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Review Paper

The centrality of water resources to the realization of Sustainable Development Goals (SDG). A review of potentials and constraints on the African continent

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ABSTRACT

Africa is endowed with vast water resources including but not limited to lakes, rivers, swamps and underground aquifers. However, the way of life in Africa does not reflect this kind of wealth owing majorly to degradation and underutilization of these water resources. This review discusses the centrality of water resources in Africa's pursuit of the Sustainable Development Goals (SDGs). Following the Sustainable Development Model, the paper thematically examines and synthesizes the importance and potentials of water resources to Africa's development through exploring their contributions and limitations to the various economic sectors namely; agricultural and livestock production, energy, manufacturing and processing, tourism, health, fisheries, trade and other institutional mechanisms such as payment for ecosystem services (PES), mutual cooperation and economic cooperation. Data were collected by review of online peer-reviewed and grey literature published between the year 2000 and 2015. It is observed that sustainable management of water and sanitation for all (SDG 6) will be central to the attainment of all the other SDGs (particularly SDG 1 (No poverty), 2 (No hunger), 3 (Good health), 14 (life below water) and 15 (life on land)) across Africa. African states should therefore increase their commitment to water conservation and management as this will significantly decide Africa's future development paths.

Contents

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1. Introduction

Water is life, so the old adage goes. This is owed probably to the ubiquitous nature of the resource. Water is a universal component of every living thing but more importantly of human life. It is not only home to myriads of marine species (Polidoro et al., 2008) but also a huge driver of man's economic and social expediency making his home a lot more habitable (FAO, 2011). Globally, water is one of the leading drivers of economic development but also a source of contention and conflict (UNEP, 2010). Even when the images of our planet show vast quantities of water, this is only a mirage as most of the water is salty and not suitable for human consumption (UN, 2015; World Business Council for Sustainable Development (WBCSD), 2006). NEPAD (2006) states that only 2% of the global water is freshwater fit for human use. This leaves the global population with only 0.5% (10,000,000 km^3 in underground aquifers, 119,000 km^3 net of rainfall falling, 91,000 km^3 in natural lakes, over 5000 km^3 in man-made facilities and 2120 km^3 in rivers) to survive on (UN, 2015). Africa has 9%, the least percentage of fresh water at continental level. America has the largest share of the world's total freshwater resources with 45%, followed by Asia with 28% and Europe with 15.5%. This natural distribution of water together with several anthropogenic factors has, in part, created the water problem that the global village is battling with today (UNEP, 2010). The natural distribution of water is highly variable geographically and seasonally (United Nations World Water Assessment Programme WWAP, 2015); with some areas having huge amounts of water while others have little or none and seasons of extremely high rainfall are often followed by long periods with no rain. These patterns of inequity, variability, extremity and unreliability are worsening in many areas because of the impacts of climate change – especially in those areas occupied by the poorest and least resilient communities (Ashton, 2002; Donkor, 2003; Freitas, 2013; IPCC, 2014; Wolf, 2001; UN DESA, 2015; WWAP, 2015). For a continent whose countries are ranked among the least developed countries in the world (Freitas, 2013; Winkler & Marquand, 2009) and whose population growth is unprecedented (African Union (AU), 2014; IRENA (International Renewable Energy Agency), 2015), Africa needs its water more than any other continent. Africa has great potential of underground water resources which according to Africa Progress Report (APR) (APP, 2015), are 100 times more than surface water sources. Though still a poor continent, Africa is fast picking pace on the development track with GDP growths as high as above 6% per annum in some sub Saharan countries like Rwanda, Ghana, Nigeria, Kenya and South Africa (African Development Bank (AfDB) et al., 2015; APP, 2015). As we move from the Millennium Development Goals (MDGs) to embrace the new and more promising Sustainable Development Goals (SDGs), also termed as the Global Goals (Fig. 1), the contribution of water resources to the continent's development paths cannot be undermined. As demonstrated in the subsequent sections, this paper explores the extent to which African water resources can enhance the attainment of SDGs. Specifically, the paper examines the importance and potentials of water resources to Africa's development through exploring their contributions and limitations to the various sectors of growth namely; agricultural and livestock production, energy, manufacturing and processing, tourism, health, fisheries, trade and other institutional mechanisms such as payment for ecosystem services (PES), mutual cooperation and economic cooperation.

