



Community Knowledge and Perception on Climate Change and Drinking Water Supply in Nzoia River Basin, Kenya

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Nzoia River Basin is one of the regions in Kenya that is highly vulnerable to climate change. An understanding of community knowledge and perception on climate change and drinking water supply will provide strategic directions for national and county government policy, adaptation strategies and development of community-based guidelines on climate change. This study assessed community knowledge and perception on climate change and drinking water supply in Nzoia River Basin. A cross-sectional survey design was used. Three counties were randomly selected from the basin for study with Busia representing the lower catchment, Kakamega middle catchment and Trans Nzoia upper catchment. The study was carried out from May, 2017 to September, 2017. Multistage random sampling technique was used to select the 403 households administered with questionnaires. An observation checklist was used by the interviewers to collect household- and community-related information. The study results revealed that the community largely comes from low socio-economic background: only 24 % had post secondary education or higher, the majority were small scale farmers, housewives, casual workers and househelps (58 %), and only 25 % earned a monthly income above Ksh. 20,000 (equivalent to US \$200). The majority of the participants 81 % had some knowledge about climate change but 19 % did not. On level of

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knowledge about climate change, 70% know a little/something about climate change, 21% know nothing about climate change and 9% know a lot about climate change. Majority of respondents, 76% receive climate change news from mass media (radio, newspaper and magazines, television); and 81 % point out that climate change will have public health risks in the community. The knowledge level about climate change in the basin was average. National and county governments should work with the sector stakeholders in the basin to improve community knowledge and perception regarding climate change, drinking water supply and health needs with proper content. The results of this study will go a long way in bridging the gap between policy formulation and building adaptive capacity to climate change in the basin.

Keywords: Nzoia river basin; climate change; knowledge; perception; drinking water supply.

1. INTRODUCTION

In recent times, climate change and global warming have become matters of great concern. Despite some skeptics [1,2], experts agree that climate change is occurring and is being fueled mainly by unsustainable activities such as combustion of fossil fuels, industrial pollution, deforestation, and changes in land use [3,4,5]. There is now widespread agreement that climate change is a well-established reality [6]. Observational evidence from all continents and most oceans, according to the Intergovernmental Panel on Climate Change, [3], shows that regional climatic change is already affecting many ecological systems. Increasing temperatures, melting glaciers, rising sea levels, changes in precipitation patterns, recurring droughts, and disastrous floods are the most visible manifestations of climate change [3]. According to available scientific evidence, the globe warmed by around 0.6 degrees Celsius on average over the twentieth century [7] and is projected to warm by approximately 2–3 degrees Celsius by the end of the twenty-first century [3]. The last 50 years of the twentieth century, according to Holdren [8], were the warmest in 600 years. Several other studies agree that the frequency and severity of droughts and floods, both of which are climate change indicators, have increased over the last 50 years, particularly in Eastern Africa [9,10].

Continued greenhouse gas (GHG) emissions are expected to cause various changes in the global climate system in the twenty-first century, many of which will be bigger than those witnessed in the twentieth century [11]. Furthermore, it is more likely that the effects of climate change will unfold in a non-linear and unpredictable manner. Climate change will have both beneficial and negative consequences, with the negative consequences being felt far more severely in

poorer countries [7]. Africa is one of the continents most exposed to the effects of climate change [3,12]. Climate change's negative effects have exacerbated poverty, bad policy, and weak institutional frameworks, worsening the livelihood situation in Africa [13]. Climate change has the potential to stall African growth and undermine the attainment of Sustainable Development Goal (SDG) -13, which focuses on increasing climate change resilience [14].

Kenya's climate change crisis is worsening at an alarming rate [15]. The whole of the East African region including Kenya is already facing higher temperatures than never witnessed before [16]. Climate change forecasts, according to SEI (2009) [17], indicate upward movement in Kenya's mean annual temperatures of between 1.0 and 3.5°C by 2050. This warming is expected to result in the melting of glaciers on Mount Kenya [3], lower water levels in several rivers, and power outages in most parts of the country [18]. Climate change and variability will have a significant impact on Kenya's economy. According to SEI (2009) [17], Kenya will record a GDP loss of approximately 3% each year by 2030. Community knowledge and perception on climate change and drinking water supply will prepare them to effectively cope or adapt to the impacts. As Mtambanengwe et al. (2012) [19], observed, an assessment of the level of awareness on climate change and variability may contribute towards the formulation of adaptation strategies designed to improve rural livelihoods and reduce vulnerability.

Climate change awareness and perception vary within and between regions, according to various empirical reports [20,2]. Climate change awareness and risk perception were unevenly distributed around the world in the period 2007–2008, according to a study by Lee et al. (2015) [21]. In the report, the highest level of awareness (over 90 percent) was concentrated in the

developed world. The majorities in developing countries of Africa, Middle East and Asia reported not having heard about climate change. Earlier climate change awareness studies in the developed world found that respondents were aware of climate change [20,21], but it was not a high priority environmental issue in most of those countries [22,20]. On the contrary, studies in developing nations demonstrate that, despite their great vulnerability to the effects of climate change, the vast majority of the people are unaware of climate change [20,23,24].

According to GOK (2010) [15], the majority of Kenyans have no information on climate change and are more concerned about food insecurity arising from the country's frequent droughts and flooding events. Even though the population is mostly unaware of climate change issues, the depth and scale of this unawareness needs to be determined [25]. Mutimba et al. (2010) [26] observes that, despite the low awareness on climate change issues among Kenyans as noted by the NEMA assessment, there have been a number of global conferences, conventions and events taking place on the Kenyan soil, and these are likely to have elevated the level of awareness amongst Kenyans. The 12th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) and the second Meeting of the Parties to the Kyoto protocol were held in Nairobi, Kenya between 6th and 17th November, 2006. This event was heavily covered by the local, regional and global media houses, enough to raise awareness amongst Kenyans. The 2006–2009 drought episodes have been linked to climate change and their effects on local ecosystems such as the Mau Forest conservation issues have been heavily debated by the local media. Even the National Climate Change Response Strategy (NCCRS) was developed through a participatory approach involving the grassroot communities with a lot of sensitization on climate change issues. These and many other activities that have taken place on climate change in the country are sufficient to raise the population's awareness. However, multiple additional studies still find that climate change awareness in Africa, and particularly among Kenyans, is extremely low [15,25,26,27]. A consideration of these facts raises uncertainty about knowledge and awareness on climate change, and the current study attempts to establish community knowledge and perception on climate change and drinking water supply in Nzoia River Basin, Kenya. This knowledge will

bridge the gap between policy formulation and building adaptive capacity to climate change in the basin.

2. MATERIALS AND METHODS

2.1 Study area

The study area, Nzoia River Basin lies entirely within Kenya along the border with Uganda in the Lake Victoria Basin. It's situated between latitudes 1° 30' N and 0° 05' S and longitudes 34° E and 35° 45' E with an area of 12,959 km² and a river length of 334 km up to its outfall into Lake Victoria. This study was carried out in three counties of the basin; Trans Nzoia in the upper catchment, Kakamega in the middle catchment and Busia in the lower catchment. Nzoia River Basin has a population of about 3.7 million people [28].

Agriculture is the dominant land use in the region with the main food crops grown as maize, sorghum, millet, bananas, groundnuts, beans, potatoes, and cassava while the cash crops include coffee, sugar cane, tea, wheat, rice, sunflower and horticultural crops. The inhabitants of the basin also practice dairy farming together with traditional livestock keeping.

