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The perception of the locals on the impact of climate variability on non-timber forest products in Ghana

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ABSTRACT

All biological products obtained from forests other than timber are considered non-timber forest products (NTFPs). NTFPs production levels in Ghana are affected by climate change. Over the past years, NTFPs have adversely affected by prolonged droughts and short rainfall in Ghana. In rural areas, where NTFP enhance livelihoods for rural dwellers, this adversely affects their food security. This study aimed to determine how rural dwellers in Ghana perceive the impact of annual variability in rainfall and temperature on their non-timber forest products. To better understand how residents perceive climate change's effect on NTFPs, 732 residents were interviewed. Household information and perceptions regarding changes to the availability of NTFP (snails, mushrooms, honey, etc.) were recorded using structured and semi-structured questionnaires. As a result of the sharp rise in temperature and the decline in rainfall, combined with a prolonged drought, there has been a decline in the production levels of NTFPS in the forest areas of the country. The respondents reported a decline in the production levels of honey, snails, and mushrooms, as well as income generated. It is imperative that the Ghana government, through the Ghana forestry commission, educate rural dwellers about the importance of NTFP sustainable use and implement afforestation programs to help regenerate degraded forest areas that threaten some of the organisms required for the production of NTFPs. Embarking on afforestation programs will help improve the climatic conditions supporting the production of NTFPs.

1. Introduction

Any product derived from managed or natural wooded areas other than timber is classified as non-timber forest products (NTFPs) [94]. These exclude timber but include flowers, barks of trees, roots of trees, tubers of shrubs, corms, leaves of trees, seeds of trees and shrubs, fruits, saps, resins, honey, fungi, and other animal products [5,6,73]. A significant portion of the livelihoods of Ghanaian forest fringe communities is derived from forest resources (NTFPs) [4]. In the growing season (farming season), NTFPs play an important role in household food security, nutrition, health, and income [5,6]. NTFPs are used in food, medicine, barter, and market retail [46].

Even more, NTFPs have cultural, religious, and social benefits for the locals [72,90,105]. As NTFP income generates income and serves as a safety net, NTFPs will continue to provide positive benefits to rural families who are otherwise economically disadvantaged [3,48]. NTFP provides outside employment opportunities for those seeking outside employment in an unpredictable economic environment[71,91]. Rural

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communities have to support themselves, relying on the income generated by NTFP [91].

In recent years, the global market for NTFP has grown nearly 20% annually, with an estimated value of nearly US$ 11 billion [46]. Although less than 50% of rural household income comes from NTFPs, the importance of this contribution can be linked to its accessibility during times of need [52,60,91]. Forest resources such as fruits, nuts, mushrooms, vegetables, medicinal plants, fibres, and honey contribute between 30% and 50% to the income of rural dwellers in Nigeria, Cameroun, etc [71,102]. The nutritional and health values of NTFPs warrant concerns about their effective conservation and management [96].

It cannot be overstated how essential NTFPs are to the economies of developing countries such as Nigeria, Cameroon, Uganda, and the Democratic Republic of the Congo [41,79]. Some forest-dependent communities have NTFPs as their sole source of livelihood [38,104,108]. It is estimated that approximately 1.5 million inhabitants in the Brazilian Amazon obtain a fraction of their revenue from the gathering and harvesting of NTFPs [42,113]. About 20% of the working population in Southern Ghana, where most tropical rain forests are located, earns income from NTFPs [71]. Consequently, these rural forest dwellers' lives are intertwined with the resources available to them [96]. The continuous flow of benefits from NTFPs depends on the conservation and sustainable management of forest resources. Several research works have shown the benefits and marketable values of NTFPs [8,54]. Other studies have investigated the feasibility of introducing NTFPs on tree crop farms to expand their benefits to a wide range of farmers [24,65,99].

It is impossible to underestimate the benefits NTFPs provide to forest communities and developing countries. However, deforestation, overexploitation, and climate change are contributing to the decline in forest NTFPs production [32,74,76]. NTFPs' sustainability depends on existing climatic conditions and management strategies, whether in natural forests or tree crop farms. The effects of climate change are having an adverse impact on the world's ecosystems, and it is expected that the magnitude of these impacts will increase as temperatures rise in the next century [78]. Climate change may hinder the adaptation of several species and ecosystems because other stresses, such as land-use changes, overexploitation of resources, pollution, and fragmentation, are compounding the effects of global warming and associated disturbances [78]. The forest ecosystem that NTFPs are a part of has been affected by climate change [39,69]. Yields of some NTFPs have declined in Ghana [2,8,93], and this change has prompted management and research attention [7].

1.1. Locals' perceptions of non-timber forest products (NTFPs)

A community's perception of non-timber forest products (NTFPs) will vary depending on its cultural, socioeconomic, and environmental context [75,76,110]. The economic value of NTFPs is recognised by many local communities. They view these products as essential sources of income, livelihoods, and economic opportunities [85]. Evidence shows that non-timber forest products can provide supplemental income for rural communities, particularly those living in or near forested areas [70]. NTFPs can provide locals with a means of diversifying their income sources, reducing their reliance on agriculture or timber, and improving their economic well-being [115]. Local cultures and traditions are often deeply ingrained in NTFPs [44,53]. It is possible to use NTFPs in rituals, ceremonies, traditional medicines, crafts, and other forms of cultural expression [33,98]. Due to their cultural heritage, locals may have a strong attachment to these products and may actively engage in the sustainable harvest and management of these products.

NTFPs are essential in maintaining healthy forest ecosystems, and many local communities recognise their ecological importance [85]. Locals may perceive NTFPs as indicators of forest health and biodiversity. To ensure the long-term sustainability of both the products and the forest itself, sustainable harvesting practices and conservation of NTFPs are seen as crucial [82,83]. The local community may possess traditional knowledge and practices related to the sustainable management of NTFPs that have been passed down through generations [49,80]. Furthermore, local perceptions of NTFPs may include concerns about their sustainability and potential threats. Many local communities are concerned about the declining abundance of certain species, the loss of traditional knowledge, and the need for appropriate management strategies to ensure the long-term viability of NTFPs [37]. To ensure sustainable management and conservation of NTFPs, it is essential to understand local perceptions of these resources. By engaging local communities, respecting traditional knowledge, and incorporating their perspectives into decision-making processes, we can help ensure the preservation of NTFPs and the well-being of local communities [31,34].

