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Assessing the Impacts of Migration on Land Degradation in the Savannah Region of Nigeria

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Abstract: Migration-induced land degradation is a challenging environmental issue in Sub-Saharan Africa. The need for expansion due to urban development has raised the question of effective sustainable measures. Understanding migration and land degradation links is paramount for sustainable urban development and resource use. This is particularly true in Nigeria, where elevated migration levels frequently result in accelerated land degradation due to urban expansion. Given the need to understand the impact of migration on land degradation in the Savannah Region of Nigeria (SRN), this study introduces a novel approach by integrating remote sensing data (NDVI, NDBI) with local community perceptions (mixed-methods approach) to assess the impact of migration on land degradation in four migration destination communities located in two local government areas (LGAs) (Sabon Gari East and Sabon Gari West of Fagge LGA; Zuba and Tungamaje of Gwagwalada LGA). We conducted focus group discussions and a semi-structured survey with 360 household heads to obtain a comprehensive view of perceptions. Our findings revealed that 41.1% and 29.5% of the respondents agreed and strongly agreed that migration significantly contributes to land degradation. We analysed the spatiotemporal patterns of the Normalised Difference Vegetation Index (NDVI) and the Normalised Difference Built-Up Index (NDBI) acquired from Landsat 8 datasets for 2014 to 2023. While increasing NDBI values were observed in all communities, a slight decrease in NDVI was noted in Sabon Gari East and Tungamaje. Our analyses highlighted activities leading to land degradation such as land pressure due to built-up expansion at Sabon Gari East, Sabon Gari West, and Tungamaje, and deforestation at Zuba. Based on the varying challenges of migration-induced land degradation, we recommend adequate community participation in suggesting targeted interventions and policies to foster various adaptive capacities and sustainable environments within SRN communities and Sub-Saharan Africa.

Keywords: internal migration; vegetation loss; urban development; sustainable planning; land degradation

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Citation: Aweda, E.D.; Okhimamhe, A.A.; Obateru, R.O.; Schürmann, A.; Teucher, M.; Conrad, C. Assessing the Impacts of Migration on Land Degradation in the Savannah Region of Nigeria. *Sustainability* **2024**, *16*, 8157. https://doi.org/10.3390/su16188157

Academic Editor: Fernando António Leal Pacheco

Received: 1 August 2024
Revised: 12 September 2024
Accepted: 16 September 2024
Published: 19 September 2024

1. Introduction

Globally, urban growth driven by migration has become a major driver of land degradation, particularly in peri-urban areas [1,2]. Consequently, inadequate land planning increases land degradation through pressure on available resources and habitat destruction [3–5]. The continuous influx of migrants into urban areas drives unplanned urban expansion, leading to encroachment of natural habitats and exacerbation of land degradation [5–7]. Effective land planning is essential for sustainable development, but migration-driven urbanisation often challenges this endeavour [8,9].

In Sub-Saharan Africa, especially Nigeria, migration is a key driver of urban growth and land degradation [10,11]. Climate change, population increase, and socioeconomic conditions propel internal migration [12]. Over 70% of Nigerians live below the national poverty line, and migration is often adopted as a way to escape poverty and conflict, further intensifying urban expansion and land degradation [13]. This leads to the search for better economic opportunities and higher standards of living [4,14,15]. Internal migration within Nigeria often occurs across settlements, wards, local government areas (LGAs), and states through rural–urban, rural–rural, urban–urban and urban–rural movements [16]. This impacts the environment and livelihoods of the country by causing drought, erosion, food insecurity, and unemployment [17]. Studies have shown that urban growth and industrial activities contribute to land and environmental degradation [18–22], and attract migrants to emerging urban centres, further intensifying urban expansion and land degradation [23–25]. The rapid and poorly managed transition from natural landscapes to built-up areas, driven by increasing demographic pressure, plays a key role in vegetation loss and expansion of impervious surfaces [26–28].

Poor land governance, characterised by inadequate incorporation of land users' perceptions and experiences, results in less efficient mitigation measures against land degradation [29]. While remote sensing has been used for assessing urbanisation trends [30,31] and land degradation [19,32], identifying actual land degradation processes from assessments of a few land use change classes with comparatively low resolution remains challenging [33,34]. However, it can be suggested that integrating remote sensing with the description of site-specific processes and local community perceptions could facilitate a more comprehensive understanding of the negative trends induced by migration and the necessity for mitigation measures. Understanding the views of communities regarding who should lead such discussions can enhance the efficacy of these interventions. This will foster sustainable development, improve resilience against environmental challenges, and ensure the well-being of present and future generations [4,35]. Currently, no study in the Savannah Region of Nigeria (SRN) has considered people's perceptions of the impact of migration on land degradation. This study significantly contributes to the existing literature by incorporating the experiences and perceptions of local communities, which have been overlooked in previous research. This novel approach is crucial for urban planners and policymakers to understand the link between migration and land degradation, especially in historically urbanised or settled areas. The absence of recent, accurate data from regular population censuses in Nigeria has made it challenging to understand migration patterns [24]. However, local knowledge and perception can provide valuable insights into migration dynamics. Therefore, this study aims to evaluate the perception of the impact of migration on land degradation in the Savannah Region of Nigeria.

The study objectives are to:

1. Identify land degradation processes through the analysis of remotely sensed data at the migration hotspots;
2. Assess the perspectives of residents and migrants on the influence of migration on land degradation;
3. Evaluate the link between community perceptions of activities leading to land degradation and the remotely sensed land degradation processes;
4. Identify responsibilities in migration and land degradation interventions.

This research addresses the existing gap in understanding the complex relationship between migration and land degradation, particularly through the lens of local knowledge. Therefore, it contributes to developing sustainable practices and resilience against environmental challenges, and provides insights for sustainable development and resilience against environmental challenges. This will also contribute towards achieving the United Nations' Sustainable Development Goals, particularly Goal 15—"Life on Land".

2. Materials and Methods

2.1. Study Area

The study was conducted in four communities identified as major migration hotspots in the SRN. The study locations were Sabon Gari East, Sabon Gari West, Zuba, and Tungamaje (Figure 1). The selection process is part of the survey, as described in Section 2.3. The communities of Sabon Gari East and Sabon Gari West are located within the Fagge Local Government Area (LGA) of Kano State and have long been known to be one of the oldest immigrant settlements in Kano, dating back to the trans-Saharan trade in the 14th and 15th centuries. Traders were attracted to the city's strategic location along the trans-Saharan trade routes and the economic opportunities it offered [36,37]. Sabon Gari East and Sabon Gari West have been persistent destination hotspots for migrants to date [38]. In the indigenous language (Hausa), Sabon Gari is interpreted as "strangers' quarters", meaning an area earmarked for the settlement of migrants in the community [38]. Like other communities, they serve as major trade hubs. These communities are typical of settlements in Kano, one of Nigeria's most populous states. These areas comprise residential and commercial areas that are mostly unplanned [39]. Zuba and Tungamaje are communities within the Gwagwalada Area Council of the Federal Capital Territory. Both communities experienced in-migration due to economic and job opportunities, urban infrastructure, and proximity to the Federal Capital City of Abuja [40,41]. This has resulted in urban expansion and the rapid development of housing and infrastructure, leading to the encroachment of previously undeveloped land, loss of vegetation cover and an overall increase in land and environmental degradation, as evidenced in other communities in Abuja [42].

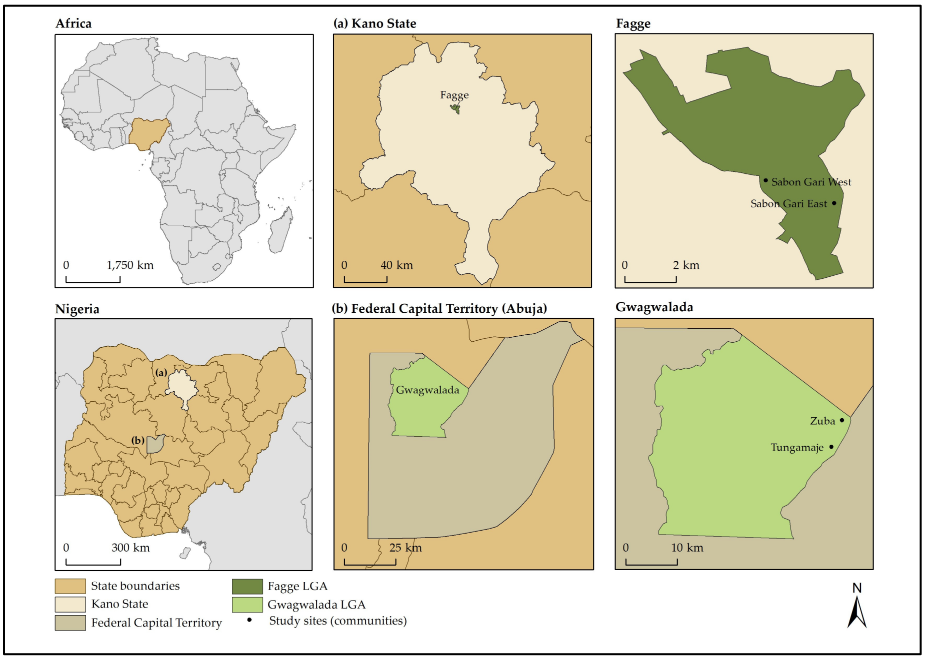

Figure 1. Map of Nigeria showing the study areas. Maps in left column indicates location of Nigeria (brown colour) in Africa and location of LGAs within Nigeria (bottom left). Central column highlights the LGAs location within the respective state of Nigeria and right column shows location of study areas within respective LGAs.

