Original Research Article

Strategic Assessment of Climate Change Impact on Production of Some Selected Crops: Evidence from 2021 Cropping Season in Katsina State Nigeria

ABSTRACT

Aims: The purpose of this paper is to assess the impact of climate change on crop production in the state in the year 2021.
Study design: Cross-sectional survey design
Place and Duration of Study: Katsina state Agricultural and Rural Development Authority, under the ministry of agriculture and Natural Resources, between October 2021 and March 2022.
Methodology: A multi-stage sampling technique was employed. The first stage involved classifying the state into three ecological zones. The second stage comprises random selection of three villages from each 34 LGAs to give (102 villages). The third stage accomplished, based on the lists of farmers (26,589) frame, obtained from Katsina State Agricultural and Rural Development Authority (KTARDA), twelve thousand (12,000) farmers were selected proportionately for the study, using systematic random sampling technique.
Results: The results indicated that male and youthful age dominate production respectively (78%) (54). While, more than three-quarter (95%) fall within formal to post primary education and also, more than two-third (69) had no extension contact and majority (35%) obtained income from 300,001-450,000. The findings on impact of climate change on crop production showed that (648.3 hectares) cultivated land and (633.95 tons) of crops were lost. The analysis further unveiled that among the three ecological zones of the state, Sahel Savannah had the most devastating effect of losses, at both cultivated land (292.2 hectares) and crop yield (267.1 tons). More so, the result portrayed that amongst the assorted crops produced in the area, millet, groundnut, cowpea, and sorghum were the major crops hindered by climate change scourge
Conclusion: Climate change is real and its manifestations are becoming alarming progressively, hence urgent steps need to be taken to avert the menace. It is recommended that farmers be educated on climate change aspects in respect to crop production and research station should develop more seeds adaptable to a given circumstances. Government should ensure accurate estimation of climate to facilitate other stake holders' early preparation.

Keywords: Climate change; Crop production; Impact.

1. INTRODUCTION

The current pattern of climate change is an important concern for many socio-economic and climate-sensitive sectors such as agriculture and food production that documented approximately about 1.2–1.5 billion hectares of global land area are under crop production (1). Similarly, agriculture is largely dependent on climate and therefore, climate change has caused a shortage and instability in food supply, with manifestation of severe competition for limited resources, even between man and crop (2). Agriculture is an industry highly sensitive to climate change (3). This concurred with a vast literature on crop production that

documented a negative impact of climate change on crop outputs and apparent threat to food security (4, 5).

Climate change impacts on food sufficiency and livelihoods thereby frightening and touching millions of smallholder farmers in sub-Saharan Africa (6). With frequency and gravity of droughts, excessive heat and over reliance on rain fed agriculture, there is a mounting crisis in agricultural productivity, declining food availability of the households and the danger posed by countries whose prospect of national economies are dependent on agriculture (7). Nigeria is one of the nations that is confronted by the impact of climate change. Scholars like (8, 9) discovered that uncertainty of rainfall distributions and variation, excessive heat stress and drought can unfavourably affect food production and result in food scarcities. Whereas states in the north are highly susceptible to climate change that became a menace to food security (10). In the same note, (11) postulated that irregular and unpredictable rains were amongst the major features of climate change manifestation bedevilling the north, causing serious crops failures.

Evidently, Katsina state is not exempted from the climate change effects, being in an area situated within semi-Arid to Sahel in the extreme north-western part of Nigeria. The area is characterized with desertification, drought, and scanty rainfall (12). Recent climate change emergence was witnessed in the year 2021 cropping season. The Seasonal Climate Prediction (SCP), released by Nigeria Meteorological Agency (NIMET) projected an annual rainfall commencement from 7^{th}–28^{th} June 2021 and was estimated to cover the length of 108 to 146 days (5 months) (13). However, a general dry spell of 3-4 weeks was experienced from June and July, which resulted to farmers' substantial crops losses that necessitated for replanting thereby reducing both production and productivity due to late planting (14).