2. Materials and methods

Ford et al. (2011) and Koricheva and Gurevitch (2013) demonstrated the increasing utility of meta-analyses in social sciences in the search for generalizable principles through the systematic assessment of carefully selected literature. The methodological approach of this study involved extensive review of both peer-reviewed and grey literature published from the year 2000–2015. Online sources such as Web of Knowledge, Google Scholar and Google were utilized with grey literature collected from various institutional websites using search filters "water resources + sustainable development goals + Africa's economic drivers" (Fig. 2).

The review analysis was informed by the sustainable development model by Flint (2004). Sustainable development in this case is taken to mean working to improve human's productive power without damaging or undermining society or the environment. By acting under the principles of sustainable development, our economic desires/demands become accountable both to an ecological imperative to protect the ecosphere and to a social equity imperative to create equal access to resources and minimize human suffering. These requirements are the foundation of sustainable development as represented by the three circle model (principle elements) of sustainability. These three elements interact with each other so continuously that we cannot make decisions, make policy, manufacture, consume, essentially do anything without considering the effects and costs upon all three simultaneously. Each circle (sustainability principle) is defined as follows (Flint, 2004).

Economic Vitality (Compatible with Nature) development that protects and/or enhances natural resource quantities through improvements in management practices/policies, technology, efficiency, and changes in life-style.

Ecologic Integrity (Natural Ecosystem Capacity) understanding natural system processes of landscapes and watersheds to guide design of sound economic development strategies that preserve these natural systems.

Social Equity (Balancing the Playing Field) guaranteeing equal access to jobs (income), education, natural resources, and services for all people: total societal welfare. Carrying out activities that are sustainable requires simultaneous, multi-dimensional thinking about the consequences of present actions in a cause and effect pattern on future public and environmental health through examination of the connections among environmental, economic, and social concerns when we make choices for action.

Informed by this model, the literature was thematically synthesized according to Africa's main economic drivers (including; agriculture and food production, livestock production, energy, manufacturing and processing, tourism, health, payment for ecosystem services, fisheries, mutual cooperation and economic integration, transportation and trade).

Fig. 1. The Global Goals
Source: http://www.globalgoals.org/Public Domain.

Fig. 2. The conceptual model of sustainable development that illustrates the relationship among economic, ecologic, and social issues of concern in decision-making. The black overlap of the three circles represents the nexus of connection among issues.
(Adapted from Flint, 2004).

3. Results and discussions

Results from the synthesis are presented and discussed in the following sub-sections.

3.1. Agriculture and food production

Development of water resources and making water available is a key ingredient for agricultural and broader economic growth (FAO, 2011; UN DESA, 2015; WWAP, 2015). Most economies in Africa are closely tied to natural resources with rain-fed agriculture, largely the single most important economic driver of economic growth for most countries (UNEP, 2010), accounting for about 20% of Africa's GDP. According to AU (2014), for Sub Saharan African countries like Uganda, agriculture will not only be the main source of foreign exchange and savings but also an important source of inputs for industries like the ever growing food industry. Water is directly linked to agriculture (UNEP, 2010). Hence it will play a decisive role in ending poverty in all its forms (SDG 1), firstly and straight forwardly, not only because it accounts for 60% of the labour force in Africa, but also it is a main source of income to the majority of Africans (UNEP, 2010). By providing over 90% of the African foods (German Development Institute (GDI), (2015)), it enhances the attainment of SDG 2 (ending hunger) and SDG 3 (good health and wellbeing). AU (2014) argues that Africa is the only continent where the growth in food production is less than the growth in population, yet water availability for agriculture is already limited and uncertain in some African countries including but not limited to Chad, Cameroon, Niger and Nigeria, Mauritania and Sudan (UNEP, 2008) owing to the increasing erratic rainfall, and the situation is predicted to worsen (IPCC, 2001, 2007, 2014; de Wit & Stankiewicz, 2006). This is a big blow for the African economy whose leading sector relies immensely on water withdrawals. Even with such a bleak future, water-reliant agriculture has a dormant potential to transform the continent but only if tapped into.

Water can be made available for agriculture through various innovative ways. Firstly, through effective rain water harvesting and storage for use in drier and more erratic seasons. Food and Agriculture Organization (2005b) states that 7% of the arable land in Africa is currently under irrigation. Secondly, increasing the area under irrigation can also ensure uniform and continuous supply of water to the fields throughout the seasons. Employment of water and energy-efficient methods and techniques of irrigation can also ensure agricultural productivity and consequently economic growth. Thirdly, conservation of the environment and watersheds will guarantee perpetual flow of water to agricultural fields and productivity all year round. Finally agriculture does not necessarily require clean. As such water from other uses can be appropriately treated and recycled in agriculture fields. This concurrently increases water's lifecycle and agricultural productivity both of which contribute to economic, social and ecological perpetuity. Therefore, the utility of water in running Africa's agriculture will depend on the commitment presented by sovereign governments to make water available to the plants at the right time and in optimum amounts. This commitment will be reflected in technological advances, breeding exercises, informed policies and water management techniques; all of which must take care of the social, economic and ecological dimensions of development.

