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Review Article

The Vulnerability of Communities to Climate Change Induced Water Scarcity in Ethiopia and Kenya: A Systematic Review

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ABSTRACT

Climate change, as it is in many other parts of the world, is one of the many variables affecting the availability of water in Ethiopia and Kenya. Water scarcity problems are brought on by a lack of precipitation combined with a quick and persistent rise in temperature. The objective of this review paper is to examine how vulnerable communities in Ethiopia and Kenya are affected to water scarcity brought on by climate change, as well as how they can adapt. The analysis of 23 studies using systematic review methods identifies the characteristics of planned and spontaneous adaptations to water scarcity in Ethiopia and Kenya. Impacts of climate change were primarily caused by dry weather and uncertainty. According to empherical evidences, Ethiopia and Kenya are currently experiencing rising temperatures and fluctuating rainfall, and future forecasts point to an even worse situation. On a spatiotemporal basis, yet climate change varied, and in both countries, changes in the quantity and quality of water resources were among the effects that famed out. Population density, growing urbanization, and industrial are other factors that contribute to and exacerbate water scarcity in Ethiopia and Kenya. Nearly every economic sector in Ethiopia and Kenya has been impacted by the effects of climate change on water resources, including agriculture through unpredictable rainfall patterns, human health through water-borne illnesses during flooding, and trade through the destruction of road and telecommunication infrastructure. The degree of community susceptibility varies by nation, area, and geographic capabilities, with women and children being particularly vulnerable to climate change-related water scarcity that requires adaptation or mitigation. Building Ethiopia's and Kenya's resilience to the impacts of climate change on water resources necessitates a holistic strategy that integrates systems thinking and risk management techniques. The prevention of a water shortage depends on prompt action using science, technology, and innovation, rules governing water audit and management, and involvement of the private, public, and international sectors.

Keywords: Climate change; Mitigation; Water scarcity; Vulnerability

INTRODUCTION

According to Gan, et al., Ahmadalipour, et al., and Markonis, et al., climate change is most likely to be the physical cause for potential water scarcity in Africa which will be made worse by human causes like population growth. These physical causes include altered rainfall patterns, decreased precipitation and runoff, and increased evapotranspiration rates. Rendering to Asmall et al., Muller and Stringer et al., however, scholars are aware that in Africa, overall water resources might mask inequalities in access and utility because scarcities of water is influenced by a wider range of factors than just physical water resources, such as governance, institutions, gender equality, poverty, security, education, and health. In addition, climate change affects not only the hydrological cycle but also these societal drivers of water scarcity, and human responses to water

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scarcity can have cumulative and cascading consequences on the resource's ability to respond in the now and the future [1].

Climate change is causing the Horn of Africa to experience increasingly irregular temperature and rainfall patterns, and this tendency is only expected to get worse, according to UNICEF, McSweeney et al., WMO and IPCC. Despite the chance for higher rainfall in some places, rain will be diminishing in many areas of the region and similar to how the predicted global average temperature increases would be higher and more rapid. Reduced rainfall will lead to lower surface water levels and less groundwater aquifer replenishment, two vital sources of water for communities. Greater water evaporation from land and water surfaces as a result of higher temperatures reduces soil moisture and increases water losses from reservoirs. This has an effect on both the availability of water for domestic use and agricultural productivity. Intense heat also increases the danger of waterborne infections, which thrive in warmer climates. Additionally, it might damage water infrastructure. Extreme rainstorms that produce an excessive amount of water can endanger the water supply because they can corrode pipelines; contaminate wells, and damage infrastructure [2]. Water scarcity in a large portion of the Horn of Africa has led to a demand for water resources that is greater than the availability. In other words, there isn't enough water to meet the expanding demands of families, children, and the agricultural, energy, industrial, and ecological needs.

Ethiopia is one of the country's most at risk from climate change, and reports of fatalities from floods, domestic water supply scarcity, hunger, and the elevation expansion of malaria transmission are becoming more frequent. In addition to causing death, injuries, water-borne infections, hunger, and mental illness, flooding is one of the climate related hazards that can have a negative impact on people's health. Typically, Ethiopia's northern and eastern regions are more vulnerable to drought and flooding. Prolonged droughts that hit the country between 1983 and 1985, 2002 and 2003, 2011 and 2012, and 2015 and 2018 had an effect on millions of people. The water-scarce regions of Tigray, Afar, and Somalia are particularly vulnerable to these hydrological droughts. Every year, at least 1.5 million of Ethiopia's 100 million residents are affected by droughts; but, during very dry years, the number of affected communities can swiftly rise. Although, according to Water.org, WHO, IGAD, and IPCC, the lack of water caused by climate change and the related risks to human health are a significant issue for many populations in Ethiopia, especially those in rural areas and they are more vulnerable to climate change-related water scarcity.