Previous studies on the phenomenon in Katsina state were found in the works of; (15) who examined maize producers' cultural practices exacerbating climate change, also, (16) evaluated the perspectives of farming communities on impact of desertification and climate change on woody vegetation. Whereas, (17) assessed climate change awareness and risk perception among rural people and in addition, (18) analyzed people's perception of the changing climate and human influence. In another perspective, (19) determined awareness of climate change and its dangers among local farmers. On the other hand, (20) surveyed the implications of climate change for rural resource elements. However, none of these studies has attempted to investigate the impact of climate change on crop production, this study is therefore the first empirical study that covers the whole state. The following are the objectives of the study:

1. Describe the socioeconomic characteristics of the respondents
2. Evaluate the effects of climate change of crop performance in the area
3. Identify ecological zone majorly affected by climate change
4. Determine which crops is most highly affected

2. MATERIAL AND METHODS

The research was conducted in Katsina state that has 34 Local Government Areas (LGAs) and is divided into three ecological zones. The area is situated between latitude 12°15'00" and 12°25'00" N and longitude 7°30'00" and 7°500"00" E of the Greenwich meridian. Based on climatic features, its characterized by hot semi-arid, having high temperature usually all year round with the highest values from the months of January to May being within 43°C to 56°C and the lowest values from the months of June to September about 12°C and again

rises from the months of November and December being 63°C to 125°C. The annual rain fall is usually about 50-150 cm. The vegetation is the Sudan Semi-Arid enriched with varieties of grasslands, Shrubs, trees, and the spare drought resistant trees (21).

This research adopted a cross-sectional survey design and the data for this study were produced via questionnaire administration to the respondents. A multi-stage sampling technique was employed. The first stage involved classifying the state into three ecological zones. The second stage comprises random selection of three villages from each 34 LGAs to give (102 villages). The third stage accomplished, based on the lists of farmers (26,589) frame, obtained from Katsina State Agricultural and Rural Development Authority (KTARDA), twelve thousand (12,000) farmers were selected proportionately for the study, using systematic random sampling technique.

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Respondents

Table 1 presents a summary of the respondents' socio-economic, and it shows that majority of the respondents (78%) were males, while female counter parts constituted only (22%). Thus, infers that male dominate production. In terms of age distribution, respondents' have between 20 to above 50 years, and the table shows that majority (54%) are in productive ages within 31-40, considered to be agile and ready to take risks in adoption of technology, and only 16% are within the age group of above 50 years. The result on education background indicated low level of literacy, only (5%) of the respondents had tertiary education, whereas, the greatest majority (95%) fall within non-formal, primary, and secondary education respectively, which is grossly inadequate to be conversant with the technical aspects of the technology. Additionally, the findings on contact with extension agents reveals that (31%) had contact with extension agents and more than two-third (69%) had no communications with the change agents, which posed serious challenge towards ameliorating climate change scourge in the face of attaining food security. Consequently, Table 1 further portrays the estimated annual income of the respondents (in Nigerian Naira). Majority (35%) estimated their annual incomes from 300.001-450.000, followed by (31%) above 450.001 and (20%) put it at 150.001-300.000, and lastly (14%) estimated their income to less than 150.000.

Table 1: Socio-economic characteristics of the respondents

Characteristics	Variables	Frequency	Percentage
Sex	Male	9360	78
	Female	2640	22
	Total	**12000**	**100**
Age	20-30	1200	10
	31-40	6480	54
	41-50	2400	20
	> 50	1920	16
	Total	**12000**	**100**
Education	No formal education	3120	26
	Primary	4560	38
	Secondary	3720	31
	Tertiary	600	05

	Total	**12000**	**100**
Extension contacts	Yes	3720	31
	No	8280	69
	Total	**12000**	**100**
Income	< #150.000	1680	14
	150.001-300.000	2400	20
	300.001-450.000	4200	35
	>450.001	3720	31
	Total	**12000**	**100**

Source: KTARDA Field survey 2021

3.2: Impact of Climate Change of some selected Crops in 2021 Cropping Season in 34 Local Government Areas

Result of the findings according to KTARDA revealed that seasonal data collected from NIMET on the state's 2021 annual rainfall commences from 7th–28th June, starting from the southern part towards the northern axis. However, 3-4 weeks short of rainfall was recorded at the peak of recommended planting date of the major crops usually mid-June to mid-July, which drastically hinders crop performances due to insufficiency of moisture that resulted to crop mortality in high magnitude, and sequel to this, farmers' have to replant their crops in late-July that was considered as late planting. Further manifestation of climate change emanates via early cessation of rains in the second week of September in most parts of the state, against the predicted time from 10th–27th October 2021, and this monumentally contribute to greater crop failure such as Sorghum, Millet, Cowpea (late maturing), Rice, Soybeans, groundnut, and Maize. Table 2 documented that 648.3 cultivated hectares were lost and recorded a loss of assorted food to the tune of 633.95 tons, due to climate change scourge. This corroborates with Ray et (22, 23, 24) Consistence to this, (25) postulated that these altered climate change conditions have led to regional average yield reductions of 10–20% for millet and 5–15% for sorghum in the two-crop model study. Additionally, we discovered an average annual production loss across West Africa in 2000–2009 associated with historical climate change, relative to a non-warming counterfactual condition (that is, pre-industrial climate), accounted for 2.33–4.02 billion USD for millet and 0.73–2.17 billion USD for sorghum