1.2. Climate change and its effects on NTFPs

Much attention has been placed on the overexploitation of forest resources as the major cause of the decline of NTFPs [88]. Meanwhile, climate alterations have affected the forest ecosystem of which NTFPs are part. Climate change is happening at a fast pace due to anthropogenic factors resulting in increased emissions of greenhouse gases (GHGs) which deplete the ozone layer (IPCC [56]). Within the last 50 years (1956 to 2005), the earth's atmospheric temperature has increased by approximately 0.74 °C, and within the last century (1906 to 2005), it has doubled [109,119]. Alteration of the world climate negatively influences the ecosystem globally [92]. As a result, there are other stressful effects, such as land use changes, over-dependence on resources, pollution, and disruption of natural systems. It has been predicted that a rise in temperature of 1.5 to 2.5 °C may lead to the extinction of a third of the flora and fauna of the planet [55]. NTFP species may experience a shift in distribution due to climate change, resulting in habitat alterations [47,103]. Temperature and precipitation patterns can impact the growth and survival of NTFP species, resulting in a decline in their populations in some areas while they expand in others [69,114]. Local communities that rely on specific NTFPs for their livelihoods and cultural practices may be adversely affected [105,114].

NTFP productivity and quality can be affected by climate change [61]. The effects of extreme weather events, such as droughts, floods, and heat waves, can negatively affect the growth, regeneration, and overall productivity of NTFP species [117]. NTFP quality and medicinal properties may also be affected by changes in temperature and precipitation regimes [29]. Climate change can disrupt traditional knowledge and practices related to the harvesting and management of NTFPs [49,101]. It is important to note that this may pose challenges for local communities that rely on traditional ecological knowledge to sustainably use NTFPs. Climate change impacts on NTFPs must be recognised and addressed to ensure their sustainable use and the well-being of the communities that depend on them [35,114]. Through adaptation strategies, conservation efforts, and integrating traditional knowledge with scientific approaches, it is possible to mitigate climate change's negative impacts on NTFPs and support the resilience of both ecosystems and local communities.

1.3. The perception of forest fringe communities to the effects of climate change on NTFPs

Local communities possess a wealth of knowledge and perspectives that can contribute to decision-making [45,120,121]. Over millennia, local communities whose livelihoods are directly tied to the environment have developed a body of traditional knowledge to manage natural resources efficiently and sustainably [66]. This socio-ecological knowledge is in consonant with the traditions, value systems and norms of the local communities. Moreover, traditional knowledge tends to influence the perception of the local communities about their immediate surroundings and the natural environment (e.g., [20,118,122]). Within the framework of Mindsponge Theory, the perceptions of local communities influence their behavioural outcome toward a social artefact or the natural surroundings, particularly climate change impact on NTFPs [20,82,83,95,122]. The concept of mindsponge (ecomindsponge) offers a comprehensive and effective approach to understanding the nature-human relationship, information exchange and system interactions [84]. The local pool of knowledge such as traditional norms, values and taboos concerning the management of natural resources particularly NTFPs are disseminated and transmitted through social learning (e.g., [18,25,86]). The mode of natural resource management is shared knowledge normally acquired through observation, imitation, storytelling and folklore [14,18,21,22]. This local (or traditional) knowledge interacts in a web of associations within the social networks of the local communities (see, [97,111]) and influences their subjective environmental paradigm (e.g., [40,84,121]). Local knowledge is collective across generations and cumulative (e.g. [51,67]). It is acquired through initiation into a group consciousness [112]. This knowledge influences local communities' sphere of perception of climate change impacts on NTFPs.The knowledge about NTFPs is learnt and practically demonstrated through social interaction among the locals and it is typically transmitted through oral history or tradition (e.g., [89]).

The perceptions of forest fringe communities regarding climate change and its impact on the production of NTFPs will invariably affect the exploitation and management practises of these forest resources (e.g., [66]). The forest ecosystem has been a food source and livelihood for local communities for generations [63]. Due to their traditional ecological knowledge and expertise, they are highly in tune with climate change and its impacts on NTFP production. The understanding of local communities' perceptions will provide invaluable insights into how climate change affects specific NTFP species, particularly their habitats and the ecosystem as a whole [20,47]. Based on these observations and experiences, local communities can provide invaluable information regarding the timing, abundance, and quality of NTFP resources [36,103]. The understanding of forest fringe communities' perceptions of climate change and NTFP production will contribute to the development of trust between the local communities and forest managers. As a result, this will facilitate a collaborative approach and the evolution of more effective sustainable management strategies to align with local communities' needs and aspirations [124]. In addition, the information thus generated in the process will provide bases promoting "eco-surplus culture" among the forest fringe communities ([82,83]). This is a more effective and sustainable management strategy that will protect NTFPs' resource base, support local livelihoods, and enhance the resilience of forest ecosystems in the face of climate change.

1.4. *Objective of the study*

For the forest to continue to provide services in these current times, forest management strategies must not ignore climate change. To maintain forest services under this climate change regime, local communities must be involved in forest management [77,97]. However, the perception of locals regarding the effect of climate change on NTFPs has not received as much attention as it should have. It is, therefore, paramount to assess the perception of the locals on climate change and its impact NTFPs production. The objective of the study is, therefore, to evaluate the perception of the locals on climate alteration and its effects on the production levels of NTFPs and its influence on the livelihoods of people living in forest fringe communities.