2.1.1 Climatic conditions

The study area has a tropical humid climate with a high variation in monthly average temperatures. The annual average temperatures vary from 16°C in Cheranganyi and Mt. Elgon areas to 28°C in the lower semi- arid plains of Bunyala. Night temperatures vary from 4°C in the highlands to 16°C in semi-arid lowlands. The highest rainfall ranges from 1100 – 2700 mm annually. Lowest rainfall ranges from 600 – 1100 mm annually. As a result of the inter-tropical convergence zone (ITCZ), Nzoia River Basin has four rainfall seasons each year. There are two rainy seasons and two dry seasons. Long rains come between March and May (MAM), while short rains fall between October and December (OND), both of which are linked to the ITCZ. There is no distinct dry season, although the months of December, January, and February (DJF) and, in some areas, June, July, August, and September (JJAS) are dry seasons in comparison to the rainy seasons. The local relief and influences of Lake Victoria alter the normal weather pattern, resulting in a third rainfall peak from June to August (JJA). The ITCZ has a rather complex structure over the East Africa

region that consists of the zonal and meridional arms. The double passage of the zonal arm is associated with the long and short rainfall season during which a large portion of the annual rainfall total is received.

2.1.2 Drinking water supply

Groundwater is the main drinking water resource, supplying 78.8% of the residents leaving 21.2% for surface water resources. Many of the large piped schemes supplying the towns and rural areas have their intakes built on Nzoia river and its tributaries. On the existing sources of drinking water supply, 62 % of the residents of Nzoia River Basin use improved water sources. Out of these, 3 % use piped water into dwellings, 7% water piped into compound, yard or plot, 3% public tap/standpipe, 6% tube well or borehole, 11% protected dug wells, 31% protected springs and 1% rainwater collection systems. Those using non-improved sources are 38%. Out of

these, 10% use unprotected dug wells, 19% unprotected springs, 1% tanker truck/cart with small tank, 8% surface water (river, dam, lake, pond, stream, canal, irrigation channel) and 0 % bottled water. Individuals frequently have to wait for long periods of time to draw water from point water sources, especially during the dry season. The people of Nzoia River Basin have strong preferences for safe, clean drinking water, and will sometimes walk long distances past alternative sources to get drinking water from sources deemed safe. Women and children collect water for drinking and cooking and transport it home in pretty standard-size 20 liter jerricans for adults and 5-10 liter jerricans for youngsters. Adults and older children in some villages still prefer to bathe in rivers, despite the fact that children under the age of five are routinely bathed at home in basins. Nzoia River Basin water sector still lacks suitable infrastructure as well as the requisite operational and management structures and capacities [28].

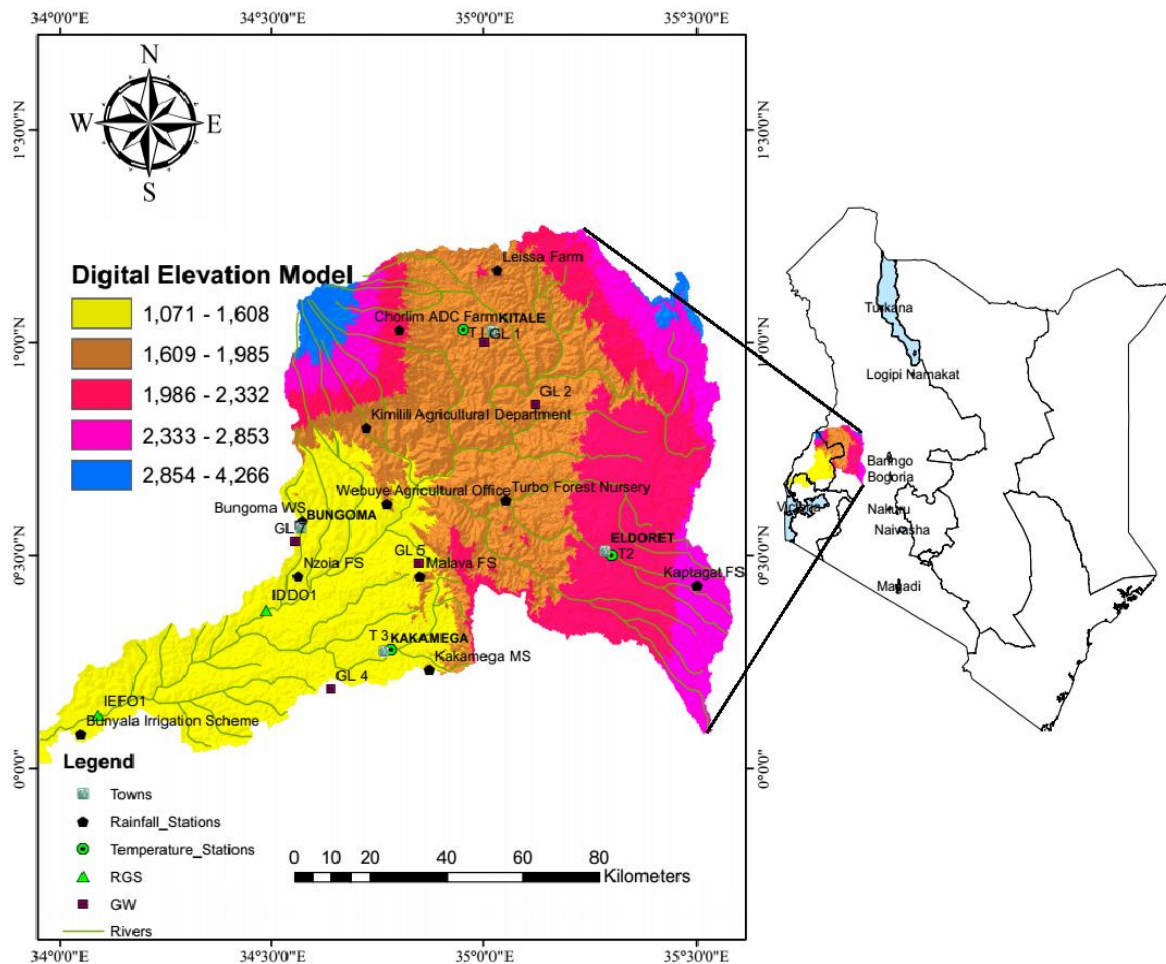


Fig. 1. Map of Nzoia River Basin, Kenya

2.2 Methods

The study adopted a cross-sectional survey design. Three counties were randomly selected from Nzoia River Basin for study with Busia representing the lower catchment, Kakamega middle catchment and Trans Nzoia upper catchment. The study was carried out from May, 2017 to September, 2017. Multistage random sampling technique was used to select the 403 households administered with questionnaires. The questionnaire survey was conducted by the Author with the assistance of trained University students. An observation checklist was used by the interviewers to collect household- and community-related information. The head of each household was the eligible participant for the interview. The study also used secondary data which entailed the collection and analysis of published materials and information. The collected data were summarized and carefully analyzed.