3.2. Livestock production

Water plays an unequivocal role in driving the livestock industry right from watering point of the livestock to the consumer. In the dairy sector, water is a major component of milk and greatly curtails milk yields if absent or taken in inadequate amounts (FAO, 2005a, 2005b). For instance, the production of eggs, pig meat and poultry meat in Sub Saharan Africa tripled between 1970 and 2000 while that of milk and mutton and goat meat doubled and that of beef increased by nearly 70% (Otte & Knips, 2005). However, the increases in production were not big enough to keep pace with population growth (Otte & Knips, 2005). FAO (2005a, 2005b), states that over 90% of household cash incomes are derived from livestock and livestock products. This implies that the livestock industry can variously play a significant role in attaining SDGs 1, 2, 3 and 4. A slight diversification of the livestock industry can result into production of biogas energy, hence contributing to SDG 7.

The beef sector though not as heavily dependent on water as the diary, its reliance on water resources is significant and cannot be undermined. Water is not only a requirement in mixing acaricides(Estrada-Peña & Salman, 2013) for vector elimination but also a necessity of steers putting on weight for the beef market. In poultry, water is as essential as it is in the other sectors with both broilers and layers laying significant claims to the existing water resources. Water is an essential component in the manufacturing of a number of livestock products including milk and hides, and beef and chicken (Wilkinson, 2003). However, with the acute water stress in most African countries, most animals, like people, go without water and some starve (UNEP, 2008). This is exacerbated by the fast changing climate triggering various shocks, stresses and extremes with a huge impact on the industry in particular and the economy at large (de Wit & Stankiewicz, 2006; APP, 2015). Thus the livestock industry in Africa operates well below half its full potential (FAO, 2005a).

If well planned and managed, Africa's water resources have the potential to build the industry to its desired glory. This requires the involvement of all stakeholders from government to Non-Governmental Organizations to the communities interfacing with these resources. Rightly informed and guided water policies can turn the situation around and set the continent on a better development path. Since most of the water resources in Africa are communally owned (JICA, 2010), collaborative management of these resources will ensure security of water for livestock even in fragile areas. Consequently, water resources can only transform the livestock industry and contribute to the continent's development only if cognitive decisions are taken that carefully address the diverse needs of both crop farmers on one side and livestock herders on the other, as has been evidenced across several communities within Africa.

3.3. Energy

Energy is harnessed from either renewable or non-renewable sources (IRENA, 2015). Non-renewable sources require millions of years to replenish and include petroleum, coal and radioactive elements while renewable sources can replenish within the lifespan of man though can become non-renewable if their rate of depletion surpasses their rate of restocking (IFAD, 2010; IRENA, 2015). Renewable energy sources include wind, the sun, tides and water. Africa practically runs on both renewable and renewable energy as it drives its factories, feeds its people, and transports its goods. Hydro power from water accounts for 17.8% of the total energy consumed on the continent (UNIDO, 2009). Africa has got over 1270 hydropower dams with almost half of them in Southern Africa (UNEP, 2010). Hydropower has not only been a source of economic development across Africa but also of controversy over shared and transboundary water resources. Africa's susceptibility to potential water-induced conflict can be separated into four regions: the Nile, Niger, Zambezi, and Volta basins. Running through Egypt, Ethiopia, and Sudan, the Nile's water has the potential to spark conflict and unrest. In the region of the Niger, the river basin extends from Guinea through Mali and down to Nigeria. Especially for Mali - one of the world's poorest countries - the river is vital for food, water and transportation, and it's over usage is contributing to an increasingly polluted and unusable water source. In southern Africa, the Zambezi river basin is one of the world's most over-used river systems, and so Zambia and Zimbabwe compete fiercely over it. Additionally, in 2000, Zimbabwe caused the region to experience the worst flooding in recent history when the country opened the Kariba Dam gates. Finally, within the Volta river basin, Ghana is dependent on its hydroelectric output, but plagued by regular droughts which effect the production of electricity from the Akosombo Dam and limit Ghana's ability to sustain social and economic growth as well as environmental protection. Paired with the constraints this also puts on Ghana's ability to provide power for the area, this could potentially contribute to regional instability (UNEP, 2010; http://www.aljazeera.com/programmes/struggleoverthenile/; https://en.wikipedia.org/wiki/Water_scarcity_in_Africa), These scuffles may end up offsetting the recognized benefits of the resource on the naturally wealthy continent, thereby constraining the attainment of all the 17 SDGs.

