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Key dimensions of land users' perceptions of land degradation and sustainable land management in Niger State, Nigeria

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ABSTRACT

Declining land productivity remains a challenge for agriculture-based livelihoods and for achieving food security. Yet identifying how land users perceive land degradation and their capacity to manage land in an environmentally sustainable manner can influence the measures initiated to address it. Using the case of Niger State, Nigeria, this study examines land users' perceptions of land degradation and land management measures to address it in the Nigerian Guinea Savannah. We used the Moderate-resolution Imaging Spectroradiometer derived Normalized Difference Vegetation Index as a proxy for degradation status, selecting 30 communities based on the extent of degraded areas. We adapted the World Overview of Conservation Approaches and Technologies, Sustainable Land Management questionnaires to capture perceptions and administered 225 questionnaires to land users. Through key informant interviews, we collected narrative insights and data on perspectives and motivations of land users to understand land degradation situations and to interpret the questionnaire surveys. We analysed data through descriptive statistics, Principal Component Analysis and qualitative analysis. Our analysis identified four perceptions dimensions of land degradation characteristics, two perceptions dimensions of land degradation drivers, and six perceptions dimensions of sustainable land management. The results also confirmed that degradation in Niger State is both due to widespread unsustainable human activities within Niger state and those by migrant farmers and pastoralism from adjoining Sudan Sahelian states that push people further south, a leakage of ongoing land degradation and conflicts in other areas. To deal with local land degradation in Niger State, improved land tenure, alternative livelihood strategies, poverty eradication and awareness, nature-based sustainable land management practices such as tree-based initiatives, environmentally friendly agriculture such as Farmer Managed Natural Regeneration supported by the necessary political will and institutions are critical.

1. Introduction

Land degradation (LD), the long-term loss of biomass or decline in land productivity (Le et al., 2016; UNCCD, 2015) occurs in several world regions, with differentiated impacts on ecosystems and human well-being (Olsson et al., 2019). In Sub-Saharan Africa (SSA), where many rural population depend largely on agriculture and natural resource use, LD contributes to worsening their livelihood vulnerability (Webb et al., 2017). About 28% of the 924.7 million Africans occupy or own degraded land (Le et al., 2016). LD in the SSA involves the progressive loss of vegetation, the conversion of vegetated land to bare lands or desert-like landscapes, including an increase in sand dunes, which results in the silting, drying, and shrinking of water bodies, such as the Lake Chad in the West African Sahel (FGN Federal Government of Nigeria, 2012; Gadzama, 2017). In West Africa, Nigeria experiences one of the highest rates of LD with biomass decline amounting to about 400,000 ha per year and agricultural productivity losses (FAO Global Forest Resources Assessment 2010: main report, FAO Forestry Paper, 2010). Demand for agricultural land displaces forests or leads to agricultural productivity losses (Arowolo and Deng, 2018), which drives degradation in remote areas (Adenle and Ifejika Speranza, 2020). The management of the country's agroecological zones such as the semi-arid savannah ecosystem and their resources are constrained by land-use change, unsustainable agricultural practices, and poor land governance (CILSS, 2016; Ifejika Speranza et al., 2019).

In addition to socioeconomic constraints, a poor understanding of land users' experiences, inappropriate governance and low attention to sustainable land management (SLM) limits the effectiveness of measures to reduce LD (Adenle and Ifejika Speranza, 2020; Ifejika Speranza et al., 2019). Thus, considering the perceptions of LD by land users and other actors is crucial for implementing effective measures

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(Jendoubi et al., 2020; Mirzabaev, 2016). This is important given that the local context, local responses to multi-level drivers, and associated land-use decisions influence global land change (Lambin et al., 2006; Malek et al., 2019). Although various SLM measures exist (Liniger et al., 2019), their misalignment with land users' experiences hinders their extensive adoption and performance (Mirzabaev, 2016; Pulido and Bocco, 2014). Also, the low priority given to SLM practices and implementation slows the successful tackling of LD through SLM (Nkonya et al., 2016). Though studies have attributed regreening success to approaches that incorporate land users' perspectives and apply appropriate governance arrangements (Mortimore, 2016), there is still a strong need for a people-centred approach that integrates land users' and other relevant actors' perspectives and experiences of LD into SLM measures for more effective outcomes (Jendoubi et al., 2020; Mirzabaev, 2016). Understanding perceptions of LD by multiple actors is thus essential for identifying pathways to SLM and effective governance (Aíza et al., 2021; Herrmann et al., 2020).

This paper examines how local land users in Niger State in the Nigerian Guinea Savannah (NGS) perceive LD and how they rate SLM solutions. With LD affecting 16%–62% of the land, Niger State is representative of LD-affected areas in the NGS (Adenle et al., 2020). Our study aligns with the global interest of integrating people, local knowledge and community experiences in understanding land concerns (Kugler et al., 2019; Mashi and Shuaibu, 2018), and tackling global challenges such as climate change (Badmos et al., 2018), biodiversity management as well as LD (Díaz et al., 2015; Scholes et al., 2018). This is particularly relevant in rural contexts in Nigeria, where degradation threatens and adversely impact people with natural resources dependant livelihoods (Adenle et al., 2020; Ifejika Speranza et al., 2019). Despite the worsening degradation and the urgent need for better governance of land and natural resources (Ifejika Speranza et al., 2019; Macaulay, 2014), the identification of LD mitigation measures based on local experiences has received little attention in Nigeria (Adenle and Ifejika Speranza, 2020). Therefore, understanding perceptions of LD by multiple actors is essential for identifying pathways to SLM and effective governance (Aíza et al., 2021; Herrmann et al., 2020). We however focus on how rural land users in Niger state, a region affected by LD in the NGS, perceive LD, their drivers, and related SLM and governance measures. We addressed the following research questions: (i) What is the spatial extent and status of LD in Niger State? (ii) How do land users characterise and identify indicators of LD in Niger State? (iii) What drivers of LD do they identify in the study area? (iv) How do the land users perceive SLM practices and strategies for minimizing LD? Lastly, (v) what insights can be drawn for SLM and governance in the study area?

2. Materials and methods

2.1. Study area

Niger state is located in west-central Nigeria (the middle-belt). It is the largest of the country's 36 states covering one-tenth of the country's landmass (Fig. 1). Niger state is in the Nigeria Guinea Savannah (NGS) agro-ecological zone, with a mean annual rainfall of 782–1250 mm and a mean annual temperature of about 27 °C (Iloeje, 2001). Trees such as the African locust bean *(Parkia biglobosa)* and Shea butter (*Vitellaria paradoxa*) are widespread in the state.

The River Niger and the River Kaduna flow through the state. Niger state also includes protected areas such as the Foge Islands and the Kainji Lake National Park, and tourist sites such as the Gurara Waterfalls. Administratively, the state comprises 25 Local Government Areas (LGAs) and 3 "Geopolitical Zones" (a category used by the Nigerian government to select political representatives), namely zone A-B-C, with their headquarters in Bida, Kuta and Kontagora, respectively (Alhaji et al., 2018). These three geopolitical zones also correspond to three agro-geographical zones of Niger state with varying climatic conditions and farming methods (Alhaji et al., 2018). The state had an estimated population of about 5550,000 in 2016 -according to National Bureau of Statistics (NBC, 2017), mostly rural dwellers, who engage in farming crops such as yam (Iloeje, 2001). They also keep livestock such as cattle, goats, and sheep for meat production. The population belongs to diverse ethnic groups including the Nupes' who are in the majority, the Gwaris', the Kambaris' and the Bisasan as well as the nomadic Fulani pastoralists.

2.2. Theoretical framework

We understand human-induced LD as an outcome of social-ecological interactions (Batunacun et al., 2019; Nkonya et al., 2016). We adapt Schakelton et al. (2019) conceptual framework of the factors influencing peoples' perceptions to the case of LD (Fig. 2). The authors identified six broad factors influencing LD perceptions which correspond with the boxes and circles in Fig. 2. These factors are:

(a) Individual (e.g., land users') mental processes: As perception is a mental construct that changes over time and space, Shackleton et al. (2019: 7) identify demographic factors, experience, "*knowledge systems, sense of place, social relationships and group membership, and value systems*" as fundamental factors influencing perceptions at the individual level **(Fig. 2f)**. In this study, we chose socio-economic attributes such as age and education.

(b1) Extent of LD in Niger state: The ecosystem of study is the savannah in Niger State and its characteristics include the degree of LD. Degradation can occur in various severity and spatial extent such as in small patches (small-area degradation) or over larger areas-large-area degradation (Adenle and Ifejika Speranza, 2020). Thus, perceptions of degradation might differ depending on the type of LD, its history or duration.

