Magna Scientia Advanced Research and Reviews

eISSN: 2582-9394

Cross Ref DOI: 10.30574/msarr

Journal homepage: https://magnascientiapub.com/journals/msarr/

(Research Article)

Check for updates

Effects of climate change on the availability of non-timber forest products (NTFPs) in the Kavonge and Museve hilltop forests in Kenya

Vandi Alex Saffa *, Harun Mutuma Kiruki and Festus Mbatha Mutiso

Department of Environmental Sciences and Land Resources Management, School of Agriculture, Environment, Water and Natural Resources, South Eastern Kenya University, P.O Box 170-90200, Kitui, Kenya.

Magna Scientia Advanced Research and Reviews, 2024, 11(02), 032–041

Publication history: Received on 20 May 2024; revised on 29 June 2024; accepted on 02 July 2024

Article DOI: https://doi.org/10.30574/msarr.2024.11.2.0102

Abstract

The study evaluated the effects of climate change on the availability of NTFPS in Kavonge and Museve hilltop forests in Kitui County, Kenya. The specific study objective was to assess local community perception on rainfall and temperature patterns on NTFPs availability. A sample size of 120 respondents were selected for the study using the Yamane formula. A purposive sampling method was used to select villages within 5 kilometer radius to both hilltop forests and a systematic transect line design of 1km by 1km was used to select households for data collections. Data were collected by employing structured questionnaires, key informant interviews and focus groups discussions. The data was analyzed using descriptive statistics (frequencies, percentages, bar charts), chi-square test and logistic regression. The result revealed that majority 83.0% of respondents strongly agreed that climatic conditions of the area has changed. The results submit that 96% of the respondents perceived an increase in temperature pattern during this recent period of 2018-2023 while, 100% perceived a decrease in rainfall pattern during this recent period of 2018-2023. The logistic regression model results revealed that, age, education, occupation and residency period significantly ($p < 0.05$) influenced community perception of climate change (rainfall and temperature) patterns on NTFPs availability in the study area. It is ascertained that the Kavonge and Museve forests edge communities still rely on the available NTFPs as a safety net when faced with unfavorable circumstances, such as crop failure due to climate change. However, it was reported that the available quantities of NTFP are declining due to climate change. I conclude that, available NTFPs will continue to decrease if stringent sustainable utilization and management measures are not implemented.

Keywords: Climate Change; Forest; NTFPs; Community; Kavonge; Museve

1. Introduction

The long-term change in distribution of weather patterns over some period of time from decades to millions of years is known as climate change [1,2]. The increase in temperature and atmospheric carbon-dioxide as well as rainfall variation, frequency and severity of extreme climatic events have been observed globally [3]. The notable changes have several impacts on global forest ecosystems through extinction of species (including plants and animals), long growing and fluctuations of seasons and change in forest fires. The human induced global climate change has entered into second half of the last century [4,5]. The change in the climatic system negatively impacts natural and manmade forests mainly artificial forest designed for carbon sequestrations. [6] estimated that 294 million ha which is 7 % world forest areas and natural regenerating forests accounting 93% of the world forest area. The changes in extreme weather and climate conditions affects forestry and agriculture productivities and increase food shortages. The effects of climate change on species populations and ecosystems affect the availability and supply of ecosystem services including changes to provisioning, regulating, supporting and cultural services are pronounced [7]. Due to changes in the ideal temperature

* Corresponding author: Vandi Alex Saffa

range, climate change has also endangered the integrity and survival of multiple species, accelerating the loss of NTFPs by gradually altering the forest structures [8].

Non-timber forest products (NTFPs) are integral part of the forest ecosystem playing supportive roles on landscape, habitat conservation and wildlife, maintenance of macro-climate and soil conservation [9,10]. This further provides a supportive role on livelihood and socio-economics security during change in agricultural systems that are essential part of communities living near forests [11,12,13]. The third world countries which are mainly the agriculture dependent are most vulnerable to climate change consequences. These countries cannot promptly prevent and respond to its impacts due to the lack of adequate knowledge on policy formulation and funding's to mitigate the effects [14]. The disastrous impacts and the rise of vulnerable groups on communities increases seasonally and periodically. Researchers has proposed the increasing effects of climate change on the impoverish population through rise in death rate, malnutrition, tropical diseases and urban heat stress by the year 2030 [15,16].

The goals and aspirations of Africa continent for sustainable development are thought to be threatened by the reality of climate change [17]. Climate change has the potential to reverse decades of African development, which is worth emphasizing. For instance, climate change is not just considering global warming but other variations in climate variability, frequency and intensity of extreme occurrences. This include an increased in droughts and floods across forest edge communities that are depending on NTFPs. Along with the effects of unexpected weather occurrences, there is also the chance of climate change accumulations until certain points are reached, which might lead to the collapse of forest communities dealing with NTFPs. This generally perceived a potential risk to livelihoods and socio- economic systems of communities depending on NTFPS [18]. According to Muzari *et al. and* Martinez *et al.* [19,20], understanding local stakeholders' attitudes and perspectives of climate change is vital since their ability to effectively adapt and have the incentive to do so depends on their ability to perceive and understand the phenomenon. Additionally, the perspectives and experiences of the local community play a vital role in supporting the planning of overall adaptation during climate change mitigation in forest edge communities.

