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Agricultural community-based impact assessment and farmers' perception of climate change in selected Ecological Zones in Nigeria

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Abstract

Background: The impacts of climate change are affecting sustenance and livelihood of many rural farmers in Africa. The majority of these farmers have low adaptive capacity. This study investigates climate change impacts, farmers' perception, adaptation options and barriers to adaptation in three selected ecological zones in Nigeria using three staple crops. Rainfall and temperature data of over 35 years were analysed using ANOVA, Mann Kendall and Sen's Slope Analysis. Farmers' perception of climate change and cropping experiences were assessed with the aid of a well-structured questionnaire, semi-structured interview and focus group discussion.

Results: The results of the study revealed high variability in the annual and monthly rainfall and temperature during the study period. The highest annual maximum temperature was recorded in Kwara with Tmax > 32 ℃. Though, there appeared to be spatial and temporal variations in rainfall in the study area, the highest was in Ogun with mean annual rainfall = 1586.9 mm and lowest in Kwara with mean annual rainfall = 1222.6 mm. Generally the Mann Kendall and Sen's slope analysis revealed general increase in the minimum and maximum temperature, while rainfall revealed generally downward trend. The study revealed a difference in farmers' perception but nearly 74% of farmers perceived that climate is changing, which is affecting their farming activities. Nearly 70% claimed that lack of financial capital is the major barrier to climate change adaptation.

Conclusions: The study concludes that rainfall and temperature variability have significantly impacted cropping and that farmers are aware of long-term changes in temperature and rainfall, but some are unable to identify those changes as climate change. There is a need for affordable and available improved seedlings and variety of crops that can adapt to climate change conditions.

Keywords: Climate change, Farmers' perception, Community-based impacts assessment, Nigeria

Background

Climate change and associated impacts have been reported to be capable of posing imperative short-term and long-term impacts on crop production and food security. The impacts of climate change is evident on livelihood of many, especially the rural farmers in Africa who depend on rainfall for crop cultivation [1–4]. Some studies have revealed that climate change is manifested through change in weather events: windstorms, droughts, rainstorms/floods and dust storms which are becoming more frequent and severe [5–7], while other studies showed that changes in land use and land surface temperature, sea level rise, and coastal erosion is already presenting significant long-term challenges of climate change [8–11].

Climate impacts crop production with a direct effect noticeable in quality and quantity of yield which is usually adverse. Among the elements of climate, rainfall and temperature are the major determinants for crop production

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[12, 13]. Thus, climate change has become a menace to economies of different countries, especially the agrarian nations. Since the world attention was drawn by Fourier in 1824, climate change has been an academic discussion of vehemence that is inevitable and has been established to portend threats to agriculture. With many economies depending on agriculture, most especially the developing countries, the change affecting agriculture invariably affects the economy of the developing countries [14, 15]. Understanding meteorological conditions is very essential [4, 16, 17], because natural variability plays important role in climate which affects agricultural activities. Certain weather experiences are becoming more prominent and severe with extended odds and natural limits associated with climate change [18]. According to Food and Agricultural Organization [19], rain-fed agriculture employs the majority of the labour force in Sub-Saharan Africa, which is about 70% of the total population and accounts for 25% Gross Domestic Product (GDP) in the region and responsible for the nearly 90% of Sub-Saharan Africa food production. Thus, forming the major activity of livelihood for about 70% of the population [19]. The current change in climatic conditions are becoming obvious especially in areas where rain fed agriculture is dominantly practiced.

Despite the effect climate change portends to agriculture, there are limited studies on climate change, perception of farmers and their cropping experiences generally in Nigeria and other part of Africa [20–22]. The present study focuses on three (3) different states in Nigeria which falls within three different ecological zones by assessing perception of farmers on climate, their cropping experiences and how it has impacted the yield of the selected staple crops (maize—*zea mays*, rice—*oryza sativa* and cassava—*manihot esculenta*) which have not been well-documented in literature.

Materials and methods

Study area

The study covers three states: Ondo in rainforest ecological zone, Ogun in freshwater and Kwara in guinea savannah (Fig. 1). Ondo State is located between longitudes 5° 5′ and 5° 83′ E; and latitudes 7°10 ′N and 7°15 ′N [23]. Ondo State is of lowland tropical rain forest having two distinct seasons of wet and dry with mean temperature ranging between 27 ℃ in the south and 30 ℃ in the north and mean relative humidity is over 75% [24]. The rain falls throughout the year with relative dryness from November to January with annual rainfall of 2000 mm. Ogun state is located between latitudes 6°12′0 ″N and 7°47′60 ″N and longitudes 3°0′0 ″E and 5°0′0 ″E [25]. Ogun State (freshwater) is typical of tropical climate consisting of two different seasons of wet and dry. The annual rainfall value range is between 1400 mm and 1500 mm with a relatively high temperature of an average of 30 ℃ [14, 15]. Kwara is located between latitudes 7°45 ′N and 9°30 ′N and longitudes 2°30 ′E and 6°25 ′E East [24]. Kwara state (guinea savanna) lies within the tropical climate and it is characterized by double rainfall maxima with tropical wet and dry climate with the seasons lasting for about 6 months each with annual rainfall ranging from 1000 to 1500 mm and annual mean temperature ranging between 30° and 34 °C [24]. The study area is shown in Fig. 1.

The majority of people of Ondo state are into agriculture with high production of both tuber and root crops. The tuber crops include yam, cassava, cocoa yam etc. and grain crops like maize and rice. Also cash crops like cocoa, coffee, plantain, banana, kolanut, palm oil, among others are also grown. Also, there is a large scale production of timbers because of the large forest reserves of about 2008sq km which yields timbers for furniture, fuel wood and industrial uses [25, 26]. Ogun state is also agro based state in which agriculture has employed many especially those in the rural areas. Arable crops like maize, rice, yam, cassava, cocoyam, groundnut, melon, banana, plantain, oranges etc. are grown [25]. Agriculture is the major occupation of the people of Kwara with many into food crop (e.g., cereals like rice, maize, millet and tuber crops like yam, cassava, cocoyam etc.) cash crop production like cocoa, coffee, kolanut, palm produce are also grown [24].

Data acquisition and analysis

This study employs both primary and secondary data. The primary data was sourced through Semi-Structured Questionnaire, Key Informant Interview (KII) and Focus Group Discussion (FGD) administered to farmers in the selected agricultural settlements from the selected ecological zones to assess their perception on climate, cropping experiences, level of adaptation and barriers to practice of adaptation. For this study a total of 180 copies of a questionnaire, 6 Key Informant Interviews and 3 Focus Group Discussions were used. 60 copies of a questionnaire, 2 KII and a Focus Group Discussion were done at each of the selected states belonging to different ecological zone which was further divided into three communities. To ensure data quality, data were sourced from farmers who are above 45 years of age. Climatic data of 37 years (1982–2017) including rainfall, minimum and maximum temperatures were sourced from the archive of Nigerian Meteorological Agency (NiMet) Oshodi. This data was daily data collected from the synoptic stations located at Akure, Abeokuta and Ilorin in Ondo, Ogun and Kwara states, respectively. NiMet carried out the data recording at these stations using the British Standard Rainguage and Dine's tilting siphon rainfall recorder

