4 Climate change and access to water resources in the Lake Victoria basin

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INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) has, as indicated elsewhere in this publication, concluded that climate change and variability have the potential to impact negatively on water availability, and access to and demand for water in most countries, but particularly in Africa.[1] Climate change is expected to alter and hence bring changes to the hydrological cycle, temperature balance and rainfall pattern. This has wide-ranging implications since water is one of the most important of all natural resources for socioeconomic, cultural, political and environmental development. It is a commonly used resource and hence a fundamental economic asset for sustainable development. Water is required in an adequate and sustainable supply for domestic, farming (livestock and agriculture) and industrial use, and other environmental functions on all spatial and temporal scales. It is estimated that globally 70 per cent of water withdrawn is used for irrigated agriculture, 20 per cent for industry and the remaining 10 per cent for other uses including domestic use.[2]

Although water is a renewable resource through the hydrological cycle, it is likely to be significantly affected by climate change and variability primarily

because the main source of water is rainfall – a component of climate. Rainfall change and variability in the arid and semi-arid zones, such as in the Lake Victoria Basin (LVB), will result in the uneven distribution of water resources over time and space, and this may have a significant negative impact on access to and utilisation of water resources.[3] Consequently, climate change and variability are expected to increase the vulnerability of socioeconomic activities through hydrological extremes such as prolonged droughts and extensive floods. It is in this context that this chapter examines the effects of rainfall changes and variations in access to and utilisation of water resources and the resulting conflicts regarding their use in the LVB, with particular focus on the Mara River Sub-basin (MRSB), a sub-basin in the LVB. The chapter begins by describing the state of the LVB, which is followed by an examination of the emerging evidence of rainfall changes and variations in East Africa, and then a consideration of the impact of rainfall changes and variations on the availability of water for different uses. It then proceeds with an assessment of the effects of water scarcity on economic development, followed by a consideration of the likely water-use conflicts, their causes and effects. Finally, there are concluding remarks and recommendations to enhance adaptation to and mitigation of the impacts of climate change and variation.

LAKE VICTORIA BASIN: AN OVERVIEW

Geographically, the LVB includes Tanzania, Uganda, Kenya, Burundi and Rwanda. The latter two countries are part of the LVB catchment area as a number of tributaries originate in these countries.[4] The LVB occupies an area of about 240 000 square kilometres of which about 69 000 square kilometres are the lake itself. The largest part of the LVB lies in Tanzania (44 per cent), followed by Kenya (21,5 per cent), Uganda (15,9 per cent), Rwanda (11,4 per cent) and Burundi (7,2 per cent).[5] Lake Victoria, which is the main water source in the region, is the largest freshwater body in Africa and second in the world after Lake Superior in North America.[6] Water from Lake Victoria is a transboundary resource shared between Kenya, Tanzania and Uganda. The inflows to the lake from major and small tributaries contribute about 13 per cent of the water entering the lake annually, while the remaining 87 per cent comes from rainfall.[7] The White Nile is the only outflow from the lake at Jinja in Uganda.[8]

Most parts of the LVB can be characterised as semi-arid with the exception of some areas close to the lake which have a relatively high rainfall of between 1 200–1 500 millimetres per annum.[9] The LVB is estimated to host a human population of about 30 million. These people engage in several activities in support of their livelihood, including agriculture, fishing, quarrying and mining, hydroelectric power generation and trade.[10] Agriculture, however, is the dominant economic activity in the LVB, supporting over 80 per cent of the population, of which 60 per cent practise rain-dependent agriculture, which generates in the range of 30–40 per cent of basin states' gross domestic product (GDP).[11] Lake Victoria also supports freshwater fishing with estimated annual fish yields of about 500 000 tonnes, which contributes significantly to both local consumption and export earnings in the region.[12]

Although the LVB is known to have a diversity of both terrestrial and aquatic life, it has undergone enormous environmental changes in the last 40 years.[13] Climate change – particularly the decrease of rainfall – and land degradation together with rapid human population increase have been repeatedly recognised as among the major contributors of rapidly evolving changes in the LVB that seriously threaten its ecosystem functions, overall biodiversity and the livelihoods of the basin's population.[14] Water levels in the lake are said to have been decreasing over time, with climate change, land degradation and the overutilisation of water from the lake for hydroelectric generation being cited as the main causes.[15] Overutilisation of water for hydroelectric power generation and other socioeconomic activities are likely to cause tension between the countries sharing the lake, and this may result in water-use conflicts.

