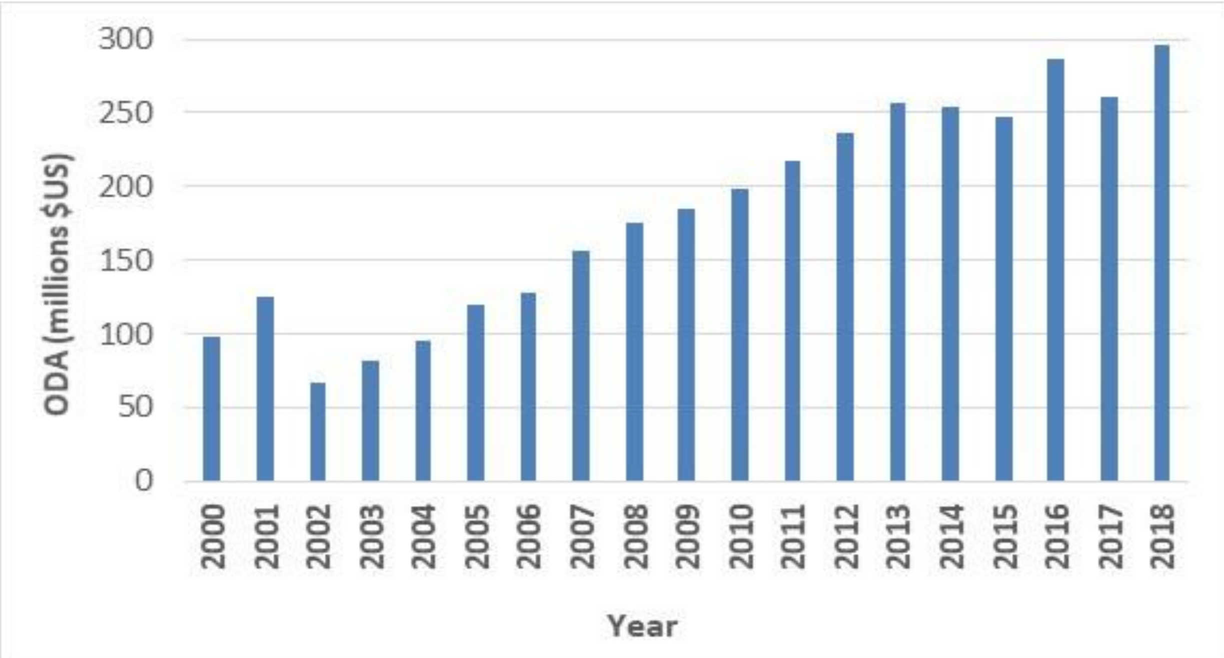

Figure 1: Gross ODA disbursements for water and sanitation to SSA covering the period 2000 – 2018 (Source: https://www.sdg6data.org/)

Although the status of national contributions towards WSS targets were not readily available, limited access to WSS services in SSA indicate that these contributions may be insufficient. In fact, it has been reported that as of 2014, only 50% of total spending for WSS was funded by SSA countries (Salami, Stampini, Kamara, Sullivan, & Namara, 2014). Funding deficits have also been identified as a major constraint to achieving sanitation target in North Africa (Kherbache & Oukaci, 2020). Many reasons may account for the low apparent governmental investment in WSS from within SSA. Some of these include: (1) high initial capital cost required to build new water infrastructure, (2) high cost of maintaining water supply and sanitation facilities, (3) priority of education and health care provision by governments and donors compared to WSS, (4) lack of financial sustainability for sanitation projects, (5) weak technical and administrative capacity, (6) limited private sector involvement particularly in the provision of sanitation services, and (7) low stakeholder participation (Libey, Adank, & Thomas, 2020; Ndikumana & Pickbourn, 2017; Perard, 2018; Salami et al., 2014). Our review clearly highlights that, access to WSS in SSA faces a myriad of challenges, and these seem to be impacting countries progress towards achieving these targets.