Kenya is one of the countries in sub-Sahara Africa that depends on agricultural produces, earning about 69.7% from export and engaging 80% of Kenyan work force in manufacturing and distributions [21]. The country is endowed with diversity in climate and geological formations owning substantial climate change effect in the ASALs region. Forests in Kenya just like other forests in Africa are facing climate change related challenges leading to reduction in available NTFPs species. These climatic changes also impact on Kavonge and Museve hilltop forests in Kitui County. Despite multiple benefits which NTFPs provide, the effects of climate change on its availability has not been investigated at Kavonge and Museve hilltop forests area. Previous studies carried out in the two forests focused on anthropogenic activities on tree species composition and diversity in Kavonge and Museve hilltop forests [22]. The study took place in Kavonge and Museve hilltops forests in Kitui Central. The study aimed to evaluate the effects of climate change on the availability of NTFPs in Kavonge and Museve hilltop forests. The current study provides an understanding on how Kavonge and Museve hilltop communities perceive on the availability of NTFPs through local experiences on rainfall and temperature patterns. Also it's generate information for timely scientific input for strategic management to policy makers which can be used during initiatives to combat climate change effects. To achieve this aim, the specific objective used was to assess the local community perception on local rainfall and temperature patterns on the availability of NTFPs in the Kavonge and Museve hilltop forests.

2. Materials and Methods

2.1. The Study Area description

The Kavonge and Museve hilltop forests are located between latitude 1°19'59" S and longitude 38°2'59" E. The hilltops are dry land forests fragments both covering an area of 436Ha [23]. The forests are rock outcrops which rise above the sedimentary plains and are usually low in elevation [24, 25]. The area receives an annual average rainfall ranging from 750 mm to 1150 mm distributed in two rainy seasons. A temperature ranges from a minimum of 15.7℃ to a maximum of 27.1°C annually, with two rainy seasons, the long and the short rains seasons. The long rains seasons starts at the end of March till May, while the short rains season starts at the end of October till December [26, 27]. Temperature varies throughout, during the day, the normal temperature is around 23 ℃ and at night it is around 17℃. Dry season starts in July to August. It was estimated that the sources of livelihoods of the rural people in developing countries and their income is between 20-25% obtained from natural resources [28]. The main economic activities around Museve and Kavonge forests include raising livestock, growing agricultural crops, hunting, trading on traditional medicine, timber, firewood, building poles and charcoal burning. The location of the two forests is as shown in figure 1 below.

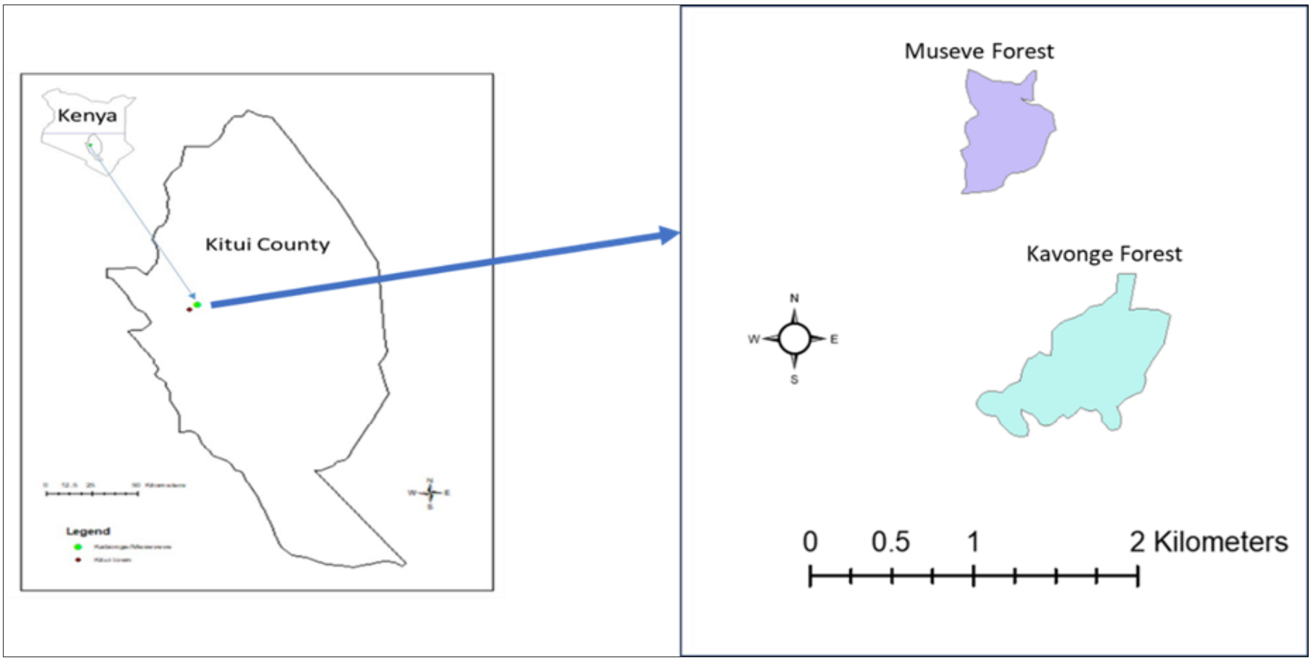

Figure 1 Location of the Kavonge and Museve hilltop forests within Kitui County in Kenya