Table 2: Impact of Climate Change of some selected Crops in 2021 Cropping Season in 34 Local Government

CLIMATE CHANGE IMPACT ON 2021 WET SEASON AGRICULTURAL PRODUCTION OF SOME SELECTED MAJOR CROPS IN LOCAL GOVERNMENT AREAS, KATSINA STATE																
LGA	**Sorghum**		**Millet**		**Cowpea**		**Rice**		**Soy-beans**		**Maize**		**Groundnuts**		**TOTAL**	
	Area Affected ('000 ha)	**Crop Loss ('000 Mt.)**	**Area Affected ('000 ha)**	**Crop Loss ('000 Mt.)**	**Area Affected ('000 ha)**	**Crop Loss ('000 Mt.)**	**Area Affected ('000 ha)**	**Crop Loss ('000 Mt.)**	**Area Affected ('000 ha)**	**Crop Loss ('000 Mt.)**	**Area Affected ('000 ha)**	**Crop Loss ('000 Mt.)**	**Area Affected ('000 ha)**	**Crop Loss ('000 Mt.)**	**Area Affected ('000 ha)**	**Crop Loss ('000 Mt.)**
1. Batagarawa	10	75	5	4	3	1.1	0	0	0	0	5	7	2.1	1.1	25.1	88.2
2. Bakori	0	0	0	0	0	0	10	12.5	5	6	10	12	0	0.8	25	31.3
3. Baure	0	0	10	7.5	3	1	0	0	0	0	0	0	2.1	0.6	15.1	9.1
4. Batsari	5	3.7	5	3	0	0	3	3.7	0	0	3	4	2.5	1.3	18.5	15.7
5. Bindawa	5	4	5	2.3	3	1.2	1	1.2	0	0	0	0	2	1	16	9.7
6. Charanchi	0	0	0	0	4	1.8	0	0	0	0	2	2.8	0.9	0.9	6.9	5.5
7. Daura	0	0	10	*7.5*	4	*1.5*	0	0	0	0	0	0	0	1	14	10
8. Dutsinma	3	2.8	0	0	1.5	1	2	1.5	10	*12*	5	*6*	*0*	0.8	21.5	24.1
9. Danmusa	2	2	0	0	1.5	1	2	1.5	10	*12*	5	*6.5*	*0*	1.1	20.5	24.1
10. Danja	0	0	0	0	0	0	7	*8.6*	0	0	10	*11.5*	*0*	1.1	17	21.2
11. Dand	0	0	0	0	0	0	10	*8.5*	0	0	5	*6*	*0*	0.9	15	15.4

ume																
12. Dutsi	5	*3.2*	5	*3*	3	*1.8*	0	0	0	0	5	*7.5*	*2.2*	0.9	20.2	16.4
13. Faskari	0	0	0	0	0	0	5	*6*	0	0	5	*5.4*	*0*	0.6	10	12
14. Funtua	0	0	0	0	0	0	5	*5.8*	0	0	0	0	0	0.5	5	6.3
15. Ingawa	5	2.8	1.5	1.2	1.5	1	0	0	0	0	5	*7.5*	*1.9*	0.7	14.9	13.2
16. Jibia	0	0	5	*2*	4	1.5	0	0	0	0	0	0	2.5	0.6	11.5	4.1
17. Katsina	5	*3.8*	10	*4*	5	*2*	0	0	0	0	3	*4*	*2*	1.1	25	14.9
18. Kaita	10	*7*	15	*12*	10	*6*	0	0	0	0	5	*6.5*	*3.1*	0.9	43.1	32.4
19. Kurfi	4	2.8	0	0	0	0	1	1	1	0.6	2	*2.8*	*1.9*	1	9.9	8.2
20. Kankia	10	*7.1*	2	1	3	*1.2*	2	1	16	*16*	10	*12*	*2.5*	1	45.5	39.3
21. Kankara	0	0	0	0	2	1	5	*6.2*	10	*12*	0	0	0	1.3	17	20.5
22. Kafur	0	0	0	0	2	1	15	*15*	0	0	5	7	0	0.5	22	23.5
23. Kusada	10	*7.5*	1	0.8	3	*1.2*	0	0	0	0	5	*8*	*2*	1.3	21	18.8
24. Mashi	5	*3*	10	*8*	3	*1.5*	0	0	0	0	0	0	2	1.3	20	13.8
25. Mani	10	*7.5*	5	*4*	3	*1.2*	0	0	0	0	2	*2.8*	*1.8*	0.9	21.8	16.4
26. Mai'adua	0	0	10	*4.8*	2	1	0	0	0	0	0	0	1.2	0.7	13.2	6.5
27. Musawa	5	*3*	0	0	2	1	3	3.5	17	*20*	3	*3.7*	*0.5*	1.2	30.5	32.4
28. Matazu	5	*3.3*	0	0	2	1	3	3.5	17	*20*	3	*3.8*	*0.5*	0.7	30.5	32.3
29. Malumfashi	1	0.75	0	0	1	0.5	10	*8*	5	*6*	2	2.5	0	1.2	19	18.95
30. Rimi	3	*2*	5	*4*	5	*2.5*	0	0	0	0	3	*3.2*	*1.9*	0.8	17.9	12.5