The main river of the Mara River Sub-basin (MRSB), a sub-basin within the LVB, the Mara River, originates in south-west Kenya on the steep slopes of the Mau escarpment at an elevation of approximately 3 000 metres above sea level.[16] It then flows for a distance of about 350 kilometres into Tanzania to Lake Victoria, situated 1 100 metres above sea level.[17] The entire basin covers an area of 13 750 square kilometres of which 4 812,5 square kilometres (35 per cent) lies in Tanzania and the remaining 8 937,5 square kilometres (65 per cent) in Kenya. The Mara River is the main water source in the upper and middle parts of the MRSB, while both the Mara River and Lake Victoria serve as main water sources in the lower part. The main water uses in the MRSB include domestic, livestock farming, wildlife maintenance and irrigation for agriculture. Large-scale irrigation is practised on the Kenyan side, in the upper part of this basin.

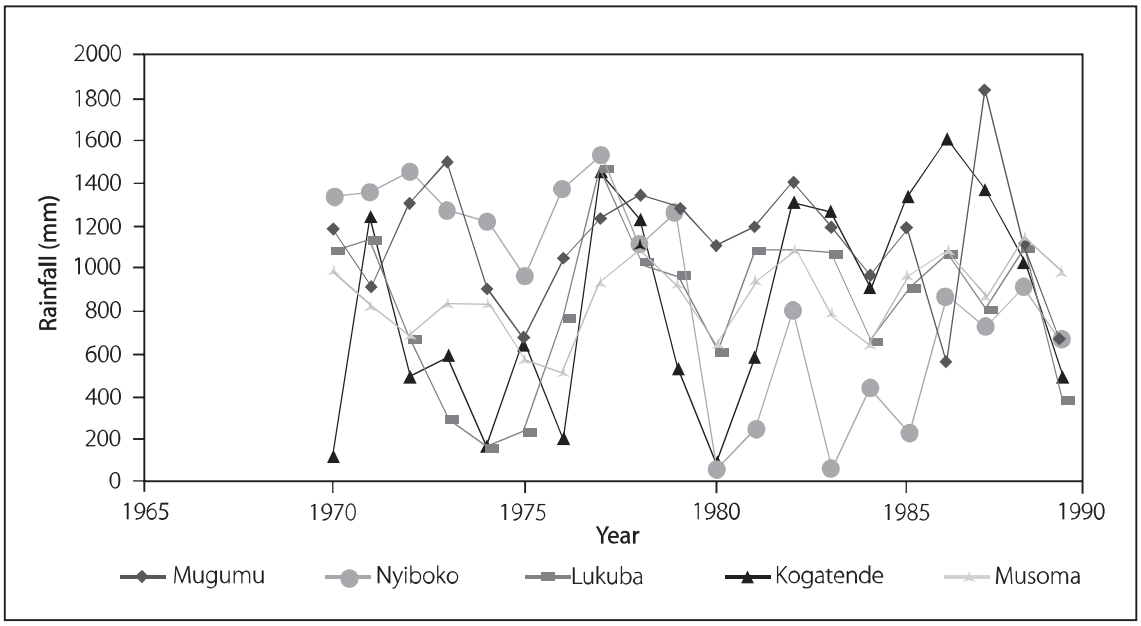
CLIMATE CHANGE INDICATORS

The climate of East Africa has changed dramatically in the last century or so, as it has throughout the world. Kiage and Liu used information from paleo-environmental records of the past 50 000 years, based on the level of Lake Victoria and ice-core records among other indicators, to show that there have been major climate and vegetation changes in East Africa, with warmer and cooler periods, and wetter and drier conditions.[18] However, Mote and Kasser and Gasse investigated ice cores from Kilimanjaro and concluded that the diminished snows and glaciers of the mountain are not due to climate change, but to rainfall changes and variability – mainly decreased rainfall on the mountain.[19] They relate the decrease in rainfall to deforestation around the mountain. Thus, although Mote and Kasser and Gasse blame human activities for being the main cause of deforestation, they fail to give explicit reasons for these activities, which may well be associated with the impacts of climate change. For example, local communities may clear forests in search of water for livestock because of the decrease of water flows downstream. Similarly, the incidences of forest fires tend to increase during the prolonged droughts (dry seasons). In turn, deforestation may expose the land and make an area vulnerable to the negative effects of climate change.