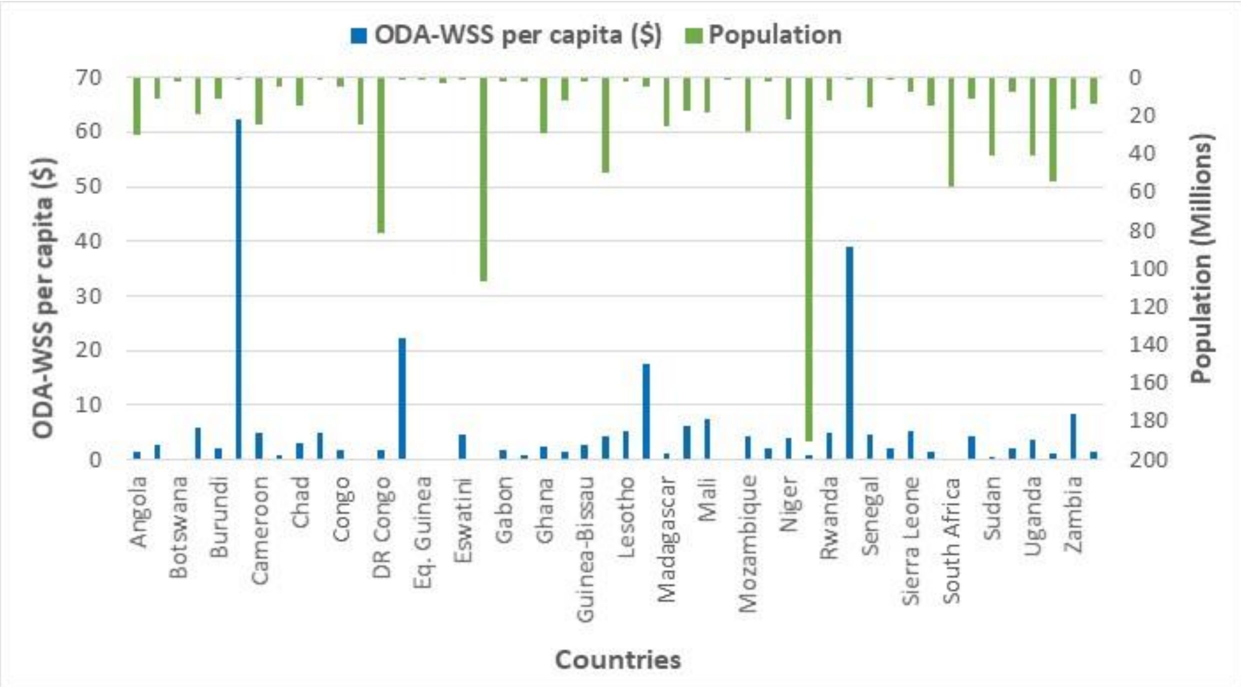

Figure 2: ODA-WSS per capita vs population. The figure shows that the disbursement of ODA-WSS per capita does not follow demographic trends.

Figure 2 shows a plot of ODA-WSS per capita against the population for each country. We observe that ODA-WSS disbursement does not follow the demographic trend, and the disbursements are mostly below $10 per capita with only four countries Cape Verde, Djibouti, Liberia and Sao Tome and Principe exceeding this amount (Figure 2).

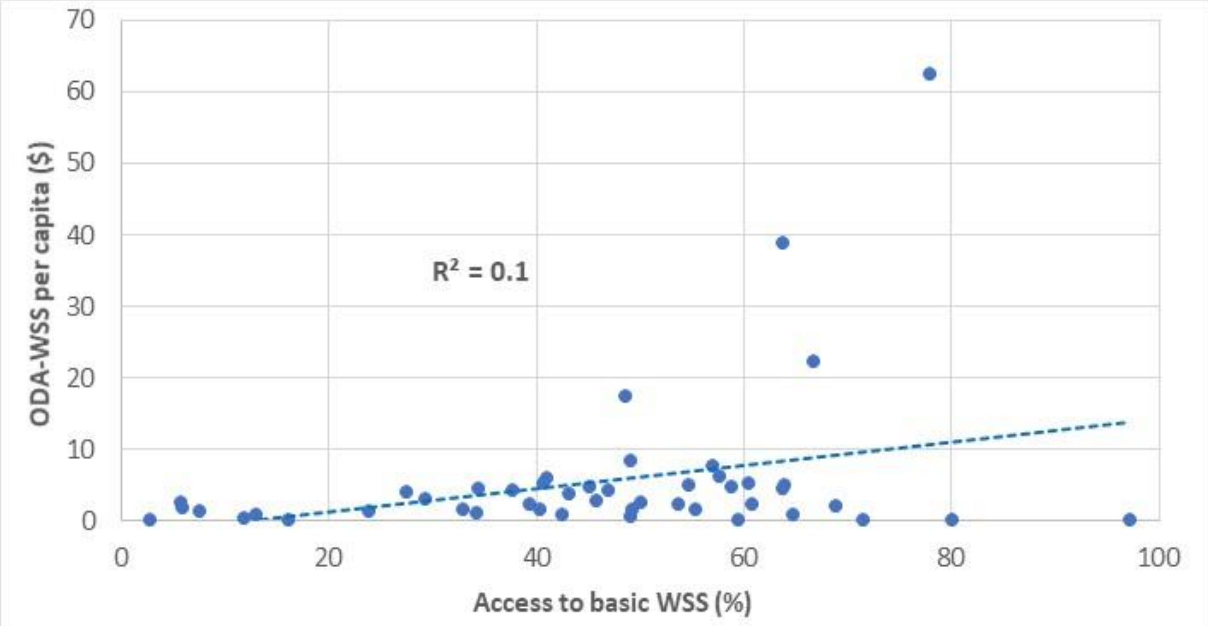

Figure 3: ODA-WSS against access to basic WSS. The figure show that correlation between ODA-WSS and access to basic WSS is weak.

Figure 3 shows a plot of ODA-WSS per capita against access to basic WSS. To obtain access to basic WSS, access to drinking water was given a weight of 60% while access to basic sanitation services received a weight of 40%. It can be observed that access to basic WSS had weak albeit statistically significant correlation (R^2 = 0.10) with ODA-WSS per capita. This suggest that increasing ODA-WSS per capita may have a positive impact on access to WSS in SSA as previously reported (Ndikumana & Pickbourn, 2017; Salami et al., 2014).