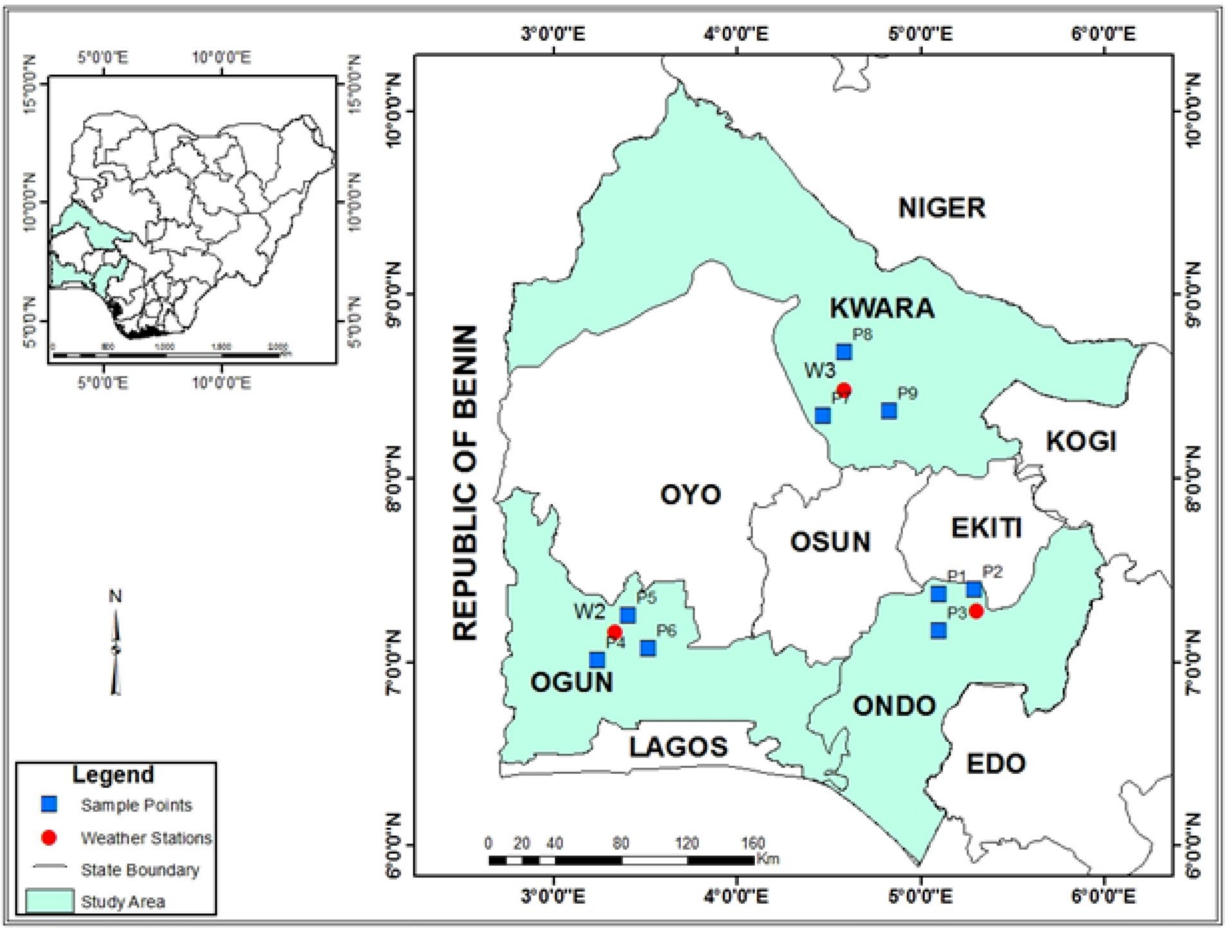

Fig. 1 Map of the study area showing weather stations and sample points

for rainfall and thermometer. These three stations were selected first because of their spatial location in different ecological zones and second, connectedness. Crop yield data was sourced from the archive of Agriculture Development Programme (ADP) offices in Ondo, Ogun and Kwara states. The yield is calculated by dividing the total output of the year by the land area, measured in metric tons per hectares.

The primary data from the questionnaire was analysed using tables, charts and content analysis, the secondary data (climatic data) was analysed using ANOVA, Mann Kendall and Sen's Slope Test. ANOVA test was carried out to show the difference in the mean of the climatic parameters in the three stations in the study area. One-way ANOVA assume that a group of data is derived from normal distribution with a roughly constant variability within the group. Statistically, one-way ANOVA is a simplification of the two sample t-test with F statistic comparing the variability that exists between and within the groups.

Mann Kendall (MK) and Sen's slope analysis was used in this study to assess the trend and the slope of climatic data in the study area. MK test is a widely used technique for the detection of trends in climatic time series [27]. This test is used for assessing the monotonic upward and downward trend of climatic variables derived as given in Eqs. 1–4. Also, the Thiel Sen's slope non-parametric test was done to assess the trend in climatic time series and it is calculated as shown in Eqs. 5, 6.

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \mathrm{sig}\left(X_j - X_i\right) \tag{1}$$

$$\mathrm{sig}\left(X_j - X_i\right) = \begin{cases} +1 \text{ if } \left(X_j - X_i\right) > 0 \\ \;\;0 \;\text{ if } \left(X_j - X_i\right) = 0 \\ -1 \text{ if } \left(X_j - X_i\right) < 0 \end{cases} \tag{2}$$

$$V(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p\left(t_p - 1\right)\left(2t_p + 5\right)\right] \quad (3)$$

$$Z = \begin{cases} \frac{S-1}{\sqrt{\mathrm{VAR}(S)}} & \text{if, } S > 0 \\ 0 & \text{if } S = 0 \\ \frac{S+1}{\sqrt{VAR(S)}} & \text{if, } S < 0 \end{cases} \quad (4)$$

In these equations, the chronological order of the observations is X_i and X_j series, where n is the length of time series, t_p is the number of ties for pth value, and q is the number of tied values. Positive Z values indicate an upward trend in the climatic time series. If $/Z/ > Z_{i-\alpha/2}$, (H_0) is rejected and a statistically significant trend exists in the climatic time series. The critical value of $/Z/ > Z_{i-\alpha/2}$ for a p value of 0.05 from the standard normal table is 1.96. A value of Z greater than 1.96 confirms an increasing trend, while a negative value smaller. Sen's slope non-parametric method was used to analyse the slope of the time series data:

$$T1 = \frac{x_j - x_k}{j - k} \quad (5)$$

In this equation, x_j and x_k represent data values at time j and k, respectively:

$$Q_i \begin{cases} T_{(N+1)/2} & N \text{ is odd} \\ \frac{1}{2}\left(T_{N/2} + T_{(N+2)/2}\right) & N \text{ is even} \end{cases} . \quad (6)$$

Multiple regression statistics was done to find the combined impact of climate on each of the selected crops. With the use of climatic (temperature and rainfall) data, impact of climate on yield was established. The formula for regression is as shown in Eq. 7.

$$b_1 = \frac{\left(\sum x_2^2\right)\left(\sum x_1 y\right) - \left(\sum x_1 x_2\right)\left(\sum x_2 y\right)}{\left(\sum x_1^2\right)\left(\sum x_2^2\right) - \left(\sum x_1 x_2\right)^2}, \quad (7)$$

where x_1 = Independent variable 1 (temperature); x_2 = Independent variable 2 (rainfall); y = Dependent variable (crop yield).

Results and discussion

Climatic variation and crop yields in the selected ecological zones

The results reveal significant difference in the annual minimum temperature [f (2, 99) = 148.87, $P < 0.05$], maximum temperature [f (2, 99) = 31.97, $P < 0.05$] and rainfall [f (2, 102) = 15.77, $P < 0.05$] which are all statistically significant (Table 1). The overall minimum temperature spatial behaviour unveiled spatial changes in annual minimum temperature. The highest was recorded in Ogun (23.38 ℃), while it was lowest in Kwara (21.64 ℃). The results of ANOVA for the minimum temperature showed that the minimum temperature varied spatially and temporally in the stations. The variation in minimum temperature can be explained by several factors. The temperature is lowest in Ondo state as revealed by statistics.

Table 1 Annual climate variability in the study area

Variable	*N*	Mean ± SD	df	*F*	*P*
Minimum temperature					
			2	148.87	0.00
Ondo	36	21.78 ± 0.59			
Ogun	36	23.38 ± 0.39	99		
Kwara	30	21.64 ± 0.38			
Maximum temperature					
			2	31.97	0.00
Ondo	36	31.34 ± 0.71			
Ogun	36	31.55 ± 0.07	99		
Kwara	30	32.38 ± 0.08			
Rainfall					
			2	15.77	0.00
Ondo	36	1484.5 ± 232.7			
Ogun	36	1586.9 ± 284.4	102		
Kwara	33	1222.6 ± 309.0			

The maximum temperature patterns showed spatial changes in annual maximum temperature also. The highest was recorded in Kwara (32.38 °C) and lowest in Ondo (31.34 °C). The maximum temperature is expected to be highest in the northern part of the country and lowest in the southern part and in agreement with the ecological distribution of the vegetation zones in the country. The rainfall also varied spatially and temporally as shown by the analysis. It is highest in Ogun (1586.9 mm) and lowest in Kwara state (1222.6 mm).

