Research Paper

Future of Food: Journal on Food, Agriculture and Society
9 (4) November 2021

Farmers' perceptions on climate change and adaptation strategies in Yendi Municipality, Ghana

Selase Kofi Adanu[1*], Theophilus Abole[2], Shine Francis Gbedemah[3]

[1]Ho Technical University, P.O. Box HP 217, Ho.
[2]Abole Farms, P.O. Box 50, Bolga, Ghana.
[3]Department of Geography & Earth Science, University of Environment & Sustainable Development, PMB, Somanya, Ghana

* Corresponding author: sadanu@hotmail.com

Data of the article

First received : 25 December 2020 | Last revision received : 16 September 2021
Accepted : 27 September 2021| Published online :29 November 2021
DOI : 10.17170/kobra-202110144892

Keywords

Climate, perception, adaptation strategies, farm practices, Ghana.

It is common to hear and read about climate change in the literature, media, and interpersonal discussions among farmers and environmental groups. Farmers' understanding of climate change differs amid these discussions because of individual experiences and perceptions after many years of farming. Rainfall is declining, and the temperature is rising are the common perceptions farmers hold on climate change which they see as adversely affecting agriculture. In moments of such adversity, farmers think about what adaptation measures to implement. The objectives of this study were to find out what farmers perceive as climate change, what they consider as the causes of the change, and how they adapt to climate change. Methods used for collecting data were administering questionnaires to farmers in six towns in the Yendi Municipality, obtaining information through focused group discussions, and talking to agricultural extension officers. Data analysis was done using Excel software. The results show farmers are aware that the climate is changing. The changes are perceived as a result of bad farming practices, including cutting down trees, the influence of supernatural forces in preventing rainfall, and changes in wind direction which deprive communities of rainfall. Adaptation measures to cope with climate change mentioned by the farmers include crop diversification to plant drought-resistant crops and diversify from high grass consuming ruminants to low grass consuming ones. The paper concludes that the government should assist farmers to adapt fully to climate change, otherwise, food security will be hampered.

1. Introduction

Climate change refers to changes in the statistical properties of climate systems persisting for decades and could last for about 30 years resulting in climate variability and extreme weather events (Australian Academy of Science, Undated). The Intergovernmental Panel on Climate Change (IPCC) has argued that total human Green House Gas (GHG) emissions continued to rise from 1970 to 2010, with the highest emissions occurring from 2000 to 2010 (IPCC, 2014). Recent climate reports show that between 2015 and 2019, there have been a continued increase in carbon dioxide (CO2) levels at a rate of 20%, which is higher than the previous five years (Olivier & Peters, 2020; World Meteorological Organization, 2019). The in-

crease in atmospheric carbon due to climate change contributes to less predictable weather patterns, making it difficult to cultivate lands in countries that rely on rainfall for farming (National Geographic, 2020). The United Nations (UN) advocates for urgent and ambitious climate change mitigation and adaptation, as well as a rights-based approach to climate action (UN, 2021; UN, 2019).

A major driving force of such emissions is agriculture which is believed to be responsible for releasing 10 - 12% of greenhouse gases such as carbon dioxide, nitrous oxide, and methane (Dai et al., 2021; Gołasa et al., 2021; IPCC, 2007). As a result, the earth's global temperature has increased by 0.740C from 1906 to 2005 and is expected to increase further by 6.40C on average in the 21st century (IPCC, 2007). The rise in global temperature has contributed to increased earth surface temperature and variations in rainfall (Collier et al., 2008). However, it is unclear to scientists and farmers what the future holds as it is difficult to predict in absolute terms what will happen except to use models to simulate climate change scenarios that are likely to occur in the future (Challinor et al., 2007).

Despite the awareness of climate change in the world's scientific community, scientific knowledge among farmers on climate change in developing countries like Ghana is lacking as such, negatively affecting agricultural production which also affects food security (Wood et al., 2021). The objectives of this paper are to find out what farmers in the Yendi municipality perceive as climate change, what they consider as the causes of the change, and how they are adapting to the new phenomena. A review of literature on farmers' perception of climate change and adaptation strategies are discussed in the next section.

1.1. Literature review

1.1.1. Farmers perception of climate change

According to Whitmarsh & Capstick (2018), climate change perception is a complex issue that can be attributed to different social, psychological, and environmental constructs like knowledge, beliefs, attitudes, and concerns about how the climate in an area is changing. Perceptions on climate change can be influenced and shaped by the characteristics of the person perceiving it, their experience, culture, occupation, the information that the person received, and at times the age of the person in question (van der Linden, 2015). African farmers are aware of climate change (Antwi-Agyei & Nyantakyi-Frimpong, 2021; Zougmoré et al., 2021); however, the majority of farmers do not have the capacity to handle the impacts of climate change. In the Central region of Ghana, farmers' perception of climate change focuses on a rise in temperature over time but not on reduction in rainfall, even though scientific data shows a reduction in rainfall as a major indicator of climate change (Dadzie, 2021).

Fierros-González & López-Feldman (2021) observed that literature on climate change in Latin America has increased since 2000 but not up to the volume of literature in Africa and South-East Asia (Karki et al., 2020). In Ghana, some amount of literature exists on climate change in general. However, it is quite limited when it comes to farmers' perceptions of climate change in the northern regions and the mitigative measures to cope with climate change. In developed countries such as Italy, Germany, and France, climate change has been perceived by farmers as a change in climate over the past decades (Mwaniki, 2016). Rokhani et al. (2020) identified factors influencing farmers' perceptions of climate change in developed and developing countries. In developed countries such as France and Switzerland education on climate change is done using scientific data, unlike Ghana, a developing country where minimal education is done using scientific data.

In China, farmers' perceptions of climate change are high as China's central government has prioritised such climate change issues since 2009 (Wang & Zhou, 2020). In Thailand and Vietnam, the geographic location of farmers influences their perception of climate change (Waibel et al., 2018). In the United States of America, tribal farmers believe that climate change has occurred as a result of anthropogenic activities which are causing harm to human society (William et al., 2014).