These study locations are in the Savannah Region of Nigeria (SRN). The SRN's predominantly rain-fed agricultural economy contributes to the region's livelihoods. It is home to diverse food crops cultivated primarily during the rainy season, including corn, sorghum, millet, rice, cowpea, groundnut, cassava, yam, and mango. Additionally, the region is a major producer of cash crops such as shea butter, citrus, acacia, and baobab [43,44]. Although the SRN is the food basket of the nation [45], it remains highly vulnerable to climate change and human-induced land degradation, thereby increasing food security issues [46].

2.2. Geospatial Analysis of Land Degradation

To assess land degradation through the spatiotemporal changes of vegetation and build-up within the last decade at the study locations, 30 m spatial resolution collection 1 tier remotely-sensed imagery scenes and data were obtained from Landsat 8 Operational Land Imager (OLI) between 2014 and 2023 using the Google Earth Engine (GEE) platform (https://earthengine.google.org, accessed on 29 May 2024) [47]. Images were selected from December, which represents the peak of the dry season, to obtain the highest quality, consistent data, and the least cloud cover within the context of the regular yearly pattern for locations in the tropical savannah [48]. The Fmask (Function of mask) algorithm was employed to select Landsat scenes from a single date, thereby ensuring minimal influence of cloud cover and shadows [49]. The mean of all values at each pixel across the stack of all matching bands for the two scenes available for the December image collection was then calculated. Then, the Normalised Difference Vegetation Index (NDVI) and Normalised Difference Built-Up Index (NDBI) were generated using the spectral bands of the Landsat 8 datasets. This was done to characterise the changing land degradation status of the communities.

NDVI is a widely used indicator of vegetation health and land degradation [50]. This is based on the difference between the near-infrared (ranging between 0.85 µm and 0.88 µm for Landsat 8/9) and red reflectance (ranging between 0.64 µm and 0.67 µm), [51]. It is calculated using Equation (1):

$$\text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}} \tag{1}$$

The NIR and RED spectral reflectance bands are the respective near-infrared and red spectral reflectance bands of the Landsat 8 data.

In the range of −1 to +1, NDVI can be used to indicate the presence of healthy vegetation and land degradation. NDVI values close to +1 indicate healthy and dense vegetation, whereas low NDVI values characterise non-vegetated surfaces. NDVI values close to zero are characteristic of bare soils and rocky and sealed surfaces, whereas water, clouds, and snow produce negative values [48]. A decrease in NDVI over time indicates loss of vegetation cover, a key indicator of land degradation.

The normalised difference built-up index (NDBI) is a useful metric for assessing the intensity of urbanisation, land cover change and land degradation in an area [52]. It is based on the difference between the shortwave infrared (SWIR) (wavelength ranging between 1.57 µm and 1.65 µm for Landsat 8/9) and NIR reflectance (0.85 µm–0.88 µm). The calculation of NDBI is expressed using Equation (2):

$$\text{NDBI} = \frac{\text{SWIR} - \text{NIR}}{\text{SWIR} + \text{NIR}} \tag{2}$$

SWIR and NIR are the shortwave infrared and near-infrared spectral bands of the Landsat 8 data, respectively.

NDBI values range from −1 to +1 and high NDBI values indicate large proportions of built-up areas and impervious surfaces [53]. An increase in NDBI values depicts the conversion of natural lands to urban or built-up areas, which is also a form of land degradation.

The analyses of changes in NDVI and NDBI complement each other to provide a comprehensive understanding of land degradation trends by capturing vegetation loss and expanding built-up areas [54].

2.3. Field Survey Data Collection and Analysis

We surveyed migration and land degradation using a purposive multi-stage random sampling design. The first stage involved a purposive selection of locations undergoing rapid urbanisation (Kano and Abuja). Second, four communities were selected based on official enumeration areas (EA) from two LGAs, Fagge (Kano) and Gwagwalada (Abuja), as identified destination hotspots for migrants [36,55,56]. The survey was conducted in enumeration areas (EA) as cluster communities, as adopted by (Oyeniyi, 2013) [16] and also recommended by (Taiwo et al., 2023) [57] for enhanced information accuracy. These areas were identified as in-migration hotspots by preliminary reconnaissance surveys. Finally, we selected a sample size of 90 household heads for each EA (totalling 360 respondents). This was due to the limited accessibility and availability of respondents (as utilised by (Oyeniyi, 2013) [16,58]. This approach ensured that a comprehensive picture of the different perceptions and experiences of the respondents was captured. Semi-structured questionnaires were administered. The data collection process was conducted by digitally integrating the questionnaire survey into the KoboToolbox application (Version 2.022.44) on mobile devices to ensure the accuracy and integrity of the collected data.

In each community, joint interaction sessions were conducted as open-ended focus group discussions (FGDs) (as suggested by Biaou et al., 2021 [59]) involving migrants, non-migrants, community elders, and various household heads. The first section highlights the respondents' perceptions of the impact of migration on destination communities. The second section presents how communities perceive the challenges of land degradation posed by migration. The third section provides the level of agreement on the impact of migration on land degradation on the scale of "strongly agree", "agree", "neutral", "disagree" and "strongly disagree". The last section examines respondents' views on who should take the lead in addressing migration-induced land degradation. The discussions focused on the participants' perceptions and opinions regarding the effects of migration on the host communities, with a focus on the past twenty years.

The Statistical Package for the Social Sciences (SPSS 20) was used for coding, processing descriptive statistical analysis of the obtained field survey data, and quantifying the perceived activities leading to land degradation, among other parameters. The results are presented as percentages, tables, and figures. The Kruskal–Wallis rank sum test, a nonparametric alternative [60], was employed to determine differences in perceptions of various communities. After the significant differences between communities were identified, pairwise comparisons were conducted to determine how specific communities perceived activities differently. These included adjustments, such as the Bonferroni correction, to control the overall Type I error rate (false positive) in the case of multiple comparisons [61].

2.4. Linking Processes and Perceived Activities Leading to Land Degradation

This study employs a novel methodological approach, integrating remote sensing data (NDVI and NDBI) with local community perceptions. This combination allows for a more detailed analysis of land degradation processes driven by migration, particularly at the community level. We evaluated the relationship between the remotely sensed processes and activities leading to land degradation as perceived by the respondents using the multinomial logistic regression model proposed by Hedeker (2003) [62], to analyse clustered or longitudinal nominal or ordinal response data. This methodology has been previously used to examine the relationship between land use changes (dependent) and socioeconomic (independent) variables [63], as well as community perceptions of population growth, economic activities, and climate (as independent variables) [64]. The factors (independent variables) leading to land degradation were identified based on local knowledge from field surveys at the study locations. The logistic regression model is often employed to assess the probability of the effects of independent variables on dependent variables [63] (Equation (3)).

$$\mathrm{Logit(Y)} = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n \quad (3)$$

where Y is the dependent variable, α is the intercept, $\beta_1 \ldots \beta_n$ are the coefficients of the associated independent variables, and $X_1 \ldots X_n$ are the independent variables. In this study, the NDVI and NDBI values as indicators of land degradation are the dependent variables, and the perceptions of activities leading to land degradation are the independent variables. This implies that changes in vegetation and built-up areas occurred due to identified activities that led to land degradation in each community.

The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were employed to determine the optimal model for regression analysis. In addition, the strength of the relationship between the observed land degradation processes and the perceived activities leading to land degradation was evaluated utilising the Nagelkerke R^2, as proposed in [65]. Nagelkerke R^2 represents an adjusted R^2 value that quantifies the proportion of the overall variance in the dependent variable that can be explained by the independent variables included in the logistic regression model [66]. The significance of these tests was established at a confidence level of 95%.

2.5. Ethical Considerations

This study addressed ethical issues and strictly adhered to relevant considerations. Efforts were made to ensure the cooperation of respondents in both interviews and focus group discussions (FGDs) by clearly explaining the purpose and aim of the study. They were also reassured of the utmost anonymity and confidentiality in their responses. Verbal consent was obtained from the respondents before the interviews and discussions, and they were informed that this study would not negatively impact the community or any individual.

3. Results

3.1. Spatiotemporal Patterns of Land Degradation

The NDVI and NDBI in the Sabon Gari East and Sabon Gari West communities of Fagge LGA exhibited spatial and temporal variations between 2014 and 2023 (Figures 2 and 3). A decline in vegetation was observed in the northern region of the larger surroundings of the investigated communities (in Fagge LGA) (Figure 2a,b). This development is also visible in the western part of Sabon Gari East, where new buildings have been constructed along a small body of water (Figure 3). Conversely, vegetation has increased slightly in Sabon Gari West, although this is not reproducible in the Google Earth images (Figure 3). The settlement areas in LGA Fagge underwent intense densification (Figure 2c,d). Meanwhile, both communities exhibited comparable temporal patterns of increased built-up areas, with Sabon Gari West experiencing a notably larger proportion than Sabon Gari East. The descriptive summary statistics of these indices (Table 1) and a view of the Google Earth images of both communities in 2014 (Figure 3a) and 2023 (Figure 3b) confirm the increase in the built-up areas, particularly in Sabon Gari West, and the minimal presence of green spaces and changes in vegetation. On the other hand, the multiannual Landsat data (2014–2023) of these communities demonstrate considerable variations in the utilisation of NDVI and NDBI over the years (Figure 4). The well-known challenges associated with the use of these indices (such as the varying quality of the atmospheric correction, alterations in illumination and viewing geometries, and the dependency on seasonal meteorological development) introduce an inherent degree of uncertainty to the indices. However, these trends underpin the interpretation of the change analysis.