The crop yields also vary over time and space. Figure 2 reveals the change in the yield of maize, rice and cassava. For maize, the yield was relatively stable for some years and significantly increased in 2013 in Ondo state. The year 2013 was marked with rainfall below or about normal with minimum and maximum temperature above normal in all stations. For Ogun and Kwara states, there is a slight fluctuation in the yield of maize. Rice on the other hand was only steady in Ogun state but fluctuation was observed in the yield of rice for Ondo and Kwara throughout the study period. Cassava yield has an upward trend in all stations though with fluctuations but there is a sharp drop in the yield of cassava in Ondo state since 2014. Increase in land devoted to maize and rice production may bring no corresponding increase in yield as rainfall amount and frequency during the period

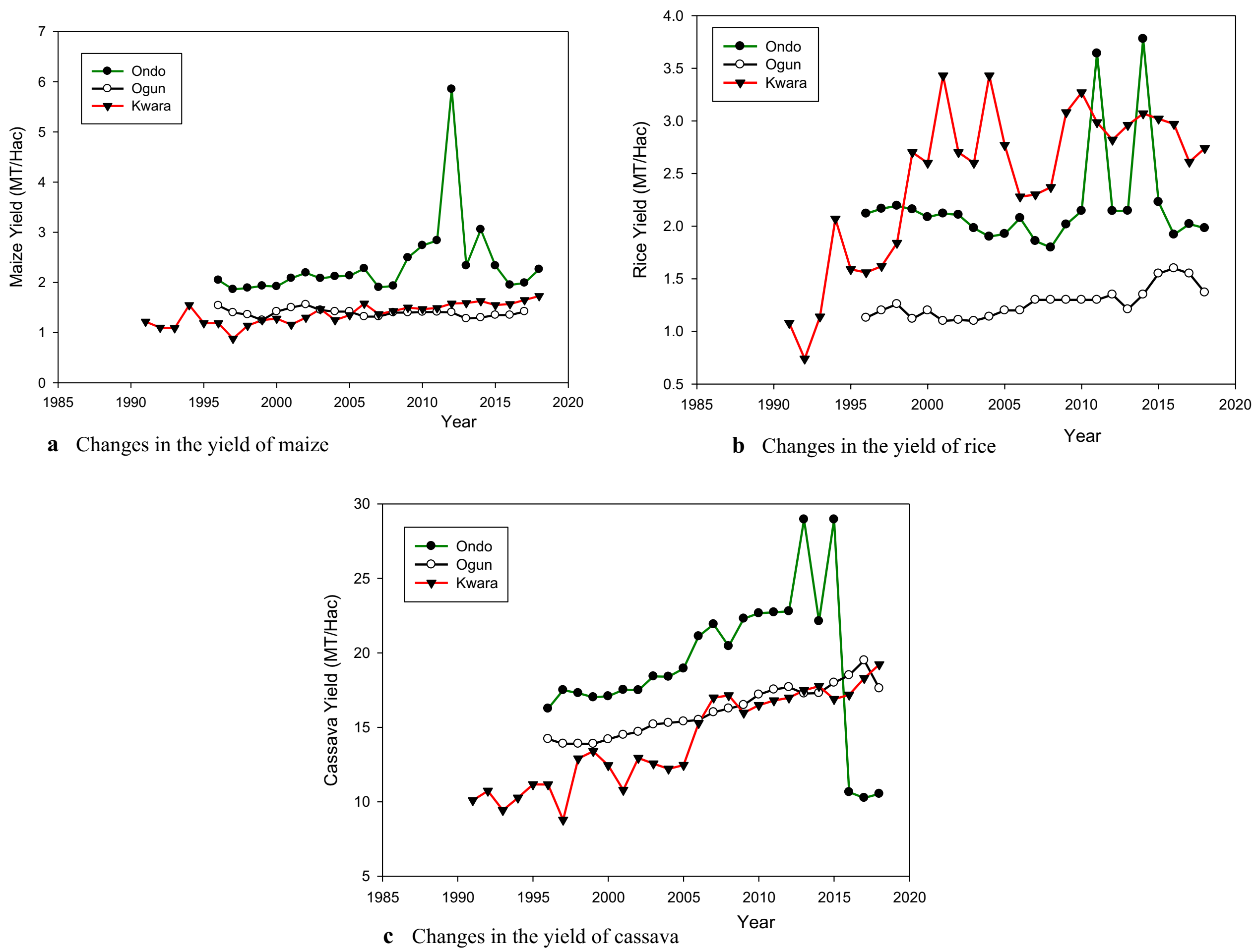

Fig. 2 Changes in crop yield: Maize (**a**), Rice (**b**) and Cassava (**c**)

shortly after planting affects yield. Though maize and rice can be less sensitive to rainfall at the onset and cessation of the growing season, several factors can account for reduction in yield of maize as both reduction and erratic rainfall affects maize yield, rainfall variability influences maize yield but it depend on the level of inputs such as fertilizer in maize cultivation [24]. Prolonged dry spells can also affect yield of maize negatively, the impacts of rainfall and temperature on tuber crops are obvious especially for cassava which can even be up to 95% probability levels [24]. There is possibility of increased yield even with reduction in land area with introduction of superior maize varieties and the liberalization of seed value chain that increased the availability of improve seed to farmers [24].

Variation in climate and time series from Mann Kendall and Sen's Slope Detection

The results of monthly trend tests showed a mix of randomness and upward trend in different stations. Mann–Kendall (MK) and Sen's slope tests were used on monthly scale to detect trends in the minimum temperature record at different stations. Table 2 shows the result of MK test and from the result MK and Sen's slope tests were different in pattern for the minimum temperature in the stations of Ondo, Ogun and Kwara states. From Table 2, the results of the MK test for Ondo state, January has a random trend of z value of 1.66 in minimum temperature with a slope of 0.044 which is statistically not significant at $p > 0.05$. In February, there exists uncertainty in MK trend of z value of 1.26, while the Sen's slope test showed a slope of 0.028, but in March, a random trend of z value of 0.71 and a slope of 0.19 that is statistically significant was detected. In April, a random MK trend of value 0.82 and a Sen's slope of 0.010 that is not statistically significant. For May, a random MK trend of z value of 1.65 and a Sen's slope of 0.031 that is statistically significant was detected. In June, a positive MK trend with a z value of 2.00 and a positive Sen's slope value of 0.018 that is statistically significant. In July, a positive MK

Table 2 Mann Kendall and Sen's Slope analysis of minimum temperature

Minimum temperature (℃)												
Month	Ondo				Ogun				Kwara			
	S	*Z*	Trend	Slope	*S*	*Z*	Trend	Slope	*S*	*Z*	Trend	Slope
January	123	1.66		0.04	31	0.43		0.04*	25	0.43		0.01
February	93	1.26		0.03	183	2.49	+	0.02	53	0.98		0.04*
March	51	0.71		0.02*	102	1.43		0.20*	108	1.92		0.03
April	61	0.82		0.01	189	2.67	+	0.03*	71	1.26		0.01
May	117	1.65		0.03*	141	1.99	+	0.04*	110	2.05	+	0.03*
June	142	2.0	+	0.02*	166	2.34	+	0.03*	110	1.96		0.02
July	141	1.99	+	0.02*	207	2.93	+	0.03*	203	3.64	+	0.02
August	56	0.78		0.01*	157	2.13	+	0.01	129	2.30	+	0.02
September	160	2.18	+	0.03	158	2.23	+	0.03*	176	3.15	+	0.03
October	140	1.97	+	0.03	165	2.33	+	0.05*	36	0.63		0.00
November	80	1.08		0.01	173	2.44	+	0.04*	−34	−0.59		−0.01
December	197	2.67	+	0.08	143	1.94		0.02	−16	−0.27		−0.01
Overall	134	1.89		0.03*	187	2.64	+	0.03*	163	2.91	+	0.03

(+), Positive Trend; (-), Negative Trend; (), Random; (*), Significant at 0.05

trend with a positive value of 1.99 and a positive Sen's slope value of 0.024 that is statistically significant was detected. In August, a random MK trend with a value of 0.78 and a slope of 0.10 that is statistically significant was detected. In September, a positive MK trend with a value of 2.18 and a positive Sen's slope of 0.016 that is not statistically significant was detected (Table 2). In October, a positive MK trend with a value of 1.97 and a Sen's slope of 0.026 that is statistically not significant was detected. In November, a random MK trend with a value of 1.08 and a Sen's slope of 0.014 that is not statistically significant was detected. In December, a positive MK test trend with a value of 2.67 and Sen's slope value of 0.075 that is not statistically significant was detected. In general, throughout the study period, a random MK trend with a value of 1.89 and a Sen's slope of 0.025 that is not statistically significant was detected for all the years covering the study period (Table 2).

From the results of the MK test for Ogun state (Table 2), January had a random MK trend of z value of 0.43, while the Sen's slope showed a value of 0.43 that is statistically significant in minimum temperature at $p > 0.05$. In February, there exists a positive MK trend of z value of 2.49, while the Sen's slope test showed a value of 0.02 that is not statistically significant. In March, a positive MK trend of z value 1.43 and a Sense's slope of 0.20 that is statistically significant was detected. In April, a positive MK trend of value 2.67 and a Sen's slope of 0.032 that is statistically significant was detected. For May, a positive MK trend of z value of 1.99 and a Sen's slope of 0.041 that is statistically significant was detected. In June, a positive MK trend with a z value of 2.34 and a positive Sen's slope of 0.033 that is statistically significant was detected. In July, a positive MK trend with a value of 2.93 and a positive Sen's slope of 0.029 that is statistically significant was detected. In August, a positive MK trend with a value of 2.13 and a Sen's slope of 0.014 that is statistically not significant was detected. In September, a positive MK trend with a value of 2.23 and a positive Sen's slope of 0.031 that is statistically significant was detected. In October, a positive MK trend with a z value of 2.33 and a positive Sen's slope of 0.046 that is statistically significant was detected. In November, a positive MK trend with a z value of 2.44 and a positive Sen's slope of 0.040 that is statistically significant was detected. In December, a random MK test trend with a z value of 1.94 and a Sen's slope value of 0.024 that is not statistically significant was detected.