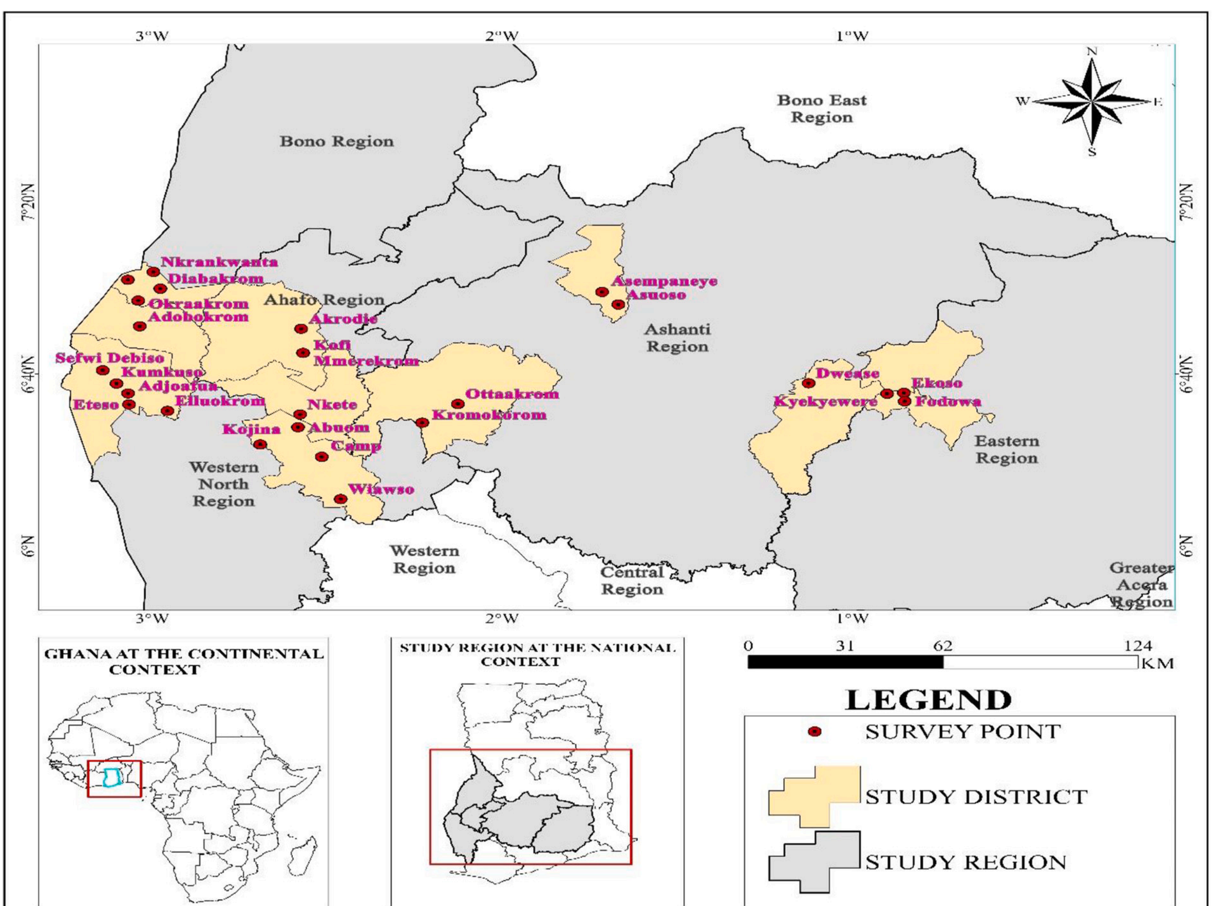

Fig. 1. The Map of study sites showing the regions and selected communities.

2. Methods and materials employed in the study

2.1. Description of the region of study

In this study, a total of five selected regions (namely, Western North, Bono, Ahafo, Ashanti, and Eastern regions) (see Fig. 1) and four ecological zones were examined in Ghana. We selected these regions since they contained relatively large areas of tropical rainforest. The chief economic activities in the study are agriculture (farming), trade and commerce, and services (hotels, auto mechanics, sawmills, banks, etc.). Upper canopy trees are evergreens and deciduous trees, while lower canopy trees are evergreens. It is the moist semi-deciduous forests that contain the tallest trees, some of which can reach 50 to 60 m in height. A semi-equatorial climate characterises the study area, with annual rainfall between 1500 and 1800 mm. (See Table 1.)

Climates in these regions are tropical rainforests, characterised by warm temperatures and heavy rain all year round. The peak rainfall months are May–June and September–October. A maximum temperature of 31-33 °C is recorded during the hottest months (February or March), while a minimum temperature of 19-21 °C is recorded during the coldest months (August). There are several species of trees found in the study area, including *Triplochiton scleroxylon* (wawa), *Antaris africana* (Kyenkyen), *clorophora excels* (Odum), *Ceiba pentandra* (Onyina), and others.

2.2. Sample design & data collection

The study population included residents of forest-adjacent districts, communities, and villages within the selected regions. Various households, market areas, and public centres within the districts, communities, and villages in the regions were involved in the study. Individuals who met these criteria were excluded from the study (Individuals who are not Ghanaians, who have not lived in the district for a long period (2 years or above), and children under 18). We selected the districts within the study area based on their proximity to forest reserves. Also, communities in the districts were selected based on the number of reserves and how close they are to the forest (reserved and off-reserve). An integrated mixed-methods approach was applied to the study, which included qualitative and quantitative components. An essential characteristic of qualitative research is that it incorporates individual opinions, expressions, and subjective interpretations of the research topic. A quantitative approach, on the other hand, involves using numbers to describe data or variables, establish relationships between variables, and determine whether two variables are significantly different. To achieve viable results, both approaches were merged in this case.

For the purpose of calculating sample size, Cochran's formulas and procedures were used [30].

Table 1
Socio-demographic characteristics of participants.

Socio-demographic Variables		Frequency	Percentage
Age	18–20	**5**	**0.7**
	21–29	**115**	**16.3**
	30–39	**63**	**8.9**
	40–49	**95**	**13.5**
	50–55	**298**	**42.2**
	60 or older	**130**	**18.4**
	Total	**706**	**100.0**
Level of Education	High School degree	**60**	**8.5**
	High School, no degree	**237**	**33.6**
	Primary school only	**368**	**52.1**
	Some Graduate Level Courses	**41**	**5.8**
	Total	**706**	**100.0**
Gender	Female	**208**	**29.5**
	Male	**498**	**70.5**
	Total	**706**	**100.0**

$$n_o = \frac{w^2(p)(1-q)}{e^2} = \frac{(1.96)^2(0.5)(1-0.5)}{0.03^2} = 600 \quad (1)$$

Where n_o= sample size, W = Value for selected alpha level of 0.025 in each tail = 1.96 (the alpha level of 0.05 represents the level of risk that the true margin of error may exceed the acceptable margin of error). (p)(q) = estimate of variance = 0.25. Where **e** = acceptable margin of error for proportion being estimated = 0.035 (error researcher is willing to accept). An anticipated non-response rate of 15% will be calculated and added to the sample size:

$$Nfs = \frac{\frac{W^2(p)(1-q)}{e^2}}{1 - anticipatedNon - response} = \frac{600}{1-0.15} = 706 \quad (2)$$

Where Nfs total sample size. The total sample size (Nfs) (706) of the study took into account the age, gender, educational level, occupation, the number of years respondents have lived in the community, the kind of NTFPs they collect, whether they changes that have occurred in their collections to the NTFPs they gather. Mushrooms, snails, and honey were the NTFPs we researched. A selection of these products was made based on their anticipated importance in the trade of NTFPs in the study areas.

