Asian Journal of Environment & Ecology

15(1): 33-48, 2021; Article no.AJEE.68660
ISSN: 2456-690X

Assessment of Climate Change Awareness in the Kakamega-Nandi Forest Complex in the Western Region

Wabusya Moses Wetiba[1], Mugatsia Tsingalia[2*], Njira Njira Pili[1] and Vincent Kakembo[3]

[1]Department of Biological Sciences, Moi University, P.O Box 3900-30100 Eldoret, Kenya.
[2]Department of Biological Sciences, Jaramogi Oginga Odinga University of Science and Technology, P.O Box 210-40601 Bondo, Kenya.
[3]Department of Geosciences Summer strand (South) Campus, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEE/2021/v15i130220
Editor(s):
(1) Dr. Wen-Cheng Liu, National United University, Taiwan.
Reviewers:
(1) Helene Gichenje, Universidade de Évora, Pólo da Mitra, Portugal.
(2) Sarhan Ahmed Soliman, Agricultural Research Centre, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/68660

Original Research Article

Received 09 March 2021
Accepted 16 May 2021
Published 29 May 2021

ABSTRACT

Aims: This study assessed the level of climate change awareness among the forest-adjacent communities in the Kakamega-Nandi forest ecosystem complex. Four locations were chosen for the study, Buyangu and Isecheno in the Kakamega forest, Kaptumo in Nandi South and Kipsamoite in Nandi North forest ecosystems.
Study Design: A cross-sectional survey design was used to collect data from primary sources. Structured questionnaires were administered to the residents aged 25years and older within the study area.
Place and Duration of Study: The Kakamega, north and south Nandi forest ecosystems in western Kenya between June -December 2019.
Methodology: A total of 280 questionnaires were randomly administered to the forest-adjacent respondents with, Kakamega forest 163 respondents, South Nandi forest 60, while North Nandi

**Corresponding author: E-mail: hmugatsia@jooust.ac.ke, mugatsi2005@gmail.com;*

had 57respondents. A total of 217 questionnaires were filled and returned and the information wherein used in data analysis. Focused Group Discussion and key informants were used to supplement data collects by the questionnaires.

Results: Majority of the residents (54%) were less concerned about climate change. In addition, 85% of the respondents had very little knowledge on coping and adapting to the adverse impacts of climate change. Some 40 % and 45% of the respondents got information about climate through televisions and radios, respectively. Further analysis of the results revealed that climate change was responsible for fourteen key impacts. These included an increase in rainfall, prolonged drought, decrease in the quality and quantity of fresh water, decrease in food security, an increase in temperature, a decrease in agricultural resources, an increase in sickness and disease, a decrease in quality of life, flooding, decrease in forest cover, loss of homes, reduction in biodiversity, and rise in storm surge. A Chi test revealed a significant relationship between forest cover decline and changes in rainfall patterns (X^2 = 111.86, df =12, p<0.001), increasing temperature (X^2 = 80.492, df =12, p<0.001);, drought((X^2 = 204.84, df =16, p<0.001) and storm surges (X^2 = 74.34, df =8, p<0.001)]. The respondents' level of education was significantly different from their level of climate change awareness (X^2=44.88, df=4, p<0.001).

Conclusion: Forest-adjacent communities in the Kakamega-Nandi forest ecosystem complex are vulnerable to climate change as a result of insufficient knowledge about climate change and its impacts. The Kakamega-Nandi forest ecosystem is already experiencing climate change effects such as erratic rainfall and increasing food insecurity.

Keywords: Climate change; climate change awareness; mitigation and adaptation strategies.

1. INTRODUCTION

Climate change has emerged as one of the most significant challenges of the 21st century [1,2,3]. This has amplified the level of climate change vulnerability particularly in developing countries [4]. Developing nations are dependent on rain-fed agriculture [5] that relies on natural soil fertility and precipitation, but characterized by unsustainable agricultural land use practices [6]. These cannot be ignored because they increase vulnerability to the impacts of climate change [7]. In these countries, small scale farmers have limited financial capacity, low adaptive capacity, inability to detect and predict occurrences of extreme meteorological events, limited infrastructure, low levels of literacy, inadequate skills, low awareness levels and insufficient capacity to diversify [8,9,10]. According [11], there will be over 200 million food insecure people by 2050, with the majority of them being poor, small-holder farmers who rely entirely on rain-fed agriculture in developing countries. The major drivers of climate change are unsustainable human practices such as pollution, land use change, deforestation, and the use of fossil fuels [12,13,14,15,16]. These activities are responsible for elevated greenhouse gases (GHS) that are responsible changes in the global climate system [17]. Poverty, poor policies, weak institutional frameworks, and insufficient knowledge on the effects of climate change catalyze the intensity of the negative effects of climate change (African Ministerial Conference on Environment [18,19].

Kenya is no exception to the effects of climate change [20]. High temperatures have been recorded, as have floods, prolonged droughts, declining water levels, and the loss of ecosystems and ecosystem services [21,20,22,23,24,25,26]. Because most economic activities rely on climate-sensitive sectors such as agriculture and tourism, the effects of climate change and variability are a threat to the country's economy and peoples' livelihoods [10,27,28,29,24]. Majority of Kenyans are unaware of climate change and its effects; and are more concerned about food insecurity caused by the recurring droughts and floods [30,31]. There are low levels of climate change awareness and there is urgent need the determine its extent [23]. Kenyans' low climate change awareness reveals some degree of uncertainty in climate change preparedness, coping, and adaptation [32,33]. As a result, there is a mixed discourse on people's perceptions of climate change, its impacts and climate change vulnerability [34].

Agriculture is dependent on favourable prevailing climatic conditions that are vulnerable to climate changes [35]. Several studies show that farmers believe climate change is real based on occurrences of heavy rains, changes in rainfall timing, irregular droughts and temperature

changes landslides, increased crop pest incidences, thunderstorms and hailstorms, winds and floods [6,24],

Forest-adjacent communities of the Kakamega-Nandi Forest Ecosystem Complex (KNFEC) rely on unsustainable climate-sensitive activities for livelihoods. Unfortunately, knowledge about climate change in the KNFEC is not well documented. According to [36], land-uses without meaningful forest cover, such as bare-land, subsistence agriculture, bush-land, and grassland, reduce soil organic carbon sequestration, which alter the climate and increase vulnerability to climate change. In KNFEC, forest-adjacent communities are legally allowed to cultivate subsistence crops such as maize, finger millet, beans, and cabbages in state forests by clearing indigenous bush land in order to prepare the land for the cultivation of perennial trees. This practice, also known as the 'Shamba System' initiative [37,38] alters the forest structure, increases emission of greenhouse gases and ultimately alters the climate of region. It is therefore important to assess the level of climate change awareness among the residents within KNFEC [39]. Assessing the awareness of climate change among the forest-adjacent communities in the KNFEC is imperative, because resilience and adaptive capacity to the changing climate are dependent on awareness, perception and vulnerability to climate change [40]. Socioeconomic and environmental factors such as level of education, food security, farming experience, household size, rainfall pattern, and temperature, influence perception of climate change [41]. Climate change perception and awareness have been assessed among small farmers in Kenya [42,16], but these studies were conducted among non-forest adjacent communities.

