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Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria

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ABSTRACT

This paper examines smallholder farmers' perceptions of climate change, climate variability and their impacts, and adaptation strategies adopted over the past three decades. We use ethnographic analysis, combined with Cumulative Departure Index (CDI), Rainfall Anomaly Index (RAI) analysis, and correlation analysis to compare farmers' perceptions in Southwestern Nigeria with historical meteorological data, in order to assess the way farmers' observations mirror the climatic trends. The results show that about 67% of farmers who participated had observed recent changes in climate. Perceptions of rural farmers on climate change and variability are consistent with the climatic trend analysis. RAI and CDI results illustrate that not less than 11 out of 30 years in each study site experienced lower-than-normal rainfall. Climatic trends show fluctuations in both early growing season (EGS) and late growing season (LGS) rainfall and the 5-year moving average suggests a reduction in rainfall over the 30 years. Climatic trends confirmed farmers' perceptions that EGS and LGS precipitations are oscillating, that rainfall onset is becoming later, and EGS rainfall is reducing. Overall impacts of climate change on both crops and livestock appear to be highly negative, much more on maize (62.8%), yam (52.2%), poultry (67%) and cattle (63.2%). Years of farming experiences and level of income of farmers appear to have a significant relationship with farmers' choice of adaptation strategies, with r≥0.60@ $p < 0.05$ and r≥0.520@ $p < 0.05$ respectively. The study concluded that farmers' perceptions of climate change mirror meteorological analysis, though their perceptions were based on local climate parameters. Smallholder farmers are particularly vulnerable to climate change since the majority of them do not have enough resources to cope.

1. Introduction

The scientific evidence has shown that climate change is a global challenge facing humans and their socio-economic activities, health, livelihood, and food security (Romieu et al., 2010; Amjath-Babu et al., 2016; Mitchell and Van Aalst, 2008; Clarke et al., 2012). Changes in climate affect developed and underdeveloped nations and poor and rich people are also affected by its impacts. Underdeveloped nations and the poor are, however, more vulnerable (Adger et al., 2003). Rural farmers in Sub-Saharan Africa are likely to be more vulnerable to climate change, particularly because of compounding challenges of poverty, low infrastructural and technological development, and high dependence on rain-fed agriculture (Lipper et al., 2014; Ericksen et al., 2011; Nelson et al., 2014; Adimassu and Kessler, 2016). More than 95% of agricultural production in sub-Saharan African is rain-fed (see Simelton et al. (2013), Adebisi-Adelani and Oyesola (2014) and Zake and Hauser (2014)).

Climate projections show that Africa is likely to experience significant climatic changes, as extreme drying and warming will occur in most subtropical regions with slight increments in precipitation in the tropics (Adebisi-Adelani and Oyesola, 2014; Christensen et al., 2007; Abegaz and Wims, 2015). The climate change models also estimate that the impacts of climate change would be greater in regions across Africa (Christensen et al., 2007; Sylla et al., 2016). The major challenge of these climate change models and scenarios for Africa, however, is that they are somehow complicated by uncertainty regarding changes in precipitation that may occur as climate is changing. Nearly all models show a drying Southern Africa, as well as uncertainty between projections in some regions, particularly West Africa while reports by the IPCC (IPCC, 2014, 2013) and other studies (Yamana et al., 2016; Valdivia and Antle, 2015; Hulme et al., 2001; Dosio and Panitz, 2016) revealed uncertainty about future rainfall patterns in southern Sahara, the Guinea Coast and the Sahel. At the same time, there has been an increase in the number of publications on the implications of climate

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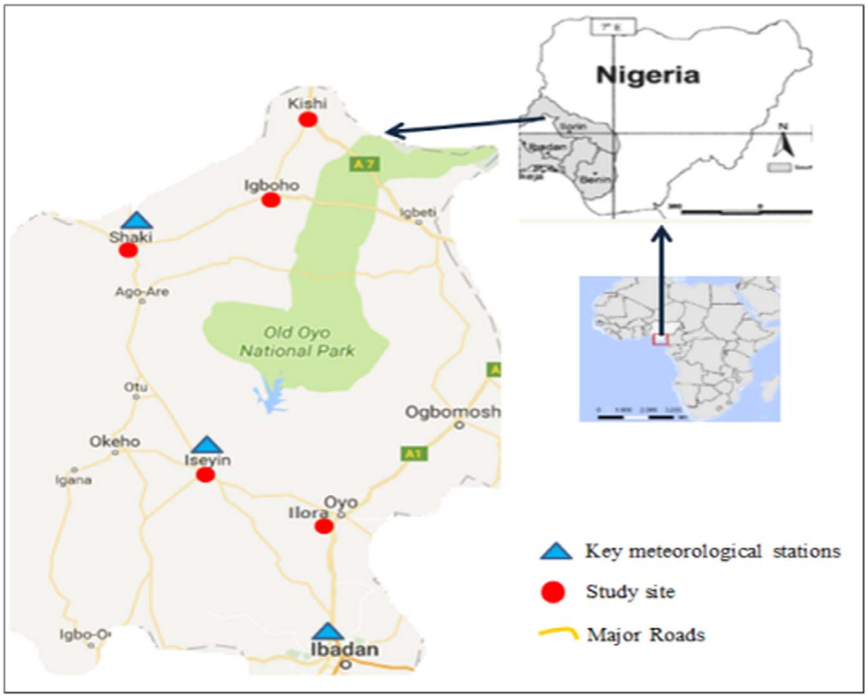

Fig. 1. Study site in southwestern Nigeria and key meteorological stations (modified from Google Earth accessed: 23/08/2016).

change and consequential weather extreme events such as erosion processes, drought, marine flooding, storm surges among others. Over the years, studies on climate change principally assessed impacts and adaptation, based on climate change scenarios, using only quantitative climatic data and models. However, a successful understanding of climate change will not necessarily be limited to values of climate parameters; it will also encompass variability and associated extreme weather events, and the understanding of these by local farmers who are being affected. Therefore, there is a need for an in-depth study, to examine farmers' understanding of extreme weather events, their significant impacts on crop and livestock production, and their strategies for adaptation. Communicating scientific findings to farmers, and incorporating their understandings will be very useful in implementing and monitoring strategies which would improve the crop yield not only in Africa but in the other part of tropical regions. This understanding will enable rural farmers to prepare a local response to the anticipated impacts of climate change (Zake and Hauser, 2014; Nyasimi et al., 2013; Savo et al., 2016; Adimassu and Kessler, 2016).