In general, throughout the years and months covering the study period, a positive MK trend with a value of 2.64 and a positive Sen's slope of 0.029 that is statistically significant was detected for the station in Ogun state which can be concluded to be an increasingly positive trend in minimum temperature. In Ogun state, there exists positive trends with upward movement and significant slope values in the increase in the slope for all the months of the year excluding January, March and December. And there exists statistically a significant trend at $p < 0.05$ in almost all the months excluding February, August and December. In Kwara state though, a random MK trend of Z value of 0.43 and with Sen's slope value of 0.014 that is not statistically significant at $p > 0.05$ was observed in

January minimum temperature (Table 2). In February, there exists a random MK trend of z value 0.98, while the Sen's slope test showed 0.0044 that is statistically significant. In March, a random MK trend of z value of 1.92 and a Sen's slope of 0.027 that is statistically not significant was detected. In April, a random MK trend of value 1.26 and a positive Sen's slope of 0.014 that is not statistically significant was detected. For May, a positive MK trend of z value of 2.05 and a positive Sen's slope of 0.025 that is statistically significant was detected. In June, a random MK trend with a z value of 1.96 and a positive Sen's slope of 0.022 that is statistically not significant was detected. In July, a positive MK trend with a value of 3.64 and a positive but not statistically significant Sen's slope of 0.023 was detected. In August, a positive MK trend with a z value of 2.30 and a positive Sen's slope of 0.017 that is not statistically significant was detected. In September, a positive MK trend with a value of 3.15 and a Sen's slope of 0.025 is not statistically significant was detected. In October, a random MK trend with a z value of 0.63 and without a Sen's slope of value 0.004 that is not statistically significant was detected. In November, a negative MK trend with a z value of −0.59 and a negative slope of −0.011 that is statistically not significant was detected. In December, a negative MK trend with a z value of −0.27 and a with negative Sen's slope value of −0.007 that is statistically not significant was detected. In general, throughout the study period, a positive MK trend with a value of 2.91 and a positive Sen's slope of 0.025 that is statistically not significant was detected for the station in Kwara state. In Kwara state, most months were found to have a random trend in the MK test, the Sen's slope analysis shows a significant increase in the slope of minimum temperature only in February and May and Mann Kendall Test shows a positive trend in July, August and September with the general trend throughout the study period to be positive trend (Table 2).

Table 3 shows the result of the Mann–Kendall and Sen's slope test for maximum temperature in the stations of Ondo, Ogun and Kwara states. From the results of the MK test for Ondo state, January has a positive random trend of z value of 0.15 in maximum temperature with a slope of 0.00 which is statistically significant at $p > 0.05$. In February, there exists negative trend of z value of −0.04, while the Sen's slope test shows a slope of 0.00 that is statistically significant. In March, a negative trend of $z = -0.05$ and a slope of 0.00 that is not statistically significant was detected. In April, a negative value of −0.61 and a slope of 0.00 that is not statistically significant. For May, a positive trend of z value of 2.47 and a slope of 0.00 that is not statistically significant was detected. In June, a positive trend with a $z = 2.55$ and a slope of 0.00 that is statistically significant. In July, a random trend with a positive value of 2.22 and a slope of 0.00 that is statistically significant was detected. In August, a random trend with a positive value of 1.90 and a slope of 0.056 that is statistically significant was detected. In September, a positive trend with a positive value of 1.97 and a slope of 0.00 that is statistically significant was detected. In October, a random trend with a positive value of 1.17 and a slope of 0.00 that is statistically significant was detected. In November, a negative trend with a value of −0.74 and

Table 3 Mann Kendall and Sen's slope analysis of maximum temperature

Maximum temperature (℃)

Month	**Ondo**				**Ogun**				**Kwara**			
	S	***Z***	**Trend**	**Slope**	***S***	***Z***	**Trend**	**Slope**	***S***	***Z***	**Trend**	**Slope**
January	11	0.15		0.00*	0	0.00		0.01*	94	1.65		0.03
February	−4	−0.04		0.00*	−101	−1.42	−	−0.05*	66	1.22		0.05*
March	−36	−050		0.00	−128	−1.73	−	−0.02	155	2.75	+	0.06
April	−43	−0.61		0.00	54	0.75		0.00*	117	2.08	+	0.04
May	167	2.47	+	0.00	151	2.13	+	0.03*	63	1.16		0.04*
June	172	2.55	+	0.00*	155	2.19	+	0.06*	75	1.39		0.03*
July	155	2.22	+	0.00*	112	1.58		0.09*	153	2.72	+	0.04
August	133	1.90		0.06*	183	2.59	+	0.08*	59	1.04		0.01
September	136	1.97	+	0.00*	155	2.19	+	0.08*	110	1.96		0.02
October	81	1.17		0.00*	161	2.27	+	0.05*	15	0.25		0.00
November	−51	−0.74		0.00	104	1.41		0.01	8	0.13		0.01*
December	−14	−0.19		0.00	185	2.51	+	0.02	104	1.93		0.07*
Overall	83	1.22		0.00	159	2.24	+	0.04*	110	2.05	+	0.04*

(+), Positive Trend; (-), Negative Trend; (), Random; (*), Significant at 0.05

a Sen's slope of 0.00 that is not statistically significant was detected. In December, a negative MK test trend with a value of −0.19 and a Sen's slope value of 0.00 that is not statistically significant was detected. In general, throughout the study period, a random trend with a value of 1.22 and a Sen's slope of 0.00 that is not statistically significant was detected.

From the results of the MK test for Ogun state (Table 3), there is uncertainty in the trend for January $z = 0.00$ of MK test and same with Sen's slope test with a value of 0.00 in maximum temperature but the Sen's slope analysis shows the value is statistically significant at $p > 0.05$. In February, there exists negative trend of z value of −1.42, while the Sen's slope test shows also a negative slope of −0.048 that is statistically significant. In March, a negative trend of z value of −1.73 and a negative Sense's slope of −0.016 that is not statistically significant was detected. In April, a random MK trend of value 0.75 and a Sen's slope of 0.00 that is statistically significant was detected. For May, a positive MK trend of z value of 2.13 and a Sen's slope of 0.029 that is statistically significant was detected. In June, a positive MK trend with a z value of 2.19 and a positive Sen's slope of 0.057 that is statistically significant was detected. In July, a random MK trend with a value of 1.58 and a positive Sen's slope of 0.092 that is statistically significant was detected. In August, a positive MK trend with a positive value of 2.59 and a positive Sen's slope of 0.083 that is statistically significant was detected. In September, a positive MK trend with a value of 2.19 and a slope of 0.080 that is statistically significant was detected. In October, a positive MK trend with a z value of 2.27 and a positive Sen's slope of 0.053 that is statistically significant was detected. In November, a random MK trend with a z value of 1.41 and a positive Sen's slope of 0.013 that is not statistically significant was detected. In December, a positive MK test trend with a z value of 2.51 and a positive Sen's slope value of 0.024 that is not statistically significant was detected. In general, throughout the study period, a positive MK trend with a value of 2.24 and a positive Sen's slope of 0.036 that is statistically significant was detected for the station in Ogun state.

In Kwara state (Table 3), January has a random MK trend of z value of 1.65 and with Sen's slope value of 0.033 in maximum temperature but the Sen's slope analysis shows the value is statistically not significant at $p > 0.05$. In February, there exists random MK trend of z value of 1.22, while the Sen's slope test shows also a positive slope of 0.050 that is statistically significant. In March, a positive MK trend of z value of 2.75 and a positive Sen's slope of 0.056 that is not statistically significant was detected. In April, a positive MK trend of value 2.08 and a positive Sen's slope of 0.038 that is not statistically significant was detected. For May, a random MK trend of z value of 1.16 and a positive Sen's slope of 0.038 that is statistically significant was detected. In June, a random MK trend with a z value of 1.39 and a positive Sen's slope of 0.030 that is statistically significant was detected. In July, a positive MK trend with a value of 2.72 and a positive but not statistically significant Sen's slope of 0.038 was detected. In August, a random MK trend with a positive value of 1.04 and a positive Sen's slope of 0.09 that is not statistically significant was detected. In September, a random MK trend with a value of 1.96 and a Sen's slope of 0.020 that is not statistically significant was detected. In October, a random MK trend with a z value of 0.25 and without a Sen's slope of value 0.00 that is not statistically significant was detected. In November, a random MK trend with a z value of 0.13 and a positive Sen's slope of 0.014 that is statistically significant was detected. In December, a random MK test trend with a z value of 1.93 and a positive Sen's slope value of 0.071 that is statistically significant was detected. In general, throughout the study period, a positive MK trend with a value of 2.05 and a positive Sen's slope of 0.035 that is statistically significant was detected for the station in Kwara state.

