

CLIMATE CHANGE AND AGRARIAN RESILIENCE: AN INDEX BASED APPROACH TO RANKING CLIMATE RISKS AND RELATED HAZARDS IN SELECTED COMMUNITIES OF PLATEAU STATE

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Abstract

Climate change is increasing the risk of hazards leading to not only extreme weather events but also slow onsets of temperature variations, shifts in precipitation, and changes in other features of the climate system. Climate risks have significant implications for agrarian livelihoods, food security and national development. Understanding the nature of climate risk is vital for informed decisions on risk management. This study utilized the index-based approach to rank climate risk in three communities of Shendam Riyom, and Mangu in Plateau State. Using a mixed methods sequential design with first semi-structured interviews followed by survey questionnaires, data on climate risks and related hazards was collected from 22 key informants alongside 229 questionnaires administered to farmers who provided information on the experiences of climate risk events within their environment. Content analysis was used to analyse information elicited from the semi-structured interviews whilst descriptive statistics of ranking used to ascertain the climate risk index computing the frequency of occurrence against the magnitude of impact of climate hazard events in the communities. Findings reveal that flood (0.81), Changing rainfall pattern (0.41), and water shortages (0.36) ranked the highest. The study further showed that seasonal experiences varied as drier conditions of stream-flow changes, warmer temperatures, less rain days and late onset of rains were dry season related risks. While heavier rains and destructive winds are high risk events of the wet season. Also, community experiences differed across the three selected locations, also. The study recommends a development of comprehensive climate risk assessments and mapping in order to improve the preparedness and contingency plans for climate change.

Keywords: *Climate change, Risk Index, Hazards, and Agrarian communities*

INTRODUCTION

Risk is the chance that a hazard event with negative consequences will occur. Hazard is defined as the potential occurrence of a natural or human induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (Smith, Fearnley, Dixon, Bird, & Kelman, 2023). A hazard remains potential until exposed to a vulnerable victim or system. Based on its origin, a hazard can be classified into natural or anthropogenic types (Chaudhary & Piracha, 2021). Natural hazards can be classified into discrete (perturbations) and continuous hazards (stressors) (Turner et al., 2003). Cutter et al.,(2014) refers to these as sudden onset and slow onset hazard events respectively. Sudden onset hazards, such as floods and earthquakes, are events that happen rapidly but last a short time while slow hazards, such as droughts or sea level rises are very slow events that are hardly noticeable to the community.

Although they differ, hazards and disasters are often used interchangeably in literature. Hazards,

particularly natural hazards, are regarded as the dynamic processes of the environment (De Angeli, Malamud, Rossi, Taylor, Trasforini, & Rudari, 2022). They can emanate from the interactive nature of natural and human systems; however, when it leads to the loss of life and property it is then considered a disaster. Hence, to lessen the chances of the occurrence of a disaster, it is necessary to reduce the exposure and vulnerability to hazards (The United Nations Office for Disaster Risk Reduction, 2012). Both natural and man-made hazards are increasing globally which highlights the need for research to understand the interplay between natural and human systems.

Climate Change Hazards

Climate change refers to changes in average weather conditions that persist over a period of time. The IPCC likens climate change to any identifiable change in the average weather conditions over a period of time, either due to natural variability or as a result of human activity (Jones, Abatzoglou, Veraverbeke, Andela, Lasslop, Forkel, & Le Quéré, 2022). These changes include temperature variations, shifts in precipitation, changing risks of certain types of severe weather events, and changes in other

features of a climate system (Choffnes, Hamburg, Relman, & Mack, 2008). Stern and Kaufmann (2014) identified the natural causes of climate change as including orbital changes, volcanic eruptions, variation in solar radiation, movement in crystal plates and ocean currents, while the anthropogenic causes include, among others, deforestation, fossil fuels, urbanisation, and the increased emission of CO₂. Temperature and rainfall are critical climate elements determining weather conditions. Climate changes, evidenced by a shift in average weather patterns, contributes to wide climate variations and increase the chances of natural hazards. Mahdjoubi et al. (2017) stated that climate change is not a new occurrence but that recent evidence shows rapid and compelling changes.