Additionally, the capacity in terms of cost and technical expertise of most African countries to establish and maintain the power dams is absurdly inadequate (AfDB et al., 2015). This is evidenced by the frequent power rationing and blackouts experienced in several countries. It is estimated that the continent has the potential to produce more energy from water alone than it produces presently (UNIDO, 2009). For the continent to have this as a reality, it needs to have sound policies regarding energy and the environment, secure enough funding for mega hydro projects and develop alternative renewable sources of energy. Uncertainties in water availability accompanied with climate change based hazards like floods leaves hydropower, the most used form of energy in Africa's industrial sector in suspense hence sending the majority of African countries development at a standstill (APP, 2015). This in turn will directly constrain the attainment of SDG 7 and indirectly inhibit the attainment of the majority of the SDGs. Africa's energy state has to be wisely boosted because the entire developing industrial and other economic sectors require energy which employs an increasing number of local people hence contributing to the attainment of SDGs 1, 3 and most of the other SDGs directly and/or indirectly.

3.4. Manufacturing and processing

Africa's human population growth now standing at 4.8% annually is unparalleled (IFAD, 2010; IRENA, 2015). This growth requires industries to clothe, house and feed the people hence contributing to the attainment of SDGs 2, 3, 6 and 8. This in turn means rapid increase in the number of manufacturing and processing industries across the continent. Global water demand for manufacturing is predicted to increase by 400% from 2000 to 2050, which is much larger than any other sector and most of this increase will be in emerging economies and developing countries (AU, 2014). Principal manufacturing industries on the continent include food products, plastic and rubber, chemicals, basic metal work, and non-metallic mineral products (Wilkinson, 2003). These industries directly or indirectly rely on water for smooth flow of operations and activities. Manufacturing and processing industries use water directly as a solvent, sanitation agent or as a coolant.

Indirectly, these industries heavily rely on power (hydropower) generated from fast speed water. A significant amount of all the hydropower produced on the continent is consumed by this sector

(Wilkinson, 2003). However, the sector's contribution to the much needed development is usually hampered by the recurrent blackouts the continent is experiencing. For instance, according to APR (2015) and WWAP (2015), energy-sector bottlenecks and power shortages cost the African region 2–4% of GDP annually, undermining sustainable economic growth, jobs and investment. With cheap labour (UNDP, 2011), copious quantities of minerals (Winkler & Marquand, 2009) and favourable climate on the continent, the sector singly has an enormous potential to transform Africa. For the continent to recognize this potential, member countries have to fine tune their policies regarding energy use, provide the required infrastructure (SDG 9), encourage investment in the sector and allocate a significant percentage of their national budgets to the sector.

3.5. Tourism

Africa is beautiful owing to its natural endowment (Rogerson, 2007). The continent boasts of more than 1100 mammal species, 2500 bird species and over 4200 species of reptiles only in East Africa (Christie & Crompton, 2001). These attract myriads of tourists to the continent and, therefore, foreign exchange. The tourism sector contributes over 2% of the GDP and over 5% of exports in Sub Saharan African countries (Rogerson, 2007). In Rwanda and Kenya, like some other countries on the continent, tourism is the principal sector driving the national economy and the leading foreign exchange earner (Nielsen, 2010). Tourism in Africa can directly or indirectly contribute to the attainment of SDG 8 (Promote sustained, inclusive economic growth, full and productive employment and decent work for all); SDG 12 (Ensure sustainable consumption and production patterns) and SDG 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) (http://icr.unwto.org/content/tourism-and-sdgs).

Water resources and tourism are closely interwoven with a huge number of tourist attractions either being water resources (like Murchison falls in Uganda) or acting as habitats of famous sought living species like lake Mburo National Park (UTB, 2014). Species synonymous with water resources include birds (including migratory birds) for example the 606 bird species near Lake Edward in Queen Elizabeth National Park, crocodiles and hippopotamus in Lake Mburo National park (UTB, 2014), native fish all of which are prominent tourist attractions. However, tourism linked with water resources is hampered by degradation of water resources (Christie & Crompton, 2001; Willem & Saayman, 2005) through pollution, indiscriminate fishing and encroachment. In Africa, tourism, notably ecotourism, has the potential to support the continent's socio-economic transformation and growth paths. This potential may, however, remain a dream if governments do not increase funding to the sector, encourage research, move towards a green tourism economy, engage the private sector, promote cultural heritage and build politically stable countries (Rogerson, 2007; UNEP, 2011).