Overall, the current ODA-WSS disbursement to SSA could be considered to be insufficient to meet SDG 6.1 and 6.2 targets. This suggest that governments and donors would need to substantially increase capital investment in the region in order to cover the WSS funding deficit. Given that revenue collected by water utility companies cannot cover the full cost of service delivery, it has been suggested that governments and development partners need to provide additional support to cover this gap (Libey et al., 2020). Countries may also need to identify new financing mechanisms to bridge the funding gap and explore ways of making sanitation services sustainable.

3.1.2 *Community participation in drinking-water supply planning programs*

Evidence uncovered here suggests that the level of community participation in drinking-water supply management in SSA is relatively high (Kelly et al., 2017; Tantoh & Simatele, 2017). The high level of community engagement in this area may be attributed to policies that promote community participation as a means to increase access to safe drinking water supply in SSA particularly in rural areas (Whaley et al., 2019). Contrastingly, in urban areas, community engagement is attributed to the failure of both the governments and the private sector to meet the increasing demand for drinking-water supply (Ellis Adjei Adams & Zulu, 2015; Alda-Vidal, Kooy, & Rusca, 2018). Therefore, community participation in drinking water supply management in SSA is driven by different factors depending on the location.

It has been suggested that to increase access to drinking-water supply and boost community participation in water management in urban areas, governments in SSA will need to (1) increase funding to local authorities, (2) upgrade existing water infrastructure while building new ones, (3) avoid political interference, (4) reduce the financial burden imposed on poor communities, (5) reform the existing institutions to ensure transparent management (Ellis A Adams et al., 2019). Furthermore, the heterogeneity of the urban population and differences in income levels must also be considered when implementing new plans.

To increase community participation in drinking-water supply management in rural areas, it has been suggested that stakeholders must work together to identify the most appropriate resources mobilisation mechanisms which are inclusive of poor community members and to train members on fair financial management (Behnke et al., 2017). Other studies have suggested that development partners should seek ways of strengthening existing water supply management institutions, practices, and governance systems that consider local realities rather than attempting to create new institutions (Jones, 2011; Whaley, Cleaver, & Mwathunga, 2020). More research is needed to explore other options that can be used to spur community participation in water management both in urban and rural areas across SSA.

3.2 Water quality

Although there is acute paucity in water quality data in most countries in SSA, evidence suggests that water quality is a critical and growing challenge to water security in the region (Chishugi et al., 2021). Lack of water quality data in SSA like in other regions have been attributed to the fact water quality was often not considered in water security assessments until water pollution became a critical factor affecting sustainable development in many countries (Vanham et al., 2018).

Several factors may account for poor water quality in SSA. For example, naturally occurring hazardous compounds in the soil such as nitrates and arsenic are increasingly being detected in groundwater systems across SSA (Bretzler et al., 2017; Ouedraogo & Vanclooster, 2016). Aquifer characteristics including depth, type and groundwater recharge rate also contribute to increase the vulnerability of groundwater systems to pollution (Lapworth et al., 2017; Ouedraogo & Vanclooster, 2016). Anthropogenic factors such as mining also have significant impact on both groundwater and surface water quality across many countries e.g., Cameroon (Rakotondrabe et al., 2018), Guinea (Sow et al., 2018), Zimbabwe (Masocha, Dube, Mambwe, & Mushore, 2019) and Nigeria (Adewumi & Laniyan, 2020). Industrial pollution from oil and gas exploration is another source of water pollution through oil spillage and leakages from pipelines with cases reported in Nigeria (Arojojoye et al., 2021). Leaching of agrochemicals from agricultural fields is also a major source of water pollution in SSA (Curchod et al., 2020; Teklu, Hailu, Wiegant, Scholten, & Van den Brink, 2018). Invasive alien plant species have equally been identified to contribute to freshwater pollution (Chamier, Schachtschneider, Le Maitre, Ashton, & Van Wilgen, 2012). Land use/cover change resulting to increase sediment loads from upstream catchments is also a major source of water pollution (Dutton et al., 2018; Stenfert Kroese et al., 2020).

Untreated sewerage discharged or leakage of organic and microbial pollutants to water bodies also contribute to the deterioration of water quality in many countries resulting in several public health threats and disease outbreaks in SSA (Gumbo, Dzaga, & Nethengwe, 2016; Houéménou et al., 2020). Seawater intrusion particularly in coastal areas is another source of shallow groundwater contamination, rendering it undrinkable and not suitable for irrigation (Oiro & Comte, 2019; Takem et al., 2015). Emerging organic contaminants have equally been detected in wastewater, surface water and groundwater wells across many countries (Gwenzi & Chaukura, 2018; Sorensen et al., 2015). Recently, pharmaceutical residuals have also been found in surface water bodies and groundwater wells in some countries (Branchet et al., 2019; K'oreje et al., 2016). Our review has highlighted that water pollution is widespread across SSA threatening both human health (SDG 3) and ecosystems (SDG 14 & 15). We observe that substantial research has been conducted to establish the factors impeding the achievement of target 6.3 & 6.4 in SSA. This suggest that water quality monitoring must become a priority in current and future strategies to address water security in SSA. There is equally an urgent need to investigate the impact of plastic pollution on water quality in SSA.