1.1.2. Adaptation to climate change

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as 'Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm

ISSN-Internet 2197-411x OLCL 862804632

or exploit beneficial opportunities' (IPCC TAR, 2001; 5). Various types of adaptations can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC TAR, 2001). According to Burton et al. (2006), these adjustments reduce the negative effects of climate change on people's health and well-being. Adaptation to climate change takes various forms that are passive, reactive or anticipatory. They aimed at ameliorating the adverse consequences associated with climate change (Smit & Pilifosova, 2003). A study on farmers' adaptation strategies in South Africa, Zambia, and Zimbabwe revealed that farmers focus on long-term changes in rainfall, temperature, and farm-level adaptation measures (Global Environment Facility, 2018). Adaptation to climate change involves a wide range of options such as crop selection and distribution strategies across different agro-climatic zones. It also involves substituting new crops for old ones that are seen as not capable of coping with climate change (Easterling, 1996; Njeru et al., 2016).

Cultivating different crop varieties that adapt appropriately to soil and prevailing environmental conditions at specific places in terms of drought and waterlogged soils are further adaptation measures (Salick & Byg, 2007). According to the FAO (2007), long-term adaptation strategies of farmers include changes in the way the land is used, the use of new land management techniques and technologies and water-use efficiency techniques. In Ethiopia, strategies adopted by farmers and livestock keepers include shifts in livestock types, where goats and sheep are preferred to the rearing of camels that consumes a lot more pasture. Other farmers have fish farms in addition to keeping livestock (Gebre & Kifle, 2009).

2. Methods

2.1. Study area

Yendi is located between latitude 9° 26′33.79 North and 0° 00′35.68 East. The municipality shares boundary with six districts: Saboba to the East, Chereponi and Zabzugu to the South, Nanumba to the North, Gushegu and Mion Districts to the West. The district stretches over an area of 1,446.3 sq. km. (GSS, 2010). The district experiences a mean annual rainfall of about 1,125mm during the peak rainy season of March to September. The daily temperature ranges from 21°C to 36°C. The vegetation is savanna vegetation which is characterised by short to medium trees. The main economic activities are farming and animal rearing. The soil comprises sedimentary rocks of voltaic sandstone shales and mudstone. The soil is predominantly laterites, ochrosols, sand and clay. In terms of administration, the Municipality has three town councils: Yendi zonal council, Malzeri zonal council, and Gbungbaliga zonal council. There are 268 communities in the Municipality (GSS, 2014).

2.2. Sample selection

A purposive non-probability sampling technique was used to select 6 out of 21 farming communities with technical assistance from the Yendi District Assistant Director of the Ministry of Food and Agriculture (MOFA). The six study communities are Dabganjado, Sukaani, Bagbani, Kpaatia, Kulkpanga and Tindang (Table 1). Data were obtained from farmers through face-to-face interviews using a questionnaire to collect information on farmers' observations and perceptions on climate change, levels of awareness on climate change, causes of climate change, adaptation strategies, and barriers to climate change adaptation. Two hundred and forty (240) farmers were randomly selected for an interview with assistance from agricultural extension officers working under the Ministry of Food and Agriculture.

Focus group discussions (FGDs) were held for local people known to be experts in weather prediction. The FGD participants and key informants were purposively selected from seven (7) communities to understand the climate information needs of farmers and also find out the extent to which indigenous knowledge has been helpful to predict rainfall. Processing of data was done using descriptive statistics shown in tables, graphs, and charts.

3. Results

The general perception among farmers in Yendi is a view of rapid changes occurring in climate over decades which is the source of harsh climatic conditions that negatively affect farming. Study results show the majority of the farmers (86.3%) noticed the climate is changing, while (9.5%) said the climate is not changing. A few (3.5%) were not sure about changes in the climate despite the annual variations in the pattern

Table 1: Study communities

Community	Population	Sample Size	Number of People in Focus Group
Dagbanjado	1,548	34	4
Sukaani	1,057	23	5
Bagbani	643	19	4
Kpaatia	1,154	21	5
Kulkpanga	1,650	46	8
Tindang	1,502	38	7
Yendi	51, 335	59	12
Total	**58,889**	**240**	**45**

of rainfall characterised by a decline in precipitation even in months when rain is expected, a situation that has resulted in a much drier Northern Savannah zone. When the farmers were asked about specific observations on the frequency and amount of precipitation in a year, 64.1% mentioned a decrease in precipitation in the past 30 years. Still, a few of them 2.8%, said rainfall rather increased. Those who did not notice any change in rainfall and said the rainfall pattern is somehow irregular were 11.4% 1.2%, respectively. Please refer to Figure 1.

As far as change in temperature is concerned (Figure 2), 58.3% of the farmers said the temperature is rising, and 2.6% perceived a decrease in temperature. Those who said there is no variation in temperature were 14.6%, and 20.4% of the farmers perceived fluctuations in monthly and daily temperatures.

3.1. Awareness of climate change

When farmers were asked about the sources of information available to them on radio and television, 50% of them rated their source of information from media as a 'medium' level of awareness on climate change. Their explanation of what a medium level of awareness means is getting information at least once every six months from a media source. The response of farmers to awareness of climate change is shown in Figure 3.

Those with a low level of awareness constitute 29.6%, and they obtain information at least twice a year on climate change. A few of them, 20.4%, had a high level of awareness of climate change as a result of the occasional visit of agricultural extension officers who educated them on what to do to cope with climate change.

3.2 .Causes of climate change

The farmers mentioned multiple causes for climate change, including superstitious beliefs, seasonal changes, farming practices, and the destruction of trees. Destruction of trees is perceived to be the most common cause of climate change, according to 47.5% of the farmers. The farmers have observed that the absence of trees prevents cloud formation, a requirement for rainfall. Others believed there are supernatural forces such as local gods that can stop the rain from falling whenever the iniquities of communities become unbearable, as mentioned by 22.5% of the farmers (Figure 4).