There are diverse opinions in the literature to the effect that rural farmers' knowledge of climate change and their adaptive capacity is insufficient for reliable adaptation. Some scientists also perceive that rural farmers' knowledge is insufficient for rigorous evaluation of planned adaptation. The recent IPCC report (IPCC, 2014) reveals, however, that local awareness and vulnerabilities are increasingly being

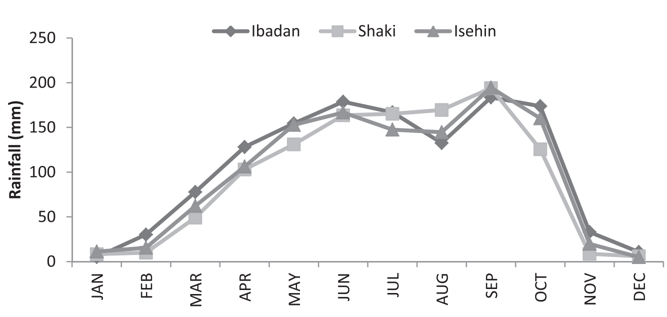

Fig. 2. Average monthly rainfall for the key meteorological stations around the study sites (1970–2014).

incorporated in interdisciplinary, multi-stakeholder assessments. The report of the IPCC and previous studies in Africa have shown the need for assessments of the potential impacts of climate variability/change and for the integration of rural people's awareness of these changes alongside other weather stresses (Heltberg et al., 2009; Mubiru et al., 2015; Nyasimi et al., 2013; Van Griensven et al., 2016; Tschakert et al., 2014).

A review of the climate change literature shows that more attention has been paid to climate change system modeling, climate change impacts, adaptation and risk assessment, but relatively little attention has been devoted to the perceptions and options for adaptation of those experiencing climate change. In the case of climate change impacts on smallholder agriculture, what is apparent is the gap between scientists' analysis of global climate change and rural farmers' awareness. Despite the great advancement of climate science in understanding and dealing with the problem of climate change and its impacts on the agricultural sector at the international level, awareness and the concern for the problem at local levels, especially among the rural farmers in Africa, remains crucial. Studies in other part of the world have shown that farmers cope with climate change based on their perceptions of changing climate (Li et al., 2013; Abid et al., 2015).

In Nigeria, studies have shown that most crop farming is rain-fed, thus rainfall in the most important element of climate (Odekunle et al., 2007; Adejuwon, 2006), a change which could greatly affect both crop and livestock farming in the country. These studies reveal that crops and livestock farmers are likely to be more severely affected because of their lack of adaptive capacity to climate change/variability (Mertz et al., 2009).

Though good agricultural management practices have the potential to be the basis for effective climate change adaptation methods, local knowledge should be used in conjunction with scientific knowledge systems for impact reduction (Morton, 2017). When crop yields are low, due to losses as a result of climate change as evidenced in changing times for the start and stop of rainy (growing) and dry seasons, farmers pay dearly for their ignorance or unpreparedness. In the present study, rural farmers' awareness of climate change, its impacts, and their specific adaptation measures, are valid starting points for science-driven assessments, for appraising the climate trend. This was based on the general objective of assessing how farmers' perception of climate change closely mirrors the climatic trend from the scientific meteorological analysis. This paper, therefore, examines farmers' perceptions of climate change and their adaptive strategies at the local level. The paper compares the perceptions of rural crop farmers and livestock keepers with the meteorological analysis in order to assess the way farmers' perceptions mirror climatic trends. An in-depth understanding of climate changes among the rural farmers in Africa would be very useful for better adaptation strategic planning which will later improve planning scheme in agriculture and other economic sectors.

2. Materials and methods

2.1. Study area

The study was carried out in Southwestern Nigeria, located in the tropical humid climate zone (Fig. 1). The region experiences two seasons: the rainy season (April-October) and the dry season (November-March) (Adejuwon and Odekunle, 2006). The study area is unlike other parts of the country in terms of rainfall and temperature. The sites are located within the Guinea Savanna agro-ecological zone, with the majority of people engaged in farming. The sites represent diverse farming systems and livelihoods with clear differences between the communities in terms of ecological characteristics. The majority of households are crop farmers, but in Ilora and Kishi many of them are livestock farmers who mainly rear chicken and cattle respectively. Mean minimum temperature ranges from 20 °C to 22 °C, while the mean maximum temperature for the hottest months is 32.6 °C. The climate and physical characteristics of Southwestern Nigeria are described in previous studies (Ojo, 1977; Iloeje, 1965; Odekunle, 2006; Odekunle et al., 2005). The climate of Southwestern Nigeria is influenced by the movement of three main wind fluxes: the Equatorial Easterlies, the Tropical Maritime (Tm) air mass, and the Tropical Continental (Tc) air mass. The equatorial easterlies are originated from the east and flow in the upper atmosphere along the climatic equator and it is characterized by intermittent cool air mass. Both Tm and Tc usually meet alongside a slanting surface called the inter-tropical discontinuity (ITD). The studies by Ojo (1977) and Odekunle et al. (2005) further reported that the rainfall patterns in the Southwestern part of Nigeria are influenced by the position of the ITD movements.