3.3 Water stress and variability of water resources

Evidence suggests that most countries appear to have low levels of water stress because the percentage of freshwater withdrawal compared to available water resources is low (Supplementary material). However, water stress remains a significant challenge in most countries because there are marked differences in water availability within the same country due to spatial and temporal variability in rainfall which affects water supply (Twisa & Buchroithner, 2019). Therefore, low water stress at national scale has the potential to mask water stress hotspots at local scale within the same country and highlights a need to monitor water resources at local scale. Water stress in SSA may be attributed to several reasons. Firstly, about 43% of the land in SSA is classified as arid or semi-arid implying the area is vulnerable to drought caused by rainfall deficit which then propagates to water supply shortages (Hadebe, Modi, & Mabhaudhi, 2017). Secondly, water stress in some countries may be due to population growth, changing lifestyle, and economic growth thereby exacerbating the imbalance between water availability and demand (Gain, Giupponi, & Wada, 2016).

Land use/cover change is also reported to exert significant pressure on water resources in SSA as it can lead to an increase in runoff and streamflow (flood) and decrease in groundwater recharge (Baker & Miller, 2013; Guzha, Rufino, Okoth, Jacobs, & Nóbrega, 2018; Yira, Diekkrüger, Steup, & Bossa, 2016). Invasive alien plant species have also been identified to increase water stress in SSA by contributing to reduce annual runoff volumes through increased evapotranspiration (Le Maitre et al., 2020; Mkunyana, Mazvimavi, Dzikiti, & Ntshidi, 2019).

Other studies have reported that water stress in some areas may be attributed to fluctuations in groundwater levels as a result of climate variability and changes in the precipitation patterns (Bonsor, Shamsudduha, Marchant, Macdonald, & Taylor, 2018; Nanteza, De Linage, Thomas, & Famiglietti, 2016). However, groundwater exploitation to reduce water stress is currently constraint by limited financial resources and lack of institutional support (Cobbing, 2020).

Whilst much research has established the biophysical drivers of water stress in SSA, there is a need to assess the level of water stress (low, moderate, or high) across countries and basins in the region and to identify the socioeconomic drivers of water stress. This information may be critical for managing transboundary basins considering the potential for conflict among riparian states that may arise from water stress. Climate information services (CIS) have been identified as critically important for supporting water management in SSA (Dinku et al., 2018). However, current applications of CIS in water management have focused mostly in providing seasonal forecasts for soil moisture and vegetation to monitor food security (Agutu et al., 2017; Asfaw et al., 2018). Other studies have focused on disaster management (de la Poterie et al., 2018; Mwangi, Wetterhall, Dutra, Di Giuseppe, & Pappenberger, 2014). The application of CIS for managing other aspects of water security have received less attention. This is a key knowledge gap and highlights a need to explore how CIS can be used to enhance other aspects of water security such as water supply, IWRM, transboundary basins and aquatic ecosystems.

3.4 Water use efficiency.

Across SSA, there is a general lack of quantitative data on water supply, use and distribution, coupled with the absence of a credible baseline information to monitor progress on this target. Evidence suggests that water use efficiency (WUE) across SSA is generally low (Supplementary material). In economic terms, this suggest that the added economic value output per unit volume of water input is low in SSA.

WUE is calculated as the sum of the WUE in agriculture, industries, and services weighted according to the proportion of water used by each sector over the total uses. The low WUE scores in SSA may be attributed to several factors. Firstly, the contribution of irrigated agriculture to WUE in SSA is relatively low as most of the agriculture is rain-fed (Rockström & Falkenmark, 2015). Secondly, WUE from industrial activities such as mining and quarrying may be difficult to quantify given the high rate of artisanal mining and quarrying activities (Fold, Allotey, Kalvig, & Moeller-Jensen, 2018; Hilson & Garforth, 2012; Maconachie & Hilson, 2011). Such unregulated industrial activities may not have been considered in the calculation of WUE even though contributions from such activities could be substantial in economic terms. Thirdly, most countries in SSA are classified as low-income countries by the World Bank implying that informal economic activities are substantial making it difficult to capture WUE scores. Lastly, the contribution of urban water utilities to WUE may equally be low due to different factors such as network leakages, meter reading inaccuracy, unauthorised consumption from theft and illegal connection (Mutikanga, Sharma, & Vairavamoorthy, 2011). There is paucity of information on water losses from water distribution networks in SSA while the contribution of artisanal mining and quarrying to WUE are poorly documented which directly affects the monitoring of SDG6. These are potential research gaps in WUE assessment in SSA that have been identified here for the first time. Despite the limited number of case studies on this target, available evidence suggest that water policy reforms can lead to an increase in WUE particularly in the agricultural sector (Thiam, Muchapondwa, Kirsten, & Bourblanc, 2015).