The vegetation patterns in the Zuba and Tungamaje communities of Gwagwalada LGA (Figures 5 and 6) were similar to those observed in Fagge LGA. The NDVI indicated a decline in vegetation cover in Zuba, whereas Tungamaje exhibited minimal changes in vegetation between the study years. Despite the apparent stability of the vegetation cover, Tungamaje exhibited a higher rate of built-up expansion and densification of settlement bodies, a result similar to that observed in Sabon Gari West. In contrast, Zuba demonstrated a slight increase in the expansion of built-up areas. The descriptive summary statistics of these indices (Table 1) and a view of the Google Earth images of Zuba and Tungamaje in 2014 (Figure 7a) and 2023 (Figure 7b) indicate an increase in built-up areas, particularly in Tungamaje. The built-up areas in Zuba were already well-established in 2014.

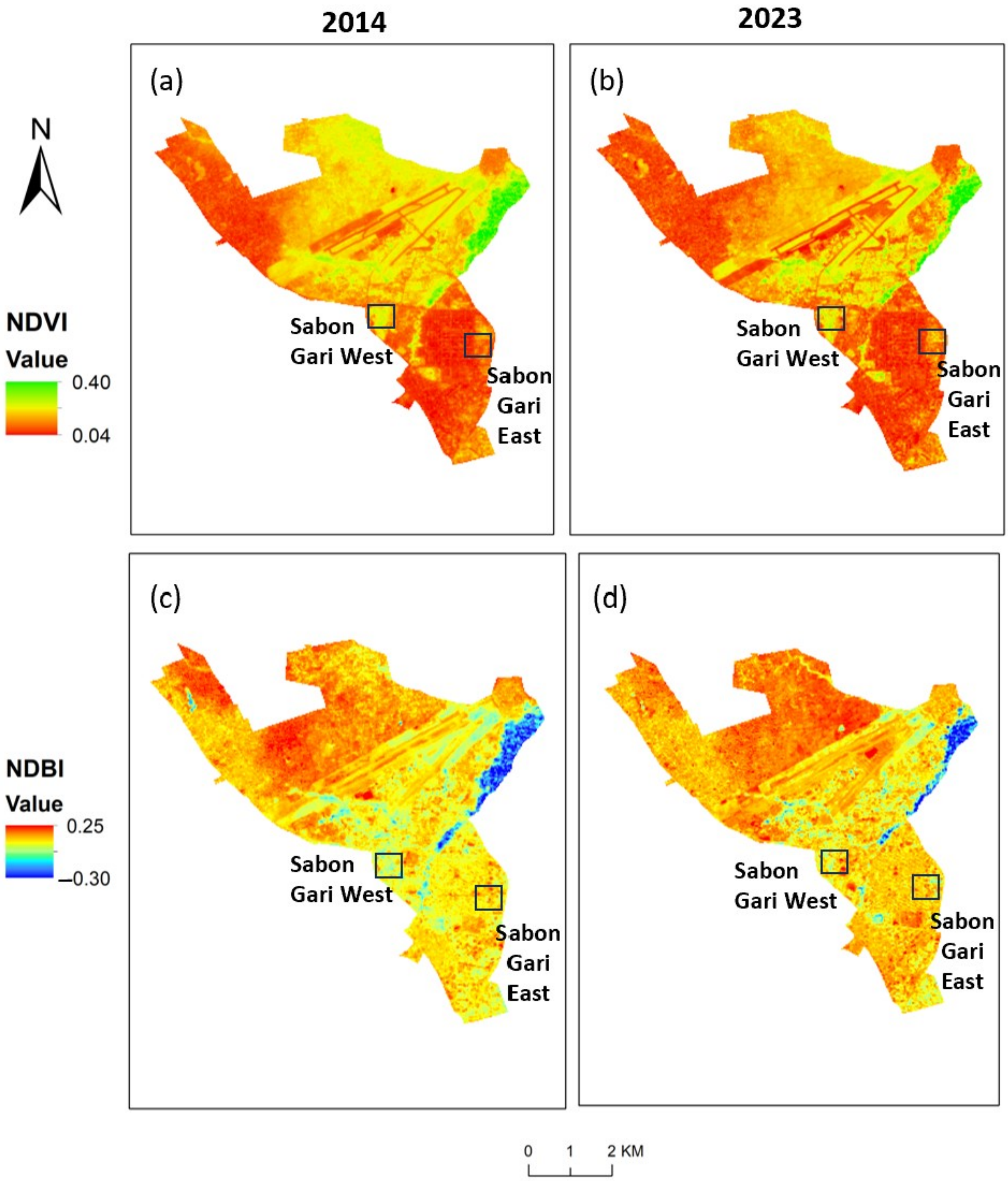

Figure 2. Spatial distribution of NDVI (**a**,**b**) and NDBI (**c**,**d**) at the study locations in Fagge in 2014 and 2023.

Table 1. Summary of NDVI and NDBI distributions at the study locations.

Location	Parameter	Year	Mean	Minimum	Maximum	SD
Sabon Gari East	NDVI	2014	0.05	0.02	0.15	0.02
		2023	0.05	0.00	0.19	0.03
	NDBI	2014	0.02	−0.02	0.08	0.01
		2023	0.03	−0.07	0.11	0.02

Table 1. *Cont.*

Location	Parameter	Year	Mean	Minimum	Maximum	SD
Sabon Gari West	NDVI	2014	0.10	0.04	0.18	0.03
		2023	0.10	0.02	0.22	0.04
	NDBI	2014	0.01	−0.07	0.08	0.02
		2023	0.03	−0.05	0.19	0.03
Zuba	NDVI	2014	0.16	0.04	0.28	0.05
		2023	0.14	0.03	0.32	0.05
	NDBI	2014	0.02	−0.18	0.15	0.04
		2023	0.04	−0.14	0.15	0.03
Tungamaje	NDVI	2014	0.16	0.06	0.30	0.05
		2023	0.16	0.04	0.33	0.05
	NDBI	2014	0.02	−0.16	0.20	0.04
		2023	0.02	−0.17	0.23	0.03

(a)

(b)

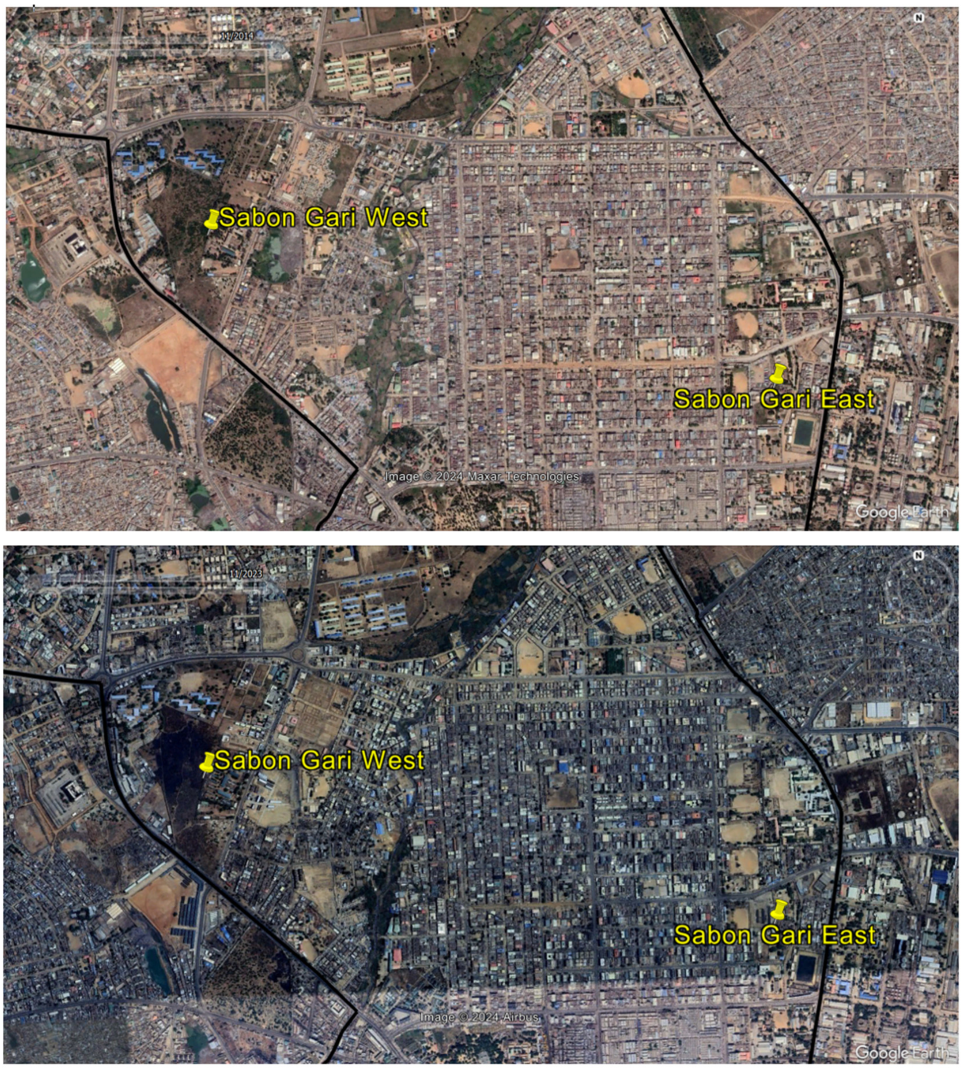

Figure 3. Built-up areas at Sabon Gari East and Sabon Gari West of Fagge LGA in (**a**) 2014 and (**b**) 2023 (Source: Google Earth, 2024).