A large proportion of the population in the region lives in rural areas, with agriculture as their main livelihood. About 59% of the population live below the poverty line (Ogwumike, 2002). The vegetation, soil and agricultural practices in these communities reflect the climatic conditions. The rainfall is bimodal (Fig. 2). For this study, therefore, a year is divided into two major growing seasons; "early" growing season- EGS (April – Mid August); and "late" growing season- LGS (late August–October). Each season is divided by the little dry season, which usually occurs within the month of August (Adejuwon and Odekunle, 2006).

2.2. Data collection

We use data collected from farmers, combined with climate data to assess smallholder farmers' perception of climate variability and change, and compare the perceptions of historical trends from meteorological data. Historical meteorological and household data were used in descriptive statistics, to show farmers' perceptions (both crop and livestock farmers) and adaptive capacity. Climate data were collected from meteorological archives of the Nigerian Meteorological Agency, Oshodi, Lagos. Specific climate data included daily rainfall and temperature over the last 30 years. Data from the World Bank climate change data portal were also used to compute long-time decadal and seasonal rainfall variability. The climate data were used to evaluate the intra-annual and decadal trends, based on historical precipitation data.

Table 1
Summary of questionnaires administration and focus group discussion.

	Igboho	Ilora	Iseyin	Kishi	Shaki
Questionnaires (n=285)					
Number of households interviewed	28	20	24	12	16
Crop farmers (%)	48.1	37.2	49.3	41.5	58.6
Livestock farmers (%)	30.2	42.4	17.8	33.7	26.9
Both crop and livestock farmers (%)	21.7	20.4	32.9	24.8	14.5
Focus group discussion (n=97)					
Number of people participating in focus groups	28	15	26	8	20
Crop farmers	15	8	20	5	16
Livestock farmers	5	6	0	2	1
Both crop and livestock farmers	8	1	6	1	3
Interview (n=23)					
Number of people participating in key person/informant interviews	4	6	8	2	3
Crop farmers	2	2	4	1	1
Livestock farmers	2	4	1	0	2
Both crop and livestock farmers	0	0	3	0	0

Table 1 presents a summary of questionnaire administration, interviews, focus group discussions and the descriptive statistics used in this analysis. A multistage sampling method was used in this study. A total of 300 households were selected from the five communities where questionnaires were administered. The selection of households was done by dividing the total member of the households in each community by the sample size required. The household lists were collected from leaders of the communities, where the questionnaires were conducted. Systematic sampling method was achieved by applying this simple equation:

$$K = \frac{N}{n} \tag{1}$$

The households were drawn by selecting every K where N is the total number of the households in the community and n is the sample size desired (Saunders, 2011). Out of 300 questionnaires sent out, only 287 were returned, but 7 were not effectively or fully filled, so a total of 280 questionnaires were analyzed. The numbers of questionnaires administered in each community were contingent on the number of household in the communities. The questionnaire tagged overall change in climate as noticed by farmers over the past 30 years, change in the onset and stop of rainfall, change in the temperature, the degree of impacts of these changes on both crops and livestock, and adaptation technologies used by the farmers.

A set of semi-structured questions were used to collect data through in-depth interviews and focus group discussions. Care was taken to purposely interview individuals who have been farming for periods longer than 10 years (Table 1). The farmers who participated in the interviews and focus group discussions were asked questions about the demographics of their household; the agricultural practices; the perceived changes in climate and impacts they have experienced over time; and adaptation strategies they have employed to cope with the effects of climate changes. The focus group discussion was carried out with five to twenty-eight men and women farmers of ages 35–75 years in each case (Table 1). In-depth interviews were conducted in each community, with not less than two key persons interviewed. The interviewees were asked to give a time that they could be available when there would be no disruption. Furthermore, a place where they would have the freedom to express their views was chosen, so as to not influence the responses from them. The data from interviews and focus group discussions were used for triangulation of respondents' perceptions obtained from the questionnaire. The transcription of the audio records taken from sample areas, where interviews and focus group discussions were carried out, was translated from Yoruba and Pidgin-English into English.

2.3. Data analysis

Meteorological data from the nearest meteorological station to each study site were used. Climate data from the Iseyin meteorological station were used for Iseyin (IS); the Ibadan meteorological data were used for Ilora (IL) while, the data from Shaki meteorological station were used for, Shaki (S), Igboho (IG) and Kishi (K). The Cumulative Departure Index (CDI) and Rainfall Anomaly Index (RAI) analysis were used for the analyses of annual and seasonal rainfall variability respectively. Both were used to assess the trend of rainfall during EGS and LGS seasons; patterns of onset and length of the rainy season; and assessment of the overall intensity and within-season variability of rainfall. Cumulative Departure Index was calculated using Eq. (2).

$$CDI = \frac{(R_a - R_m)}{SD} \tag{2}$$

where CDI is the cumulative departure index; R_a is the actual rainfall for growing season months (developed from daily rainfall data); R_m is the mean rainfall and SD is the standard deviation of the total length of the period of study. Rainfall Anomaly Index (RAI positive and negative) was calculated using Eqs. (3) and (4).

$$RAI = +3\left(\frac{RF - M_{RF}}{M_{H10} - M_{RF}}\right) \tag{3}$$

$$RAI = -3\left(\frac{RF - M_{RF}}{M_{L10} - M_{RF}}\right) \tag{4}$$

where RAI is the rainfall anomaly index; RF is the rainfall for the year in question, M_{RF} is the mean actual annual rainfall for the total length of the period; M_{H10} and M_{L10} are the mean of 10 highest and lowest (respectively) values of rainfall ($_{RF}$) of the period.

