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Understanding Local Perspectives on the Trajectory and Drivers of Gazetted Forest Reserve Change in Nasarawa State, North Central Nigeria

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Abstract

Understanding forest-cover change and its drivers is vital for global forest management and policy development. This study analyzed perceptions of historical drivers behind land-use/land-cover change (LULCC) and forest change in gazetted forests from 1966 to 2022 to evaluate the impact of human activities around the gazetted forest reserves, comparing three forests in Nasarawa State, North Central Nigeria. Data were collected through questionnaires, interviews, and focus group discussions. Three gazetted forests (Doma, Risha, and Odu) were sampled to represent the three geopolitical zones of the state. SPSS IBM version 29, NVivo 1.7, and Python 3 were used for data analyses to generate statistics and identify coherent themes across the forests. Results show that changes were perceived to be triggered by sixteen drivers (direct and indirect) related to social, economic, environmental, policy/institutional, and technological elements. Agricultural expansion, lumbering, and charcoal production were the most reported direct drivers, while population growth, poverty, and government policies were the most perceived indirect drivers. The results showed variations in human activities across forest sites. For example, agricultural expansion, lumbering, and grazing were more widespread, while construction and settlement activities differed between forests. The Risha forest community saw agriculture expansion ahead of other drivers, Doma forest people saw population growth above other drivers, and the Odu forest community saw lumbering aiding other drivers that led to change. Implementation of policies focusing on these key drivers must match local perceptions and priorities to engage people in forest conservation. These efforts could ensure effective forest protection that is vital for achieving global biodiversity and climate targets and safeguarding local livelihoods. The specific drivers of changes in each forest need to be targeted in conservation efforts.

Keywords: land-use drivers; local perceptions; forest conservation policy; human–environment interactions; Africa

Academic Editor: Dietrich Schmidt-Vogt

Received: 3 June 2025
Revised: 4 July 2025
Accepted: 8 July 2025
Published: 11 July 2025

Citation: Chunwate, B.T.; Marchant, R.A.; Jew, E.K.K.; Stringer, L.C. Understanding Local Perspectives on the Trajectory and Drivers of Gazetted Forest Reserve Change in Nasarawa State, North Central Nigeria. *Land* **2025**, *14*, 1450. https://doi.org/10.3390/land14071450

1. Introduction

Human-caused alterations of the Earth's surface frequently lead to the destruction of forests and woodlands, as well as the degradation of forested areas [1–3]. The primary issues surrounding forest conservation and livelihood change are attributed to land use and human interactions [4–6]. These human activities are linked to deforestation and forest degradation, which work against the protection of forests and their management systems [7,8]. Assessing these factors is vital for the effective local, regional, and global development of environmental settings [9,10]. The impact of land-use change and its driving factors has been shown to negatively affect forest cover and biodiversity, which has important implications as biodiversity sustains the livelihoods that people depend on to survive [11–13].

It is important to evaluate drivers that contribute to changes and degradation in forest cover and to protect areas, drawing on the local perspective [10,14]. This approach ensures that interventions are relevant to the specific context, garner community support, address root causes, and adapt to changing conditions, ultimately leading to better outcomes for both forests and local people who depend on them, often directly, for their livelihoods [15,16]. Incorporating a local perspective enables the consideration of both environmental and human aspects of forest management.

Forests play a crucial role as valuable resources, providing a diverse array of ecosystem services, including timber, food, fuel, and non-timber bioproducts [17]. Additionally, they contribute to the maintenance of ecological functions, including carbon storage, nutrient cycling, water and air purification, and preservation of wildlife habitats, which are essential for promoting human well-being and supporting life [18–20]. Human activities have led to a 60% decrease in ecosystem services globally, according to the Millennium Ecosystem Assessment [21], reiterated by [14,22]. As the primary means of subsistence for people living in poverty, they rely heavily on these services, so often lose out the most in terms of ecosystem change and degradation [23–25].

According to the Millennium Ecosystem Assessment [21], when a driver of change has an evident influence, it is referred to as a "direct driver". When it underlies or leads to a "direct driver," it is referred to as an "indirect" (underlying) driver. Direct drivers have a clear and straightforward cause-and-effect relationship with observed changes. They comprise activities or actions that directly affect forest cover and land use, such as agriculture, urban expansion, mining, logging, livestock grazing, and forest fires, among others [2,26,27]. Indirect drivers encompass complex political, socioeconomic, cultural, and technological interactions [13,27–29]. Other indirect drivers of deforestation include corruption, inadequate governance, population growth, climate change, and ambiguous land tenure arrangements [15,30,31]. According to Geist and Lambin [32] and the Millennium Ecosystem Assessment [21], changes in these drivers influence not only land cover but also forests, although the drivers and their impacts differ regionally. In most developing nations in Latin America, Asia, and Africa, the key driver of deforestation is the conversion of forest land to agriculture (commercial and subsistence), linked to activities such as logging, charcoal, collecting fuelwood, forest fires, and livestock grazing [10,33,34].

While the Millennium Ecosystem Assessment [21] provides a useful lens for categorizing ecosystem changes and drivers, this study also draws on broader theoretical frameworks, particularly land system science and political ecology, to provide a more comprehensive analysis of the complex human–environment interactions influencing forest change. Land system science emphasizes the spatial, ecological, and social dynamics of land-use transitions, helping identify feedback between human activities and environmental outcomes [13,27,28]. Political ecology foregrounds issues of power, governance, inequality, and historical legacies in shaping land-use decisions and forest management

practices [35]. By integrating these perspectives, this study situates local land-use patterns within larger political–economic and institutional contexts, thereby enhancing understanding of the root causes and structural constraints that shape forest degradation and conservation outcomes.

According to Global Forest Watch, Nigeria has approximately 20 million hectares of forest area, with about 200,000 hectares lost annually in recent years. The country has lost nearly 95% of its forest cover, primarily because of aggressive deforestation, which occurred at a rate of 5% annually from 2010 to 2015 [36]. Demand for land and scarcity of fuelwood further intensify deforestation, even within protected forest reserves, broadly driven by agricultural growth, increasing population, and resource exploitation [33,37,38]. While previous research in Nigeria has been conducted on land-use and land-cover change (LULCC) and its drivers using remote sensing and survey data [37–39], there has been limited research on the current drivers of protected and forest reserve changes, particularly in the North Central region of the country [39–41]. Although remote sensing data and Geographic Information System (GIS) applications have been used to quantify the extent of changes in land use and forest in many regions [41–44], they cannot explain the rationale behind the anthropogenic drivers that are felt or perceived by stakeholders in forest communities. Understanding perceptions is important to understand how local communities feel about changes in the forests, and this can help to identify important entry points for forest conservation actions. Gaining understanding about perceived drivers of forest change requires both quantitative and qualitative approaches.

Overall, the integration of qualitative and quantitative approaches in this study allows a more comprehensive understanding of forest degradation and conservation in Nigeria. It makes a unique contribution by providing insight into the perspectives of Nigerian forest communities, an aspect that remains underexplored, and highlights the strategic role of gazetted forest reserves in both national conservation and policies to tackle climate change. By situating research within broader global discourses, the study contributes to ongoing efforts aligned with the Sustainable Development Goal (SDG) 15: Life on Land and Convention on Biological Diversity (CBD). Specifically, it supports the objectives of halting biodiversity loss, promoting the sustainable use of terrestrial ecosystems and land use, and integrating local communities into conservation plans [22,45–52]. To strengthen its relevance, we integrate comparative analyses of deforestation drivers across African forest reserves to contextualize its findings within the broader literature on West African deforestation [33,36,40].

