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Climate change and integrated water resources management to prevent water disputes in Africa

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Abstract

The water resources in Africa is very sensitive to climate changes and climate variability. Over 95 percent of Africa's agriculture is rain-fed and rural populations depend on agriculture and other natural resources for their livelihoods, and their crops are sensitive to the small changes in temperature and rainfall regimes. Climate change is expected to alter not only the hydrological cycle, temperature balance, and the rainfall patterns across Africa but also has the potential to add to existing pressure on basin biodiversity, basin biological and water productivity. Africa has experienced at least one major drought each decade over the past 30 years. Climatologists have underlined the high year-to-year inconstancy of precipitation sums and the related dry season time frames and warmth waves. It is expected that worldwide there will be a 40 percent increase in demand for water by 2030. Major concerns for the water sector in Africa include the limited access to water, including groundwater, and limited governance capacity. Excessive pumping of shallow aquifers in Africa may bring about saltwater intrusion only as contamination of groundwater, lakes, and decrease in hydropower vitality as an immediate outcome to climatic changes and may prompts genuine water disputes. Water management is a pressing challenge, which, if not improved now, could see its problems greatly exacerbated in a future, warmer climate.

Keywords: Climate Change; Conflict Mitigation; Negotiation; Water Disputes; Water Productivity; Water Resources Management; Water–Stressed Basins

INTRODUCTION

Water is one of several current and future critical issues facing Africa. About 25% of the contemporary African population experiences water stress, while 69% live under conditions of relative water abundance. However, this relative abundance does not consider other factors such as the extent to which that water is potable and accessible, and the availability of sanitation. Despite considerable improvements in access in the 1990s, only about 62% of Africans had access to improved water supplies in the year 2000 (WHO/UNICEF, 2000). One-third of the people in Africa live in drought-prone areas and are vulnerable to the impacts of droughts (World Water Forum, 2000), which have contributed to migration, cultural separation, population dislocation and the collapse of ancient cultures. Climate change will progressively affect Africa because of numerous components. These effects are as of now being felt and will increment in extent if move isn't made to decrease worldwide carbon emanations. The effects incorporate the higher temperatures, dry season, changing precipitation patterns and expanded atmosphere inconstancy. Globally, climate change is required to prompt the strengthening of precipitation, as outrageous precipitation increments at a quicker rate with warming than all out precipitation does (CILSS, 2016). Recent work shows that across Africa worldwide

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models are relied upon to under-gauge the pace of progress of this precipitation intensification (Hijmans *et al*., 2005) and changes in precipitation limits might be considerably more far reaching than those anticipated by worldwide models.

Fig. 1. Major transboundary river basins representing surface water resources in Africa (Transboundary Freshwater Dispute Database, 2000)

