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Research Article

Understanding the Perception of Mango (*Mangifera indica*) Farmers on the Impact of Climate Change on Mango Farming in Nigeria

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Climate change (CC) scenario is already acknowledged as one of those environmental challenges that threaten every facet of life including mango farming. This study was designed to investigate into mango farmers' perception of the impacts of climate change (CC) on mango farming. A structured questionnaire was administered among 480 mango farmers across six of the states where mango farming is carried out in Nigeria. Both descriptive and inferential statistical methods were applied in the analysis of the data. From the 418 completed and returned questionnaires analysed, it was found that the male gender dominated the respondents in the survey with a proportion of 68% while 61% use pesticides to control pests and 35% own between 1 and 3 acres of mango farmland. The data were subjected to KMO and Bartlett's tests, the results of which showed that the data are factorable with $p \leq 0.05$. Factor analysis (FA) extracted six (6) out of the fourteen (14) variables analysed which were significant to explain the perceptions of the farmers on the impact of CC on mango farming, namely: (i) change in the volume of mango production; (ii) effect of high temperature; (iii) prolonged dry season; (iv) rainfall pattern; (v) incidence of flooding; and (vi) poor performance of mango seedlings. Further analysis showed the prominence of issues relating to climate change. The implication of these results is that mango farming is also being threatened by CC. Hence, it calls for urgent mitigation actions to salvage this subsector. Farmers need to be adequately supported by stakeholders in their efforts to adapt to the ravaging effects of CC on mango farming through relevant policies and programmes. The work also recommended further investigation on the efficacy of the adaptive methods on mango yields.

1. Introduction

Climate change is a global environmental challenge that poses significant threats to various sectors, including agriculture [1–3]. The consequences of CC have prompted several meetings and conferences across the globe seeking to channel ways of mitigating the challenges of the scenario. For instance, the meeting of the United Nations Framework Convention on CC tagged COPS27 held in Egypt between 6th and 18th November, 2022. Some of the consequences of CC include extreme heat, flash floods, erratic rainfall incidence, degradation, defaunation, and fragmentation, among others [1]. Mango (*Mangifera indica*) is one of the popular fruit trees grown in more than twenty countries of the world which is of *Anacardiaceae* family. Mango production is significant to the global economy as it is grown in many countries of the world [4]. It is valuable, rich in vitamins, and generally health beneficial [4–6]. The producing countries include India, the world's largest producing country, China, Sri Lanka, Nigeria, Egypt, Ghana, Togo, and many more [7]. Nigeria is Africa's largest producer of mango with about 800,000 metric tonnes of annual production [7]. It is dominantly produced in most states within Guinea and Sudan Savannah ecological zone, namely, Benue (the highest