2.3. Survey methods and study approach

To arrive at our objective, we conducted 706 interviews with a team of interviewers to investigate the perceptions of locals in rural communities in five (5) Ghanaian regions (Ahafo, Ashanti, Bono, Eastern, and Western-North). We developed a draft questionnaire in March 2022 in Ghana after discussing it with a group of economists, market players, locals and the forest commission of Ghana. In Ghana, the questionnaire for the survey was reviewed by three lecturers, one from the School of forest science at the University of Eastern Finland, one from the University of Cape Coast Ghana, and one from the Forest Research Institute of Ghana. To ensure language and conceptual clarity, these faculty members assisted in formulating and adjusting the wording. A well-formulated timetable (From April 2022 to June 2022) was developed for the data collection with the various regions, districts and local communities to be visited for the locals to be interviewed. A focus group discussion was conducted in June 2022 in the vicinity of the study areas to obtain feedback from NTFP collectors, marketers, and farmers. The in-person interviews were conducted from May to June 2022 in the selected communities in the regions. After all, data collection, data cleaning, data quality check and data management were done between July and August 2022 with the assistance of one of the lecturers at the University of cape coast in Ghana in the research team.

2.4. Data analysis

We categorised interviewees into three distinct classes based on their involvement with the value chain of NTFPs (collectors, buyers, and consumers) to investigate perceptions about climate change and its impact on NTFPs. Descriptive statistics were analysed using SPSS Statistics 20.0 (IBM, New York, USA). Tables and graphs were created to display descriptive statistics related to sociodemographics, common NTFPs, the perceptions of the locals on climate change, and factors related to NTFP collection. To evaluate the impact of climate change on the forest, we reviewed secondary data from government resources and published literature. We paid particular attention to patterns of temperature and rainfall.

3. Results

During the study, a higher proportion of males responded to the interviews because men are the heads of families and are responsible for most of the activities involved in gathering and hunting NFPS. Most women were also observed to be shy when answering most of the questions. Of the respondent, 208 female respondents (29.5%) and 498 male respondents (70.5%) participated in the survey. The age group that had the high number in the survey were the ages between 21 and 29,115 responded (16.3%), whiles 18–20, 5 responded (0.7%) the least, and this was the reason that the time of the data collection was school section time, so most of the age class were in school. It was observed that a high number of the locals only had primary education, with few who had some graduate courses. Of the total respondent, 368 (52.1%) had only primary education, while only 41(5.1%) completed the graduate level. This high primary level could be attributed to financial constraints in sponsoring their education.

3.1. Type of NTFPs to be collected from the forest by the response

The study examined the non-timber forest products that are common and mainly collected within forest communities in the study region (Fig. 2). Based on the findings of the survey, most of the respondents indicated that the collection of snails and honey accounts for 21.69% and 20.55%, respectively, of all NTFPs harvested in the study regions. Mushroom collections were collected by 15.21% of respondents. Furthermore, 12.22% of study participants hunted for games and 10.78% collected herbs. A total of 8.32% of straw, 3.46% of leaves, 2.99% of chewing sticks, and 1.89% of raffia palms were collected, respectively.

Honey, snails, and mushroom had the highest response in its collection due to the easy commercialisation of the products. Raffia palm and pestles are hard the lowest due to the difficulty in processing and gathering.

3.2. Perception of locals on causes of climate change and its impacts on NTFPs

The response made it clear that many locals are aware of the change in climate and how climate has impacted NTFPs. According to the survey, 95.5% of respondents were aware of climate change and its impacts on their livelihood, while 32 respondents (4.5%) did not know and did not believe climate change existed. According to residents, illegal mining, deforestation, overexploitation of resources and illegal logging are some of the major contributing factors to climate change, which negatively impacts NTFPs and the environment. In addition to the change in rainfall pattern (Fig. 3), locals also state that the increase in atmospheric temperature, diseases, and pest infestations have also affected the production levels of NTFPs. The high temperatures, prolonged droughts, short rains, and increased use of chemicals on soils and farms have contributed to an increase in mortality among most insects that produce some NTFPs. This confirms [1] that in 2005–2014, the decadal mean rainfall decreased from 1308 mm in the 1960s to 1147 mm in Ghana. According to the decadal mean rainfall ratios for Ghana, the current climate from 2005 to 2014 is the driest ever, where a significant period of wet weather occurred in the 1960s [1].There is no doubt that NTFP production levels have significantly decreased. According to a local, he used to collect a large number of snails and mushrooms. At one point, the earnings from NTFPs were used to pay for his children's tuition, but now it is challenging to obtain mushrooms, snails and honey. As a result of the application of insecticides on the land to control weeds, pest and diseases in the farms, the insect that supports the production of mushrooms and honey are dead, which malfunction the production process.