3.5 Integrated water resources management and transboundary water management

Due to the advantages offered by integrated water resources management (IWRM) such as promoting water diplomacy, international policy and water law, IWRM has been adopted as a key component of national water policy and climate change adaptation strategy by many countries in SSA (Mehta & Movik, 2014; Nkiaka & Lovett, 2019). It has also been used to test different water management options in some countries (Mersha, de Fraiture, Masih, & Alamirew, 2021). However, evidence suggest that only a few countries have made substantial progress towards achieving this target while others are either stagnating or regressing (Supplementary material).

Many factors may account for the slow implementation of IWRM in SSA. These include limited skills and capacity for water sector practitioners, stakeholders do not fully understand the processes involved in the implementation of an IWRM plan, absence of water management plans at basin scale, lack of financial resources, weak governance, limited stakeholder participation, and lack of coordination among different institutions involve (Malaza & Mabuda, 2019; Osumanu, Yelfaanibe, & Galaa, 2014; Van Koppen, Tarimo, van Eeden, Manzungu, & Sumuni, 2016). Considering the pivotal role of women in IWRM implementation, gender inequality limit the participation of women in IWRM processes (Elias, 2017). It has been suggested that for IWRM to be successful in SSA, specific IWRM policies that can deliver high societal impact should be targeted for implementation rather than trying to implement all aspects of IWRM at the same time (Duncan, de Vries, & Nyarko, 2019; Gallego-Ayala & Juízo, 2011). Furthermore, the implementation of IWRM could also be fostered through the coordination of sub-regional economic commissions (Ladel, Mehta, Gulemvuga, & Namayanga, 2020). However, there is an urgent need for more research to identify the key policy actions that can deliver high societal impacts and to develop operational tools such as decision support systems to support IWRM in SSA (Ladel et al., 2020)

Beyond national-scale indicators, transboundary basins also represent an important spatial scale for assessing progress towards achieving SDG6 because many geophysical processes and environmental feedbacks on SDG6 occur at this level (Scown, 2020). Effective transboundary water management can lead to international cooperation among riparian states and enhance regional integration. Evidence suggests slow progress towards implementing this target across SSA (Supplementary material). There are 42 countries sharing transboundary basins in SSA (McCracken & Wolf, 2019) and many transboundary basin organisations (e.g. Lake Chad Basin Commission, Niger Basin Authority, Limpopo Water Course Commission) that can facilitate the implementation of this target. Few studies have highlighted the importance of transboundary basin organisations in the effective management of transboundary watercourses in SSA (Mogomotsi, Mogomotsi, & Mosepele, 2020). The slow progress towards achieving this target may be attributed to several factors such as a pervasive weakness in water governance and differences in financial and technical capacity and development priorities among riparian states (Keller, 2012). As climate change is expected to increase water stress in many transboundary basins in SSA, there is a need to strengthen water cooperation among riparian states to ensure adequate allocation and efficient water management (Mgquba & Majozi, 2018). There are also knowledge gaps to evaluate how existing institutions have enhanced transboundary water cooperation in SSA. In contrast, similar operational arrangements for transboundary groundwater aquifers are absent. Given that groundwater plays a crucial role in mitigating water stress, there is an urgent need to put in place transboundary groundwater aquifer institutions to enhance groundwater management in SSA.

3.6 Water related ecosystems.

Evidence suggests that few countries appear to have achieved this target and are working towards sustaining the results while others are on track toward achieving it (Supplementary material). This is also evident by the increasing number of Ramsar sites in SSA which increased from 190 in 2011 to 289 Ramsar designated sites in 2020 (Mitchell, 2013; Xi, Peng, Ciais, & Chen, 2021). However, the impact of unsustainable water use, flow regime alteration and water pollution on aquatic ecosystems is still poorly understood. Evidence show that flow alteration due to dam construction, unsustainable water use, and climate change has caused the collapse of many ecosystems in SSA with a notable example in the Lake Chad basin (LCB) (Gao, Bohn, Podest, McDonald, & Lettenmaier, 2011). Dam construction on the Omo River has also resulted to a substantial drop in the Lake Turkana water level with serious implications on its ecosystem (Avery & Tebbs, 2018; Gownaris et al., 2017; Tebbs, Avery, & Chadwick, 2020). Considering that many multipurpose dams are currently under construction or planned to be built across SSA (e.g., the Grand Ethiopian Renaissance Dam [GERD]); governments, the civil society, and the research community are called upon to provide detailed environmental impact assessments of such projects on aquatic ecosystems.

Other studies have reported that land use changes have resulted to dramatic changes in water levels in the Rift Valley Lake system (Nakuru, Baringo, Bogoria, and Elementaita) altering the biogeochemical cycle of these lakes with severe consequences on aquatic ecosystems (Kiage & Douglas, 2020). Crude oil exploration has also led to substantial damage to mangrove ecosystems in SSA (Chinweze, Abiola-Oloke, & Jideani, 2012; Sam & Zabbey, 2018). Population pressure resulting to increased demand for agricultural land, rapid urbanization, deforestation, and demand for fuel wood has also led to a substantial loss in wetland and mangrove areas (Adanguidi et al., 2020; Beuel et al., 2016; Munishi & Jewitt, 2019; Phethi & Gumbo, 2019).