3.6. Health

Economies cannot survive without a healthy labour force (AfDB et al., 2015; Hall, 2011). The failure to provide safe drinking water is perhaps the greatest development failure of the 20th century (Gleick, 2006). A report by Corcoran et al. (2010) shows that about 90% of all waste water in developing countries, most of which are in Africa, is discharged untreated directly into the available water sources. This compromises people's health to the extent that over half of the hospital beds in Africa have patients suffering from water- borne related illness (Pan African Chemistry Network (PACN), 2010). AU (2014) shows that 80% of all diseases in Africa are water borne, especially, diarrhoea and dysentery. Attainment of the SDGs in Africa will thus be an illusion if water related illnesses continue to prevail among the people and ecosystems.

For a continent whose level of mechanization is still very low (AfDB et al., 2015), reliance on human labour force is not only necessary but also cheap. Clean water sources will, to a good degree, guarantee a sound and healthy citizenry on the continent and, therefore, help spur growth. UN Water (2008) approximated that 340 million people were lacking access to safe drinking water; and whether water resources will transform the continent through their effect on human health and labour will depend on the commitment of governments to provide safe drinking water to the populations.

3.7. Payment for ecosystem services (PES)

Water can be harnessed as a good when it is used in factories, homes and sustaining people's livelihoods. It plays a key role as a service through conservation and support inbuilding self-perpetuating ecosystems. Water also provides ecosystem services like regulating, supporting, cultural and provisioning services (Forest Trends et al., 2008). The world has realised and recognized that the potential of water and countries are slowly putting together efforts to maximise it. Payment for Ecosystem Services (PES) is a relatively new mechanism with new emerging markets. PES is entails building self-sustaining ecosystems (Forest Tends et al., 2008) through commoditizing their services, attaching a price to them and trading in such services. These emerging markets include Carbon, biodiversity and water markets termed thus according to the ecosystem providing the service. The idea is that countries and companies that cannot provide the defined ecosystem service can offset their failure by buying credits from their counterparts who can provide the service in excess or at a lower cost.

Water resources can provide the service directly through the water market but also aid other ecosystems in providing their services to the respective markets. This is evident in cases where water resources are biodiversity hotspots like in Southern Africa (Brett et al., 2012) or active carbon sinks in forests thus generating credits for both biodiversity and carbon markets. In Africa, PES markets channel in millions of dollars annually, employ a significant number of locals and maintain the ecosystems on which they depend (Watson et al., 2005). However the biggest challenge is how to integrate PES programmes with other rural development initiatives in order to avoid contradictory policies and actions in rural development and land use planning (Andrew & Masozera, 2010; Richards & Jenkins, 2007) Appropriate involvement of water in PES can help in directly attaining SDG 14 and 15 and indirectly contribute to the achieving of most of the other SDGs. If governments improve their management of water resources, these markets have an enormous potential to brighten the continent's paths towards meeting her SDGs.

3.8. Fisheries

Africa's water resources are home to around 600 fish species representing over 60% of the global fish stocks (FAO, 2014; UNEP, 2010). This has spurred a rapid growth of the fishing industry on the continent turning in a significant amount of money in foreign exchange and providing nutrition and employment to a huge number of locals within resident countries. However, the fish future for Africa is clouded by unsustainable fishing techniques like over fishing and indiscriminate fishing, underdeveloped fishing technology and pollution of fish habitats. Available evidence points to the fact that several of Africa's fish species are already extinct, endangered, threatened or over fished (Polidoro et al., 2008)

further crippling the industry's future. Even when marred with such hiccups, the industry when targeted for development through more investment and community collaboration can be turned into a major earner for a number of African countries. Fish is the main source of proteins to African communities surrounding water bodies. Hence the fishing industry, if packaged well can directly and indirectly help improve the health of Africans thus significantly contributing to the attainment of SDG 1 (no poverty), SDG 2 (no hunger), SDG3 (ensuring healthy lives and promoting well-being for all at all ages) and SDG 14 (life below water).