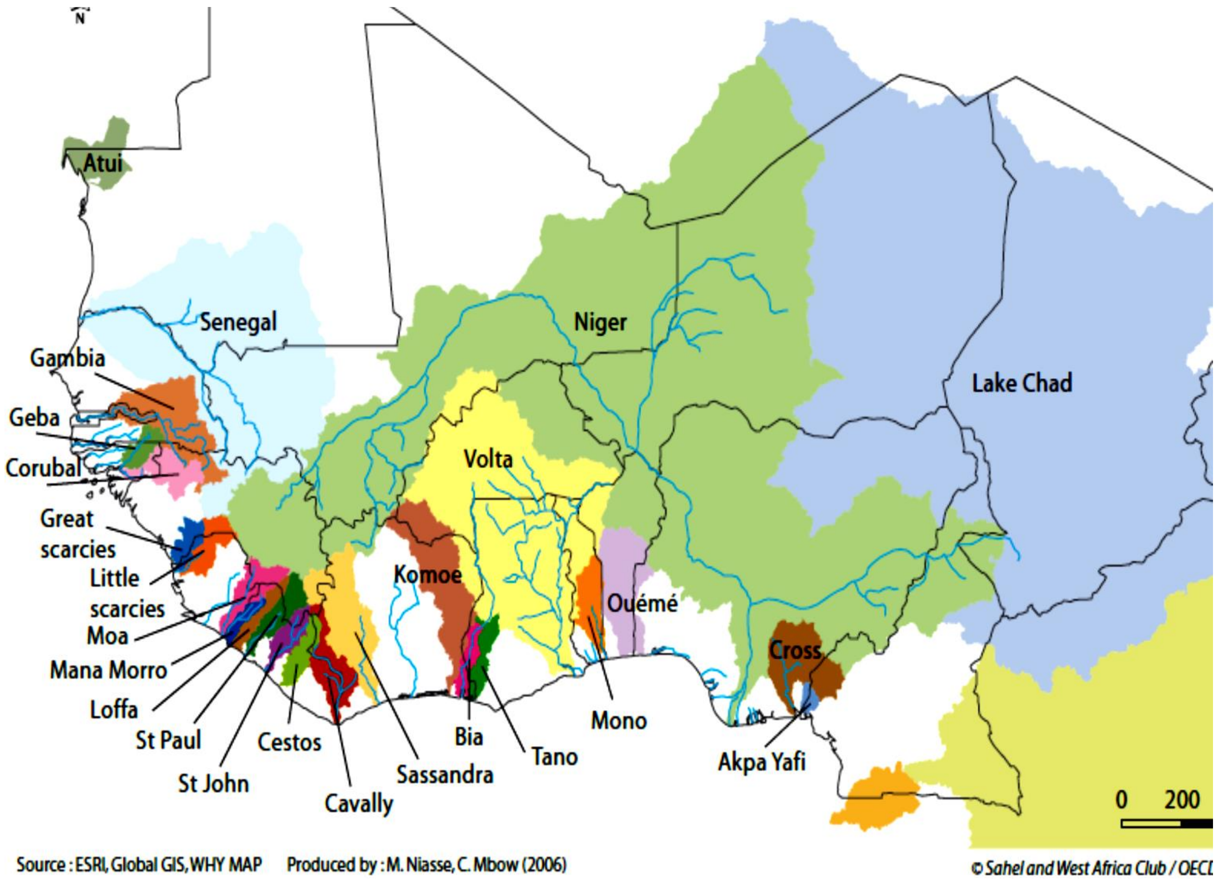

Fig. 2. Major river basin in West Africa (Transboundary Freshwater Dispute Database, 2000)

RESULTS AND DISCUSSION

Shared water resources in West Africa

In West Africa, 25 transboundary water resources are shared among 17 African nations (Figs. 1 and 2) of which 11 for Niger-Benue, 4 for Senegal, 6 for Volta and 4 for Comoe .Transboundary water resources because of expanded freshwater request and diminished accessibility because of compounding atmosphere conditions communicated as far as the adjustment in precipitation pattern in West Africa as appeared in Fig. 3 .The 17 nations in West Africa that share 25 transboundary basins (Fig. 2) have quite high water interdependency (Niasse, 2007). Eastern and southern African nations are likewise described by water pressure achieved by atmosphere fluctuation and more extensive administration issues (Ashton, 2002). Critical advancement has, notwithstanding, been recorded in certain locations of Africa to improve this circumstance, with urban populaces in the southern African area accomplishing improved water access over late years.

Shared water resources in East Africa (IGAD region)

In East Africa Nile Basin are shared among 9 African countries (Fig. 4) described by water pressure realized by climate change (Ahmed *et al*., 2017).

Problem definition

More than 70% of the population of Eastern Africa is rural and practices subsistence agriculture (WHO/UNICEF, 2000). Rapid population growth and increasing demand for food, combined with the high variability in rainfall and frequent droughts, are putting growing pressure on natural resources. Analyses of current economic and environmental trends reveal increasing competition over access and use of freshwater resources, while population growth, industrialisation and climate change are adding stress to these resources. There is also competition for access to water resources between countries, some of which depend on fresh water not only for domestic, agricultural, and industrial consumption but also for hydropower generation. Freshwater availability and access are thus priority issues for the entire region. The major river basins in Eastern Africa that are internationally shared include: Rufiji, Juba, Victoria/Upper Nile, Turkana and Shaballe (Fig. 4). Eastern Africa has experienced at least one major drought each decade over the past 30 years. There were serious droughts in 1973/74, 1984/85, 1987, 1992/94, and in 1999/2000. There is evidence of increasing climatic instability

