Research Article

Perception of Cassava-Based Farmers to Climate Variability in the Rain Forest and Derived Savannah Biomes of Nigeria

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Abstract | Climate variability influences the pattern of agricultural production, especially in those parts of Africa, where agriculture is mainly rain-fed. A disparity exists in how farmers perceive and adapt to climate variability that influences their production decisions and improved livelihoods. We analysed the perception of cassava-based farmers to climate variability in two ecosystems in Nigeria. Climate data (spanning 1951 to 2010) were used to corroborate and evaluate the perceptions of farmers. Four hundred smallholder farmers were interviewed in Ogun State (rain-forest zone) and Kwara State (derived savannah) using a multi-stage sampling technique. Farmers perceived climate variability as unpredictable weather situation over the years (65.41%), though some (23.31%) perceived it as the act of God or the wrath of God (11.28%). In terms of adaptation measures, 63.4% of the respondents had access to the weather forecast, some (55.4%) utilise it, while 58.4% engaged in artisanship (blue-collar jobs) and vegetable production (63.2%). Lessons on adaptation are critical for putting in place, policies that reduce the vulnerability of arable crop farmers to help to achieve sustainable development goals. The State governments should reintroduce the highly adaptable and high yielding TMS 30572 (an improved cassava variety) to farmers, given its inherent capability to withstand cassava mosaic virus disease, extreme weather conditions, and its long gestation period. Government of both states should provide infrastructure support to improve the cassava-based farmers' adaptive capabilities to climate variability and reduce their vulnerability.

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Introduction

Climate variability is currently evident all over the world. In particular, studies (Dasgupta *et al*., 2014; Shimola and Krishnaveni, 2013; Ayal and Filho, 2017; Asrat and Simane, 2018) projected that rural farmers in developing countries could experience these impacts in terms of water scarcity, food insecurity, infrastructure support and income to farm production. This is because the sub-sector is highly dependent on natural resources and have low adaptive capacity. The rural areas account for upward of 50% of the population (World Bank, 2018), where rain-fed agriculture employs more than 95% of farmed land (Awulachew, 2019).

Nigeria is largely dependent on rainfall and temperature thereby making the issue of climate variability and associated concerns to be important subjects of empirical investigation in an agricultural-based economy (Hardaker *et al*., 2004; Adejuwon, 2006; IPCC, 2007, 2013, 2014; Busby *et al*., 2014; Williams *et al*., 2017; Mahouna *et al*., 2018). The frequency and magnitude of these climatic events would be felt through multiple non-climate stressors (situations that cause constraints to farmers), which include under-investment in agriculture, and associated issues relating to land policy and other natural resources which are important factors of the environment (Ziervogel *et al*. 2006; United Nations-UN, 2015; UN, 2016). Cocoa, maize, and cassava are the most affected crops by climate variability in the South western part of Nigeria (Ayanlade *et al*., 2018). Despite this, farm households manage to cope with their income, food and livelihoods security needs during changing climatic conditions (unfavourable weather conditions, e. g. flood and drought) due to farmers adoption of adaptation strategies predicated on their perception of climate variability phenomena (Kandlinkar and Risbey, 2000).

Perception of arable crop farmers to climate change enables them to plan for the reduction of the potential damage that can be caused by climate variability by making tactical responses to these changes (Ziervogel *et al*., 2006; IPCC, 2007; Gbetibouo, 2009; Simbarashe, 2013; Tambo and Abdoulaye, 2013; Antwi-Agyei *et al*., 2014; Ibrahim *et al*., 2015; Ziervogel *et al*., 2016; William *et al*., 2017). Farmers' perceptual capabilities are, therefore, important variables governing their ability to combat the problems of climate variability as they affect crop production.

Various national and international scholars (Babatolu and Akinnubi, 2016; Limantol *et al*., 2016; Ayal and Filho, 2017; Falola and Achem, 2017; Mupakati and Tanyanyiwa, 2017; Yamba *et al*., 2019; Raphollo, 2020; Foguesatto and Machado, 2021) have logically analysed how farmers perceive the manifestations of climate variability, through droughts, observed variations in rainfall and its distribution, late-beginning or early retreat, decreased intensity and duration of rainy days, increasing average temperatures, escalated pest infestation of crops, livestock and pasture, or vegetation loss as well as earlier crop ripening.