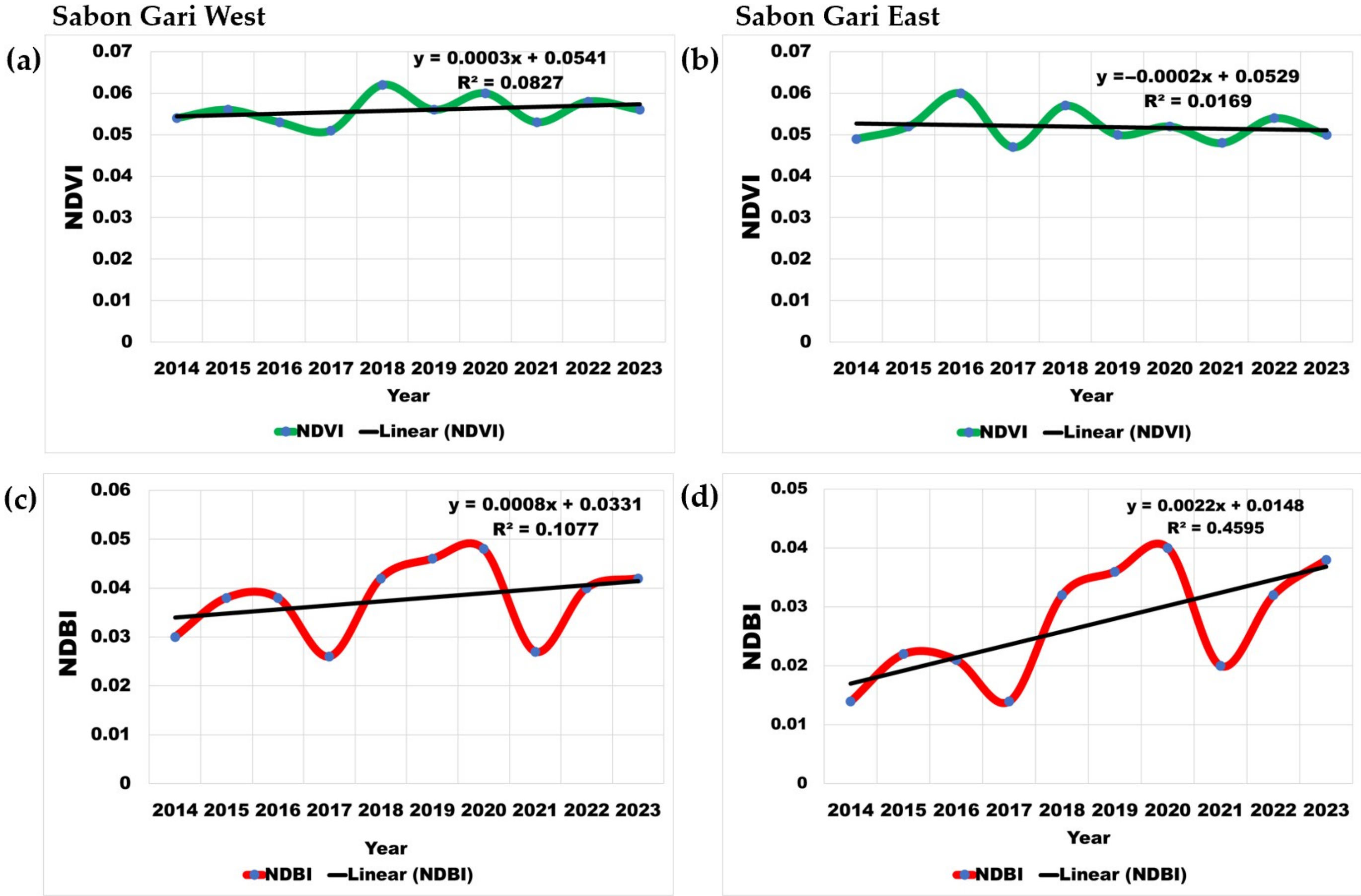

Figure 4. Temporal variations in NDVI (**a**,**b**) and NDBI (**c**,**d**) at Sabon Gari West and Sabon Gari East in 2014 and 2023.