Risk is the chance that a hazard event with negative consequences will occur. Climate change will increase the risk of hazard events leading to extreme events, such as floods and droughts. These are already becoming more frequent globally with adverse impacts on poorer or developing regions (Hui-Min, Xue-Chun, Xiao-Fan, & Ye, 2021). Climate changes is expected to cause a rise in mean temperatures, an increase in land and sea evaporation rates, and accelerated snowmelt/ glacier retreats (Rounce, Hock, Maussion, Hugonnet, Kochtitzky, Huss, & McNabb, 2023). Similarly, projections have it that regions such as Africa are warming faster than the global average and there is a likelihood of warmer conditions due to an average rise of 3-4°C, drier conditions in the sub-tropical regions and wetter conditions in the tropics (Batibeniz, Hauser, & Seneviratne, 2023). Also, Ainsworth, & Long, (2021) projected an increasing concentration of global CO₂, even though this can be beneficial to increase crops yields in other regions. There is currently clear

changes in extreme events with fewer colder days and more hot days being experienced. Frequent and more serious hazards, such as droughts leading to reductions in available water, are recorded on one side of the extreme while changing rainfall patterns and altered river flows leading to floods emerge on another side (Fotso-Nguemo, Weber, Diedhiou, Chouto, Vondou, Rechid, & Jacob, 2023).

In 2014, FAO also predicted a rise in the intensity of rainfall, particularly in record breaking rains from convectional rainfalls along the tropics, which leads to floods on one hand while on the other hand decreases in rainfall and consequent water shortages triggers droughts in drier regions. Findings reveal that the current decade has been exceptionally warm accompanied by an accumulation of extreme weather; this raises questions as to whether these events are linked to climate change (Lesk, Anderson, Rigden, Coast, Jägermeyr, McDermid, & Konar, 2022). They concluded that rising temperatures, increase in thermally driven moisture and record-breaking rainfall are all linked to climate change. Labeyrie, Renard, Aumeeruddy-Thomas, Benyei, Caillon, Calvet-Mir, & Reyes-García, (2021) identified that threats within systems will be worsened by climate change as long- and medium-term climatic trends and the inherent rising frequency of extreme weather events impact areas differently. Similarly, Birkmann, Jamshed, McMillan, Feldmeyer, Totin, Solecki, & Alegria, (2022) argue that global extremes are on the rise and that the consequences of the interactions between natural events and human vulnerabilities will lead to more changes and so the need for index validation for adaptation planning. The Intergovernmental Panel on Climate Change (2013) provides projections of future climate change, as indicated in Table 1.

Table 1: Likelihood of Climate Change Events in the Early and Late 21st Century

Climate event and trend	Likelihood of global scale changes	
	Early 21 st Century (2016-2035)	Late 21 st Century (2081-2100)
Warmer and/or fewer cold days and nights over most land areas	Likely	Virtually certain
Warmer and/or more frequent hot days and nights over most land areas	Likely	Virtually certain
Warm spells/heat waves. Frequency and/or duration increases over most land areas	Unknown	Very likely
Heavier precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation	Likely over many land areas	Very likely
Increases in intensity and/or increases duration of drought	Low confidence	Likely on a regional to global scale
Increases in intense tropical and cyclone activity	Low confidence	More likely than not
Increases incidence and/or magnitude of extreme high sea level	Likely	Very likely

Source: Intergovernmental Panel on Climate Change, 2013

Future climate change is expected to not only shift the average conditions but also to increase the probability

of extreme events, such as droughts and floods. Natural hazards are potential disasters, and until an

interaction with environmental processes they remain hazards. Future uncertainties will have implications for global economies. However, with appropriate measures in place for climate risk reduction, the potential impacts of disaster events can be minimised in order to guard against the collapse of economies.

MATERIALS AND METHODS

Study Area

This study was conducted in Plateau State, Nigeria, which is divided into three geopolitical zones:

Northern, Central, and Southern zones. These zones served as the natural strata for the selection of case study sites. A multiple case study design was adopted, focusing on three agrarian communities Shendam, Riyom, and Mangu, each located within one of the three geopolitical zones (Figure 1). Specifically, Shendam Local Government Area (LGA) is situated in the Southern Senatorial Zone, Riyom LGA in the Northern Zone, and Mangu LGA in the Central Zone of Plateau State.