Furthermore, apart from farmers' perception of climate variability, farmers' native intelligence also allowed them to perceive the critical effects of perceived climate variability. These perceived effects of climate variability include decreased agricultural yield (Somboonsuke *et al*., 2018; Karki *et al*., 2019), land erosion, high cost of production, and movement of labour into the non-agricultural sector (Somboonsuke *et al*., 2018), moving to fallow land (Shimola and Krishnaveni, 2013) and repeated droughts and reduced agricultural yields (Asrat and Simane, 2018). Furthermore, having an idea about how farmers perceive climate change in terms of its features, extent, perceived reasons for change, as well as their perceived effectiveness of the change, will go a long way in determining their adaptation strategies.

Justification for focussing on cassava

Cassava was picked as a focal staple crop for this study because, apart from the fact that Nigeria is the world's largest producer of cassava with 60,001,531 metric tonnes constituting 19.5% share of global production in 2020 (FAO, 2021), its production is dominated by traditional, small scale, male and female farmers (Kareem *et al*., 2017). Cassava is especially a food security crop to most poor households in Nigeria. In fact, according to Uba (2018), there may be food crisis with scarcity of cassava. It is also widely consumed daily (after rice) in various forms by Nigerians as a cheap source of daily carbohydrate (Okoye *et al*., 2021), and it is consumed in various forms; either boiled, baked, or processed into shelf-stable roasted products (e.g *gari*), dried products (e.g. *tapioca)* or powdered forms (e.g. *lafun,* cassava flour for baking and confectionery purposes) or for industrial purposes (for the manufacture of high quality cassava flour [HQCF], glucose syrup, industrial glue, industrial starch, etc.), while the leaves of the edible variety is used as vegetable.

The negative effects of climate variability on cassava could therefore, be a major blow to poor Nigerians, who constituted 40.0% of the population in 2020

(National Bureau of Statistics, 2021). This study therefore, examined the various adaptation strategies employed by the cassava-based farmers, while also describing the cassava-based farmers' survival strategies that influenced their choice of decisions to combat climate variability. This study also compared the observed pattern of selected climatological variables with perceived views of farmers on climate variability and also describes farmers' perception, extent, perceived reasons for climate variability as well as their perceived effectiveness of the change in two agro-ecological zones of Nigeria.

Materials and Methods

Study area

The research targeted cassava-based farmers in the two predominant growing zones (rainforest and derived savannah) of Nigeria; Ogun and Kwara States.

The capital of Ogun State is Abeokuta, and it is located in the South-western region of Nigeria, between latitude 7°06′ and 7°13′ N and longitudes 3°15′ and 3 °25′ E. It also falls in the rain forest (also known as the tropical rain forest) zone of the country, which is suitable for the cultivation of cassava and other related arable and cash crops. This agricultural zone experiences average monthly rainfall spanning between 228.8 mm and 16.2 mm from August and January and a mean monthly temperature between 30.0°C and 24.8°C (World Bank, 2018). The state has a tropical climate which used to have two well-defined rainfall seasons-wet season (between April and October), and dry season (between November and March) before manifestation of the effects of climate variability.

Kwara State, with Ilorin as the capital city is located in the derived savannah (between the rain forest and guinea savannah) in Nigeria. It consists mainly of a mixture of grasses and scattered trees. Ilorin has a period of rains spanning from March to November, with annual rainfall between 1,000 mm and 1,500mm, which peaks from September to early October (Tunde *et al*., 2013), and a generally high mean monthly temperature of 26.6°C. This zone is also highly suitable for cassava-based production system.

Data source and data collection

The mixed-method (quantitative and qualitative) data collection was used. Climatic data spanning 51 years (from 1951-2010) were obtained from Climate Research Unit (CRU) and were analysed to investigate the trend of climate variability of the study area, over the designated period. The CRU data, created by interpolation station datasets is gridded at 0.5° by 0.5° resolution (Harris *et al*., 2014). Further description of the CRU version TS3.22 data which are widely used in Nigeria, are available with the University of East Anglia, (Oguntunde *et al*., 2012).

Other quantitative data such as farmers-specific socio-economic data and adaptation strategies were analysed with descriptive statistics. Information obtained through Focus Group Discussion (FGD) of respondents (whereby respondents were allowed to provide a 'free opinion' about the focal issues of the study) was also used in this study. Qualitative data obtained through the FGD complemented information contained in the questionnaire. The major domains of the check list for the FGD include the socio-economic characteristics, of respondents, how they perceive variations in climate, their causes and effects on arable farming (which is cassava-based), as well as the consequent change in livelihoods and their adaptation strategies (both local and conventional).