Those who claimed they do not know the causes of climate change were 12.5% of the respondents. Poor farming practices were mentioned by 10% of the farmers as the cause of climate change, and change in wind direction was mentioned by 5% of the farmers as the cause of climate change. Farmers believe that unfavourable wind directions do not enhance the formation of rain-bearing clouds that cause rain to fall. Others (2.5%) believe that change of seasons from wet to dry naturally causes dry, hot conditions, which is a natural event that cannot be attributed to climate change.

3.3. Adaptation strategies by farmers

Farmers in Yendi Municipality, like many other small-scale farmers in the world, have been adapting to cli-

ISSN-Internet 2197-411x OLCL 862804632

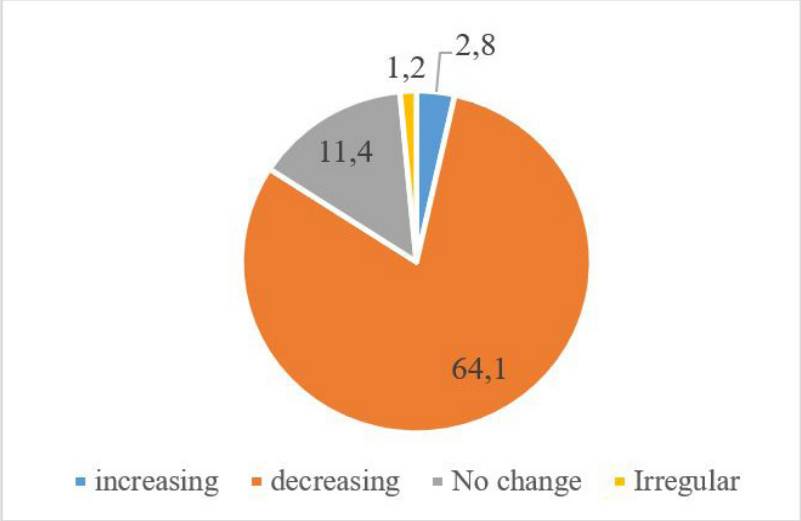

Figure 1. Farmers' perception on precipitation

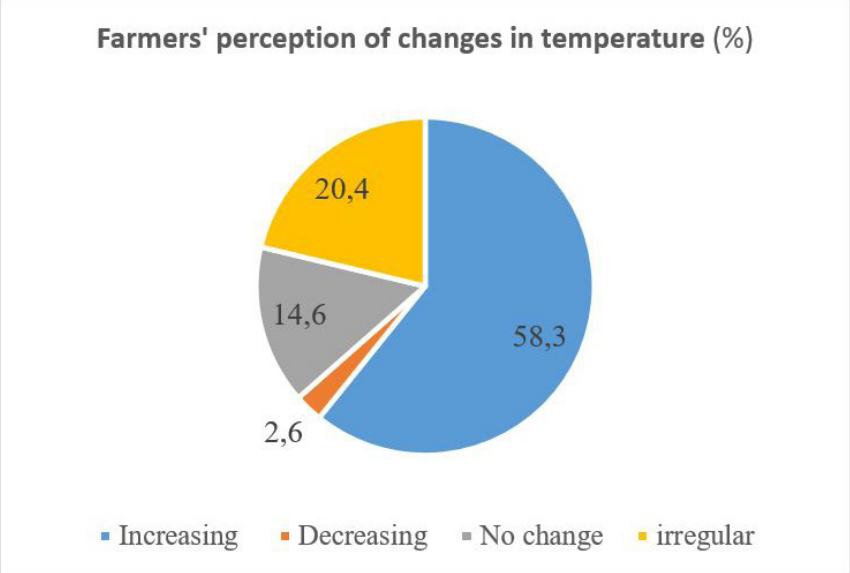

Figure 2: Farmer's perception of change in temperature

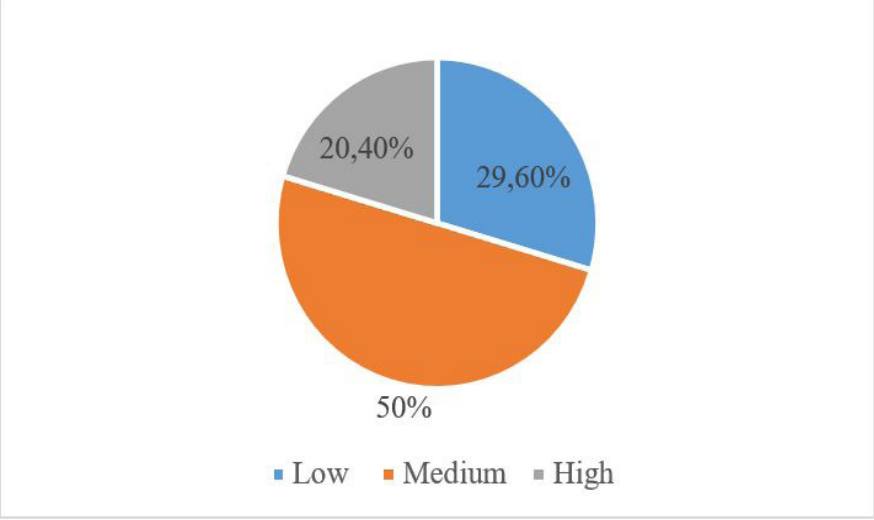

Figure 3: Farmer's awareness about climate change

mate change for many years through improved farming practices. The data shows a majority of farmers affirm they take some actions to cope with climate change. In all, about 92% said they take measures to adapt to climate change, while 8% of the respondents said they take no adaptive measures to cope with climate change.