Concerning ethical considerations, this study ensured that ethical values are not violated by closely adhering to ethical guidelines for conducting research. After the approval of the research proposal, the researcher sought for written permission from Masinde Muliro University of Science and Technology, Directorate of postgraduate studies. The researcher also through the Directorate of postgraduate studies applied to National Council for Science, Technology and Innovation (NACOSTI) for research permit and authorization to collect data in Trans Nzoia, Kakamega and Busia counties. The researcher also requested and was granted permission by the County Commissioners of Trans Nzoia, Kakamega and Busia counties; and the County Directors of Education, Trans Nzoia, Kakamega and Busia counties, for further permission to conduct research in their areas of jurisdiction. Ethics pertaining to identification, disclosure understanding, deception, informed consent, confidentiality, right to privacy and anonymity were pertinent to the study and therefore upheld. The researcher ensured that participants had informed consent at individual level and the respondent participation in the study was made without coercion. They were given adequate information about the study which included: the main objectives of the study; expected duration of participation and procedures to be followed and the benefits of the study to them. The purpose of the study was explained by the researcher as purely academic. This information

formed the basis on which the selected respondents made an informed decision to participate in the study. They were also informed of their right to withdraw from the study at any stage if they felt they would no longer continue with the interview. The respondents were assured of confidentiality and complete freedom in answering the questions. The participants were informed that the study findings would be published and this published report will keep the participants' identities confidential. Other values that were adhered to by the researcher during the study were avoidance of psychological harm to respondents by not asking demeaning questions. Finally the researcher remained objective and assured that findings, conclusions and recommendations were based solely on data rather than personal feelings and prejudices.

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of Respondents

Gender, age, education, occupation, and income level, among other socioeconomic factors, influence respondents' knowledge and perceptions of climate change and drinking water supplies. Socioeconomic factors also have a role in raising or decreasing vulnerability, as well as permitting or preventing people from taking various coping or adaptive strategies during times of crisis. The majority of respondents, 59.4% (237) were female while 40.7% (163) were male. The highest fraction of respondents were in the 41-45 years category 23% (92), followed by 46-50 years 16% (64), 51-55 years 12% (48), 56-60 years 10% (40), 61-65 years 9% (36), 26-30 years 8% (32), 31-35 years 6% (24), 36-40 years 6% (24), 66-70 years 5% (20), above 70 years 3% (12), 21-25 years 2% (8) and below 20 years 0% (0). The majority of respondents were within the middle age bracket. The study's large proportion of middle-aged people could be explained by the fact that it focused on household heads, the majority of whom are in their middle years.

The study established that majority of respondents came from low socioeconomic background: 36% (144) had primary school education, 25% (100) secondary school education, 5 % (20) vocational training, 19% (76) tertiary middle level college education, 5 % (20) university education and 10% (40) had no education at all. Further, the results reveal that the majority of the household heads who

informed the interview, 43% (172) were farmers, followed by 16% (64) businessmen/women, 14% (56) were private sector employees, 10% (40) were national and county government employees and teachers, 7% (28) housewives, 6% (24) casual laborers, 2% (8) students and 2% (8) house helps. The majority of the respondents had a monthly income of Ksh. 0- 10,000 57% (228), followed by 10,001- 20,000 18% (72); 20,001-30,000 9% (36); 30,001- 40,000 7% (28); 40,001- 50,000 5% (20); and above 50,000, 4% (16). Age, educational level, monthly income, and occupation were all found to be strongly linked with knowledge of climate change by [26]. Knowledge of climate change and its impacts were high amongst the people with a higher educational level or who lived near a school.

3.2 Community Knowledge and Perception of Climate Change in Nzoia River Basin

The study sought to establish from the household heads community knowledge and perception on climate change and drinking water supply; climate change perception/awareness in terms of beliefs (knowledge of climate change), perception on impacts to drinking water supply, stakeholders to take a leading role in responding to climate change impacts on drinking water supply, support for environmental policies leading to sustainable drinking water supply and how respondents receive communication (news) on climate change in the basin. On climate change beliefs, the respondents were asked whether they had ever heard about climate change, the knowledge they have on climate change,

whether they think climate change is happening or not, what they think causes climate change and if they are in any way worried about the effects of climate change on drinking water supply. Fig. 1 shows that the majority of the respondents 81 % (324) had heard about climate change. A small number of 19% (76) of the respondents reported not having heard about climate change. These results agree with other studies conducted in Nigeria, Asekun-Olarinmoye et al. (2014) [29] and Banstola et al. (2013) [30], where 54 % and 51.3 %, respectively, of the participants reported they knew about 'climate change'. The findings also concur with those of Abedin et al. (2019) [31], who found that, "Climate change is a familiar term to the local people in Southwestern Coastal Bangladesh". Ochieng & Koske (2013) [32] in a study on the level of climate change awareness and perception among primary school teachers in Kisumu municipality, Kenya found that the teachers were relatively aware of climate change. The study went further to establish from the respondents the magnitude or level of knowledge they had about climate change. Fig. 2 shows that majority of the respondents 70 % (280) know a little/something about climate change, 21% (84) know nothing about climate change and 9% (36) know a lot about climate change. These findings have a bearing on the community's level of education. Those highly educated are the minority in the community and know a lot about climate change. This implies that there is room for climate change awareness creation in the basin.

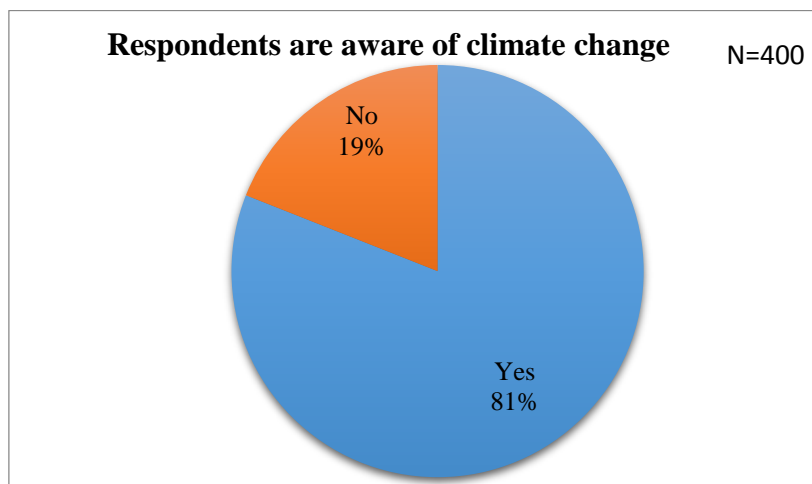


Fig. 1. Whether the household heads had heard about climate change or not in Nzoia River Basin, Kenya

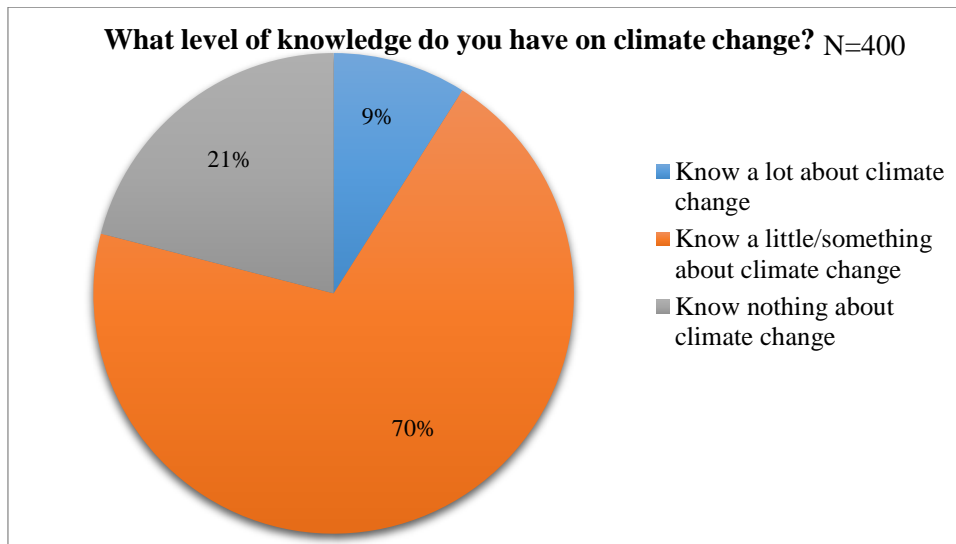


Fig. 2. Household heads level of knowledge on climate change in Nzoia River Basin, Kenya