Sampling procedure

Using a simple random sampling (SRST) technique, Ogun and Kwara States were randomly selected in the rain forest vegetation and derived savannah vegetation respectively; to allow for representativeness of data collection. Fifty per cent of the existing Agricultural Development Programmes (ADP) zones (that is 2 zones in each of Kwara and Ogun States) was selected using SRST. This gave 4 representative zones for the entire study area. The fourth stage featured the selection of 1 sub-location (block) from each location through SRST (this implies that 4 blocks were chosen in all). The selection of 5 villages each was done through SRST from the sub-locations (this gave a total of 20 villages) in order to eliminate sampling bias. Twenty households were thereafter selected for the interview through a systematic simple random sampling technique to further eliminate sampling bias as much as possible. This gave a total sample size of 400.

Following an abstraction of Gandure *et al*. (2013), we analysed the study data using descriptive statistics (frequency and percentages) to describe how farming activities are affected by climate variability and the adaptation strategies evolved by the cassava-based farmers. Descriptive statistics was also used to explain capacity-building techniques put in place for vulnerable groups and the adaptation strategies put in place by government tiers, while the graphical presentation was used to demonstrate the rainfall pattern and temperature change over years (1951 to 2010).

Results and Discussion

Climate variability in the study area: Graphical presentation of climatic variables showing rainfall and temperature climatology over Nigeria from 1951-2010 are presented in Figures 1 and 2. Observed volume of rainfall ranges from 300 mm to 2,700 mm, with most areas receiving 1,500 mm in a year. The coastal area of the country experienced the highest rainfall amount, and the rainfall generally decreased northwards, while the mean temperature spanned from 21°C to 29°C. The pattern presented in the figure indicates the presence of high spatial variability in rainfall and temperature over the country.

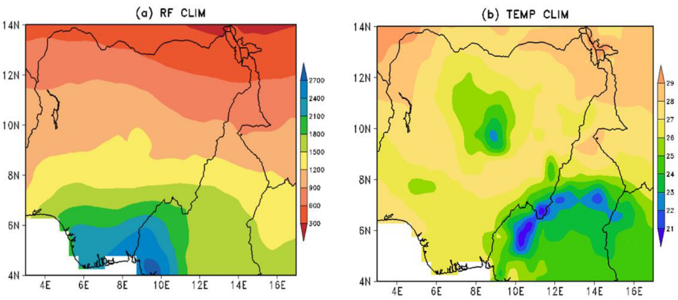

Figure 1: *(a) Rainfall climatology (RF CLIM, mm), (b) Temperature climatology (TEMP CLIM, °C) over Nigeria based on Climate Research Unit (CRU) data, 1951–2010.*

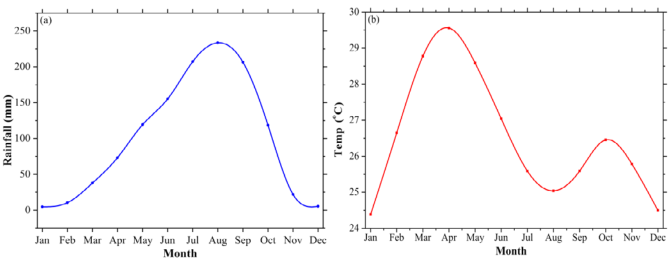

Figure 2: *Annual (a) rainfall, and (b) temperature over Nigeria.*
Source: *Climate Research Unit data, 1951–2010.*

Figure 2 indicates the rainfall and temperature annual cycle. The uni-modal rainfall is mainly received in June to October, with observable peak in August.

The rainfall and temperature trend is presented in Figure 3. The temperature is observed to be increasing while the rainfall trend is negative. The increase in temperature is in agreement with other studies both on a global and regional scale. For instance, Oguntunde *et al.* (2012) reported a warming trend over Nigeria in the period 1981–2000, while Abatan *et al.* (2018) linked the increase in temperature over the region to anthropogenic global warming. To corroborate this study results, Ogungbenro and Morakinyo (2014), also observed a reduction in rainfall in Nigeria and recommended the cultivation of drought-tolerant or early-maturing varieties of crops, especially in the Sahelian agro-ecological zone of the country, as they can adapt better to the changing trend in rainfall.