3.3. Perception of farmers and hunters in forest communities to changes in climate

As shown in Fig. 4, honey production is estimated in selected communities adjacent to forest areas. From 2001 to 2018, honey production levels declined continuously. In response to a question about how many gallons and how much money he was receiving from honey harvesting, a farmer replied, "I've been harvesting honey for 20 years, and it wasn't like this before." For about 10 years, I harvested about 70 gal per year. This was what I used to pay for my children's school fees from elementary school to university. The system has changed; I cannot even harvest 20 gal a year. This is because the rate at the youth are cutting down trees in the forest is alarming, and this has made the system change, we experience prolonged droughts and short rainfall, and the trees cannot flower, and this has also affected the production level of honey, cocoa farmers are also using insecticides to spray their farms which is killing the bees which are also affecting the production levels of honey in the farms. The government needs to do something about it to curb the situation if not, then in the next 10 years, there will be no honey to save a life". Income generated from Non-timber forest products for the locals living adjacent to the forest was asked. It was observed that there was a total decline in the income generated due to the decline of the targeted NTFPs in the selected communities. Almost all the hunters and farmers (99.6%) contacted stated that there had drastically decline in NTFPs in the reserved and off-reserve forests. When one hunter was asked about the changes that have occurred and their effects, the hunter stated, "I started hunting and looking for NTFPs at age 17 when I lost my parents, and I am 50 years now. I have hunted for NTFPs for 33 years, both in the forest reserves and off-reserves in this village. During the rainy season, I can hunt for about 50 bags of snails, which is about 3000 pieces of snails in those days, which I used to get money from it. I remember in 1990 I hunted for mushrooms and I got enough money out of which I bought a motorbike.

It is now very hard for me to even get a bucket of snails for about two days hunting in both reserve and off-reserve forest". The hunter continued, "this is because most of the trees in the forest are logged. Consequently, the snails and the organisms that help in the production

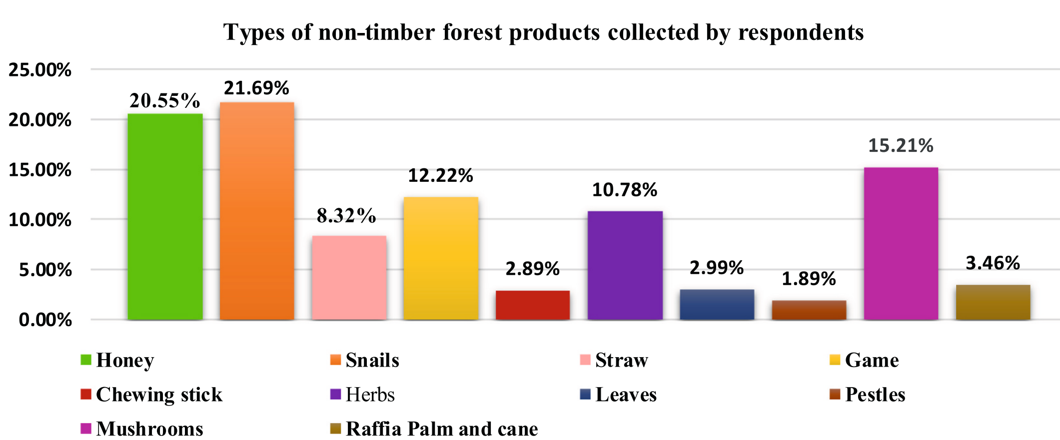

Fig. 2. Types of non-timber forest products collected by respondents.

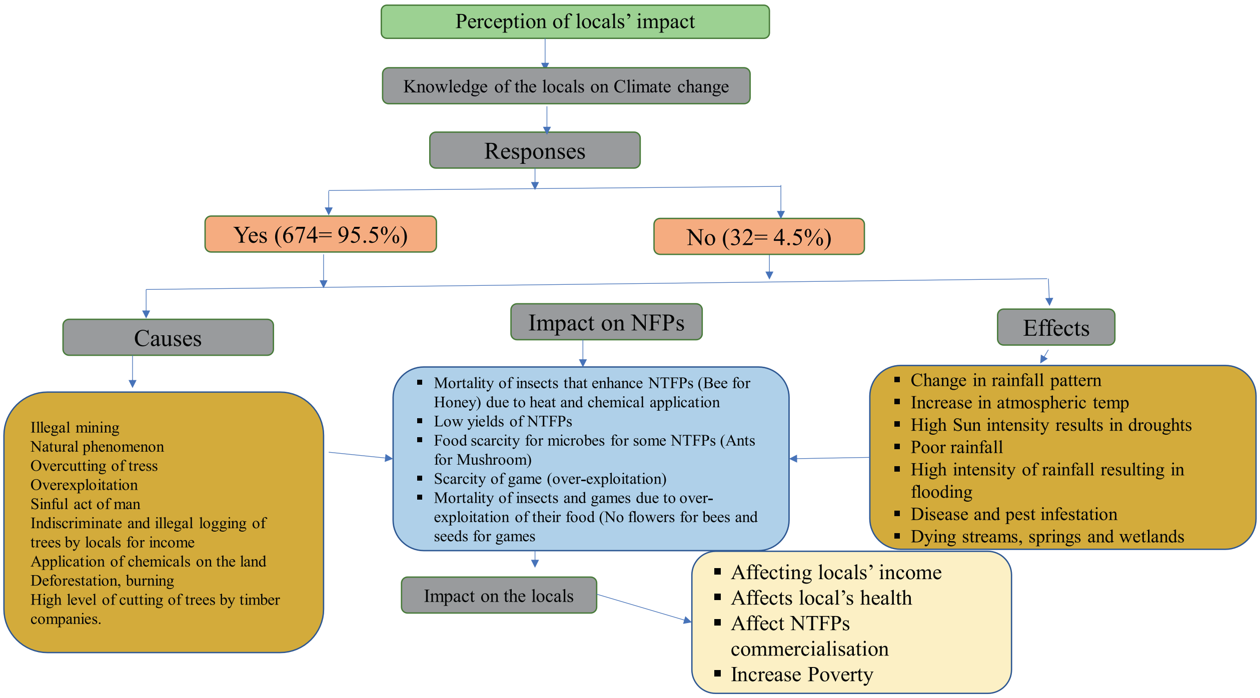

Fig. 3. Locals' perceptions of climate change and its impact on NTFP production in the study area. $n = 706$.