(b2) Effects of LD: With effects, we refer to changes (positive or negative) to the social-ecological system (SES) or its parts due to LD (Shackleton et al., 2019). The social and economic effects of LD have been widely described (Nkonya et al., 2016; von Braun et al., 2013). Ecologically, LD is negatively perceived as it reduces productivity, but perceptions might differ depending on the type and severity of degradation as well as the degree of livelihood dependence on land and the ecosystem services (Crossland et al., 2018; Pulido and Bocco, 2014; Tesfahunegn, 2019).

(c) Socio-cultural context: The socio-cultural context refers to the three geopolitical zones, namely zone A-B-C. Shackleton et al. (2019: 11) describe socio-cultural context as the ways people interact with one another in "*a social realm of rules, traditions, practices and ideas*". The authors differentiate between structural socio-cultural factors such as "*social institutions and rules*" including land tenure systems, land ownership and land management history, "*level of socio-economic development*" such as wealth levels or social value systems including those shaped by media discourses. Further, social structures such as gender, class, ethnicity or race and their intersections, influence how land users respond to LD and how LD affects them (Shackleton et al., 2019). Non-structural socio-cultural factors include social memory, which can change over time.

(d) Landscape context – the NGS: The landscape context is the NGS agro-ecological zone. With this dimension, a focus is on the larger context, that is, the NGS, which covers about 49% of the country's landmass and 25 of its 36 states. In this context, ecosystem type, land use and cover, availability of land for conversion to agriculture, management history are key factors identified to influence perceptions of LD.

(e) Governance, institutional and policy context: This includes "*historical processes, institutional frameworks, international agreements, legislation, regulation and enforcement, policy and governance strategy*" (Shackleton et al., 2019: 7). Policy and governance affect people's perceptions by shaping values and social relationships, and attitudes and behaviours (Shackleton et al., 2019) through land management **(Fig. 2g)** that over time feedback to the social-ecological system of focus.

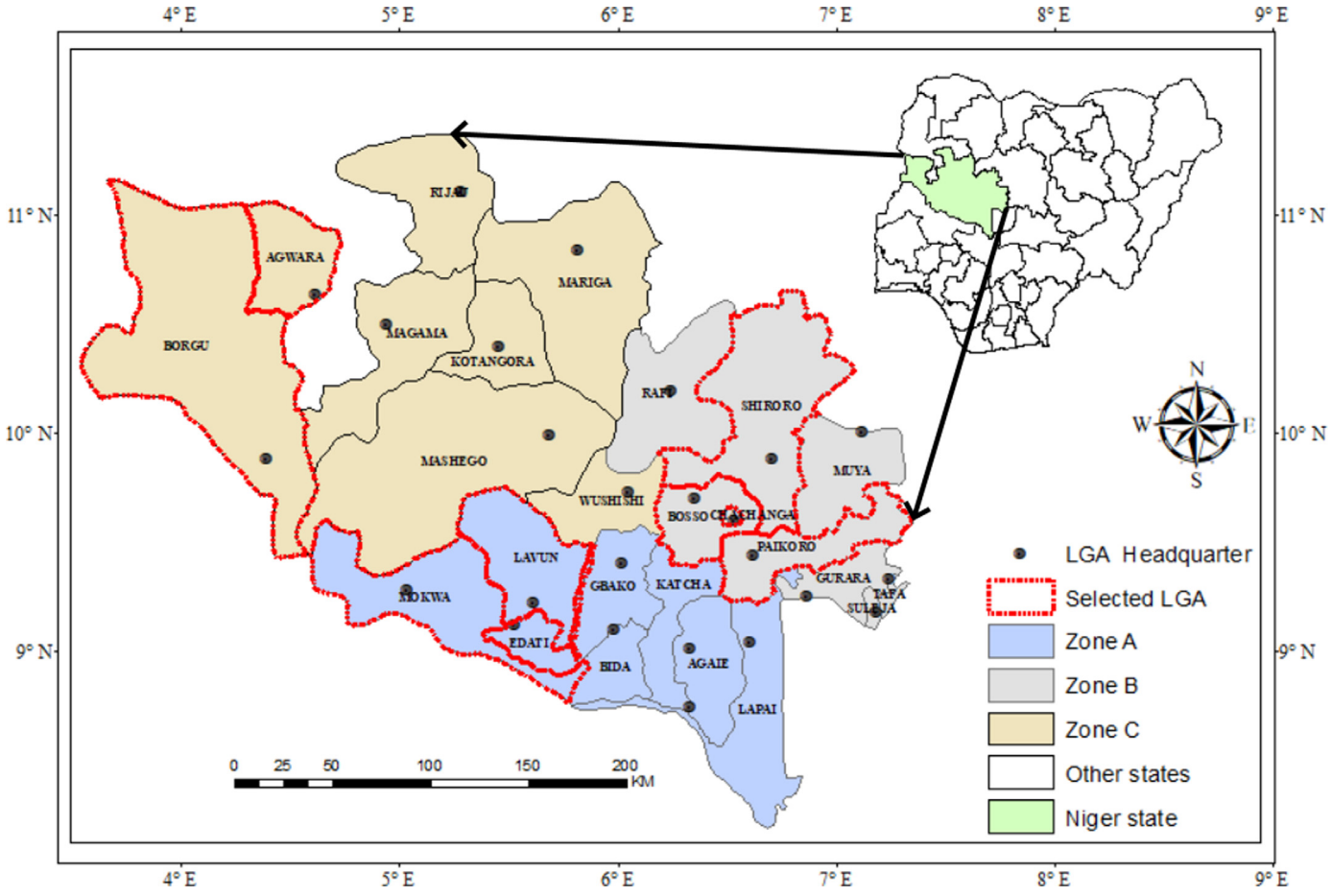

Fig. 1. Map of Niger State, showing the three Geopolitical zones (A, B, C) and the LGAs.

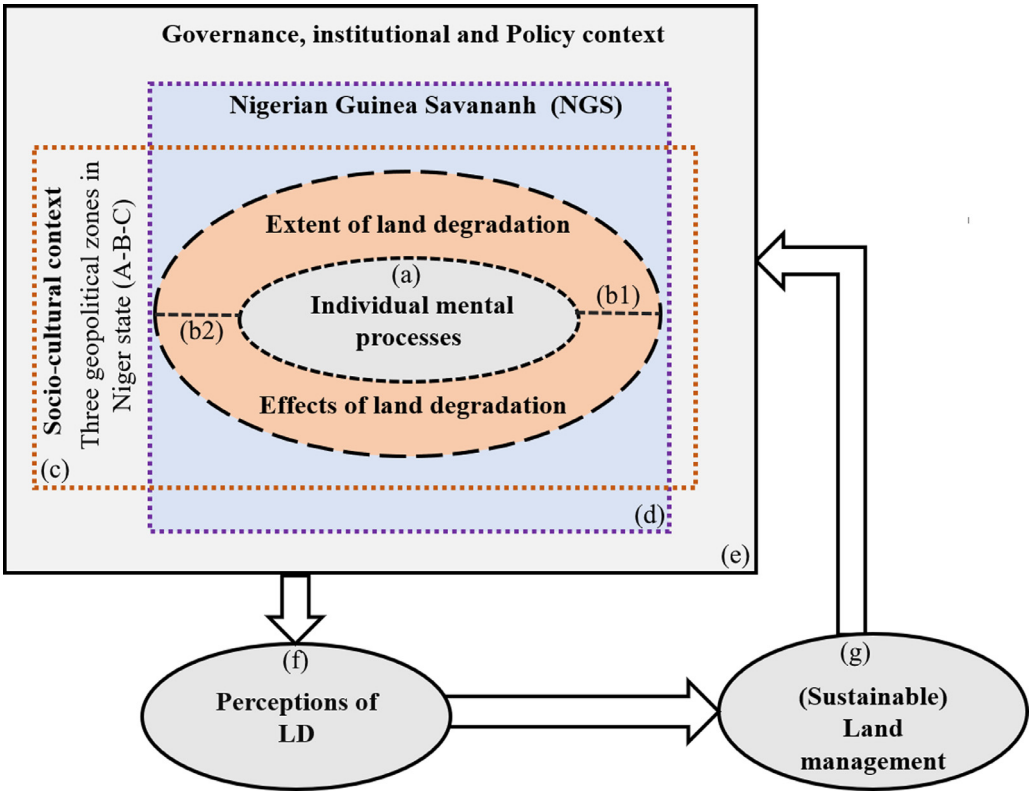

Fig. 2. Conceptual approach for linking land users perceptual experience for LD (Adapted from Shackleton et al. (2019)).