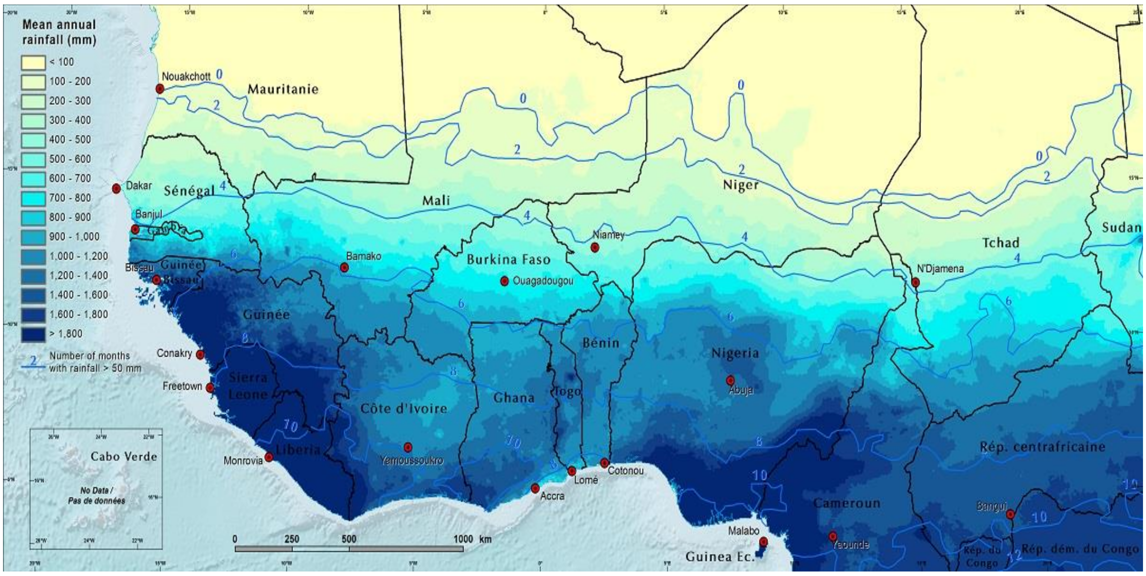

Fig. 3. Mean annual rainfall in West Africa, source: (Hijmans *et al*., 2005)

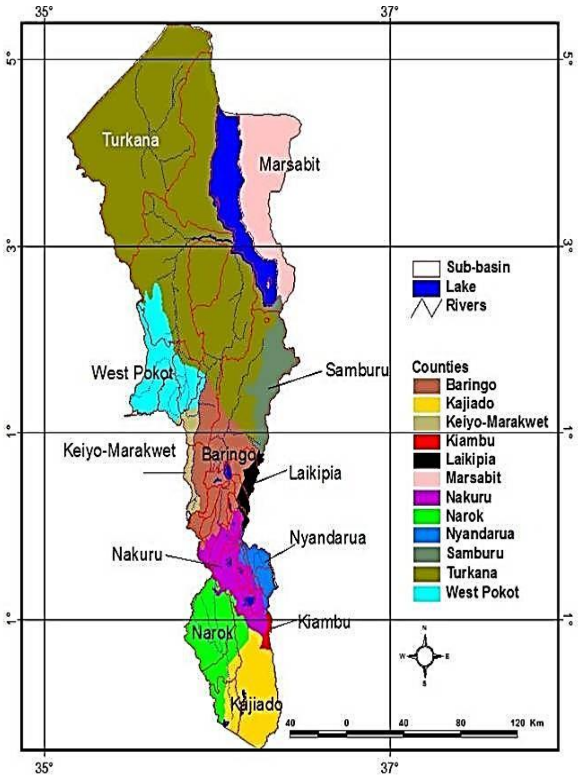

Fig. 4. Major river basins and lake drainage areas of Eastern Africa
Source: (Transboundary Freshwater Dispute Database, 2000)

in the region in terms of increasing frequency and intensity of drought (FAOSTAT, 2000). Eastern Africa is fairly well endowed with fresh water, with a total average renewable amount of 187 km^3/yr. Uganda has the largest share of this, with 39 km^3/yr (1,791 m^3/capita/yr) while Eritrea has the smallest, with 2.8 km^3/yr (data on per capita resources are not available; (UNDP *et al*., 2000).