Kenya also the most vulnerable nation in East Africa to climate change and the situation is worse in the northern and eastern desert and semi-arid regions. Numerous social, economic, political, demographic, and environmental elements contribute to the tendency of climate change and ultimately affect a country's ability to adapt to its repercussions [3]. Deforestation, unsustainable farming practices, a lack of suitable storage (such as dams), as well as an increase in water demand due to population growth and an expanding economy, are all aggravating the effects of climate change on Kenya's water supply. Extreme flooding, droughts, rising lake levels, water scarcity, and alien species invasions in water bodies like the water hyacinth in Lake Victoria and other water bodies are just a few examples of how climate change is affecting Kenya's water sector. Kenya's aims and goals must come to fruition if water security is to be attained. Climate change impacts may make these goals more challenging to fulfill if significant action is not done quickly enough.

For many years, Kenya has struggled with a lack of water. This is for a number of reasons. Firstly, there is in equitable delivery of water to various regions in the country. Second, a significant portion of the population lacks access to potable water due to the country's poorly dispersed freshwater basins. About 20.5 million Kenyans, who number 50 million, do not have access to safe and clean drinking water. Kenya's water situation is still dire, and climate change will only make things worse [4].

Based on the above mentioned statements, the essential objective of this review paper is to analyze the vulnerability of communities to climate change induced water scarcity in Ethiopia and Kenya, with the specific objectives:

- To describe the trends of climate change in Ethiopia and Kenya.
- To explain the impacts of climate change on the vulnerable communities associated with water scarcity in Ethiopia and Kenya.
- To identify the adaptation and mitigation strategies employed by communities during climate change induced water scarcity in Ethiopia and Kenya.

LITERATURE REVIEW

This systematic review paper aimed to analyze the vulnerability of communities to climate change induced water scarcity in Ethiopia and Kenya. To review this paper the methods that adopted was a literature search and analysis of relevant pertinent peer-reviewed articles and unpublished works from internet databases, including Scopus, Web of Science, Google Scholar, Sage Publisher, Springer, and Research Gates.

Subsequently, supplies pertinent to the purpose of the paper were collected and reviewed; at that juncture, the analyzed result was inscribed and offered in this paper. Unpublished papers and conference proceedings were all examples of grey literature. Searches for the terms "climate change," "vulnerability of communities to climate change," "adaptation," and phrases like "climate change induced water scarcity," "adaptation strategies to climate change," and "climate change impacts in Ethiopia and Kenya" were conducted in order to find the pertinent articles.

The review includes articles that had undergone peer review and were released after 2010. The current work retrieved 223 articles from all the databases after receiving pertinent keyword input [5].

It was screened to get rid of duplicates. On the basis of the results of the initial screening, 126 studies were chosen after 97 duplicates were eliminated. All unrelated articles were disregarded. Only 67 items out of a total of 126 were kept, and the complete texts of those 67 pieces were read. After full text

reading, a total of 45 articles were discarded, leaving a final group of 23 acceptable publications that were taken into consideration for systematic review.

Impacts of climate change on the vulnerable communities associated with water scarcity in Ethiopia and Kenya

Country overview of climate change in Ethiopia and Kenya: Ethiopia's climate is characteristically tropical in the southeastern and northeastern lowland regions, but much cooler in the large central highland regions of the country and the mean annual temperatures are around 15°C-20°C in high altitude regions, whilst 25°C-30°C in the lowlands. Mean annual rainfall distribution has maxima (>2000 mm) over the Southwestern highlands and minima (<300 mm) over the southeastern and northeastern lowlands. Yet, as Redda and Roland dissect trends in severe of seasonal rainfall over the period 1965-2002 with declining trends found for Kiremt (main rainy season between June-September) and declining trends in extreme rainfalls in Belg (small rainy season from March-May) [6].