producing state in Nigeria), Jigawa, Plateau, Yobe, Kebbi, Kaduna, Kano, Bauchi, Sokoto, Adamawa, Taraba, and the Federal Capital Territory (FCT) [8]. Some of the southern states that are noted for production in Nigeria are Oyo, Calabar, Enugu, and Akwa Ibom States. Eight species of mango grown across these states are Cotonou mango, German type, Benue type, normal sweet and aromatic (Ogbomoso/Enugu (eastern), Calabar/Abuja Yellow mangoes, Sheri mango, Julie mango, Peter/Jane/Binta sugar mango, and kerosene mango [9]. However, mango farming is not excluded from other crops that are facing the challenge of climatic variability. Impact of CC on mango production has been reported in some West African countries such as Ghana [10, 11], Nigeria [12, 13], and Côte d'Ivoire [14], to mention but a few. The impact of CC on mango production has far-reaching consequences for both farmers and the broader economy because it has the potential impact on industrial production, which depends solely on mango fruits as their inputs [15], sustainable living for those that depend on mango production as a source of livelihood [4, 16, 17], and generally on the citizenry that delights in enjoying the sweet taste of the fruit [18]. CC is altering the weather patterns and increasing the frequency and intensity of extreme events such as droughts, floods, and heatwaves, which directly affects mango production [12]. The authors of [19] revealed enormous impact of CC on mango production from farmers' point of view in Bangladesh, which was outlined to include the pattern of rainfall, the quality of mango fruit, and high temperature. The work therefore suggested education of farmers to boost their knowledge on the scenario and technical and financial aids to enhance their coping strategies of CC. In the same vein, the authors of [20] corroborated Imtiaz's finding and lamented the aggravation of pests and diseases due to CC. However, Yeo et al. discovered that no strategy was put in place by the farmers to mitigate the impacts of CC on mango farming. Thus, he recommended training and promulgation of relevant policies to enhance farmers' coping with the menace. In supporting these views, the authors of [10] added post-harvest losses and frequent droughts as part of the perceptions of mango farmers on the effect of CC on their farming, then suggested unhindered access to various socioeconomic resources and education to boost their adaptive capacity. Mango trees require specific climatic conditions to thrive, including a defined temperature range, adequate rainfall, and distinct dry and wet seasons [10]. The authors of [10, 21] further asserted that changes in these conditions have capacity to disrupt the growing cycle of mango, flowering, fruiting, and overall mango yields. For instance, rising temperatures can lead to heat stress which could affecting the growth and development of mango trees [20, 21]. The authors of [11, 22, 23] further revealed that higher temperatures can also accelerate the ripening process, reducing the quality and shelf life of mango fruits. The authors of [24] also added that changes in rainfall patterns can cause irregular flowering and fruit set, leading to reduced yields and yield components. Increased occurrences of extreme weather events can result in the destruction of mango orchards through floods, storms, and cyclones, causing substantial economic losses for farmers [25]. In view of the harsh and counter-production condition created by the scenario of CC, it has become expedient to the researchers and other stakeholders to identify ways of mitigating the effects of CC on sustainable mango production. The effort of these stakeholders may be truncated in a situation of inadequate or total lack of relevant data, most especially in the developing countries. The authors of [25] reported that the situation created by the scenario has afforded production of mango in high altitudes. He enumerated the consequences of CC to include delay maturity, delay fruit ripening, poor fruit quality, distorted colour development, sun burn fruits, poor panicle emergence, and improper flower pollination, among others. Similarly, the authors of [26–28] had reiterated that the complex interaction of altered temperatures has the potential to influence the shift in the maturity of most fruits, including mango fruits, which are vulnerable to high temperature, and also, the home base of most fruits may induce shift to a large extent. Thus, it was suggested that sustainable adaptation strategy is desirable for mango fruits and other tropical fruits because of the intensity of CC situation. The authors of [29, 30], in corroborating on the impact of CC on fruit production, identified the consequences of climate extremes such as scorching sun, erratic rainfall, drought and hurricane, development of increased soil salinity in some regions, lower and more irregular rainfall, rise in mean temperatures, and increase in atmospheric carbon dioxide (CO_2). However, the authors of [31, 32] lamented on the lack of crop model for mango which aversely impedes the prediction of the effects of CC on the development and production of the crop. This situation, according to the authors of [33], implied that the development of mango fruit will only be dependent on the knowledge of local farmers in the era of climatic variability and its associated consequences. The authors revealed that the adaptation of mango production to CC may have to include cultivar and rootstock selection, and improvement on the cultural practices.

The implication of all these experiences of mango farmers is that losses may result, having the potential of discouraging them from remaining in the business. Until recent times, emphasis has been on the general impact of CC on agricultural activities [34, 35]. There is still dearth of information on the impact of CC on mango farming specifically in the sub-Saharan region. Thus, an investigation as this is desirable to fill the gap. This research was designed to examine how mango farmers in Nigeria have perceived the fingerprints of CC on mango farming. This will enable us to examine how the farmers have been adapting to the consequential effects of the harsh climate birthed by climate scenario to survive. The objectives of the study are to (i) explain mango farmers' understanding of what CC is; (ii) explain ways by which mango farmers have been adapting to the manifestations of CC; and (iii) identify and rank the perceptions of mango farmers about the scenario of CC on their farms. It is expected that the results obtained from this investigation will avail the opportunity to channel ways of boosting mango production for human livelihood and its sustenance, having suppressed the impacts of CC.