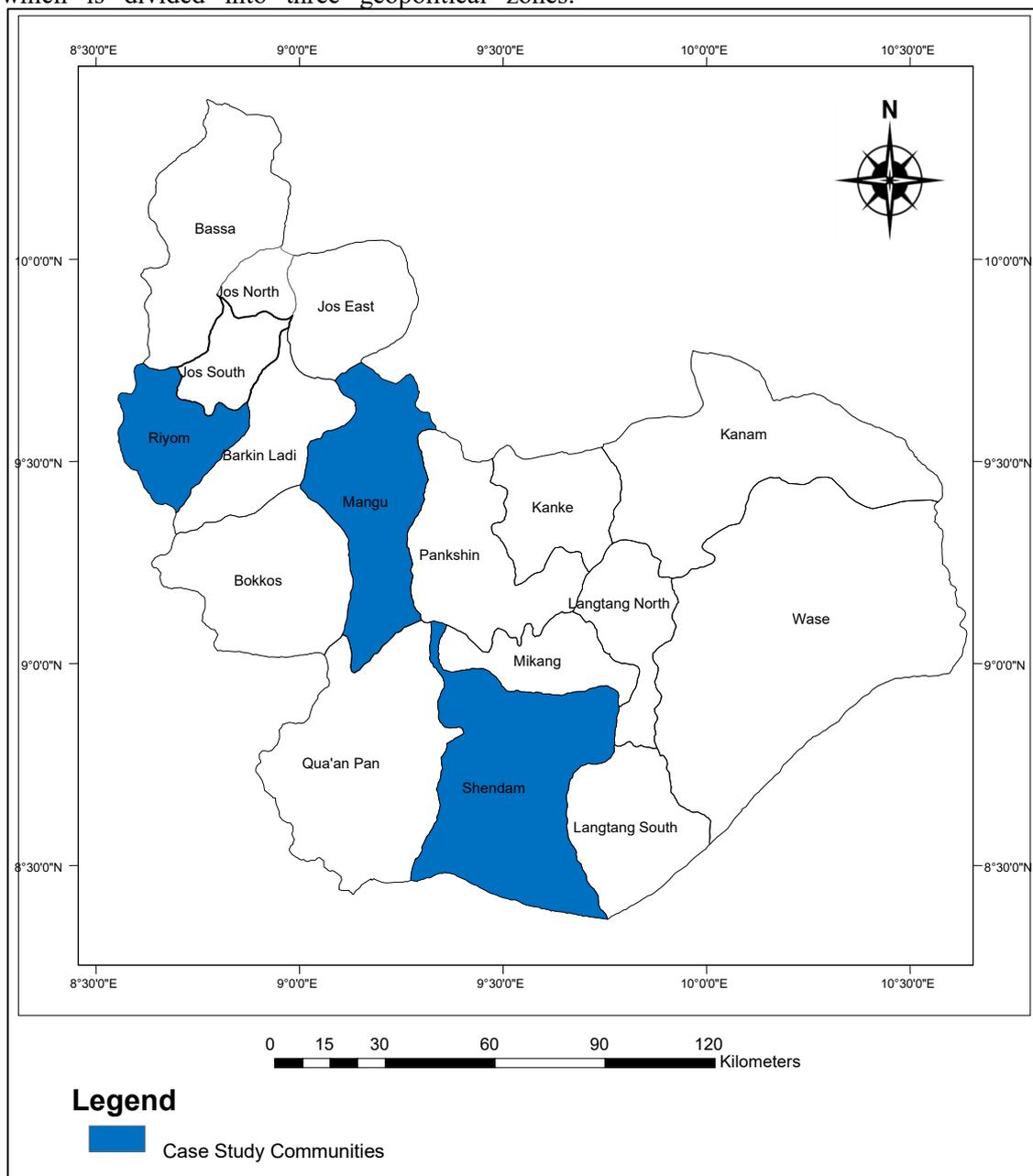


Fig. 1: Riyom, Mangu and Shendam LGAs in Plateau State.

Source: National Center for Remote Sensing Jos, 2023

These regions represent diverse agricultural practices, socio-economic conditions, and infrastructure networks, offering a rich comparative basis for analysis. The communities were purposively selected

based on a combination of criteria, including regional representation, the intensity of agricultural activity, the degree of accessibility, the level of infrastructural development, and the extent to which climate change

has impacted agriculture in these communities. A mixed methods sequential research design was adopted for the study, where qualitative data was first collected through interviews with key informants followed by the collection of quantitative data from questionnaire administered to farmers in selected agrarian communities in Plateau State, Nigeria. It is generally recognised that the management of climate risks and adaptation strategies occurs at community levels except for extreme cases where decisions at higher levels are required. As such, an integrated view from both key informants and farmers was found suitable for risk identification.

Since climate risk results from climate change hazards, which occur either as slow or rapid onset events both classes of event can have devastating effects on the environment, and as such, there is a need to consider both in assessing risk. Included under study are (i) Slow onset hazard events, such as warmer temperatures, changes in rainfall patterns, and longer dry seasons; and (ii) Rapid onset events including, heavier rains, storms, floods, extreme temperatures, and droughts.