Shared water resources in North Africa

North Africa is frequently viewed as an "climate change hotspot" (Diffenbaugh and Giorgi, 2012) that has been getting expanding consideration as of late, especially from characteristic and social researchers (Fig. 5). Climatologists, for example, have underlined the high year-to-year inconstancy of precipitation sums and the related dry season time frames and warmth waves (Cook *et al*., 2016; Lelieveld *et al*., 2016). A few specialists have contemplated the effect of climate change on the water circumstance and farming. For instance, Schmitz *et al*. (2013) venture expanded water shortage in North Africa, while Alboghdady and El-Hendawy (2016) show that a 1% expansion in temperature in the winter brings about a 1.12% reduction in horticultural creation in the Middle East and North Africa (MENA) region. Some social researchers have contended that water shortage in the MENA area is a "man-made issue" (Haddadin, 2001) and generally brought about by solid populace development. Others have focused on that not so much precipitation but rather more sporadic precipitation are significant drivers of water shortage which will most firmly influence the helpless populace in country areas, Scheffran *et al*. (2019) express that in areas relying upon groundwater took care of agribusiness, dry piezometers can expand the danger of common clash (Schilling and Krause, 2018) (Fig. 5).

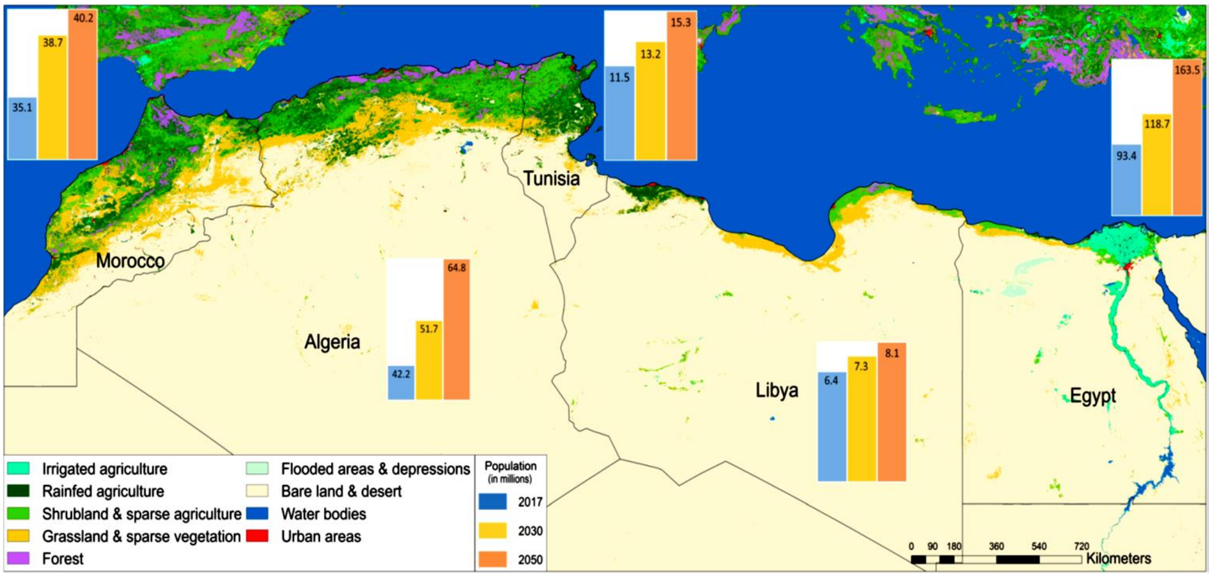

Fig. 5. Land use, topography, and population growth in North Africa (PRB, 2017)