2.2. Data collection

Many datasets were collected using both primary and secondary data. The primary data was collected using household survey questionnaires, Key informant interviews, Focus Group Discussions and direct field observations. The secondary data was collected using pertinent books, journals and published papers in the area of study. Secondary data intended to uncover research gaps and evaluate previous work related to the study's focus. A reconnaissance survey was carried to obtain fundamental understanding of the study area, pre-testing of research instruments, stakeholders identification and to give the researcher a clear general picture on the socio-economic activities, ethnicity, population size and settlement patterns of the study area. The study area was purposively selected based on their closeness to the forest while a systematic transect line design of 1km by 1km within a 5km distance from forest edge was used for household selection. The 5km distance was considered as the maximum distance from forest edge where one can make trips to the forest to collect NTFPs (figure 2). The study employed a sample of 120 respondents using lists of households established in collaboration with the village chief for each village to determine the representation through the formula adopted from Yamane [29].

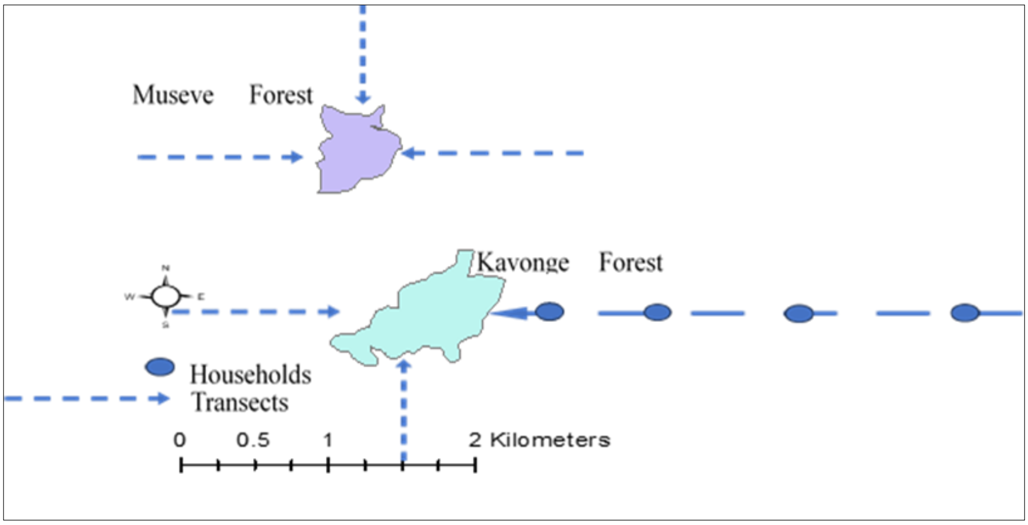

Figure 2 Research design

2.3. Data Analysis

The data were analyzed using descriptive statistics (frequencies, percentages, bar charts, etc.) and logistic regression analysis. Percentages were used to analyze perception and bar charts to represent the same. The differences in perception between the socio-economic characteristics such as age, educational level, occupation and resident duration of Museve and Kavonge hilltop forests communities were analyzed using logistic regression model. It was further applied to identify the factors that determine perception and collection of NTFPs in forest edge communities of Museve and Kavonge hilltop forests. The model specification as outlined by Gujarati [30] and applied by Ndung'u and Bhardwaj [31] is presented below

$$Y1 = \alpha + \beta 1X1 + \beta 2X2 + \beta 2X2 + \beta 3X3 + B4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7 + \beta 8X8 \text{ …………………….. (1)}$$

Where Y_i is a dichotomous dependent variable (Access to forest or not, specified as yes = 1, no =2. A is the Y-intercept whereas $\beta_1 - \beta_8$ is a set of co-efficient to be estimated X1- X8 are explanatory variables factors (Table 1) hypothesized based on theory and related work, to influence climate change effects on NTFPS in Museve and Kavonge hilltop forests, Kitui County.

Equation (1) can be rewritten as;

$$\text{Logit } (p) = \log (p/ 1\text{-}p) = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 \text{ ……………2)}$$

Where p is probability that Y = 1 i.e. p = probability (Y =1). In terms of probability, equation (2) Can be expressed as:

$$P = \exp (\alpha + \beta 1X_1 + …. +\beta 10X_{10})/1 + \exp \alpha + \beta 1X_1 +…. + \beta 8X_8 \text{ ……………………………… (3)}$$

The table 1 below described the explanatory variables that explains the community perception on local rainfall and temperature pattern in the Kavonge and Museve hilltop forests areas.