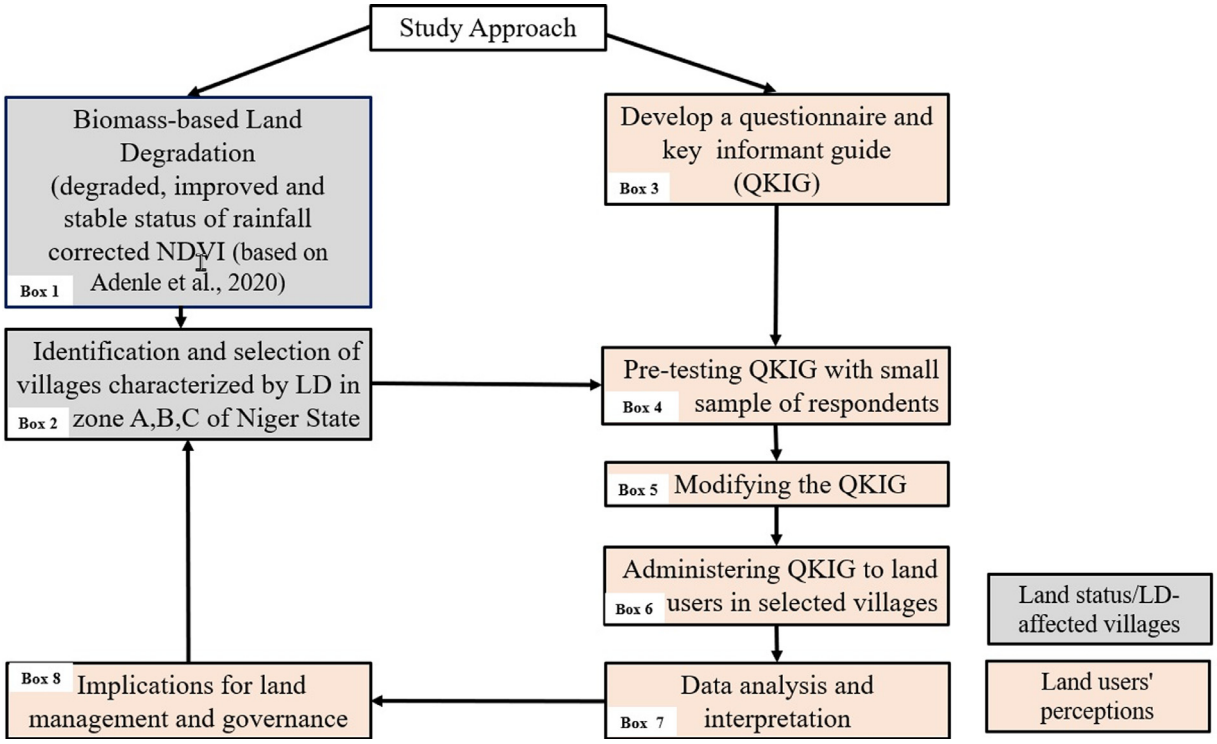

Fig. 3. Flowchart of the research process.

Other definitions used in this study relating to SLM (**Fig. 2g**): Institutional actors refer to persons, stakeholders, or policymakers, who are respected, including those involved in formulating and making decisions on SLM (von Braun et al., 2013). Technological practices are field based/physical SLM approaches that reduce LD using measures such as agronomic, vegetative, structural, and management measures to enhance land productivity (Liniger et al., 2011; WOCAT, 2018). Conservation practices aim to conserve land resources such as soil, water, and vegetation, to ensure the maintenance or improvement of a healthy and functioning landscape (Liniger et al., 2011; WOCAT, 2018). Policy initiatives refer to activities guided by specific visions of a government or organization (e.g., legislation, regulations, and plans), and principles to achieve set goals (Ifejika Speranza et al., 2019).

2.3. Methods

2.3.1. Assessing land degradation

To capture land conditions in Niger state and the landscape context for the greater NGS, we used a LD map derived from the Moderate-Resolution Imaging Spectroradiometer Normalized Difference Vegetation Index (MODIS NDVI) between 2003 and 2018 as a proxy (Adenle et al., 2020) (Fig. 3, Box 1). The map was developed by calculating the mean of the yearly sum of the (monthly 10-day) maximum NDVI and by applying Residual Trend Analysis (RESTREND) to adjust for the effects of rainfall on the biomass condition over the NGS. The result captures land with declining (degrading), stable, and increasing (improving) biomass conditions in Niger State (Adenle et al., 2020), which guided in identifying the LD status and communities affected by LD in the 3 geopolitical zones (Fig. 3, Box 1). In the zones, 8 accessible LGA's with no security threats Fig. 1 were purposely selected. From the selected LGAs, 30 LD affected villages linked to the identified archetypes of rural remoteness (Adenle and Ifejika Speranza, 2020) were selected.

They include in zone A, eleven villages in Mokwa, Lavun and Edati LGA, in zone B, ten villages in Boss, Shiroro and Paikoro LGA, and in zone C, nine villages in Agwara and Borgu LGAs (Fig. 3, Box 2), (Supplementary Table (ST) 1–3). The difference in the number of selected villages was due to access and insecurity reasons. The eligibility criteria for selecting respondents for questionnaire administration in each village includes household heads with age ≥20 years or people who have engaged in land use-based activities in the NGS for (≥10 years) and live in the village. We assumed that respondents fulfilling these characteristics will be able to provide relevant information on LD. Before data collection, village meetings were conducted to inform the villagers about the study and to obtain approval from the relevant authorities and willing respondents.

2.3.2. Questionnaire

We developed a semi-structured questionnaire based on the qualitative results from three Focus Group Discussions (FGD), the LDN workshop report from Nigeria and the WOCAT (FGN, 2018; Liniger et al., 2011; Mganga et al., 2015) (Fig. 3, Box 3–5). We then presented respondents a list of LD characteristics and LD drivers and asked them to rate them on a 1–5 Likert scale (1 =Strongly disagree, 2 =Disagree, 3 =Neutral, 4 =Agree, 5 =Strongly agree). The questionnaire contained sections on the LGA, village, house and socio-economic characteristics of the respondents and their experiences (characteristics /drivers) of LD. The respondents also provided information on SLM by ranking four categories - institutional actors, technological- and conservation practices, and potential policy initiatives relevant for SLM.

2.3.3. Data collection

Fieldwork was conducted from February to May 2019, with 225 questionnaires distributed across the three geopolitical zones (Fig. 3, Box 6). The respondents were mostly farmers (Fig. 3, Box 2), who cultivate crops such as yam and sorghum. They were mostly male respondents due to the socio-cultural and religious context, which encourages men to engage in farming activities while women assist or engage in post-harvest processing. Most interviews took place on a one-one basis and lasted between 50 min and 1 h 30 min. Based on respondent availability, key informant interviews (10–15 experts) for the three geopolitical zones were used to obtain additional information for interpreting

the questionnaire data (Fig. 3 Box 7) and the land management implications of LD (Fig. 3 Box 8). The questionnaires were administered in local languages (Hausa, Nupe, and Gbagi) and translated back to English with the help of trained field assistants. Narratives were collected through the recording of key informant interviews and three focus group discussions (FGD). The data was anonymized to protect respondents' privacy.

2.3.4. Statistical analysis

Using the Statistical Package for Social Sciences (SPSS), we performed descriptive and inferential analysis of respondents' perceptions of LD characteristics/drivers/SLM. We examined the preliminary examination of (no) multicollinearity (correlation matrix) between variables at a correlation coefficient > 0.8 (Matter et al., 2021) showing that most of the variables were not highly correlated. We tested the suitability of the variable set for Principal Component Analysis (PCA), through the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test based on previous studies, with a KMO value >0.5 and a significance level <0.05 considered appropriate (Matter et al., 2021). Using PCA, we reduced the dimensionality of the initial large set of LD characteristics/drivers/SLM. Based on the total variance explained by the breaks from the scree plot ((Supplementary File 1), and the insights from parallel analysis, the transformed and the extracted LD characteristics/drivers/SLM with strong influence were reported as components (Jolliffe and Cadima, 2016; Patil et al., 2017). The components are derived aggregates of the original variables that are representative of the loading from the original large dataset (Tabachnick and Fidell, 2014). Through the components loading and rotation (i.e., Varimax/Promax Rotation), we interpreted the components based on contributions from LD characteristics/drivers/SLM. We considered Eigenvalue contribution >0.75, 0.75–0.5, and 0.5–0.3 as 'strong', 'moderate', and 'weak' perception influence respectively (Liu et al., 2003). Interpreted components were identified for the Perceptions of LD Characteristics (PLDC), Perceptions of LD Drivers (PLDD) and Perceptions of Sustainable Land Management (PSLM) practices. To capture the Sustainable Land Management (PSLM) practices. To capture the respondents' priority for SLM measures, we analysed the SLM practices with the Relative Importance Index (RII). RII has been applied to capture perceptions and to rank measures that can guide the formulation of policies (Azman et al., 2019; Somiah et al., 2015). The RII (Eq. (1)) involves calculating the mean for the SLM options based on the weights on the Likert scale assigned by the respondents.

$$RII = \frac{\sum W}{A * N} \quad (1)$$

Where RII = Relative Importance Index; *W*= weight given to each SLM by respondents (ranging from 0 to 4); *A* = highest weight (i.e., 4 based on a 5-point Likert scale in this case); and *N* = total number of respondents. The higher the RII, the more important/effective the land users consider the SLM practice. Thus, SLM with the highest weight is ranked RII = 1, while the next lower weight has RII = 2, and so on. The narrative data collected through informant interview/FGD were analysed through content analysis.