This study assessed the level of awareness and perception among forest-adjacent communities in the KNFEC. The working hypothesis was that raising climate change awareness among KNFEC communities would enhance their mitigative and adaptive capacities to climate change impacts. Findings of this research will support knowledge-based decision-making by national and county governments, the private sector, development partners, and civil society, among others. Findings will also bridge the gap between policy formulation and the development of mitigative and adaptive capacity to climate change among residents in the study area.

2. MATERIALS AND METHODS

2.1 Description of the Study Sites

This research was carried out in Kakamega-Nandi forest ecosystem complex which is made up of the Kakamega, Nandi South, and Nandi North forests. These forests are believed to have been one single block in the past [43,44] and have a lot similarities in species diversity. A number of studies have as , however, provided contradictory data that contradicts this theory and have attempted to demonstrate that the forests are indeed distinct but closely related [45]. There is insufficient data on the extent of their similarities. These forests serve as water catchment areas for the Isiukhu and Yala rivers, which flow into Lake Victoria [46].

2.2 Target Population

Households of forest-adjacent communities in the Kakamega-Nandi forest ecosystem were the target population. Community members who had lived in the ecosystem for at least twenty-five years were selected for the data collection. These residents were better placed to provide an evaluation of their experiences with the weather events, climate changes and mitigative capacities for climate change [59].

2.3 Sampling Procedure

The study used a cross-sectional survey design to collect data using both primary and secondary sources. Primary data was obtained using structured questionnaires. A household survey was conducted by administering structured questionnaire which included both close and open-ended questions to collect qualitative and quantitative data on households and their activities.

Household data as well as information on climate change awareness among the forest-adjacent residents of the North Nandi forest (Kipsamoite), South Nandi forest (Kaptumo), and Kakamega forest (Buyangu and Isecheno) were collected. The information gathered included household characteristics such as gender, age, length of stay in forest ecosystem, education, and the number of people in each household. Household resource characteristics included the type of house, the source of communication, the source of water, and main sources and availability of food. Climate change characteristics assessed included knowledge about climate change, the

impacts of climate change, sources of information about climate change, the level of concern about future climate impacts, causes of climate change, extreme weather events such as floods, drought, and storms, and finally the mitigative and adaptive strategies for climate change impacts. Residents aged 25years and above were chosen at random and asked to fill the questionnaires.

The random sampling method was used to select household respondents for the questionnaire. The number of respondents was determined on the basis of the total number of households within the ecosystem (Table 2). Three hundred and ninety-seven (397) households were selected for random administration of the questionnaires questionnaires from all the villages.

The number of questionnaires was determined using the formula described by Yamane (1967) and Israel (1992).

$$n = \frac{N}{1 + N(e^2)}$$

Where:

n = sample size
N = total of households per village
e = marginal error (0.05).

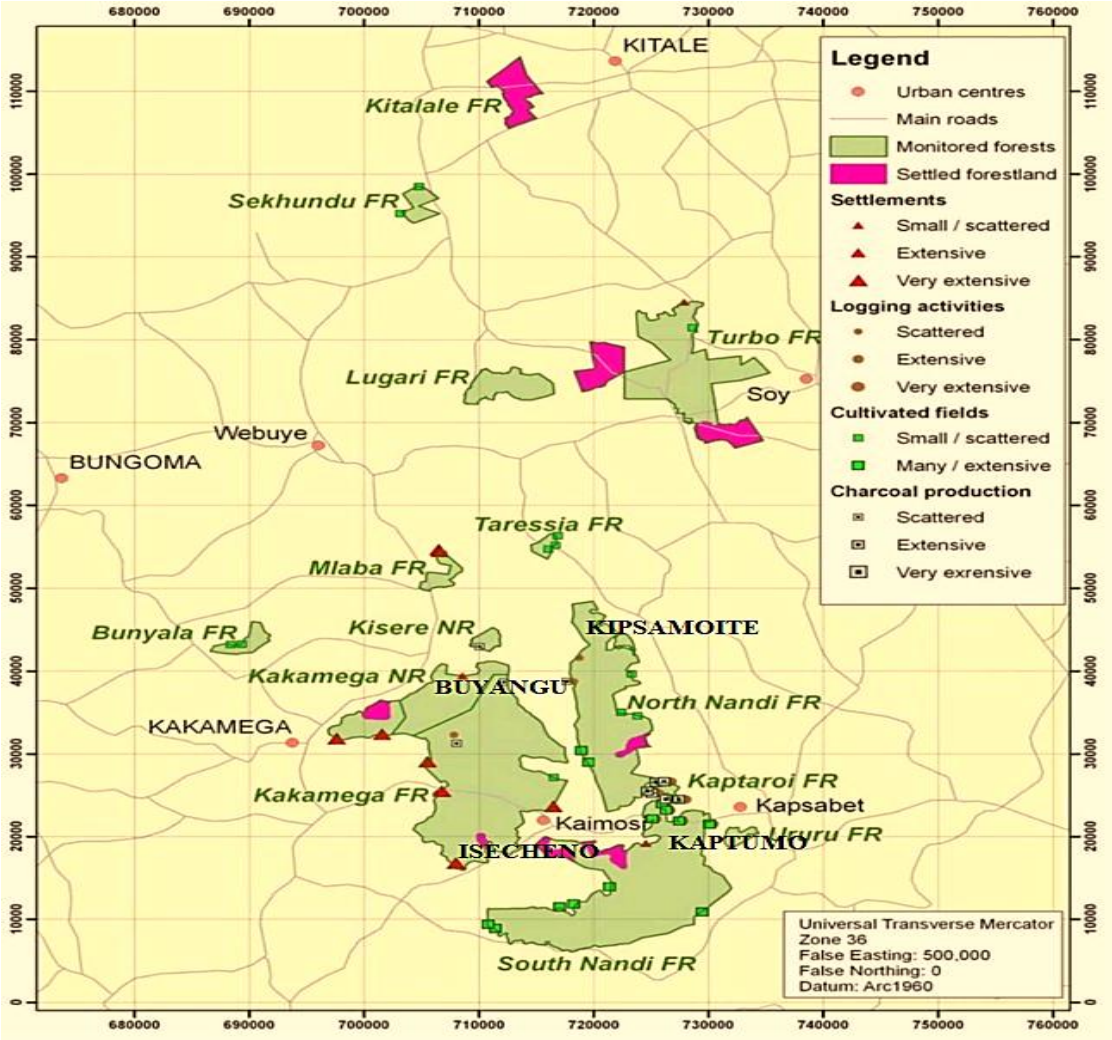

Fig. 1. Map of Kakamega, Nandi South and Nandi North forests showing the sampling areas (Adapted from Klopp, 2012)

Table1. Characteristic feature of Kakamega, Nandi South and Nandi North forests

Variable	Units	Kakamega	Nandi South	Nandi North
Area	Ha	23,841[a]	17,894 ha[a]	10,332ha[a]
Longitude		34°46'08.0'' E and 34°57'26.5'' [a]	37^{o} 05E-37^{o}23'E and 0^{o} .00'-0^{o}.15'N[b]	34^{o} 51' 0" E and 35^{o} 10' 0" E[m]
Latitude		00°08'30.5'' N and 00°22'12.5'' N[a]	0^{o} 18'N-0^{o}32N and 34^{o} . 45'E-35^{o} .07'E [b].	0^{o} 33' 30" N and 0^{o} 4' 30" N[m]
Altitude	m a.s.l	1500-1700[a]	1700 – 2000[b]	2000 – 2140[p]
Annual temperature	^{o}C	20±4.8[f]	17°C - 20°C [b]	17°C - 18°C [b]
Annual rainfall	mm	1956-2215[a,d,e]	1600-1900[b]	1200-2000[b]
Soil types		Ferrisols[c]	Ferralic-orthic and humic Acrisols, mollic Nitosols and humic Cambisols[l] Friable sandy clays (Acrisols)[e] Humic Nitosols[k]	Sandy and clay loam having humic nitisols[m].
Geology types		Basalt, phenolites and ancient gneisses[b]	Granitic and Basement System rocks[e]	Ferralochromic acrisols[b]
Flora		Guineo-Congolian and Afromontane species Its characterized with endemic plant species and is known for its large species diversity .	Dominated by *Croton megalocarpus*[g] Guineo – Congolian origin species such as *Antiaris toxicaria, Harungana madagascariesis, Trilepisium madagascariense and Zanthoxylum gilletii*[h]	Guineo-Congolian and Afromontane species