In the LVB, water scarcity and its negative impact on socioeconomic development are attributed to the changes and variations in rainfall, which is the main source of both surface and subsurface water in the region. The IPCC and Hulmes, Doherty, Ngara et al have shown that Africa has experienced an increase in temperature of 0,05°C per decade in the 20th century.[20] On the other hand it is predicted that East Africa's temperature will increase by between 0,2°C per decade (low scenario) and more than 0,5°C per decade (high scenario) in the 21st century. According to the IPCC, the warmer temperatures in East Africa may lead to a five to 20 per cent increase in rainfall for December to February (wet months), and a five to ten per cent decrease in rainfall from June to August (dry months). Rainfall changes and variations are not expected to be constant, but rather more sporadic and unpredictable, resulting in periods of prolonged droughts and periods of high rainfall leading to floods.

East Africa has undergone periods of both prolonged drought and of high rainfall – rainfall changes and variations. In the last 20 years, for example, East Africa has experienced prolonged droughts in 1983/84, 1991/92, 1995/96,

Figure 1 Annual rainfall variations at five rain gauge stations in the MRSB (1970–1989)



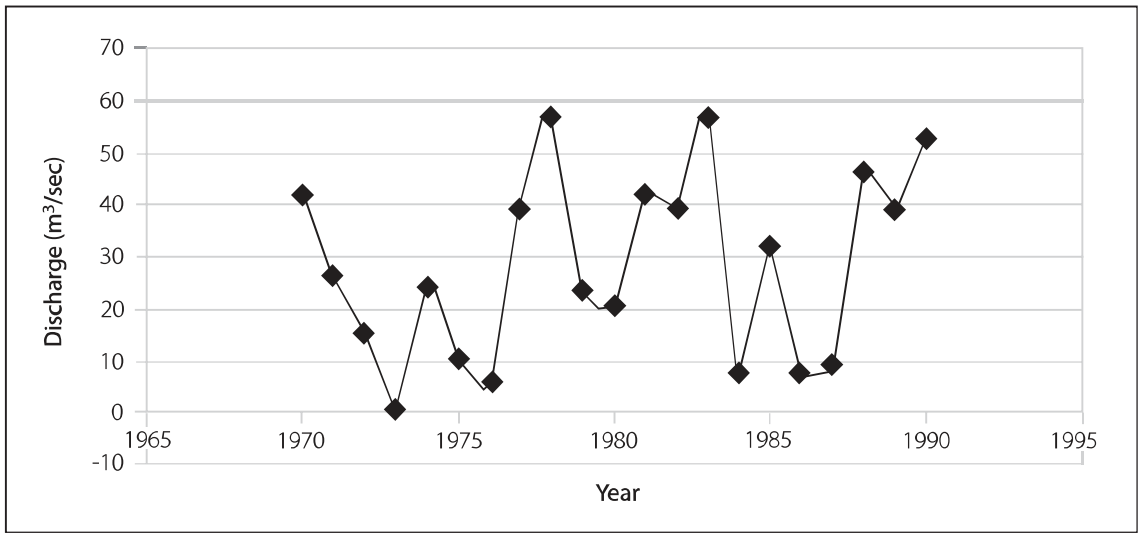
Source Author's own compilation

2004/2005 and the La Niña-related drought of 1999/2001, all of which led to famine in the region.[21] Similarly, the El Niño-related floods of 1997/98 were considered to be evidence of the impact of climate change.[22]

Furthermore, the analysis of total annual rainfall for 21 meteorological stations in selected regions of Tanzania reveal that there is a trend towards decreasing rainfall for more than 13 stations, and a trend towards increasing rainfall for only seven, while one station has recorded a constant pattern.[23] Moreover, it was noted that at most of the stations variability in rainfall cycles was common. Similarly, an analysis of information and data published by the Sokoine University of Agriculture (SUA) shows rainfall variability both over time and space in Tanzania. According to SUA's analysis, the Lake Victoria zone as represented by Bukoba and southern zone represented by Mbeya show a positive trend for both long and short rainy seasons, while the central region represented by Dodoma and the northern region represented by Arusha show a negative trend.[24] The data reveals that areas close to Lake Victoria, such as Bukoba, receive relatively high rainfall compared with areas far away from the lake.