3. Results

3.1. Land conditions

Based on the MODIS derived NDVI as a proxy for ongoing degradation status, Fig. 4 and Table 1 shows the extent of LD in Niger State (Adenle et al., 2020).

Table 1 shows the LD status according to the three geopolitical zones in Niger state over the 16 years (Adenle et al., 2020). Degradation is extensive across the three zones and occurs in two-thirds of the area. Zone C has the largest extent of LD, next to zone A and zone B. Zone B accounted for the largest stable area covering 38.2%. Improvement is visible in less than 5% of the area in each zone.

3.2. Respondents' socioeconomic characteristics

Table 2 shows the socioeconomic characteristics of the 225 respondents.

3.3. Perceptions of land degradation characteristics

Fig. 5 shows that more than 70% of the land users agreed to the presented LD characteristics as occurring in their communities. The major indicators of LD in Niger State (over 80% agreement), include soil erosion, desertification, the decline in native species, change in vegetation structure with loss of palatable species, the experience of drier conditions with loss of soil fertility and increasing encroachment into protected areas (Fig. 6). The breakdown of the response on LD characteristics is presented in ST:4. The PCA identified four components of perceptions of LD characteristics (PLDC) (Table 3) with a cumulative loading of 62.8% (ST 6c) key informant interviews from LGAs in the zones confirm these characteristics of PLDC and descriptive analysis According to a key informant from Wabi village, Lavun LGA, zone A,*"here is a great concern about our environment because some of the characteristics of the Sahel and Sudan region, which we hear or see on television are now noticeable in our areas like sandiness, barren soil and loss of vegetation* Fig. 6. *There are many species of wood and plant that have been lost due to logging promoted by international trade with the Chinese who entice people with money to get those woods. Our environment is now changing with a lot of degradation and pollution with more absence of natural vegetation; we do not feel comfortable like we used to feel".*

In Bako village Bosso LGA, zone B informant said *"before we only had just two houses and families living here but looking around, we have more people and more houses. It was even very difficult to get to the Lapia market or main Niger to Abuja express road because we were surrounded by thick dense natural forest, which is no more available like in my father's time. From the old Lapia Market, there was no road but thick forest. We had to pass through another route to another village to go to Abuja. Also, our soils are eroded, and our lands are not doing well for our crops like before. We now need plenty of expensive fertilizers or else no food from the farm for our family.*

The was also corroborated by the observation by informant in Borgu LGA in zone C: *"In the entire Niger state, there is nowhere you will get a land that is uncultivated except Borgu LGA but now those lands are almost gone due to soil erosion and vegetation loss. For instance, abnormal dryness and desertification already in Niger state after the Borgu sector of the national park immediately after the second bridge to Luman village, just observe the other side of the national park, just compare the landscape you will find out more as you are moving up to Lumna Baare, Swanshi, Gala till Agawara. In the entire Agawara and Magama area, they are semi-desert, you will not find natural vegetation and they cannot produce much again because the LGA is degraded. Also, there is Kali Hill that serves as boundary and protection to the Kanji Lake National Park but now farming has encroached into the hill, affecting the habitat of the animals in the park and causing animals to migrate".*

3.4. Perception of land degradation drivers

Over 65% of respondents mostly identified factors such as God, sin and failure to pray, secret sales of communal land for selfish gains, migrants' activities from surrounding degraded states such as Kebbi and Zamfara, deforestation/logging, over-cultivation, overgrazing, and crime due to armed banditry and kidnapping in all three zones. In zone A, dry spell/drought and mining were most mentioned. More than 60% of respondents mentioned urbanization across the three zones. Mining, overpopulation due to higher birth rates leading to large family size and "western ways of doing things", which introduces sophisticated equipment like tractors compared to traditional farming approaches considered more environmentally friendly was also key in zone C (ST:5) From

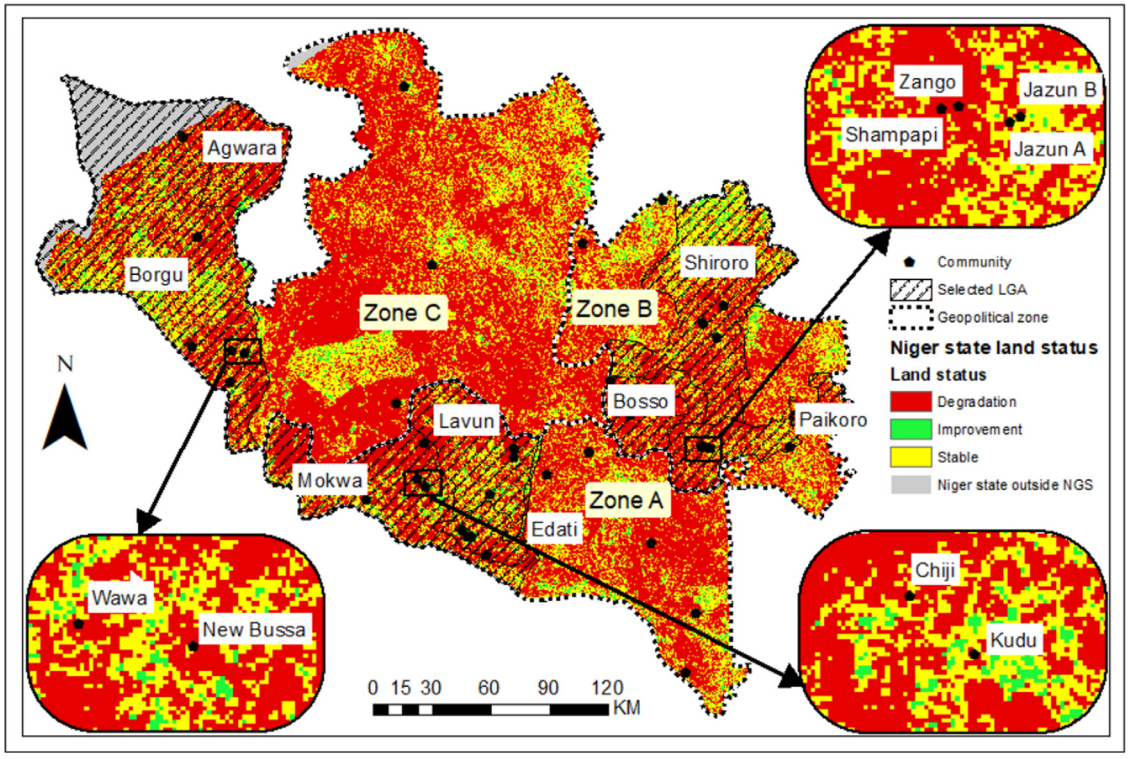

Fig 4. Selected villages and Land-degradation status in Niger State based on MODIS NDVI (Adapted from Adenle et al. (2020)) (Note: the grey area in the Northwest lies outside the NGS and was not part of this analysis).

Table 1
Extent of land degradation status in Niger state (in% and km^2).

Land status	Total Area (km^2)	Total area (%)	Zone A (km^2)	Area (%)	Zone B (km^2)	Area (%)	Zone C (km^2)	Area (%)
Degradation	48,045.4	62.9	12,273.2	65.5	10,199.7	57.8	25,964.1	66.8
Stable	24,060.9	31.5	5651.3	30.2	6736.8	38.2	11,449.8	29.5
Improvement	3131.7	4.1	807.6	4.3	721.4	4.1	1434.2	3.7
Area within NGS	75,238.1	98.5	18,732.1	100.0	17,657.9	100.0	38,848.1	100.0
Area outside NGS	1124.9	1.5	0	0	0	0	1124.9	1.5
Total area	76,363.00	100.00						

the PCA, two major components of PLDD were identified for Niger state (Table 4) with a cumulative loading of 51.3% (ST:7c).

Information from key informant interviews supports the two major PLDD (ST:7c) loading and perceptions of LD drivers by the respondents. A land user in Shiroro LGA, zone B reports, *"after my house, there is a stream and thick forest that cannot be accessed by strangers, the kidnapper attacked us once from there because the forest is an access route to kidnapers' hideout. They were pursuing one Fulani man with a large cattle-herd, so they followed the stream and mentioned my name. They came in to take control of my house while pursuing a Fulani man but then they were not kidnapping but now they have started kidnapping. The persistence of kidnapping activities makes us cut down the thick vegetation around our villages. Aside from the use of savannah trees for timber, firewood and charcoal, bandit activities and kidnappers visit the village at night to kidnap people into the forest. So, we decided to cut down trees and forests around our village to prevent kidnapping and to see them when they are coming. Last night, bandits from Alawa Forest still came to kidnap people from the village"*.