[a] [47]; [b][48]; [c][49], [d][50], [ek][51], [f] [52], [h][53], [l][54], [j][55], [l][56], [m] [57], [n] [58]

Table 2. Number of households in Kakamega forest ecosystems

Location	Number of households	No. of Households sampled
Kakamega Central	21206	160
Kakamega North	5139	39
Kakamega East	18668	141
Kakamega South	3816	28
Kakamega West	3897	29
Total	52729	397

(Source: KNBS, 2010)

The number of questionnaires for sampling was calculated as:

$$n = \frac{N}{1 + N(e^2)}$$

52379/1+ 52729 $(0.05)^2$
=397 households

We used Cochran's (1977) sample size formula to calculate the sample size for this study.

$$n = \frac{n_o}{1 + \frac{(n_o - 1)}{N}}$$

Where;

n_o = Cochran's sample size recommendation,
N = the population size, and
n = the new, adjusted sample size

A total of 280 structured questionnaires respondents were chosen as the desired sample size to assess the awareness of the residents about climate change. The questionnaires were randomly distributed to residents aged 25 and

above in the forest complex In South Nandi forest, 54 questionnaires were distributed, 76 in North Nandi while 150 were distributed in the Kakamega forest ecosystem. Random sampling was used to identify respondents for the questionnaire. Data collected was corroborated through Focused Group Discussion and key informants.

Focused group discussion (FGD) involved specialized groups such as the women groups, village elders, local administrators, CBO working in the ecosystem, among others. A total of thirty (30) key informants were randomly selected for the discussion and they were distributed as follows; 2 government officials, 3 local leaders, 2 representative of women groups , 2 selected households, 3 experts in climate change and 3 representatives from CBOs working in the area. This number of key informants is in agreement with Kumar (1989) of between 15-35 persons. The FGD was important in collecting data on how information on the climate change was disseminated and the level preparedness. In addition, the FGD identified the channels through which authorities communicated information on climate change.

The process of Key informants involved interviewing key people working the forest ecosystem and included, staffs from Kenya Wildlife Service Kenya Forest Service the County and National environmental officers, and agricultural and extension officers at the national and county levels. The process employed structured interviews whose focus was on climate change preparedness, mitigation and adaptive capacity by the forest adjacent communities. The interviews revealed the economic activities the communities were involved, making it possible to identify the number of alternative survival mechanisms.

The surveyed households data was analyzed by use of Statistical Package for the Social Sciences (SPSS). Reliability of questionnaires, was assessed by the test-retest method using 30 questionnaires in the Cherengani forest-adjacent communities, two weeks apart. The Cronbach alpha coefficient was calculated using the following equation [60] which gave a Cronbach alpha coefficient of 0.8, indicating that the information gathered using the questionnaires was acceptable [61].

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

N = the number of items.
c̄ = average covariance between item-pairs.
v̄ = average variance.

2.4 Data Analysis

The Statistical Package for Social Sciences (SPSS) version 25 was used to quantitatively analyzed the data. First, the data was analyzed to determine frequencies and proportions. Factor analysis was performed to identify the most important factors contributing to climate change. Chi square tests were used to determine the association between variables because descriptive statistics were insufficient to determine significant relationships between dependent and independent variables.

3. RESULTS AND DISCUSSION

3.1 Socio-economic Profiles of Respondents

Fifty-six (56) percent of the respondents were males while 44% were females (Fig 2a). The percentage of respondent finding based on sex has also been on observed in a number of studies [62,63,64]. The Kaptumo and Buyangu sites had the most male and female respondents, with 29 and 30 percent, respectively. Isecheno had 20% while Kipsamoite 21% (Fig. 2b). The study's higher male respondents could be explained by the fact that it targeted household heads, the majority of whom are males in the region. The disparity in respondents across study sites is attributed to sample size estimation, as explained in the methods section above.

The majority of the households heads sampled were between the ages of 31 and 50 years, accounting for 59 percent of all respondents. Interestingly, 19 percent were between the ages of 61years and above (Fig. 3). The study's high percentage of middle-aged people is related to the study's target population, many of whom are household heads in their middle age (31–50 years) [28]. The percentage of respondents of over 60 years old, suggest that many of them are retired and spend most of their time at home, making it easier to reach them.

The findings revealed that 47% of respondents had a secondary school level of education, while

16% had a primary level of education, 5% had a degree, and 14% had a diploma. 18 percent had no formal education (Fig.4). This observation is in disagreement with the 2009 Kenya Bureau of Statistics (KNBS) census report [28]. According to this report, the majority of Kenyans (51%) had completed primary school, followed by those who had completed secondary school (17%) [65]. However, the low percentage of respondents with primary school education reflects the elderly population over the age of 60 years who may not have benefited from free primary and secondary education.

3.2 Factors Contributing to Climate Change

Using factor analysis, fourteen key factors were identified as impacts of climate change. These factors included an increase in rainfall, prolonged drought, decrease in the quality and quantity of fresh water, decrease in food security, an increase in temperature, a decrease in agricultural resources, an increase in sickness and disease, a decrease in quality of life, flooding, a decrease in forest cover, storm surges and flooding, reduction in biodiversity (Fig. 5). These findings are consistent with other observations made about the key indicators of climate change [15,42,66,67].

Storm surges, decreasing mean rainfall, increased floods, and temperatures all have higher Eigen values, according to our findings (Fig. 5). This is most likely because the residents of this forest complex have always been buffered by having a forest in their immediate surroundings, which creates a microclimate, and any slight change in parameters can be easily noticed, as opposed to those who live further away from the forest and observe variation in the mentioned parameters as a norm. People who are mostly exposed to climate change effects will have a lower vulnerability index than their counterparts who are not exposed to climate change effects [40].

The Chi square test revealed a significant relationship between forest cover decline and changes in rainfall patterns, increasing temperature, drought, and storm surges [(X^2 = 111.86, df =12, p=0.0000); (X^2 = 80.492, df =12, p=0.0000); (X^2 = 204.84, df =16, p=0.000); (X^2 = 74.34, df =8, p=0.000)]. This observation is consistent with the findings of [68], who found that declining forest cover always caused an increase in local temperature, decreased rainfall, and prolonged drought. According to [69], forest cover modifies the microclimate of areas adjacent to the forest. Similar results were also reported by [70] who pointed out that the major driver of climate change was deforestation that has aggravated release of greenhouse gases in the atmosphere resulting in an increase temperature. The respondents' level of education was also found to be significantly different from their level of climate change awareness (X^2=44.88, df=4, P0.000). This is because access and understanding of information is directly linked to the literacy level. It is on record that highly educated respondents have more information about climate change than those individuals who are less literate or semi-literate [17,71,72].