Despite the progress made by countries towards attaining this target, there is still a need for improvement. Another critical area of concern is the urgent need to investigate the impact of plastic pollution on aquatic ecosystems in SSA.

4 SOCIO-ECONOMIC AND ENVIRONMENTAL FACTORS DRIVING WATER INSECURITY IN SUB-SAHARAN AFRICA.

In the preceding section, we provided an overview of the progress and challenges impeding the achievement of each SDG6 target in SSA. In this section we examine the different political, socioeconomic, and environmental factors undermining or with potential to undermine water security in SSA. We group these factors under the following themes: water governance, conflict and migration, climate change and urbanization/population growth.

4.1 Water governance

The race to achieve water security has brought water governance to the forefront of major scientific and political interests which has led to different definitions of water governance (Pahl-Wostl, 2017). In this paper, we adopt the definition proposed by the Organization for Economic Cooperation and Development (OECD) which defines water governance as "the range of political, social, economic, and administrative systems that are in place to develop and manage water resources, and to deliver water services at different levels of society" (OECD, 2011). The challenges faced by countries in SSA towards achieving water security reflects a general weakness in governance across the region (Gain et al., 2016). Weak water governance is exacerbated by the spatial and temporal variability of freshwater resources, the transboundary nature of many basins and limited cooperation among riparian states in transboundary water management (Kanyerere et al., 2018). This implies, for example, that the quality of water as it moves across national boundaries is influenced by different local catchment management strategies; water withdrawal being influenced by competing demands in each country and flood and drought management policies are different in each riparian state.

Weak water governance within the same country is also exacerbated by limited cooperation between different governance units (water, agriculture, energy, disaster management, environment), private sector and non-governmental organisations acting at different levels (local, national, and sub-regional) (Kim, Keane, & Bernard, 2015). Each governance unit at each level has different interests in the country's water resources making water governance a complex issue (Meissner & Jacobs, 2016). Therefore, the current organisation of governance units and their apparent fragmentation may inhibit the balancing of water governance benefits across different scales, sectors, and stakeholders. This remains a major challenge constraining the achievement of sustainable water management in SSA.

Water governance is also constrained by policies involving significant compromises – and the political will/capacity to address these may be lacking. Some of these include urban water supply governance (Ellis A Adams et al., 2019), sanitation governance (Ekane, Kjellén, Westlund, Ntakarutimana, & Mwesige, 2020; Ekane, Nykvist, Kjellén, Noel, & Weitz, 2014), irrigation governance (Lefore, Giordano, Ringler, & Barron, 2019; Woodhouse et al., 2017), groundwater governance (Jiménez et al., 2017; Whaley et al., 2019), community water supply governance (Alexander, Tesfaye, Dreibelbis, Abaire, & Freeman, 2015), governance of water related disasters (Bahta, Jordaan, & Muyambo, 2016; Bottazzi, Winkler, & Speranza, 2019; King-Okumu, Jillo, Kinyanjui, & Jarso, 2018). The multiple dimensions of water governance suggest a need to adopt a polycentric approach to water governance considering the interlinkages among the different dimensions. In addition, putting in place the different policies and legislation to ensure sustainable water governance demands inputs from stakeholders with expertise that may currently be lacking in many countries. This suggests an urgent need for capacity-building assistance to enhance water governance in SSA (Hegga, Kunamwene, & Ziervogel, 2020)..

Many river/lake basin organisations have been put in place in SSA and IWRM adopted as a new paradigm for sustainable water management at national and regional scale. Our review has revealed that these too are confronted by different contextual factors due to differences in political and socio-economic priorities among riparian states and a lack of cooperation. To achieve sustainable water governance in SSA, these complexities must be acknowledged to develop plans that consider the local context and the specificities of each country or riparian state for transboundary basins because a one-size-fits-all approach may not deliver the expected results.

4.2 Conflict and migration

Competition for access to water is a source of conflict that has persisted for centuries and has led to many claims about the relationship between water scarcity, conflict, and migration (Ayana, Ceccato, Fisher, & DeFries, 2016; Selby & Hoffmann, 2012). Water related conflicts are expected to increase under climate change as droughts which drive water scarcity become more frequent due to erratic rainfall patterns (Fjelde & von Uexkull, 2012; Levy, 2019). This may have dire consequences for people living in areas already facing water scarcity such as the Horn of Africa, the Sahel, and the southern Africa sub-region. Water may also be used as a trigger, target, or weapon in conflict and has been reported to be both a trigger for conflict in SSA (Almer, Laurent-Lucchetti, & Oechslin, 2017), and a target for conflict as well e.g., in the LCB (Okpara, Stringer, & Dougill, 2017) and Kenya (Detges, 2014). Conflicts related to sufficient water availability have also been reported in some countries and sub-regions (Mack et al., 2021; Selby & Hoffmann, 2014). Most conflicts triggered by water scarcity are often between different water user groups within the same countries. The recent use of water as a target in the LCB between state and non-state armed groups (Kamta, Schilling, & Scheffran, 2020), suggest that water conflicts in SSA are becoming increasingly complex and could have wider geopolitical ramifications with potential to threaten global security.