2. Method of Study

2.1. Study Area. The study area comprises of six (6) major mango-producing states, namely, Benue, Kaduna, Plateau, Cross River, Osun, and Oyo States. The states (Figure 1) showed that three of them were found within the ecological zones of guinea savanna belt in the north central part of the country while the other three are within the tropical ecological zone in the southern part. The two ecological zones are favourable for mango production in terms of rainfall and temperature required and soil qualities.

The Guinea Savanna Zone is one of the ecological zones in Nigeria, and a transitional zone between the more southern humid rainforest and the dry Sahel zone in the country. It is characterized by a distinct grass vegetation and a unique blend of climatic conditions [36]. It is in the northern part of the country and spans across several other states, including Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, Bauchi, Gombe, Yobe, Borno, Taraba, Adamawa, and parts of Niger and Benue states. The zone experiences a semiarid climate, characterized by a distinct wet and dry season [36, 37]. The wet season typically lasts from May to October, during which the region receives average annual rainfall ranging from 800 mm to 1200 mm, supporting the growth of grasses, shrubs, and scattered trees [37, 38]. These vegetation types form the characteristic savanna landscape, consisting of a mix of tall grasses, baobab trees, acacias, and shea trees [37]. Mango production is supported with favourable climatic conditions and well-drained soils in the region. The rainforest belt experiences high temperatures with little seasonal variation. The average annual temperature ranges from 25°C to 30°C (77°F to 86°F). There is relatively little variation in temperature between seasons, with only slight variations throughout the year. The zone receives abundant rainfall throughout the year of between 1500 mm to over 3000 mm, with no distinct dry season [38]. The rainforest belt of Nigeria is home to various mango varieties, including popular cultivars such as Keitt, Tommy Atkins, Kent, and Ogbomoso. At times, mango trees are grown with cocoa, kola nut, and other tree crop plantations in the zone.

3. Method of Data Collection

3.1. Sampling Technique. Multistage sampling technique was used to arrive at the sample size selected. From the states where mango farming is practiced in Nigeria, six (6) were picked for study. The states selected include Benue, Kaduna, Plateau, Oyo, Osun, and Cross Rivers states. Based on the available fund and the time frame for the investigation, four LGAs were selected in each of the states, out of which four (4) rural communities consisting of mango farmers were selected. Twenty (20) mango farmers were then randomly selected from each of the four (4) rural communities, given a total of eighty (80) respondents from each state. Thus, a grand total of four hundred and eighty (480) respondents were involved in the survey.

3.2. Data Collection. Primary data were generated for the purpose of this investigation. The target respondent was the population of mango farmers in the areas of study. Structured questionnaire was designed and administered among eighty (80) randomly selected mango growers in each of the six selected states. The first section of the questionnaire contained personal information on the respondent such as name of village, size of farm, gender, and knowledge about CC, among others. The second part of the instrument was structure questions on the perceptions of mango farmers on the impact of CC on their respective mango farms. The survey was conducted mostly in the morning and evening time to ensure that the farmers were reached during their off-farm period. However, four hundred and eighteen (418) copies of the questionnaire were completed and retrieved across the study areas for analysis. The selected villages from each of the states are as shown in Table 1:

3.3. Method of Data Analysis. The data generated were subjected to both descriptive and inferential statistical analyses. The descriptive analysis includes use of tables and percentages to present some of the basic attributes of the respondents. On the other hand, inferential statistics involved use of factor analysis (FA) to identify by ranking the significant variables that explain the perception of the mango farmers on the impact of climate variability on mango farming. SPSS software was used for the analysis. Kaiser–Meyer–Olkin (KMO) and Barttlet's test of sphericity showed the factorability of the dataset with KMO value of 63.3 which is significant at $p \leq 0.005$. In the use of FA, the Eigen value was set at the minimum of 1.000. Thus, any variable which fails to meet up with this standard is discarded and declared as insignificant in explaining the subject matter. Significant variables are the ones with the highest values across the six orders of the rotated component matrix (RCM). The hypothesis which was set for validation or otherwise was that: mango farmers' perception on the impact of CC on their mango farms requires stakeholders' attention.