In the MRSB, available data from five rain-gauge stations in Tanzania indicate significant changes and variation in rainfall between 1970 and 1989 as indicated in Figure 1.[25]

Figure 2 Average annual discharge at MRSB (1970–1990)



Source Author's own compilation

Rainfall variations are well correlated with the average annual water discharge in the Mara River, the main river in the MRSB, in the same period (1970–1990). This ranges from 0 to 57 cubic metres per second with the mean annual discharge of 28,4 cubic metres per second as indicated in Figure 2.[26]

Anthony as comment 1 above Traditional environmental management systems related to changes and variations of water resources in semi-arid Tanzania.

Since the main water catchment area for the Mara River is in the Mau forest complex in Kenya, making the MRSB a transboundary entity, the same rainfall trends may have been evident for the whole MRSB. However, other factors such as modified land use and land cover may have contributed to the changes of the river's flow.[27] These variations in the flow of the Mara River significantly affect water availability and hence determine access to and utilisation systems, which, if not properly coordinated, may result in water-use conflicts.

BIODIVERSITY DEGRADATION AND CLIMATE CHANGE

One of the factors influencing rainfall distribution in arid and semi-arid climates is the type of land use and land cover. Change in land use and land cover, particularly the decrease of forests, may alter rainfall run-off and run-off infiltration processes. In East Africa, forested land is said to have decreased extensively in the last three decades or so, at the rate of between one to four per cent, with a two per cent reduction in forests in Kenya, one per cent in Tanzania and four per cent in

Uganda.[28] The main reasons for deforestation include clearing forests and woodlands for agriculture and settlement, mining, wild fires, charcoal production and the overexploitation of wood resources for commercial purposes. All these activities contribute to the increase of carbon dioxide (CO_2) in the atmosphere as the carbon sinks are progressively reduced.

In the MRSB, comparisons of land use and cover between the 1960s and 1996 using land-use/cover maps indicate the major changes to forests and wetlands. Analyses of these maps, for example, indicate the decrease of wetlands on the Tanzanian side of the MRSB by 13 per cent within three decades (1966–1996).[29] The decrease in wetland areas is mainly associated with the decrease in the rainfall. This has resulted either in the dramatic decrease or drying up of water in the swampy areas because of the decline and variability of river flows that feed wetlands. Similarly, an analysis of land-use and land-cover maps on the Kenyan side of the MRSB reveals a 2,3 per cent reduction in forests, while about 30 per cent of the basin was opened up for agriculture between 1986 and 2000.[30] The findings for the Kenyan side of the MRSB, however, show that wetlands have increased by 7,5 per cent in the same period as opposed to the decrease on the Tanzanian side of the MRSB. This difference in the status of the wetlands in Kenya and Tanzania in the MRSB may be due to increased large-scale irrigation on the Kenyan side, hence more water retention in the agricultural land. It may, in fact, reflect a misleading interpretation of LANDSAT images in which water retention in the agricultural land is interpreted as wetlands development.

The decrease or removal of vegetation from the Earth's surface tends to increase surface run-off and consequently reduces the infiltration capacity of the water, although this may depend on other factors such as the nature of the landscape. Furthermore, the increase of surface run-off may increase soil erosion and hence the amount of eroded material that is transported and deposited in the rivers and streams. This, in turn, results in the decrease of the water storage capacity of the rivers and streams, and consequently natural water sources may become seasonal, flowing only during the rainy season. As Ndiiri and Mutie et al observed, in the MRSB the changes in the seasonal variability of the Mara River's flow is thought to have been exacerbated by land use and land cover change over time and the consequent reduction in rainfall in the catchment areas.[31] Jacob, on the other hand, reports that the decrease of Mara River flows is a result of changes to most tributaries from being permanent to becoming seasonal water sources.[32] The decrease of forest cover therefore is expected to

affect water resources availability negatively – mainly through reduced storage – and hence result in water scarcity in the region.