The overall aim of the work is to evaluate the perceived drivers of forest change (both direct and indirect) using an empirical perspective at the local community level, including those populations living close to three gazetted forest reserves. The research questions are as follows:

(i) What are the socioeconomic characteristics of the sampled households from communities living near the gazetted forest reserves?
(ii) What are the perceived direct and indirect drivers of forest change in forest-dependent communities, and how do these differ across the three forested regions in the state?

2. Research Design and Methods

This section describes the geographical setting of the research area, the methods used, the procedures employed, and the techniques used to gather and analyze data. This study was conducted in Nasarawa State, Nigeria (Figure 1).

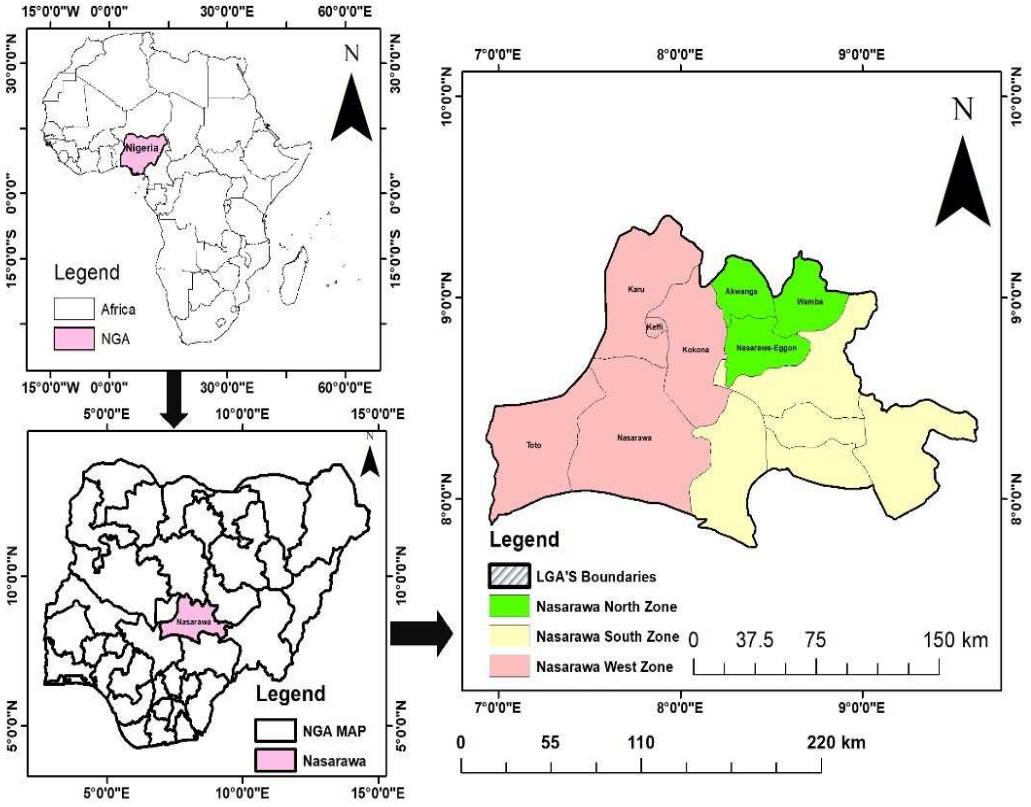


Figure 1. Map of Africa with Nigeria showing Nasarawa State, its Local Government Area administrative boundaries, and geo-political zone subdivisions.

Nasarawa State is home to 41 officially recognized forest reserves, which were established and charted in 1966 with legal documentation (Figure 2), although some were proposed without complete legal authorization [53]. Due to varying years of official recognition, not all were mapped. These reserves are distributed across Nasarawa North, South, and West Senatorial Districts (Figures 1 and 2), with the majority located in the southern region, followed by the northern and western areas, respectively. They were officially recognized under the Benue Plateau State of Nigeria, gazetted supplement part B to Northern Region gazetted No.8, vol. 2, 1966. While this recognition meant that local residents were prohibited from clearing vegetation, forest communities retained resource access rights while preserving the forest cover. They were allowed to gather water, thatching grass, dead wood, stones, fruits, and medicinal plants that are important to their culture. However, resource extraction remains restricted to personal domestic use and not for commercial purposes, with a view to ensuring no harm to the vegetation cover [53].

Three forests, Doma, Risha, and Odu, were chosen to represent each geopolitical zone: Doma in the south, Risha in the north, and Odu in the west (Figure 2). This selection ensured a comprehensive approach and considered ecological similarity, cultural significance, and geographic distribution, representing various ecological zones and forest types of different sizes with comparable biodiversity [54–59]. The selection of forest sites also sought to avoid areas known for their security threats, including kidnapping risks, farmer–herdsmen conflicts, inter-community crises, and cultural barriers. Prior to the field visits, consultations were held with Nigerian security services to obtain relevant security information before travelling to the area, making our final site selections, and commencing data collection.

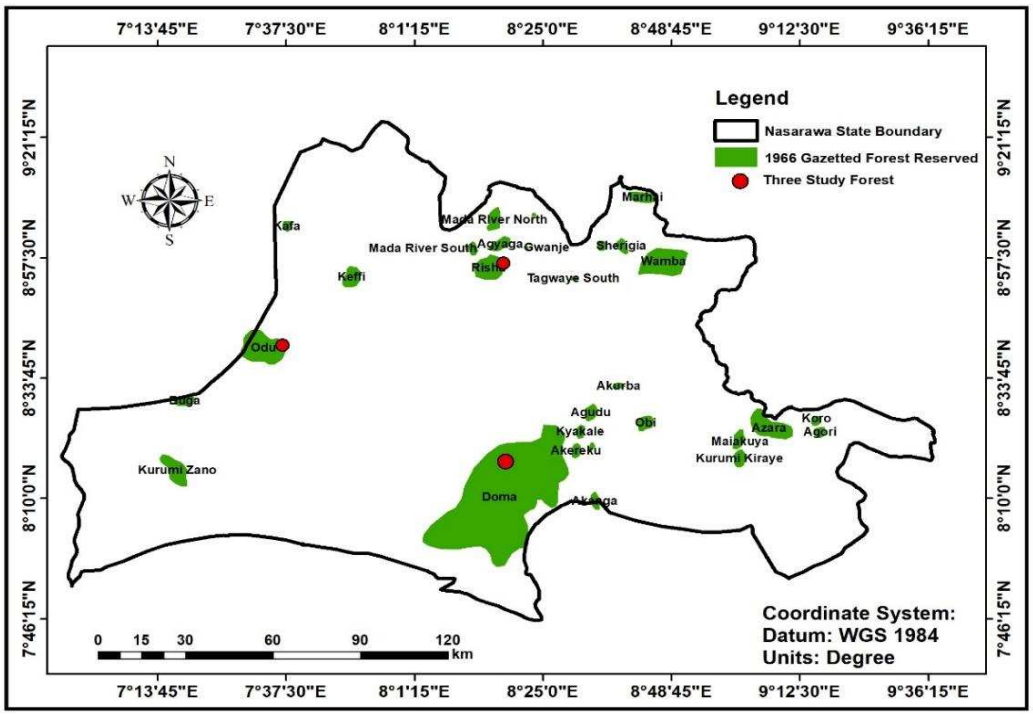


Figure 2. Nasarawa State map showing the gazetted forest reserve distribution for 1966. This was an extraction from the Nasarawa shapefile from the Ministry of Environment, Abuja, and Nasarawa Geographic Information Service, 2020.