4. Results and Discussion

The breakdown of the 418 retrieved questionnaire revealed that the respondents are of diverse attributes. These are as follows:

4.1. Gender Distribution of the Respondents. The results showed that more male gender participated in the survey than the female gender. Figure 2 shows that 68% (284) were males while 28% (117) were females and the remaining 4% (17) did not declare their gender. The authors of [39] found that, though more females engage in agriculture in Nigeria but revealed that the involvement of both genders is complementary. The more male respondents in this survey could reflect the belief in male headship of families in African

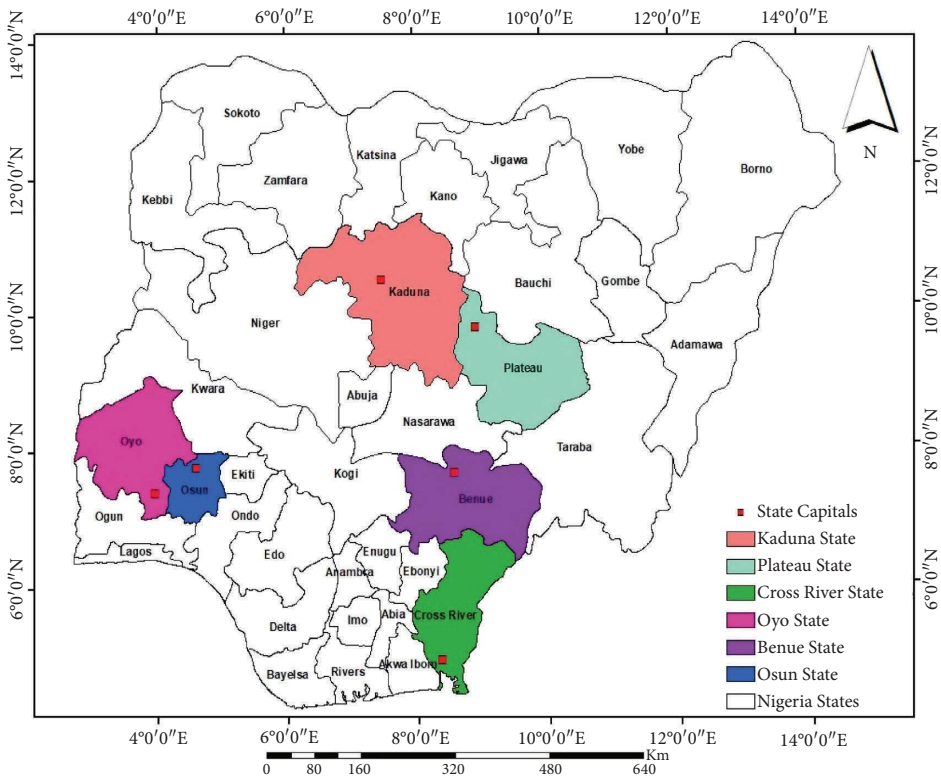

Figure 1: Map of Nigeria showing the six states of investigation.

homes. The survey was carried out with preference for male household heads and wherever not available, the spouse was chosen for the survey.

Access to CC information of the entire 418 respondents, 80.14% (335) claimed access to CC related information while 16.75% (70) claimed no access to CC information and the remaining 3.11% (13) did not declare their status on this (Figure 3). The authors of [31] had revealed that more efforts are still required for the dissemination of CC related information in their study area. This is similar to the report of [14] who found that 94% of their respondents are aware of the prevailing CC. However, the results here showed an improved access to information on CC. This is expected to improve on taken measures to checkmate the consequences of CC as also reported [14].

4.1.1. Medium of Obtaining the Information. Figure 4 shows that about 98% of those that have access claimed that they got most of their information through radio, television and public enlightenment, 3% got the information through reading and from friends while 2% declare obtaining the information from their experiences about weather condition and rainfall variability over the years. The dominant sources of information on CC as observed in this work corroborated the findings of [31].