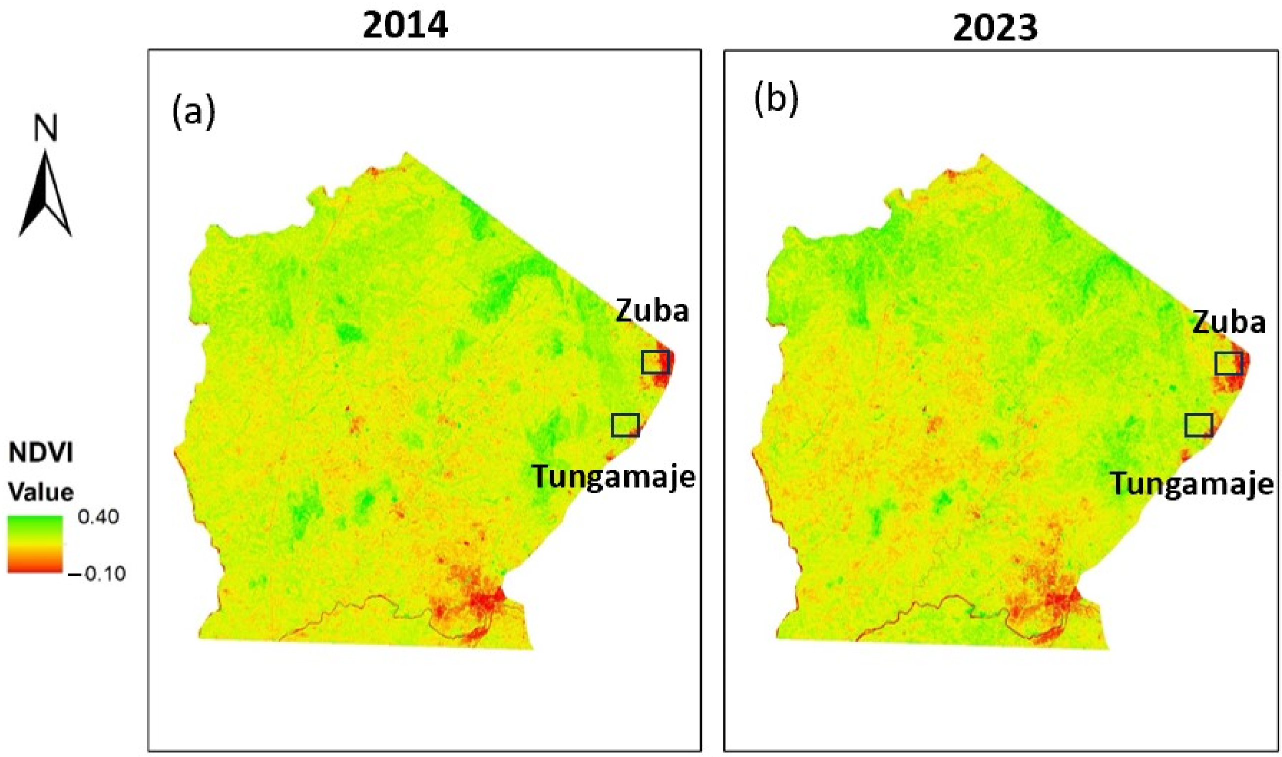

Figure 5. *Cont.*

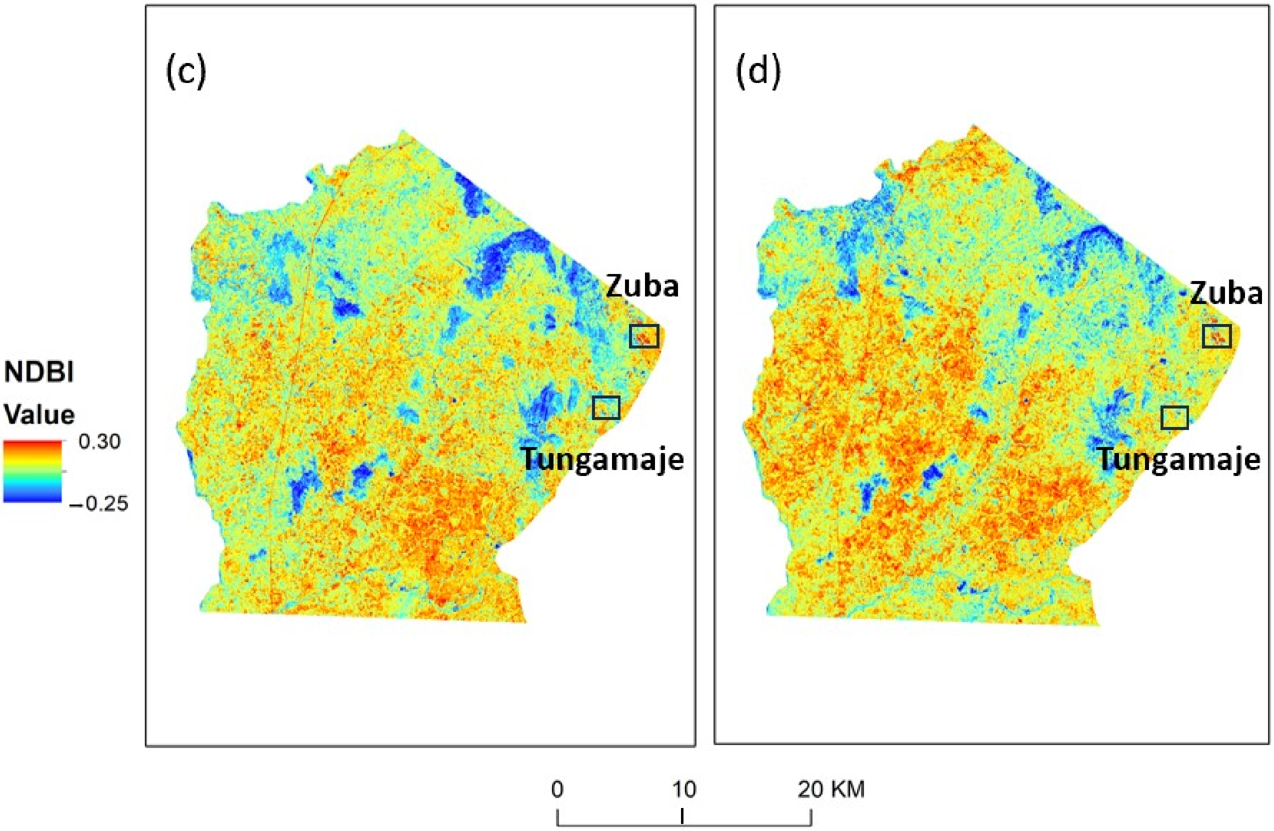

Figure 5. Spatial distribution of NDVI (**a**,**b**) and NDBI (**c**,**d**) at the study locations in Gwagwalada in 2014 and 2023.

(a)

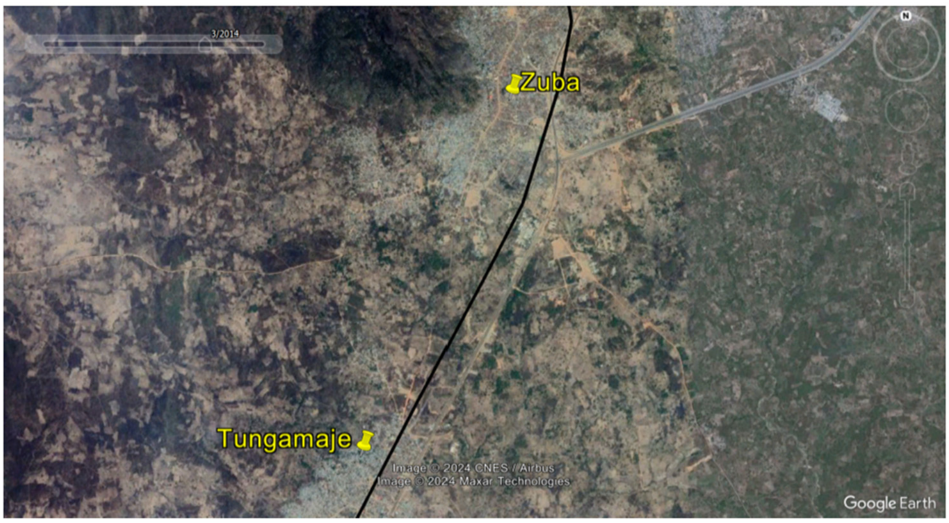

Figure 6. *Cont*.

(b)

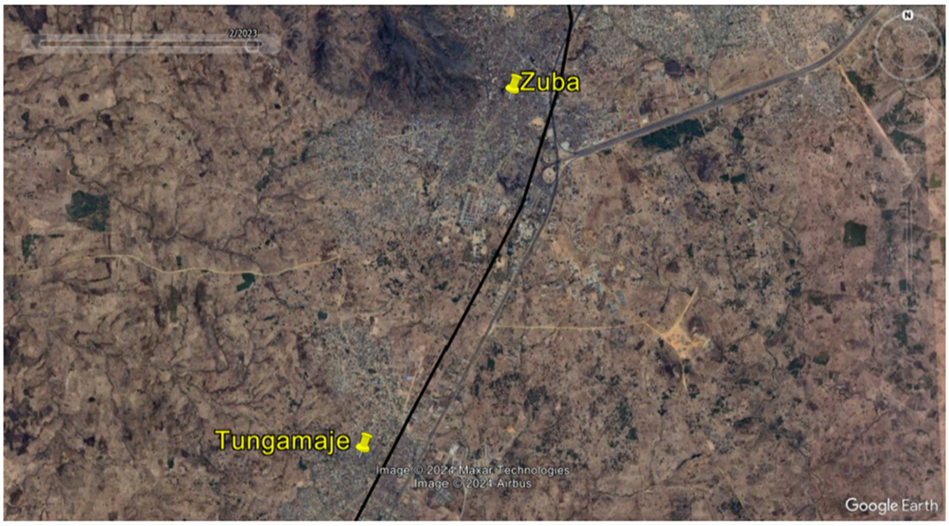

Figure 6. Built-up areas in Zuba and Tungamaje of Gwagwalada LGA in (**a**) 2014 and (**b**) 2023 (Source: Google Earth, 2024).

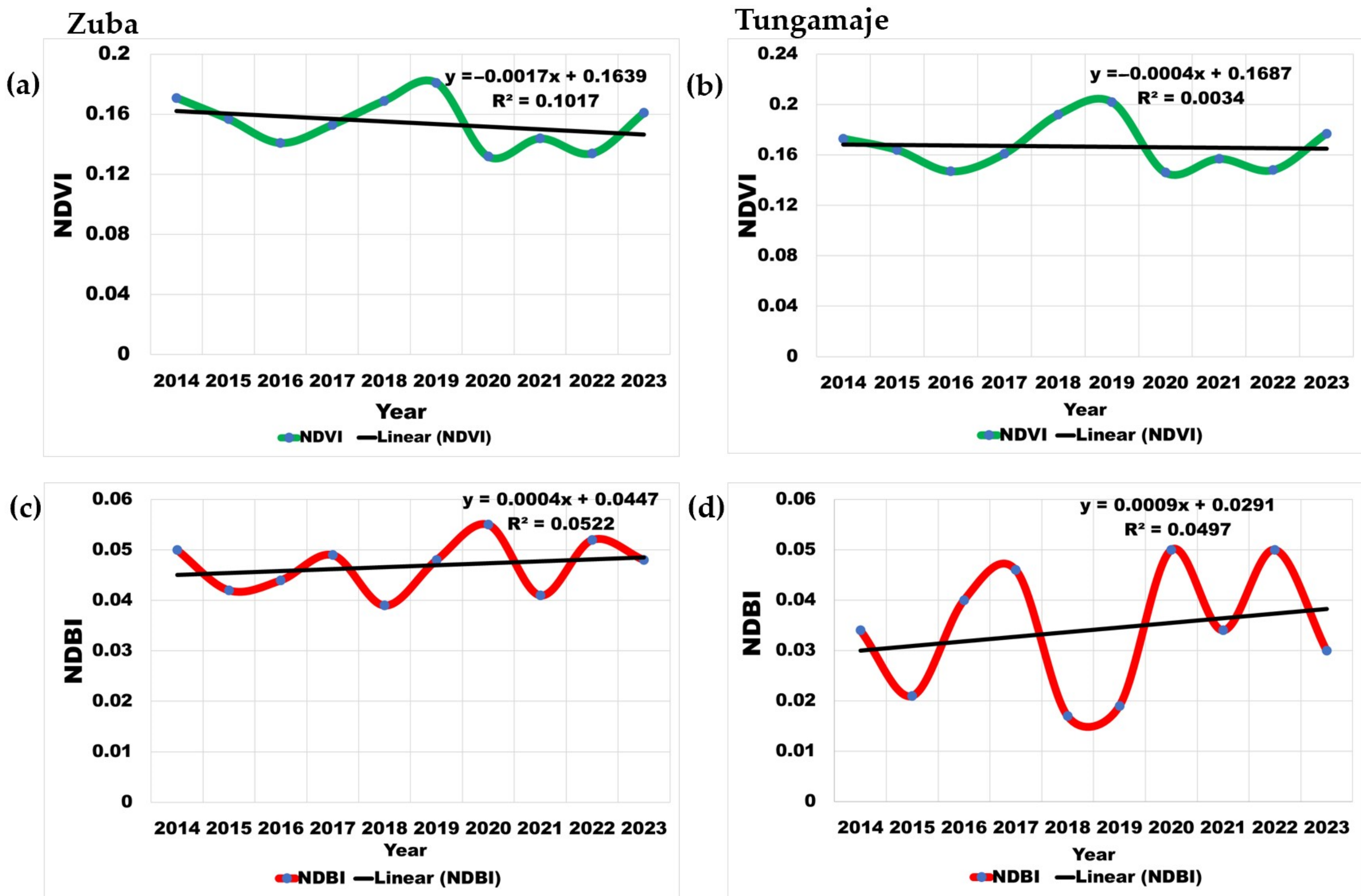

Figure 7. Temporal variations in NDVI (**a**,**b**) and NDBI (**c**,**d**) in Zuba and Tungamaje in 2014 and 2023.