2.1. Data Source and Methodology

The study employed a mixed-methods research design [60,61], combining household surveys, key informant interviews (KII), and focus group discussions (FGD) to understand the perceived historical drivers and human activities that contribute to the trajectory of the gazetted forest reserve change in the study area (Table 1).

Table 1. Data collection methods and sampling for the Household Questionnaire Surveys, KIIs, and FGDs used in the study.

Method	Type of Respondent	Sample Size and Number of Participants		Sampling Approach
Interviews	Four Groups' Stakeholders	Local leaders Local people Policymakers Experts Total	15 15 5 5 40	Snowball sampling method
FGDs	Four Group Stakeholders	Local leaders Local people Policymakers Experts Total	15 15 5 5 40	Snowball sampling method
Household Questionnaire	Three Communities Local to the Selected Forest Reserves	Doma Forest Reserve Risha Forest Reserve Odu Forest Reserve Total	84 84 84 252	Multi-stage sample method

2.1.1. Household Survey

The survey comprised a set of structured questions specifically designed to gather comprehensive insights and perspectives from the local communities living near the selected

forest reserves. It was difficult to obtain precise figures and population data on the villages and communities surrounding the forest reserves, resulting in challenges in establishing a valid sample size and ensuring representativeness. A multi-stage sample approach was used to choose household survey respondents [62,63]. This involved selecting respondents in a series of stages, typically narrowing down from larger, more general groups to smaller, more specific groups, resulting in an overall sample size of 252 (Table 1). The survey was conducted in the Hausa language during the wet season in June and July 2022.

2.1.2. Key Informant Interviews (KIIs)

Interviews were conducted to gather in-depth insights from individuals with significant knowledge, experience, and expertise in forest use, management, and conservation. Forty stakeholder participants were recruited through snowball sampling with the help of community heads and local contacts.

The local community groups were selected based on their experience with forest resource use, understanding of land-use changes, and active involvement in forest-related activities (Tables 1 and 2). Semi-structured interviews were conducted in English and Hausa, allowing participants to share their perspectives on the drivers, human activities, and benefits of ecosystem services provided by gazetted forests. The Hausa responses were later translated into English for analysis. These interviews provided valuable qualitative data for understanding the complexities of historical drivers and human activities in the local communities around the gazetted forest area.

Table 2. Stakeholder groups involved in KII and FGDs and their description.

Stakeholder Groups	Description of the Stakeholder Group
Local people	These are the forest users in the communities; they interact frequently with the forest for resources to derive immediate benefits for their livelihoods within their forest communities, and include farmers, hunters, charcoal producers, and timber contractors.
Local leaders	These stakeholders are responsible for protecting their local environment through management of forest use, land ownership and disputes, and local regulations. This group includes Traditional Rulers, Village Heads, Youth Leaders, Women Leaders, and Market Leaders.
Government officials	These are government custodians who monitor and analyze forest uses, generate funds for the government, maintain forest-designated areas, record forest activities, and take legal action against forest law violations. The participants from this group were from the Nasarawa State Ministry of Environment and Natural Resources.

Table 2. *Cont.*

Stakeholder Groups	Description of the Stakeholder Group
Experts	These are independent experts who advocate for forest and land use for sustainability and advise the government and the people to understand forest policy implementation strategies, considering their impact on the environment, and particularly the importance and role of forests in environmental sustainability. This group includes land-use planners, environmentalists, geographers, and foresters in academic and forestry institutions.

2.1.3. Focus Group Discussions (FGDs)

To complement the household surveys and key informant interviews, eight FGDs were conducted with community members from the same stakeholder groups that participated in the KIIs (Tables 1 and 2).

FGDs were conducted to foster deeper engagement and dialogue, enabling participants to share their perceptions and experiences, and to evaluate the historical drivers and the trajectories of human activities leading to changes in the gazetted forest reserves and their ecosystem services. The same participants from the KIIs were invited to participate in the FGDs, ensuring continuity and cost-effectiveness of participant recruitment. Their prior familiarity with the topic facilitated deeper engagement, allowing the validation and triangulation of the findings. This approach has proven valuable for understanding community dynamics, social norms, and areas of stakeholder consensus or divergence.

The discussions were conducted in both English and Hausa to accommodate participants' language preferences. Ethical approval for the study was obtained from the Environment and Geography Department Ethical Review Committee of the University of York, UK (REF: DEGERC/RES/24032022/1), prior to the commencement of the research. Informed consent was obtained from all participants prior to data collection. For illiterate participants, the consent process was conducted verbally in the presence of a witness, and their consent was recorded either through a thumbprint or verbal confirmation documented by the research team. The number of authorizations was recorded to ensure ethical transparency and compliance with institutional guidelines. Informed consent was also obtained from all participants for audio recordings. Field notes were taken to capture nonverbal cues, contextual factors, and other relevant observations. This strategy provided a comprehensive dataset that facilitated a detailed and nuanced analysis of participants' responses. The audio recordings were subsequently translated from Hausa into English and transcribed for analysis.

2.2. Data Analysis

Quantitative data from the household survey were analyzed using the statistical packages for social science (SPSS) IBM Version 29, and qualitative data derived from KIIs and FGDs were coded and analyzed using NVivo software. The process was conducted in two stages. The initial stage of coding produced numerous categories without limiting the number of codes, which is in line with the grounded theory style approach proposed by Charmaz [64] and further elaborated by Ganesha [60]. Emerging ideas were identified, relationship diagrams were developed, and frequently cited keywords were utilized to formulate key themes aligned with the study's research objectives. In the second stage, the

initial codes were refined through elimination, amalgamation, or subdivision of categories, with emphasis placed on recurring concepts and broader thematic patterns [64]. Direct quotations from participants were used to substantiate and support the narrative within the research storylines based on the categories underpinning each theme.

3. Results

This section addresses each of the research questions in turn, first characterizing the respondents in the household questionnaire survey and then integrating the qualitative and quantitative data across the FGDs, KII, and household questionnaire survey.

3.1. Socioeconomic Characteristics of Surveyed Respondents Across the Three Study Forests in Nasarawa State

Across the three forest communities, the sample was predominantly male (84%), indicating male-dominated involvement in forest-based decision-making roles. This may also be linked to cultural limitations that restricted the interaction of women with male surveyors. The 36–55 age group represented the largest proportion (47%), followed by 56–75 (24%) and 18–35 (23%), with 6% aged 76 and above; 92% of respondents were married, while single, widowed, and divorced individuals made up 8%; and 95% of respondents were non-salaried, indicating the dominance of informal economic activities (Appendix A Figure A1).

Comparing across the three forests (Doma, Risha, and Odu), non-salaried earners constituted 98%, 96%, and 90%, respectively, with agricultural activities most prevalent in Risha and Doma (81%). Common crops included yam, maize, cassava, and guinea corn. Income levels were generally low, with 67% earning less than NGN 40,000 monthly (34% between NGN 21,000 and NGN 40,000 and 33% below NGN 20,000). Only 12% earned above NGN 61,000 (USD 40) per month. In this study, a household is defined as a group of people living together in the same compound and sharing living arrangements. The majority of households were relatively large, with 31% comprising 5–6 members, 23% having 7–8 members, and 24% consisting of >8 members. Farming was the primary occupation (72%), while 24% combined farming with trading, artisanal work, civil services, or fishing. Educational attainment varied: 30% had secondary education, 22% held university degrees, 20% had National Certificate in Education (NCE) qualifications, 14% had only primary education, and 6% had no formal education.