Phase 1: Qualitative Data - A total of 22 interviews was conducted across selected study communities. A purposive sampling technique was employed to select the first respondent after which the snowballing technique was employed to recruit subsequent respondents. Interviews were recorded with the consent of participants who willingly agreed to be recruited into the survey. Recorded interviews were transcribed, sorted, coded and subjected to content

analysis. Findings on main themes particularly identified climate risks are counted and tabulated as frequencies, percentages and weighted scores. Participants' narratives are presented as anonymous codes in order to maintain the confidentiality of research participants.

Phase 2: Quantitative Data Collection - A total of 229 copies of a questionnaire was administered using the stratified random sampling technique to farmers in the three selected communities in Plateau State. The questionnaire was carefully designed to capture information about climate risks identification, likelihood of hazard occurrence and the possible level of impacts on agrarian communities. A five-point Likert scale to quantify respondents' opinions on the frequency of risk events, and the impacts of hazard on agrarian communities and livelihoods was utilized. The scale used was ordinal, which helped to rank data in an increasing sequence.

An assessment of the probability of an occurrence suggests how frequently a hazard event is likely to occur in the study location. While the frequency of occurrence was ranked on a scale of 1 to 5 with 1 = never and 5 = always, as presented in Table 2. Similarly, the magnitude of impact scale ranged from 1= No impact to 5= high impact.

RI= Risk Index

$$RI (%) = \frac{FI (%) * SI (%)}{100} \text{ -----(i)}$$

$$FI (%) = \sum a (n/N) * 100/5 \text{ and}$$

$$SI (%) = \sum a (n/N) * 100/5$$

Table 2: Climate risk Index¹

Rank	Probability of Occurrence	Definition	Magnitude of Impact	Risk Index Weighting	Risk Score	Priority Level
1	Never	Hazard event not likely to occur	No impact	0	0	No risk
2	Rarely	Hazard event likely to occur once in every 50 years	Very low impact	0.01 -0.25	1	Very low
3	Sometimes	Hazard event likely to occur at least once in 10 years	Low impact	0.26 - 0.50	2	Low
4	Often	Hazard event likely to occur at least once in every 5 years	Moderate impact	0.51 - 0.75	3	Moderate
5	Always	Hazard event likely to occur at least once every year	High impact	0.76 - 1.0	4	High

Source: Scoring scheme adopted from Garvey (2008); Mell, Scarfone, and Romanosky (2007).

¹ Rating is based on perceived estimates and not in absolute number of years

The climate risk ranking is determined by plotting on a radar chart the frequency of occurrence against magnitude of impact. This established the fact that

high probability of occurrence of a risk event does not necessarily mean a higher magnitude of impact.

Results and Discussion

Phase 1: Climate Risk Analysis from Qualitative data

Findings from key informant interviews reveal that interviewees had relative knowledge of climate hazards and risk of climate change impacts. Interviewees generally acknowledged that climate change was a challenge to current agrarian management strategies. Interviewees in identifying some of the climate related hazards experienced in the area mentioned irregularity in weather patterns of both slow onset changes and rapid onset changes. Slow onset changes such as drier conditions due to several local changes were reported across the area as participants indicated that at least one case of water shortages, reduced stream flow or quick drying of water bodies was a risk to the functioning of agrarian infrastructure such as irrigation facilities in the northern part of the state. An interviewee explained water shortages thus: “... during the dry season, these water sources dry up. We expect that water should be flowing in the streams during the dry season so that it can be channelled for irrigation but because of this issue of climate change and other things, the water dries up immediately because of the harsh impact of global warming. When the water dries up, it limits the activities of irrigated planting” (I₀₇).

Interviewee I₀₃ explained how water shortfalls are leading to agricultural droughts in the area. Indicating that water was becoming increasingly insufficient for irrigation farming as surface water does not last to the end of the dry season. Interviewee further mentioned that there was evident drying of wetlands, saying: “...Areas that were swampy and waterlogged about 20 years ago are now completely dry. Other participants explained instances of total loss of water bodies particularly in shallow depths and changes in water levels, thus: “...unlike the way it was so many years ago, ... the flow of water was very very low during the dry season. ...how climate change is affecting the water levels” (I₁₃) and also, “... we initially envisaged a small stream that would serve the farm but when we started the stream dried up” (I₀₈). Interviewee explained how retreats of stream flow are experienced sometimes 2 months before the usual time that farmers had to dig deep river beds to pump water for irrigation.