According to Simane and Bird, and McSweeney, et al., the mean annual temperature of the country has increased by 1.3°C between 1960 and 2006, an average rate of 0.28°C per decade. The mean annual temperature is projected to increase by 1.1 to 3.1°C by the 2060's, and 1.5 to 5.1°C by the 2090's and as Conway and Schipper which indicated on Table 1 also, using the medium high SRES A2 emissions scenario show an annual warming throughout Ethiopia of 1.2°C by the 2020's with a range of 0.7°C-2.3°C, and warming of 2.2°C with a range of 1.4°C-2.9°C by the 2050's as Table 1. Under a single emissions scenario, the projected changes from different models span a range of up to 2.1°C. Rainfall can range between 0 mm to over 4,000 mm annually and the mean annual precipitation is 815.8 mm for the latest climatology.

Table 1: Climate changes in Ethiopia.

		Temperature	Rainfall	Extreme events
1	Historic pattern	From 1960 to 2006, the average temperature climbed by 1.3°C. There are more hot days and nights than chilly ones.	Extremely erratic from one year to the next, season to season, and decade to decade. No discernible pattern.	Recurring, catastrophic drought and flood occurrences. There is no proof that the extremes' frequency or intensity have changed.
2	2020's	+1.2°C (0.7-2.3°C)	+0.4%	Oct to Dec saw greater increases in rainfall, notably in the south and east.
3	2050's	+2.2°C (1.4-2.9°C)	+1.1%	Occurrences with heavier rainfall. Future uncertainty. The effects of El Nino are highly unknown.
4	2090's	+3.3°C (1.5-5.1°C)	Wetter circumstances	Events like floods and droughts are likely to occur more frequently.

As NEMA, and Republic of Kenya, Kenya's varied topography causes wide variations in temperature, with the highlands generally being much colder than the coastal and lowland areas. The average temperature ranges from 18°C at higher elevations to 26°C towards the coast, with no seasonal variation observed [7]. The amount of rainfall varies greatly across the nation, from less than 250 millimeters (mm) in the North's arid regions to more than 2,000 mm per year in the west. Highland regions, where most agriculture is practiced, each year, it receives about 1,000 mm of rain. The seasonal migration of the ITCZ defines four distinct seasons in Kenya, which are distinguished by two rainfall intervals: January to March, which is typically referred to as the "warm dry season," April to June, which is known as the "long wet season," July to September, which is the "cool dry season," and October to December, which is referred to as the "short wet season."

According to NEMA, MENR, and WBG CCKP, by the 2050's, Kenya's temperatures are predicted to have risen by another 1.7°C and by about 3.5°C by the end of the century. In addition, there will be more hot days and nights; by the middle of the century, it is predicted that 19% to 45% of days will be classified as "warm days" [8]. By the middle of the century, it's expected that 45%-75% of nights would be hot, and by the end of the century, 64%-93%. It's predicted that there won't be as many cold days or nights based on National Environment Management Authority and WBG CCKP.

Kenya's rainfall is forecast to continue to be highly unpredictable and uncertain, but by the middle of the century, average rainfall is predicted to rise, especially during the "short rains," which occur between October and December. Additionally, it is anticipated that the proportion of heavy rainfall that occurs during heavy events will increase as well as the frequency, duration, and severity of extreme rainfall events. The time

between intense downpours could lengthen, though. Importantly, it is predicted that rainfall in the arid zones will largely decrease as WBG CCKP.

Impacts of climate change on the vulnerable communities associated with water scarcity in Ethiopia and Kenya: Contemporary study on the impacts of climate change on water resources forecast the estimated decline in water availability in the majority of Ethiopia regions. According to Stevenson, et al., Gurara, et al., and World Bank, the primary concern in Ethiopia relating to women's psychological distress is the lack of access to water, water collection, and distance from water sources, unprotected water sources, and food instability. The most important issue in the article is how Ethiopian women's access to water is threatened by climate change, and how this can affect them if they must commute to collect water for their family. According to Negewo and Sarma, Stevenson, et al., and Suriyaarachchi and Rashini, in Ethiopia's rural areas, a large number of women and children must trek for up to six hours every day to gather water, which they do from unprotected ponds they share with animals who more affected and vulnerable communities by climate change associated with water scarcity in Ethiopia. A study conducted by Stevenson et al., in rural areas of Ethiopia's Amhara regional state's South Gondar zone reveals the effects of women's difficulty in accessing water [9].