Another key informant in Borgu, zone C reports: *"Because of the proximity of Niger state to Kebbi state, which is in the Sudan Savannah with fewer trees, people from Kebbi state do most of their logging and charcoal making in Niger state. Their farmers also migrate into Niger state. I can say 60% of the farmers in Niger state are from Kebbi, Zamfara and Sokoto state. Go to Mashegu Zurgurma, Ibi, virtually all the farmers are from Sokoto, Kebbi and Zamfara, and they do not care for economic trees that our people cherish"*. His-opinion was also corroborated by another key informant in Borgu, zone C who said *"there are two major causes of LD in Niger state. The Influx of foreign farmers that is in-migrating farmers mostly from Kebbi, Zamfara, Sokoto and foreign farmers from Togo and Benin Republic including our neighbouring degraded local governments such as Magama and Rijau. Second is the activity of wood loggers who cause biomass degradation usually from the southern parts and middle-belt of the country like Plateau, Nasarawa, Ebonyi, from the southwest like Ekiti and Osun. Initially, our people do not know about mobile sawmills, they only know about the traditional approach of looking for a mature tree, cutting it down and taking it to the sawmill. With the coming of mobile sawmill and sophisticated equipment, the majority of our people now practice "sawmill on the go"*. Others include overgrazing by Fulani herders and fuelwood activities like charcoal making, firewood collection and mining activities.

3.5. Perception of SLM

3.5.1. Perceptions of the importance of institutional actors for implementing SLM

From Fig. 8a, all the institutional actors were considered relevant, aligning to the single perception-component loading from all the institutional actors in the PCA (i.e. PLDS 1). The four highest ranked (i.e. responses >70%) include local institutional actors such as traditional rulers, Community Based Organisations (CBO), local government agen-

Table 2
Socio-economic and other characteristics of respondents in Niger state (n = 225).

Parameters	Frequency (N)	Percentage (%)	Parameters	Frequency (N)	Percentage (%)
Gender			**Source of livelihood**		
Male	218	96.4	Farming	160	71.1
Female	7	3.1	Household activity	5	2.2
Age			Wage labour	5	2.2
20 to 29	22	9.8	Small business	4	1.8
30 to 39	54	24	Salaried employee	36	16
40 to 49	62	27.6	Studying	1	0.4
50 to 59	49	21.7	Remittances	1	0.4
60 and above	38	16.9	Others	10	4.4
Marital status			**Average income per month (USD)**		
Single	10	4.4	1 to 24	3	1.3
Married	144	64	24 to 48	7	3.1
Divorced/Widowed	59	26.2	48 to 72	22	9.8
Education level			72 to 96	155	68.9
Quranic/Vocational	43	19.1	None	38	16.9
Primary	29	12.9	**High access to land for farming**		
Secondary	34	15.1	Yes	212	94.2
Tertiary	69	30.7	No	13	5.8
None	39	17.3	**Land ownership**		
Years of residence			Do not know	42	18.8
10yrs - < 20yrs	9	4	Inherited	140	62.3
20yrs - < 30yrs	29	12.9	Bought/Ownership	27	12.2
30yrs and above	175	77.8	Rented/Leased	5	2.2
Household size			Others	10	4.5
1 to 4	56	24.9	**Awareness of LD**		
5 to 8	110	48.9	Yes degraded	191	75.1
9 to 12	52	23.1	No not degraded	30	11.5
13 and above	7	3.1	Do not know	34	13.4

(Source own field survey 2019).

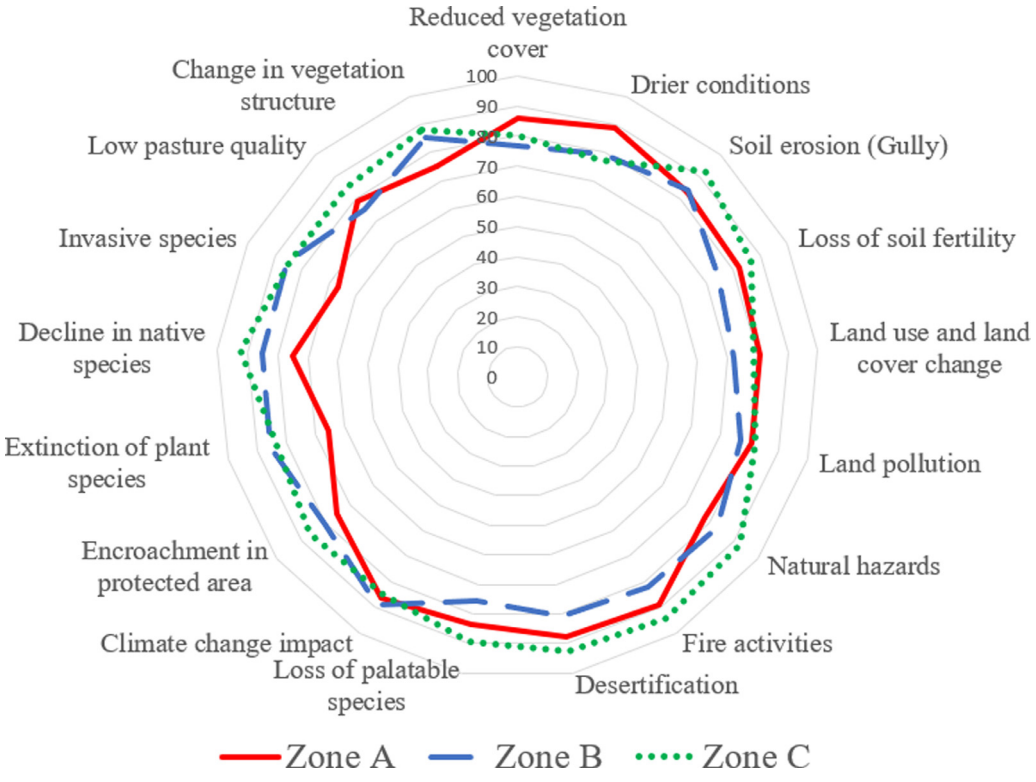

Fig. 5. Land users' perception of LD characteristics (Source: own field survey data 2019).

cies, and religious institutions. However, respondents also perceived the Federal Government's (70.4%) efforts as more important than the state government in addressing LD. A key informant confirmed the ranking preference, reporting that "*..the death of the Wawa traditional village head in Borgu, zone C in 2009, caused more areas to be degraded especially during the chieftaincy tussle because of the absent traditional head who authorize and make allocation decision over land*". Another key informant in zone C, highlights the need for community and local actions and institutions: "*Not God but human activities like selfish farming and selling of community land including having more of the local young men who because of civilization do not want to assist their fathers on farmland but want to sell native land to foreigners, sand miners for quick money. We are more helpless be-*

Table 3
Perception components of LD characteristics (PLDC).

Components	Brief description of PLDC
PLDC 1: Vegetation condition dominated characteristics	Perception is dominated by changes in vegetation structure, low pasture quality, presence of invasive species, and extinction of plant communities (SL), but moderate declining native vegetation, encroachment into protected areas, fire and desertification (ML).
PLDC 2: Soil condition dominated characteristics	Perception loading is dominated by moderate soil erosion (Gully), loss of soil fertility, land pollution, fire and desertification.
PLDC 3: Vegetation with Sudano-Sahelian characteristics	Perception is dominated by strongly reduced vegetation cover typically found in the Sudan-Sahel (SL), drier conditions, natural hazards, fire and desertification (WL).
PLDC 4: LULC with the prevalence of drier conditions	Perception dominated by Land Use Land Cover Change (LULCC) (ML), drier conditions (SL), reduced vegetation, gully erosion and encroachment into protected areas (WL)

Legend: Strong loading; SL, Moderate Loading; ML, Weak Loading; WL.

Table 4
Perception components of LD drivers (PLDD).

Components	Brief description PLDD
PLDD 1: Human activities dominated drivers at a smaller scale	Perception dominated by strong agreement with over-cultivation, overgrazing, migrants' activities (SL) and moderate deforestation/logging, overpopulation, urbanization, sin and failure to pray, and crime including western ways of doing things – i.e. technologies (ML)
PLDD 2: Larger-scale drivers (nature-driven)	Perception dominated by high loadings from climate change and variability (SL), moderate dry spell/ drought, pollution of rivers, mining activities, poor waste management (ML)

Legend: Strong loading; SL, Moderate Loading; ML, Weak Loading; WL.