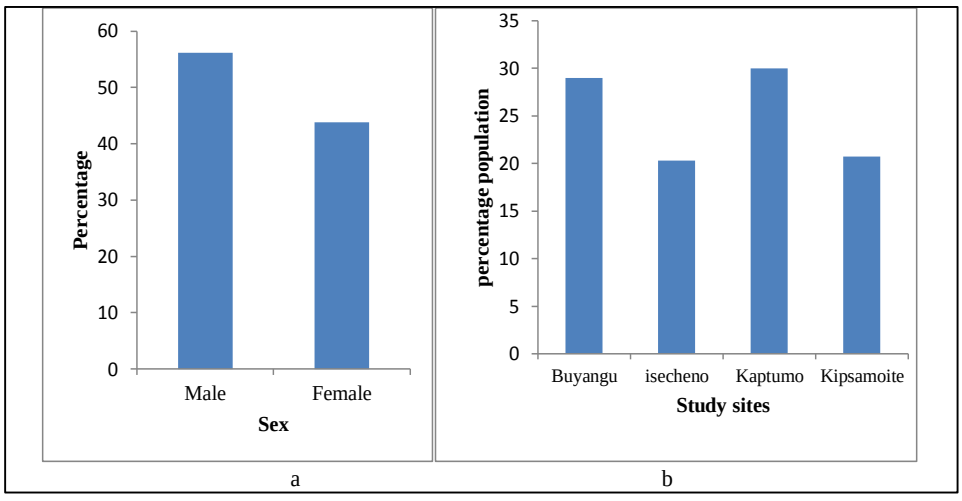

Fig. 2. Shows the differences in the gender of the respondents (a) and percentage population of the respondents in the study site (b)

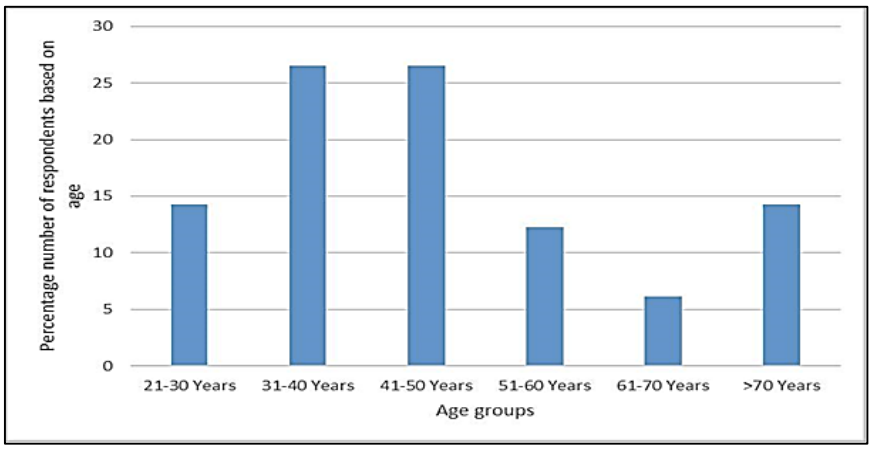

Fig. 3. The percentage age distribution of the respondents within households in the KNFC

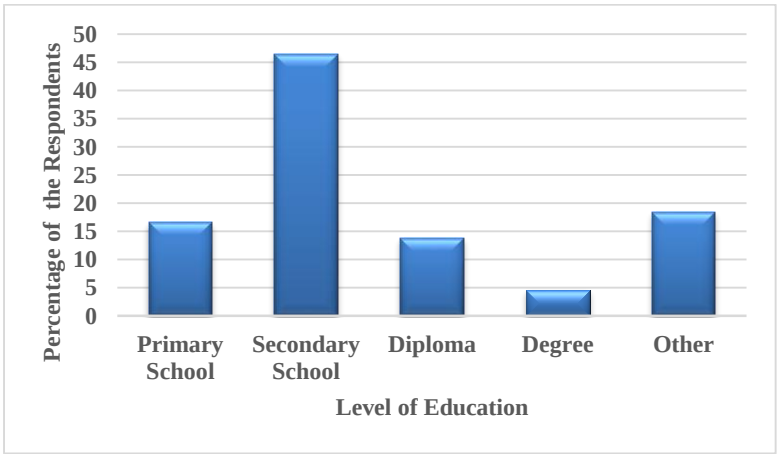

Fig. 4. Percentage level of education among the respondents in KNFEC

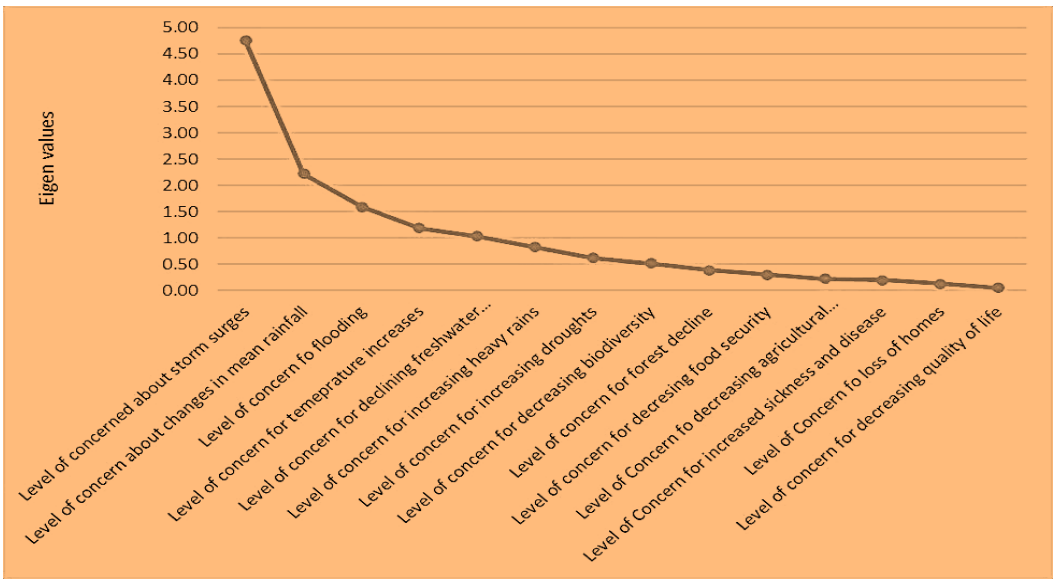

Fig. 5. Key factors contributing to climate change using Eigen values

3.3 Concerns about Climate Change

There were greater concerns from the respondents about declining food security, rising temperatures, increasing droughts and declining forest cover compared with other key underlying indicators of climate change, such as storm surges and the declining forest cover (Fig. 6). These findings are consistent with those obtained by [42] in the Nyanza region. These findings concur with those of [73], who found that most Kenyans are preoccupied with immediate and short-term effects of climate changes such as food insecurity. It is therefore critical to train and educate the residents of this forest ecosystem complex on the underlying activities that cause the climatic conditions of any region to change. This includes the conversion of natural forest to agricultural land, which disrupts the soil organic carbon balance and causes a large influx of carbon dioxide into the atmosphere. This is evidently being practiced in the study via the 'shamba system' [37,38].