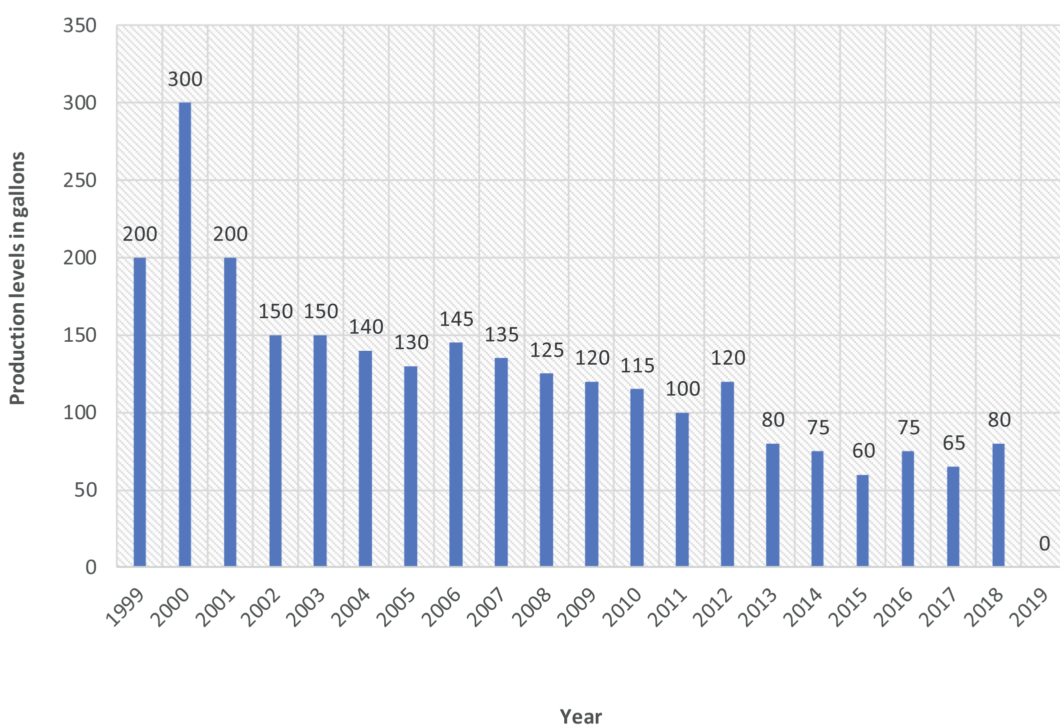

Fig. 4. Estimated honey collections in gallons by farmers in forest adjacent communities.

of mushrooms are all dead. The rains do not come at the right time, and there has been a long drought, making it difficult for the snails to survive. Now it is a problem". This hunter further stated, "NTFPs were helping us all the year round, and we were getting money from it all the time. We used income earned from NTFPs to care for our families, but now it is not like that, and life is hard here". Other respondents made similar submissions.

The effects of climate change on NTFPs production in forest areas in Ghana should be considered, as it is glaring. Late rains and intermittent and prolonged droughts have become more frequent. This has posed a considerable challenge to farmers and local communities and people living adjacent to the forest, NTFPs, hunters, and producers as traditional coping mechanisms are increasingly challenged. With the focused group discussions and Key Informant interviews with the market players like the market women who sell NTFPs like snails and mushrooms were contacted, and discussions were held with them on the changes that have occurred in the production level of NTFPs. According to the market women contacted, they made it clear that it is hard to get snails and mushrooms during the rainy season as it used to be. Some stated that the system has changed; there has been a long drought and short rains in most forest areas where they get most of the NTFPs for the market. When the rains do not come at the right time, one market woman stated, "Look at how dusty the environment is; for the past 4 months, there has not been a drop of rain. Do you think snails can survive without rains?" Other businesswomen contacted in the interview stated it clearly that it is hard to get NTFPs, and this has disrupted the business, and the business is fading away slowly.

4. Discussions

4.1. Locals' perception of climate change and its impacts on NTFPs

To understand the impact of climate change on non-timber forest products (NTFPs), local communities must have direct interaction with the environment. Depending on the experience, observations, and cultural beliefs of locals, perceptions of climate change and its effects on NTFPs may differ. According to our study, locals have noticed that the climate has changed over time. There has been an increase in temperature, a decrease in rainfall, or a change in rainfall pattern. Results indicate that NTFP production yields have declined over time, possibly due to increasing temperatures, changing rainfall patterns (long and short rainfalls), chemical fertiliser use, and illegal mining. In addition to supporting the secondary data, NTFP collectors' survey responses indicated that infrastructure development and a changing climate have had an impact on NTFP yield and, as a result, have had an impact on their income from NTFPs.

Our study was keen on assessing the perception of the locals on the impact of climate change and if it has had an impact on NTFPS availability. From the response of the locals, 95.5% confirmed that they are aware of the alteration of climate, which has altered the atmospheric temperature and rainfall pattern and has declined the production levels of NTFPs [13,69]. Among the collectors who responded to a survey regarding the impact of climate change on NTFP yield, most (96.5%) stated that there had been an increase in temperature and a decrease in or unusual rainfall patterns. According to the respondents, insects that facilitate the production of NTFPs are drying out as a result of climate change. Additionally, the water table has been decreasing over the years, negatively impacting the production of NTFPs. Temperature changes and changes in precipitation patterns have been shown to have a negative impact on NTFP ecosystem services [16,28,106].

The variations in the amount of rainfall and temperature across space and time can significantly influence agricultural and forest products, which in turn can substantially affect food security and household income [27]. This is particularly the case in most parts of Africa, including Ghana, where climatic conditions continue to threaten the forest, its products, agricultural production, and the livelihoods of people living in poor and marginalised rural communities [43]. Dozens of forest species and forest ecosystems may not be able to withstand the effects of global warming and its associated disruption, for example, prolonged drought, floods, wildfire, and outbreaks of insects which will have adverse effects on the forest ecosystem. Due to the sharp increase in temperature, most organisms cannot survive in extremely warm temperatures. In the current state of temperature in the southern part of the country, where the study was conducted, it was observed that the highest temperature ranges from 30.1 to 31.9 °C, which can drastically affect snail production. Optimum temperatures vary according to species, but most land snails prefer warm temperatures from 13 °C to 32 °C and high-humidity environments. Looking at the temperature range in the southern part of the country, it can be said that a slight rise in the temperature will not be conducive to snail production in the southern part of the country.