Although no interstate water conflicts have been reported in SSA (Levy, 2019), the recent diplomatic stand-off among some Nile Basin riparian states (Egypt, Ethiopia and Sudan) over the filling of GERD highlight the likelihood of future interstate conflicts over water. Water scarcity could also become a threat multiplier in regions where diplomatic relations between riparian states are absent (Levy, 2019). Considering that many dams are planned or currently under construction across SSA, there is an urgent need to strengthen transboundary water cooperation in the region. This is because such dams could become a source of interstate conflicts between upstream countries where dams are located and downstream countries facing water scarcity caused by the dam. There is equally a need to train more hydrologists and specialists in hydro-diplomacy to be able to lead complex water sharing negotiations among riparian countries (Niyitunga, 2019).

Conflicts resulting from other socio-economic and political crisis also have the potential to undermine water security through the destruction of water infrastructure, reducing the operational capacity of government agencies and could weaken transboundary water governance (Kut, Sarswat, Bundschuh, & Mohan, 2019; Roach & Al-Saidi, 2021). There are currently many ongoing conflicts in SSA which have resulted to forced displacement of people both internally and as refugees. Such massive displacement of people has serious implications on water security and could lead to tension between the host communities and the IDPs (Kamta, Schilling, & Scheffran, 2021). Although the impact of conflicts on water security in SSA is poorly documented, achieving peace and stability in the region could be another critical condition for attaining water security.

4.3 Climate change

SSA is one of the most vulnerable regions to climate change which is expected to influence the availability of water resources through changes in soil moisture, evaporation, runoff, and groundwater recharge as well as increase the demand for water (Taylor et al., 2013). Analysis of past observational records in SSA show increasing trends in mean annual temperatures over the past several decades with the trend expected to continue in the future (Almazroui et al., 2020; Hoffman, Kemanian, & Forest, 2018). This increasing temperature trend is expected to be accompanied by an increase in the frequency of extreme temperatures and aridity leading to a decline in agricultural production (Dale, Fant, Strzepek, Lickley, & Solomon, 2017; Serdeczny et al., 2017). Enhanced evaporation as result of rising temperature is also expected to alter the relationship between rainfall and 'available water' (i.e., precipitation minus evaporation) which will likely increase water stress in many areas across SSA (Bornemann et al., 2019).

Climate change is also projected to alter precipitation patterns in SSA which will increase water stress in many areas (Faramarzi et al., 2013; Serdeczny et al., 2017), and increase the frequency and intensity of extreme precipitation (Kendon et al., 2019; Taylor et al., 2017). It will equally contribute to sea level rise in many coastal areas (Serdeczny et al., 2017). Precipitation projections for SSA also show large spatial variability with some areas expected to observe a decrease while others will experience an increase (Almazroui et al., 2020). Climate change is also expected to affect groundwater quality in SSA (Aladejana, Kalin, Sentenac, & Hassan, 2020). These factors will have serious implications for water security in the region.

Climate change may also significantly disrupt water availability in dryland areas in SSA forcing people to migrate to urban areas (Henderson, Storeygard, & Deichmann, 2017; Kniveton, Smith, & Black, 2012). Forced migration to urban areas may increase water security challenges in areas where the host communities are already struggling to meet their water demands. Under climate change, longer dry spells are expected to become frequent during the rainy season resulting to soil moisture deficits during the growing season with impact on rainfed agriculture and food security (Kendon et al., 2019).

Climate model projections also show that the frequency and intensity of extreme events such as El Niño-Southern Oscillation (ENSO) will increase with more severe droughts and floods expected across SSA (Cai et al., 2014; Gizaw & Gan, 2017; Wang et al., 2019). Climate change will also increase the frequency and intensity of tropical cyclones which may trigger extreme storms and floods with potential to destroy critical water infrastructure thereby undermining the achievement of water security (Mendelsohn, Emanuel, Chonabayashi, & Bakkensen, 2012).

4.4 Urbanization and population growth

Rapid population growth has led to an increasing trend in urbanization across SSA with the urban population projected to exceed 1.3 billion by 2050 (Güneralp, Lwasa, Masundire, Parnell, & Seto, 2017). However, this trend is expected to vary spatially with the coastal zones experiencing the highest rate of population growth and urbanization driven by migration from arid and semi-arid areas due to climate induced water scarcity (Henderson et al., 2017; Neumann, Vafeidis, Zimmermann, & Nicholls, 2015).

Increased migration to urban centres will lead to an increase in water demand (Dos Santos et al., 2017). Given that most water supply to urban areas is captured from surface water bodies in rural catchments, increased pollution from agricultural fields in these areas will increase the financial cost of water treatment which will be charged on urbanites by water utility companies (Niasse & Varis, 2020). Achieving water security in urban areas could also be constraint by a lack of proportional investment in water infrastructure to match the rapid urbanization coupled with poorly maintained aging infrastructure (Dos Santos et al., 2017; Nlend et al., 2018). It is reported that limited access to water supply in informal settlements in SSA is already forcing residents to rely on polluted shallow groundwater wells and surface water bodies thereby increasing exposure to water-related diseases (Niasse & Varis, 2020).