Data from the questionnaire and interview were categorized based on different categories of farmers' perceptions of rainfall onset, amount, frequency and duration, intensity, variability/change and cessation in the study area. Samples of quotes from the interview and focus group discussion about farmers' perceived changes in climate from study sites are presented in tabular form. These perceptions were compared and tested by CDI and RAI during growing seasons for the whole study period. Statistical Package for Social Scientists (SPSS) and GIS modeling techniques were used to illustrate the spatial and temporal pattern of climate over the study periods. The SPSS was used to analyze the data and make statistical inference. To calculate correlation, the variables were the timing and duration of EGS and LGS, the adaptive methods currently employed by the farmers, the length of time for which the respondent has been a farmer, rural farmers' perception and their adaptation strategies. For enhanced presentation and interpretation of correlation results, a structural equation model (SEM) were developed using maximum likelihood estimation. SEM was used to show cross-sectional statistical relationship and path analysis of factors that determine farmers' choice of adaptation strategies. Step-wise orders were used continually to refine SEM in order to remove the non-significant pathway. Only factors with significant correlation coefficients are reported in a significant pathways figure.

3. Results and discussion

3.1. Farmers' perceived changes in climate

Crop farmers and livestock keepers perceived a notable change in climate in recent years. Table 2 presents the demographic characteristics of the household. The majority of the heads of household were male farmers (71%) and some female farmers (29%), with different years of farming experiences. Length of farming experience varied and ranged between 10 and 20 years (46.5%); 21–40 years (33.9%); and > 40 years (19.7%). The demographic characteristics were further used in correlation analysis, to test the relationship between farmer's adaptation methods and their demographic characteristics (see Section 3.3 below). Climate change is obviously perceived by both crop and livestock farmers (Table 3). The majority of the farmers perceived a recent prolonged dry spell and recurrence of drought. Nearly all the farmers perceived that the onset of rainfall is much later in last ten years than 20 years ago and they also noticed that rainfall ceases halfway into the end of growing seasons. The farmers noted that in recent 5 years "it may not rain for a full month within the rainy season" and some farmers further noted that the patterns of rainfall during EGS and LGS are very different over the past ten years. They perceived that rainfall is much more "unreliable" over the past 10 years. They stated that "rains used to start mostly in the month of March, but now start late and sometimes start in the month of May". Some livestock farmers perceived that prolonged drought and recent delays in the onset of rainfall, due to climate change, increased the incidence of pest and disease outbreaks which are the major disasters that occurred in their communities. They further stated that even when it rains, they observe that rain falls for a short month within growing seasons and the duration is limited compared to the past 30 years (Table 3).

Table 2
Summary of demographic and farming characteristics.

Variables	Mean or percentage
Length of farming experience (in years)	
10–20	46.5%
21–40	33.8%
> 40	19.7%
Sex of household head	
Male	71.1%
Female	28.9%.
Marital status	
Married	86%
Single	13%
Others	1%
Highest level of education	
Primary	30.4%
Secondary	16.1%
Tertiary	30.9%
Others	22.6%
Agricultural practices	
Crop farming	48.2%
Livestock	17.8%
Crop and livestock	34%
N	285

The farmers' perceptions of climate change were further categorized based on the similarity in the ways they perceived changes in climate. Table 4 presents the summary of farmers' perception of climate change/variability based on common specific observations and their length of farming experiences. In all, what is common in participants' responses to the issues of climate change is that; they expressed some observation of recent change in climate, leading to late onset of rainfall, oscillations in early and late growing season precipitation, increased temperature, prolonged dry spell with growing seasons and recurrent drought (Table 4). Many farmers expressed some observation of recent changes in onset of rainfall (40%, category C); oscillations in early and late growing season precipitation (50.6%, category C); recent drought and long dry spell (48.2%, category B) and recent increase temperature (35%, category B). What is noticeable from this result is that the greater the years of farmers' farming experiences (Table 4) the greater the percentage rate of their climate change perceptions. The majority of respondents interviewed perceive a change in the climate and consequent impacts on rainfall and temperature patterns.

Table 3
Major perceptions from the interviews and focus group discussions.

	Frequency	Amount	Duration/intensity	Variability/change
Onset of rainfall	The onset of rainfall is much later. Rains used to start in the month of March, but now late April or May (IG 67%; K 65%; IL 59%).	That the rainfall over the years has seriously reduced in quantity as compared to some years back (IS58%; S 62%).	It used to rain for the whole of April till July, and September to November for the late growing season. But, now rainfall onset is not predictable (IL 63%).	Sometimes rain may start early while it may take a long time before the rain starts. The onset of rainfall highly varies recently (IG 57%; K60%).
Rainfall cessation	Farmers notice rainfall ceasing half way into the wet seasons (S 71%; IL 68%).	In recent years, it rains early and stops raining or finished quickly (IL 68%; S 65%).	"I observe that rain falls for a short time and the duration is limited compared to the past 30 years" (IS 61%; S 65%)	
Number of rainy days	The number of rainy days has reduced (IG 69%; K 67%).		Now we very low rainy days even during the wet seasons (S 62%; K 67%).	
Temperature	I observed increase in temperature in recent years (IG 61%; S 55%; IS 59%; IL 57%)	Temperature has been a challenge to livestock farmers as chicken farmers have issues with the rise in temperature as the chicken are fragile animals compared to others and cannot really cope with the rising temperature (IL 71%; K 69%)		We observe serious challenge of an increase in temperature in the past few years compare to past 40 years (S 67%).
Windstorm	Windstorms were said, by farmers, to have been excessive recently as they break the branches of some tree crops and destroy other crops like maize, cassava, and plantain e.t.c (IG 68%; IL 63%, S 67%).		Turbulent windstorms usually happen when rain is about to fall, in recent years(K 64%)	Sometimes the rainstorm becomes so much that it causes the destruction of certain crops like maize, cassava, and many other crops, although the resistance of each crop varies (IG 64%; K 61%).
Rainy season	Recently we observed droughts or some prolonged dry spells in rainy season (K 65%; IL 62%)	We observe reduction in the quantity of rainfall and the rainy days (S 61%; IG 67%; IS 62%)	It may not rain in a full month within rainy season. (IS 71%) We start experiencing these phenomena recently(S 66%; IL 71%; IG 67%; IS 64%).	Rainfall is now highly variable and no one can predict when the rainy season can start (IS 67%; IG 61%; IL 66%).
Drought/dry spell	Drought has now become a phenomenon with long dry season such that plants get dry and the soil becomes so hard to tell (IL69%; IG 70%; K 72%; IS 68%; S 62%)			When there is no rainfall there will be an increase in temperature; this is our recent observation (IL 61%; IS 65%; K 68%)
Oscillations in early and late growing season precipitation	The pattern of early and late wet season rainfall are very different than in the past, more unreliable (IL 62%; IG 61%; K 61%)		Reduction in the quantity of precipitation during the late growing season is obvious recently (IS 60%; S 59%; IG 61%).	In the past, there were rains in late March, and now we observe little rainfall during the late growing season (K 65%; IL 62%).