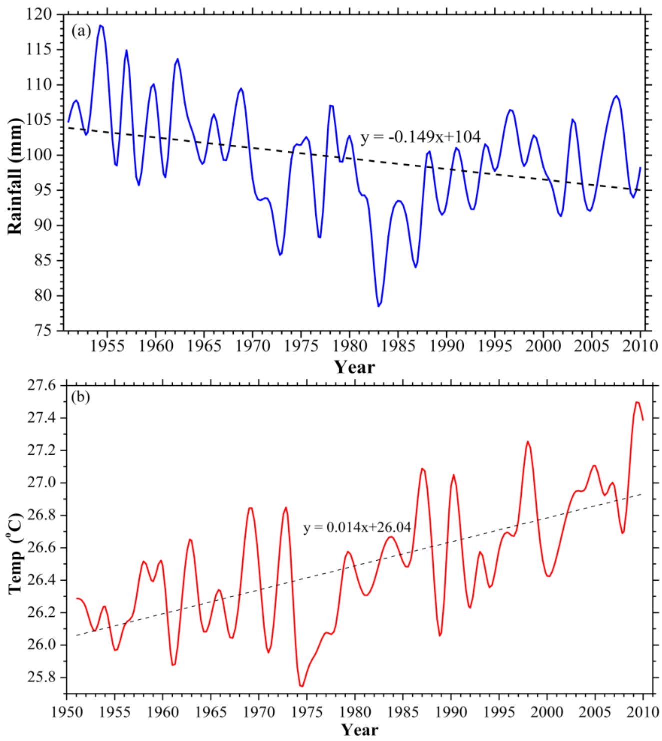

Figure 3: *Inter-annual variability of (a) rainfall, and (b) temperature over Nigeria. Climate Research Unit data, 1951 to 2010.*

Farmers perception of climate variability and change
Given variation in the rainfall patterns in space and time, rainfall variability is often under-sampled by the contemporary spatial distribution of meteorological stations because the rainfall trends are not easily detectable (Jellason *et al.*, 2019). Nonetheless, farmers' perception of climate variability shows an interesting fact that farmers, although not versed in the formal knowledge of climate change/ variability, can notice changes in weather parameters (especially rainfall and temperature) over the years with seeming agreement of views across the respondents interviewed in the study.

Rainfall variability

Table 1 shows respondents' views of climate variability. Respondents generally perceived rain as highly unpredictable over the years, although farmers have come to live with these rainfall fluctuations. This view supports climatological evidence in Figure 3a and 3b.

As expected, farmers had observed the irregularity of rainfall, at least in the last ten years. They observed rains no longer commence at the expected onset towards the end of March in Abeokuta, Ogun State and in Ilorin, Kwara State. This makes it difficult to target the early period of planting by cassava-based farmers. This incapability to take accurate decisions on planting dates imposes perceived risks of yield loss on the farmers. Many farmers therefore, have resorted to planting sequentially (vary planting time for the same crop within the year) to minimize revenue loss.

The uncertainty arising from heavy rainfall in some years (Table 1) leaves the farmers incapable of protecting their farms from flooding and lodging of their crops (especially respondents who cultivated maize plant which is highly susceptible to lodging). This consequently, leads to the destruction of farmland through flooding, lodging of maize plants, and yield reduction of cassava (which performs poorly in badly drained or waterlogged soil). This, therefore, leads to yield loss and the attendant reduction in farm income.

Adequacy of rain (Table 1) was also viewed mainly from the ambit of water sufficiency for crop growth, development, and yield. The implication of rainfall inadequacy, on the other hand, is that many farmers were unable to produce maize twice a year (which was the usual tradition). This arose from delayed commencement and early stoppage of rainfall in a year or unclear line of demarcation between the onset of early and late raining seasons most of the years. According to Obot *et al*. (2011), the distinctive period of early rains (which occurred in early March) and late rains (which occurred in early September), which was a common phenomenon many years ago is no more. This has led to the inability of smallholder farmers to produce maize twice in a year (that is, have two production cycles). This has therefore, reduced capability of the farmers to generate additional revenue, thus leading to reduced income.