These demographic and economic conditions are significant for understanding patterns of forest use, pressure on natural resources, and the adaptive capacity of local communities. These findings underscore widespread poverty and informal livelihoods, highlighting significant pressures within the communities surrounding the gazetted forest reserves.

3.2. Forest Change

Participants described significant changes across the landscape over the past 60 years, with dense, biodiverse forests in the 1960s gradually transforming into degraded landscapes with a loss of biodiversity (Table 3). The direct and indirect drivers of this change were identified by participants and are described in turn.

Table 3. Overview of stakeholder perspectives from the content analysis of FGDs on forest reserve changes and drivers.

Forest Reserve	1960–2000	2001–2022	Key Drivers of Change	Processes of Change
Doma	Dense, biodiverse forests with tall trees and abundant wildlife. Minimal degradation.	Significant deforestation, biodiversity loss, and near disappearance of reserves.	Population growth, agricultural expansion, logging, charcoal production, bushfires, overgrazing, weak policy enforcement.	Loss of vegetation cover, economic exploitation, lack of reforestation, habitat destruction, invasive species, and inadequate enforcement.
Risha	Rich vegetation, wildlife, and water bodies with strong government control.	Near-total forest-cover loss, ecosystem disruption, species extinction, water body depletion.	Agricultural expansion, timber/charcoal extraction, firewood harvesting, and overgrazing.	Land clearing, hunting, changing cultural attitudes towards conservation, and economic pressures.
Odu	Intact forests with strong traditional laws limiting exploitation.	Accelerated degradation, habitat loss, soil erosion, reduced resilience.	Logging, agricultural expansion, urbanization, timber extraction, overgrazing, weak governance, and climate change.	Shift from traditional conservation to unsustainable exploitation, changing cultural attitudes towards conservation, population pressure, and economic reliance on forest resources.

3.3. Perceived Direct Drivers of Change

Community perceptions of the direct drivers that contribute to the gazetted forest reserve change in their community are quantified based on analysis of the household survey data (Figure 3). Multiple options were given to respondents so that they could select any number of possible drivers of change. Across the Doma, Risha, and Odu forest reserves, key direct drivers, including agricultural expansion, timber logging, fuelwood/charcoal production, and grazing, were consistently identified through household surveys, KIIs, and FGDs. However, their intensity, sequence, and perceived significance varied by site.

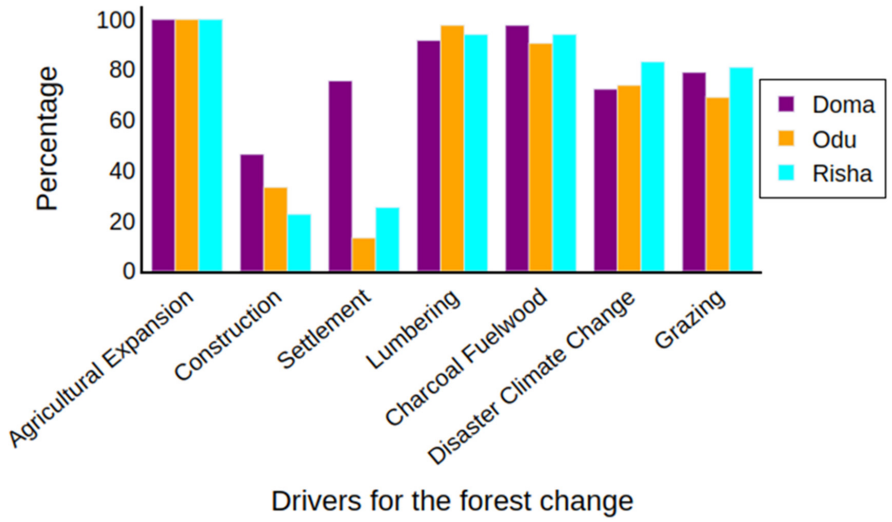


Figure 3. Comparative responses across the three forest communities on the perceived major direct drivers of gazetted forest change.

3.3.1. Lumbering

The extraction of timber was identified as the first step in forest clearance, preceding agriculture (Doma Stakeholder FGDs). Lumbering was perceived as a direct form of degradation across all three reserves, conducted for both commercial and non-commercial timber purposes, targeting valuable species including Iroko (*Milicia excelsa*), Obeche (*Triplochiton scleroxylon*), Gmelina (*Gmelina arborea*), Mahogany (*Khaya* spp.), Opepe (*Nauclea diderrichii*), and African Copaiba (*Copaifera mildbraedii*). This affects forest quality, composition, and size, leading to a decrease in forest cover: "*The practice of timber extraction has persisted for decades, focusing on economically valuable tree species like Iroko, mahogany, obeche, shea butter trees. These trees have been harvested to meet the substantial demand for timber exports, serving diverse applications abroad and within local communities. This industry includes forest-dwelling individuals and private commercial enterprises, generating revenue for governmental bodies. Consequently, these logging operations have significantly altered the designated forest reserve*" (Doma Local People KII 003, June 2022). FGD participants further noted that as the population grows, the demand for timber for construction increases, driving unsustainable practices. One local stakeholder reiterated that "*Lumbering is one of the key contributors to human activities that lead to the degradation of the forest reserve in this area. People are often felling or cutting down trees in and around protected forest areas, particularly to obtain timber for construction materials such as roofing houses. Over time, this persistent practice not only depletes tree populations but also undermines efforts to maintain the ecological balance and biodiversity within this reserve*" (Risha, Local people KII 004, June 2022) (Appendix B, Table A2).

3.3.2. Agricultural Expansion

All respondents indicated agriculture expansion as a major driver of change (Figure 4 and Scheme 1). Increasing demand for farmland and settlements as the population grows has led to an expanding agricultural frontier. Within Doma, farming began in the 1970s, with crops including yam, maize, guinea corn, and beans. Risha Forest Reserve saw rapid agricultural expansion after 2001, resulting in the near-total loss of forest cover: "*The forest reserve has changed due to agricultural expansion because we are farming there. We farm crops like yam, groundnut, melon, maize, guinea corn, beans, and soya beans and so on*" (Risha Local leaders KII 001, June 2022) (Appendix B, Table A2). While Odu also has high deforestation rates due to agriculture, farmers practice shifting cultivation as a traditional method, abandoning farms after a period of time to enable the forest to regenerate. However, degradation is still pervasive: "*Agriculture has contributed to forest changes here since the 1970s, as we depend on farming and forest resources for income and survival, with no alternative livelihoods*" (Odu, Local Community members, KII 003, June 2022).