Both crop and livestock farmers perceived changes in climate, in Igboho (IG), Ilora (IL), Iseyin (IS), Kishi (K) and Shaki (S). In this Table, similar perceptions are merged in percentage for each location.

Table 4
Perception of climate change and variability by farming experience.

Perceived changes in climate (%)	Category A	Category B	Category C
Observation of recent changes in onset of rainfall	25.6	34.4	40.0
Oscillations in early and late growing season precipitation	20.8	28.6	50.6
Observation of recent drought and long dry spell	12.6	48.2	39.2
Recent increase in temperature.	30.4	34.6	35.0

Percentages are of those agreeing with the observation/perception given. Category A represents farmers with 10–20 years, B represents 21–40 and C represents > 40 years of farming experiences. Multiple responses were allowed.

3.2. Comparing farmers perceptions with the meteorological data

Farmers' perceptions were compared with the results of historical trends from meteorological data. Figs. 3–5 show the RAI results with 5-year moving average for Iseyin (Fig. 3), Shaki (Fig. 4) and Ibadan (Fig. 5) weather stations. Fig. 6 illustrates the results from the cumulative departure Index (CDI) analysis for both EGS and LGS. The analysis was done from daily rainfall data from 1982 to 2014. RAI with 5-year moving average and EGS/LGS growing seasons' fluctuation analysis based on CDI were compared with farmers' perceptions. The results from Figs. 3–5 reveal that there is a persistent high variability in annual rainfall based on 5-year moving average The 5-year moving average trend lines are not consistent throughout the 30 years. Approximately half of the years within the study periods experienced annual rainfall that is below normal in all study sites (Figs. 3–5). For example, the RAI results illustrate that 12 out of 30 years experienced annual rainfall below normal in Isehin (Fig. 3), 11 out of 30 years in Shaki (Fig. 4), and 14 out of 30 years in Ibadan (Fig. 5). These results imply that those years actually experienced lower-than-normal rainfall, also are characterized by late onset rainfall and early cessation. The values support the farmers' perception that there is recently variability in the quantity of rainfall and the rainy days. The reasons for the notable variability in rainfall in recent years were due to several dry spells during rainy seasons and pronounced little dry season (Adejuwon and Odekunle, 2006; Odekunle et al., 2005) which are the evidence of change in climate.

We verified further farmers' observed oscillations in EGS and LGS precipitation and late onset of rainfall, which they considered to result in reduction in EGS rainfall in recent years. The results in Fig. 6 show significant fluctuations in rainfall during the growing seasons. The CDI reveals a general below normal rainfall pattern during the EGS compared to the LGS. Fig. 6a and b show more intense, below normal rainfall during the EGS for the two stations, but the EGS were above normal only in 1998. However, LGS were below normal only in 8 out of 30 years in Iseyin (Fig. 6a), and 5 out of 30 years in Shaki (Fig. 6b). More so, about 5 years out of 30 years experienced EGS that were above normal. These results show a general and consistent negative value for EGS rainfall, which implies that the rainfall during the EGS has reduced. This might confirm the farmers' perception that early and late growing season precipitations are oscillating, late onset of rainfall and reduced in EGS rainfall in recent years.

The impacts of change in EGS and LGS, late onset and early

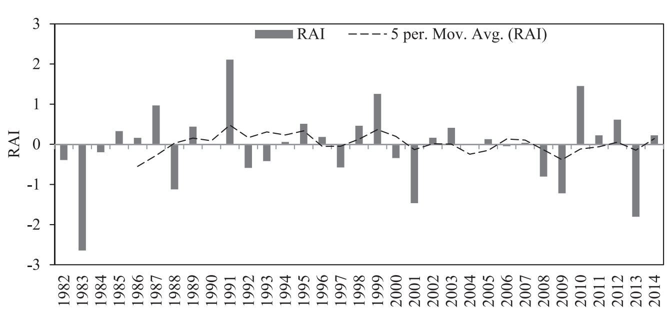

Fig. 3. Rainfall Anomaly Index (RAI) and 5-year moving average analysis for Isehin, from 1982 and 2014.

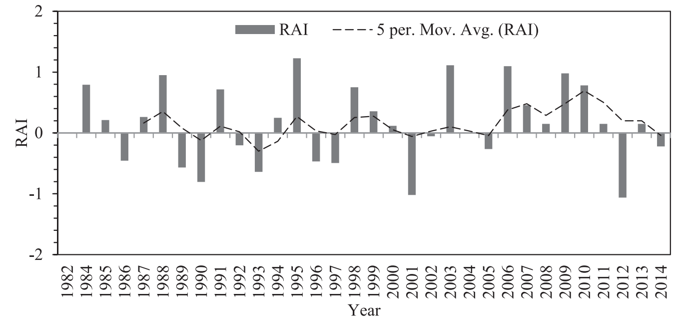

Fig. 4. Rainfall Anomaly Index (RAI) and 5-year moving average analysis for Shaki, from 1982 and 2014.