3.9. Mutual cooperation and economic integration

Several of Africa's natural water resources are shared amongst two or more countries and are commonly known as transboundary water resources. A case in point is Lake Victoria which is shared between Uganda, Kenya and Tanzania. Transboundary water resources have been observed to be sources of contention and conflict amongst the riparian parties not only in Africa but also across the entire globe (Wolf, 2001; UNEP, 2010; http://www.aljazeera.com/programmes/struggleoverthenile). The most heated conflict has been the scramble for ownership, use and development of River Nile pitting Egypt and Sudan against the upstream countries. Though Egypt and Sudan wish to maintain the old colonial agreement which hands them a lion's share of the Nile's waters, the upstream countries have signed a new agreement pushing for equal rights over the Nile (Urama & Ozor, 2010; http://www.aljazeera.com/programmes/struggleoverthenile). These conflicts are not only expensive in terms of resources, but also in straining relationships amongst riparian countries as is the case with countries sharing Lake Chad (Fig. 3). However, an increasing number of scholars and political analysts are refusing to see one side of the story and state that these shared resources can as well be a source of mutual cooperation amongst the conflicting parties (Ferraro, 2009; UN, 2015). Besides breeding conflicts and wars, which has implication on SDG 11, transboundary water resources can provide opportunities for conflicting parties to mutually cooperate and thus foster socio-economic integration (Wolf, 2001). Where mutual use of transboundary water resources is allowed, involved countries or regions will in this case strive to attain SDGs 8, 10 and 16 (reducing inequality within and among countries). In a nutshell, the capability of shared water resources to transform the continent will depend on whether they are seen as sources of conflicts or as opportunities to cooperate.

3.10. Trade

Africa does not produce all that it consumes nor does it consume all that it produces. This situation necessitates the continent to import goods that it lacks and export those in excess thus earning foreign exchange. Goods in and out of the continent are either flown in or shipped and rarely conveyed by road, railway or pipes. Some of prominent ports include Tunis, Port Said, Alexandria, Tangier in North Africa; Dakar, Abidjan, Lagos, Tema and Douala in West Africa; Mombasa, Dar es Salaam, Djibouti in East Africa; Durban, Cape Town Port Elisabeth, Walvis Bay in Southern Africa (AFDB, 2010). Annually a significant amount of goods are shipped in and out of the continent (AfDB et al., 2015) further