Although most respondents did not agree that change in temperature was a challenge, 9% (I₀₂ & I₁₆) participants opined that temperature changes contributed to the dry conditions experienced in the area. Identified changes such as shortfalls in surface and ground water sources is also said to result in agricultural droughts. Although respondents do not consider this as extreme drought, they however opined it affected agricultural productivity in the area.

Interviewees also mentioned that, prolonged dry spells dragging up to 14 days beyond the usual 5-7 days are sometimes experienced in parts of the state. This alongside, late onset of rains and early retreat of rains reduces the number of rainy days as mentioned by I₀₅. A participant, I₀₈, explained that though not constant, demands for the use of irrigation facilities can stretch for 4 weeks or more due to delays in the rainy season.

Interviewees generally observed that changes in rainfall patterns are more conspicuous in recent years. 40% interviewee described the manner of rainfall changes as heavier, unpredictable, and destructive patterns. Findings also show that the first few rains after delayed rains are heavier, destructive and often accompanied by thunder and hail storms (I₀₅). Also mentioned is that, this pattern has progressively increased in the last 10 years. Flooding was identified the greatest climate risk (81%) and destructive storms the least for rapid onset events (13%). Interviewees explained that floods are becoming more frequent particularly along rivers. The increased variability in rainfall patterns often results to the occurrence of floods. Historical records show that though current cumulative annual rainfall is lower, higher amounts of rains are experienced within shorter periods. Hence, a higher probability of floods and surface runoff is expected.

On the other end, late onset of rains and irregular breaks within the rainy season add to the spread of plant epidemics. I₀₂ mentioned that one of the ways local farmers quickly identify changes in rainfall and temperature patterns is the slightest invasion of parasites. Further said is that, rains occasionally cease earlier than expected but interviewee did not consider this a challenge as most crops at this time are at the maturity stage. However, interviewee went ahead to explain that early retreat of rains is an indication that water shortfalls are expected in the following irrigation season.

Weighting Climate Risk

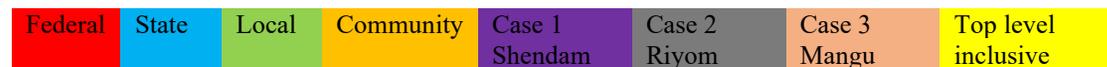
Based on the number of responses on each climate risk identified, percentage scores are assigned to each category to determine the level of risk for each hazard event. Results of variable weighting and ranking is presented on Table . Results show 3 risk levels: High, low and very low risk level. Flooding ranks the highest with score 4 (high risk event), rainfall changes, drier conditions, and incidences of plant diseases score 2 (low risk events), while temperature changes and storms rank 1= very low risk events.

Table 3: Climate Risk and changing patterns²

Indicators of Climate Change/ Changes observed	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total n=22	Percent (%)	Weight	Score		
A) Slow onset changes																												
a) Drier conditions																												
Water shortages, less water in streams, quick drying of water bodies	1	1			1			1	1					1						1	1			8	36.4	0.36	2	
ii) Temperature changes																												
Warmer temperature		1														1								2	9.1	0.09	1	
B) Rapid onset changes																												
i) Rainfall changes																												
Heavier rains, unpredictable, destructive, late onset, irregular breaks				1	1	1		1			1			1	1	1								9	40.9	0.41	2	
ii) Flooding																												
Unusual, destructive, devastating, a lot of cases, greatest problem, more floods.	1		1	1	1	1	1		1		1	1		1	1	1	1	1	1	1	1	1	1	18	81.8	0.82	4	
iii) Destructive storm																												
More destructive floods				1			1		1															3	13.6	0.14	1	
iv) Plant epidemics																												
Incidences of plant diseases driven by changes in temperature and rainfall	1	1		1	1		1	1	1															10	45.5	0.46	2	

Source: Authors' Analysis

²



Phase 2: Quantitative

Fifteen indicators earlier identified from literature alongside findings from qualitative data were rated by respondents to ascertain the frequency of occurrence and magnitude of impact. This informed knowledge on the nature of climate risks experienced and a measure of the probability of event occurring in the selected study communities. Results show the distribution of responses on the fifteen indicators of climate change based on respondents' perceptions. Findings show that respondents generally indicated perceived changes in both dry and wet conditions.