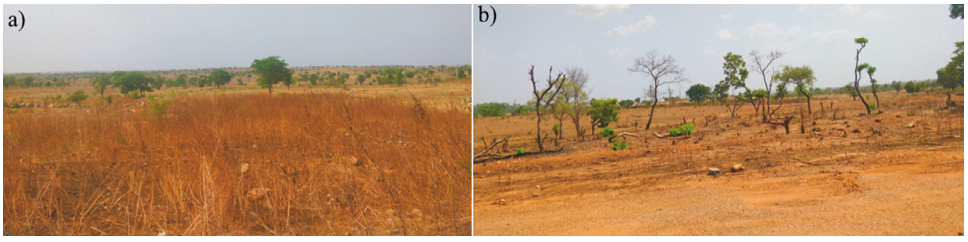

Fig. 6. Degraded savannah in Niger state (a) cleared land in Lavun LGA (b) logged and burnt woodland patch in Agwara LGA (Source: Own fieldwork, 2019).

Table 5
Ranking of the SLM categories.

Category of SLM	RII (%)	Rank order
Institutional actors	70.0	1
Technological practices	67.6	2
Conservation practices	66.8	3
Policy initiatives	66.5	4

cause the act of selling the land for sand mining is encouraged by the local government and community heads that give receipt to the landowners who sell the land and sand to these sand miners. Here, the government does not interfere in the giving of land but traditional rulers and village chiefs like the Seriki Dagi, Seriki Maranba, and Seriki Noma who belong to the local palace, mostly give land to migrant farmers for money without considering the environmental implications like degradation".

3.5.2. Perceptions of effectiveness of technological practices in tackling land degradation

Technological practices in tackling LD received the second highest RII value of 67.6% (Table 5). Based on Fig. 8b, most respondents highly ranked vegetative measures, which include natural and semi-natural forest management, agroforestry, forest plantation management, and windbreaks, as well as area closure as the five most effective technological practices to combat LD while the remaining technologies ranked below 70%. The three PCA components identified include PLDS 2-natural resources management; PLDS 3-environmentally friendly agricultural practices and PLDS 4-tree-based initiatives (Table 6). Respondents in zone C rated all technological practices higher than respondents in the other two zones (i.e. with choices ranging from >35%). However, other practices such as energy efficiency technology, beekeeping, aquaculture, poultry, home garden and disaster risk reduction were highly rated across the three zones.

3.5.3. Perceptions of effectiveness of conservation practices in tackling land degradation

With an RII of 66.8% conservation practices is ranked third (Table 5). In Fig. 8c, most of the respondents identified agronomic measures (contour farming) and structural measures (terraces) as effective for tacking LD i.e., response >70% and above, while the combination of other measures such as promoting crop diversity and native species habitats ranked <70%. However, the component PLDS 5 shows that all the conservation practices were considered relevant (Table 6). A key informant in Borgu, zone C captured the insights of the various SLM technological and conservation practices: "*Most farmers are not well informed that different trees and vegetation cover have importance beyond firewood and charcoal. Crops have different nutrient absorption rates like Maize and Guinea corn and if they continue farming on a particular land for say five years that area will need some agricultural practice to bring the soil nutrient back. But a traditional Kamari farmer does not think of replenishing the soil nutrient through improved means when they till for years, they move to another place to farm. That is why you see migrant farmers moving from neighbouring state in search for fertile land without engaging in practices to replenish soil fertility but continuous cultivation till the land fertility is lost*". In another instance, he said that "*it is a taboo to cut economic trees like shea butter and locust bean found on their farmlands but for the migrant farmers with a different farming approach they have no selection for trees through the indiscriminate cutting of trees*".

3.5.4. Perceptions of effectiveness of policy initiatives in tackling LD

With an average RII of 66.5%, policy initiatives/themes occupy the fourth position amongst the SLM categories (Table 5). According to the

Table 6
Perception components of SLM (PLDS).

Components	Brief description
PLDS 1: Institutional actors' effect	High perception influence from all institutional actors i.e. have similar strength (SL)
PLDS 2: Natural resources management	High influence from natural resource management: diversion/drainage, surface water management, groundwater management and wetland protection, disaster risk reduction (SL) and water harvesting and irrigation management (ML).
PLDS 3: Environmentally friendly agricultural practices	High perception influence of agricultural practices: improved ground/vegetation cover, integrated crop-livestock management, pastoralism/grazing land management, and minimal soil disturbance (SL). Moderate loading (ML): rotational system, integrated soil fertility, improved plant varieties/animal breeds and water harvesting.
PLDS 4: Tree-based initiatives	Strong contribution from natural and semi-natural forest management, forest plantation management agroforestry (SL) and loadings from windbreak, area closure and crop rotation (ML)
PLDS 5: Conservation initiatives	High perception influence from conservation practices. i.e., SL from all the conservation practices (SL)
PLDS 6: Policy initiatives	High perception influence from policy initiatives. i.e., SL from all listed policies.

Legend: Strong loading; SL, Moderate Loading; ML, Weak Loading; WL.

RII (Fig. 8d), the top five ranked factors for the land users include desertification and drought control, population control, and climate change response including strict conservation, and land tenure, while the least-ranked five factors are migration control, strict anti-grazing, mining control, gender-based policies, and controlled/partial conservation. From the PCA, the matching component PLDS 6 shows that all the policy practices are relevant in the study context (Table 6).

4. Discussion

4.1. Land users' perceived characteristics of land degradation

4.1.1. Perceived vegetation-related characteristics of land degradation (PLDC 1 & PLDC 3)

Vegetation related indicators such as desertification, change in vegetation structure and decline in native species, as well as reduced vegetation (PLDC 1), were ranked high as LD indicators in the study area. These characteristics align with UNCCD's consideration of biomass quality and productivity as characteristic of LD conditions. However, other most mentioned indicators such as soil erosion, desertification with drier conditions experienced along with loss of soil fertility are the effects of the absence or shortage of vegetation cover reflecting LD as a process (Macaulay, 2014). Further, LD drivers such as deforestation, the emergence of Sudano-Sahelian vegetation (i.e. (PLDC 3) desertification/drought) further worsen the declining biomass conditions.

4.1.2. Perceived soil-related characteristics of land degradation (PLDC 2)

Soil erosion and loss of soil fertility (Fig. 5) indicators of LD are connected to the absence of vegetation cover. However, the dominance of farming activities as the sole livelihood engagement of most rural inhabitants in Niger State makes this indicator pronounced (Macaulay, 2014; Sule et al., 2020). Extensive biomass loss due to unsustainable human activities (PLDD 1), expose the soils to the wind and rain, which increases the risk of soil degradation (Le et al., 2016) such as soil erosion as mentioned by most respondent across the zones. It thus follows that addressing vegetation-related LD is likely to reduce soil-related degradation in Niger state.

4.1.3. Perceived land use and land cover change (LULCC) as land degradation (PLDC 4)

Perceptions of vegetation loss, desertification, the decline in native species, change in vegetation structure with loss of palatable species and drier conditions as well as increasing encroachment into protected areas are captured under LULCC in the study area. Studies have also linked these characteristics of land cover change to land use activities across the zones (Arowolo and Deng, 2018; CILSS, 2016). These local perceptions of LD highlight the need for people-centred initiatives for addressing LD (Mortimore, 2016; Pulido and Bocco, 2014).

4.2. Land users' perceived drivers of land degradation

4.2.1. Land use and management practices

Drivers such as over-cultivation, overgrazing, farming activities, mining and deforestation/logging, were highly scored over 70% as the observable drivers of change in biomass condition (Macaulay, 2014; Olorunfemi et al., 2020). These same drivers trigger LD through promoting land clearing for agricultural expansion, and excessive wood extraction (Arowolo and Deng, 2018; Fagbemigun, 2015). They represent the driver that load strongly into the PLDD 1. However, the slight difference observed shows that perceptions were relatively similar but depend on the prevalence of the drivers in the zone. For instance, that overgrazing is ranked higher than cultivation can be linked to the prevalence of encroaching grazing activities into protected areas in zone C. Mining in zone C corresponds to sand mining activities. Deforestation and logging prevail in zone A. Thus, the emergence of Sudano-Sahelian (i.e. dry spell/drought) conditions (PLDD 2) in a Guinea savannah region (Macaulay, 2014) was corroborated by the key informant interview in zone C

4.2.2. Urbanization as a driver of land degradation

The identification of urbanization (Fig. 7) as a driver (PLDD 1) of LD depicts the degree to which zones has diversified away from farming and exploitation of natural resources. Urban centres provide other job opportunities and means of livelihood away from farming but require land conversion for housing (Gautam and Andersen, 2016; Owusu, 2009). Zone B for instance has the highest urbanization but the least degradation in terms of NDVI decline due to cities pre-existing the 15 years of analysis, such as Suleja, which shares a boundary with the Federal Capital Territory (FCT), Abuja. The State capital Minna as well as moderate commercial and industrialized urban centres providing alternative livelihoods are also located in this zone. This is unlike zone C and A, which are dominated by remote farming communities with a high proportion of their population relying on natural resources. Urbanization increases agriculture in adjacent rural farming areas due to the demand for food, triggers land-use change and LD in Nigeria (FGN, 2018; Olorunfemi et al., 2020), but the rate of urbanization in Niger State is not fast enough to drive LD through increased agricultural activities (Arowolo and Deng, 2018; Macaulay, 2014). However, at the LGA level, Bosso, in which the State capital is located, has the greatest LD (75%) through urbanisation.