Table 1 Description of explanatory variables

Variables	Description
X_1	Occupational (1 = employed; 2= farmer: 3=business: 4 others)
X_2	Gender of household head (1= Male , 2= Female)
X_3	Age (Age of household head in years)
X_4	Household size (number of family members in household)
X_5	Marital status (1= single; 2 = married;3=widowed;4=divorced)
X_6	Education level (1 = educated; 2 = no formal education
X_7	Average monthly income in Ksh
X_8	Residency period (number of Years)

3. Results

3.1. People's general perception on climate change

A large number 83.0% of respondents strongly agreed that climatic conditions of their area has changed. Only 1.5% of respondents were not sure of the changes in climate (Figure 3).

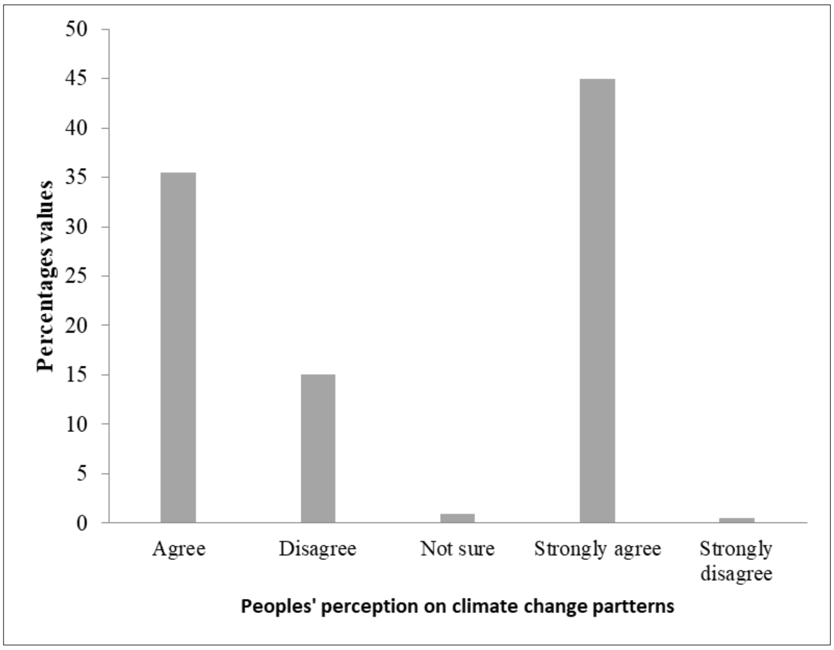

Figure 3 Percentage distribution of People's general perception on climate change

3.2. Socio-economic characteristics influencing climate change perceptions

A logistic regression analysis on people's perception on climate change using the socio-economic factors such as age, education, occupation and residence time was done (Table 2). There were significant differences in perception of respondents due to age, education level, occupation and residence time ($p<0.05$). In other words, climate change was perceived in terms of respondents age, education level, occupation and residence time.

Table 2 Logistic regression model on peoples' perceptions on climate change

Factor	X^2	Df	`p-value	Odds Ratio
Gender	0.355	1	0.552	0.361
Marital status	1.502	3	0.682	0.493
Age	0.400	1	0.001*	0.971
Education	15.426	2	0.01*	0.270
Occupation	11.675	2	0.003*	0.241
Household size	7.447	3	0.059	0.530
Income	0.153	2	0.362	0.540
Residence	5.871	3	0.046*	0.243

significant level $p<0.05$

3.3. People's perception on changes in temperature patterns

A big proportion of the respondents 96% perceived an increase in temperature during this recent period of 2018-2023 while 4% reported no change. In 2013-2017, 98% of the respondent's perceived increase in temperature while only 2% perceived decreased in temperature. Also in the period of 2008-2012 the results found out that 80% of the respondent's perceived increased, 12% decreased and 8% reported no change in temperature patterns. Additionally, during the period of 2003-2007, 75% of the respondents perceived increased, 20% decreased and 5% no change in temperature of the area. Furthermore, the respondents' local perceptions in 1998-2002 periods revealed a mixed pattern, in which 46% reported a significantly decreased temperature, while 45% perceived a significant temperature increment. Lastly, during 1993-1997 period, 78% of the respondents reported significant decrease in temperature and 22% perceived an increased in temperature (Figure 4).