Ochieng & Koske (2013) [32] found that, “even when teachers in Kisumu were asked to state how much they think they know about climate change, only 6 respondents claimed to have not heard about climate change while another 29 respondents claimed to know a great about it and the remaining 61 knew a little about it”. Fig. 3 shows that majority of the respondents 83 % (332) think climate change is happening, 6% (24) think climate change is not happening and 11% (44) don’t know. The results clearly indicate that the majority of the residents are aware that climate change is happening and this is consistent with the findings of LVBC (2011) [33], vulnerability assessment to climate change impacts in lake Victoria basin, which observes that “most people in the Lake Victoria Basin had experienced climate change markers related to adverse changes in weather”. Ndambiri *et al.* (2012) [34] in his study on Assessment of farmers’ adaptation to the effects of climate change in Kenya: the case of Kyuso District noted that, “94 % of farmers in Kyuso were aware of climate change and its effects”. Contrary to the findings of these studies and our current study. Pelham (2009), GOK (2010) and Mutimba *et al.* (2010) [27,15,26]; observe that climate change awareness levels amongst Kenyans are low.

The study went further to establish from the respondents what causes climate change. The results as shown in Fig. 4 indicate that majority of the respondents, 32 % (128) think that climate change is caused by both human activities and natural changes in the environment, 27% (108)

say mostly by human activities, 21% (84) mostly by natural changes in the environment and 20% say they don’t know. Sulistyawati *et al.* (2018) [35], in a study on Assessment of knowledge regarding climate change and health among adolescents in Yogyakarta, Indonesia observes that, “majority of participants said that they somewhat know the cause of climate change (79.53%), the consequence (53.94%), and the attempt to tackle climate change (59.45%). Most of them also believed that climate change is an unbreakable process due to their assumption that climate change is caused by a natural process (51.18%), not caused by human activity. Respondents relatively understood (51.18%) that CO₂ has a high impact on climate change. Moreover, 77.36% of the respondents agreed that the industrial sector had a considerable contribution to climate change”.

On the causes of climate change, there are various schools of thought. The current climate change is attributed mostly to human activity and partly to natural processes, according to a report by the Intergovernmental Panel on Climate Change [3].

Cunningham & Cunningham (2004) [36] noted that the distinction between human and natural-induced climate change is that human-induced change occurs quickly, whereas natural-induced change occurs gradually. Climate change is linked to social and spiritual issues among the locals. Climate change, according to the Maori of New Zealand, is caused by a lack of spirituality, brutality, and selfishness [37]. People interpret

hailstorms as punishment from God, according to a review of literature by Kemausuor et al. (2011) [38] on the perceptions of causes of climate change. This is especially true when young women terminate their pregnancies. Communities consider drought as God's plan, according to a research conducted by Speranza et al. (2010) [39] in semi-arid areas of Kenya's Makueni county. As a result, drought cannot be

mitigated. Farmers in the Rural Sahel, according to Mertz et al. (2009) [40], regard weather as a divine intervention over which they have no control. Farmers in the Nigerian Savannah, according to Tambo & Abdoulaye (2012) [41], believe that climate change is a punishment from God for sin, disobedience, and unfaithfulness to Him.

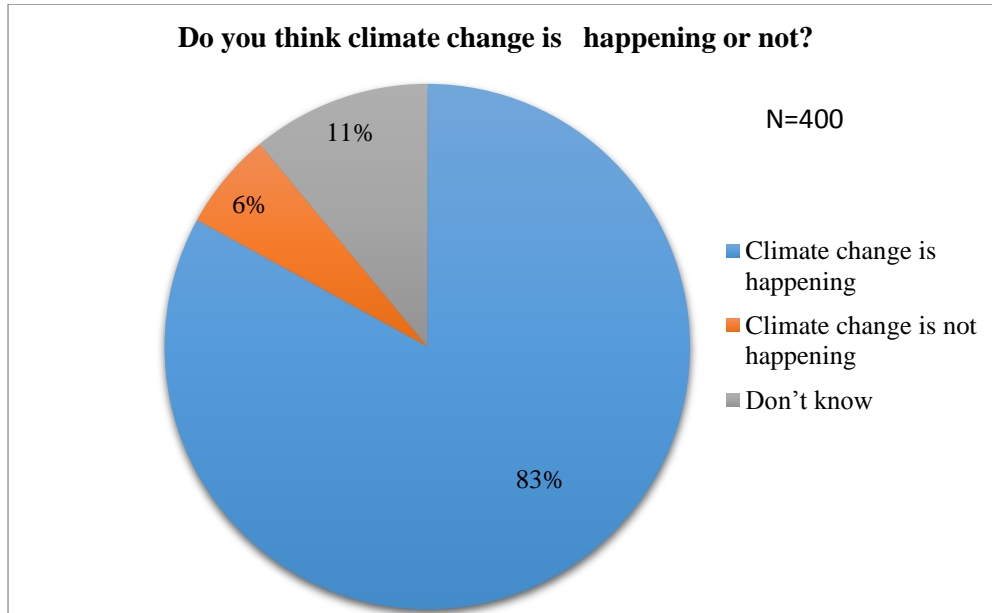


Fig. 3. Whether Household heads think climate change is happening or not in Nzoia River Basin, Kenya

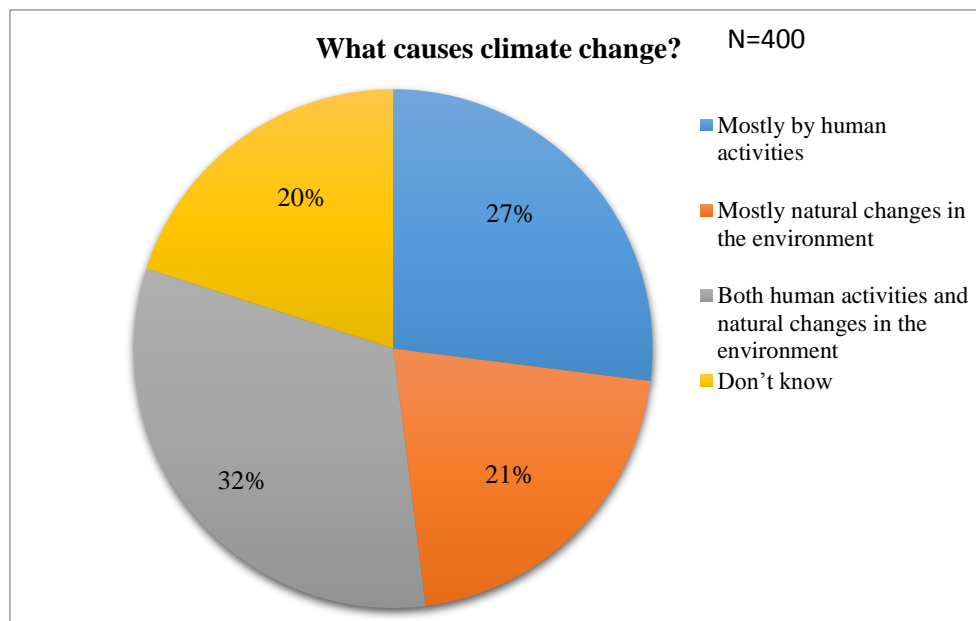


Fig. 4. What causes climate change in Nzoia River Basin, Kenya

Fig. 5 shows the results on respondents' worry about the effects of climate change in Nzoia River Basin. The majority of respondents, 55 % (220) were worried about the effects of climate change, 20% (80) were very worried, 15% (60) said they don't know and 10% (40) said they were not worried. These findings concur with those of Abedin et al. (2019) [31], in Southwestern Coastal Bangladesh, who found that "the majority of the respondents stated that present climatic conditions have changed compared to the last 25-30 years. They recognized remarkable changes in temperature, precipitation pattern, salinity intrusion, scarcity in availability of water, and spread of various infectious diseases that are directly or indirectly related to climate".