The effect of heat occasioned by high temperatures on snails could be in the form of reduced feed intake and utilisation, reduced egg production, reduced growth rate, low body weight, poor hatchability and fertility [123]. Honeybees maintain the temperature of the brood nest between 32 °C and optimally 35 °C so that the brood can develop naturally. When the temperature in the nest is recorded to be too high, the bees ventilate by fanning the hot air out of the nest or using evaporative cooling mechanisms. When the temperature is too low, bees generate. Research has revealed that even small deviations (more than 0.5 °C) from the optimal brood temperatures have a significant influence on the development of the brood and the health of the resulting adult bees. Bees raised at sub-optimal temperatures are more susceptible to certain pesticides than adults [26,59].

The study further assessed the perception of the locals on the causes of Climate change; it was mentioned that illegal mining, bush burning, deforestation, over-exploitation, and application of chemicals to the land are the major contributor of climate change, which affect the production levels of NTFPs. This affirms [15] the misuse of lands affecting the forest ecosystem. Deforestation has become one of the major challenges to climate change, especially in Africa, where timber and other forest resources are overexploited for economic benefits [9,11,57]. Deforestation is considered the second most dreadful causal agent of climate change apart from the use of fossil fuels [15]. The continuous overexploitation and degradation of the forest will therefore intensify climate alteration events leading to a prolonged drought, floods, extreme weather conditions, erratic rainfall patterns, and sea-level rise, among others [19,64,107]. The annual contribution from deforestation and changing land use is 23% of the total emission of CO2 to the atmosphere [12,62]. The conversion of forests to agricultural land is estimated to be 13 million hectares annually, contributing to the release of carbon stored in trees as CO_2 emissions into the atmosphere [58,68]. According to the respondents, Illegal mining is a major threat to the forest and has negatively affected NTFPs level. According to most respondents, several non-timber forest products were abundant in their communities prior to illegal mining activities. Most respondents indicated that snail mushrooms and rats, a delicacy in many Ghanaian cookeries, were plentiful in the area before illegal mining activities commenced. This validated [87] that illegal mining in forest areas has affected the production levels of NTFPs. The forest is not threatened only by logging, agriculture, mining, and other human activities but also by climate change [78]. Forests are exposed to different forms of disturbances or disruptions that are highly influenced by the climate, which the locals mentioned climate's impact on the forest. Disruptions such as extreme drought and wildfire have a high negative impact on the forest which in turn affects the production levels of NTFPs. In the tropics, prolonged drought exposes most of the vital organisms to danger, where most of the microorganisms cannot withstand the temperature and the dry conditions of the forest. For instance, a high amount of fuel loads exposes the forest ecosystem to fire in the dry seasons. When fires are set in the forest either by natural or man-caused, it causes more harm, wipes out most of the living organisms in the forest, and interrupt the forest ecosystem [100,116], which affects the production levels of NTFPs in forest areas. Climate change will also reorient the dynamics of the native forest and its species in it, which will end in the establishment of non-native species in the forest ecosystem. Climate change and its effects on the forest ecosystem are glare. There are other species that were found in the past 100 years that cannot be found in the same forest today, being that those species could not withstand the changes that occurred [100]. Organisms that have greater mobility can seek shelter from excessive radiant heat in their burrow or within the confines of the relatively cooler area of a forest or woodland. For organisms, such as snails, that do not make fast movement tend to perish, and mushrooms and other forest products which cannot tend to perish will go extinct.

4.2. Perception of locals living adjacent to the forest on climate change

It is reported that in Ghana, climate change, particularly heavy rain downpour which leads to flooding and long drought seasons, caused about 6.3% and 9.3% reduction in agricultural produce and forest products. This results in increased food insecurity, poverty, and livelihood challenges, particularly at the grassroots, where livelihood and food security are dependent mainly on agriculture. Knowing the perception of smallholder farmers in the forest communities enables policymakers to have a deeper understanding of the realities of climate change at the local level, which is essential for policy formulation and implementation. The perception of the locals living in the forest communities about climate change was found. From Fig. 3, it was observed that most of the locals had observed changes in the rainfall pattern. Some locals explained that there have been short rainfall and prolonged drought in recent years. Other locals also made mentioned that climate changes can be attributed to superstition. They mentioned that humanity's evil deeds have resulted in sharp climate changes.

4.3. Decline of honey collections by farmers in forest adjacent communities

The bees of the Apis genus, who are responsible for the production of honey, are distributed throughout the globe in diverse climates. A change in climatic conditions is bound to affect the survival of honeybee species that are closely associated with their environment. Climate alteration can have an impact on honeybees at different levels. The alteration in climate can directly influence honeybee behaviour and physiology, affecting their production levels. Alterations in climate can alter the quality of the floral environment and increase or reduce colony harvesting capacity and development[10,23]. Honeybees adjust their behaviour to weather conditions; they do not go out when it rains and in extremely high temperatures. They gather water to keep the colony cool, affecting honey's production level. Fig. 4 shows the estimated honey collections in gallons by farmers and hunters in the forest-adjacent communities in Ghana. The above figure shows the production levels of honey in the selected communities adjacent to the forest areas in Ghana. It was observed that honey production levels steadily declined from 1999 to 2018. Most of the contacted farmers narrated that "we used to get more honey from the forest when we go hunting for honey. We used to get more honey, and when sold, we get more money which I used to pay for my children's fees, but now we hardly get honey when we go hunting. I can spend days in the forest but do not even get more than 4 gallons of honey. This has affected my living standard". This is a clear indication that there has been a sharp decline in honey. Snails, mushrooms, and other non-timber forest products in the forest were not an exception. The low production levels of Non-timber forest products have had a negative effect on the income levels of the locals in the forest areas since most of their income is generated from some of the NTFPs.

Two of the most important services the honeybee renders to human is the pollination of domestic and wild fruit crops and the production of honey. Honeybees have become indispensable in our agricultural economy and may be considered a relatively not a new story. The more bees get crops pollinated, we get abundant food, and the more they help in honey production. The long period of drought makes all trees shed their leaves and do not flower on time, affecting the bees' activities, affecting their production levels. This has become a key factor in the low level of honey production in recent times in the forested areas in Ghana. A period occurs in the tropics and temperate zones during which environmental conditions are unfavourable for the bees, and as a result, the colony's activity diminishes. In tropical zones, adverse conditions for honeybees may occur in different periods and may be caused by other factors: In some areas, the temperature rises so high that the colony's activity is reduced. Few or no plants are flowering. Only a few bees fly out, and as a result, very little, if any, nectar is collected. In other areas, drought occurs, and the lowering of flowers, and therefore the amount of nectar available, is reduced considerably. This has adverse effects on honey production.