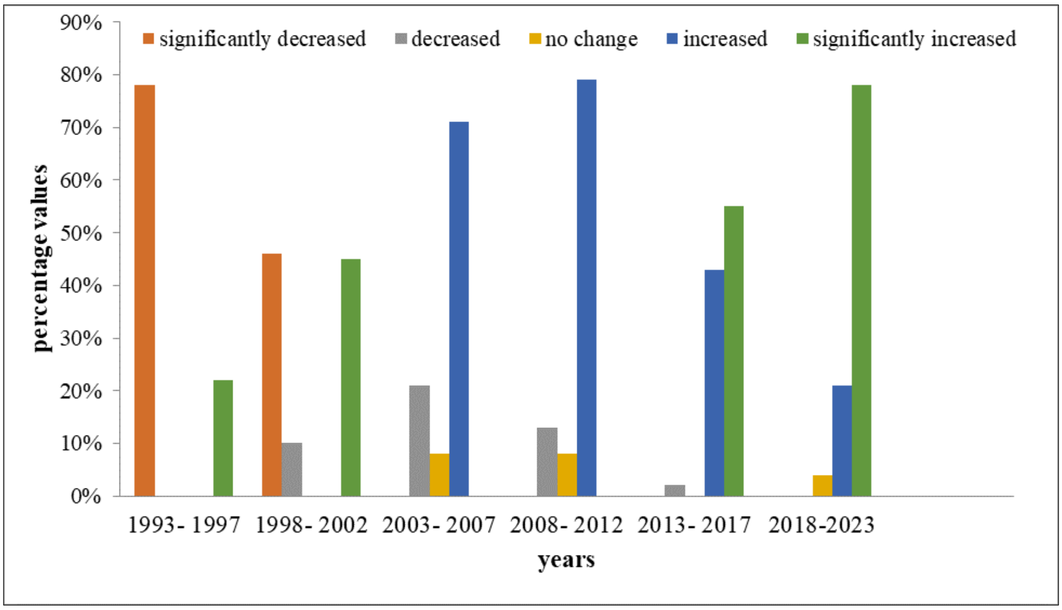

Figure 4 Percentage distributions of respondents on perceptions of changes in temperature patterns

3.4. People's perception on rainfall change patterns

A big proportion of the respondents 100% perceived a decrease in rainfall during this recent period of 2018-2023. In 2013-2017, 94% of the respondents perceived decreased in rainfall while only 6% perceived no change in rainfall. In contrast, during the period of 2008-2012 the results revealed that 95% of the respondent's perceived increased in rainfall, while 5% reported no change in rainfall patterns. Additionally, during the period of 2003-2007, 80% of the respondents perceived increased in rainfall while, the respondent's local perceptions in 1998-2002 periods revealed that, 98% of the respondents reported to have experienced an increment in rainfall at that time. Lastly, during 1993-1997 period, 97% of the respondents attested significant increment in annual rainfall (figure 5).

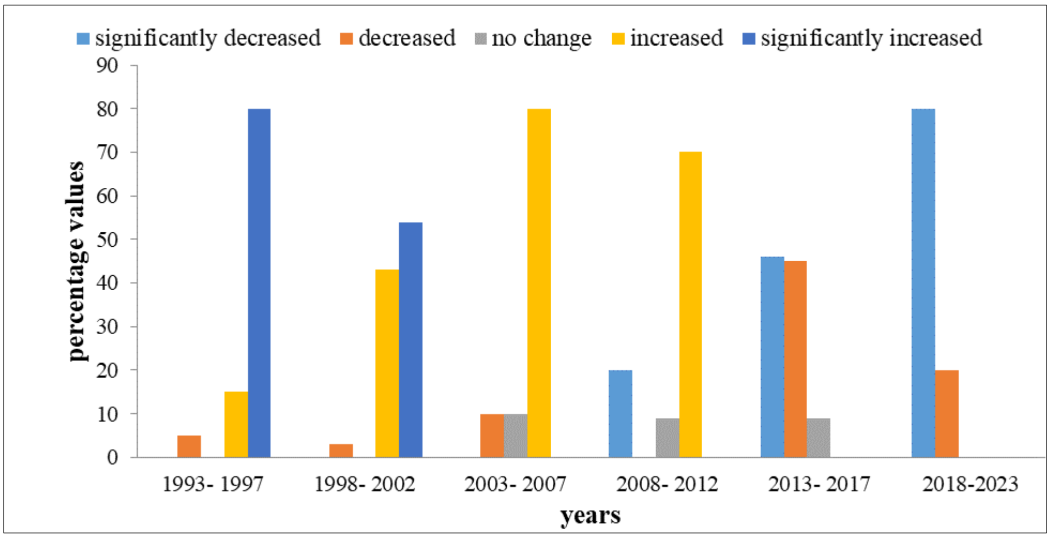

Figure 5 Percentage distribution of respondents perception of changes in rainfall patterns