Perceived Changes of Drier Conditions

Respondents were asked to provide information based on their perceptions on local changes suggesting drier than usual conditions. In terms of the frequency of climate risk occurrence, results indicate that for rise in temperature, only 2.6% of respondents opined that there was never a time when temperatures were higher than normal, while 97.4% respondents chose to sometimes (65.1%), or often (27.5%), or always (4.8%). In response to drier periods 6.1% of respondents opined that drier periods never extended beyond the normal, while the remaining 90.4% agree to rarely (4.8%), sometimes (64.2%), often (20.5) and always (5.7%). For evident drying of wetlands, 9.2% of respondents indicated no evidence of wetland drying, while 88.6% indicated there were evidences of drying and 2.2% undecided. Results also shows that all (100%) respondents indicated evidences of stream and river flow on a scale of sometimes (68%), often (25.3%) and always (6.6%). For changes in the number of rainy days, 6.6% respondents are of the opinion that the number of rainy days is normal, while 92.5% indicated various frequencies of changes as rarely (0.9%), sometimes (67.2%), often (20.5%) and always (4.8%). Results of change indicator of prolonged dry spells within the rainy season shows that 12.7% perceived that periods of dry spells follow the usual pattern, while 87.4% indicated that prolongation of dry spells was sometimes (74.7%) or often (12.7%).

Results of the frequency of drought incidences shows that 24% respondents indicated that drought never occur in the area, while the remaining 70.8% revealed that it rarely occurs (5.2%), sometimes occur (60.3%), often occur (6.6%) or always occurred (3.9%). Other changing patterns suggesting drier conditions were the late onset of rains and the early retreat of rains. In response of late onset of rains, 5.7% respondents showed that the rains never delayed, while 94.3% indicated otherwise on

different frequencies. Most respondents (66.8%) specified rains sometimes delayed, 23.6% opined it often delayed and 3.9 agreed that rains always delayed. So also, responses on the early retreat of rains, 5.7% revealed rains never retreated before the expected date, while 91.6% indicated early retreats on frequencies of rarely (2.6%), sometimes (72.9), often (17%) and always (1.7%). Results show that respondents' opinions on drier conditions were centred around the neutral value of sometimes. This is an indication that though there are evidences of local climate changes, these were not extreme cases. However, responses on the magnitude of change impact varied.

Table 4: Percentage distribution of responses for climate risk events

Indicator tested	Frequency of Occurrence (%)						Magnitude of Impact (%)						Mean score		
	Never	Rarely	Sometimes	Often	Always	Total	No impact	Very low	Low	Moderate	High	Total			
Dry conditions	Rise in temperature	2.6	-	65.1	27.5	4.8	97.4	3.3	13.1	0	16.6	38	32.3	86.9	2.9
	Drier periods	6.1	4.8	64.2	18.3	6.6	90.4	3.1	8.3	1.7	27.5	41.5	21	90	2.7
	Drying of wetlands	9.2	2.2	62.4	20.5	5.7	88.6	3.1	17.0	0.9	31.4	37.6	13.1	82.1	2.5
	Reduced stream flow	0	0	68.1	25.3	6.6	100	3.4	6.6	0	32.3	37.1	24	93.4	2.8
	Less rain days	6.6	0.9	67.2	20.5	4.8	92.5	3.2	11.4	0	25.8	34.9	27.9	88.6	2.8
	Prolonged dry spells	12.7	0	74.7	12.7	0	87.4	2.9	11.8	0.9	31.4	32.3	23.6	87.3	2.7
	More droughts	24	5.2	60.3	6.6	3.9	70.8	2.2	22.7	6.1	27.5	20.5	23.1	71.1	2.3
	Late onset of rains	5.7	0	66.8	23.6	3.9	94.3	3.2	8.7	0	26.2	38	27.1	91.3	2.8
	Early rain retreat	5.7	2.6	72.9	17	1.7	91.6	3.1	17.5	0	21.8	32.3	28.4	82.5	2.7
Wet conditions	Heavier rains	0	0	66.0	24	10	100	3.4	0	0	17	35.4	47.6	100	3.3
	Overflowing waters	14.4	3.5	59.4	14.8	7.9	82.1	3.0	11.8	5.2	16.2	38.9	27.9	83	2.7
	Irregular rains	5.2	0	69.4	23.1	2.2	94.7	3.2	9.2	0	27.9	31	31.9	90.8	2.9
	Destructive winds	2.6	0	73.4	16.6	7.4	97.4	3.3	3.9	0.9	20.5	40.2	34.5	95.2	3.0
	Destructive hail	23.6	1.7	64.6	7.4	2.6	74.6	2.6	22.7	0	26.6	26.2	24.5	77.3	2.5
	Plant epidemics	0	2.6	64.6	24.5	8.3	97.4	3.4	0.9	0	14.8	27.1	57.2	99.1	3.4