4.4. Perception of locals on climate change enhancing decision-making in forest management

According to the Mind Sponge Theory, individuals, particularly those within local communities, possess a vast reservoir of information, experiences, and perspectives that can be compared to a sponge. It emphasises the importance of tapping into this valuable resource when making decisions and addressing complex challenges [122]. Based on the theory, individuals living within their local communities are deeply rooted in their environment and uniquely understand it. Their knowledge has been acquired through generations of living in close proximity to nature, observing patterns, and adjusting to changing environmental conditions.

Decision-makers can enhance the quality and effectiveness of their decisions by recognising the potential of local communities as "mind sponges." The process involves actively seeking input from the community and engaging in meaningful dialogue with them. The report acknowledges that local communities are well-versed in their ecosystems, including natural resource dynamics, ecological relationships, and the effects of climate change on them. Mind Sponge Theory emphasises the importance of valuing and respecting local knowledge as complementary to scientific knowledge. There is an acknowledgement that local perspectives and experiences are unique and can help shape more comprehensive and context-specific solutions. Including local knowledge in decision-making processes can result in more sustainable and equitable outcomes, as it reflects the needs, values, and aspirations of those directly affected by those decisions.

In the context of climate change and natural resource management, the Mind Sponge Theory emphasises the importance of involving local communities in decision-making processes [17,81]. Recognition of their knowledge and perspectives fosters a sense of ownership, empowerment, and collaboration [50]. Moreover, it recognises that people are intrinsically connected to their environment and that local communities are vital in ensuring ecosystem sustainability and resilience.

4.5. Climate change adaptation and mitigation

Alteration in Climate in Ghana affects every aspect and sector of our socio-economic development, and it is all sectoral inclusive. It outdoes the traditional focus on environmental issues because it affects Ghana's overall well-being and economic growth. It then points to the fact that the response must be all-inclusive, involving all stakeholders in addressing the impacts of climate change on all sectors, mostly on natural resources management which our interest will be in the forest, agriculture, and others like economic development, infrastructure, energy, and transportation.

Some of the available options to mitigate the impact of climate change include changing the cropping patterns; avoiding further development on wetlands, flood plains, and close to sea level, avoiding land degradation; developing crops that are resistant to drought, heat, and salt; afforestation programs of degraded land with tree species that can sequestrate more carbon, a policy of cut one plant ten in the forest areas and environmental engineering defences against diseases. Designing and building new water projects for flood control and drought management. Introduction of afforestation programs on degraded land, reduction of deforestation, and making honey, mushroom, and snail farms in the afforestation lands.

NTFPs for food, medicines, and water are forest-related priorities for climate adaptation methods. Strategic forest management (SFM) is seen as the simplest way to attain global climate change adaptation and mitigation, furthermore as poverty reduction and economic and social development. Several ways of getting used are vulnerability maps and developing adaptation strategies using forest resources. Ghana has adopted the Taungya program as the simplest way to revive the lost forests within the country. The Forestry Commission of Ghana ought to review the program within the transition zone of the country's forest to push a taungya system as a climate adaptation strategy. This is often wherever the communities are actively concerned and involved in conservation and afforestation programs. The taungya system includes several elements of adaptation strategies. The role of forests should be processed and articulated in national adaptation programs of action (NAPAS).

4.6. Conclusion

The study revealed that climate change has sizable and widespread effects on forests and forest health in Ghana. There are indications, for example, short rainfall, long drought seasons, and an increase in atmospheric temperature have an adverse effect on the forest and the products in it. The effects cannot be overlooked and the direct influence of natural harm on the forest stands a high chance to build adverse effects on the forest and the products therein. Which in turn has reduced the production levels of NTFPs in the forest areas in Ghana. From the study, it was revealed that the high rate of deforestation by both legal and illegal timber loggers has led to the influence on the alteration of the climate. The high rate of deforestation has also adversely affected the production levels of NTFPs in the forest areas in the country. It was revealed that there had been a decline in rainfall and an increase in the atmospheric temperature in the country. It was realised that there has been a long drought season which results in the rise of the atmospheric temperature, and a short rainfall season, adversely affecting the forest. This has altered the production levels of NTFPs in the forest communities, affecting the marketability of the NTFPs in the country. These have affected the income levels of the locals in the forest areas in Ghana. Which has affected the living standards of the locals living in the forest areas.

The study revealed that the locals have perceived changes in the climate in their locality. The locals have observed that there has been a sharp decline in rainfall and a sharp increase in temperature within a period that has had effects on the production levels of NTFPs.

Deforestation, illegal mining, over- exploitation and others were seen to be the major causes of climate change in the forest areas; it was also seen as the cause of the decline of the production levels of NTFPs in the forest areas in Ghana. This issue can be managed by educating the locals on the need to preserve and protect the forest. On the side of the legal loggers, the government, through the Ghana forestry commission, should monitor their operations in the forest to manage the illegal activities held in the forest, which is fuelling deforestation in the country.

The introduction of the afforestation programs like the modified Taungya system by the Forestry Commission of Ghana for the regeneration of degraded land can be considered a way to mitigate climate change and improve the production of NTFPs in the country. The modified Taungya system can be improved by educating and giving incentives to the locals to get fully involved in the process. This can help improve the microclimatic conditions in the forest areas and provide a conducive environment for the living organisms that help in the production of NTFPs. This can help increase the production levels of NTFPs, which can also increase the income levels of the locals and improve their living standards. In collaboration with the country's forestry commission and other Non-governmental organisations, the government of Ghana could come together to educate and support forest-adjacent communities on how to improve upon their NTFPs utilisation and their adaptation to climate change. Realising that climate change affects the production levels NTFPs; it will be recommended to find out if NTFPs have the strength to alleviate poverty in most of the communities in the tropics.

Declaration of Competing Interest

None.

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