4. Discussion

4.1. Socio-economic characteristics influencing climate change perceptions

Understanding the dynamic relationship between the effects of climate change on the availability of Non-Timber Forest Products (NTFPs) requires evaluating local perceptions of people on climate change as represented by prevailing rainfall and temperature patterns as well as their socio economic parameters. The study finding indicated that majority of the respondents in the Kavonge and Museve hilltop forests area attested to the fact that indeed the climate of the area have been changing due to climate change effect on the forest. From the findings in this study it was observed that age, education, occupation and residency periods were found to have a significant effect on how respondents perceive changes in rainfall and temperature patterns on the availability of NTFPs. This is because age positively reflects life experience and hence more opportunity to see weather related changes, hence an elderly person is more reliable and has accumulated more experience in the climate change patterns in the study area. Education indicates that a person can be able to correctly perceive rainfall and temperature trends than an uneducated person. Occupation is a reflection of livelihood strategy and especially those depending on environmental resources discern temperature and rainfall changes more easily. Residence duration reflects life time experience of respondents and have help residents that have lived in the area for more years to have a lot of experience and knowledge on climate change issues in the study area. The findings are comparable to Suleiman *et al*. [32] who found out that elderly people have more experience compared to young people living around forest areas. Educated people stand a good chance of understanding climate change scenarios and adopting new technologies to cope with it consequences. Education increases working efficiency and productivity, making households with more educated individuals to benefit more from generation of income from NTFPs. The local knowledge can aid in a more thorough understanding of the localized effects of climate change on NTFPs availability and its impact on communities dealing with the changing climate conditions [33].

4.2. People perception on changes temperature and rainfall patterns

Local perceptions on temperature changes throughout the study period reported a steady increment in temperature patterns in the most recent period of 2018–2023. This was closely attributed with the global conversation on climate change and the observed warming trends worldwide. The results are in line with [34, 35, 36, 37] who reported that changes in precipitation patterns and increment in global average temperatures will have an effect on the availability of NTFPs. Equally the study reported that all the respondents in the Kavonge and Museve hilltop forests area perceived a decrease in rainfall of the area in the recent years. In this study the consistency of local views with recognized scientific discoveries emphasizes the importance and veracity of these local observations on rainfall and temperature patterns. This phenomenon is in line with research done by Smith *[38] and Brooks et al.,* [39] who highlighted the need of using local knowledge to supplement and validate climate information gathered using conventional scientific techniques. Furthermore, the results agreed with the findings of [19, 20] who reported that local community's perspectives and experiences play a crucial role in supporting the overall planning of adaptation measures. In order for local stakeholders to properly adapt and be motivated to do so, it is critical to comprehend their attitudes and perspectives regarding the changing climate. The fact that the locals in the Kavonge and Museve hilltop forests area are aware of temperature increment, its provides a crucial element in context to the larger climate change narrative on the decrease in available NTFPs. These impressions act as an early warning system and can guide local adaptation plans. Additionally, the concurrence between local opinions and scientific data supports the validity of climate change research and the necessity of addressing its effects as soon as possible. The significance of the study included local knowledge and views in climate research and adaptation techniques which has been stressed in numerous publications. Typically, local populations are frequently the first to experience and adjust to the effects of climate change as noted by Nyong' [18] and their insights are priceless for decision-makers and academics. Local views and scientific findings being in agreement highlight the possibility for traditional knowledge and climate science to work in agreement to improve climate mitigation and adaptation efforts [40].

In this study, the local population's capacity to identify and describe temperature patterns highlighted their significance as crucial players in measures to manage resources and increase climate resilience. According to Brooks [41], their perceptions can form the basis for community-driven adaptation initiatives. Adapting agricultural operations, shifting NTFPs harvesting dates, or creating sustainable resource management plans that take climate change into account are some examples of such strategies of NTFPs and the livelihoods of people living in mountainous forest. The main climate related changes enumerated in the study area were observed to be the cause in temperature change patterns and unpredictable rainfalls. These has led to the decreased in NTFPs availability, dryness of river sources, damage to crops by high temperature intensity, pest and disease damage to crops farmers. Also, the observed changes were not only in the total amount of rainfall but also in the timing of the rains; with rains coming either earlier or later than expected. Equally, the Focus Group Discussions also indicated that the rapid changes in rainfall and temperature patterns in the study area has led to the continuous decreased in NTFPs availability over the years. The findings were ascertained by Haule, [42] who concluded that both climate variability and anthropogenic activities are responsible for NTFPS reductions both in quality, availability and quantity.

5. Conclusion

The local people's long time experiences on rainfall and temperature patterns play an important role in understanding the current dynamics of changes in climate of the study area. It is indicated that education level, age, occupation and residence duration significantly influence the peoples' perceptions on climate change and variability impacts on NTFPs availability in the Kavonge and Museve hilltop forests areas. The study also concludes that, the local perception of people on the rainfall and temperature pattern of the Kavonge and Museve hilltop forests area are in line with the scientific conclusions that rainfall is decreasing while temperature is increasing in the study area.

Recommendations

The findings of the study established the following recommendations:

- Local people's knowledge and experience should be relied to a greater extent when seeking to understand long time climate change dynamics especially for rainfall and temperature pattern. This will help the researcher understand better the climate change scenarios of the study area, especially when dealing with both the people's perceptions and the scientific data on the climate for comparisons.
- Based on the declining position of NTFP resources, serving as forest food safety net for resident in Kavonge and Museve hilltop forests areas, I recommend that both Central and County government to support residence with tree seedlings and encourage them to establish own forest farm for maintaining continuous supply of NTFPs for their sustenance and income generation.