Impact of climate change on water resources in North Africa

The Middle East and North Africa (MENA) region is particularly vulnerable to climate change because of its already scarce water resources, the high levels of aridity, and the long coastal stretch. It is expected that worldwide there will be a 40 percent increase in demand for water by 2030 (Catley-Carlson, 2011). All this has been compounded by a changing climate in which, globally, temperatures are going to rise and precipitation levels will fall (IPCC, 2007) (Fig. 6), leading to diminishing resources coupled with increasing demand. The MENA region is the most water-scarce in the world, with actual renewable water resources per capita of about 1,100 m³/year (World Bank, 2007), which is far below the water security threshold of 1,700 m³. Further, it uses more of its renewable water resources than other regions and more water than it receives each year (World Bank, 2007). For example, Ragab and Prudhomme (2000) estimated that Tunisia is using 83 percent of its available renewable resources, whereas Egypt is using 92 percent, Libya 644 percent, and Gaza 169 percent.The FAO (2012) estimated that all Gulf Cooperation Countries, with the exception of Oman, are using in excess of 100 percent of their available freshwater resources. The World Bank (2007) reported that the average national percentage of total renewable water resources withdrawn in the MENA region was nearly 338 percent for the period 1998–2002 (Fig. 6). By 2050 it is expected that the demand for fresh water in the MENA region will increase by 50 percent, coupled with a halving of the per capita water availability (UN ESCWA, 2006). Currently, nearly 75 percent of the water resources in the MENA region is allocated to agriculture, 22 percent to domestic use, and 3.5 percent to industries (FAO, 2012). Most MENA countries are using their precious water resources excessively .This situation is not going to improve for – as several studies indicate – the precipitation in the MENA region will decrease between 5% and 30 percent. Thus, recharge of groundwater and replenishment of surface waters in the region will decrease. The World Bank (2012) reported that 2010 was the warmest year since the 1800s, with 5 of the 19 countries setting national high-temperature records being Arab countries. Average global surface temperature is likely to rise between 0.6° to 4°C by 2100 (Barghouti *et al.*, 2013), leading to an increase in evaporation and evapotranspiration. The expected impacts of climate change on water resources may be summarized as follows:

- Decreased flows in most rivers due to reduced precipitation. The Nile may be a significant exception
- Deterioration of freshwater aquifers due to seawater intrusion resulting from sea-level rise
- Increase in the intensity of floods
- Reduction in snow cover in many mountainous areas
- Increases in the frequency and duration of droughts

Problem Definition

Average global surface temperature is likely to rise between 0.6° to 4°C by 2100 (Adams *et al.*, 2018; Buhaug, 2015; Mach *et al.*, 2019), leading to an increase in evaporation and evapotranspiration. These projected trends, according to Sensitivity measured by the water situation, based on three indices shown as Fig. 6 (Jemmali, 2018; PRB, 2017). when combined, would indicate increases in floods and droughts, which would negatively affect the populations and economies of the region.

Shared water resources in South Africa

Southern Africa is already experiencing critical water scarcity. Falkenmark *et al.* (1997) suggested five 'competition intervals' for water with categories defined in terms of the number of people who depend on a supply of 1 million cubic metres of water per year. She argues that countries having 10,000 cubic metres per person per year or more have limited water problems; general problems over water occur in states with 1670 - 10,000 cubic metres per person per year; 'chronic water scarcity' obtains in states with supplies of between 500 - 1000 cubic metres per person per year and 'beyond the water barrier' status occurs in states with less than 500 cubic metres per person per year. Other hydrologist (Shuval, 2000) proposed different figures to describe water scarcity levels. Shuval suggested that states with over 2000 cubic metres per person per year should be considered as water abundant while those with less than 500 cubic metres per person per year are water stressed. These figures though contested offer concrete basis for quantitative measurements of scarcity and help to indicate the water resource vulnerability of states. Falkenmark (1997) suggested that many countries in Southern Africa will be in this category by 2025 (Fig. 7). Using Falkenmarkís competition intervals to determine scarcity, the following picture emerges for Southern African countries by 2025. Malawi will be beyond the water barrier; Lesotho and South Africa will be facing absolute water scarcity while Mozambique, Tanzania and Zimbabwe will be experiencing water stress. Angola, Namibia, Botswana, Swaziland, and Zambia will be experiencing only quality and dry season water problems (Fig. 7). But national averages sometimes mask chronic water scarcity that is usually experienced at local levels, this suggests that even resource rich states could be facing water resource vulnerability. The statement is true of the economic development levels and water demand patterns in the Zambezi basin. The countries to the South of the basin are relatively more developed economically than those on the Northern basin. Also the Southern basin states face more water scarcity problems than those on the Northern basin. These factors are likely to make the process of regime negotiations more acrimonious and long. Basin or parts of some basins may be characterised by exceptional political strife thus providing a protracted conflict setting against which water issues are going to be discussed and negotiated.