4.2. Respondents' Interpretation of What Climate Mean. Figure 5 reiterates that most of their respondents believed that CC is the major cause of erratic rainfall (83%) while some other believed that prolonged dry season (9%) is because of CC scenario. Apart from these viewpoints, some other farmers claimed that incessant flooding (5%) and extreme high temperature (3%) are prominent indicators of the change in the climate. The authors of [31, 40, 41] had reported diverse interpretation of what CC is to different individuals in Nigeria. These include the pattern of rainfall, temperature and long dry season as noted here. The authors of [42] had to conclude that climate change impact is albeit based on different ecosystems while perception about the impacts is often culturally specific.

Figure 6 shows that 61% of the respondents adopted the use of pesticides to curtail the activities of pest and diseases which they believed arose as a result of CC scenario. 21% adopted soil water conservation through mulching, planting of cover crops; 16% decided to engage in other crop farming such as yam, cassava, maize, and sweet potato, to adapt to the prevailing CC effects. The authors of [14, 40] revealed that in view of the prevailing unreliable rainfall incidence coupled with extreme temperature, farmers adopted soil water conservation methods to cushion the effect of CC on the crops. The planting of hybrid seeds with shorter maturity period is another strategy to adapt to CC among mango farmers.

Table 1: Distribution of questionnaire across the study areas.

S/no	Ecological zone	Name of state	LGA	Name of villages	No of respondents	No retrieved	Cumulative total retrieved
1	Guinea savanna ecological zone	Benue	Gboko	Luga	80	72 (90.0%)	72
			Ukum	Kyado			
			Kon shisha	Gungu			
			Ukum	Ukukal			
		Plateau	Jos north	Kuru	80	68 (85.0%)	140
			Bassa	Jingre			
			Ryom	Tahoss			
			Bassa	Ruguba			
		Kaduna	Rigacikun	Kawo	80	69 (86.25%)	209
			Gaza	Dumbi			
			Giwa	Zaria			
			Zango	Chikun			
2	Rainforest ecological zone	Cross river	Boki	Bukalum	80	61 (76.25%)	270
			Akamkpa	Iko Esa			
			Biasse	Ikotana			
			Yakuur	Agoi mbami			
		Oyo	Surulere	Oko	80	75 (93.75%)	345
			Ogbomoso north	Pakiotan			
			Ogo-oluwa	Pontela			
			Afijio	Fiditi			
		Osun	Ayedire	Olupona	80	73 (91.25%)	418
			Iwo	Toto			
			Egbedore	Iwoye			
			Ejigbo	Ifeodan			
					480	418 (87.65)	

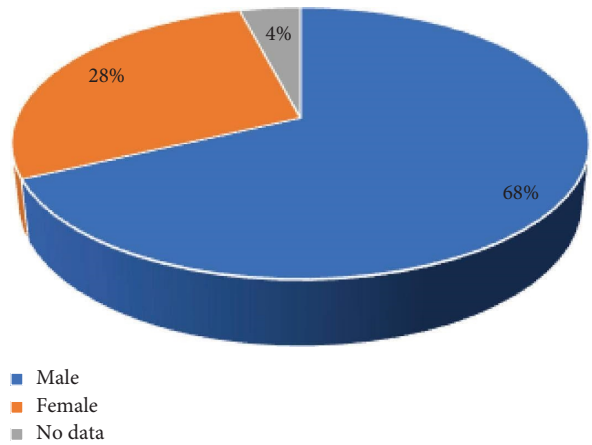

Figure 2: Gender distribution of the respondents.

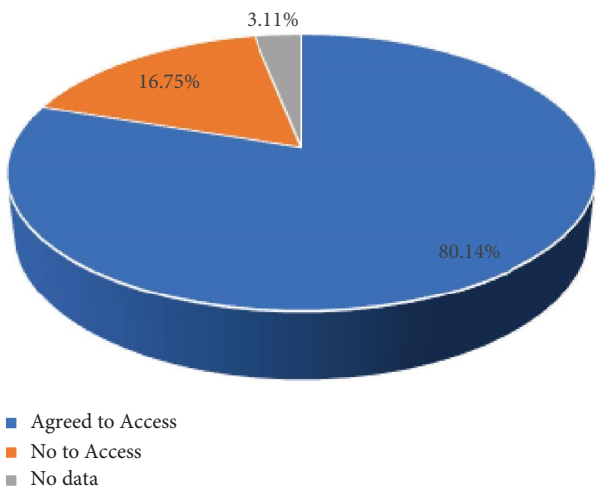

Figure 3: Respondents' access to information on climate change.