As Stevenson, et al., Gurara, et al., and Suriyaarachchi and Rashini, also show that high percent of women said that they kept a girl home from school to help with the collection of water, which implies that the collection of water prevents children from going to school. Suriyaarachchi and Rashini, and Gurara, et al., provides the perspective of a young Ethiopian girl those also more vulnerable groups by climate change related with water scarcity in Ethiopia, who lives in a remote region of Ethiopia. They must walk for a lengthy hour round trip every day in order to reach their closest river to get water [10]. Given their situation, they are unable to attend school and do not have time to learn, play, or be a child.

Based on de Trincheria, et al., and Negash, the hydroelectric industry provides approximately all of Ethiopia's electricity. In light of this, the nation's energy industry is extremely vulnerable to the effects of climate change. The hydrology of the rivers in Ethiopia is predicted to change due to climate change, primarily increasing water level unpredictability. As a result, there may be effects on the production of hydroelectric power since both droughts and floods may become more frequent and severe. While catastrophic floods can significantly increase the safety issues for dams, droughts can cause a drop in water levels in dams. Increased soil erosion from uplands and sediment input into dams could arise from more intense rainfall that is predicted to happen as a result of climate change Negash, and Gelete, et al.

According to Wasike, Funk, et al., and Murphy and Chirchi the water scarcity index for the Kenya has gotten worse along with its rapid population increase and is predicted to drop from about 586 m^3 per person in 2010 to as low as 293 m^3 per person by 2050. As a result, Kenya is extremely vulnerable to the negative consequences of climate change. This will negatively affect Kenya's tourism, agriculture, manufacturing, and energy sectors, which has major repercussions for Kenya's Vision 2030; Murphy and Chirchi, and Republic of Kenya. The extremes of floods and droughts, as well as the significant inter and intra-annual rainfall variability, have a significant impact on Kenya's freshwater resources already (Table 2) [11]. Lake levels decrease as a result of future changes to rainfall patterns, rising temperatures, and increased soil moisture deficits.

As NEMA, and Murphy and Chirchi, cities in Kenya already experience considerable difficulties with access to water. In Mombasa, for instance, rationing and the continuous use of private sources are necessary because there is currently barely enough water to cover half of the city's needs. These situations will get worse as the temperature rises and the rainfall becomes more erratic. Due to the contamination of freshwater aquifers in coastal areas, sea level rise is anticipated to cause even more severe difficulties with water supply and salinization. The expected climate changes would make water scarcity, especially more vulnerable area in the country's dry and semi-arid regions. Increased temperatures may significantly affect the availability of water and people's overall well-being in addition to presumably worsening the drought conditions [12].

Rendering to Funk, et al., and NEMA, it is anticipated that existing vulnerabilities in agriculture, forestry, urban areas, as well as in livestock and dry land water resource management, will grow as a result of the anticipated changes in rainfall, along with greater aridity and more severe droughts. In Kenya's dry and semi-arid regions, conflicts over finite water resources, which are already serious, will undoubtedly get worse. Further stressing water supplies and the flows of glacially fed rivers, rising temperatures are also hastening Mount Kenya's glacial retreat. River flows, irrigation potential, water management, and flooding will be affected by changes in precipitation patterns, especially the expected yearly decreases in rainfall. Because of its small water storage facilities, Kenya is increasingly dependent on unpredictable rainfall patterns.

As Wananchi and Sauti, People in Kenya who lack access to safe drinking water have been compelled by climate change to forage for water on their own. It is well known that women and children have to spend a lot of time gathering water. Water collection is a difficult duty that women in Kenya must complete every day [13]. According to Funk, et al., and Wananchi and Sauti, in rural Kenya, over 26% of women and children spend an hour or more getting water, 20% take between 30 and 60 minutes, and 54% can access it in less than 30 minutes. 78 percent of urban homes can fetch water in 30 minutes, but 12 percent take an hour or longer.