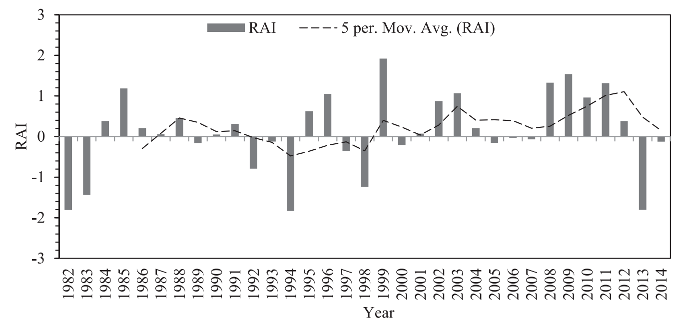

Fig. 5. Rainfall Anomaly Index (RAI) and 5-year moving average analysis for Ibadan, from 1982 and 2014.

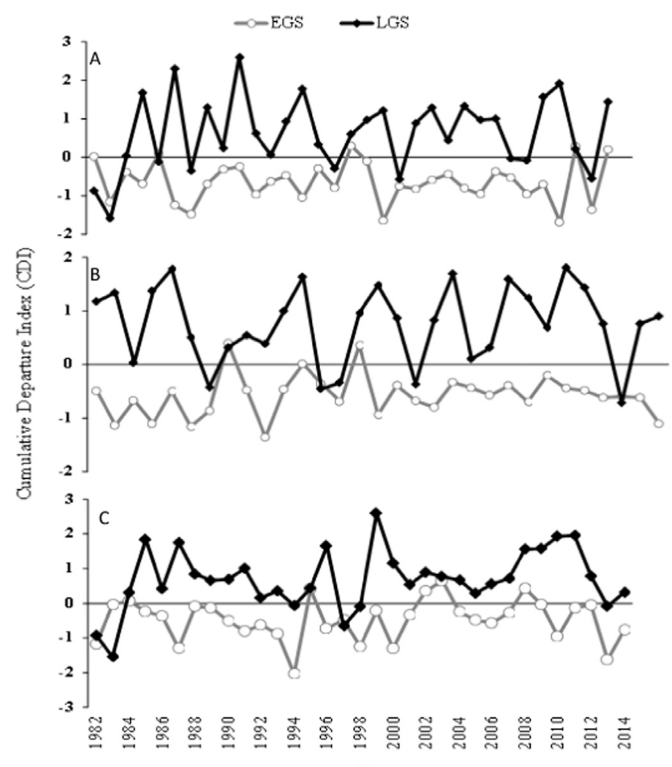

Fig. 6. Growing season fluctuation analysis based on Cumulative departure Index (CDI) between 1982 and 2014. A=Iseyin meteorological data, B=Shaki meteorological data, and C=Ibadan meteorological data.

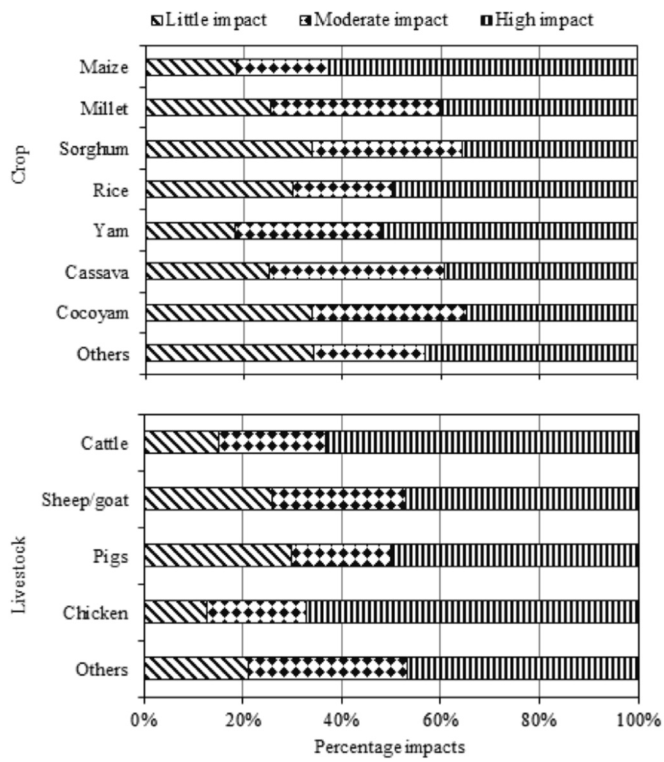

Fig. 7. Farmers perceptions of climate change impact on both crop and livestock.

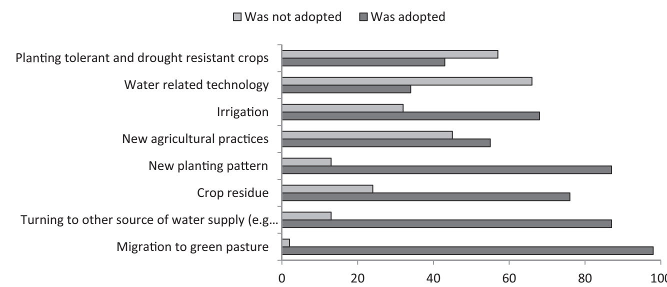

Fig. 8. Comparison of farmers' adaptive strategies.