Table 4 shows the result of the Mann–Kendall and Sen's slope test for rainfall in the stations of Ondo, Ogun and Kwara states. From the results of the MK test for Ondo state, January has a random trend of z value of 0.91 in rainfall with a slope of 0.00 which is statistically not significant at $p > 0.05$. In February, there exists random MK trend of z value of 0.43, while the Sen's slope test shows a slope of 0.00 that is statistically not significant. In March, a random trend of z value of 0.37 and a slope of 0.529 that is not statistically significant was detected. In April, a negative MK trend of value −0.61 and a negative Sen's slope of −0.725 that is not statistically significant. For May, a negative MK trend of z value of −0.12 and a negative Sen's slope of −0.920 that is not statistically significant was detected. In June, a random MK trend with a z value of 1.01 and a Sen's slope value of 1.053 that is not statistically significant. In July, a random MK trend with a positive value of 1.22 and a positive Sen's slope value of 2.746 that is statistically significant was detected. In August, a random MK trend with a positive value of 0.87 and a slope of 0.361 that is not statistically significant was detected. In September, a random MK trend with a positive value of 0.34 and a positive Sen's slope of 0.361 that is not statistically significant was detected. In October, a negative MK trend with a value of −0.90 and a negative Sen's slope of −1.146 that is statistically not significant was detected. In November, a random MK trend with a value of 1.32 and a positive Sen's slope of 0.563 that is not statistically significant was detected. In December, a negative MK test trend with a value of −0.52 and Sen's

Table 4 Mann Kendall and Sen's Slope analysis of rainfall

Rainfall (mm)												
Month	**Ondo**				**Ogun**				**Kwara**			
	S	**Z**	**Trend**	**Slope**	**S**	**Z**	**Trend**	**Slope**	**S**	**Z**	**Trend**	**Slope**
January	65	0.91		0.000	−4	−0.04	–	0.000	−5	−0.07		0.000
February	32	0.43		0.000	65	0.87		0.167	−20	−0.31		0.000
March	28	0.37		0.529	91	1.23		0.890	−81	−1.24		−0.690
April	−46	−0.61		−0.725	11	0.14		0.000*	84	1.29		1.429
May	−83	−1.12		−0.920	83	1.12		1.317	8	0.11		0.058
June	75	1.01		1.053	73	0.98		1.742	42	0.64		0.704
July	87	1.22		2.746*	40	0.53		0.938	58	0.88		0.974
August	65	0.87		1.523	29	0.38		0.628	−21	−0.31		−0.324
September	26	0.34		0.361	127	1.72		3.026	66	10.1	+	1.529
October	−67	−0.90		−1.146	101	1.36		2.000	160	2.46	+	3.994
November	98	1.32		0.563	185	2.51	+	1.375	1	0.00		0.000
December	−36	−0.52		0.000	42	0.59		0.000	−11	−0.22		0.000
Overall	48	0.64		1.297	113	1.59		12.667*	69	1.05		4.000

(+), Positive Trend; (-), Negative Trend; (), Random; (*), Significant at 0.05

slope value of 0.00 that is not statistically significant was detected. In general, throughout the study period, a random MK trend with a value of 0.64 and a Sen's slope of 1.297 that is not statistically significant was detected.

From the results of the MK test for Ogun state (Table 4), January had a negative MK trend of z value of −0.04 0.00 of MK test, while the Sen's slope showed a value of 0.00 that is not statistically significant in rainfall at $p > 0.05$. In February, there exists random MK trend of z value of 0.87, while the Sen's slope test showed a positive value of 0.167 that is not statistically significant. In March, a random MK trend of z value 1.23 and a positive Sense's slope of 0.890 that is not statistically significant was detected. In April, a random MK trend of value 0.14 and a Sen's slope of 0.00 that is statistically significant was detected. For May, a random MK trend of z value of 1.12 and a positive Sen's slope of 1.317 that is statistically not significant was detected. In June, a random MK trend with a z value of 0.98 and a positive Sen's slope of 1.742 that is not statistically significant was detected. In July, a random MK trend with a value of 0.53 and a positive Sen's slope of 0.938 that is not statistically significant was detected. In August, a random MK trend with a positive value of 0.38 and a positive Sen's slope of 0.628 that is statistically not significant was detected. In September, a random MK trend with a value of 1.72 and a positive Sen's slope of 3.026 that is not statistically significant was detected. In October, a random MK trend with a z value of 1.36 and a positive Sen's slope of 2.000 that is not statistically significant was detected. In November, a positive MK trend with a z value of 2.51 and a positive Sen's slope of 1.375 that is not statistically significant was detected. In December, a random MK test trend with a z value of 0.59 and a Sen's slope value of 0.00 that is not statistically significant was detected. In general, throughout the study period, a random MK trend with a value of 1.59 and a positive Sen's slope of 12.667 that is statistically significant was detected for the station in Ogun state.

In Kwara state (Table 4), a negative MK trend of z value of −0.07 and with Sen's slope value of 0.000 that is not statistically significant at $p < 0.05$ was observed in January rainfall. In February, there exists negative MK trend of z value −0.31 while the Sen's slope test showed 0.000 that is statistically not significant. In March, a negative MK trend of z value of −1.24 and a negative Sen's slope of −0.690 that is not statistically significant was detected. In April, a random MK trend of value 1.29 and a positive Sen's slope of 1.429 that is not statistically significant was detected. For May, a random MK trend of z value of 0.11 and a positive Sen's slope of 0.058 that is statistically not significant was detected. In June, a random MK trend with a z value of 0.64 and a positive Sen's slope of 0.7040 that is statistically not significant was detected. In July, a random MK trend with a value of 0.88 and a positive but not statistically significant Sen's slope of 0.974 was detected. In August, a negative MK trend with a z value of −0.31 and a negative Sen's slope of −0.324 that is not statistically significant was detected. In September, a random MK trend with a value of 10.1 and a Sen's slope of 1.529 that is not statistically significant was detected. In October, a positive MK trend with a z value of 2.46 and without a positive Sen's slope of value 3.994 that is not statistically significant was detected. In November, there was randomness in MK test with a z value of 0.00 and no slope with Sen's slope of 0.00 that is statistically not significant was detected. In December, a negative MK test trend with a z value of −0.22 and with no slope, as Sen's slope value of 0.00 that is statistically not significant was detected. In general, throughout the study period, a random MK trend with a value of 1.05 and a positive Sen's slope of 4.00 that is statistically not significant was detected for the station in Kwara state.

The result of monthly trend tests showed a mix of randomness; and a positive trend in different stations over the years. Mann–Kendall (MK) and Sen's slope tests were used on monthly scale to detect slope in the minimum temperature, maximum temperature and rainfall recorded at different stations. The result is as presented in Tables 2, 3 and 4. Generally, the study found out that while there is general increase or upward trend in the minimum and maximum temperature as shown by the Mann Kendall and Sen's slope analysis, there is generally negative trend for rainfall. The decrease in rainfall can be noticed in many months and this is enough to bring about poor yield. Climate change has taken a centre point in the midst of diverse threatening environmental challenges of our time which have promoted discourses on causes, long term effects and how to forestall the lingering and frustrating impact as many tropical and sub-tropical countries are more vulnerable to the threat because of their dependence on rain fed agriculture [24].

Community-based perception of climate change

Majority of rural farmers in Ondo and Ogun states opined that the temperature in general has become warmer while in Kwara states, the majority believed it has remained the same (Table 5) and Fig. 3. Though farmers perceived it has remained the same on a general note, the climatic data of the Ogun and Kwara states showed that it has been warmer since the year 2000 to the end of the study period in 2017 in Ogun state and for Kwara, it was warmer between 1982 and 1986, colder between 1987 and 1997 and have generally remained warmer since. The perception of the temperature in Ondo state is in line with the climate data which showed that it has remained warmer since 2010 with fluctuation in the preceding decade. The coldest season is between December and January during harmattan. Majority of the farmers in the three states believe that the temperature of the coldest season has remained the same over the years. Whereas, Mann Kendall and Sen's slope analysis of climatic data showed that there is an positive trend in December temperature in Ondo, fluctuation in Ogun and a negative trend for Kwara. While in January there was no significant increase in Ondo and Kwara but there is a statistically significant increase at $p < 0.05$ in Ogun state.