3.2. Impacts of Migration on Destination Communities

3.2.1. Perceived Challenges of Communities Due to Migration

In each community surveyed, the respondents identified various challenges associated with migration within the 500 m radius of where they lived. In Sabon Gari East, competition for jobs was perceived as the most prominent challenge, (52.2%), followed by insecurity (15.9%) (Figure 8). Insecurity was identified as the primary challenge in Sabon Gari West and Tungamaje, with 55.6% and 53.8% of respondents citing concerns about safety and crime rates (Figure 6). Interestingly, Zuba residents expressed relatively lower levels of concern about insecurity but highlighted issues such as land degradation (24.8%) and pressure on agricultural lands (5.7%) (Figure 6). Insecurity was generally mentioned as having the greatest migration challenge across communities, followed by competition for jobs and land degradation. The Kruskal–Wallis test revealed a statistically significant difference in the perception of various community challenges due to migration ($H = 30.324$, $p < 0.05$) (Table A1). The post hoc test identified significant pairwise variation between the communities: Sabon Gari West–Tungamaje ($H = -69.060$, $p < 0.05$), Sabon Gari East–Tungamaje ($H = -64.840$, $p < 0.05$), and Zuba–Tungamaje ($H = 64.840$, $p < 0.05$) (Table A2).

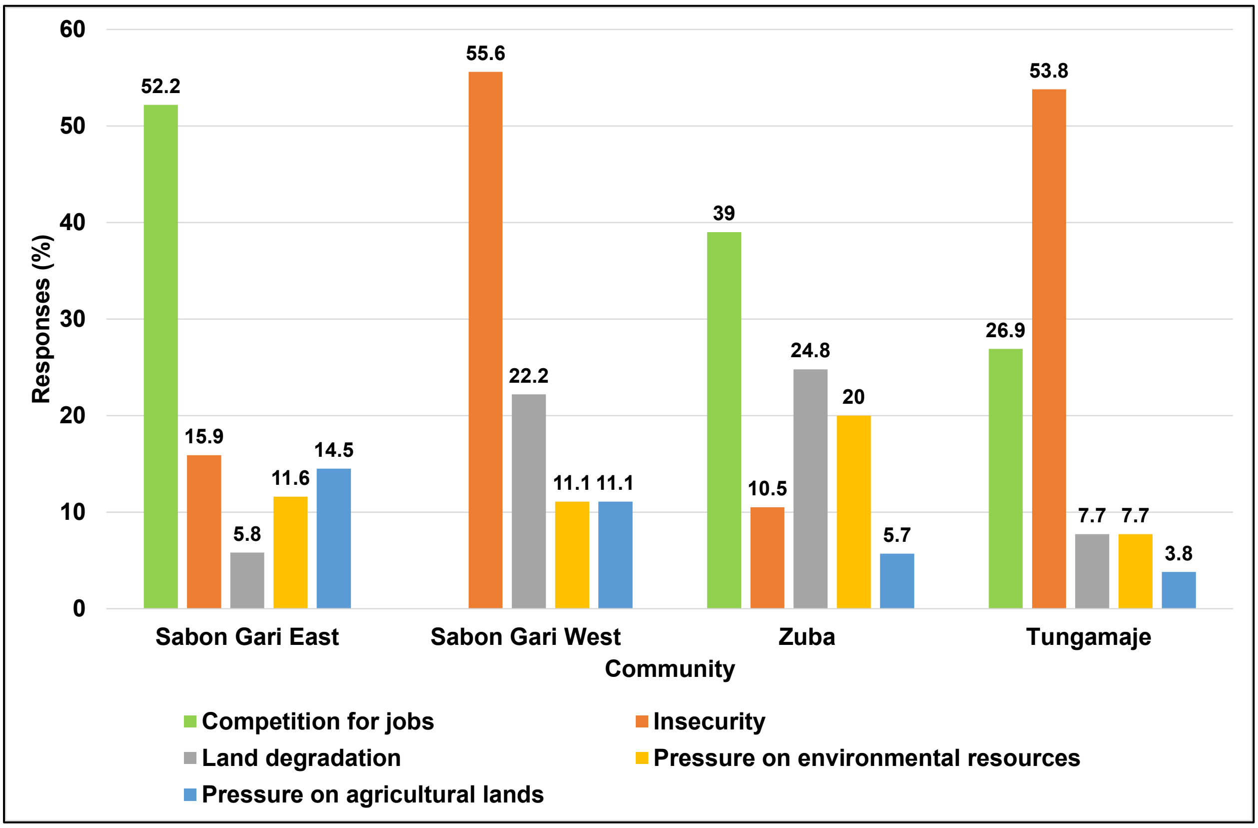

Figure 8. Perceptions of community challenges due to migration.

3.2.2. Perceptions of Land Degradation Challenges Due to Migration

In each surveyed community, respondents perceived different land-degrading activities within 500 m of where they lived. Pressure on land for development was the major concern in Sabon Gari West and Sabon Gari East (59.5% and 71.7%, respectively) (Figure 9). Deforestation and vegetation loss were also concerns in Sabon Gari West, with 35.1% of respondents identifying this as a key issue (Figure 9). In Tungamaje, pressure on agricultural lands and pressure on land for development were equally cited as the main challenges by 50% of respondents (Figure 9). Notably, in Zuba, deforestation/vegetation loss was overwhelmingly identified as the only challenge, with 100% of respondents expressing concerns about this issue (Figure 9). On average, pressure on land for development and deforestation/vegetation loss were the two highest factors of land degradation. There was no significant difference in perceptions of migration as a reason for land degradation ($H = 6.853$, $p = 0.077$) (Table A1), as the communities generally agreed on the common activities leading to land degradation.

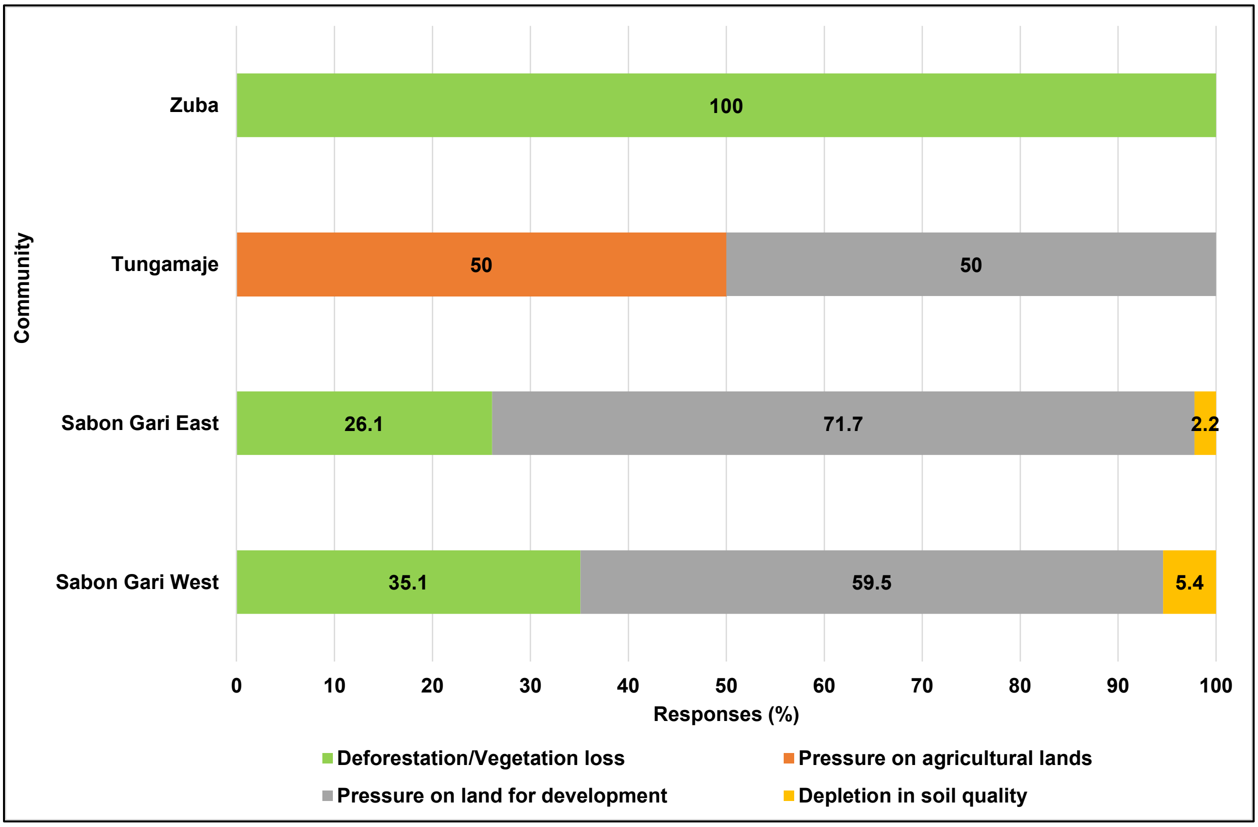

Figure 9. Perception of land degradation challenges due to migration.

The average proportion of respondents who strongly agreed and agreed that migration contributed to land degradation was 29.5% and 41.1%, respectively, while 18.4% were neutral (Table 2). There was no significant difference in these levels of agreement among respondents from the different communities ($H = 4.010$, $p = 0.260$) (Table A1). This was confirmed by the participants at the FGDs, who unanimously agreed that most land degradation activities were consequences of population pressure caused by the influx of migrants into their communities.

Table 2. Perception of migration as a cause of land degradation.