3.4 Levels of Concern about Climate Change

Despite being aware of the climate change indicators, analysis of the level of concern about climate change among residents in the ecosystem revealed that the majority of residents were a little concerned with approximately 54%, followed by moderately concerned 26%, very concerned 5 %, and those not concerned at all 15% (Fig 7). These observations reflect perhaps, the residents' level of education and experiences of the adverse effects of climate change [17,72] possibly buffered by the forest. This has made them to be less keen although they are extremely vulnerable to impacts of climate change [26]. These findings concur with those of [71] in which they found variation in the levels of awareness about climate change with 75% in Brazil, 41% in South Africa, 59% in China, and highest awareness was in United States with 94% [74]. These levels of awareness reflected the levels of economic developments from which they concluded that, less developed countries have limitations of spreading awareness about climate change hence the low levels of concern level of development with [71].

3.5 Levels of Knowledge to Cope and Adapt to the Adverse Impacts of Climate Change

In this study, 85% of respondents admitted that they have no idea on how to respond to the adverse effects of climate change. Approximately 5% of respondents stated that it is possible to cope with and adapt to the negative effects of climate change (Fig. 8). These findings may be attributed to the level of education/knowledge about climate change among the residents in the study area. Majority of the residents had only attained secondary school level of education, which may explain the lack of skills to cope and adapt to the impacts of climate change. According to [38,75] climate change knowledge and information form the foundation of residents' preparedness and adaptability to the adverse effects climate change. Nevertheless, the findings from the present study concur with studies by [76,18,77]. They argue that age, income, and other socio-economic characteristics have a significant effect on farmers' perception of climate change and choice of adaptation strategies and perceptions of climate change. It is also possible to note that the nature of livelihood by residents determines the ability to adapt and cope with impacts of climate change [78,79,80]. For instance, farmers who rely solely on climate sensitive practices will develop coping and adaptation strategies easily unlike those with blue collar jobs [35]. The Kakamega-Nandi Forest Ecosystem complex has experienced relatively stable climatic elements for some time and therefore knowledge on coping and adapting strategies has not been adequately embraced by the residents. The smaller percentage of comprehensive and moderate knowledge may be a result of the high level of illiteracy in the ecosystem [81]. In a study carried in Pakistan about coping and adapting to the impacts of climate change established that low literacy level among respondents reflected low levels of climate change awareness and consequently impacting the ability to adapt and cope with adverse effects of climate change [64].

3.6 Source of Information about Climate Change

Fig. 9 shows results on sources of information about climate change. Approximately 50% and 30% of the KNFEC respondents got information about climate through televisions and local radio stations, respectively. This was followed by print media with about 20%. Village meetings/training and friends sources of information about climate change accounted for 5%. These results contradict the findings of [82] in a study in Indonesia where they found that broadcast media as a source of information about climate change accounted for 7%. Unlike in Indonesia

where there are varied sources of information. Kenya relies predominantly on broadcast media as the main sources of information. It is notable that family meetings/talks accounted for 53% of sources of information about climate change. This was attributed to the fact that their study focused on the adolescents' respondents. A study by [2] in India concurs with our findings. They found that the most common source of information about climate change was television. Their results on other sources information varied greatly with our findings by 60% newspaper and magazines 42%, radio 13%, and internet 9%. This sharp difference is perhaps linked to the literacy among the respondents in the study area. This finding may be linked to the level of literacy of the respondents in the study area in India. A study by [83] in Kisumu revealed that the library was considered the most appropriate media of passing information about climate change followed by the internet and local radio stations respectively while national radio stations and television were perceived the least appropriate. These findings differ from the findings of this study on the basis of the respondents sampled [29]. However, it is worth to note that there is significantly, less information on climate change channeled through the widely used and easily accessed media such as radios, newspapers and televisions.