cessation of rainfall for crops and livestock were examined. The results from this study demonstrate that farmers in southwestern Nigeria have a good perception of climate change and its impacts on both crops and livestock agriculture. Though, historical crop yield and production data were not available for comparison, from Fig. 7 it is obvious that the farmers' perceptions of climate change impacts on both crop and livestock are likely accurate. Fig. 7 shows farmers' perceptions of climate change impacts on both crops and livestock. The majority of them noticed changes in rainfall patterns and the frequency of extreme events which they said has impacts on both crops and livestock. In all study sites, most of the farmers claimed that the overall impacts of climate change on both crop and livestock are estimated to be highly negative, much higher impacts on maize (62.8%); yam (52.2%) and rice (49.7%). Likewise, most livestock farmers perceived that the climate change impacts are high on livestock such as chicken (67%), cattle (63.2%), pig (49.9%); sheep and goat (47.15) as illustrated in Fig. 7. Other studies support similar findings that climate change is currently the principal threat to the agricultural sector in all parts of the world (Mertz et al., 2011; Muller and Shackleton, 2014; Dhanya and Ramachandran, 2015). It has been reported in the literature that both crop and livestock farming are vulnerable to climate change (Aggarwal, 2008) and that this might lead to expected reduction in the yields of some important crops (Parry, 2007; Sima et al., 2015).

3.3. The climate change adaptation strategies and determinant of farmers' choice

Adaptation and coping strategies to climate change varied between crops and livestock farmers. Fig. 8 illustrates the percentage of farmers' adaptation strategies considered in this study with their descriptive statistics. New planting pattern is an adaptive strategy to climate change widely adopted by crop farmers in the study area (Fig. 8). This adaptive strategy includes changes in planting times during early and late growing seasons. The majority of livestock farmers migrate to green pasture while some turn to another source of water supply to cope with changes in climate (Fig. 8). Factors that determine the choice of adaptive strategies by farmers were further assessed. The relationship between some factors and farmers' choice of climate change adaptation strategies were further tested in the correlation analysis. The results of correlation analysis were presented in path analysis (Fig. 9) and correlation table (Table 5). Fig. 9 displays the path analysis of farmer characteristics and climate change adaptive capacity, with standardized coefficient while Table 5 shows detailed correlation results of all variables used. Oval shapes represent adaptation strategies that are peculiar to livestock farmers and the majority of them were highly significant at $p < 0.05$ and $p < 0.01$.

Generally, the farmers' adaptation strategies are significantly correlated with the level of farmers' income (INC), the level of education (EDU), and years of farming experiences (YFE). New agricultural practices and irrigation show a significant relationship with income, by r≥0.50@ $p < 0.05$ (Table 5). This value implies that level of income determines the extent to which farmers can use new agricultural practices and irrigation systems in adapting to climate change. It is obvious that EDU is negatively correlated with search for pasture (Fig. 9). This is not surprising that more educated livestock households are less mobile. However, YFE appears to have a significant relationship with adaptation strategies such as water-related technology (r > 0.52@ $p < 0.05$), new planting pattern (r > 0.60@ $p < 0.05$), and planting tolerant and drought resistant crops (r > 0.54@ $p < 0.05$). Correspondingly, the results also show that possibility that a farmer will change the use of animal health services to adapt to climate change is relatively determined by the level of income of the farmer; since r > 0.48@ $p < 0.05$ (Fig. 9). Only crop residue strategy is relatively significant with YFE, for livestock farmers adaptation methods with r > 0.47@ $p < 0.05$ (Fig. 9).

What is obvious from these results is that YFE and INC probably

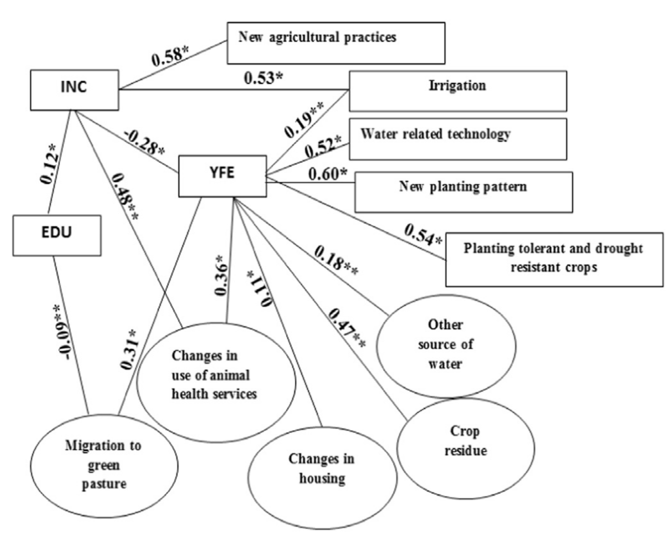

Fig. 9. Significant pathways analysis of farmer characteristics and climate change adaptive capacity, n =285, *p < 0 0.05. **p < 0.01; standardized regression coefficient above arrows. EDU, INC, and YFE represent level education, monthly income and years of farming experiences of the farmers respectively.

Table 5
Comparison of factors of climate change adaptation strategies.