31. Sandamu	4	*2.5*	5	*4*	5	*2*	0	0	0	0	0	0	1.2	1.1	15.2	9.6
32. Sabuwa	0	0	0	0	0	0	10	*7.8*	0	0	0	0	0	0.9	10	8.7
33. Safana	4	3.1	0	0	3	1.2	2	1	1	0.5	4	*4.6*	*0.9*	0.7	14.9	11.1
34. Zango	3	*2*	5	*3*	5	*2*	0	0	0	0	0	0	2.6	0.8	15.6	7.8
TOTAL	**114**	**148.85**	**114.5**	**76.1**	**84.5**	**39.2**	**96**	**96.3**	**92**	**105.1**	**107**	**137.1**	**40.3**	**31.3**	**648.3**	**633.95**
Production/Ha		*1.5*		*2*		*0.75*		*2.5*		*2*		*2*		*0.8*	1.65	
% Loss		***87***		***33***		***62***		***40***		***57***		***64***		***97***		***59***

Source: Field survey 2021

3.3: The Effects of Climate Change on the Agro-ecological Zones in Katsina State, Nigeria.

Generally, climate change has differing effects on a particular place, and is influenced by agro-ecological variability in terms of rainfall distribution, vegetation cover and other natural endowments bestowed to each area within the domain. Katsina state is divided into three Agro-ecological zones namely, Zone (1) Ajiwa, which situated in the Sahel Savannah. While Zone (2) Dutsinma is in Sudan Savannah and Funtua zone (3), falls under Northern Guinea Savannah. The rainfall pattern and distribution indicates that rains begin from zone 3 and by and large has the highest intensity, preceded by zone 2, then to the least zone 1, which is more prone to climate change catastrophe due to drought and desertification nature of the areas (26)**.** The result of the research in Table 3 on comparisons of the ecological zone majorly affected by climate change revealed that Sahel Savannah suffers most, in terms of area under cultivation (292.2 hectares) and yield (267.1 tons). Affirmatively, soil type, climatic and vegetation characteristics of the area favoured the actualization of climate change. The finding concurred with (27) pointed that climate change remains the main factor that threatens the livelihoods of rural farming families in the Sahel region of West Africa. In the same context, (28) noted that climate change and variability considerably hinders crop production, particularly in the Sahel drought-prone areas, where farmers relied solely on rainfall that is scanty and unreliable.

Table 3: The Effects of Climate Change on the Agro-ecological zones in Katsina State, Nigeria.

SN	Agro Ecological Zone	Local Government Area	Area Affected ('000 ha)	Crop Lost ('000 Mt.)
	Ajiwa Zone (1)			
1		Katsina	25.0	14.9
2		Batagarawa	25.1	88.2

3		Rimi	17.9	12.5
4		Kaita	43.1	32.4
5		Batsari	18.5	15.7
6		Mashi	20.0	13.8
7		Jibia	11.5	4.1
8		Mani	21.8	16.4
9		Bindawa	16.0	9.7
10		Dutsi	20.2	16.4
11		Daura	14.0	10.0
12		Baure	15.1	9.1
13		Zango	15.6	7.8
14		Sandamu	15.2	9.6
15		Maiaduwa	13.2	6.5
		Total		**292.2**
267.1				
	Dutsinma Zone (2)			
1		Safana	14.9	11.1
2		Danmusa	20.5	24.1
3		Musawa	30.5	32.4
4		Matazu	30.5	32.3
5		Dutsinma	21.5	24.1
6		Kurfi	9.9	8.2
7		Kankia	45.5	39.3
8		Kusada	21.0	18.8
9		Charanchi	6.9	5.5
10		Ingawa	14.9	13.2
		Total		**216.1**
209				
	Funtua Zone (3)			
1		Sabuwa	10	8.7
2		Dandume	15	15.4
3		Funtua	5	6.3
4		Faskari	10	12.0
5		Danja	17	21.2
6		Bakori	25	31.3
7		Kankara	17	20.5
8		Malumfashi	19	18.95
9		Kafur	22	23.5
		Total	**140**	**157.85**