Compliance with ethical standards

Acknowledgments

My appreciation and sincere gratitude goes to the Program for the Protection of Forestry (PAP for), Conservation Society of Sierra Leone (CSSL), Birdlife International, and Royal society for the protection of Bird (RSPB), for providing the funds which gives me the opportunity to pursue my postgraduate studies in Climate Change and Agroforestry.

I wish to also thank the Ministry of Environment and Climate Change in Sierra Leone especially Mrs. Kate M. B. Garnet, the Director of Forestry Sierra Leone and the entire Forestry staff of the Ministry, for giving me this kind opportunity of leaving my duty station to pursue my Master of Science degree study in Kenya.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Forner, C. and Robledo, I. (2005). An introduction to the impacts of climate change and vulnerability of forestsBackground document for the South East Asian Kick-off meeting of the project Tropical Forests and Climate Change Adaptation. 45pp.

[2] Parmesan, C. and Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. Nature 421: 37 – 42

[3] FAO (2008). Climate Change Impacts on Forest Health. Forestry Department Food and Agriculture Organization of the United Nations. Forest Health and Biosecurity Working Papers. Beverly Moore & Gillian Allard- Forest Resources Development Service Forest Management Division Forestry Department. 1-29.

[4] Cook, J., Nuccitelli, D, Green, S. A, Richardson, M., Winkler, B, Painting, R., Way, R., Jacobs, P. and Skuce, A. (2013). Quantifying the consensus on anthropogenic global warming in the scientific literature Environ. Res. Lett. 8 024024.

[5] Reusswig, F. (2013) History and future of the scientific consensus on anthropogenic global warming Environ. Res. Lett. 8 031003.

[6] FAO (2020). Impacts of Climate Change on the Forestry Sector in Africa. Consultative Meeting for the Southern and Eastern Africa Sub-Regions on the AU Climate Change Strategy. Food and Agricultural Organization (FAO) of United Nation.

[7] Malhi, Y., Franklin, J., Seddon, N., Solan, M., Turner, M. G, Field, C. B and Knowlton, N. (2020). Climate Change and Ecosystems: Threats, Opportunities and Solutions Philos. Trans. R. Soc. B Biol. Sci. 375 1–8

[8] Leal, A., Benchimol, M., Faria, D., Dodonov, P. and Cazetta, E. (2021). Landscape-scale forest loss shapes demographic structure of the threatened tropical palm Euterpe edulis mart. (Arecaceae). For. Ecol. Manag. 502:119716.

[9] Talukdar, N. R., Choudhury, P., Barbhuiya, R. A., & Singh, B. (2021). Importance of non-timber forest products (NTFPs) in rural livelihood: A study in Patharia Hills Reserve Forest, northeast India. Trees, Forests and People, 3, 100042. https://doi.org/10.1016/j.tfp.2020.100042

[10] Gurung, L. J., Miller, K. K., Venn, S., & Bryan, B. A. (2021). Climate Change Adaptation for Managing Non-timber Forest Products in the Nepalese Himalaya. Science of the Total Environment. 796, 148853.

[11] Shanker et al, (2004). Livelihood Gains and Ecological Costs of NTFP Dependence: Assessing The Roles of Dependence, Ecological Knowledge and Market Structure in Three Contrasting Human and Ecological Settings in South India Germany.

[12] Magry, M. A., Cahill, D., Rookes, J., & Narula, S. A. (2022). An integrated value chain analysis of non-timber forest products: A case of Jharkhand state of India. Small-scale Forestry, 1–25.

[13] Yadav, S., Bhattacharya, P., Areendran, G., Sahana, M., Raj, K., & Sajjad, H. (2022). Predicting impact of climate change on geographical distribution of major NTFP species in the Central India Region. Modeling Earth Systems and Environment, 8(1), 449–468. https://doi.org/10. 1007/s40808-020-01074-4

[14] FAO (2001). State of the World 's Forest. FAO Forestry Paper No. 140. 84 pp

[15] Mugenda, O. M, Mugenda, A. G (2003) Research Methods, Quantitative and Qualitative Approaches. ACT, Nairobi.

[16] Kremen C, Niles, J. O, Dalton, M. G. (2000) Economic incentives for rain forest conservation across scales. Science 288:1828–1832.

[17] Gourdji, S. M, Sibley, A. M, Lobell, D. B. (2013). Global crop exposure to critical high temperatures in the reproductive period: historical trends and future projections. Environmental Research Letters 8, 24041.

[18] Nyong, A. (2015). Beyond IPCC projections: Lessons from community-based adaptation. Climate Policy, 15(4), 493-514.

[19] Muzari, W., Muvhunzi, S., Soropa, G. and Kupika, O. L. (2014). Impacts of climate variability and change and farmers' responsiveness in the agricultural sector in Zimbabwe. Int. J. Sci. Res.(IJSR), 3(9): 1726-1731.