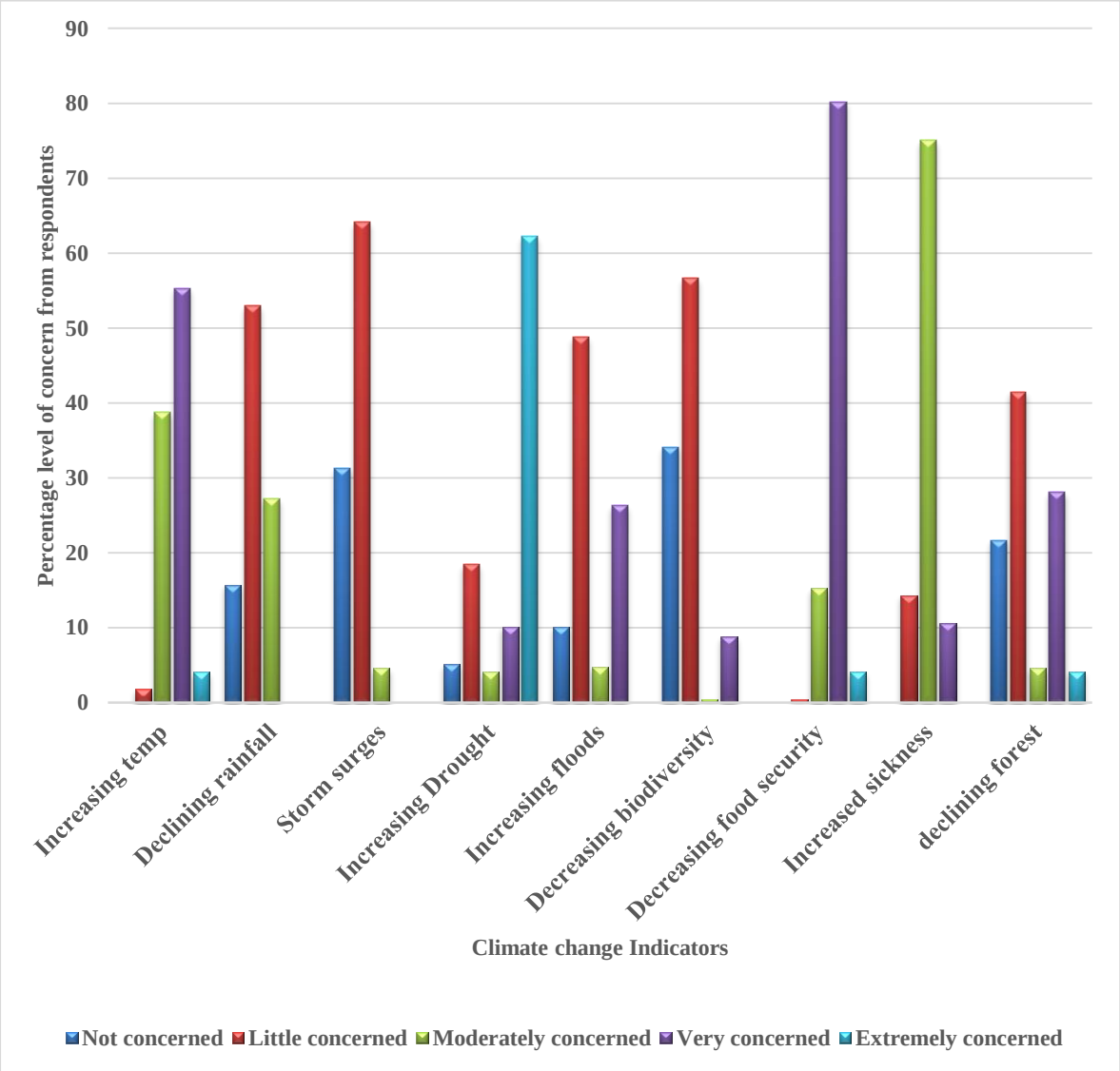

Fig. 6. Level of concern about the changing indicators of climate change

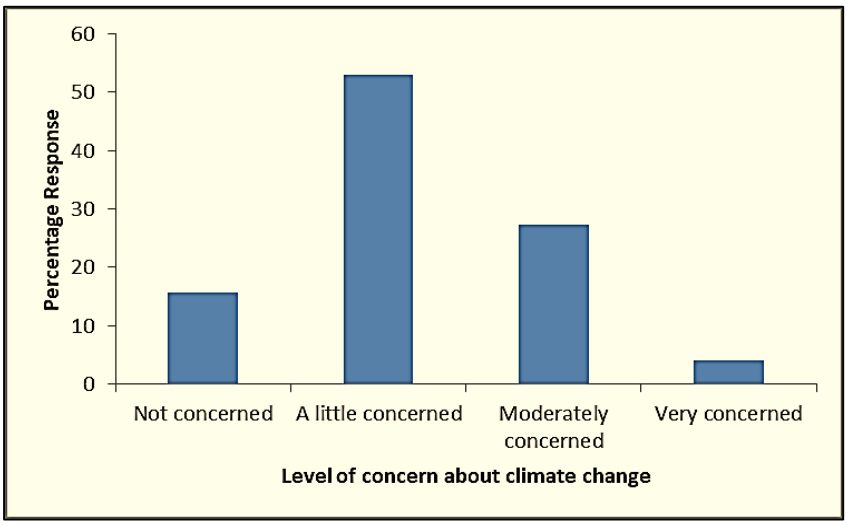

Fig. 7:. Level of concern about climate change in the study site

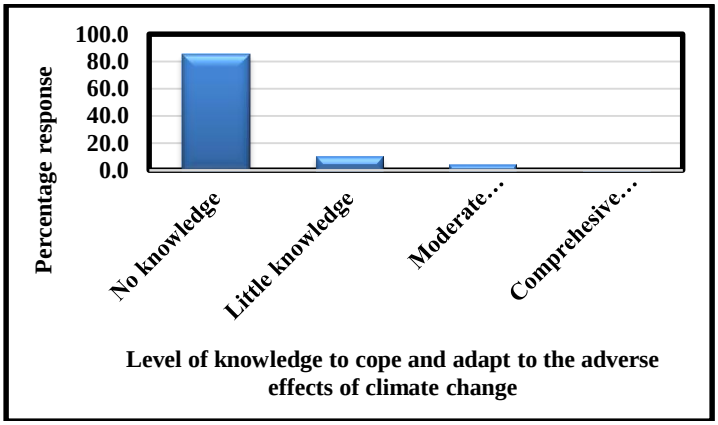

Fig. 8. Levels of knowledge to cope and adapt to the adverse impacts of climate change

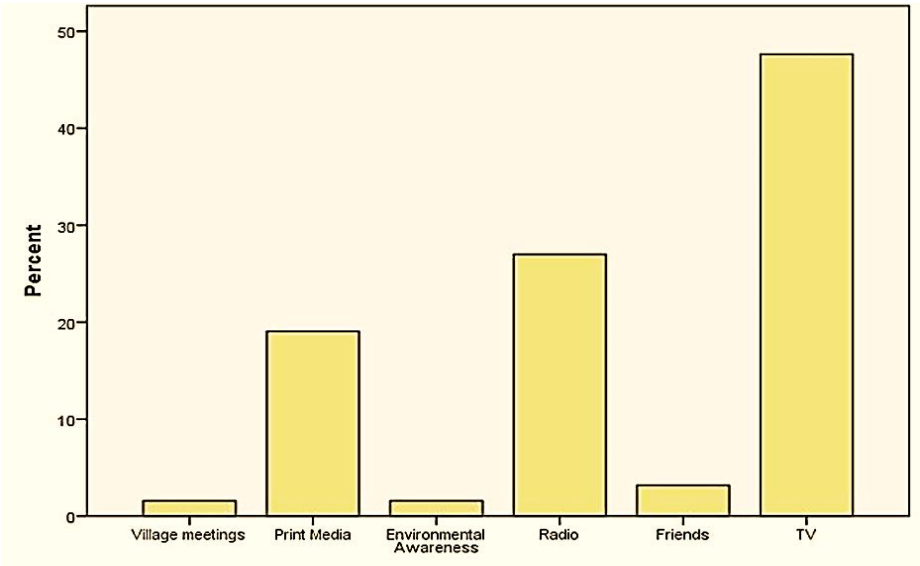

Fig. 9. Sources of information about climate change in KNFEC

4. CONCLUSION

Residents of Kakamega Nandi forest ecosystem complex are vulnerable to climate change and are unaware about climate change in the region. Less than 10% of the forest-adjacent community members were aware and concerned about climate change and its impact. A large percentage of about 85% had no information at all about coping and adapting strategies to the adverse effects of climate change. The decline in the forest cover appears to be responsible for the rise in temperature, prolonged droughts, changes in the rainfall patterns and increased incidents of diseases. The main source of information about climate change is TV, radio and print media. However, from our results there is need to embrace the modern technology in spreading climate change awareness by developing interactive mobile apps that will enhance efficient and effective passage of information.

6. RECOMMENDATION

There is the need to develop a program whose aim will be to improve the knowledge and awareness about climate change of the forest-adjacent communities. Broadcast media should focus on both the hazards caused by effects of climate change and awareness, mitigation and adaptive strategies. Further, there is need to embrace modern communication technologies in spreading information on climate change awareness such us of mobile apps among other social platforms that have a larger audience. Finally, more effort should be placed on the development of climate change vulnerability indices(CCVI) for this complex forest ecosystem. This would help in monitoring and development of both mitigation and adaptation strategies

ETHICAL APPROVAL

The research was approved by Moi University's Graduate School as part of the PhD thesis after meeting the university's post-graduate guidelines.

FUNDING

The study was supported by grant from NACOSTI, Kenya 2014/2018

STATEMENT OF CONFLICT OF INTEREST

The authors declare that no commercial or financial relationships existed that could be construed as a potential conflict of interest when conducting the research.

ACKNOWLEDGEMENTS

We thank the Kenya Forest Service, Kakamega Regional Centre for mapping development resources, and the farmers for allowing us to collect information within the forest complex.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. IPCC Climate change and land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. 2020 Intergovernmental Panel on Climate Change; 2020.
   ISBN 978-92-9169-154-8.
2. IPCC. Climate Change Impacts, Adaptation and Vulnerability -Summary for Policymakers. Contribution of Working Group II to the Fourth Assessment Report of the IPCC; 2007b.
   Adejuwon SA. Impact of climate variability and climate change on crop yield in Nigeria. Contributed paper to Stakeholders workshop on Assessment of Impact & Adaptation to Climate Change (AIACC); 2004.
3. Millenium Ecosystem Assessment (MEA) Ecosystem and human well-being: Our human planet. Summary for policy makers, Island Press; 2005.
4. Howe PD, Markowitz EM, Lee TM, Ko CY, Leiserowitz AA Global perceptions of local temperature change. Nat Clim Chang. 2013;3:352–356.
   DOI: 10.1038/nclimate1768
   Available:https://doi.org/10.1088/1748-9326/11/9/094025
5. IPCC. Impacts, adaptation and vulnerability. IPCC working group II, third assessment report. McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS, editors. Cambridge: Cambridge University Press; 2001.
6. Semenza JC, Ploubidis GB, George LA. Climate change and climate variability:

Personal motivation for adaptation and mitigation. Environ Health. 2011;10:46.
7. Ishaya S, Abaje IB. Indigenous people's perception of climate change and adaptation strategies in Jema's local government area of Kaduna State, Nigeria. Journal of Geography and Regional Planning. 2008;1(1):8–143.
8. World Resources Institute. The Wealth of the poor-managing ecosystems to fight poverty. United Nations Development Programme, United Nations Environment Programme, World Bank, World Resources Institute, Washington DC; 2005.
9. Kurukulasuriya P, Mendelssohn R. Endogenous irrigation: The impact of climate change on farmers in Africa. CEEPA Discussion Paper No. 18. Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa; 2006.
10. FAO. Social protection and agriculture: breaking the cycle of rural poverty. Food And Agriculture Organization Of The United Nations. Rome; 2015.
11. IPCC. Climate change (2014) synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland; 2014.
12. Cook J, et al. Quantifying the consensus on anthropogenic global warming in the scientific literature. Environ Res Lett. 2013;8(2):1–7.
DOI: 10.1088/1748-9326/8/2/024024
13. Canadel JG, et al. Interactions of the carbon cycle, human activity, and the climate system: A research portfolio. Curr. Opin. Environ. Sustain. 2010;2:301–311.
DOI: 10.1016/j.cosust.2010.08.003
14. Weart SR. The idea of anthropogenic global climate change in the 20th century. WIREs Clim Change. 2010;1:67–81.
DOI: 10.1002/wcc.6
15. IPCC. Climate Change (2007) Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press; 2007.
GoK. National Climate Change Action Plan 2018-2022. Nairobi: Ministry of Environment and Forestry; 2018.
16. Nichols A, Maynard V, Goodman B, Richardson J. Health, climate change and sustainability: A systematic review and thematic analysis of the literature. Environ Health Insights. 2009;3:63–88.
17. Pachauri S, Spreng D. Measuring and monitoring energy poverty. Energy Policy. 2011;39(12):7497–7504.
DOI: 10.1016/j.enpol.2011.07.008
18. Deressa TT, Hassan RM, Ringler C, Alum T, Yesuf M. Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile basin of Ethiopia. IFPRI Discussion Paper No. 798. Washington D.C: International Food Policy Research Institute, IFPRI; 2008.
19. AMCEN. Addressing climate change challenges in Africa: a practical guide towards sustainable development. African Ministerial Conference on Environment (AMCEN), Nairobi; 2011.
20. Government of Kenya. National climate change response strategy (NCCRS). Ministry of Environment and Mineral Resources. Nairobi; 2010a.
21. Huho JM, Kosonei RC. Understanding extreme climatic events for economic development in Kenya. IOSR Journal of Environmental Science, Toxicology and Food Technology. 2010;8(2):14-25.
22. Herrero M, Ringler C, Van de Steeg J, Thornton P, Zhu T, Bryant E, Omollo A, Koo J, Noternbaert A. Climate variability and change: Impacts on Kenyan Agriculture. Washington: International Food Policy Research Institute, IFPRI; 2010.
23. Mutimba S, Mayieko S, Olum P, Wanyama K. Climate change vulnerability and adaptation preparedness in Kenya. East and Horn of Africa, Nairobi: Heinrich BöllStiftung; 2010.
24. SEI. The economics of climate change in Kenya. Oxford: Stockholm Environment Institute, SEI; 2009.
25. Kuria D. Coping with climate change: understanding local communities' knowledge and their coping strategies to climate change. A Project Report to START; 2009.
26. Mtambanengwe F, Mapfumo P, Chikowa R, Chamboko T. Climate change and variability: Smallholder farming communities in Zimbabwe portray a varied understanding. Africa Crop Sci J. 2012;2(2):227–241.

27. GoK. Kenya Vision 2030 (2007): A globally competitive and prosperous Kenya. Nairobi: Government Printer (GoK); 2007.
28. GoK National climate change response strategy. Nairobi: Government Printer; 2010.
29. Ochieng M. Climate change awareness and policy implications among primary school teachers in Kisumu City ,. Masters dissertation, Maseno University; 2014.
30. NEMA. Kenya's capacity needs to implement article 6 of the united nations framework convention on climate change. Nairobi; 2005.
31. Pelham BW. Awareness, options about global warming vary worldwide; 2009. Available:http://www.gallup.com/poll/117772/awareness-options-Global-Warming-Vary-Worldwide.aspx#2.
32. Leiserowitz AA, Climate change risk perception and policy preferences: The role of affect, imagery, and values. Clim Change. 2006;77:45–72. DOI: 10.1007/s10584-006-9059-9
33. Brechin SR, Bhandari M. Perceptions of climate change worldwide. WIREs-Clim Change. 2011;2:871–885. DOI: 10.1002/wcc.146
34. Collier P, Conway G, Venables T. Climate change in Africa. Oxford Reviews of Economic Policy. 2008;24(2):337. DOI: 10.1093/oxrep/grn019
35. Stern N. The economics of climate change. Cambridge University Press. 2007;712.
36. Wabusya WM, Pili NN, Bekuta BK, Tsingalia HM, Kakembo V. Effects of land use changes in soil chemical parameters in Kakamega-Nandi forest Complex. Tropical and subtropical Agroecosystems. 2020;23(3):1-9.
37. Oduol PA. The Shamba system: An indigenous system of food production from forest areas in Kenya. Agroforestry systems. 1986;4.
38. Coyle D, Meier P. New technologies in emergencies and conflicts: the role of information and social networks, USA; 2009.
39. Mertz O, Mbow C, Reenberg A, Diouf A. Farmers' perceptions of climate change and agricultural adaptation strategies in rural sahel. Environmental Management. 2009;43:804-816.
40. World Bank. Sustaining forests: A development strategy. Washington D.C.: The World Bank; 2004.
41. Akter S, Bennett J. Household perceptions of climate change and preferences for mitigation actions: The case of the carbon pollution reduction scheme in australia. environmental economics research hub research report No. 19. Canberra, Australia: Australian National University; 2009.
42. Ajuang CO, Abuom PO, Bosire EK, Dida GO, Anyona DN. Determinants of climate change awareness level in upper Nyakach Division, Kisumu County, Kenya. SpringerPlus. 2016;5(1). Available:https://doi.org/10.1186/s40064-016-2699-y
43. Doute RN, Ochanda N, Epp H. Forest cover mapping in Kenya using remote sensing techniques. Kenya Rangelands Ecological Monitoring Unit Technical Report No. 30; 1981.
44. Tsingalia HM, Kassilly FN. The origins of kakamega forest grasslands: A critical review. Journal of Human Ecology. 2009;27(2):129-135.
45. Mitchell N, Schaab G, Wolfgand Wagele J. Kakamega forest ecosystem: An introduction to the natural history and the human context; 2009.
46. Fashing PJ, Forrestel A, Scully C, Cords M. Long-term tree population dynamics and their implications for the conservation of the Kakamega Forest, Kenya. Biodiversity and Conservation. 2004;13:753–771.
47. KIFCON. Kakamega forest - The official guide, Kenya Indigenous Forest Conservation Programme, Nairobi, Kenya; 1994.
48. Cords MC. Demography of blue monkeys in the Kakamega Forest, Kenya. International Journal of Primatology. 1987;8:546.
49. Schultka W. Gehölz-sukzessionen in regenwald- und feuchtsavannen-gebieten bei Kakamega (West-Kenia), Oberhessische Naturwissenschaftliche Zeitschrift, Band. 1975;42:35-48.
50. Lung T. Assessing processes of long-term land cover change and modeling their effects on tropical forest biodiversity patterns – a remote sensing and GIS-based approach for three landscapes in East Africa. PhD Dissertation, Technical University of Dresden; 2010.
51. Blackett HL. Forest inventory report no. 10: North Nandi, Kaptaroi and Taressia. Forest Department / KIFCON (Kenya Indigenous