Based on Daron and Funk, et al., flooding, drought, changes in the frequency and distribution of rainfall, rivers drying up, water bodies receding, and landslides are all effects of climate change that have been seen or could be seen on Ethiopia's and Kenya's water resources. Table 2 lists these consequences in accordance with the main effects felt in Kenya and Ethiopia. Even though the evidence has been reiterated above, the dry environment and insufficient government financing and help in Ethiopia and Kenya are the key causes of these nations' water challenges. Ethiopian and Kenyan national access rates to clean water from

1990 to 2015 are shown in Figure 1. While progress has been made in both countries, Ethiopia has outperformed Kenya by a wide margin, increasing its access rate by 45 percentage points, compared to Kenya's access rate's 20 percentage point increase. Despite these advancements, in 2015, more than one-third ofKen yans and close to half of Ethiopians still lack access to clean water.

Table 2: Climate change related impacts on water resources in Ethiopia and Kenya.

	Country	Climate change related impacts
1	Kenya	Persistent drought and flooding during the rainy season
2	Ethiopia	Periodic droughts, floods, earthquakes, and volcanic eruptions due to the great rift valley's geological activity

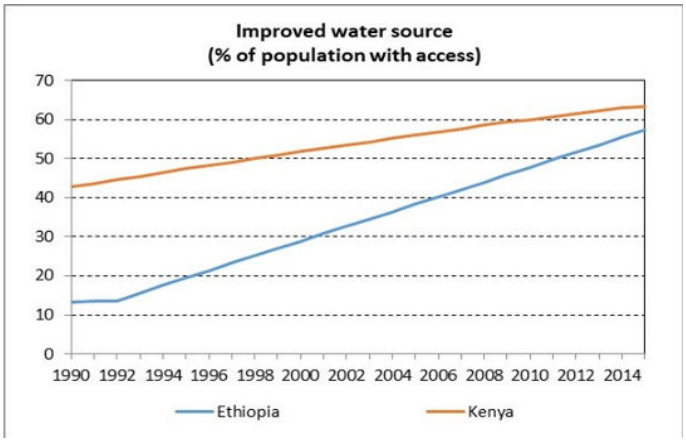

Figure 1: Access to safe water in Kenya and Ethiopia, 1990-2015.

Adaptation and mitigation strategies employed by vulnerable communities during climate change induced water scarcity in Ethiopia and Kenya

With regard to Haile, et al., Legesse and Shimelese, Simane, et al., and EPC, adaptation and mitigation strategies used by vulnerable communities during climate change-induced water scarcity in Ethiopia, as well to how adaptation strategies in other sectors should incorporate measures for all stages of the adaptation chain, including enhancing resilience, preparation, reaction/response, and recovery for the impacts on water resources sector at the national level should do the same [14]. The progressive consequences of climate change and extreme events both have preventative and resilience-building measures associated to water resources. For extreme occurrences like floods and droughts, preparation, reaction, and recovery strategies are primarily important.

According to Soboksa, et al., World Bank, and EPC, climate change will have an impact on the water resources sector through decreased river run-off, decreased energy output, and contributes to a rise in both floods and droughts. Activities for adaptation in the water sector should consist of:

- Performing research to analyses water resources (taking an inventory of the quantity and quality of surface and subterranean water to create a suitable use of the resources that are already accessible).
- Introducing enhanced techniques for water storage, management, and conservation.
- To provide a sufficient supply of water for cultivation and home usage, modest check dams and rainwater gathering systems are constructed.
- Using soil conservation techniques that protect water sources from pollution and help to decrease soil erosion and siltation.
- Putting in place initiatives and programs for watershed management and conservation that encourage community involvement.
- Developing techniques for maintaining flood control infrastructure and protecting against flooding.

Adversity risk reduction strategies must be extensively disseminated and grounded in local knowledge in order for every population to be aware of potential adaption mechanisms utilized by vulnerable populations in Ethiopia amid water scarcity brought on by climate change. A higher level of productivity will result in more efficient water resource usage, which will cut down on resource losses (nutrient, water, energy, etc.) and increase biomass, which will enhance carbon sinks [15]. The most successful adaptation to the effects of climate change, according to Mukuna, simultaneously seeks to lessen the cause of the change. As a result, adaption tactics will also help with mitigation. These are the major objectives of agricultural water management-based mitigation measures for climate change. Among other things, this comprises:

- Water resource protection.
- Rain water harvesting and development of water harvesting machinery.
- Improving agricultural water management in both irrigated and rain-fed agriculture.
- Appropriate planning of timing and amount of fertilizer and water application in accordance with suggestions of the individual research centers irrigation agronomist department.
- Reducing the amount of water wasted in agriculture.
- The use of renewable and more efficient energy sources for managing water.
- The drainage and rehabilitation of flooded and salinized irrigation zones to increase productivity.
- Adapt energy and water-efficient irrigation techniques where possible.
- Use renewable energy for water lifting and distribution.