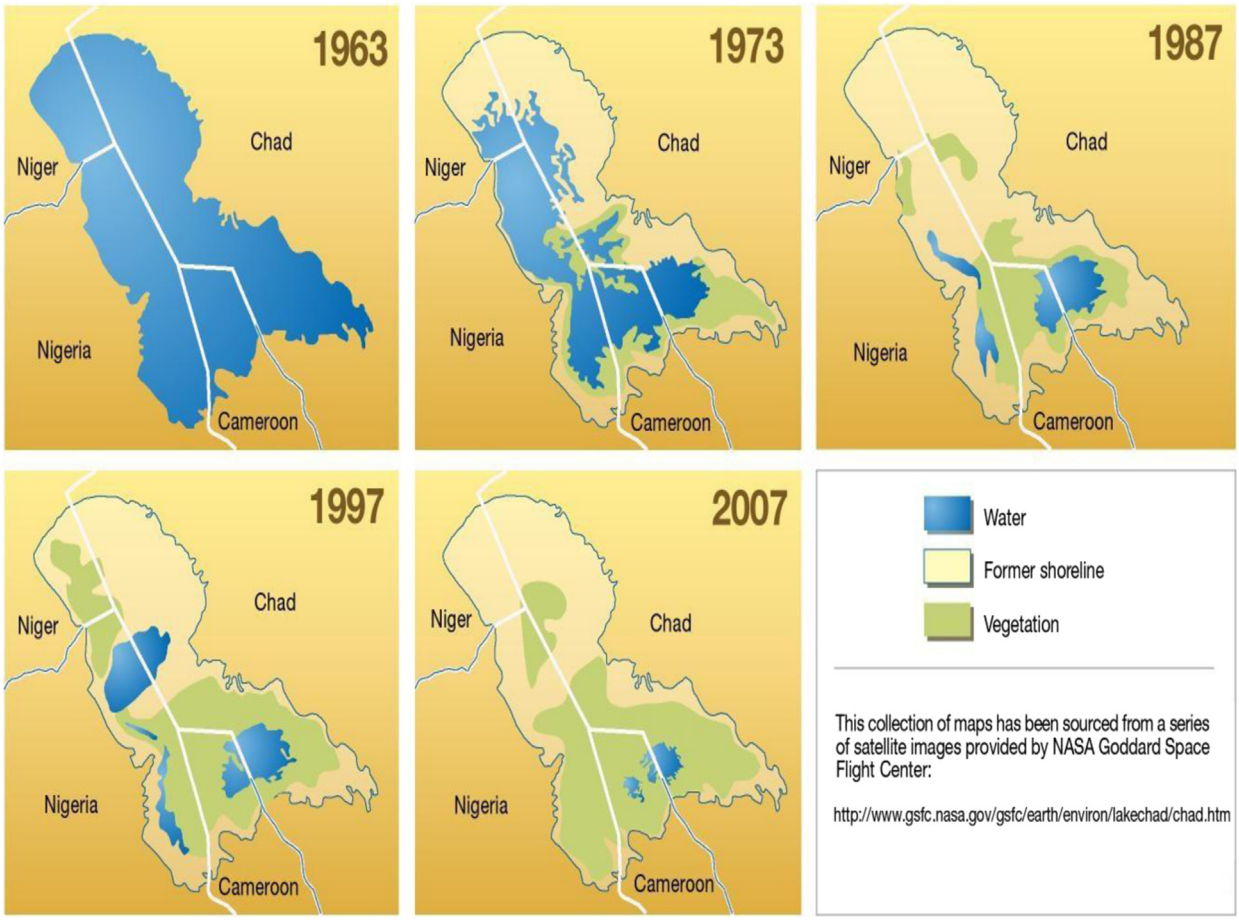

Fig. 3. Climate change and variability together with competition over water, and pollution, increasingly threaten the sustainability of Lake Chad's water resources. Source: UNEP, 2008

Table 1.
Examples of the role of water resources in achieving SDGs.(Source: UN DESA, 2015)

Sustainable Development Goal	Examples of roles of water in achieving the SDG and implications
Goal 1. End poverty in all its forms everywhere	• Target 1.4 advocates equal access to economic resources including ownership of assets such as land, natural resources – which includes water • Target 1.5 on building the resilience of the poor is achievable only under conditions of water security at national and household levels • Achieving Goal 6 on water and sanitation is a necessity for reducing poverty • Ending poverty is possible only with substantial equitable and sustainable economic growth, which is not possible without reliable and adequate supplies of water
Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	• Achieving Target 2.3, doubling agricultural productivity and the incomes of smallholders will be possible only if farmers have access to a secure supply of water among other factors, and are able to use the water productively. This applies to rained as well as irrigated agriculture. Annual freshwater withdrawals for agriculture including irrigation and water productivity have direct relevance to both sustainable water management and sustainable agriculture • Achieving Target 2.4 on sustainable, resilient and productive agro-ecosystems is achievable only with a reliable and secure water supply; a major impact of climate change is likely to be a decrease in water security, especially in the areas where the poorest people reside • Ending malnutrition in all its forms (Target 2.2) is achievable only if people have access to safe water and adequate sanitation (Goal 6) • The major threat to food security, especially of smallholders and rural people generally, is drought. Reliable and secure access to water is a necessary condition for achieving food security
Goal 3. Ensure healthy lives and promote well-being for all at all ages	• Targets 3.3 and 3.9 specifically mention reducing water-borne diseases and reducing diseases and deaths from water pollution • Achieving Goal 6 on Water and Sanitation (WASH) is a necessary condition for achieving Goal 3, promoting healthy lives and well-being of all people
Goal 4. Ensure inclusive and equitable quality education and promote life-long learning opportunities for all	• Provision of proper WASH facilities in all schools will lead to significant increases in the number of students, especially girls, who complete their education • Access to good water and sanitation combined with good nutrition enhances the performance of children in school and increases life-time labour productivity • In most of developing countries, access to water supply at reasonable distance reduces burden on girls house hold work load and leaving time for education
Goal 5. Achieve gender equality and empower all women and girls	• Goal 5.a, to "undertake reforms to give women equal rights to economic resources, as well as access to … ownership and control over land and other forms of property, … and natural resources …" should specify water as a critical natural resource over which women should have equal rights
Goal 6. Ensure availability and sustainable management of water and sanitation for all	• Needs no further discussion here
Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy for all	• Water supplies are critically important for energy generation; renewable energy, thermal and thermos nuclear plants are dependent on water; and significant amounts of energy are used in pumping and purifying water • Growing and processing bio-fuels requires significant amounts of water—expansion of bio-fuels accounts for most of the recent growth in the amount of water used in agriculture • The water-energy nexus is further discussed below in Section 6
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	• Target 8.4, "improve progressively through 2030 global resource efficiency in consumption and production, and endeavour to decouple economic growth from environmental degradation" by implication includes water use efficiency • Water security is a necessary condition for sustained economic growth. Water is a major driver for growth, and increasingly recognized by private firms as a major risk factor • Development, production and wide-spread use of innovative water technologies will create decent employment opportunities • Promoting sustainable tourism (Target 8.9) requires development and conservation of water resources
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	• Developing "quality, sustainable reliable and resilient infrastructure" (Target 9.1) will include significant investments in water infrastructure • Target 9.4 on upgrading infrastructure for sustainability and resource use efficiency necessarily includes water infrastructure (e.g. dams, irrigation schemes, water supply systems) (see also 9.a on African infrastructure)
Goal 10. Reduce inequality within and among countries	• Investment to improve access to and productive use of water for agriculture, energy, industry and other sectors is an important strategy to improve the growth rates of the poorest 40% of the population
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	• Ensuring access to safe, reliable and affordable water and sanitation services is a necessary condition to achieve the cities and human settlements goal • Target 11.5 on reducing the number of deaths and economic losses from natural disasters specifically mentions water-related disasters
Goal 12. Ensure sustainable consumption and production patterns	• Target 12.2, "by 2030 achieve sustainable management and efficient use of natural resources", clearly includes water • Reducing global food wastes (Target 12.3) will significantly reduce water losses • Target 12.4 on reducing release of harmful chemicals and wastes to minimize their impacts on people specifically mentions water • Target 12.5 implicitly includes water ("by 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse")