Source: Field survey 2021

3.4: Most Affected Crops by Climate Change

Conducive climatic conditions and soil fertility enabled different crops to thrive within various ecological entities, which facilitates cereals and legumes production in commercial quantities across the state. The findings of the study in Table 4 revealed that the crops affected generally by the early cessation of the rain included sorghum, millet, cowpea (late maturing), rice, soybeans, and maize. Whereas variations of loses exist within the zones, as in the case

of Northern Guinea Savannah (maize and rice) were least affected and being the large potential production area. On the other hand, in both Sudan and Sahel Savannahs crops such as sorghum, millet, cowpea, rice, soybean, groundnut and maize were mostly affected. The findings of the study further indicated that 60% of farmers across the 34 LGAs experienced one loss of crop or the other, ranging from 50–100%. Accordingly, result of the analysis in Table 4 assert that millet, groundnut, cowpea, and sorghum were amongst the top major crops affected higher losses, all of which are majorly produced in the Sahel savannah agro-ecological zone. Further result of the analysis buttressed that 20% of the farmers had 100% crop lost, mostly (millet and sorghum) in Daura, Kaita, Mashi, Dutsi and Jibia LGAs, domicile at Sahel zone, while others recorded losses from 40% to 90% of their crops.

Table 4: Most affected Crops by Climate Change

Crops	Area Cultivated (Ha)	Area Affected (Ha)	Crop Loss (Mt.)
1. Sorghum	190,250	114,000	148,850
2. Millet	190,800	114,500	761,000
3. Cowpea	140,833	84,500	200,000
4. Rice	160,925	96,000	92,000
5. Soybean	153,750	92,000	105,100
6. Maize	178,650	107,000	137,100
7. Groundnut	67,166	40,300	310,000
TOTAL	**1,082,374**	**572,300**	**1,754,050**

Source: Field survey 2021

4. CONCLUSION

This study assessed climate change impact on crop production in respect to 2021 cropping season in Katsina State. The study described the socioeconomic factors of the farming families and established monumental losses caused by climate change based on cultivated hectares and crops in tons. It further unveils the ecological zone that had the most devastating effect, and crops that were majorly hindered. Hence, climate change has become a foremost threat especially to the rural dwellers that relied on agriculture as the main sources of their livelihoods. Thus, urgent steps need to be taken to avoid forced migration and its attendant menaces of criminal activities, starvation and malnutrition that emanate from food insecurity. The study provides additional inferences to the policymakers, individuals, and non-governmental organizations in charge of agriculture and climate change proficiencies with adequate knowledge for policy sustainable, mitigation and adaptation strategies against future climate recurrences. The study recommended that:

- The State Government should endeavour to complete the ongoing project on Sustainable Platform for Agriculture (KASPA), this will provide the vehicle for agricultural information to and from farmers using modern and mobile technologies that will ensure seamless agricultural production and food system operations.
- There is need for integration of Automatic Weather Stations (AWS) into NIMET system that allows for more detailed climate prediction down to district or ward levels, which will ensure climate resilient agricultural practices that will drastically reduce production loss.

- The Government extension system should intensify climate resilient agricultural practices via constant capacity building training of extension agents for effective delivery of information to the farmers in that respect.
- To cushion the effect of food unavailability, the state government should purchase at least 30% percent of annual crop production and keep in their stores. This will serve as food supply in emergency as well use in stabilizing the market food prices in times of rising cost beyond the average of the farming families' income.
- The Government should further reinforce the synergy with research institutes to provide seed varieties that are early maturing, resistant and adaptable to varied ecological zones.
- The production of crop and or area specific fertilizer should be encouraged, and appropriate fertilizer application methods should introduce to reduce cost of production as well as soil fertility enhancement.
- Farmers' need to be educated by the extension agents on the need to abide with recommended practices in climate resilience agronomic practices and other mitigation means of curtailing the danger posed by climate change.

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