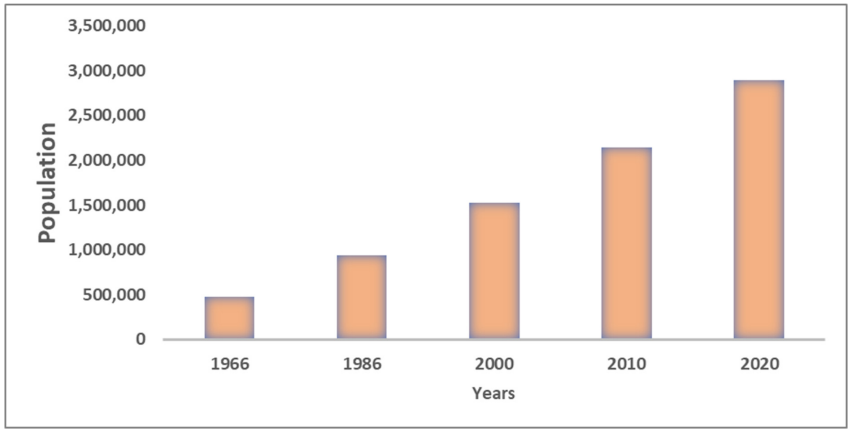
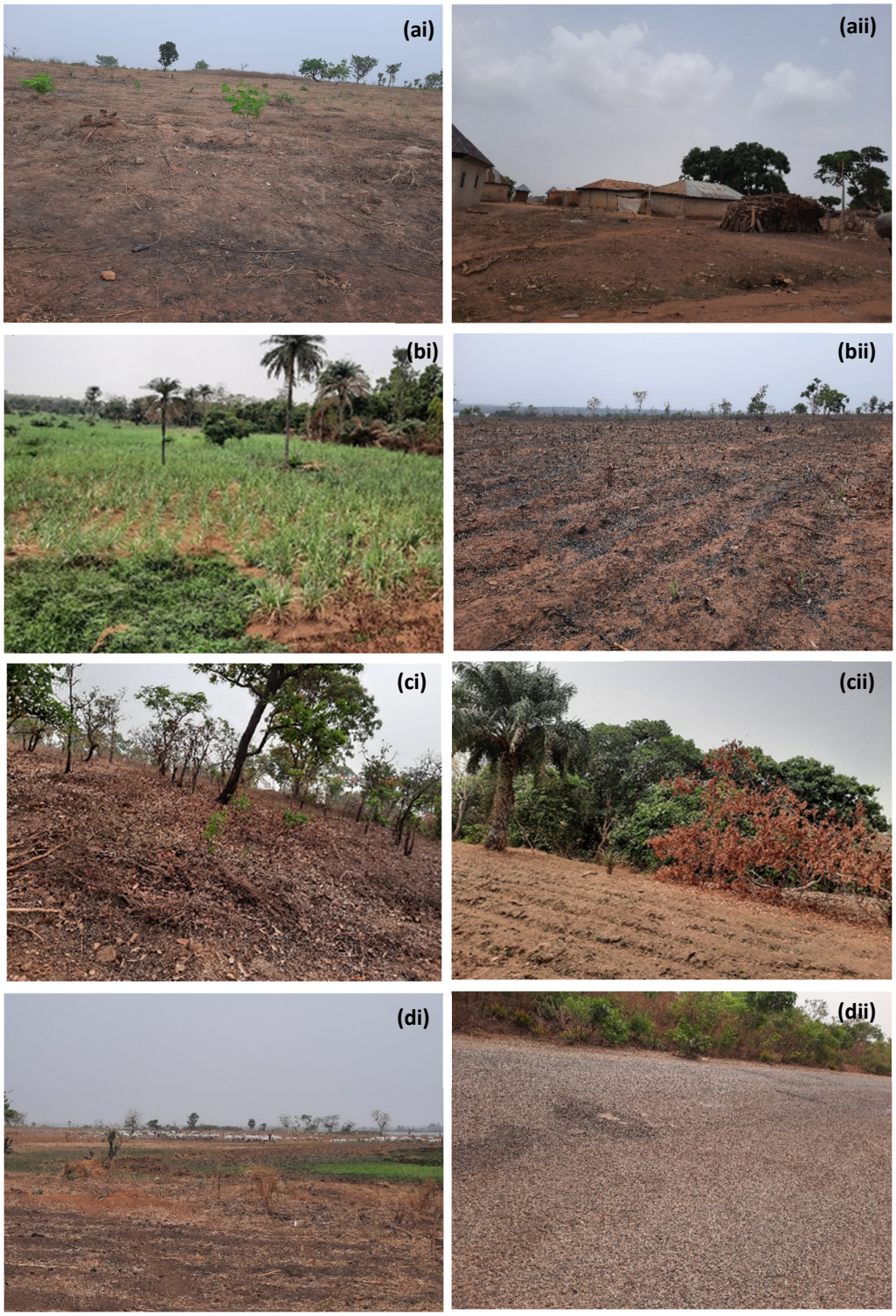


Figure 4. Population trends in the study area (Nasarawa state) over the period 1966–2020. Source: website: https://www.nationalpopulation.gov.ng, accessed on 4 October 2022).



Scheme 1. Evidence of identified land-use activities around the gazetted forest reserves in the study sites. From top right: (**ai**,**aii**) clearing primary forest land for agriculture activities and settlement in Odu Forest; (**bi**,**bii**) agriculture cultivation and fuelwood cultivation in Doma Forest; (**ci**,**cii**) clearing of forest area for farming activities and cultivation in Risha Forest Reserve; (**di**,**dii**) grazing activities in Doma and construction along Risha Forest Reserve. Source: Fieldwork July 2022.

3.3.3. Charcoal and Firewood

Fuelwood collection and charcoal production are essential for the generation of household energy and additional income, particularly as energy costs rise (Expert FGD). Specific tree species are used: *"Local communities frequently harvest trees, such as Vitellaria paradoxa*

(shea tree), *Daniellia oliveri* (African Copaiba balsam tree), *and Prosopis africana, for firewood and high-quality charcoal due to their dense wood and high calorific value. This targeted harvesting has significantly contributed to the depletion of forest cover and resources in the reserve, driven by domestic use and economic necessities*" (Doma, local community leader KII 004, June 2022). Observations during fieldwork confirmed the ongoing exploitation of the forest for fuelwood and charcoal production (Scheme 1).

3.3.4. Grazing

Grazing by livestock was cited by 81% of respondents in Doma, 90% in Risha, and 69% in Odu (Figure 3). FGDs revealed that herders allow livestock to graze on croplands and grasslands and cut some specific tree species to feed their livestock within the reserve, which reduces forest cover and changes grassland composition. Cattle trampling and the cutting of branches for fodder further exacerbate the problem. Additionally, herders have been reported to clear forested areas to build camps, adding to the deforestation pressures noted by both the local people and lead stakeholders (Appendix B, Table A1). KII participants from the local community in Doma elaborated and confirmed that "*Grazing by herdsmen contributes to the destruction of the forest reserve; they move into the forestry area and cut down the trees and grasses to feed their animals', this reduces the composition and size of the forest reserves; their activities affect forest growth and cover*" (Doma, Community member KII 003, June 2022). Grazing on farmland can cause conflict. It is important to note that herders were not included as participants in these FGDs because of their inaccessibility, which precluded the opportunity to gain insight into their perspectives regarding the impact of their activities on forest degradation.

3.3.5. Construction and Settlement

Construction and settlement were perceived as less important in driving forest change across the three reserves. Respondents in Doma considered construction (referring to the physical building and related infrastructural development in the state) to be a significant driver of change, and Doma had the highest construction response (47%). Construction is often encompassed within lumbering, as it is often difficult to identify whether timber is being extracted for local construction or regional/national sale. Seventy-six percent of respondents in Doma identified settlement, which involved the establishment or expansion of communities in a given area, as one of the major drivers, while only a few in Risha and Odu mentioned it.

3.4. Perceived Indirect Drivers of Change

Themes derived from analysis of qualitative KII and FGD data indicate interconnected indirect drivers, such as population increase, poverty, climate change, corruption, governance, government policies, insecurity, land grabbing, and migration, which interplay with the direct drivers.