Urban expansion resulting to increased impervious areas is also reducing the rate of groundwater recharge across many cities leading to a drop in groundwater levels (Olarinoye, Foppen, Veerbeek, Morienyane, & Komakech, 2020). Considering that groundwater is a vital source of fresh water supply in many cities in SSA (Oiro, Comte, Soulsby, MacDonald, & Mwakamba, 2020), this may have significant impact on sustainable water supply in urban areas. Urbanization and population growth in SSA could also lead to the rapid depletion of groundwater and surface water stocks which will exacerbate water scarcity (Niasse & Varis, 2020; Oiro et al., 2020). Despite a low rate of irrigation in SSA, accounting for less than 7% of cultivated land, an increasing population is expected to increase the amount of water used in agriculture to meet food-supply demands (Niasse & Varis, 2020). The quantity of water used in hydropower production is also expected to increase to generate more electricity needed in urban areas and to fulfil rural electrification policies/strategies.

As a result of changes in land-use, and particularly increases in the prevalence of impervious surfaces, urbanization will significantly contribute to higher flood peaks and increase the risk of flash flooding in cities (Amoako & Frimpong, 2015; Mahmood, Elagib, Horn, & Saad, 2017). The expansion of informal settlements mostly built on marginal land, including flood prone areas will increase exposure to flood risk (Dalu, Shackleton, & Dalu, 2018). Incidence of urban floods in SSA have also been attributed to the blockage of drainage systems by solid waste including plastics (Mahmood et al., 2017; Roebroek et al., 2021). This highlights the importance of maintaining drainage systems to mitigate urban flooding in cities. Rapid urbanization and population growth in coastal areas will equally lead to increased exposure to coastal flooding caused by sea level rise triggered by global warming (Neumann et al., 2015). Based on evidence uncovered here, there is an urgent need to incorporate water security in urban development strategies across SSA.

5 CONCLUSION

In response to recent calls for consolidated evidence on progress towards the attainment of the SDGs and associated challenges, this review aimed to evaluate progress made, unpack the challenges impeding the achievement of different SDG6 targets and examine the political, socioeconomic, and environmental factors undermining water security in SSA.

Our review has revealed that SSA faces substantial water security challenges with WSS targets well below global benchmarks. Unless a radical approach is adopted, current progress indicates that many countries may not achieve water security by 2030. Not achieving water security will directly impact the possible achievement of other goals that are interrelated to water: Especially SDG1 (no poverty), SDG2 (food security), SDG3 (good health), SDG5 (gender inequality), SDG7 (affordable energy), SDG14 (life below water) and SDG15 (life on land).

The complex nature of the challenges impeding the achievement of SDG6 targets and the factors undermining or with potential to undermine water security in SSA implies that a holistic approach involving local, national, and international stakeholders is urgently needed to address SDG6 if the 2030 target is to be met. Approaches to enhance water security may equally consider underpinning peace and security and the commitment of more financial resources by countries and donors. Achieving water security has now become ever more apparent due to the current COVID-19 pandemic, where access to clean water and soap to wash hands are a primary means of controlling virus transmission. We hope the COVID-19 pandemic will be a wake-up call for governments and donors to prioritise access to WSS in SSA and also considering that access to WSS is a basic human right that has been neglected for a large proportion of the population in SSA. At the same time to recognise the importance of achieving the rest of the SDG6 targets.

Our review has uncovered significant and pervasive data gaps in relation to specific SDG6 targets including water quality, transboundary water management, WUE and water related ecosystems. These may be directly addressed by countries through timely and open reporting of data to relevant UN agencies, and establishing structures for the generation and dissemination of data. Additionally, researchers might also seize the opportunities offered by Earth Observation for large scale monitoring (Kapalanga, Hoko, Gumindoga, & Chikwiramakomo, 2020) and Citizen Science due to its low-cost to setup water quality monitoring programs to resolve data challenges (Quinlivan, Chapman, & Sullivan, 2020). Our review has revealed that water pollution is increasingly becoming a major threat to water security in SSA given the range of hazardous compounds that have been detected in both surface water and groundwater wells and their potential impact on human health and the environment.

The review has equally revealed many unexploited research areas that need urgent attention to address specific SDG6 targets. Examples include: (1) identifying factors driving water stress in different countries and transboundary basins, (2) investigating how CIS may be used to enhance water management in SSA, (3) examining and understanding barriers to effective water management among riparian countries, (4) evaluating water losses in urban water distribution systems, and (5) the development and management of trans-boundary organisations to administer groundwater aquifers. Also deserving attention is the need to investigate the impact of population growth and climate change on agricultural water demand and how this may affect future water security in SSA.

In sum, we find that little progress has been made by SSA countries towards SDG6. It is clear that challenges in achieving SDG6 are enormous, and the knock-on effects of not doing so to other SDGs are apparent. Nevertheless, there are clear viable opportunities for both progress and improvement in a number of key areas. Indeed, in this endeavour, findings from this review will be invaluable to governments and development partners as well as the academic community. This is the first article to provide an overview of the status of SDG6 and its targets in the global south thereby contributing to enrich the literature evaluating the progress made by countries and regions towards achieving the UN SDGs.

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