[20] Martinez, P. J, Pepa, A. A, María, M. D. S. (2018). Understanding Climate Change Perception in Community-Based Management Contexts: Perspectives of Two Indigenous Communities. Print Publication: 01 Jul 2018 Page(s): 471–485.

[21] GoK, (2021). Food: Our Wealth Health and Security. Agriculture Policy. Ministry of Agriculture, Livestocks, Fisheries, and Cooperative.

[22] Musau, J. M. (2021). Anthropogenic influences on tree species composition, diversity and density: a comparative study of Museve and Mutuluni forest fragments, Kitui county, Kenya.

[23] KFS (2013). National Forest Resource Mapping and Capacity Development for the Republic of Kenya. Forest Preservation Programme, Report No. KEF09/11494/01. Nairobi: Kenya Forest Service.

[24] MENR, B. T. C, (1994). Kitui District Forestry Master Plan. Nairobi: Government Printer.

[25] MoA (1983). Farm Management Handbook of Kenya Vol. II – Part C Natural Conditions and Farm Management Information. East Kenya (Eastern and Coast provinces), Nairobi.

[26] Jaetzold, R., Schmidt, H., Hornetz, B. and CShisanya, C. (2006). Farm Management Handbook of Kenya, Vol II. Natural Conditions and Farm Management Information. Part C. East Kenya. Nairobi: Ministry of Agriculture, Kenya.

[27] Corbett, J., D. (1998). Classifying maize production zones in Kenya through multivariate cluster analysis. In R.M. Hassan (ed.), Maize technology development and transfer: a GIS application for research planning in Kenya. Wallingford: CAB International (pp. 15–25).

[28] Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E. and Berg, G.K. (2007). "Forest environmental incomes and the rural poor," Forest Policy and Economics. 9 (7), 869–879.

[29] Yamane, T. (1967). Statistics: an introductory analysis. New York: Harper & Row. Temu, R.P.C. and Andrew, S.M. (2008). Endemism of plants in Uluguru Mountains. Forest Ecology and Management 255(7): 2858 – 2869.

[30] Gujarati, D. (2004). Basic econometrics. Fourth Editiom.The McGraw-Hill Companies.

[31] Ndung 'u, C.and Bhardwaj, S. (2015). Assessment of people's perceptions and Adaptions to climate change and variability in Mid –Hills of Himachal Pradesh, India. Int.j. curr. microbial. App.sci4(8):47-60.

[32] Suleiman, M. S., Wasonga, V. O., Mbau, J. S., Suleiman, A. and Elhadi, Y. A. (2017). Non-timber forest products and their contribution to households' income around Falgore Game Reserve in Kano, Nigeria.Ecological Processes, 6(1):23. https://doi.org/10.1186/s13717-017-0090-8.

[33] Shemnga, T. A. (2015). Assessment of the contribution of non-timber forest products to household food security and income around Baga catchment forest in Lushoto district, Tanzania. Sokoine University of Agriculture.

[34] Liu, X. D, Yin, Z. Y, Shao, X. M, Qin, N. S. (2006). Temporal trends and variability of daily maximum and minimum, extreme temperature events, and growing season length over the eastern and central Tibetan Plateau during 1961–2003. J Geophys Res Atmosph. 111(D19):19. doi:10.1029/2005JD006915.

[35] Maroschek, M., Seidl, R., Netherer, S., Lexer, M. (2009). Climate change impacts on goods and services of European mountain forests. Unasylva. 60:76–80.

[36] Penuelas, J, Sardans, J, Filella I, Estiarte, M, Llusia, J, Ogaya, R, Carnicer, J, Bartrons, M, RivasUbach, A, Grau, O. (2017). Impacts of global change on Mediterranean forests and their services. Forests. 8:37.

[37] Chakraborty, A, Saha, S, Sachdeva, K., Joshi, P. K. (2018). Vulnerability of forests in the Himalayan region to climate change impacts and anthropogenic disturbances: a systematic review. Region Environ Change. 18(6):1783–1799. doi:10.1007/s10113-018-1309-7.

[38] Smith, B. (2017). African perspectives on climate change adaptation. Environmental science &policy,75,1-9.

[39] Brown, G., & Adams, T. (2019). Climate change perceptions and responses among the Mapuche people in Chile. Climatic Change, 155(3), 381-397.

[40] Adger, W. N. (2018). IPCC reasons for concern regarding climate change risks. Nature Climate Change, 8(11), 937-945.

[41] Brooks, N. (2019). Aligning community-based adaptation with indigenous knowledge on water-related hazards in a changing climate in Vanu. Climate and Development, 11(3), 269-283.

[42] Haule, T. R. (2022). Determinants of the Availability of Non-timber Forest Products for Households' Adaptation to the Effects of Climate Variability in Iringa District, Tanzania. Journal of the Geographical Association of Tanzania. 42(1), 145–166