Perceived Changes in Wet Conditions

Results of analysis show various responses regarding changes in rainfall patterns. Changes include experiences of heavier rains and more incidences of floods, irregular rainfall, wind storms, hailstorms, and incidences of plant diseases. All (100%) respondents indicated that heavier rains were experienced sometimes (66%), often (24%) and always (10%). In terms of the occurrence of floods, 14.4% opined they never experience floods in the area, while the remaining 82.1% opined they experience floods either rarely (3.5%), or sometimes (59.4%), or often (7.9%) or always (7.9%). In identifying the extent of irregular, sporadic and unpredictable rainfall patterns, 5.2% respondents disproved there were such changes, while 94.8% indicated experiences of irregular rainfall was sometimes (69.5%), often (23.1%), and always (2.2%). Irregular and unpredictable rains were also accompanied with destructive winds; however, on the contrary, 2.6% responded that winds were never destructive. But 97.4% indicated that winds were becoming more destructive on a scale of sometimes (73.4%), often (16.6) and

always (7.4%). Apart from destructive winds, sporadic rains were also accompanied with destructive hailstorms as indicated by 74.6% respondents. 1.7% indicated hailstorms were rare occurrences, 64.6% respondents perceived they occurred sometimes, 7.4% reveals they occurred often, and 2.6% opined hail occurrences are always. However, 23.6% are of the opinion that hail never occurred in their area. Changes in rainfall patterns determining either excess dryness or damp conditions add to the incidences of plant diseases. All (100%) respondents agreed that the evidence of plant disease was an indication of local climate changes. 2.6% respondents indicated it was a rare occurrence, 64.6% opined it sometimes occurred, 24.5% said it occurred often and responses of 8.3% showed always. Again, similar to responses on drier conditions, the respondents' opinions concentrate around the neutral value of sometimes which is an indication of moderate occurrences. Furthermore, mean scores of risks frequency and impact are presented in the radar chart in Figure 1.

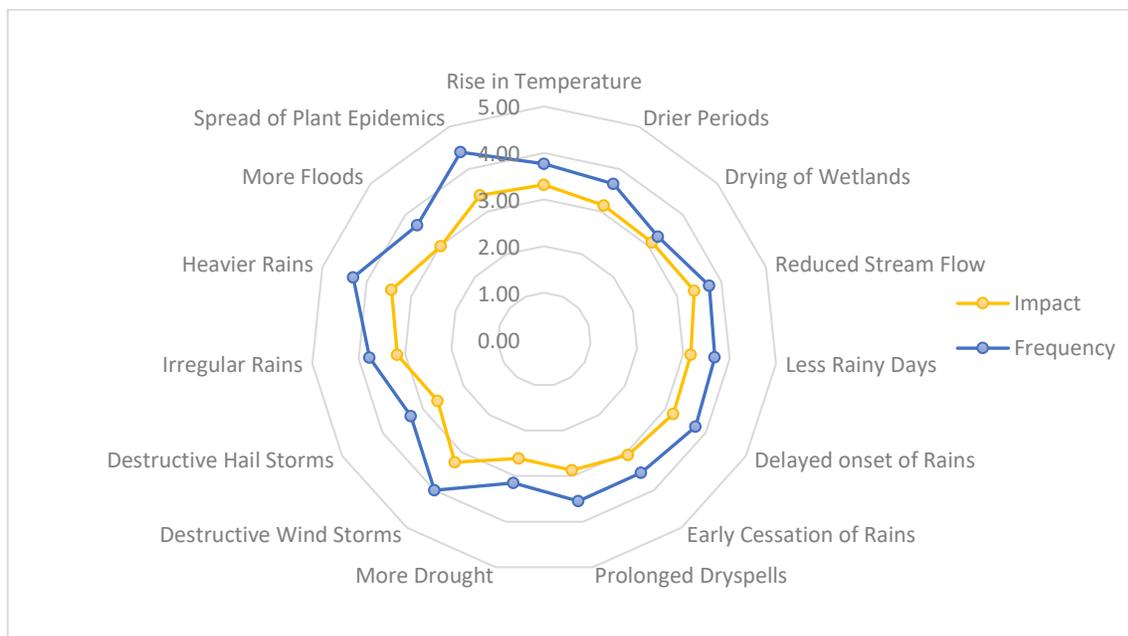


Figure 1: Comparison of climate hazard frequency against their impacts

Source: Authors' Conceptualisation

In general, most respondents agreed not only on varied frequencies of occurrence but also on the magnitude of the change impact. This could be

due to geographical variations of the case study location and the varied climate condition.