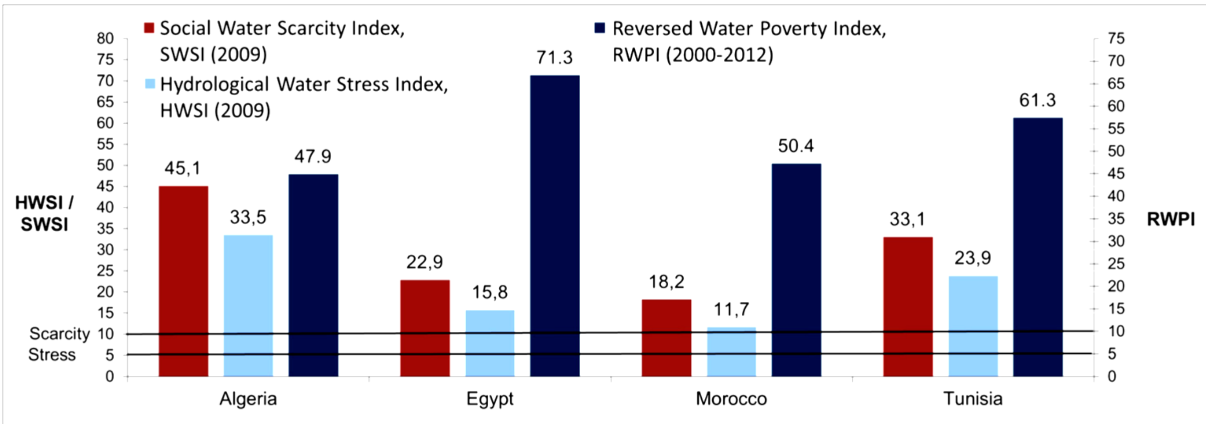

Fig. 6. Sensitivity measured by the water situation, based on three indices (Jemmali, 2018; PRB, 2017)

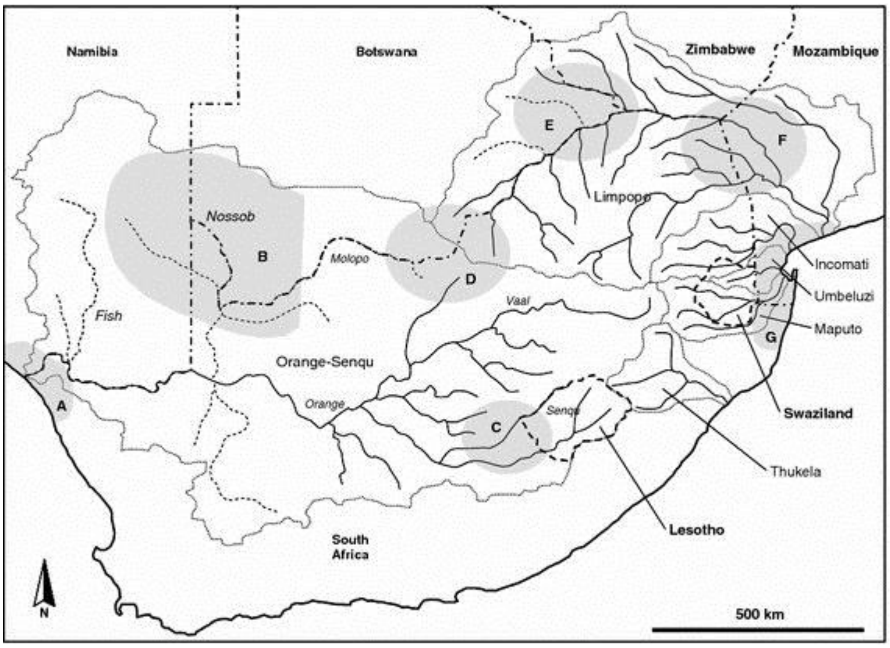

Fig. 7. River Basins of South Africa (https://www.businessinsider.co.za /2018)