IMPACT OF CLIMATE CHANGE ON SOCIOECONOMIC ACTIVITIES

Rainfall changes and variations significantly affect the availability of water for socioeconomic activities including water for domestic use, crop and livestock production, and hydroelectric power generation, particularly in arid and semi-arid areas in developing countries. Decreased rainfall, for example, is likely to reduce the water available for crops and livestock, the key economic activities of most rural populations in developing countries where rain-fed agriculture is dominant. Globally, however, the potential for food production is projected to increase with increases in local average temperatures ranging from one to three degrees centigrade. Above this temperature range, however, food production is projected to decrease. At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease even with small local temperature increases (1 to 2°C), which will increase the risk of hunger.[33]

In the LVB, where more than 60 per cent of the population depends on rain-fed agriculture for its livelihood, a dramatic decline in the rainfall in the region will have a significant effect on food security. The projected decline in rainfall of between 50 to 150 millimetres per season, and variations and deviations of the rainfall from the normal are expected to reduce food production in the region.[34] The reduction in rainfall may compel people to encroach on marginal lands such as water catchment areas, wetlands and mountain ecosystems for cultivation and the grazing of livestock. In the MRSB in Tanzania, as noted above, 13 per cent of the wetlands, for example the Kubigena wetlands were converted into agricultural land in the past three decades.[35] In the MRSB in Kenya, on the other hand, about 30 per cent of the basin, of which 2,3 per cent is forest land, was opened up for agriculture less than two decades ago.[36] Recently, a similar occurrence has been observed in the Usangu wetlands in southern Tanzania where crop cultivators and livestock keepers encroached on the wetlands owing to the persistent drought in most parts of the country between 1999 and 2001.[37]

According to Parry et al, regional predictions suggest that ten per cent of grain production in East Africa may be lost by 2080 because of climatic changes and variations manifested in the increase of temperature and decline

of rainfall.[38] However, the impact of climatic change on crop production varies considerably between regions and countries, and between types of agricultural production. With regard to Tanzania, for example, Mwandosya, Nyenzi and Luhanga argue that climate change and variations will have more impact on maize production than root crops.[39] The impact of climate change on food production is also likely to be more pronounced in the central part of the country than in other zones in Tanzania. However, it must also be borne in mind that forecasters do not always predict the changes and variations of rainfall over time and space absolutely correctly. Similar observations have been made by Ingram, Roncoli and Kirshen, namely that climate change and the failure to forecast the changes and variability correctly have negatively affected agricultural production in Burkina Faso.[40]

However, the relationship between rainfall changes and variability, on the one hand, and socioeconomic activities on the other is even more complex and interwoven. As noted above, some economic activities such as crop and livestock husbandry, charcoal making and mining contribute to the changes in land use and land cover, especially the decline in forest cover. Deforestation affects the occurrence of rainfall as it interferes with the hydrological cycle and consequently increases carbon dioxide in the atmosphere as carbon sinks are progressively reduced. Crop production may involve the clearing of forests to obtain new land for cultivation in response to greater demand for food owing to the increase in the human population and decrease in food production because of reduced rainfall. On the other hand, traditionally livestock has been grazed on the open grassland and bush country; hence livestock keepers tend to clear forests to extend their pastures. Furthermore, forests may be cleared as a strategy to eradicate tsetse flies, which threaten livestock. This cleared land is eventually used for settlements, crop cultivation or as pasture.

The relationship between economic activities, such as crop and livestock husbandry and charcoal production and water resources changes and variations in the MRSB therefore relates to the ways these activities alter natural vegetation cover, run-off and infiltration, and reduce the capacity of water sources to hold water after the rainy season. As a result, water scarcity is likely to occur particularly during the dry season owing to, among other factors, siltation that reduces the depth of water sources and hence reduces their storage capacity. Deforestation therefore increases the likelihood of both hydrological and agricultural drought, which results in water scarcity and food insecurity for areas

which depend mostly on rain for their agriculture. 'Agricultural drought' refers to the condition in which the water in the soil (soil moisture) is insufficient for crop growing. 'Hydrological drought' refers to the condition where rainfall, as the main source of water, is extremely low, to the extent that there is not enough water to meet the different demands for it.