Option	Sabon Gari East	Sabon Gari West	Zuba	Tungamaje	Average
Strongly agree	35.6%	33.3%	28.9%	20.0%	29.5%
Agree	42.2%	42.2%	37.8%	42.2%	41.1%
Neutral	15.6%	17.8%	20.0%	20.0%	18.4%
Disagree	4.4%	4.4%	11.1%	15.6%	8.9%
Strongly disagree	2.2%	2.2	2.2%	2.2%	2.2%

3.3. Effects of Perceived Land Degradation Activities on Land Degradation Processes

To reconcile the remotely sensed land degradation processes with local knowledge of the various activities leading to land degradation, the multinomial logistic regression model produced Nagelkerke R^2 values of 0.166 (Sabon Gari East), 0.225 (Sabon Gari West), 0.391 (Zuba), and 0.221 (Tungamaje) (Table A3). In Sabon Gari East, Sabon Gari West, and Tungamaje, the pressure on land for development (for urban growth and infrastructure expansion) significantly contributed to land degradation. Meanwhile, deforestation/vegetation loss substantially contributed to the observed land degradation at Zuba (Table A4). These findings align with the local perceptions of land degradation, which identified built-up expansion as a major issue in Sabon Gari East, Sabon Gari West, and Tungamaje. Meanwhile, deforestation was a key concern in Zuba.

An FGD respondent from Sabon Gari East confirmed the pressure on land for development (Figure 10a):

Figure 10. (**a**) Improper sewage disposal along a drainage system at Sabon Gari East. (**b**) Stacking of chopped logs in Zuba. (**c**) Sale of charcoal, a major cooking fuel in Zuba. (Source: Author's fieldwork, 2023).

> *We often experience flooding because of the influx of traders and the rapid increase in shopping complexes and business centres. This is worse because of the poor sewage disposal system, which has blocked the waterways. The lack of proper drainage has resulted in water runoff into our homes and businesses, and we cannot do anything about it. A rainfall period of one hour can cause everywhere to be submerged in water.*

Chopped logs and charcoal, the by-products of logging, were used to meet the growing energy demands in Zuba (Figure 10b,c). One of the FGD participants confirmed this statement:

> *For some decades now, the increase in population due to the influx of migrants has led to the cutting down of our trees to produce charcoal as fuel for cooking. This has exposed our environment, and the temperature is increasing. We hope that the government will do something about this situation.*

At Tungamaje, the participants at the FGD explained:

> *Due to the rapid development rate in our community, migrants come in and buy our lands from the government without our knowledge. We would wake up one day and discover that our farmlands had been cleared, the trees had been removed, and a new owner was building on it. We often have intense fights with impostors to defend our farmlands.*

3.4. Perceptions of Responsibility for Leading Migration and Land Degradation Interventions

Most respondents opined that the government should lead discussions and interventions on migration and land degradation, with percentages ranging from 43.7% to 59.2% (Figure 11). While 16.5% of responses at Sabon Gari East indicated that community leaders should be involved in leading land degradation interventions, this view was also supported by respondents at Sabon Gari West (16.4%), Zuba (22.7%), and Tungamaje (29.8%). Notable mentions of politicians were made at Sabon Gari East (21.6%) and Sabon Gari West (19.2%), while religious bodies and Non-Governmental Organizations (NGOs) were perceived as less prominent factors for such interventions and discussions. Communities differed significantly in their perception of who takes the responsibility to lead discussions and interventions on migration-induced land degradation (H = 12.973, $p < 0.05$) (Table A1), with the post hoc test identifying significant pairwise variations between Tungamaje–Sabon Gari West (H = 36.601, $p < 0.05$), Tungamaje–Sabon Gari East (H = 50.811, $p < 0.05$), and Tungamaje–Zuba (H = −29.844, $p < 0.05$) (Table A5).

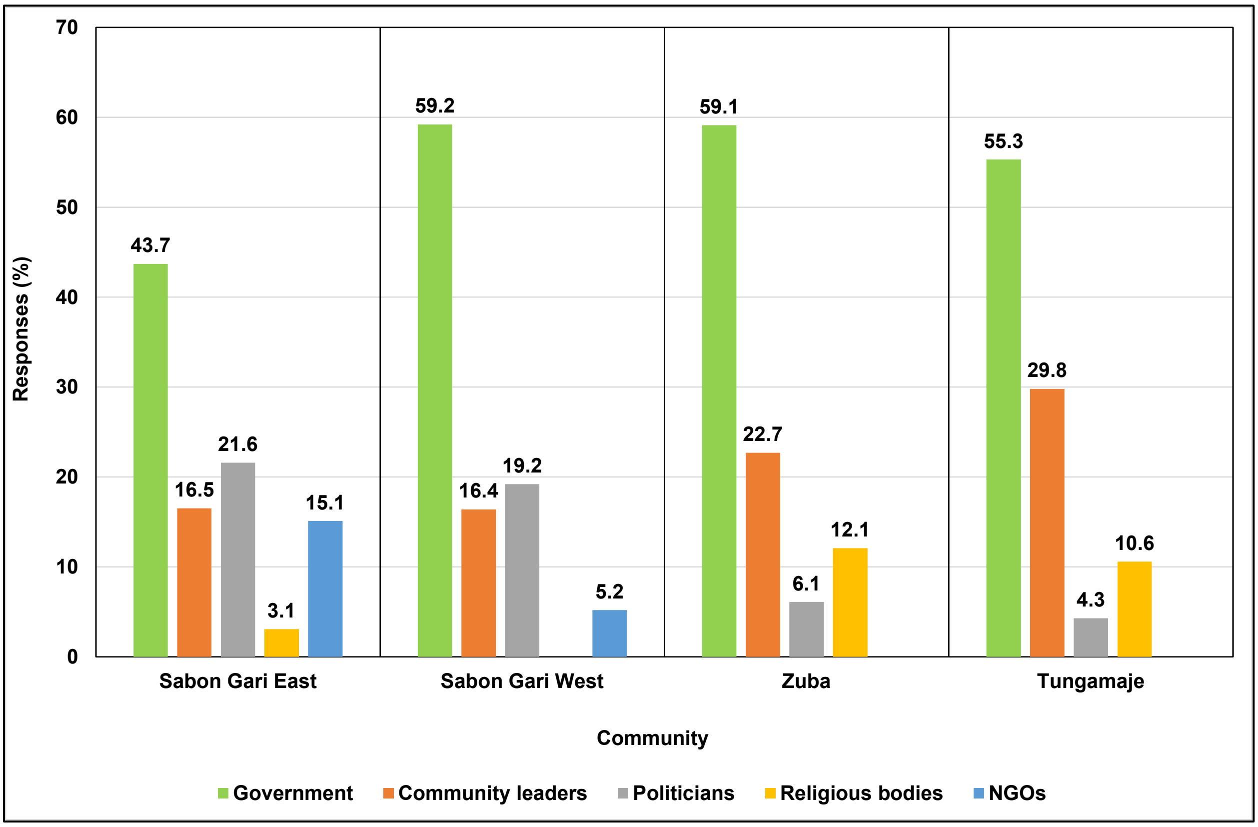

Figure 11. Perceptions of Land Degradation Discussions and Interventions.

4. Discussion

Migration poses several challenges for destination communities. Internal migration, particularly from less developed regions, negatively affects the social well-being of destination communities [67]. Land degradation was the third most prominent effect of in-migration on the destination communities, after competition for jobs and insecurity. On average, 29.5% and 41.1% of respondents strongly agreed and agreed that migration contributes to land degradation. Various stakeholders at the FGD echoed this sentiment, which attributed land degradation to the consequences of population pressure, exacerbated by the influx of migrants into their communities. Land degradation was confirmed through the decrease in NDVI and increase in NDBI between 2014 and 2023, indicating the expansion of built-up areas and a diminishing vegetation status at the study locations (Figures 3 and 4). This is consistent with the findings of Koko et al. (2021) [68] who attributed the decline in NDVI and increase in NDBI to urban expansion in Kano, northern Nigeria. The already established and further development of built-up land is at variance with the decline in vegetation, as indicated by the NDVI and NDBI analyses. The findings of the FGDs revealed that deforestation was perceived as a significant contributor to land degradation, particularly in Zuba and Sabon Gari West, where 100% and 35.1% of respondents, respectively, identified deforestation as a major activity leading to this phenomenon. Meanwhile, communities like Tungamaje, Sabon Gari East and Sabon Gari West identified pressure on land for development (due to in-migration) in proportions of 50%, 71.7%, and 59.5%, respectively, perceiving it as the major contributor leading to land degradation in their communities (Figure 8). Migration-induced pressure on land for development indicates increased demand for land for housing and infrastructure. This can lead to the loss of agricultural land, green spaces, and natural resources [69].

There was no significant difference in the perceptions of migration as a driver of land degradation and the activities leading to land degradation in the various communities (Table A1). This is consistent with findings that have attributed the existence of land degradation to anthropogenic activities in the Guinea Savannah [18] and population influx in Kano State of Nigeria [70]. The similar perceptions of most respondents establish the existence of major activities leading to land degradation through deforestation and pressure on land for development. While urban growth is associated with sustainable economic development [71], it can also lead to land degradation through the loss of natural habitats, soil sealing, and increased pollution, as highlighted by the focus group participants in all the communities. To meet the energy needs associated with urban growth, community members resort to felling of trees (deforestation), especially for cooking [72]. Further analysis through the Nagelkerke R^2 confirms that major contributors to land degradation depend on the activities peculiar to each community. Sabon Gari East, Sabon Gari West, and Tungamaje are known for built-up expansion, while deforestation and vegetation loss are prominent in Zuba and Sabon Gari West. The loss of vegetation through deforestation and degradation of natural ecosystems and agricultural lands leads to environmental impacts such as soil erosion, biodiversity loss, and climate change [73–75]. The rapid expansion of built-up areas in Sabon Gari West can be attributed to the ever-increasing urban growth typical of the Kano metropolis, as highlighted by [76].