3.4.1. Population Growth

The majority of KII and FGD participants perceived that the population of the area had increased over the study period: "*Population growth has significantly impacted forest cover and ecosystem change, interacting with other environmental pressures and direct drivers. For example, the demand for livelihood sources is influenced by population growth. Prior to 1960, the population that led to extraction and degradation remained low. However, since 2000, deforestation has escalated, largely driven by rapid population growth within the state and local communities*" (Doma Local people, KII 002, July 2022). Another participant further explained in Risha that "Due to population increase around this area, people started claiming ownership and open agricultural land for farming purposes around 1998 to date that led to significant

forest-cover change of the forest reserves area." (Risha forest, Local person 003, (Female) KII July 2022). One of the expert stakeholder participants added that "*Due to the consistent ever-increasing human population in this area, it results in increasing demand from people for other land use and human activities for livelihood, which is the key driving force of the forest change*" (Expert KII 004, June 2022).

Statistical data showing the population of each gazetted forest community was not available. State-level population data in the period 1986 to 2020 were nevertheless analyzed (Figure 4). These secondary data show the population grew by 75% between the years 1986 and 2020, rising from 939,471 to 2,895,432 individuals, with this rapid growth driven by birth rate trends and migration. During this period, the average annual increase was 2.5% (https://www.nationalpopulation.gov.ng, accessed on 4 October 2022). This suggests perceptions of population growth are supported by the statistics, at least at the state level.

3.4.2. Poverty

Poverty is considered to be an indirect driver of change: "*Poverty is one of the major drivers that led to changes in the forest reserves: we expand our agricultural land in the forest to get our livelihood since we have no good way of getting food or money to survive*" (KII Risha Local person 005, June 2022). A community leader in Doma emphasized that "*Poverty is a significant driver of changes in the forest reserve. People exploit this forest to sustain their livelihoods and meet economic needs, with community members often clearing parts of the forest to access and utilize its resources*" (KII Doma Local person 005, June 2022). A government official explained, "*One of the main reasons for changes to the forest reserve is poverty and this is a fact. The fact is that community members need money for their livelihoods and economic survival, which leads them to clear the forest around them for resource access and use*" (KII Government official 005, June 2022). Poverty has also increased forest degradation in the study area due to increased demand for fuelwood and other domestic uses because these communities depend heavily on natural resources to meet their daily needs. Government officials and experts also emphasized policy failures, poor governance, corruption, and weak enforcement as critical factors influencing forest degradation.

According to the National Bureau of Statistics (NBS), Nasarawa State recorded a multidimensional poverty incidence of approximately 57% as of the 2022 Multidimensional Poverty Index (MPI) report, indicating that the majority of the population lacks access to basic needs such as healthcare, education, and sustainable livelihoods. Such high poverty levels compel local communities to rely heavily on forest resources for fuelwood, timber, and non-timber products, often with limited awareness or capacity for sustainable management practices. Thus, addressing poverty and strengthening governance and enforcement mechanisms are essential for effective forest conservation and sustainable livelihood development in both the forest communities in this study and in Nasarawa State more widely.

3.4.3. Poor Governance and Corruption

Poor governance includes issues such as corruption and the embezzlement of funds, which adversely affect the performance of the forest conservation sector. This is exemplified by the detrimental consequences of management and monetary issues, as well as the accelerating violation of natural resource conservation laws, which greatly influence changes in the forest reserves of the area. This was particularly the case in Doma: "[In the past], *the government* [did] *take good care of the reserves but now less attention is given, so people go into the reserves and cut down trees in the reserve any time without any proper permission*" (Doma local people KII 005, June 2022).

Government policies governed the establishment of Protected Areas (PAs) and forest reserves that were intended to help reduce overall forest loss and degradation, limiting the areas in which concessions could be granted. However, many PAs and reserves were poorly managed with limited resources and capacity, resulting in implementation failure. This is recognized by stakeholders: "*Government policies are often contributing to deforestation in forest reserves. This is because these policies are not always implemented in a manner that aligns with the needs of the people for conservation. For instance, Nigeria's high cost of natural gas, cooking gas, and kerosene has led to a situation where poor residents in forest communities are forced to resort to forests for their energy needs. This has resulted in the degradation of the ecosystem and a change in the forest cover*" (Government official KII 002, June 2022). Policy interventions that recognize and reinforce traditional land stewardship while plugging enforcement gaps could enhance forest outcomes.

Poor governance and policies were also perceived as influencing corruption by forest officials in the study area. For instance, bribes are reportedly necessary when obtaining permits or documents and to secure access to forest reserves for farming, timber, and other uses, as well as to obtain agricultural concessions in these reserves. In some cases, domestic companies may even pay bribes to subcontract and overharvest logging concessions. Local community members and government officials are allegedly involved, for example in Risha: "*The government forest officers assigned to monitor, manage, and enforce the forest laws against encroachments in this forest reserve encourage the community and even foreigners by collecting small bribes from them and then allowing them to enter the forest and degrade it for timber extraction, agricultural, and other uses, which leads to a high rate of cutting forest trees and a change in the forest reserves*" (Risha local people KII 004, June 2022). Together, the direct and indirect drivers that were identified encapsulate the multifaceted and dynamic pressures that contribute to forest degradation and change, and emphasize the systemic nature of the challenges.

3.4.4. Climate Change

In terms of perceptions of disasters and climate change, more than 70% of respondents in the three forest communities considered that these drivers had contributed to changes. Both experts and Government officials noted the impacts of climate change, policy inconsistencies, and inadequate reforestation efforts. Over the years covered in this study (1986–2020), Nasarawa State experienced significant climate variability with an overall trend of increasing temperatures and fluctuating rainfall (Figures 5 and 6). These changes may have implications for the region's forest cover, agricultural activities, ecosystem services, and overall sustainability of the gazetted forest reserve, particularly as climate change and variability are often viewed as a risk multiplier for poverty.

3.5. Unique Issues Within Each Forest Reserve

While the three forest reserves, Doma, Risha, and Odu, share common direct and underlying drivers of forest degradation, several unique site-specific issues emerged from the household surveys, KIIs, and FGDs. Risha and Doma were perceived to exhibit the highest levels of agricultural expansion and forest degradation in the reserve, as evidenced by all data sources, while Odu's forest community perceived cultural control of the traditional land-use pattern of shifting cultivation. In the Risha and Doma reserves, individuals on the agricultural frontier actively cleared land for permanent agriculture, as perceived by the community. In Doma, community practices show minimal species-selective harvesting, increasing the risk of over-exploitation of vulnerable species. Moreover, the area has limited community-based forest management structures, presenting an opportunity for introducing participatory governance models.

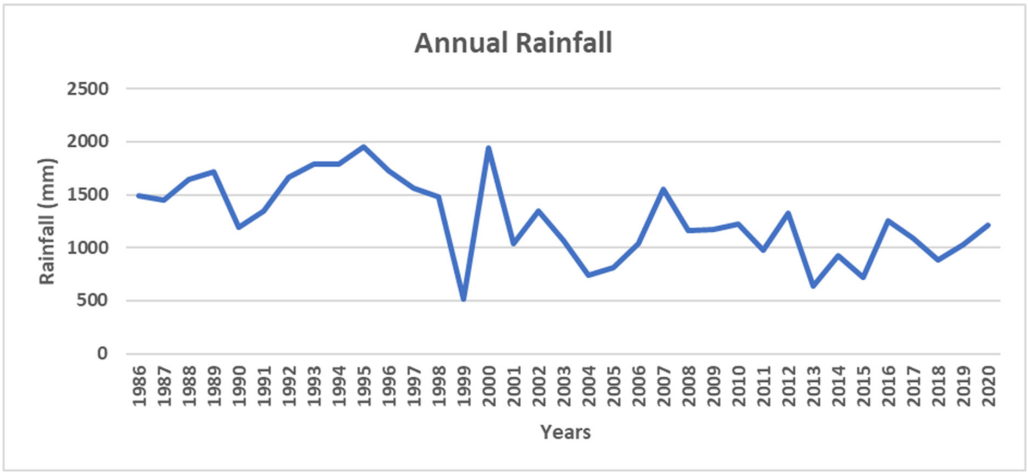


Figure 5. The study area's annual rainfall trend for the period 1986–2020 (Lafia Station). Source: Nigeria Meteorological Agency, Abuja, 2022.