The study sought to establish the households' perception on climate change impacts on drinking water supply. Respondents were asked to state who is affected by climate change, is it the respondent himself (including his family) or the people living within Nzoia River Basin, or is it the future generations to come that will be affected by climate change? The results shown in Fig. 6 indicate that majority of the respondents, 50 % (200) think that climate change impacts on drinking water supply will affect people within Nzoia River Basin while at the same time 33% (132) feel it will affect the individual respondent

and his family (Household). 17% (68) felt it will affect future generations. Thus, the respondents feel climate change will harm themselves and their own families, other people in Nzoia River Basin, and future generations. Gifford et al (2009) and Lorenzoni & Pidgeon (2006) [42,43], state that "climate change is often seen by people as a temporally distant phenomenon primarily affecting other places, times or peoples". That is why some respondents in this study, 50% (200) think that climate change impacts on drinking water supply will affect people within Nzoia River Basin and 17% (68) feel it will affect future generations.

Recent studies in the United Kingdom (UK) have found a drop in public acceptance of climate science in terms of climate change, as well as a perception of a lack of government initiatives aimed at mitigating the effects of climate change [44,45,46]. As a result, some respondents believe that climate change does not exist, and that even if it does, nothing will be done about it. According to Nisbet & Myers (2007) [47], climate change impacts are a lower priority than other social and environmental issues, and in their study, 17 percent (68) of those who believe climate change will affect future generations were more concerned about other more pressing societal issues such as widespread poverty and high cost of living.

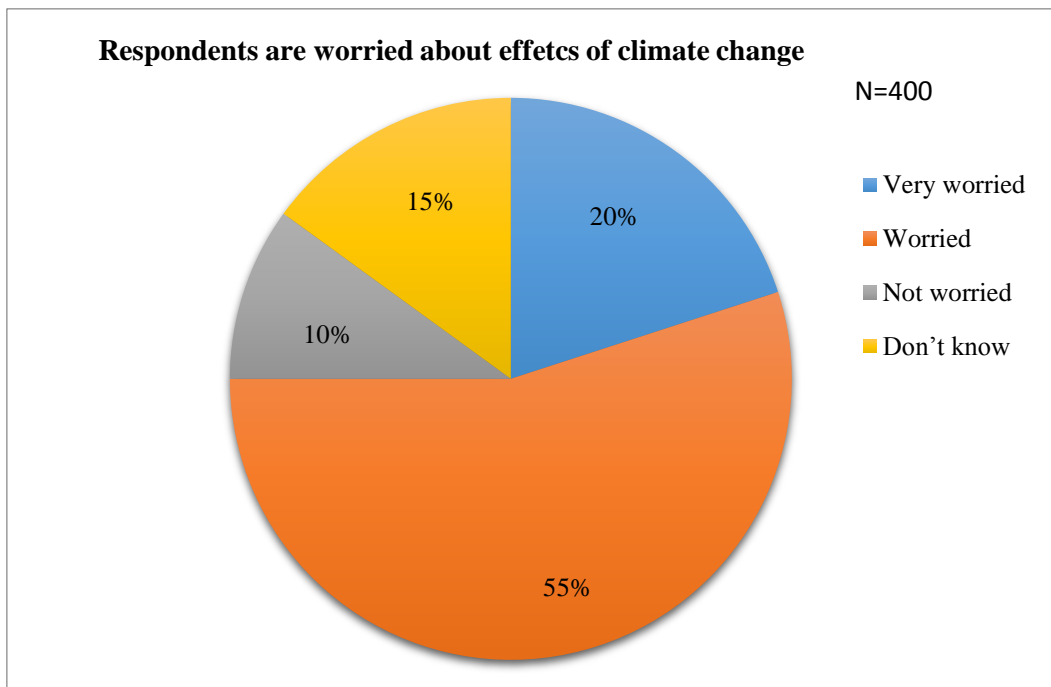


Fig. 5. Households worry on the effects of climate change in Nzoia River Basin, Kenya

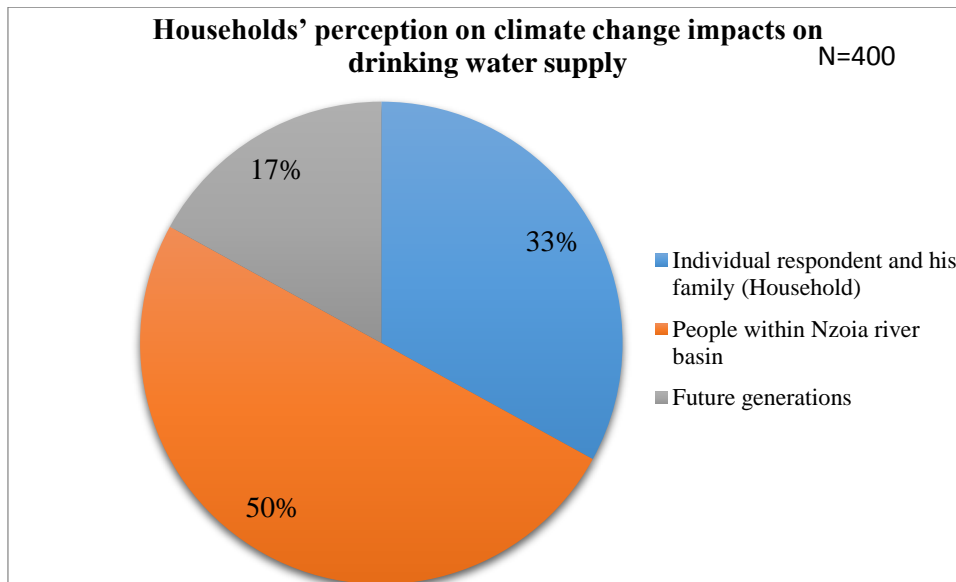


Fig. 6. Households' perception on climate change impacts on drinking water supply in Nzoia River Basin, Kenya

Sulistyawati et al. (2018) [35], in a study on Assessment of knowledge regarding climate change and health among adolescents in Yogyakarta , Indonesia observes that, “respondents reckoned that climate change was not an important problem; only less than 15% of respondents marked climate change as a very important problem. Participants paid more attention to poverty and food and water scarcity. Only about 5% of the participants assumed that the level of community seriousness about climate change was a very serious problem, while in the participants’ opinion, only about 7% of the respondents reckoned that climate change is a serious problem.”