The perception of farmers (Table 5) about the temperature of the hottest months as opined by the majority of the farmers in Ondo and Ogun states, have been reported to have increased significantly while the majority think that it has remained the same over the years in Kwara state. The rain generally and the rain during the rainy season which spans usually April to October have been reported by farmers to be higher than it has been in the past in Ondo and Ogun while a higher proportion of farmers perceived that the rain has remained the same in Kwara states and this was found to corroborate with the analysis of rainfall data. The rain during the dry season has been reported to be higher in Ondo while it has generally remained the same in Ogun and Kwara states.

The occurrence of the extreme flood was perceived by farmers to be more frequent in Ondo and Kwara while the majority of the farmers in Kwara believe that it has remained the same over the years. For the occurrence of extreme droughts, it was reported to be less frequent in Ondo, more frequent in Ogun and same in Kwara state (Table 5). The rainy season duration was reported to be earlier in Ondo while it has remained the same in Ogun and Kwara states as opined by the majority of the farmers. The length of the dry season was by majority of the farmers to have remained the same in Ondo, Ogun and Kwara states. Figure 2a shows farmers' perception on temperature generally. Majority of the farmers in Ondo state are of the opinion that the temperature is warmer while majority in Ogun and Kwara states are of the opinion it has remained the same over time. Figure 2b shows perception on rainfall for which the majority in Ondo and Ogun opined has been higher while majority in Kwara said it has remained the same. Occurrence of extreme floods is depicted in Fig. 2c for which majority said it has remained the same in Ondo meanwhile it has been more frequent in Ondo and Ogun states. However, studies have shown that there is usually variation in the farmers' perception of climate and climatic record as the farmers' perception was different from the climate data. This is probably because of the cooling effect of the present climatic condition and intense rainfall over the past few years. This may not be significant enough to be put into cognizance [28, 29]. Importantly, farmers have perceived delayed in onset of events, increased temperature and these are enough for reduction in yield.

Cropping experiences of farmers and perceived change in climate

In Onibode, Ogun state, the FGD conducted revealed that farmers have perceived climate change and are of the opinion that the drivers of climate change are

Table 5 General perception of farmers on climate change

Variables	Variables	Perception of change (%)			
		Ondo	Ogun	Kwara	Over all
Temperature generally	Same	24.1	49.2	70.9	48.2
	Warmer	44.4	35.6	14.5	31.5
	Colder	31.5	15.2	14.5	20.3
Temperature of the coldest season	Same	35.2	50.8	65.5	50.6
	Warmer	29.6	38.6	16.4	29.2
	Colder	31.5	10.6	18.2	20.2
Temperature of the hottest season	Same	27.8	35.6	52.7	38.7
	Warmer	46.3	49.2	40	45.2
	Colder	25.9	15.3	7.3	16.1
Rain generally	Same	20.8	23.7	50.9	31.5
	Lower	14.4	8.5	12.7	11.9
	Higher	64.8	67.8	36.4	56.5
Rain during rainy season	Same	24.1	27.1	52.7	34.5
	Lower	12.9	5.1	14.5	10.7
	Higher	63.0	67.8	32.7	54.8
Rain during dry season	Same	37.0	45.8	58.2	47.0
	Lower	20.4	10.1	16.4	15.5
	Higher	42.6	44.1	25.5	37.5
Extreme floods	Same	25.9	18.6	50.9	31.5
	Less frequent	13.0	30.5	12.7	19.0
	More frequent	42.6	44.1	20	35.7
	More intensive	18.5	6.8	16.4	13.7
Extreme drought	Same	29.6	16.9	50.9	32.1
	Less frequent	42.6	27.1	25.5	31.5
	More frequent	16.7	44.1	16.4	26.2
	More intensive	11.2	11.9	7.2	10.1
Rain onset	Same	29.6	83.1	70.9	61.9
	Earlier	55.6	10.2	20.0	28.0
	Later	14.8	6.7	9.1	10.1
Rainy season duration	Same	31.5	81.4	70.9	61.9
	Shorter	9.2	6.7	9.1	8.3
	Longer	59.3	11.9	20	29.8
Dry season duration	Same	51.9	79.7	72.7	68.5
	Shorter	33.3	13.6	12.7	19.6
	Longer	14.8	6.7	14.5	11.9
Awareness of climate change	Yes	81.5	88.1	81.8	83.9
	No	18.5	11.9	18.2	16.1

natural rather than human-induced. There were observed changes in the mean temperature, frequency of cold days, sunny days, the intensity of solar radiation and heavy rainfall events were generally agreed to be on the increase. The frequency of warm days with changes in mean rainfall was agreed to be higher. However, a particular farmer in a separate interview opined that heat starts from December, therefore, they start preparing land for cultivation and that dry season starts from December and last till March (about 4 months). Also, he stated that the number of rainy days is now more and farmers now grow new crops that are not native to their land. Examples of such crops include cucumber, water melon, golden melon, carrot and a specie of cassava (*Ege Nuru*) while cocoa, beans and white seed melon (*Egunsi Itoo*) have been abandoned as a result of climate change. A group of farmers in Shao, Kwara state having their ages in the range of 45–68 (the youngest in his mid-forties and

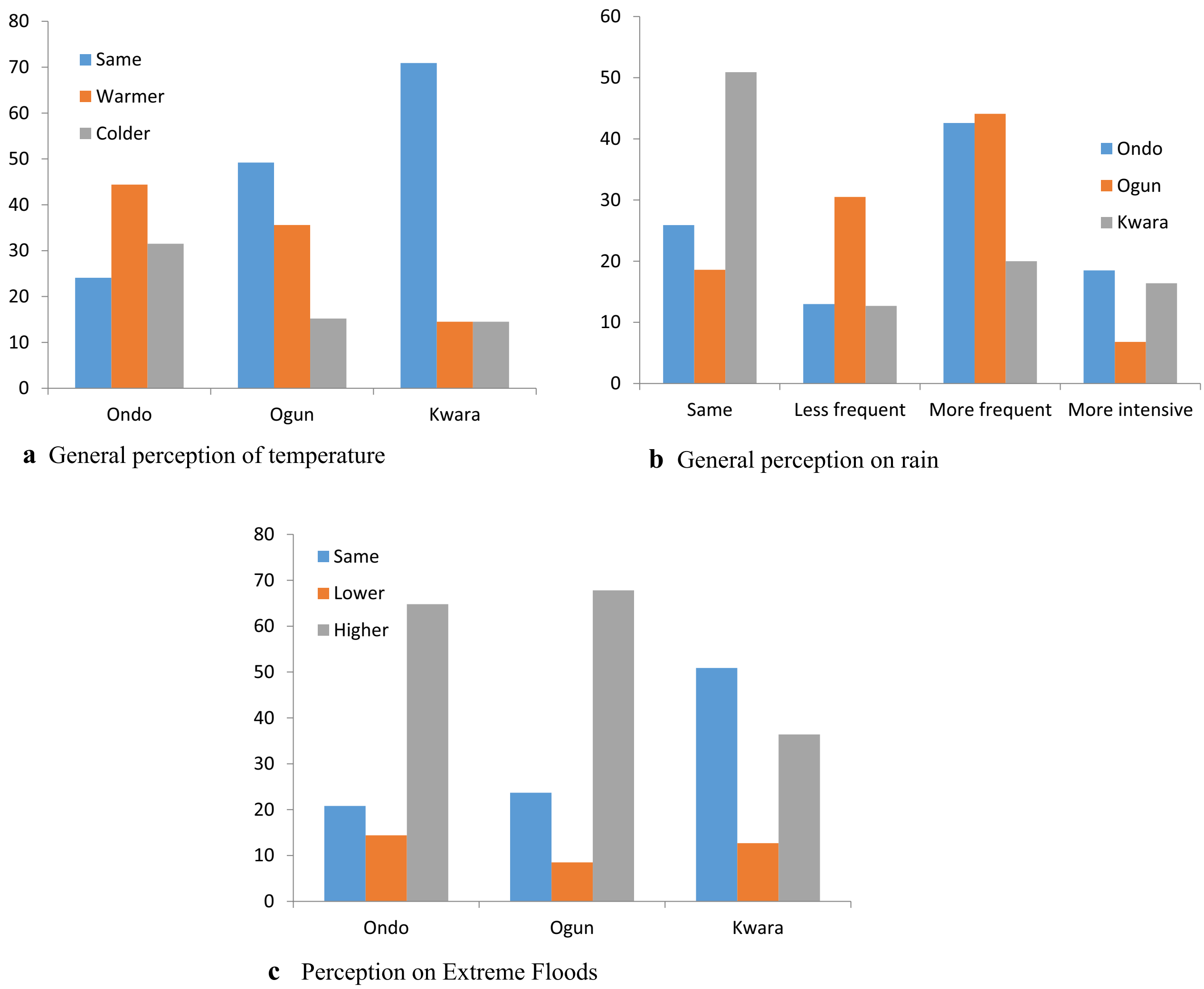

Fig. 3 Farmers' perception about temperature, rain and extreme floods

the oldest in his late sixties with over 30 years of farming experiences) in the FGD conducted stated that there is a great change in climatic events. However, the opinions about the changes are different as the temperature was argued to be on the increase by few while the rainy season duration was agreed to be on the decrease. On the intensity of rain, no agreement was reached as two of four maintained that the rain is still the same as it used to be while others believed it has changed.