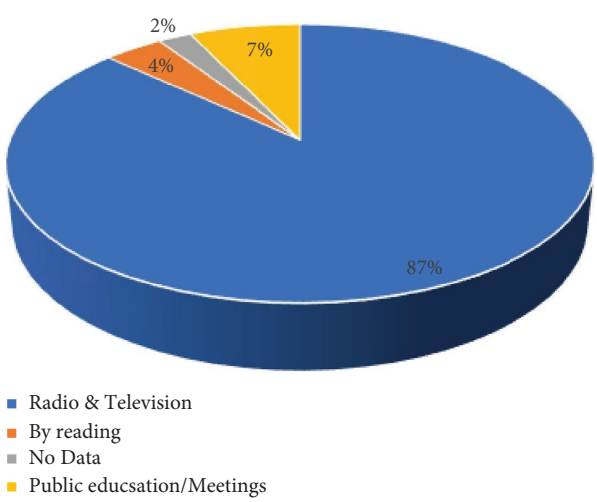

Figure 4: Sources of information to the respondents.

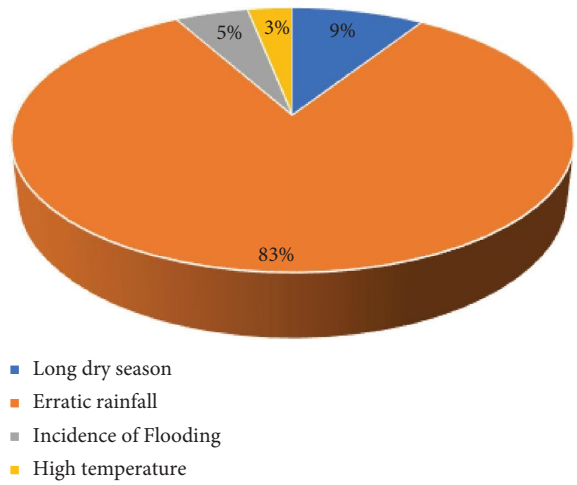

Figure 5: Farmers' respective interpretation of what climate change is.

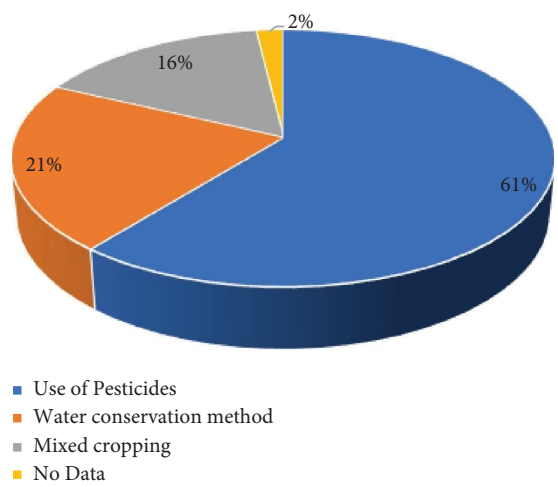

Figure 6: Farmers method of coping with the impact of climate change.

Figure 7 reveals that 146 (35%) of the respondents claimed possessing between 1 and 3 acres of mango farm, 92 (22%) having 7 to 9 acres; 75 (18%) also claimed possessing 4 to 6 acres while 71 (17%), less than 1 acre; and mango farm size greater than 9 acres being possessed by 34 (8%) of the entire respondents.

4.3. Mango Farmers' Perception on the Impact of CC on Mango Production. The results of FA are presented in Table 2, which showed that six (6) variables were identified and extracted as significant in explaining farmers' perception about CC out of the fourteen (14) which were subjected to analysis.