	Migration to green pasture	Changes in housing	Changes in use of animal health services	Other source of water	YFE	Crop residue	Planting tolerant and drought resistant crops	New planting pattern	Water-related technology	Irrigation	New agricultural practices	INC	EDU
Migration to green pasture	0	0.03	0.004	0.1	0.31*	0.07	0.12	0.13	0.01	0.14	0.06	0.17	−0.09**
Changes in housing	0.03	0	0.12	0.16	0.11*	0.04	0.41	0.07	0.13	0.04	0.02	0.05	0.21
Changes in use of animal health services	0.004	0.12	0	0.11	0.36*	0.004	0.03	0.31	0.07	0.05	0.11	0.48**	0.09
Other source of water	0.1	0.16	0.11	0	0.18	0.01	0.05	0.011	0.02	0.21	0.13	0.11	0.07
YFE	0.31*	0.11*	0.36*	0.18	0	0.47**	0.54*	0.60*	0.52*	0.19**	0.12	−0.28*	0.008
Crop residue	0.07	0.04	0.004	0.01	0.47**	0	0.05	0.08	0.03	0.01	0.18	0.21	0.02
Planting tolerant and drought resistant crops	0.12	0.41	0.03	0.05	0.54*	0.05	0	0.12	0.04	0.02	0.04	0.06	0.09*
New planting pattern	0.13	0.07	0.31	0.011	0.60*	0.08	0.12	0	0.01	0.09	0.08	0.01	0.03
Water related technology	0.01	0.13	0.07	0.02	0.52*	0.03	0.04	0.01	0	0.02	0.01	0.09	0.05
Irrigation	0.14	0.04	0.05	0.21	0.19**	0.01	0.02	0.09	0.02	0	0.11	0.53*	0.11
New agricultural practices	0.06	0.02	0.11	0.13	0.12	0.18	0.04	0.08	0.01	0.11	0	0.58*	0.12
INC	0.17	0.05	0.48**	0.11	−0.28*	0.21	0.06	0.01	0.09	0.53*	0.58*	0	0.12*
EDU	−0.09**	0.21	0.09	0.07	0.008	0.02	0.09*	0.03	0.05	0.11	0.12	0.12*	0

EDU, INC, and YFE represent level education, monthly income and years of farming experiences of the farmers respectively.
n=285, $^{*}p < 0.05$, $^{**}p < 0.01$.

determine to a large extent the adaptation strategies that farmers could adopt to cope with climate change. There are numerous studies in the literature that have reported that climate change adaptation strategies which farmers applied depend on several factors (Kuehne, 2014; Simelton et al., 2013; Burnham and Ma, 2015; Bryant et al., 2000). It has been revealed in most of these studies that smallholders farmers are more likely to respond to current climate variability (Morton, 2007, 2017), but their adaptation strategies to cope with changes in climate depend on their social and economic characteristics. For example, Kuehne (2014) has noted similar scenario among farmers from the South Australian Riverland that farmers used different adaptation methods to counter the effects of extreme weather events resulting from climate change. Simelton et al. (2013) had earlier proposed that since farmers had an understanding of how climate is changing, climate change scientist and policymaker have to be more “in tune with farmers” in order to improve adaptation strategies used by farmers for better adaptation policy formulation and implementation. Other studies, in other part of the world, have publicized that smallholder farmers perceptions of climate change and their adaptive strategies could be linked to levels of farmers’ education (Roco et al., 2015), environmental knowledge, income (Zheng and Dallimer, 2016; Deressa et al., 2009), attitudes, social and cultural beliefs (Adger et al., 2009; Below et al., 2012; Altschuler and Brownlee, 2016). In the present study, it is noticed during the field work, that the farmers find it somehow hard to identify those climate change adaptation options which go beyond those they are familiar with and had implemented to manage climate extreme events. Generally, what is understandable from these results is that income, the length of farming experience and level of education are mostly significant at 5% with farmers’ adaptation strategies (Fig. 8). This implies that the three variables have a significant influence on climate change adaptation strategies adopted by farmers.

4. Conclusion

This article draws upon both qualitative and quantitative approaches, to investigate the smallholder farmers’ perception of climate change in southwestern Nigeria and compare their perceptions to historical meteorological data. The study sites are dominated by small and medium farm households who live below the poverty line. The majority of farming systems are rain-fed. Thus climate change has adverse impacts on agriculture because there is a link between climate and the agricultural sector in Nigeria. Primarily, the study established the evidence of climate variability/change in the study area through analysis of meteorological data, over the past 30 years. The study further elicited farmers’ perception of recent variability/ change in climate; change in the onset of rainfall; recent increase temperature; oscillations in EGS and LGS precipitation; and prolong dry spells and droughts. Smallholder farmers’ perception of climate change and effective climate change adaptation methods and local knowledge were used in conjunction with scientific knowledge systems from meteorological data analysis. Farmers’ perceptions of climate change impacts on both crop and livestock were examined and path analysis of farmer characteristics and climate change adaptive capacity were assessed. Annual and growing season rainfall trends were analyzed and correlated with the farmers’ perception of climate change.

The results indicated that both crop and livestock farmers have noticed changes in climate. Most of the farmers observed changes in weather patterns and in the frequent extreme events which they said had impacts on both crop and livestock. They perceived changing times for the start and finish of the rains during the growing seasons and noticed that some crop yields are lower in recent years compared to past 30 years. Livestock farmers are now finding it difficult to find water and green pastures during prolonged dry spell. Nearly all the farmers perceived changes in the onset of rainfall. Both farmer perceptions and meteorological data show that rainfall is much more unreliable in recent years. RAI with 5-year moving average shows a general change in both EGS and LGS rainfall, but much more evidence of rainfall reduction during EGS. This confirmed farmers' perception that; early and late growing season precipitations are oscillating; rainfall onset is becoming later, and EGS rainfall is reducing in recent years. However, there are several factors that determine the choice of adaptation methods employed by farmers. The correlation results revealed that income (INC), the level of education (EDU) and years of farming experience (YFE) have significant influences on the farmers' climate change adaptation choices. It is obvious from this study that though farmers' perceptions of climate variability/change were based on local climate parameters identified by farmers, the southwestern Nigerian farmers are particularly vulnerable to climate change since the majority of them do not have enough resources to cope with change in climate.

Based on the findings of this study, there is a need for farmers' capacity development programme to cope with the changing climate. Such programme may include smart-agro-climate training to be developed by agricultural extension workers. The government could build the capacity of agricultural extension systems (Morton, 2017) and make available climate change education scheme (Ayanlade and Jegede, 2016) with ICT innovations such as cell phone applications. There is a need also for new institutions, such as Public-Private-Partnerships organized along value chain lines, which can take research findings, into the field and help smallholder farmers adapt to a changing climate.

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