In a follow-up question to find out what specific adaptation initiatives are implemented, different measures were mentioned, such as the use of chemical fertilisers and a shift from crop cultivation to animal rearing (Figure 5). The most common adaptation measure to climate change is a move away from cultivating crop varieties that cannot cope with water stress to drought-resistant crop varieties that mature in a short rainy season, as mentioned by 42.08% of the farmers. Examples of drought-tolerant crops mentioned are special millet varieties and the cultivation of more vegetables than cereals such as pepper that can be harvested in few months before droughts become severe. Other farmers (20.83%) adapt to climate change by timing themselves to take advantage of the rainfall to plant their crops. The planting dates are critical because a misjudgement will amount to the loss of seedlings. Expansion of agricultural lands is another adaptation strategy meant to cope with climate change, as 12.91% of the respondents believe extending or changing land cultivated from infertile lands to more fertile forest soils will help increase farm yields.

When it is impossible to expand farm sizes due to the absence of forest and woodlands, farmers apply chemical fertilisers to increase their yield, which was mentioned by 7.91% of them. When situations become unbearable due to climate change, most farmers migrate to cities to find menial jobs (Yaro et al, 2015). The construction of dams to irrigate farms is an adaptation method applied by 4.41% of the farmers. Rearing of animals instead of crop cultivation and diversification of livestock from high grass-eating ruminants to less grass-consuming animals amid drought conditions is an adaptation measure practised by 4.16% of the respondents.