- Rehabilitate existing irrigation infrastructure and improve management practices to increase efficiency so as to conserve water and water quality.
- Integrate soil fertility and crops management to enhance yield and water use efficiency.
- Strengthen the capacities of irrigators by providing services like.

According to Schemm, Republic of Kenya and NEMA, by improving the management of water resources, it is possible to encourage greater efficacy in the use of water resources and thereby support the restoration of critical physical and biological functions of water bodies over the short to long term. Vulnerable communities in Kenya used these methods to adapt and mitigate the effects of climate change-induced water scarcity. The government of Kenya presently promotes states to establish sub-basin management plans and adaption measures under the devolution system. Without a doubt, these strategies ought to take into account the sector's needs and shortcomings both now and in the future [16-18]. Targeted research should be conducted to identify water resource issues at the local and regional levels, and the results should be used to direct adaptation efforts. Large irrigation projects should make use of current risk assessments to properly coordinate with adaption strategies.

Rendering to NEMA, and World Bank, for several industries, including agriculture, ensuring food security, and facilitating access to water, improved water management is likely to offer a host of advantages. Putting into practice the directives and mainstreaming initiatives mentioned in the National Water Master Plan will help the institutions in charge of managing water resources work together to make sure there is water available for development and that the domestic water supply continues to be of a high standard [19,20].

Based on Nema, Kenya, and World Bank, Kenya launched the project to address water resources in response to the aforementioned effects of climate change and to improve community livelihood resilience to climate change, but the strategy aims to establish and implement the following integrated adaptive mechanisms:

- Creation of water harvesting equipment or structures.
- Supporting forestry and agroforestry ecosystem-based methods to improve water and soil conservation, food security, and climate change resistance.
- Supporting pastoral ecosystem-based adaptations that will boost resilience through the use of pasture conservation, an emergency feed bank, storage, and water supply to enhance the district's resident's social life.
- Restoration of the coastal mangrove environment.
- Early warning systems and flood control structures for disaster risk reduction and preparedness.
- Creation of a knowledge management system for this programmer, improvement of institution capability, and propagation of climate change adaptation information.

CONCLUSION

This review paper's main goal was to examine how communities in Ethiopia and Kenya are susceptible to water scarcity brought on by climate change. The greatest environmental, social, and economic challenges to all of humanity and across borders in many countries are being brought on by climate change. A community's susceptibility is more significant when it comes to the cause, effects, and necessary reaction mechanisms to adopt and deal with climate change consequences. Because of this, this review paper examines the susceptibility of communities to climate change-related water scarcity and measures for adaptation.

According to empherical evidences, climate change is caused by a complex interaction of natural forces and human activity, which has a negative impact on the water resources. Developing ways to diversify their economic prospects, entrepreneurial endeavors with resilience mechanisms, and climate change adaptation strategies must be supported for the most vulnerable communities most impacted by climate change. For the purpose of reducing climate change, it is necessary to move beyond command-and-control policies and regulations. Market-based strategies that provide incentives for local community participation and motivation in tackling climate change issues, such as carbon trading and exchange, should be prioritized. The effects of climate change on water resources are expected to be greatest in Ethiopia and Kenya, despite the fact that the causes, effects, and relationships between them are numerous. This is especially true given the countries' rapid population growth, unequal access to resources, food insecurity, weak health care systems, and poverty. The vulnerability of many people in Ethiopia and Kenya will increase as a result of these circumstances. In many cases, the water supplies in Ethiopia and Kenya are impacted by climate change, and many women and children still have to travel long distances to obtain water. Despite advancements, in both countries, more than two thirds of the population lack access to better sanitation. Although both nations have made strides in lowering their death rates, they should keep concentrating on improving access to clean water and sanitation when addressing water-borne diseases in order to further lower mortality rates, particularly child mortality rates. Thought, the effects of climate change on water resources will also worsen since Ethiopia and Kenya are falling behind in terms of scientific advancement, technological sophistication, and creativity.

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