CASE STUDIES ON AFRICAN WATER CONFLICTS

Egypt versus Ethiopia on Nile River

Problem definition:

Egypt is for the most part described as a semi-desert atmosphere, with blistering dry summers, moderate winters, and almost no precipitation. The Mediterranean coasts have more grounded breezes with a yearly normal breeze speed of about 6.0-6.5m/sec (Agrawala *et al*., 2004). The precipitation is nearly the equivalent in all destinations, with the exception of Port Said which had the most minimal pace of yearly precipitation, while Beheira had the most noteworthy pace of rate precipitation in contrast with the remainder of the locales. During the dry season the precipitation is practically immaterial in all sites.Egypt depends on the Nile for 90% of its water. It has verifiably attested that having a steady progression of the Nile waters involves endurance in a nation where water is scant (Fig. 1). A 1929 settlement (and a resulting one of every 1959) gave Egypt and Sudan being the up-stream areas, rights to almost the entirety of the Nile waters. The frontier period record additionally gave Egypt veto controls over any activities by upstream nations that would influence a lot of the waters. Ethiopia has overlooked the privileges of upstream nations in sharing and supporting any specialized issues identified with the ensuing development of pressure driven structures on the Nile River and started the development of super dam which started in 2011 on the Blue Nile tributary in the northern Ethiopia good countries, from where 85% of the Nile's waters stream (Figs 1, 8 and 9). However, the uber dam has caused a column among Egypt and Ethiopia, with Sudan trapped in the middle of, which some dread could prompt war. One of Egypt's principle concerns is that if the water stream drops it could influence Lake Nasser, the repository further downriver, behind Egypt's Aswan Dam, even though it just records for a little portion of Egypt's electricity. Egypt likewise fears that the dam could confine its effectively scant flexibly of the Nile waters, which is nearly the main water hotspot for its citizens. It could likewise influence transport on the Nile in Egypt if the water level is excessively low and influence the work of ranchers who rely upon the water for irrigation. On the other hand, the $4bn dam from the Ethiopian perspective, is at the core of Ethiopia's assembling and modern dreams. At the point when finished it is required to have the option to produce an enormous 6,000 megawatts of power. As indicated by the Ethiopian purpose of view, the vitality produced will be sufficient to have its residents associated and offer the overflow capacity to neighbouring countries. However, this issue doesn't appear to be valid according to 6000 MW of power for nation whose populace circumvents 70 million is certifiably not a serious deal. Ethiopia likewise considers that to be as an issue of national sovereignty. However in International settlement that control transboundary water resources nothing is referred to as national power according to upstream nations reserve the option to arrange the different impact of pressure driven structure that may decrease their water share .There have been fears that the nations could be brought into a contention should the debate not be settled. Accordingly, Egypt and Ethiopia could be brought into a conflict over the dam.

Fig. 8. Location map of Grand Ethiopian Renaissance Dam

Fig. 9. Grand Ethiopian Renaissance Dam during construction

The fundamental issue isn't lying in the development of the super dam on blue Nile yet in the proposed chance to fill the reservoir, the longer it takes to fill the supply, which will be greater than Greater London with an all-out limit of 74 billion cubic meters, the less effect there will be fair and square of the river. Accordingly, Egypt has proposed a more drawn out period - so the degree of the waterway doesn't drastically drop, particularly in the underlying period of filling the reservoir. Three-path talks between Egypt, Sudan and Ethiopia over working the dam and filling its store have gained no ground in progressively four years - up to the date of writing up this article which the US has now been attempting to intervene.