The study sought to establish from the respondents who should take a leading role in responding to climate change impacts on drinking water supply in Nzoia River Basin. The results shown in Fig. 7 indicate that majority of the respondents, 44% (176) think it should be the national government, 20% (80) county governments, 12% (48) members of the public, 11% (44) non -governmental organizations, civil society organizations and faith based organizations, 7% (28) business/manufacturing industry and 6% (24) media.

Kenya has decided to prioritize adaptation activities while implementing progressive mitigation actions with the goal of establishing a low carbon climate resilient development pathway, taking into account the country's

sensitivity to the negative effects of climate change. Kenya passed the 2016 Climate Change Act (CCA) and the Sessional Paper No.5 on National Climate Change Framework Policy in 2016, both of which set the country's climate change response plan. As mandated by section 13 of the CCA, these will be implemented through a five-year National Climate Change Action Plan (NCCAP). The operating model for implementing climate change through "mainstreaming" and acknowledging the critical responsibilities of diverse stakeholders has been established.

The study went further to establish from respondents how support for environmental policies leading to sustainable management of drinking water supply could be achieved in Nzoia river basin. The results in Table.1 show that majority of the respondents 32% (128) suggest requiring companies to meet high environmental standards, 18% (72) encouraging afforestation of degraded water catchment areas, 14% (56) discouraging encroachment and deforestation of water catchment areas, 11% (44) manufacturers producing more environmentally friendly products, 7% (28) introduction to the market and willingness to pay more for environmentally friendly products, 8% (32) rubbish/garbage classification and recycling, 6% (24) requiring/encouraging farmers to use organic rather than chemical fertilizers, and 4% (16) using green building materials and designs.

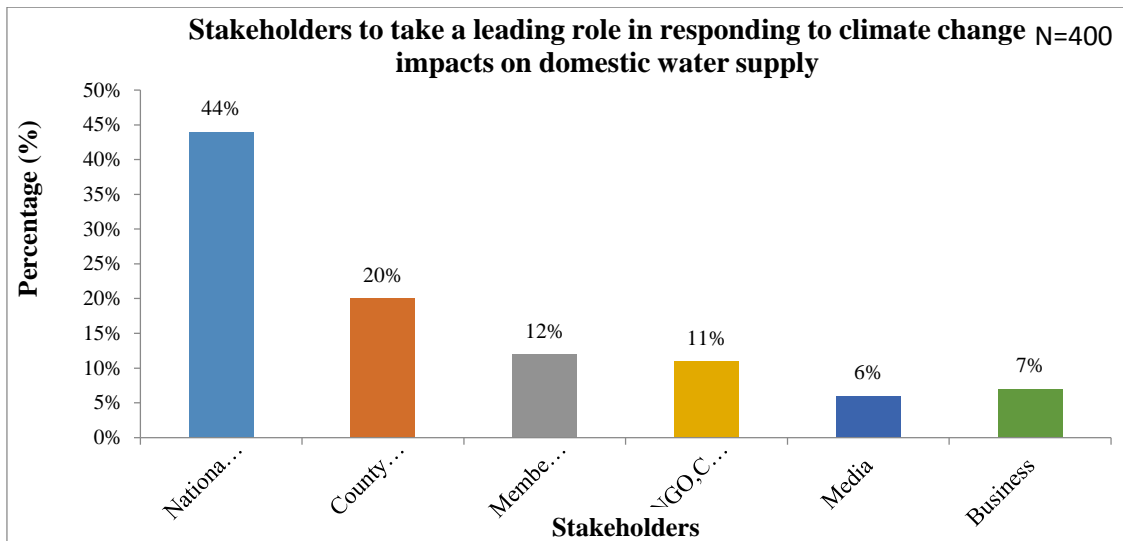


Fig. 7. Stakeholders to take a leading role in responding to climate change impacts on drinking water supply within Nzoia River Basin, Kenya

Table 1. Support for environmental policies leading to sustainable management of drinking water supply within Nzoia River Basin

Support for environmental policies leading to sustainable drinking water supply	Frequency	Percentage
Introduction to market and willingness to pay more for environmentally friendly products	28	7
Introduction and enforcement of mandatory environmental regulatory standards for		
Rubbish/garbage classification and recycling	32	8
Manufacturers producing more environmentally friendly products	44	11
Using green building materials and designs	16	4
Requiring companies to meet high environmental standards	128	32
Requiring/encouraging farmers to use organic rather than chemical fertilizers	24	6
Discourage encroachment and deforestation of water catchment areas	56	14
Encourage afforestation of degraded water catchment areas	72	18
Total	400	100

A coordinated approach to an environmentally sound, equitable, and efficient water management system is required. An integrated water resource system management approach is essential in the long run to enhance access to affordable and appropriate drinking water and sanitation services. Integrated Water Resources Management (IWRM) is a strategy that supports the coordinated development and management of water, land, and related resources in order to optimize economic and social welfare in an equitable manner without jeopardizing ecosystem sustainability. IWRM is a cross-sectoral policy approach to water resources management that aims to replace the previous, fragmented sectoral approach that has resulted

in inadequate services and unsustainable resource use.

Water resources are an intrinsic component of the ecosystem, a natural resource, and a social and economic good, according to Integrated Water Resources Management. In a water catchment area, this method addresses the demands of all users as well as the components of water balance, requirements and demand, supply, water resource protection, and climate change adaptation. The implementation of the most important measures for climate-sensitive and sustainable management, as well as the protection of water resources, is a part of the integrated water resources management

approach, which involves stakeholders, particularly the communities involved and the catchment area committee.

The study established from respondents how they receive communication (news) on climate change related to drinking water supply as shown in Fig. 8. The results show that majority of the respondents 44% (176) receive communication (news) on climate change related to drinking water supply through radios, 26% (104) newspapers and magazines, 10% (40) family and friends, 6% (24) television, 6% (24) telephones/mobiles, 4% (16) chiefs and county commissioners barazas, 2% (8) venues at marketing days and funerals, 1% (4) roadside shows and advertisements and 1% (4) through internet.

From our study, majority of respondents named mass media (radio, newspaper and magazines, television) and family and friends as their source. Very few people mentioned hearing about climate change from telephones/mobiles, chiefs and county commissioners barazas, venues at marketing days and funerals, roadside shows and advertisements and through internet. This indicates that mass media and discussions with family and friends are important source of information. There is a sectoral gap of engagement from the government system with

health and environmental issues. This is consistent with the study conducted by Abedin et al. (2019) [30]. Sulistyawati et al. (2018) [35] found that, "more than half of the respondents (53.54%) said that talking with family is their favourite source. Meanwhile, 15.16% of the respondents said that the Internet is their climate change information source". Kabir et al. (2016) [48] through a baseline survey among vulnerable communities in Bangladesh found, "the main source of information on climate change as: a Newspaper 11.4%, Weekly magazine 1.4%, Radio 39.0%, Television 55.6%, Neighbours 54.8%, Health workers 14.0%, Teachers 4.5%, Family members/Relatives 0.33%, Imams of the mosque 0.03%, NGO workers 0.14, Personal involvement in Training 0.03%, Type of change in climate as: Excessive Temperature 83.2%, Excessive cold 43.2%, Change of pattern of rainfall 53.9%, Frequent cyclone or tidal wave 36.5%, Frequent Flood 13.8%, Water logging 8.7%, Don't know/Don't understand-, Causes or reasons for climate change as: Deforestation 81.0%, Industrial effluents 28.1%, Population Growth 56.9%, Black smoke of vehicles 25.1%, Excessive carbon emission by the developed country 4.9%, Rapid urbanization and changes in life style 1.9%, Others 0.9%. Percentage total may add up to more than 100 % as multiple responses were permissible."