The first on the rank of these variables in Table 2 is the change in the volume of mango production. It has an Eigen value of 1.908 with the highest value of 82.3 among the other

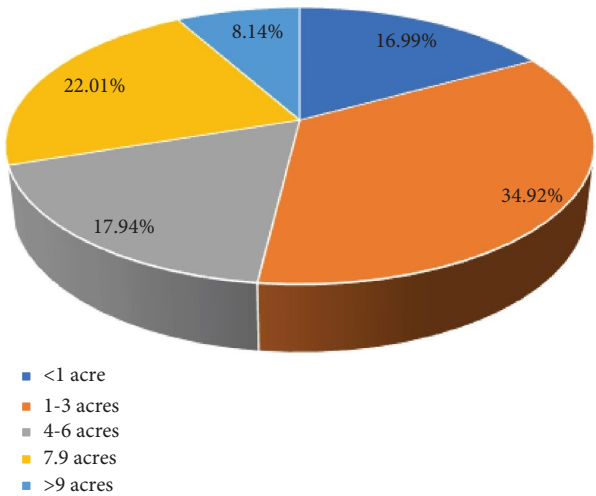

Figure 7: Farmers' mango farm sizes.

arrays of 14 variables on the RCM. It offers 13.122% of the explanation of farmers' perception of the impact of CC on mango production. This observation corroborated the findings of [13, 42], who discovered a decline in fruits production in Algeria, the situation they attributed to the impact of climate variability, especially the incidence of erratic and unreliable rainfall. Also, in their investigation, the authors of [11, 14] reiterated that CC contributed to the infection of mango fruits with pests which caused drastic fall in the volume of mango production in the past decades.

Next to this in Table 2 is the contribution of high temperature. It ranked highest with 88.3 among the other variables on the second order of the RCM. It is ranked second with an Eigen value of 1.894 and held a proportion of 12.624% of the total explanation of 66.967% offered by the entire extracted variables. The perception of mango farmers on the impact of CC on mango production as indicated here showed that temperature is significant. This finding buttressed the view of the authors of [11, 43], who established that temperature has negative correlation with mango flowering, fruiting, and maturity of mango. In the same vein, [44, 45] added that high temperature incidence contributed to the poor yields of mango as the extreme heat with late rainfall did not support good yield of mango.

The experience of mango farmers on the extended or prolonged dry period also contributed to the explanation of their perception about CC impact on mango farming. This variable was captured in the third order of RCM with the highest value of 80.8. It has an Eigen value of 1.681 and explains 11.205% of the total variance of 66.967%. This indicates that mango farmers perceived those variations in the prolonged dry season impact on mango production. In the view of [10, 33], late rainfall retarded the sustainability of flowers, fruit, and their maturity and this caused poor yield and eventual poor income from mango farming. The observed prolonged dry season by the respondents could pose serious threat to mango farming because it has the tendency to retard flowering and fruit maturity and the yields. The authors of [46, 47] had reported that mango is highly productive when the period of dryness is well defined and not erratic while the reverse is the case when it is not. The authors of [47] stressed that rainfall and temperature fluctuations, water stress and hard lateritic soils (often associated with dry period) retard mango productivity a great deal.

Following this is the unpredictable rainfall pattern, which was ranked highest in the fourth order of RCM with 88.5 in the array of 14 variables analysed. It has eigen value of 1.595 and offered 10.632% of the total variance. There are reports that CC has contributed to the erratic pattern of rainfall in the tropical region [48, 49]. The identification of rainfall pattern as a significant factor to explain the perceptions of mango farmers indicate that mango production has been inflicted by the distributional pattern of rainfall. For instance, when rain falls at the expected period, mango thrives while when it is otherwise, the reverse is the consequence. The authors of [46, 47, 50] revealed that the erratic pattern of rainfall where fruit is largely grown has reduced the volume of mango production over the years. Similarly, the authors of [33] stated that mango fruits suffered loss because of excess rainfall in their area of study.

Occurrence of flood was also identified and extracted as another significant variable that explains the perception of farmers on the impact of CC scenario on mango production. It stands out among the other 14 variables in the fifth order of the RCM with 82.4. However, it is the fifth variable extracted by FA with an eigen value of 1.493 and gave 9.951% of the total explanation of 66.967%. This result indicated that the occurrence of flood is perceived by mango farmers as being associated with the prevailing CC. According to [51, 52], flood occurrence caused devastating effect on farming, especially mango production. [53], however, attributed poor yield to the flood incidence in the area prone to flooding. They therefore called on the appropriate authority to come to the aid of mango farmers who incurred losses on their farms.