Temperature variability

Unlike rainfall, temperature patterns are detectable more easily, because it exhibits minimal spatial variability between nearby locations (Jellason *et al*., 2019). High temperature has severe effects on crops before maturity (especially maize which is affected more than cassava, given that maize has relatively shallow roots compared to cassava). Farmers also reported high temperature (Table 1) and drying up of rivers and streams for some of the years, which negatively affected the availability of water for optimum growth of the crops. This situation imposes more difficulty on farmers (especially women, youth, and children) who had to walk for long distances to seek sustainable streams for irrigation (Ibrahim *et al*., 2015). High temperature further increases the rate of evapo-transpiration (loss of water in the form of water vapour) and where there is an imbalance between water uptake and loss of water, the wilting process (of crops) commences and this affects crop performance on the field and can even lead to a total crop loss.

To find solution to the above issues raised by the farmers, the FGD outcome suggested strongly that, the state government (for the two States) should explore the adaptive capabilities of tropical *Manihot species*-TMS 30572 (an improved cassava variety) because of its resistance to extreme weather and cassava mosaic virus disease and its high-yielding capability as well as long gestation period.

Perception of Effects of Climate Variability on Farmers' Livelihoods: Based on results of farmers' perception of climate variability (as presented in Table 1), one can infer that climate variability affects respondents livelihoods. These include:

- A change in crop production pattern
- Movement of farmers away from the traditional two-shift production cycles of maize (which is less tolerant to high temperature and low rainfall) to one cycle production
- More production of vegetable and cassava production (which are more tolerant to high temperature and low rainfall).

This survival strategy was motivated and developed by the arable crop farmers (who are rational producers) in order to generate increased income, which will not be significantly affected by the impact of climate variability (Ibrahim *et al*., 2015).

Table 1: *Perception of farmers on climate variability.*

Variables	Features	Extent	Perceived reason for changes by farmers	Perceived effect of change by farmers
Rainfall	Rainfall irregularity	Highly unpredictable	Irregular rainfall, unstable rainfall	Difficult to target period of planting easily. Early planting leads to crop failure
	Rainfall intensity	Strong	Sometimes marked by thunderstorm	Flooding of farmland occur some years. Lodging of crop especially maize. Poor yield of cassava because of excessive rains except weeding is intensified
	Rainfall adequacy	Inadequate	Late onset of rainfall	Drought is becoming a common feature earlier in the year. Incessant rains have made it difficult to produce maize twice a year; reduced income. It may be helpful to return to cassava with longer gestation period e.g. TMS 30572 in order to accommodate targeting sales at periods that commands high revenue
Temperature	Temperature variability	Can be very hot or very cold	Scorching of crop, wilting of crops, excessive heat felt by farmers, drying up of streams	Reduction in crop yield. Water bodies dries up in some years, hence reduced access to drinking water for human and animals; causing cattle herd to pollute all available rivers and streams out of desperation to drink water adequately
Climate variability	Variation in climatic conditions is observable	Inconsistent yearly weather	Irregular rainfall, inconsistent (warm/cold) weather, excessive heat unpredictable rainfall patterns	Crop destruction and infestation of worms (especially maize). Scorching of crops; increased production cost and low yield. Wilting and or lodging of crop. Crop diversification. Livelihood diversification into non-farm activities (in some cases)

Diversification of farm production/ sources of livelihoods

Part of these adaptation strategies among rural farming households is diversification of farm production/sources of livelihoods into off and non-farm income generating activities (Figures 4 and 5), in order to generate additional income to meet their families' needs such as food, children education as well as other social responsibilities.

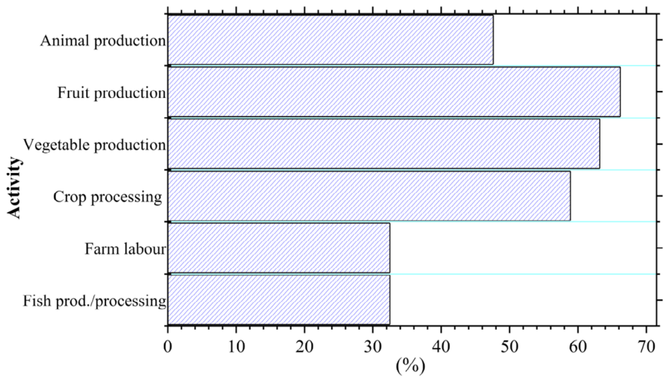

Figure 4: *Off-farm activities engaged in by farmers.*

Figure 4 shows the distribution of off-farm activities engaged in by farmers in the study area. Most (66.0%) farmers engaged in other off-farm revenue-generating activities. These range from seasonal vegetable production during the off-season (66.0%) especially in lowland areas, production of fruits (64.0%), and livestock (46.0%). Others include subscribing to paid labour services (32.5%) for other farmers or engagement in fishery production/processing (32.5%).