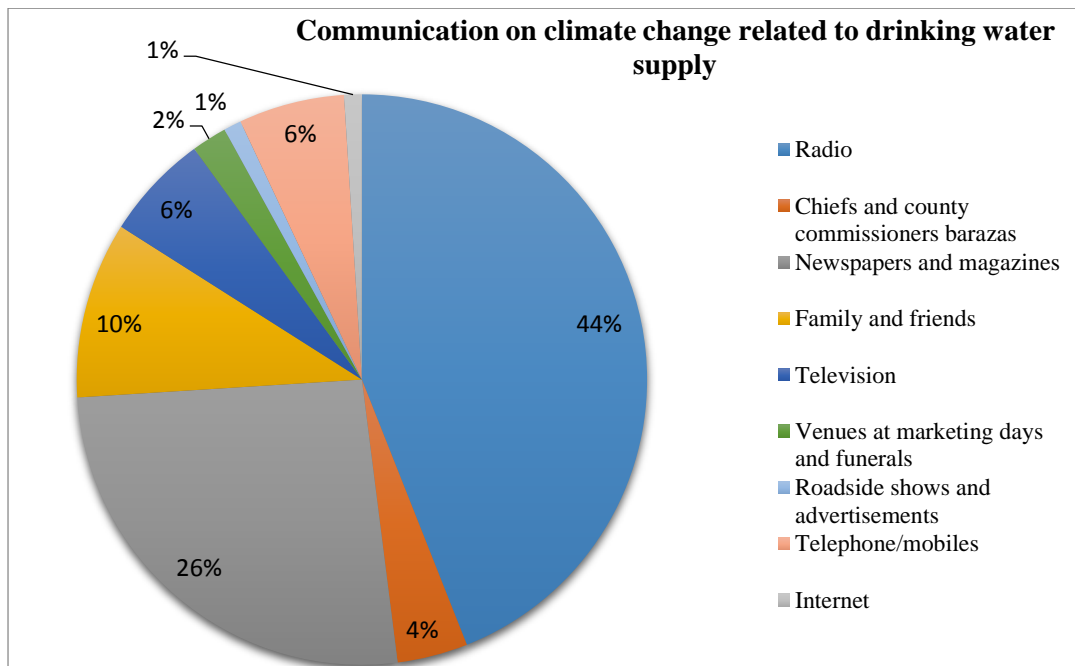


Fig. 8. How respondents receive communication (news) on climate change related to drinking water supply within Nzoia River Basin

Climate change can only be addressed successfully if effective information dissemination to the general public makes people aware of the threat and encourages them to take action. Article 6 of the United Nations Framework Convention on Climate Change, which urges governments to develop and implement educational and public awareness programs on climate change and its effects, to ensure public access to information, recognizes the importance of communicating with the public about climate change and increasing their awareness [49]. Climate change, unlike many other social concerns with which the public may be familiar, is a topic that many people learn about through the media. As a significant source of information, the mass media, to some extent, determines the reality of the situation for the general population [50]. Communication is a crucial instrument in the fight against climate change for the entire population. A well-informed, motivated, and devoted public can assist society in achieving its low-carbon objectives [49]. Radio has been a primary medium for communicating climate change news in 'developing countries,' such as Africa, particularly in rural regions [51].

The study sought to establish if climate change is set to have any public health risks in the community as a result of the ongoing climate variability and change. The results are shown in Fig.10. The majority of respondents, 81 % (324) agree that climate change will have public health risks in the community as a result of the ongoing climate variability and change; whereas a small number, 19% (76) of the respondents do not agree that climate change will have public health risks in the community. Ndambiri *et al.* (2012) [35], found that most of the adolescents (>60%) understood that climate change affects human health in Yogyakarta, Indonesia. Ochieng & Koske (2013) [32] found that 91.1% of the primary school teachers in Kisumu, Kenya perceived climate change as posing a serious threat to Kenyans. These results confirm findings of earlier studies by Pew Research Centre (2006) [20] that climate change is more likely to be perceived as a threat in developing countries. Our study results, however, contradict the results of Pugliese & Ray (2009) [21] who pointed out that perception of climate change as a threat is low among people in sub-Saharan countries as well as other developing countries in the world.

While there are projections on the long-term impacts of climate change on water resources [52,53], the long-term impacts on public health

are less well understood, owing to the uncertainty in projections of local effects (including water resources). A changing climate will, however, affect all populations to some extent, with the dangers being particularly high in the world's poorest countries, partly because these countries have a high incidence of climate-sensitive diseases and lack the resources and institutional capacity to control them. Death or injury from floods may have direct health consequences; indirect health consequences will follow from a decrease in the availability of safe drinking water, leading to a greater reliance on low-quality water sources. It is difficult to quantify the influence of climate change on public health or health hazards associated with the usage of drinking water in Nzoia river basin. The Ministry of Health is responsible for assessing health risks related to the use of water and relevant information about it. However, currently, there is no information system on relevant public health issues, which can provide data on environmental factors and the health status of the population and which would allow the Researcher to access information on infectious and non-infectious diseases like data registers, etc.

Although the connection between drinking water quality and health status has not been thoroughly investigated, case studies show that there is a strong connection between the two. This indicates that public health is inextricably linked to water services (water quality and supply reliability), and that climate change (among other causes) can have a negative impact on public health, during certain times of the year. Drinking water has been linked to incidences of diarrhoea and acute viral hepatitis, particularly in rural regions. Climate change, on the other hand, is simply one of multiple drivers in this regard, and it cannot be viewed as a stand-alone component, but rather as an exacerbating factor for other drivers in many ways. The vulnerability to public health due to climate and water-related natural hazards exacerbated by climate change in Nzoia River Basin is most probably driven by the risks of higher increasing temperatures, droughts and floods. The risk of droughts presents the vulnerability of limited drinking water availability, under supply to populations, and decreasing water quality (due to increasing water temperatures under surface water) which forces people to shift to alternative drinking water sources of lower quality exposing them to increased water borne diseases.