The last significant variable extracted by FA and with the high value on the array of the sixth order of RCM is the perceived effect of CC on mango seedlings with 64.4. It has a weighted value of 1.415 and explained 9.433% of the total variance. This observation implied that the survival and growth of mango seedlings over time had been a dictate of CC scenario. The authors of [54, 55] stated that mango seedlings have not been performing well because of climatic variability. The authors of [56] and [55, 57–59] had lamented on the impact of climate variability, stressing that farmers have been losing mango seedlings to drought which they perceived is a product of CC being broadcasted globally. Hence, capacity building and training for mango farmers on measures to mitigate this challenge on their farms were suggested.

The general view of the extracted variables showed that all their respective weights do not significantly differ. The range of the weights of 0.553 is negligible that none of the variables should be handled with levity in attending to their mitigation. In the actual sense of it, of the six variables extracted, four of them were found to be directly related to the scenario of CC. These are: (i) temperature index; (ii) prolonged dry period; (iii) rainfall pattern; and (iv) incidence of flooding, all weighing 6.753 and a total

Table 2: Extracted variables and their respective attributes.

S/no	Variable name*	RCM**	Eigen value*	% variation explained*	% cumulative variation*
1	Change in volume of mango production	82.3	1.968	13.122	13.122
2	High temperature	88.3	1.894	12.624	25.766
3	Prolonged dry season	80.8	1.681	11.205	36.951
4	Characteristic rainfall pattern	88.5	1.595	10.632	47.583
5	Incidence of flooding	82.4	1.493	9.951	57.514
6	Seedling performance	64.7	1.415	9.433	66.967

Source: *Extracted from total variation table explained generated by SPSS. **Extracted from rotated component matrix (RCM) table generated by SPSS.

explanation of 44.412% (66.319% of the absolute value) out of the overall total of 66.967%. Also, the remaining two variables, namely; (i) change in volume of mango production and (ii) impact on mango seedling performance, which offered 22.555% (33.681% of the absolute value) out of the overall total variance of 66.967% revealed the direct impact of CC scenario on mango farming.

Upon all, though only six variables were identified by FA as significant to the explanation of mango farmers on their perception on the impact of CC on mango farming, it is important to understand that all other eight variables were found valuable, though found insignificant. This indicates that none of the variables analysed in this investigation can be totally discarded.

5. Conclusion and Recommendations

This study delved into the perception of mango farmers on the impacts of CC on mango farming. The results showed that 69.0% of the respondents were males while 80.1% claimed having knowledge of the ravaging climate change, the information of which 98% claimed was gotten through electronic media (radio and television). 83% attributed the cause of CC to erratic rainfall while different methods such as: use of pesticides (61%), soil water conservation (21%); raising short-term crops like maize jointly with their mango farming (16%) to subdue the associated consequences of CC on their mango farms which are of varying sizes. Kaiser–Meyer–Olkin (KMO) and Bartlett's tests showed the factorability of the dataset with a KMO value of 63.3 significant at $p \leq 0.005$. FA extracted six variables that significantly explained 66.692% of the variance in the perception of mango farmers on the impact of CC on mango farming, namely: (i) change in volume of mango production (13.122%), (ii) high temperature (12.624%); (iii) prolonged dry period (11.205%); (iv) the pattern of rainfall (10.632%); (v) incidence of flooding (9.951%); and (vi) seedling performance (9.433%). Further analysis of the results revealed that out of the six factors, four variables (ii-iv) with a total variance of (44.512%), that is, 66.5% of the absolute value are associated with climatic parameters. This is an indication that climate change is impacting on mango farming from human viewpoint in the study area. Thus, all stakeholders need to put relevant policies in place that will enhance farmers' coping strength with the scenario of CC for sustainable mango farming. It is important that all variables that were subjected to FA be given attention because all the other eight variables were found valuable (with a total variance of 33.033%), though they were found to be insignificant to the explanation of the perception.

Data Availability

The data used for this study are available from the corresponding author with reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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