3.4. Barriers to climate change adaptation strategies

Even though much effort is put into adaptation to cli-

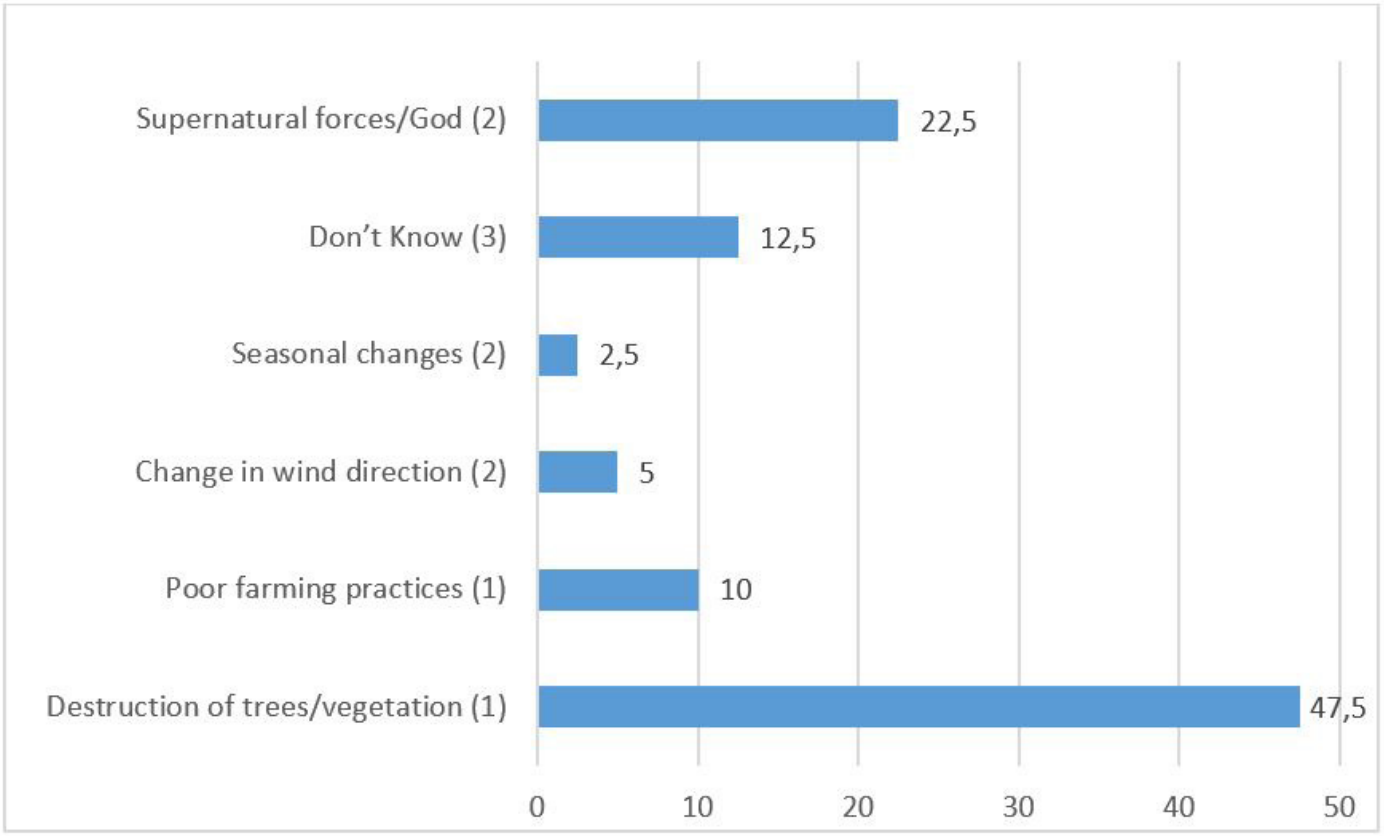

Figure 4: Perceived causes of climate change

ISSN-Internet 2197-411x OLCL 862804632

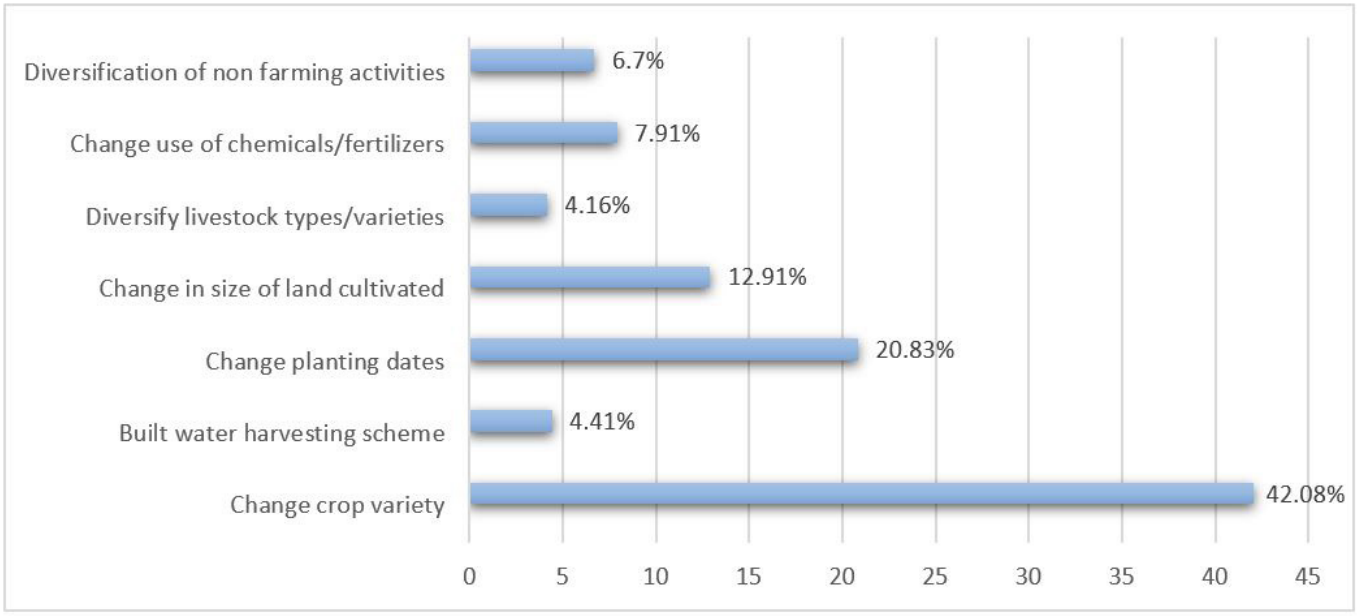

Figure 5: Types of adaptation practices of farmers in Yendi

mate change, there are some barriers to adaptation, such as lack of sufficient information on adaptation technologies and access to credit resources (Figure 6). The majority of farmers (51.9%) cited financial constraints as the main hindrance to climate change adaptation. Other challenges are lack of information (21.6%), inadequate access to irrigation facilities (9.5%), inadequate extension officers (9.4%), and insufficient access to infrastructure and inputs (7.6%). Information from a focus group discussion revealed a lack of access to weather forecast information as set back to climate change as farmers have no information to decide on the type of crop varieties to plant and the methods for planting as effective adaptation measures.

Agricultural extension officers who visit farmers to advise them on their farms are too few, given the ratio of extension officers to farmers in the Municipality (1: 200). Inadequate logistics and the lack of existing farmer co-operatives are seen as limiting adaptation to climate change.

While institutions are key to capacity building which helps farmers adapt better to climate change, they are not well resourced to build the capacity of farmers. When farmers were asked to suggest solutions to the challenges of adaptation to climate change 53.6% of the farmers cited financial assistance from the government. In comparison 10.2% said construction of irrigation facilities and recruitment of more extension officers was mentioned by 8.3% of them. Access to climate information was mentioned by (20.8%), and subsidising the price of farm inputs was suggested by 7.1% of the farmers.

3.5. Policies and incentives for climate change adaptation

Farmers made various suggestions on sustainable adaptation policies and incentives that will make them adapt better. Farmers believe formulation of a comprehensive adaptation framework for the Yendi Municipality, when well-coordinated, will serve the interest of farmers. A coordinated policy will ensure that farmers are assisted in producing and linked to the right markets for their products to be purchased. Government assistance to establish efficient irrigation systems will facilitate crop production during drought periods. The promise made by the ruling New Patriotic Party government to construct dams in every village in Ghana, if indeed implemented, would have helped farmers a great deal.

3.6. Ministry of food and agriculture's support for adaptations

The Ministry of Food and Agriculture (MOFA), whose responsibility is it to support farmers, has not been very successful in helping farmers as it is not