Water resources are highly sensitive to climate change and variations. Thus the changes in the global climate as a result of increased greenhouse gases such as carbon dioxide, nitrous compounds and methane are expected to affect the availability of water in most parts of the world, Africa in particular. The IPCC indicates that the vulnerability of water resources to climate change is a result of overdependence on rainfall as the main source of water.[41] A reduction in water supply to meet different socioeconomic, political and environmental needs is likely to result in resource-use conflicts among and between different users and uses of water resources.

Climate change and conflicts over water access and use

Climate change and variation are expected to reduce water supply for different uses. As water becomes scarce, competition in accessing and using water sources will intensify. As a result, conflicts (here referred to as a dispute about social, economic, political and territorial-related issues) are more likely to occur as a struggle to utilise this scarce resource increases. Water-use conflicts occur when one water source is used for more than one use by different users and the uses are not complementary. Conflicts over water access and use may also arise from the uneven distribution of available water between uses and users.[42] As such, we can identify several levels and types of water-use conflict.

Conflicts at the household level

At the family level, water-use conflicts relate to the gender division of labour where men and women and youths and adults have different roles. For instance, in the MRSB, men are responsible for taking care of livestock and farming, while women are responsible for household chores and farming. Here the men wanting to utilise some water sources for livestock may be opposed to the women's uses, hence creating water-use conflicts. Furthermore, because of a water shortage, some family activities that require water may not be performed. Depending on which group wields the greater power – men, women, the youth or adults, girls or

boys – conflict is more likely to occur between these groups in the use of the available water for gender-specific activities. For instance, because of water scarcity, women walk up to ten kilometres and back to collect water daily. Collected water is used for domestic chores such as cooking, washing utensils and babies. In some instances, men may request some water for a shower, but when the women refuse to part with their water, given the long distance they walk to collect it, conflict may arise between spouses, particularly because the patriarchal system gives men the right of decision making in the family.

Conflicts at village level

During the rainy season, when water is plentiful, members of one village can access water sources at another nearby village. However, as water becomes scarce owing to prolonged drought, villages may prohibit members from another village from using water sources located within their jurisdiction. This kind of restriction on water access and use has sometimes resulted in inter-village fighting, especially where members of the two villages are from different ethnic groups. Water-access and use conflict at this level involves mainly livestock keepers who take their livestock for water at a nearby village. In some instances, livestock owners migrate with their livestock to areas with permanent water sources where they put more pressure on the resource. Conflicts arise when the local community feels that the immigrants are impinging on their resources.

Conflict between local people and government institutions

As noted, the impact of climate change may result in people encroaching on marginal lands and protected areas in search for water and pasture. Access to protected areas such as game reserves and national parks and their natural resources is prohibited. However, owing to the scarcity of resources, especially water resources, local people do encroach on protected areas for crop production and livestock keeping. This creates not only conflict between the institutions that manage these protected areas and the encroachers, but also human-wildlife conflicts. In 2004, for example, more than 800 families were forcibly evicted from the buffer zone of the Serengeti National Park. These families were alleged to have invaded the area in search of pasture and water because of the persistent drought in their villages. Most parts of the Serengeti National Park lie within the MRSB. A similar example is the eviction of livestock keepers and crop cultivators from the Usangu Game Reserve in southern Tanzania.[43] Livestock keepers in the Usangu sub-basin were in-migrants from different parts of

Tanzania that had been affected by water scarcity owing to prolonged drought. In Kenya, there are water-use conflicts between local people living near the Yala swamp and the regional government authorities that granted a 25-year lease for rice cultivation to Dominion Farms Ltd. The company is accused of blocking the access of over 200 fishermen to the swamp for fishing.[44]