The significant difference in the perception of who presides over interventions on land degradation issues (Table A1) implies the need for all-inclusive decision-making. All relevant stakeholders must be involved in the decision-making process to address land degradation issues. It is also important to tailor these discussions based on specific intervention modes and unique differences in each community, as shown in Table A5.

5. Limitations of the Approach and Implications for Future Research

Remote sensing techniques can provide valuable insights into the dynamics of land degradation. However, the results of this study hinged on the temporal scope of the available data. For example, urban development had already begun in all communities before the availability of downloadable Landsat 8/9 data, which were accessible from 2014. We initially considered using a land use data transfer matrix for multiple periods. The analysis yielded minimal results due to established extensive urban growth and land use changes before adequate remote sensing data became available. The limitation of the traditional land use and land cover change analysis informed the use of NDVI and NDBI, which provided a better overview of the current state of land degradation at these locations. To better understand the history of urban growth and the long-term migration patterns of each community, it is essential to have access to archived historical information, which is not readily available from consistent, remotely sensed data across all communities. Historical city maps, plans, and official documents may compensate for this shortcoming. To obtain the optimal image quality for this study, the geospatial and temporal assessments of urban growth and vegetation changes were derived from December scenes, which correspond to the peak of the dry season. This approach was used to minimise the effects of cloud cover (which may distort the actual values). While this may provide good insight for the analysis of urban growth, it may be inadequate for illustrating the vegetative health of these locations because of the drastic decline in the vegetation properties characteristic of dry seasons. In addition, the difficulty of attributing local development derived from remote sensing to migration or other drivers of degradation, such as natural population growth, must be acknowledged. In-depth land degradation studies on such communities would require data with higher spatial resolution. One example is Sentinel-2 with a spatial resolution of 10 m. However, this sensor is not appropriate for long-term studies because the first Sentinel-2 platform was launched in 2015, and the earliest operational data available for Africa is from 2017 [77].

While efforts are continuously made to integrate remote sensing data into social survey studies, empirical inferences from such a mixed-methods approach should be made with caution due to the considerable differences in the scale and details of satellite-based indicators and perception-based data. An empirical understanding of migration patterns, dynamics and their impacts on the localised scale is important, in addition to adequate population census data at the community level.

6. Conclusions

Migration-induced land degradation is a global concern, and this study confirms its presence in the SRN, particularly in areas like Sabon Gari East, Sabon Gari (of Fagge LGA), Zuba, and Tungamaje (of Gwagwalada LGA). Using a combination of geospatial remote sensing techniques (NDVI and NDBI) and community perceptions, the study reveals ongoing urban expansion and vegetation loss, which have serious implications if not managed properly. Integrating remote sensing data with local community insights represents a novel and innovative approach to studying land degradation in migration hotspots. This approach offers valuable insights for urban planners and policymakers.

The major contributors to land degradation identified were built-up expansion and deforestation. Community involvement is essential to create targeted interventions, and migration governance should be integrated into urban planning and sustainable development strategies. Implementing sustainable land management practices and monitoring these trends through remote sensing and field surveys will help preserve land resources for future generations.

Author Contributions: Conceptualisation, E.D.A., A.A.O. and C.C.; funding acquisition, A.A.O. and C.C.; methodology, E.D.A., A.A.O. and C.C.; formal analysis, E.D.A., A.A.O. and C.C.; data curation, E.D.A.; investigation, E.D.A., A.A.O. and C.C.; writing—original draft preparation, E.D.A., A.A.O. and C.C.; writing—review and editing, E.D.A., A.A.O., R.O.O., A.S., M.T. and C.C.; supervision, E.D.A., A.A.O. and C.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research is part of a doctoral research project implemented by Rural-Urban Migration and Cross Border Migration in West Africa: An Integrated Assessment Framework for Drivers, Processes and Sustainable Responses (MIGRAWARE) and funded by the German Federal Ministry of Education and Research (BMBF).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available on request due to restrictions (privacy and ethical reasons).

Acknowledgments: The authors acknowledge the support of the staff of the Climate Change and Human Habitat Programme, West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Federal University of Technology Minna, Minna, Nigeria. We also acknowledge the support of the Institute for Geosciences and Geography, Department of Geoecology, Martin Luther University, Halle-Wittenberg, Germany.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Kruskal–Wallis test on different perceptions across communities.

Category	Null Hypothesis	Test Statistic (H)	*p*-Value	Decision
Perception of community challenges due to in-migration	The distribution of challenges encountered due to migration is the same across the communities.	30.324 [a]	<0.001 *	Reject the null hypothesis

Table A1. *Cont.*

Category	Null Hypothesis	Test Statistic (H)	p-Value	Decision
Perception of migration as a reason for land degradation	The distribution of perceptions that in-migration has led to land degradation is the same across the communities	4.010 [a,b]	0.260	Retain the null hypothesis.
Perception of land degradation challenges due to migration	The distribution of the perception of land degradation challenges due to migration is the same across the communities	6.853 [a,b]	0.077	Retain the null hypothesis.
Perception of land degradation discussions and interventions	The distribution of perception of land degradation discussions and interventions is the same across the communities	12.973 [a]	0.040 *	Reject the null hypothesis.

* Significant at $p < 0.05$. [a.] The test statistic is adjusted for ties. [b.] Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Table A2. Pairwise comparisons of community challenges due to in-migration.

Sample 1–Sample 2	Test Statistic	Std. Error	Std. Test Statistic	p-Value	Adj. Sig. [a]
Sabon Gari West–Sabon Gari East	4.198	13.853	0.303	0.762	1.000
Sabon Gari West–Zuba	−4.220	12.837	−0.329	0.742	1.000
Sabon Gari West–Tungamaje	−69.060	15.155	−4.557	<0.001 *	<0.001 *
Sabon Gari, East–Zuba	−0.022	11.582	−0.002	0.999	1.000
Sabon Gari East–Tungamaje	−64.862	14.107	−4.598	<0.001 *	<0.001 *
Zuba–Tungamaje	64.840	13.110	4.946	<0.001 *	<0.001 *

* Significant at $p < 0.05$. [a.] Significance values have been adjusted using the Bonferroni correction for multiple tests.

Table A3. Multinomial logistic regression model outcome for activities leading to land degradation.

Location	Model	Model Fitting Criteria			Likelihood Ratio Test			R^2 (Nagelkerke)
		AIC	BIC	−2 Log Likelihood	X^2	df	Sig.	
Sabon Gari East	Intercept	255.65	148.21	327.18	36.65	12	<0.001 *	0.166
	Final	108.32	395.29	223.65				
Sabon Gari West	Intercept	235.08	145.08	198.35	49.31	12	<0.001 *	0.225
	Final	149.14	189.53	117.14				
Zuba	Intercept	218.50	164.45	230.30	76.66	12	<0.001 *	0.391
	Final	155.65	195.24	123.65				
Tungamaje	Intercept	335.48	245.08	227.08	69.91	12	<0.001 *	0.221
	Final	234.34	248.97	130.33				

* Significant at $p < 0.05$.

Table A4. Likelihood ratio tests of multinomial logistic regression for specific perceived activities leading to land degradation in each community.

Effect	Sabon Gari East			Sabon Gari West			Zuba			Tungamaje		
* *Y*	X^2	df	p-Value	X^2	df	p-Value	X^2	df	p-Value	X^2	df	p-Value
Deforestation/Vegetation loss (X_1)	15.79	5	0.257	22.92	5	0.546	12.59	6	<0.001 *	-	-	-
Pressure on land for development (X_2)	14.66	5	<0.001 **	13.74	5	<0.001 *	15.82		-	-	-	-
Soil quality depletion (X_3)	21.58	5	0.127	43.01	5	0.325	-	-	-	56.23	9	0.701

Table A4. *Cont.*

Effect	**Sabon Gari East**			**Sabon Gari West**			**Zuba**			**Tungamaje**		
* Y	X^2	**df**	***p*-Value**	X^2	**df**	***p*-Value**	X^2	**df**	***p*-Value**	X^2	**df**	***p*-Value**
Pressure on agricultural land (X_4)	-	-	-	-		-			-	23.76	9	0.130

* Land degradation process (dependent variable). ** Significant at $p < 0.05$.

Table A5. Pairwise comparisons of the land degradation discussions and interventions.

Sample 1–Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	***p*-Value**	**Adj. Sig. [a]**
Tungamaje–Zuba	−29.844	15.133	−1.972	0.049 *	0.292
Tungamaje–Sabon Gari West	36.601	14.527	2.519	0.012 *	0.071
Tungamaje–Sabon Gari East	50.811	14.262	3.563	<0.001 *	<0.001
Zuba–Sabon Gari West	6.757	12.885	0.524	0.600	1.000
Zuba–Sabon Gari East	20.968	12.585	1.666	0.096	0.574
Sabon Gari West–Sabon Gari East	14.211	11.849	1.199	0.230	1.000

* Significant at $p < 0.05$. [a.] Significance values have been adjusted using the Bonferroni correction for multiple tests.

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