4.2.3. Agrarian activities-driven land degradation

Niger is the largest state in Nigeria in terms of landmass and is one of the least developed with low urbanization. In such areas, most degradation is caused by the dominance of the agrarian economy and poor land management practices such as burning, deforestation and logging and agricultural expansion into savannah areas (Arowolo and Deng, 2018; Macaulay, 2014). With the national restrictions on food importation and

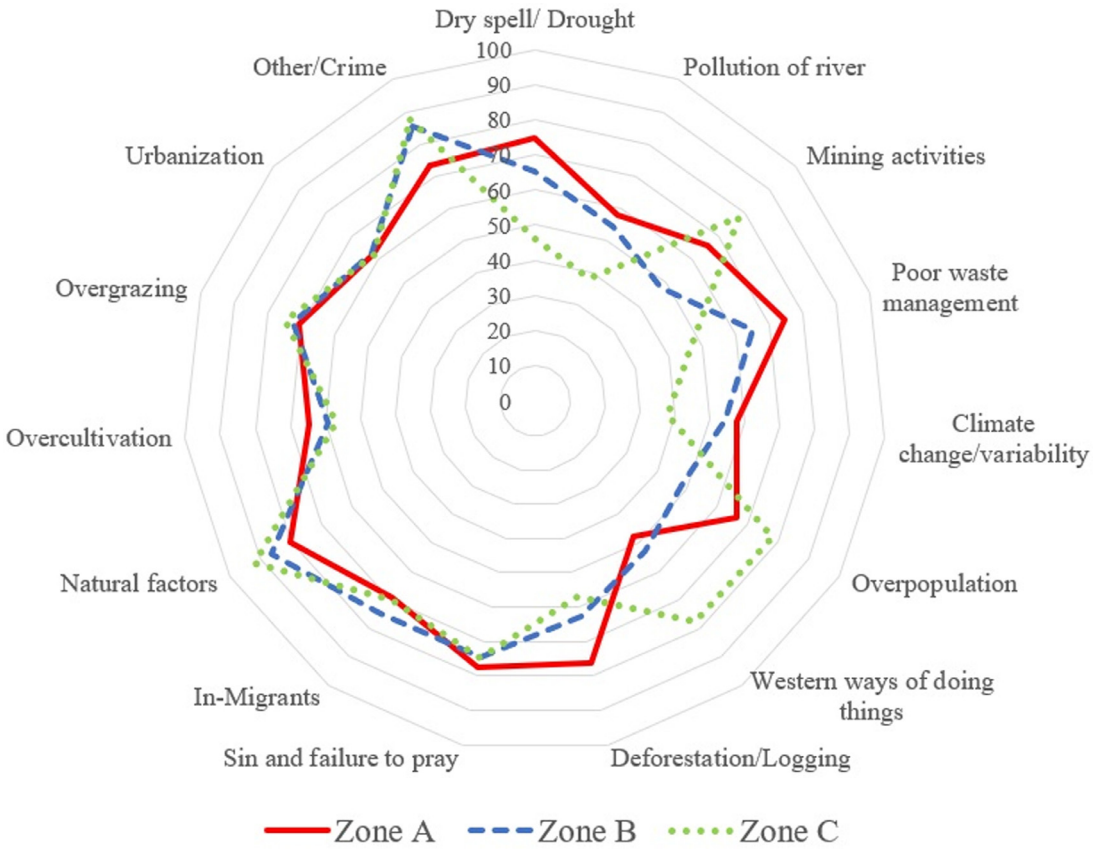

Fig. 7. Land users' perceptions of drivers of LD. Note: Natural factor refers to elements that people presume to cause change to the environment such as nature or God. Also, the respondents further identified crime as a driver of LD although it was not presented on the list of drivers.

incentives to encourage domestic food production by successive governments, the promotion of rural food supply further drives land users to cultivate more land in an exploitative manner and hence more LD (Arowolo and Deng, 2018).

4.2.4. Perceptions of technological innovations as drivers of land degradation

Technological innovations linked to "western ways of doing things" such as, tractors and the "sawmill on the go" (mobile sawmills) (PLDD 1) together with inadequate laws and regulations make it easy to cut down trees, resulting in biomass loss. While technological innovations in this context is a driver of LD, technology has been identified in other studies as contributing to the sustainable use of land resources (UNCTAD, 2021, 2018). This negative perception of technology as a driver of LD may be related to the faster pace of resource extraction compared to manual approaches, as in some cases, technology increases degradation (Ali, 2004; Assunção and Bragança, 2015). Thus, the negative perceptions of innovative technology, without accompanying sensitization measures, can hinder the adoption of environmental smart technologies (Crossland et al., 2018).

4.2.5. Migrant farmers and links to land degradation

Migration under PLDD 1 driver, is on the one hand an adaptive measure for the migrants that can result in degradation in destinations areas. (In)migration involves inter-state immigration i.e., the movement of farmers and herders from LD threatened areas like the drought-prone Sahel into the Guinea savannah (Macaulay, 2014). Land-use pressure, degradation and (armed) conflicts in northern States displaces land users and cause them to migrate further south, where available land for agriculture pulls migrant farmers and herders hence contributing to land conversions and LD (Macaulay, 2014). Without socio-cultural embeddedness, immigrant farmers and herder can be perceived to disrespect local values associated with economic trees (e.g., shea butter) which in some cases might trigger conflict (Ofuoku and Isiefe, 2010).

4.2.6. Crime and responses to crime as drivers of land degradation

Local crime such as armed banditry, kidnapping and terrorism have led to clearing thick native vegetation that serves as hideouts for criminals in rural areas (Kuo and Sullivan, 2001). Crime and insecurity have led to reduced control over land use, the loss of power of traditional authorities and communities, the erosion of institutions and rules to protect economic trees (Ofuoku and Isiefe, 2010). Thus, respondents believe that cutting down such dense vegetation around communities will reduce criminal and terrorism activities thereby causing LD (van Schaik and Dinnissen, 2014). According to the global peace index, Nigeria ranked 17th amongst fewer peaceful countries and third, as a country most affected by terrorism. As LD is an outcome of violent conflict and nature (IUCN, International Union for Conservation of Nature, 2021; van Schaik and Dinnissen, 2014), understanding the indirect causal links between people's behaviour, ethics, social cohesion and curbing communal, armed conflict and crime management is essential for tackling LD.

4.2.7. Religious interpretations

High responses on "sin and failure to pray" including natural factors "due to God" reflects religious interpretations of global environmental change (Boillat and Berkes, 2013; Jenkins et al., 2018). This interpretation might make some religious people rely on their belief that God will provide solutions to their socio-ecological problems while disregarding the causal links between their actions/inactions and the ensuing conditions (Jenkins et al., 2018), affecting the adoption of SLM. However, religious interpretations of global environmental change can also