Table 1. (*continued*)

Sustainable Development Goal	Examples of roles of water in achieving the SDG and implications
Goal 13. Take urgent action to combat climate change and its impacts	• A major impact of climate change is on the hydrological cycle and therefore on the availability of water • A major adaptation strategy to improve resilience to the impacts of climate change, for example on agriculture, is through enhancing water security • Low carbon renewable energy such as wind and solar technologies will reduce demand for water and contribute to ameliorating climate change
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	• The targets for reducing marine pollution and protection of marine and coastal ecosystems largely require interventions that improve the quality of freshwater flows
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	• Target 15.1, "by 2020 ensure conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services" specifically mentions fresh water • A major cause of land degradation is poor water management; therefore improving water management a necessary condition for reversing land degradation and for reversing desertification • Target 15.8 on invasive alien species specifically mentions water ecosystems
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	• Scarcity of and competition for water, especially transboundary water resources and between upstream and downstream communities, are potential source of conflicts between nations and communities within a nation. Therefore, promoting institutional frameworks for benefit sharing of shared rivers, lakes and aquifers is a strategy to promote peaceful societies • Indicators are needed for institutional effectiveness, including justice, equity, voice and access
Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development	• This Goal and its targets are aimed at enhancing global cooperation and partnerships to achieve the sustainable development agenda. Water is clearly part of that agenda. • Since 40% of the world's population live in transboundary river or lake basins, international cooperation to promote development and shared management of water resources for equitable benefits should be an important target

emphasising the role water resources play in trade and the economy of the continent. Even when most of the countries in Africa are landlocked (UNDP, 2011), the goods are shipped to neighbouring coasts before they are delivered to those countries by road. In East Africa for example Mombasa port is the commonly used entry port for goods to Uganda and Rwanda. Increased investment in the transport sector and mutual cooperation of landlocked countries with their coastal counterparts will enhance the role of water resources in strengthening the African economy.

A summary of the roles of water in achieving sustainable development goals and implications are presented in Table 1.

4. Conclusion

Though non exhaustive, the review has clearly demonstrated the pivotal role of Africa's water resources to a realization of the Sustainable Development Goals. Water is an enabler, indeed a requirement, for achieving all the SDGs. Water resources have been noted to penetrate every interstice of life and to support all sectors of economic growth. However, the way of life in Africa does not reflect this kind of wealth in water resources majorly owing to degradation and underutilization of these resources. The global village has moved on from the Millennium Development Goals to the new and more promising Sustainable Development Goals. Through their roles in providing energy, running industries and feeding the masses, African water resources are a principal resource in ensuring socio-economic development as well as ecological integrity. However, this can only be realised with increased commitment of member countries to enhance the potential of water resources by increasing investment to the sector, drafting sustainable policies and collaborating with the surrounding communities in water resources management. Transboundary water resources that have hitherto been sources of conflicts can as a matter of urgency provide the best opportunities for mutual cooperation and advance socio-economic integration if African unity and development are not sacrificed at the altars of national sovereignty and pride. With strategic planning and cooperation amongst member countries, water resources on the continent can be a key precursor to achieving the Sustainable Development Goals.

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