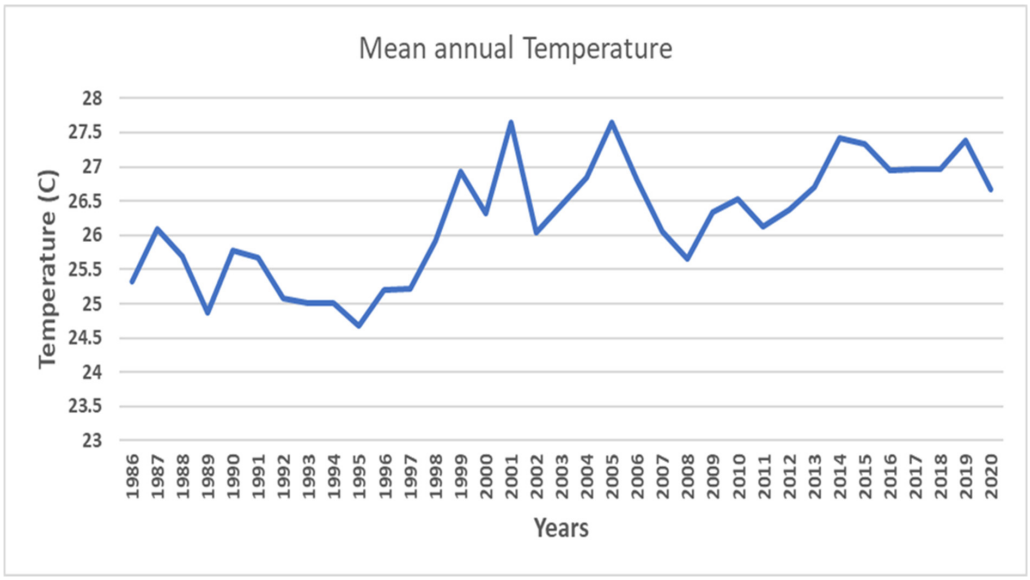


Figure 6. The study area's annual temperature trend over the period 1986–2020 (Lafia Station). Source: Nigeria Meteorological Agency, Abuja, 2022.

Risha exhibits severe governance failures and explicit corruption, with many cases of bribery for illegal timber extraction and farming spaces within the reserve, while weak institutional enforcement has resulted in accelerated deforestation in the area. Unlike Odu, Risha lacks strong informal controls or traditional norms that could mitigate unsustainable practices. Drivers within the Odu forest showed the most divergence from those in Doma and Risha. Forest degradation is slower in Odu, with sociocultural norms and community-led practices mitigating negative impacts. For example, the Odu community revealed that land was initially cleared for valuable timber, with agriculture subsequently encroaching, while various drivers and processes (e.g., population growth, poverty, and grazing) gradually contributed to the change in the degraded forest, leading to rapid agricultural expansion over decades. The Odu forest benefited from stronger informal oversight and traditional norms, contributing to ecological resilience. Odu is currently experiencing forest regeneration, as observed during fieldwork and reported by stakeholders. This has been attributed to the continued use of traditional agricultural practices, which emphasize fallow periods, thereby facilitating natural forest recovery. The case of Odu offers several key insights for forest conservation and management, such as shifting cultivation, but it is not

wholly sustainable and may present more forest-compatible land-use alternatives than permanent agriculture, particularly under moderate population pressure.

In addition, the Odu forest community shows greater ecological awareness, with selective harvesting of certain species, suggesting local knowledge can inform sustainable harvesting guidelines and displays evidence of natural forest regeneration, supported by community norms and informal governance structures. These findings suggest that hybrid governance models that integrate formal authority with empowered community institutions that reflect local realities could support positive forest futures. Poor governance and weak policy implementation nevertheless exacerbated deforestation in all reserves, with these underlying drivers perceived more widely in Risha and Doma (Appendix B, Tables A1–A4). Addressing these drivers requires targeted interventions for conservation and management, including improving governance, providing alternative livelihoods, and promoting sustainable land-use practices.

4. Discussion and Implications

The intricate relationship between social and biophysical processes that drive land-use changes, particularly those affecting forest cover, is influenced by a combination of direct and underlying factors, often stemming from human activity [8,65]. This dynamic was evident in the current research, where most participants from gazetted forest communities attributed forest change primarily to this interplay between socioeconomic factors and biophysical processes. Most of the historical drivers and human activities that drive gazetted forest change were similar across the three gazetted forests. However, perceptions differed regarding construction and settlement drivers in terms of their contribution to forest change across the three sites surveyed. Each group's viewpoint is rooted in its interaction with and dependence on forests, as well as its capacity for control over forest resources. These differences are shaped by distinct ecological conditions, cultural orientations, and governance structures, which influence how communities interact with and perceive forest resources. The literature suggests that communities located near more degraded reserves may be more likely to emphasize direct drivers of deforestation and forest degradation, such as agricultural expansion, fuelwood collection, and logging (see [65]). In contrast, communities situated closer to relatively intact forest areas may more frequently highlight indirect drivers, including poverty, weak enforcement of forest protection laws, and limited livelihood alternatives. These differences underscore the importance of understanding differences in local perspectives and the importance of incorporating local voices into other technical analyses. This is particularly relevant in the Nigerian context, where it is often challenging to access and adequately represent the views of local communities due to logistical, socio-political, and institutional barriers. Local contexts, both ecological and institutional, mediate not only the extent of forest change but also how that change is understood by the people most affected by it.

A critical insight from this study is the prominence of indirect drivers in the local narratives. While direct drivers, such as illegal logging and agricultural encroachment, are visible and immediate, communities often emphasize underlying socioeconomic factors, including poverty, unemployment, land tenure insecurity, and lack of government presence, as less visible, more fundamental causes [27,66]. These indirect drivers are both chronic and systemic, making them more difficult to address through technical fixes alone. Their strong influence suggests that addressing forest degradation in Nasarawa State and similar contexts requires integrated development and governance reforms, not just environmental regulations. Importantly, the differences between communities reflect differentiated ecological, cultural, and governance contexts, which should be further explored to better

understand localized forest management dynamics. Tailoring interventions to these unique contexts may enhance the effectiveness of conservation and policy strategies [65,67].

Understanding socioeconomic drivers and forest changes reveals how incentives and constraints shape human interactions with forest ecosystems. This study highlights the socioeconomic drivers of forest change in Doma, Risha, and Odu, with findings consistent with those of previous studies, such as Sahuri et al. [66], which reported changes in the Bukit Suligi Protected Forest Area. Communities around the forest reserves in the study area experience economic challenges (poverty), which may affect the exploitation of forest resources across the three forest reserves. With 81% of respondents being farmers, this creates pressure on gazetted forests through extensive clearing. Agricultural expansion, fuelwood/charcoal production, and lumbering, driven by poverty and population growth, created a deforestation cycle.