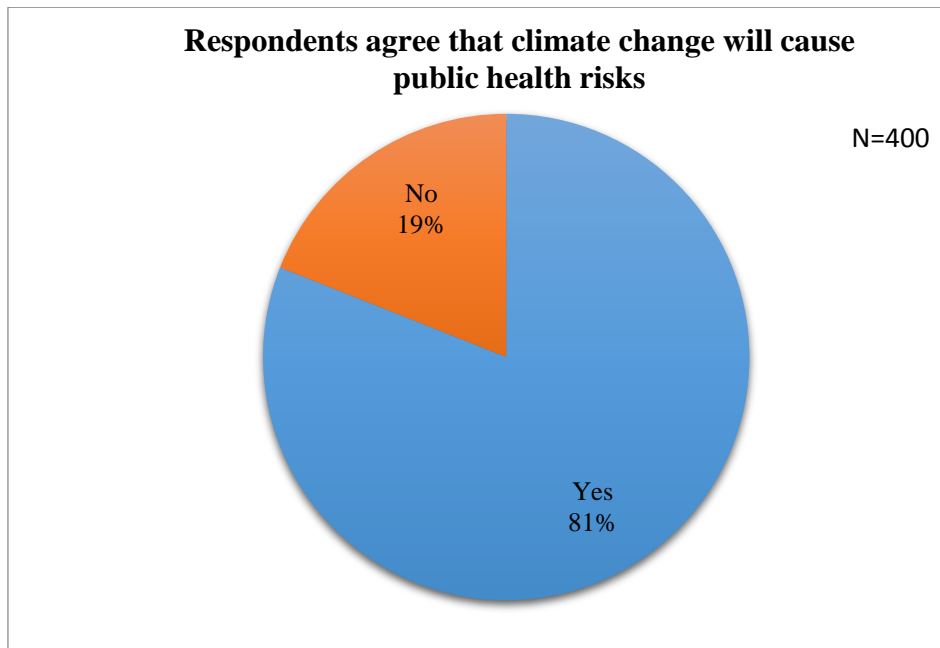


Fig. 10. Climate change and public health risks in Nzoia River Basin, Kenya

3.3 Climatic and Non-climatic Variables Influencing Drinking Water Supply in Nzoia River Basin

Climatic and non-climatic variables influencing drinking water supply in Nzoia River Basin are shown in Table 2. The variables fall into two groups, natural and anthropogenic. The natural ones include those caused by climate change such as: rising temperatures, changes in rainfall patterns, extreme weather events (frequent flooding and droughts), water logging, changes in groundwater levels, aquifer recharge and changes in streamflow. Those due to anthropogenic activities include: national and county government policy/ regulations on water use, politics, international conventions, treaties and agreements, overuse and overexploitation of surface and groundwater resources, etc. The goal of drinking water supply management in Nzoia River Basin is to protect human health while at the same time providing long-term supplies for the region's rapidly growing population and the accompanying economic activities.

Kristensen (2004) [54] posits that, "water scarcity problems occur when the demand for water exceeds the amount available during a certain period". In regions with limited rainfall and high human density, drinking water shortages are common. There are large spatial and temporal differences in the amount of water available in

the basin. Due to climate change, these inequalities are predicted to widen much further. Competition among different users, such as agriculture, homes, energy generation, and industry, exerts further pressures on water quantity. Reduced groundwater levels, which would have an impact on linked aquatic and terrestrial ecosystems such as wetlands, are one of the consequences of overuse and overexploitation of the basin's water resources. Furthermore, overuse and overexploitation of groundwater can result in saltwater intrusion into coastal aquifers. Measures aimed at reducing or controlling the demand for water include: national and county government policy/ regulations on water use, socio-economic variables (water price, income, rate structure, etc.), psychological variables (water use habits and attitudes, etc.), water savings from water conservation programs, and technological innovations [55].

The most extensively reported impacts of climate change on water resources involve water quantity. Increase in temperature affects drinking water supply through increased evaporation and evapotranspiration leading to higher water use by the vegetation and households. This results into reduced river flows and reduced aquifer recharge as manifested by falling groundwater levels. Increased temperatures also result into increased water demand by households and other activities leading to higher abstraction rates in the basin. Increased temperatures too result

into increased biological activity in soil leading to reduced infiltration and consequently reduced aquifer recharge and declining groundwater levels and streamflows. Changes in rainfall pattern results into increase in the intensity of rains, on short periods leading to reduced water infiltration in soils, reduced soil water moisture and reduced groundwater recharge. Changes in rainfall patterns will also result into variability in pattern leading to variability of water resources availability. Changes in rainfall patterns results into increase in the frequency and intensity of drought leading to reduced river flows and reduced aquifer recharge which affect drinking water supply severely. Changes in rainfall patterns result into increase in the frequency and intensity of floods leading to increase in

groundwater levels and streamflows which consequently has an impact on drinking water quality in the basin. In addition, warmer temperatures may lead to increased water demand by both water utility customers and competing users, with peak demand potentially coinciding with periods of most restricted supply. Increasing extreme events manifested by more intense and temporally variable rainfall, greater incidence of flooding and drought will also affect drinking water supply in the basin. Changes in surface and ground water use patterns will affect drinking water supply in the basin through water utility impacts such as operational reliability impacts, and financial and institutional impacts [55].

Table 2. Climatic and non-climatic variables influencing drinking water supply in Nzoia River Basin

Variables	Frequency	Percentage (%)
National and county government policy/ regulations on water use	8	2.0
Politics	9	2.2
International conventions, treaties and agreements.	4	1.0
Overuse and overexploitation of surface and groundwater resources	25	6.2
Competition amongst different users	14	3.4
Rising Temperatures	23	5.7
Changes in Rainfall patterns	32	7.9
Extreme weather events (Frequent Flooding)	14	3.4
Extreme weather events (Frequent Droughts)	29	7.3
Water logging	8	2.0
Deforestation	24	6.0
Land use changes	18	4.4
Industrial effluents	16	4.0
Population Growth	21	5.2
Demographic variables (household size, education level of household members, population changes, etc.)	8	2.0
Black smoke of vehicles	4	1.0
Excessive carbon emission by the developed country	8	2.0
Increased water demand and reduced water supplies	12	3.1
Changes in groundwater levels and aquifer recharge	25	6.2
Changes in streamflows	12	3.0
Walking distances and time taken to reach water sources	20	4.9
Rapid urbanization and changes in life style	12	3.0
Socio-economic variables (water price, income, rate structure, etc.)	8	2.1
Built environment variables (age of buildings, size of the lot, garden size, etc.)	9	2.3
Psychological variables (water use habits and attitudes, etc.)	12	2.7
Water savings from water conservation programs	8	1.9
Technological innovations	12	3.0
Others	-	-
Don't know/Don't understand	4	1.1
Total	400	100

Because of the high degree of uncertainty in data and modeling parameters, it is impossible to make precise forecasts on how climate will change in Nzoia River Basin. However, there is widespread agreement that climate change will manifest itself differently in different parts of Nzoia River Basin. The long term annual trends in rainfall will have small increases in rainfall over most parts of the basin with some fewer isolated areas recording declining rainfalls. Annual temperatures will increase all over the basin, with fewest regions recording decreasing temperatures. Annual stream flows will decline all over the basin. Annual groundwater levels will also decline all over the basin. Extreme weather events in the basin will become more frequent and severe; and this will affect drinking water supply adversely.

Warmer temperatures would lead water to evaporate more rapidly, resulting in higher total precipitation on a worldwide scale, according to another very certain prediction of climate change research. Estimates of the magnitude of the rise in rainfall vary widely, just like predictions of temperature increase. However, it is widely acknowledged that the pattern of rainfall change would be highly complicated and variable, with some places receiving more rain and others receiving less than they do now. Water use generally increases with temperatures; however, the effects of climate change on water are uncertain in terms of the weight it has on changing water use patterns. There is no evidence of climate-related long-term trend of water use in the past, partly due to the fact that water use is mainly driven by non-climatic factors [56]. Climate change will influence water demand, increasing the vulnerability of water bodies. This generalised increase in water demand caused by climate change will lead to conflicts among water users ultimately threatening drinking water supply in some parts of the basin.

4. CONCLUSION

This study attempts to assess community knowledge and perception on climate change and drinking water supply in Nzoia River Basin, Kenya. The findings provide important insights into what people think and believe from their experience at the grassroots level. The household participants were mainly from the rural areas that are vulnerable to climate change and drinking water scarcity. Nzoia River Basin like many other regions of the world is vulnerable to the adverse effects of climate change.

Respondents had average knowledge and perception on climate change which should be enhanced by the government through dissemination of information on climate change-health- safe drinking water promotion programs. This study provides baseline information for scientists, researchers, and policy makers to design and implement appropriate adaptation strategies for climate change in River Basins that are especially vulnerable.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Author has declared that no competing interests exist.

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