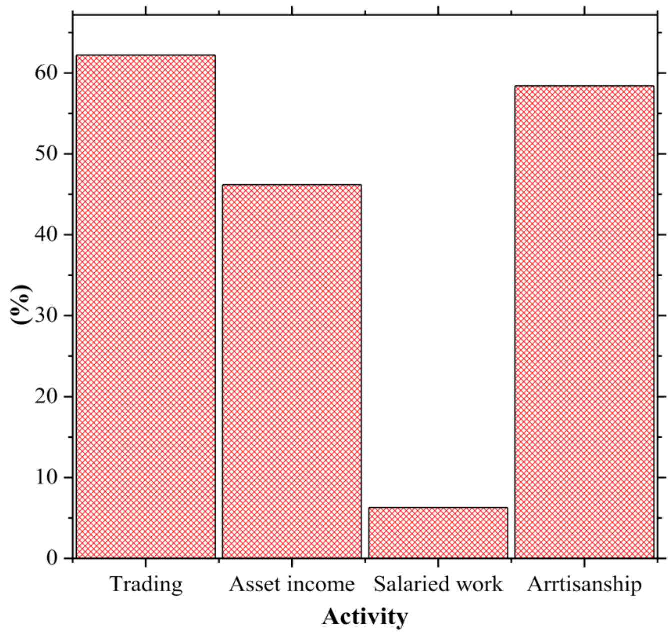

Figure 5: *Non-Farm activities by farmers.*

Farmers also reported their engagement in non-farm production activities in order to reduce the risk imposed on them as a result of climate variability (Figure 5). Also, 46.2% of the farmers were engaged in asset rental (for example, rent of baskets, local storage structures, etc.) to get additional income. Other non-farm income-generating activities include engagement in salaried jobs (6.3%) and artisanship or blue collar jobs (78.4%), which include clothes sewing, hairdressing, transportation business (especially riding of motor cycle 'Okada' for commercial purposes),

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phone charging (at costs) at the local market, production of baskets, clay pots, bead making, etc. Generally, participation in off-farm and non-farm activities generated additional income to farmers in the study area and assisted them during times of poor crop performance and crop failure, brought about by climate variability.

Conclusions and Recommendations

This study assessed climate variability, its perception, and adaptation strategies by smallholder farmers in the rain forest and derived savannah agro-ecological zones of Nigeria. The study provided evidence of variability in climatic conditions ranging from wet to dry years and periods of high and low temperatures. Farmers however, perceived climatic variability from the perspectives of rainfall irregularity, intensity, and adequacy as well as temperature variability among others. Farmers' perception of climate variability conforms to climatological analysis of data reported by this study.

Climatic variability has no doubt left farmers to explore some on-farm adaptation strategies such as increase in vegetable production, livestock production and engagement as labourers in other activities. The State governments (of Kwara and Ogun) should reintroduce the highly adaptable and high yielding TMS 30572 (an improved cassava variety) to farmers given its inherent capability to withstand extreme weather conditions, cassava mosaic virus disease and long gestation period. Furthermore, lessons of farmers' perception of climate variability and their perceived effects of the variability are therefore, critical for putting in place State governments' policies that reduce farmers' vulnerability, and provide support infrastructure to improve farmers' adaptive capabilities, in order to improve their livelihoods.

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Novelty Statement

This study is the first of its kind that compared farmers' perception of climate variability with analysed climatological data (rainfall and temperature) spanning 59 years, for the study area. The study also recorded the perceived effects of climate variability.

Author's Contribution

The lead author conceived, designed, collected field-level data, and wrote the initial draft. Dr. Johnston and Prof. Dasgupta were the appointed Supervisor and Specialist Advisor (respectively) by the sponsors of the Fellowship, tenable at the University of Cape Town. They both read and did the critique of the manuscript at every stage of the work in order to improve it. Dr. Olujimi was the lead author's in-country Mentor (for the Fellowship) and, he refined the initial design of this study. Dr. Akerele analysed and interpreted the study data collected.

Conflict of interest

The authors have declared no conflict of interest.

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