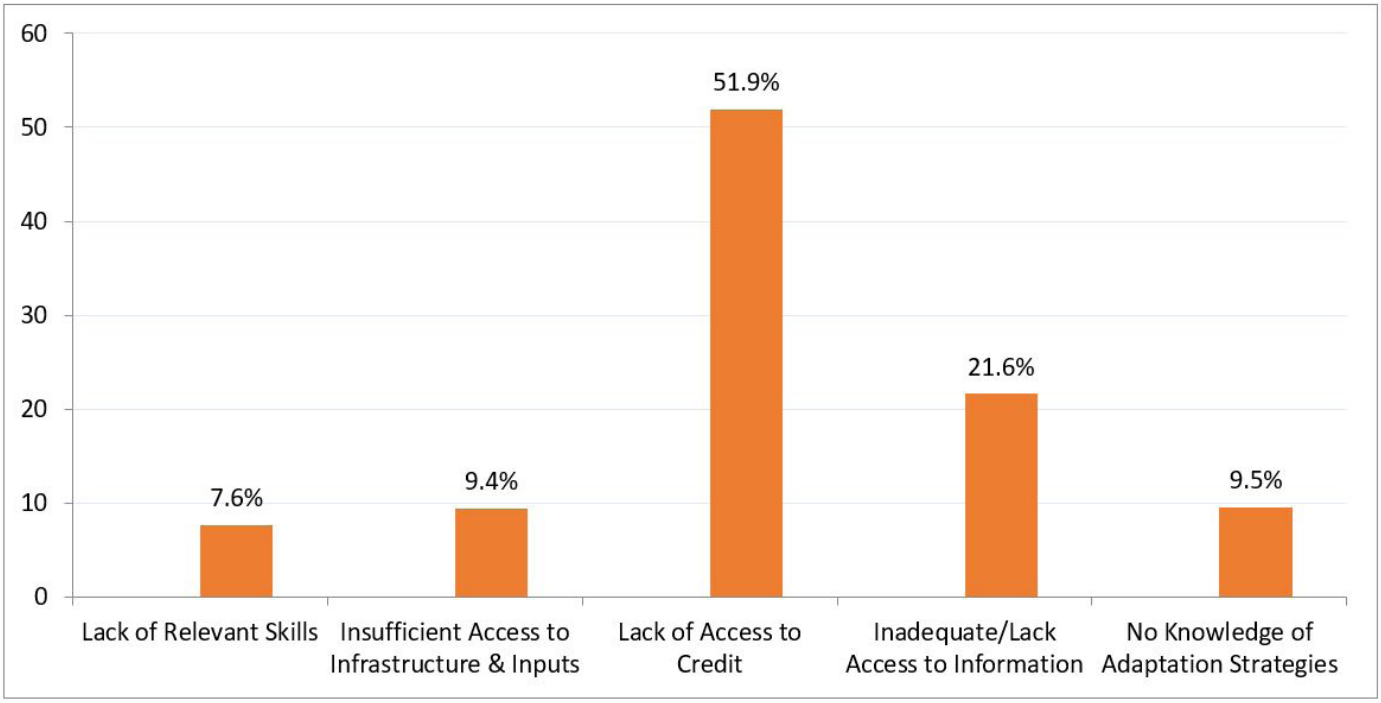

Figure 6: Barriers to climate change adaptation strategies

well resourced. The Ghana national adaptation plan was published in 2018, meaning it is very new and yet to be implemented. A focus group discussion held for farmers showed they have had support from MOFA in terms of technical support, which usually comes as educating farmers on best farm practices and supplying agro-chemicals. The education given to farmers includes bush fire prevention and correctly mixing and applying agro-chemicals on food crops, particularly maize and rice. Even though some credit facilities exist, they have so far not received any benefits. According to the agriculture extension agent for Kpaatia, farmers have not benefited from the credit scheme because they failed to form an association that gives farmers financial assistance as financial institutions find it is easier to recover loans from associations than individuals.

When farmers were asked to rank the kinds of support they preferred from the government, majority of them ranked financial support first (52.5%), followed by material support (35%) in terms of tools and agro-chemicals. Others mentioned technical support, which is the government's main support to increase farmers' output and adapt to climate change, as the least response. About 52.5% of farmers in favour of financial support believe this kind of assistance would help them mechanise their farms, purchase fertilisers, and improve seeds. Those who want material support favour the distribution of free seeds, pesticides, and fertilisers. Only 2.5% preferred technical support such as training to learn best farm practices which will equip them with the knowledge to improve their farming methods to cope with climate change adaptation.

4. Discussions

The general perception of farmers about climate change in the Yendi Municipality is that of a drier savannah zone where the soil moisture is either very limited or absent depending on the month of the year making it difficult or impossible to grow crops. It is also reported that the frequency of rainfall has declined, and temperature is increasing, a perception confirmed by the Ghana Meteorological Agency in 15 years (1997 - 2011). Similar studies in the Western Region of Ghana show farmers' perception of climate change focuses on a reduced frequency of rainfall and an increase in temperature (Acquah & Onumah, 2011). In other parts of the world, climate change is perceived as variability in rainfall and temperature

ISSN-Internet 2197-411x OLCL 862804632

(Jolly et al., 2002; Dhaka, Chayal & Poonia 2010).

Even though farmers are aware the climate has changed, there are many viewpoints regarding the causes, some of which can be based on science, such as destruction of trees/vegetation and poor farming practices that accelerate climate change, while others are based on superstition. Adaptation efforts of farmers to climate change in the Municipality are crop and animal diversification, expansion of farmlands, use of chemical fertilisers and agrochemicals to increase farm yields. Studies elsewhere show farmers resort to livelihood diversification, water harvesting schemes, crop diversification, planting of drought-tolerant crops, migration, and adjustment in planting dates as measures of adapting to climate change (Batterbury, 2004; Khan et al., 2009; Simbarashe, 2013; Nyantakyi-Frimpong, 2013; Liu et al., 2013). The vulnerability of farmers to climate change can be improved further when their capacity is built on climate change adaptation in addition to eliminating social, environmental, and cultural obstacles that hinder climate change adaptation (Sand, 2012; Raghuvanshi & Ansari, 2016).

As mentioned by 51.9% of the farmers in Yendi municipality, providing financial support and subsidies to farmers to buy fertilisers and agrochemicals is another way to adapt to climate change. The District municipal officer of MoFA explained that farmers need to organise themselves to take advantage of credit facilities since financial constraint is seen as a major setback to farmers and institutions who intend to adapt to climate change (Batterbury, 2004).

Lack of irrigation facilities has worsened the plight of farmers as they struggle to cope with climate change. The government's assistance can relieve farmers from the hardship of climate variability and enable them to cope with climate change when irrigation facilities are provided (Vidal, 2009). Government and private sector interventions are vital for farmers to be effective in adapting to climate change. It is projected that the impact of climate change will become severe such that traditional coping/adaptation mechanisms may not be sufficient to deal with these impacts (Rai, 2008).

Limited access to climate information has been a challenge to farmers when it comes to deciding on the type of crops to plant and crop cultivation methods. The availability and access to climate information would aid farmers to make informed decisions concerning their farm operations, but such information is often not available to them (Challinor et al., 2003: Kandji et al., 2006). According to Golnaraghi & Kaul (1995), in the case of Brazil, grain production in 1992 fell by 18% when the average precipitation also decreased significantly by 73%. This can be contrasted with grain production, which fell by 85% in 1987 with about 70% of average precipitation when climate forecasts were not applied.

5. Conclusions

This study concludes that farmers believe the climate has changed in the Yendi municipality with indicators of high temperature and irregular or decreasing precipitation, resulting in changes in the amount of crops produced that will affect food security in the near future. The main causes of climate change identified by the farmers in the study area are negative farming practices of cutting down trees, burning the bush during the dry season and belief in supernatural forces. Adaptation measures to climate change include diversification of crops and animal species. Farmers are ready to adapt their farming methods to cope with the changing trends they have observed but cannot do so due to barriers to adaptation to climate change, such as financial constraints and lack of access to weather information. The difficulty in adapting to climate change affects food supply and food security in Africa and Ghana in particular. Finally, the government of Ghana should put in operation the national climate adaptation plan document that was launched in 2018 to assist farmers to adapt to climate change.