However, the perception of the other two that disagreed was probably influenced by the distribution and intensity of rain in the year just before the field survey (2019). Generally, it was agreed that the temperature is on the increase, heat period, intensity, wind and other climatic elements have really changed in the past years. There is now less flooding except for this year and extreme events have not been observed for a long time. Over 65-year-old farmer in Kobape who claimed to have been farming for over 40 years said he used to plant few crops over an area of about 2–3 hectares but changes in climate has so much affected the yield and that made him increase the area under cultivation, now ranging from 5–10 hectares on yearly basis with more crops of different species planted to enhance yield. According to him, farmers who want high yield must increase the area of land cultivated and as well plant many crops. Many of the species of crops we used to know and planted are not very productive again. Some even with the application of fertilizer, the yield is not encouraging, hence, there have been changes in the species of crops planted. For cassava which used to be 2–3 years before harvest, we now have a new variety which we can plant and harvest in 6–8 months. New varieties of maize were introduced by the extension workers of the ADP which we don't need to do a thorough tilling or ploughing before a better yield is harvested. Many aging farmer said that they used to plant rice in the past but not anymore because of changes in the biophysical environment probably associated with climate change. They added that there were birds when they were growing up which used to disturb rice farm and clothes were hanged on rice farms to scare birds away (scare crows). Now the population of the bird (rice sucker) has increased and there are other birds not feeding on rice then that do now.

> *"The clothes we used to hang in rice farm to scare the birds doesn't work again, the birds observe and if there is no noticeable movement in the clothes or in the farm, they invade in their large numbers and can finish 10 hectares of rice in a day with farmers having nothing to show forth at the end of the farming season. We stopped farming rice simply because of this".*

The chief of Onibode (Baale) an adult in his early 70 s age and a farmer in his 50 s in Onibode who did not state categorically his age but have been in farming for about 30 years is of the opinion that the rain is still falling well but not exactly like it used to be both in the rainy and dry seasons. The temperature, the wind, the cloud formation among others has remained the same over the years. The date for the first rain of the year is 15th of March and that still remain intact. However, because of changes associated with market demand, some staple crops have been abandoned while new ones have been adopted. Generally, in the land, they don't grow water melon, cucumber, egg plants, lettuce and some species of tomato and pepper which are now cultivated on large scale by many farmers. He stated that the rain is not like it used to be, as there is a significant reduction in the amount of rainfall and the distribution through the year. In the past, the rain do come in different ways, we have that of 3 days, 7 days and even 15 days of continuous rainfall.

> *"In 2015, I used the first rain in February to plant maize in expectation that the rainy season has set in. Few days later there was second rain of the year and we were so happy, because the first maize of the year is usually expensive and not many farmers do have that on their farms. Normally, the maize should be due for harvest in April but not until early May before we had the third rain of the year. It amounted to great loss for me, waste of money, energy and time. Since then, I've been careful about early cultivation of maize".*

Generally, there were differences in the opinion and perceptions of farmers on climate and as have been argued by many of the farmers, some of their arguments were corroborated with climatic data analysis. However, studies have shown that there is usually a difference in climatic data analyses and farmers perception on climate change [22, 30].

Adaptive capacity of farmers toward climate change and barriers to adaptation

Figure 4 shows the farmers coping or adaptive capacity toward extreme climatic conditions. 16.7% of the respondents are engaged in agricultural diversification while 83.3% are not, 17.3% of the total respondents are engaged in changing the crops they cultivate while 82.7% are not. 20.2% are practicing crop rotation while 79.8 are not, 19.6 are practicing mixed farming while 79.8 are not. 19% for changes in the size of farmland while 81% are not, 14.9% are engaged in different crop composition while 85.1% are not. 33.3% are engaged in agricultural intensification while 66.7% are not, 30.4% are engaged in bush fallowing while 69.6% are not. 29.8% are changing the daily working time while 70.2% are not. 47.6% are presently engaged in agroforestry while 52.4% are not. 27.4% are changing the seasonal timing of sowing while 72.6% are not. 41.1% are changing the harvest time while 58.9% are not. 35.7% are into irrigation while 64.3% are not. 31.5% are into use of fertilizer while 68.5% are not 32.1% are into the use of pesticide while 67.9% are not. 56.5% are into getting loan and credit facilities while 43.5% are not. 32.7% are into getting other sources of income so as not to depend on the farm only while 67.3% are not. 44% are changing the method of storing their food while 56% are not. 27.4% are changing the quantity of food consumed by the family while 72.6% are not. And 24.4% are changing their residence by moving to another area for farming while 75.6% are not changing their residence (Fig. 4).

Twenty adaptation options were selected for this study and farmers are adapting to extreme climatic conditions but with generally low ability to cope with the extreme events. The comparative analysis for each of the selected ecological zones is depicted in Fig. 8 b–d in the annex. Figure 4 shows the percentage error graph of farmers coping or adaptive capacity toward extreme climatic conditions. 16.7% of the respondents are engaged in agricultural diversification, 17.3% are engaged in changing the crops they cultivate, 20.2% are practicing crop rotation, 19.6% are practicing mixed farming. 19% for changes in size of farmland, 14.9% are engaged in different crop composition. 33.3% are engaged in agricultural intensification, 30.4% are engaged in bush fallowing. 29.8% are changing the daily working time.