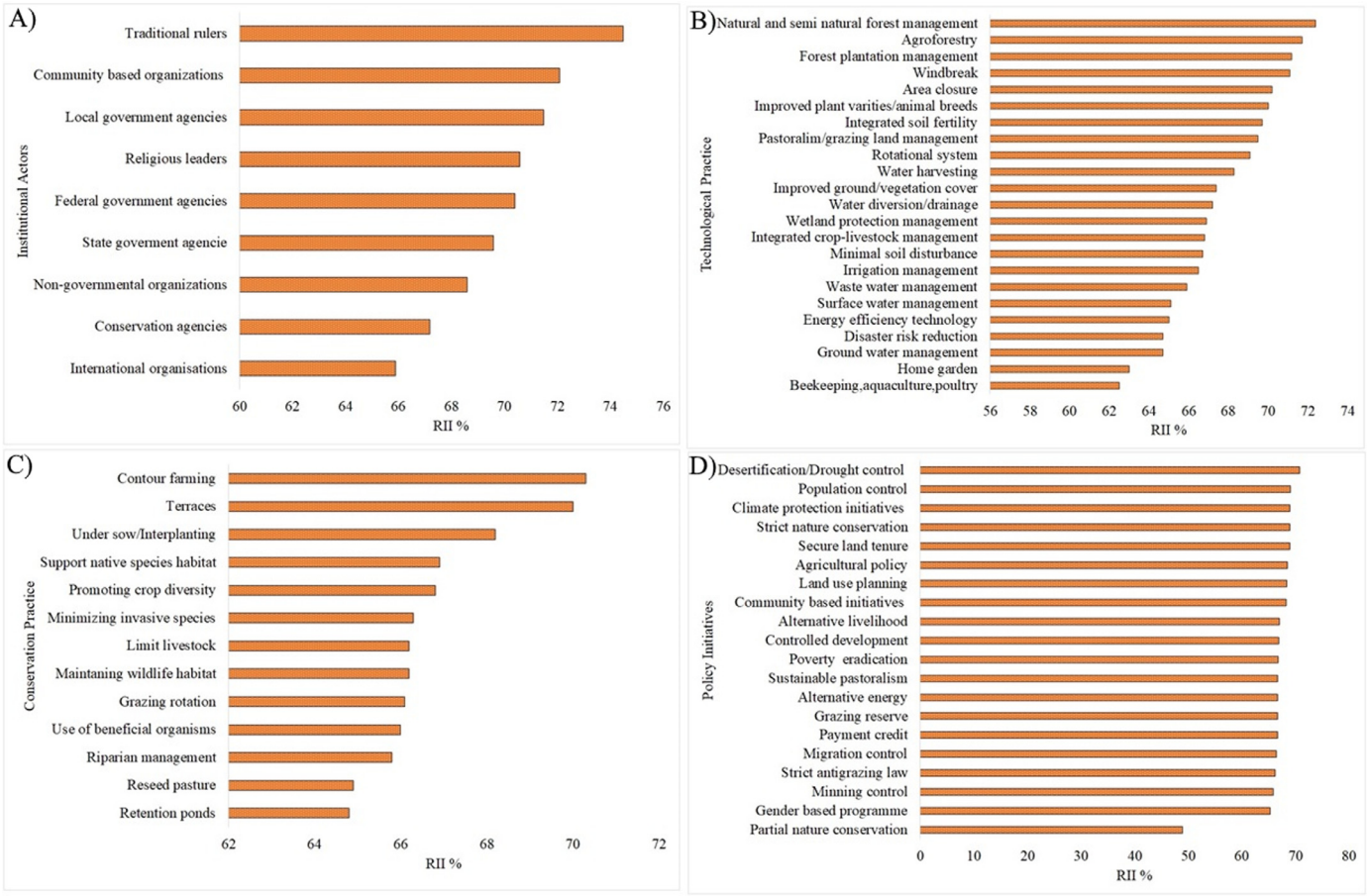

Fig. 8. RII (a) Institutional actors;(b) Technological practices; (c) Conservation practices; (d)Policy initiatives (ST:12 –15).

be beneficial in promoting local institutions and sustainable attitudes (Boillat and Berkes, 2013).

4.3. Land users' perceptions and implication for SLM and land governance

4.3.1. Perceptions by land users of institutional actors in SLM

While traditional rulers play a key role in land use practices (Gadzama, 2017), our results show that some traditional rulers, as land trustees for the people, also sell or give out native land to immigrants without giving conditions for their sustainable use. This confirms the erosion of local authorities in terms of corruption and lack of accountability. In this context, though rural land users are important agents in rural landscape modification, they lack decision-making power in land ownership and allocation. Land tenure and governance in Nigeria remain a challenge due to the lack of land reforms (Ifejika Speranza et al., 2019; Mabogunje, 2010). Many SLM initiatives fail due to institutional gaps and challenges (Gnacadja and Wiese, 2016; Ojehomon et al., 2006). Expanding local leadership to involve heads of CBOs like the association of farmers (*Seriki Noma),* local hunters (*Seriki Maranba),* and forest (*Seriki Dagi)* who work with traditional rulers in regulating land user practices (Gadzama, 2017) can be a way to reduce LD and promote accountability to preserve land resources. Studies analysing why SLM adoption succeeded (Kiage, 2013) or failed in certain regions highlight the absence of strong traditional participation, poor dissemination approaches and weak stakeholder involvement (Liniger et al., 2019). While top-down approaches usually face adoption challenges and misalignment between the local communities and interest groups (Pulido and Bocco, 2014), bottom-up approaches face barriers in spreading initiatives beyond the local. Hence the need to better link initiatives by government and international organizations (Gadzama, 2017), with the local scale, and to promote a bottom-up approach to locally mainstreaming SLM (Ifejika Speranza et al., 2019). This should also inform other international and country-led efforts such as the African Forest Landscape Restoration Initiative (AFR100) which targets restoring 100 million hectares of land in Africa by the year 2030 because re-greening will require bottom-up approaches and grassroots initiatives (Thor West et al., 2020).

4.3.2. Perceptions of SLM technology and conservation practices

The ranking shows that there is no single solution to solving LD but the selection of appropriate SLM based on land users' preference is key. The mentioned tree-based options (PLDS 4) have also been echoed in several international landscape initiatives such as the AFR100, and the Great Green Wall (GGW) initiative where countries like Nigeria and its northern States (Sudano-Sahelian region) such as Kebbi and Zamfara States have committed to planting more trees to reduce desertification and LD (Gadzama, 2017). As a response to LD, Nigeria has also committed to attaining LDN by growing more trees and preserving protected areas (FGN, 2018). However, growing trees without the strong involvement of local land users and institutions usually yield little and can even be harmful (Binam et al., 2015; Mortimore, 2016). Tree-based initiatives will perform better if the land users, relevant stakeholders and institutions (PLDS 1) are integrated through local stewardship (Liniger et al., 2019). Tree-based programmes (PLDS 4) such as afforestation are recognized but have not succeeded in Nigeria mainly because there are no alternative sources of energy to firewood. Uncontrolled land access, open grazing and pastoral mobility and water scarcity to irrigate the planted trees also hinder afforestation and reforestation programmes (Ofuoku and Isiefe, 2010). Farmer Managed Natural Regeneration (FMNR), found to reduce livelihood risk due to LD in

other West African countries (Binam et al., 2015), can offer promising alternatives to tree planting (Ojuok and Ndayizigiye, 2020).

4.3.3. Policy initiatives related to SLM

Along with the interest of incorporating local knowledge, and a bottom-up approach in managing LD, almost all identified policy initiatives were reported by the land users as highly relevant in addressing LD (PLDS 6). Since land tenure is highly unregulated due to the lack of reforms, the current land tenure system promotes LD (Mabogunje, 2010). Protected areas also lack effective management and remain prone to encroachment in Nigeria (Fagbemigun, 2015). Thus, the five topmost policy initiatives identified (Fig. 8d) by the land users such as desertification and drought control, "population control" and climate change adaptation and mitigation, strict conservation and improved land tenure align with those identified in other studies addressing land-related problems in Nigeria (Adenle and Ifejika Speranza, 2020; Ifejika Speranza et al., 2019). Therefore, a policy shift in the direction of the identified land users' preference is needed to address LD (Crossland et al., 2018; Mortimore, 2016).

5. Conclusion

Using a combination of remote sensing and analysis of questionnaire survey of land users, this study exposes the status of LD in the three geopolitical zones of Niger State. It substantiates the land user's perceptual experience with remote sensing data about LD. The results from principal component analysis yielded four perception components for LD characteristics (PLDC 1: Vegetation condition dominated characteristics; PLDC 2: Soil condition dominated characteristics; PLDC 3: Vegetation with Sudano-Sahelian characteristics; PLDC 4: LULC with the prevalence of drier conditions), two perception components for LD drivers (PLDD 1: Human activities dominated drivers at a smaller scale; PLDD 2: Larger-scale drivers (nature-driven)) and six perception components for SLM practices (PLDS 1: Institutional actors' effect; PLDS 2: Natural resources management; PLDS 3: Environmentally friendly agricultural practices; PLDS 4: Tree-based initiatives; PLDS 5: Conservation initiatives; PLDS 6: Policy initiatives). Land users' perceptions also highlight how the activities of migrant farmers from neighbouring states drive LD in Niger state. The study also shows that conflicts in these areas, as well as local crime due to terrorism and banditry drive LD. Some of the land users' views give new insights on how to curb degradation which include promoting alternative livelihood strategies, poverty eradication and awareness about nature-based SLM practices such as tree-based initiatives, environmentally friendly agriculture supported by the necessary political will and institutions. This study can further be improved by deepening research to identify other determinants of perceptions of LD, to understand their interrelations and to identify the different aspects to be tackled in addressing LD and promoting SLM.

Credit author statement

Ademola A.Adenle: Writing- Original draft preparation. **Sébastien Boillat:** Writing- Reviewing and Editing. **Chinwe Ifejika Speranza**: Conceptualisation of the research project.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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