Conflict of Interests

The authors hereby declare that there are no conflicts of interest in the gathering of data and preparation of this paper.

References

Acquah, H. D., & Onumah, E. (2011). Farmers' perceptions and adaptations to climate change: An estimation of willingness to pay. Agris, 3(4), 31-39.

Antwi-Agyei, P. & Nyantakyi-Frimpong, H. (2021).

Evidence of climate change coping and adaptation practices by smallholder farmers in Northern Ghana. Sustainability 13,1308. https://doi.org/10.3390/su13031308

Australian Academy of Science (Undated) https://www.science.org.au/learning/general-audience/science-climate-change/1-what-is-climate-change downloaded on 03-08-2021

Battaglini, A., Barbeau, G., Bindi, M., & Badeck, F. (2009). European winegrowers' perceptions of climate change impact and options for adaptation. Regional Environmental Change 9(2), 61-73. doi:http://dx.doi.org/10.1007/s10113-008-0053-9

Batterbury, S. P. J. (2004). Development, planning, and agricultural knowledge on the Central Plateau of Burkina Faso. In Robson, E. & Cline-Cole, R. (Eds.) West African worlds. local and regional paths through 'development', modernity and globalization. New Jersey: Pearson Education pp. 259-279.

Burton, I., Diringer, E., & Smith, J. (2006). Adaptation to climate change: International policy options. Arlington, VA: Pew Center on Global Climate Change. Retrieved from http://www.preventionweb.net/publications/view/15302. Retrieved On 05-06-2020.

Challinor, A. J., Wheeler, T. R., Garforth, C., Craufurd, P. & Kassam, A. (2007). Assessing the vulnerability of food crop systems in Africa to climate change, Climate Change, 83 (3), 381-399.

Challinor, A. J., Slingo J. M., Wheeler T. R., Craufurd, P. Q. & Grimes, D. I. F. (2003). Towards a combined seasonal weather and crop productivity forecasting system: Determination of the working spatial scale. Journal of Applied Meteorology 42(2), 175-192.

Collier, P., Conway, G. & Venables, T. (2008). Climate change and Africa. Oxford Review of Economic Policy, 24(2); 337-353.

Dai, X-W., Sun, Z., Müller, D. (2021). Driving factors of direct greenhouse gas emissions from China's pig industry from 1976 to 2016. Journal of Integrative Agriculture 20 (1) 319-329. http://dx.doi.org/10.1016/S2095-3119(20)63425-6

Dadzie, S.K. (2021). Farmers' perception of climate change compared with objective data: Evidence from the Central Region of Ghana. Climate Change Economics 12 (1); 2050015. doi.org/10.1142/S2010007820500153

Dhaka, B. L. Chayal, K. & Poonia, M. K. (2010). Analysis of farmers' perception and adaptation strategies to climate change. Libyan Agriculture Research Centre Journal International, 1(6); 388-390.

Easterling, W.E. (1996). Adapting North American agriculture to climate change in review. Agricultural and Forest Meteorology 80 (1); 1-54.

Fierros-González, I. & López-Feldman, A. (2021). Farmers' perception of climate change: a review of the literature for latin america. Front. Environ. Sci. 9:672399. doi: 10.3389/fenvs.2021.672399

Food and Agriculture Organization-FAO. (2007). Adaptation to climate change in agriculture, forestry and fisheries: perspective, framework and priorities. Rome:Food and Agriculture Organization of the United Nations.

Gebre, M. Y.& Kifle, M. (2009). Local innovation in climate change adaptation by Ethiopian pastoralists. Final Report, PORLINNOVA-Ethiopia and Pastoralist Forum Ethiopia (PFE). Ethiopia: Addis Ababa University.

Ghana Statistical Service [GSS], (2014). 2010 population and housing census. District analytical report. Yendi municipality. Accra: Ghana Statistical Service.

Ghana Statistical Service [GSS], (2010). Statistics for development and progress: Ghana censual report. Accra: Ghana Statistical Service.

Global Environment Facility, (2018). Climate change adaptation in Africa, UNDP Synthesis of Experiences and Recommendations. Global Environment Facility. https://www.thegef.org/sites/default/files/publications/CCA-Africa-Final.pdf

Gołasa, P., Wysokinski, M., Bienkowska-Gołasa, W., Gradziuk, P., Golonko, M.; Gradziuk, B., Siedlecka, A., Gromada, A. (2021). Sources of greenhouse gas

ISSN-Internet 2197-411x OLCL 862804632

emissions in agriculture, with particular emphasis on emissions from energy used. Energies 14, 3784. https://doi.org/10.3390/en14133784

Golnaraghi, M. & Kaul, R. (1995). The science of policymaking—Responding to ENSO. Environment 37(1); 16-44.

IPCC (2014). 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.)]. Geneva, Switzerland: IPCC.

Intergovernmental Panel on Climate Change-IPCC, (2007). Climate change 2007: Climate change impacts, adaptation and vulnerability, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson, C. E. (Eds.), Cambridge: Cambridge University Press, 433-467.

IPCC TAR, (2001). Climate change 2001: Impacts, adaptation and vulnerability. IPCC Third Assessment Report, Cambridge: Cambridge University Press.

Jolly, D., Berkens, F., Castleden, J., Nichles, T., & The Community of Sachs Harbour (2002). We can't predict the weather like we sued to: Individual observation of climate change, Sachs Harbour, Western Canada: Arctic.

Kandji, S. T., Verchot, L. & Mackensen, J. (2006). Climate change and variability in the Sahel region: Impacts and adaptation strategies in the agricultural sector. Nairobi, Kenya, United Nations Environmental Programme (UNEP) and World Agroforestry Centre (ICRAF). Available at www. unep. Org…/Themes / Freshwater/ …/Climate Change Sahel Combine. pdf (Accessed on 6 July, 2018).