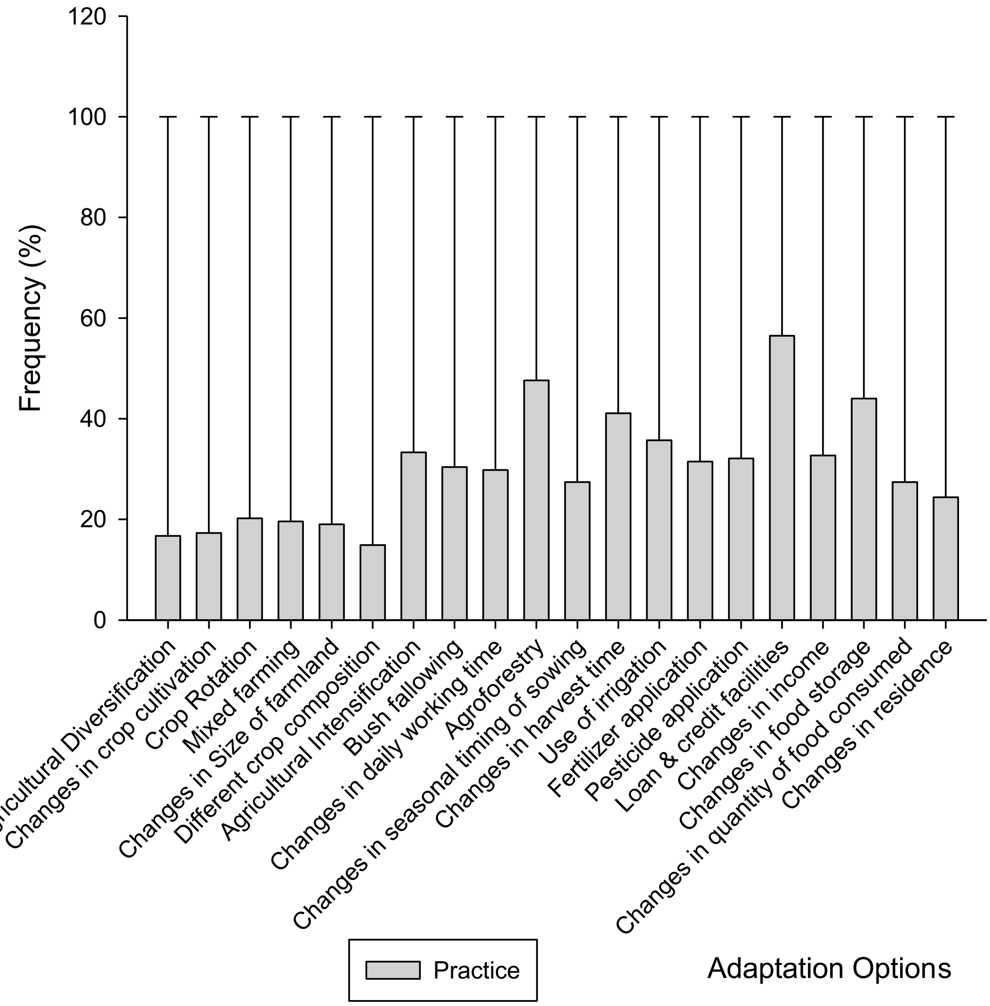

Fig. 4 General adaptation practices by farmers in the region

47.6% are presently engaged in agroforestry, 27.4% are changing the seasonal timing of sowing. 41.1% are changing the harvest time. 35.7% are into irrigation. 31.5% are into use of fertilizer, 32.1% are into the use of pesticide. 56.5% are into getting loan and credit facilities. 32.7% are into getting other source of income so as not to depend on the only farm. 44% are changing the method of storing their food. 27.4% are changing the quantity of food consumed by the family. And 24.4% are changing their residence by moving to another area for farming (Fig. 4). Importantly, Fig. 4 shows seeking for loans and credit facilities, changes in food storage, agroforestry, changing the time of harvest, use of irrigation, use of fertilizer, agricultural intensification among others are the most practiced adaptation options. Studies have reported that many farmers especially in Africa are aware of climate change and the risk associated but are however impeded by certain barriers from practicing adaptation [24]. This is against the report that rural farmers in Africa recognizes even subtle changes in climate parameters and take steps to respond [22, 30].

The study further investigated the reasons for low adaptation level. The results of the general barriers to adaptation is presented in Fig. 5 while for each of the ecological zone is shown in Fig. 5. The result showed that 41.1% are hindered from adapting, because they have low risk to climate. Low probability to climate change accounted for 42.3%, low severity of climate change accounted for 43.5%, low benefits from adapting measures accounted for 50.6%, low ability to adapt accounted for 63.7%, lack of financial capital accounted for 70.2% lack of physical capital accounted for 73.8%, lack of human capital accounted for 82.7% lack of natural capital accounted for 83.3%, lack of social capital and lack of time accounted

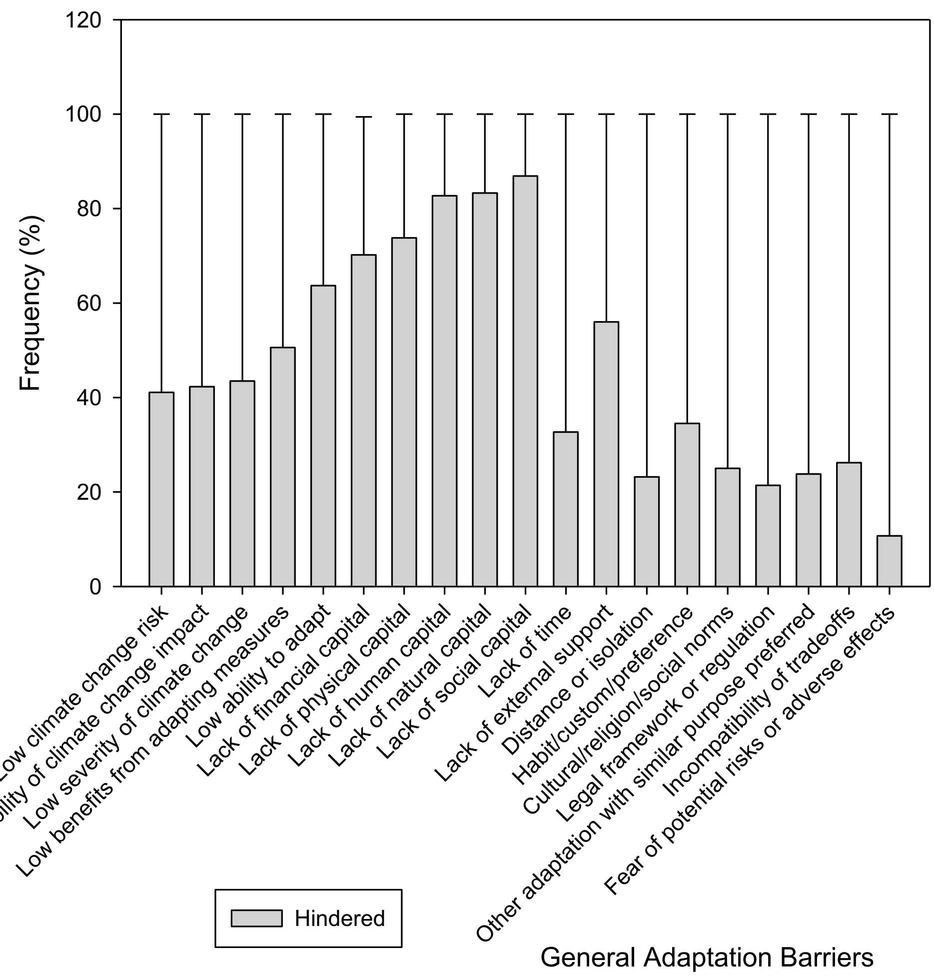

Fig. 5 General barrier to adaptation

for 86.9% and 32.7% respectively. Lack of external support 56%, distance or isolation especially from family members accounted for 23.2%, habits, custom and local preferences accounted for 34.5%, cultural, religion and social norms accounted for 21.4%, other adaptation options with similar purpose preferred accounted for 23.8%, incompatible tradeoffs of adaptation options accounted for 26.2 while fear of potential risk or adverse effects accounted for 10.7% (Fig. 5). These results imply that adaptation practices dependent on age of farmers, farm size and level of production. There has been expansion on adaptation to current and projected impacts of climate change to include barriers to adaptation and these have raised questions around social, financial, cultural, environmental and ecological conditions and changes which can hamper ability of a farmer to adapt to climate change [22, 30].

Conclusion

Analysis of climate data using Mann Kendall and Sen's slope test showed generally warming temperatures with reduced rainfall marked with irregularities. The perception of farmers were assessed. Generally, temperature of the coldest month, rain during the rainy season and rain during the dry season were believed to have remained the same in Ogun and Kwara by higher numbers of respondents, whereas statistical analyses showed that there is variation while in Ondo state. The farmers are of the opinion that the temperature is warmer generally, temperature of the hottest season is warmer, rain is higher in the rainy and dry seasons with extreme drought less frequent, onset earlier, rainy season duration longer. Though, temperature of the hottest month was believed to be warmer by a higher proportion of the respondents. Many farmers are of the opinion that extreme floods are more frequent while extreme drought, duration of the rainy and dry seasons have remained the same. In general, the farmers are aware of long-term changes in climatic factors (temperature and rainfall) but some are unable to identify those changes as climate change [4, 31, 32].

This study revealed that the effect of climate on crops is not the same across the ecological zones under consideration. The yield of cassava and rice is negatively affected in all the ecological zones though greatly affected in Ondo (rainforest) and Kwara (guinea savanna) while the yield of maize is significantly affected only in Ondo state. Therefore, there is need to enhance maize production in Ondo, rice and cassava production in the three ecological zones under consideration. According to the farmers' report, improved seedlings of maize, rice and cassava have been introduced by the Agricultural Development Programme (ADP) to enhance their practices. However, many farmers are now changing their agricultural and farming practices which can be said to be passive response to climate change. The key finding from this stduy is that the major barrier to adaptation is centered on capital which influences who can access farm inputs.

Abbreviations
KII: Key Informant Interview; FGD: Focus Group Discussion; MK: Mann Kendall; ANOVA: Analysis of variance.

Acknowledgments
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Authors' contributions
AA and IAO. developed the conception and every aspect of this study; AA played the leading role in the supervision of the research project, through which the paper was developed, While IAO. analysed the data. All authors read and approved the final manuscript.

Authors' information
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Availability of data and materials
The underlying data can be made available upon request to the corresponding author. Correspondence and requests for materials should be addressed to A.A.

Ethics approval and consent to participate
This study conforms to the ethics principles of Obafemi Awolowo University. Ethical approval for this study was obtained with standard ethics as the participants were not vulnerable in anyway, data was processed in anonymised procedure, and survey participants had the possibility to skip questions.

Consent for publication
Not applicable, because there are no data contained within our manuscript from which individual patients or participants may be identified.

Competing interests
The authors declare that they have no competing interests.

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