Conflict between livelihood systems

Water-access and use conflict may be caused by competition between groups of people practising different economic activities, such as livestock keepers and crop cultivators. In some places, livestock keepers tend to encroach and use land and water meant for crop production. Similarly, crop cultivators may utilise pastoral land, hence reducing the pasture for the livestock. Water-access and use conflicts at this level are more pronounced during the dry season when water is very scarce than during the wet season. This type of water-use conflict is also manifested between upstream and downstream users of water regardless of whether they practise the same or different economic activities. Users of the Mara River in Tanzania blame the users in Kenya for withdrawing great quantities of water for large irrigation schemes, thus leaving insufficient water to flow downstream. Downstream users of the Mara River also blame upstream users for polluting the water in the river, claiming that the brown water in the river is a result of cultivation along the river banks. This, however, as Waititu noted, is caused by the loss of forest in the Mau complex, the main source of water for the Mara River.[45] Since the Mara River is a transboundary water source, water-use conflicts between downstream and upstream water users on the Mara River, although they effect individuals, can be viewed as an interstate (Tanzania and Kenya) conflict.

Interstate conflict

As water becomes scarce owing to prolonged drought, increased temperature and the decrease of rainfall, competition for this vital resource will intensify. Competition for shared transboundary water resources between nations may occur and lead to conflict regarding access to and utilisation of the resource. In the LVB, there are several shared transboundary water sources, including the lake and its tributaries, such as the Mara River. The Mara River, for example, is a transboundary water source shared between Tanzania and Kenya. The river originates from the Mau forest complex in Kenya and flows through large-scale irrigated agriculture in Kenya to open savanna grassland in the Masai Mara

National Park in Kenya and Serengeti National Park in Tanzania. These national parks are renowned protected areas in the region. The Mara River further flows through small-scale agricultural land (crop and livestock husbandry) in Tanzania before discharging into Lake Victoria. Therefore, water from the Mara River is utilised for domestic consumption, livestock farming, irrigated agriculture, wildlife and environmental maintenance. The likely conflicts regarding access to and use of water from the Mara River will be between upstream users in Kenya and downstream users in Tanzania, and between the wildlife and human populations, which may also spark conflicts between Kenya and Tanzania. An inadequate water supply in the Mara River is caused by two main factors, which impact on each other: climate change, and land use and land cover. Climate change leads to a decrease in rainfall and rise in temperature, hence an increase in evaporation. On the other hand, a change in land use and land cover, such as the deforestation in the Mau forest complex caused by the expansion of agriculture and encroachment on the forests by livestock keepers, alters run-off and infiltration processes, thus interfering in the hydrologic cycle. Inappropriate land use and land cover can result in land degradation as a result of poor planning and ineffective water resource management systems along the Mara River in both Kenya and Tanzania.

CONCLUSION AND RECOMMENDATIONS

Climate change and variability have the potential to impact negatively on water availability, access to and demand for water in most countries, particularly in Africa. Climate change is likely to result in water scarcity, which will consequently result in stiff competition with regard to access and use. As competition for access to and use of water resources for different uses and users intensifies, water-use conflicts are likely to occur. This chapter examines the impact of climate change with specific focus on the effect of rainfall change and variability on water resource availability, access to and use in the Lake Victoria Basin. It is argued that the LVB in particular, and East Africa in general, is experiencing dramatic rainfall changes and variations over time and space, resulting in a decrease of river flows and drying up of other many natural water sources. It is further argued that, owing to the decrease of the water supply for domestic use, livestock and crop production, hydropower production and industrial use, water-use conflicts may occur at different levels such as in the family, among

villages, between ethnic groups, government institutions and local people, between different livelihood systems, and between countries. This calls for the formulation and implementation of national policies and other legal frameworks that are geared towards addressing issues of climate change, particularly the adaptation to and mitigation of climate change impacts. It further calls for stakeholders' dialogue to improve both customary and formal governance systems with regard to natural resources utilisation and management.

Since water resources touch every sector of the economy, it is important to improve water management in order to reduce the degradation of water sources and enhance equitable access to and utilisation of the resource, thus reducing or alleviating sources of conflict pertaining to water access and utilisation. It is therefore recommended that policymakers and planners integrate climate impact adaptation and mitigation measures in the formulation of policies and planning for development projects. It is further recommended that sector-specific policies that relate to the hydrology of water resources, such as forestry, agriculture and mining, be reviewed to include issues of climatic change and variations and their effects.

It is also necessary that countries that share transboundary natural resources such as water, share information on meteorological, hydrological and socio-economic activities, and the way they are practised in order to maximise the potential of the transboundary resources by minimising tensions and conflicts that may otherwise result.

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