Table 5: Distribution of climate risk index according to case study locations³

Rank	Shendam Case 1			Riyom Case 2			Mangu Case 3		
	Indicator	RI (%)	RCS	Indicator	RI (%)	RCS	Indicator	RI (%)	RCS
1	Heavier rains	65.56	4	Plant epidemics	58.14	4	Warmer Temperature	58.94	4
2	Overflowing rivers	65.03		Heavier rains	57.48		Plant epidemics	56.09	
3	Plant epidemics	64.48		Wind storms	57.16		Heavier rains	54.89	
4	Reduced Streamflow	50.22		Late onset of rains	51.56		Overflowing rivers	53.48	
5	Wind storms	48.68	3	Reduced Streamflow	51.32	3	Less Rainy days	51.21	3
6	Irregular rains	46.44		Warmer Temperature	50.88		Drier conditions	49.57	
7	Late onset of rains	43.05		Early retreat of rains	49.28		Irregular rains	49.09	
8	Warmer Temperatures	39.73	2	Less Rainy days	49.23	2	Reduced Streamflow	48.40	2
9	Drier conditions	39.51		Drier conditions	48.28		Wind storms	47.53	
10	Less Rainy days	39.13	2	Irregular rains	47.85	2	Late onset of rains	47.26	2
11	Early retreat of rains	32.94		Hail storm	47.69		Prolonged dry spells	46.32	
12	Prolonged dry spells	31.88		Prolonged dry spells	44.16		Early retreat of rains	46.32	
13	Drying of wetlands	27.03	1	Drying of wetlands	35.76	1	Water shortages	45.49	1
14	Water shortages	21.21		Water shortages	35.49		Hail storm	44.49	
15	Hail storms	12.61		Overflowing rivers	26.95		Drying of wetlands	40.74	

Source: Authors' Analyses

³ RI= Risk Index

$$RI (\%) = \frac{FI (\%) * SI (\%)}{100}$$

$$FI (\%) = \sum a (n/N) * 100/5 \text{ and}$$

$$SI (\%) = \sum a (n/N) * 100/5$$

RCS = Risk category score (ranging from 1=very low, 2= low, 3=moderate, and 4= high)

Results of the climate risk index in Table 5 indicates 4 categories of risks namely, Category 1: low frequency - low magnitude events; Category 2 risks are low frequency – high magnitude events; Category 3 risk events are high frequency – low magnitude events and Category 4: high frequency and high impact events. Results indicate that category 1 risks are found only in case study 1, category 2 risks in case studies 1 and 2; while categories 3 and 4 are present in all the 3 case study locations. Further analysis of individual case study locations shows both similarities and difference in categories of climate risk.

In regard to similarities, findings indicated that heavier rains (4) plant epidemics (4) and irregular rains (3) are categorised on the same scale across the 3 locations. Case studies 1 and 3 share a number of similar risks. Both rank overflowing rivers as category 4 risk, and reduced stream flows, wind storms and late onset of rains as category 3 risks. For similarities between case studies 1 and 2, both rank drier conditions and less rain days as category 3 and drying of wetlands category 2 risk events. For similarities between case studies 2 and 3, both rank warmer temperatures as category 4, early retreat of rains, hail storms and prolonged dry spells as category 3 risk events. This is indicative of the spillover effect of drought and aridity from northern Nigeria towards the north and central parts of the state where case studies 2 and 3 are respectively. Nevertheless, water shortages are considered on varied scales across the 3 locations. This is also indicative of different elevation levels and water table depth. Even though there are similarities in identified climate risk across the 3 case study locations, how these risks drive climate hazards and impacts in the various locations vary.

CONCLUSION

This study utilized the index-based approach to rank climate risk in three communities of Shendam, Riyom, and Mangu in Plateau State so as to understand the order of climate risk for informed decisions on risk management. This study highlights the evidence of multiple climate risks and the increasing trend of related hazard events in the three selected communities of Plateau State. The findings identified floods as a

rapid onset event and rising temperature, changes in rainfall patterns and stream-flow changes as high-risk events. The identification emerged from a combination of expert opinions and community perceptions using a range of risk measures, namely high, moderate, low and very low as demonstrated.

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