Water conflicts between Angola, Namibia, and Botswana (Okavango River Basin)

The States Parties of Angola, Botswana and Namibia share the transboundaey Okavango River Basin (Fig. 10). This shared river system that transcends boundaries has brought the three States Parties together for its protection. The Cubango-Okavango River Basin is internationally important for its hydrology, biodiversity and biological productivity", The Okavango Delta depends on the water fed by the Cubango and Cuito Rivers that originate from the Angolan highlands, passing through Namibia on its way to the Delta in Botswana. The local inhabitants call the source waters in Angola as *Fonte da Vida*, the Source of Life. Cubango-Okavango River basin is among the world's last undisturbed river systems, but faces threats due to development pressure. The Delta is home to indigenous peoples and some of the world's most endangered species of large mammal, such as the cheetah, white rhinoceros, black rhinoceros, African wild dog and lion. The entire south western part of the Okavango Delta is as dry river (Fig. 10). The Permanent Okavango River Basin Water Commission (OKACOM) was established in 1994 (Kgathi *et al*., 2006). OKACOM is basic to the future accomplishment of the participation between states as it gives a genuine organization to help guarantee the best possible administration of the water framework for protecting the river basin.

Issue definition:

Climate change is today being recast as a security threat, rather than being only an environmental issue. Historical records (Kgathi *et al*., 2006). show that in 1820 Kwebe, the first capital of Batswana, located on the foothill of Kwebe Hills and peripheries of Lake Ngami, (Fig. 11) dried up forcing the then Kgosi Moremi to move to Namanyana, which is the current day capital. The annual flood from the Okavango's catchment was at its lowest levels in 2019 so the Okavango Delta, is experiencing one of the driest periods in its history. Accordingly, it is urgently needed to change and adapt our ways to take cognisance to and adapt to this new norm.

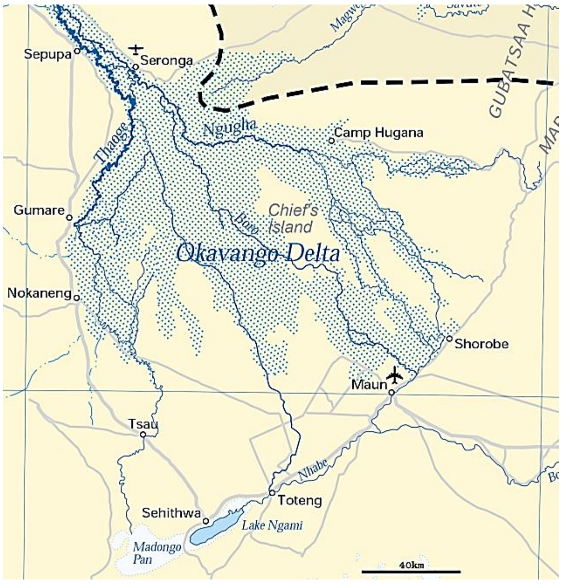

Fig. 10. The delta of Okavango River Basin

Fig. 11. An image of Okavango River Basin

CONCLUSIONS

Climate change has repeatedly been called a major threat to Africa. Indeed, Africa has time and again been considered the continent that will be affected most negatively by climate change owing to the combination of severe climate-related impacts, economies that are highly climate-dependent, and countries that have the least capacity to adapt. The results reveal that temperature can affect agricultural yields through increases in both crop and surface water evapo-transpiration, resulting in heightened water stress in the absence of irrigation. Over 95 per cent of Africa's agriculture is rain-fed, rural populations depend on agriculture and other natural resources for their livelihoods, and their crops are sensitive to small changes in temperature and rainfall regimes. Africa without appropriate administration of these shared water resources, water-disputes will keep on happening. This is mainly because climate change was noted as being a global phenomenon that required all countries to seek mitigation measures at all levels. The current unbalanced global trade relationships between the North and the South are seen to contribute to the negative ecological effects of climate change. Many international agreements and treaties have been ratified, particularly on the sharing of trans-boundary water resources. Such binding commitments will need to be reviewed in the light of climate change and apparent regional imbalances. For Africa, addressing the challenges of climate change and climate variability would be a major step towards addressing existing security threats and their concomitant challenges.

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