Karki, S., Burton, P., & Mackey, B. (2020). The experiences and perceptions of farmers about the impacts of climate change and variability on crop production: A review. Climate Development, 12(1), 80–95. doi:10.1080/17565529.2019.1603096

Khan, S. A., Kumar, S., Hussain, M. Z. & Kalra, N. (2009). Climate change, climate variability and Indian agriculture: Impacts vulnerability and adaptation strategies, In, Singh, S.N. (Ed.), Environmental Science and Engineering, Berlin Heidelberg, Springer-Verlag pp. 19-38.

Liu, Y., Goodrick, S.L., & Stanturf, J.A. (2013). Future US wildfire potential trends projected using a dynamically downscaled climate change scenario. Forest Ecology and Management 294, 120-135.

Mwaniki, F. (2016). Kenyan farmers' perceptions of and adaptations to climate change before and after a radio program intervention. Unpublished Ph.D. thesis. James Cook University. Downloaded from https://link.springer.com/content/pdf/10.1007/978-3-319-93336-8_82.pdf on 03-05-2020.

National Geographic, (2020). https://www.nationalgeographic.org/encyclopedia/climate-change/. (Accessed on 3-08-2021).

Njeru, P. N., Maina, I., Lekasi, J. K., Kimani, S. K., Esilaba, A. O., Mugwe, J. & Mucheru-Muna, M. (2016). Climate smart agriculture adaptation strategies for rain-fed agriculture in drought-prone areas of Central Kenya. International Journal of Agricultural Resources, Governance and Ecology, 12(2), 113-124.

Nyantakyi-Frimpong, H. (2013). Indigenous knowledge and climate adaptation policy in Northern Ghana.The Africa Portal, 48, 9.

Olivier, J.G.J. & Peters, J.A.H.W. (2020). Trends in global co2 and total greenhouse gas emissions: 2019 Report. The Hague: PBL Netherlands Environmental Assessment Agency.

Rai, N. (2008). Indigenous peoples and climate change: High vulnerability and unique challenges. World Bank Social Dimensions of Climate Change Workshop, Washington, DC: World Bank.

Raghuvanshi, R. M. A., Ansari, A., & Arjun, A.P. (2016). Adaptation to Climate change by farmers in Himalayan Region of Uttarakhand, Research Journal of Agricultural Sciences 9(2), 399-403.

Rokhani, A.A., Khasan, A.F., Kreft, C.S., Hubber,

R., Wupper, D.J., Finger, R., & Oyekale, A.S. (2020). Factors Affecting Farmer's Climate Risk Perception In Developed and Developing Countries: Evidence From Switzerland and Ghana. Jurnal Sosial Ekonomi Pertanian, 13(3), 296-306.

Salick, B. & Byg, A. (2007). Indigenous Peoples and Climate Change. Center for Climate Change Research. Oxford, UK: Tyndall.

Sand, I. (2012). Assessment vulnerability to climate variability and change participatory assessment approach, Kenyan case study. Bonn: German Development Co-operation.

Simbarashe, G. (2013). Climate change, variability and sustainable agriculture in Zimbabwe's rural communities, Russian Journal of Agricultural and Socio-Economic Sciences 2(4), 89-100.

Smit, B. & Pilifosova, O. (2003). From adaptation of adaptive capacity and vulnerability reduction. In: J. Smith, R. T. J. Klein and S. Hiq, (Eds.). Climate change, adaptive capacity, and development, Imperial College Press, London: pp. 9-28.

United Nations (2021). Frequently asked questions on human rights and climate change. Fact Sheet No. 38. New York: Office of the United Nations High Commissioner for Human Rights (OHCHR)

United Nations (2019). Climate change and human rights contributions by and for Latin America and the Caribbean. Santiago: United Nations.

Van der Linden, S. (2015). The social-psychological determinants of climate change risk perceptions: towards a comprehensive model. J. Environ. Psychol. 41, 112–124. doi:10.1016/j.jenvp.2014.11.012

Vidal, J. (2009). Rich nations failing to meet climate aid pledges. The Gurdian, 20th February, pp 1–3.

Wang, B., & Zhou, Q. (2020). Climate change in the Chinese mind: An overview of public perceptions at macro and micro levels. WIRES Climate Change 11, e639. https://doi.org/10.1002/wcc.639

Waibel, H. Pahlisch,T. H. & Völke, M. (2018). Farmers' perceptions of and adaptations to climate change in Southeast Asia: The case study from Thailand and Vietnam. Natural Resource Management and Policy, 52. doi 10.1007/978-3-319-61194-5_7

William, J.S., Zhongwei, L., Ahmad, S.S., & Karletta, C. (2014). Climate change perception, observation and policy support in rural Nevada: A comparative analysis of Native Americans, non-native ranchers and farmers and mainstream America. Environmental Science & Policy 42, 101-122.

Whitmarsh, L., & Capstick, S. (2018). Perceptions of climate change. In S. Clayton, and C. Manning (Eds.). Psychology and climate change: Human perceptions, impacts, and responses. Cambridge, Massachusetts; Academic Press, 13–33. doi:10.1016/B978-0-12-813130-5.00002-3

Wood, A. L., Ansah, P., Rivers III, L., & Ligmann-Zielinska, A. (2021). Examining climate change and food security in Ghana through an intersectional framework. The Journal of Peasant Studies, 48 (2), 329-348. doi: 10.1080/03066150.2019.1655639

World Meteorological Organization (2019). Record greenhouse gas concentrations mean further warming. Accessed fromhttps://public.wmo.int/en/media/press-release/global-climate-2015-2019-climate-change-accelerates. On 03-08-2021.

Yaro, J.A., Awumbila, M., Teye, J. K. (2015). The life struggles and successes of the migrant construction worker in Accra, Ghana. Ghana Journal of Geography 7(2), 113-131.

Zougmoré, R.B., Läderach, P. & Campbell, B.M. (2021). Transforming food systems in Africa under climate change pressure: Role of climate-smart agriculture. Sustainability 13, 4305. https://doi.org/10.3390/su13084305

ISSN-Internet 2197-411x OLCL 862804632