Forest Conservation programme), Nairobi, Kenya; 1994b.
52. Steinbrecher R. Impact of changing biodiversity in tropical agro-forest ecosystems in Africa on the exchange potential of trace gases between ecosystems and atmosphere, in: BIOTA East Africa, Final report phase I: 2001 – 2004; 2004.
53. White. The vegetation of Africa, a descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa. UNESCO, Natural Resource Research. 1983;20:1-356.
54. Jätzold R, Schmidt H. Farm management handbook of Kenya – Natural conditions and farm management information. Part A: West Kenya, Nyanza and Western Provinces. Ministry of Agriculture, Nairobi, Kenya and University of Trier, Trier, Germany. 1982;II.
55. Nair P, Nair PR. Soil productivity aspects of agroforestry. International Council for Research in Agroforestry Nairobi, Kenya; 1984.
56. Farwig N, Sajita N, Böhning-Gaese K. Conservation value of forest plantations for bird communities in western Kenya. Forest Ecology and Management. 2008;255(11):3885–3892.
57. KFS. Kenya forest service annual report Khisro W (2013) the effect of climate change on the vegetation cover of the Mujib Nature Reserve the Dead Sea; 2010.
58. Mitchell N, Lung T, Schaab G. Tracing significant losses and limited gains in forest cover for the Kakamega-Nandi complex in western Kenya across 90 years by use of satellite imagery, aerial photography and maps. In: CD-Rom-Proceedings, ISPRS Mid-Term Symposium 'From Pixels to Processes', 8-11 May 2006, Enschede, The Netherlands; 2006.
59. Kameri-Mbote P, Nyukuri E. Climate change, law and indigenous people. International Environment Law Research Centre. London: Edward Elgar; 2013.
60. Revelle W, Zinbarg RE. Coefficients alpha, beta, omega, and the glb: Comments on Sijtsma. Psychometrika. 2009;74(1):145–154.
Available:https://doi.org/10.1007/s11336-008-9102-z
61. Downing SM. Reliability: On the reproducibility of assessment data; 2004.
Available:https://doi.org/10.1111/j.1365-2929.2004.01932.x
62. Radeny M, Isaac A. Climate variability / change and attitude to adaptation technologies : A pilot study among selected rural farmers ' communities in Nigeria. GeoJournal. 2018;83(2):319–331.
Available:https://doi.org/10.1007/s10708-017-9771-1
63. Nyberg Y, Jonsson M, Ambjörnsson EL, Öborn I. Smallholders ' awareness of adaptation and coping measures to deal with rainfall variability in Western Kenya. Agroecology and Sustainable Food Systems. 2020;44(10):1280–1308.
64. Piracha A. Chapter25 awareness of climate change impacts and adaptation at local level in Punjab , Pakistan; 2016.
Available:https://doi.org/10.1007/978-3-319-28112-4
65. GoK. National climate change action plan 2013 - 2017 executive summary, Nairobi Kenya; 2012a.
Available:https://doi.org/10.1080/21683565.2020.1782305
66. Ndambiri HK, Ritho C, Mbogoh SG, Nganga SI, Muiruri EJ, Nyangweso PM, Kipsat MJ, Ogada JO, Omboto PI, Kefa C, Kubowon PC, Cherotwo FH. Assessment of farmers' adaptation to the effects of climate change in Kenya: the case of Kyuso District. J Econ Sustain Dev. 2012;3(12):52–60.
67. Ngigi SN. Climate change adaptation strategies: Water resources management options for smallholder farming systems in sub-saharan Africa. The MDG Centre for East and Southern Africa, the Earth Institute at Columbia University, New York. 2009;189.
68. Pitman AJ, Lorenz R. Scale dependence of the simulated impact of Amazonian deforestation on regional climate. Environ Res Lett. 2016;11:094025.
69. Mansourian S, Belokurov A, Stephenson PJ. The role of forest protected areas in adaptation to climate change. Unasylva. 2009;60(231):63-69.
70. Sanford TJ, Boucher D, Katherine Lininger PE, May-Tobin CC, Roquemore S, Saxon E, Isaac J, Mulik MK. The drivers of tropical deforestation: a comprehensive review. Conference: AGU Fall Meeting Abstracts; 2011.
71. The State of Environmental Migration International Organization for Migration (IOM). Edited by Gemenne F, Brücker P,

Ionesco D. 2012 Institute for Sustainable Development and International Relations (IDDRI) / International Organization for Migration (IOM); 2011.

72. Kabir MI, Rahman MB., Smith W, Lusha MAF, Azim S, Milton AH. Knowledge and perception about climate change and human health: Findings from a baseline survey among vulnerable communities in Bangladesh. BMC Public Health. 2016;16(1):1–10. Available:https://doi.org/10.1186/s12889-016-2930-3
73. Kabubo-Mariara J, Karanja FK. The economic impact of climate change on Kenyan crop agriculture : A Ricardian approach. Policy Research Working Paper Series 4334, The World Bank; 2007.
74. Nyberg Y, Jonsson M, Ambjörnsson EL, Öborn I. Smallholders ' awareness of adaptation and coping measures to deal with rainfall variability in Western Kenya. Agroecology and Sustainable Food Systems. 2020;44(10):1280–1308. Available:https://doi.org/10.1080/21683565.2020.1782305
75. Gichangi EM, Gatheru M, Njiru EN, Mungube EO, Wambua JM, Wamuongo JW. Assessment of climate variability and change in semi-arid eastern Kenya. Climatic Change. 2015;130(2):287–297. Available:https://doi.org/10.1007/s10584-015-1341-2
76. Bradshaw B, Dolan H, Smit B. Farm-level adaptation to climatic variability and change: Crop diversification in the Canadian prairies. Climatic Change. 2004;67(1):119–141.
77. Davis P, Ali S. Exploring local perceptions of climate change impact and adaptation in rural Bangladesh; 2014.
78. Densanker PV. Climate change vulnerability in Africa. Johannesburg: Centre for African Development Solutions; 2002.
79. Pugliese A, Ray J Gallup. A heated debate: Global attitudes toward climate change. Harvard Int Rev. 2009;31: 64–68.
80. Lee TM, Markowitz EM, Howe PD, Ko CY, Leiserowitz AA. Predictors of public climate change awareness and risk perception around the world. Nature climate change. 2015;5:1014–1023. DOI: 10.1038/nclimate2728
81. Pew Research Centre. No global warming alarm in the U.S., China. The Pew Research Centre for the People & the Press, Washington, DC; 2006.
82. Sulistyawati S, Mulasari SA, Sukesi TW. Assessment of knowledge regarding climate change and health among adolescents in Yogyakarta , Indonesia; 2018.
83. Ochieng MA, Koske J. The level of climate change awareness and perception among primary school teachers in kisumu municipality, Kenya. International Journal of Humanities and Social Science. 2013;3(21):175-179.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/68660