These observations underscore the need to recognize that indirect drivers, such as poverty and weak governance, often hold equal or greater weight than direct drivers, such as agricultural expansion, in shaping forest change. These underlying forces structure the incentives and institutional capacity available to manage or resist forest exploitation. However, Wibowo et al. [35] suggested that socioeconomic activities, when managed properly, can have positive outcomes, suggesting the dual nature of these activities in protecting forests.

Agricultural expansion remains the primary perceived driver of deforestation, particularly in Risha and Doma, consistent with findings across Africa and globally [5,67–70]. However, Odu's forest community revealed cultural controls of the traditional land-use pattern of shifting cultivation for agriculture, offering potentially important lessons. Traditional practices, such as shifting cultivation, while not wholly sustainable, may present more forest-compatible land-use alternatives compared to permanent agriculture in Doma and Risha, particularly under moderate population pressure.

These patterns highlight the need to balance food production with conservation through strategies such as buffer zones and integrated national policies. Integrating these findings with practical strategies for initiatives such as reducing emissions from deforestation and degradation (REDD+) and currently ongoing national reforestation initiatives in Nasarawa State that leverage local knowledge systems could ensure more equitable and effective forest conservation. These findings have practical implications. For effectiveness, these programs must integrate local knowledge into planning, considering community needs, strengthening local governance by empowering community-based forest management, addressing indirect drivers through strategies that tackle poverty and improve livelihoods, and ensuring inclusiveness by involving marginalized groups in decision-making. Monitoring systems should also be implemented to enable communities to assess forest change and intervention, while alternative livelihoods, agroforestry, and tree farming could reduce reliance on forest resources and support sustainable development [70–72].

Lumbering activities have been identified as a key direct driver of forest-cover change, as evidenced by research in Ghana, Kenya, and Malawi [8,71,73]. Our findings align with research by [71] in Western Kenya, which found that timber demand led to illegal chainsaw logging of indigenous trees, causing forest degradation in protected areas. This consistency across studies shows the widespread impact of lumbering on forest reserves. However, promoting sustainable wood products through tax incentives, regulations, and awareness campaigns could foster demand for certified timber and encourage eco-friendly practices aligned with the SDGs. Charcoal and fuelwood use significantly contributes to forest degradation, a trend reported across Africa. Studies by [8,72–78] have shown that fuelwood and charcoal demands drive forest-cover change, impacting forest cover and biodiversity. While communities recognize negative impacts, poverty drives continued

reliance on these practices [78,79]. Improved charcoal technology in Nepal has resulted in reduced fuelwood consumption and positive conservation impacts [80]. Transitioning to clean cooking fuels and subsidizing alternatives are crucial for protecting forests [79–82]. Subsidies for cookstoves can minimize tree cutting [82]. Expanding energy options and creating forest reserves for biodiversity and community livelihood sustainability can help preserve forests [83–85].

Grazing practices were found to exacerbate forest degradation in this study, as documented in previous research [5,8,83–87]. Inadequate grazing systems contribute to environmental issues, including drought, climate change, erosion, and species extinction. Grazing within protected areas affects wildlife habitats, species behavior, and soil degradation [87,88]. Implementing strict grazing control, quotas, and monitoring programs is crucial for biodiversity conservation and sustainable forest management [89,90].

Findings that infrastructure development and settlement expansion drive forest change align with studies documenting forest loss as a result of urbanization [1,12,91–93]. Urban growth has encroached on forest reserves [94]. Infrastructure must be provided while minimizing the environmental impacts to reduce habitat fragmentation and biodiversity loss through approaches such as environmental assessment [65,95,96]. Land allocation and non-timber forest products can also support conservation efforts during urbanization [81,97,98].

Research links weak governance and poor policy implementation to illegal logging in PAs [26,99–102], an important finding across the three forest communities in this study. Although Morales-Hidalgo et al. [103] have reported PA growth, declining tropical primary forests indicate that designation as a PA alone is insufficient. Conservation success requires addressing governance challenges [19,100]. In Africa, corruption among officials enables forest exploitation [27,104–106], while poverty and inadequate monitoring worsen these issues [1,107,108]. These findings emphasize the importance of integrated conservation approaches that focus on improving forest governance. For example, despite similar drivers of degradation across all three forests in this study, respondents in the Odu forest perceived stronger informal oversight and traditional norms, contributing to ecological resilience. These findings suggest the potential for hybrid governance models that integrate formal authority with empowered community institutions.

Although not reported as a major driver of deforestation in our findings, the literature shows that forest communities can face security threats, leading to vegetation clearing around protected reserves. Ladan's [109] study observed this, with forests being cleared owing to security threats. Lunstrum and Ybarra [110] reported a similar decline. These threats restrict conservation activities and damage forest reserves. Official policies may displace local forms of protection and increase resource exploitation. Addressing security threats is vital for PA sustainability [111,112] and needs to be considered as part of overall governance reforms.

Climate change threatens biodiversity and protected forests, although it does not primarily drive targeted forest change. Secondary data showed decreased rainfall and increased temperatures, though local communities saw other drivers (particularly agricultural expansion) as more important. Research indicates climate change could cause over 70% species loss in PAs [113]. It affects habitat fragmentation and species distribution [114,115]. Protected areas may also inadequately buffer climate impacts [83,89], making adaptive strategies essential [84,116]. The implementation of the Nigerian Forest Policy (2020) could support more sustainable forest management practices [84,117], but climate change aspects also need adequate consideration within forest conservation efforts.

The relationship between proximate and underlying drivers of forest decline is complex. Researchers have conducted studies using various indicators to establish cause-and-effect linkages between these factors and human activity in protected forest areas [2,84].

Forest-cover loss affects forest composition, biodiversity, and ecosystems, while climate change amplifies these effects. As the population grows and activities such as deforestation and urbanization increase, the negative impacts on forests also increase [10,107]. These drivers create impacts, including plant and animal species extinction, in the study area [2,118]. LULCC dynamics in gazetted forest reserves have various implications. Forest-cover loss has increased pressure on the remaining forest patches due to agricultural expansion, lumbering, charcoal production, and grazing, hindering natural regeneration [24]. Forest conversion can contribute to the loss of high-conservation-priority indigenous tree species [119,120]. This loss can occur through the direct removal of trees or by modifying the environment in ways that are unsuitable for these species. Our study shows that individuals in Nasarawa forest reserve communities continue to use forest resources even when no closed-canopy forest remains. This indicates the importance of degraded forest stands to livelihoods, while other stakeholders' perception of these lands as being worthless drives deforestation. As local experiences of these drivers affect forest-dependent communities, the consequences worsen. Intervention strategies are needed to safeguard forested areas and prevent negative environmental and socioeconomic consequences. While international agreements, such as the 2030 Agenda on Sustainable Development and the Paris Agreement on Climate Change mitigation, aim to minimize deforestation and degradation, countries must prioritize forest conservation in national policies. The governmental bodies in charge of the gazetted forest in Nasarawa State need to acknowledge the key drivers and human activity patterns that have led to the degradation of this gazetted forest, to develop policies that incorporate the forest use needs of the local population. For example, Indonesia has implemented policies related to various human activities and the drivers associated with community land-use titles, including Hutan Hak, Hutan Adat, Hutan KeMasyarakatan, Hutan Desa, and Hutan Tanaman Rakyat [119], which help reduce forest-cover loss and retain the ecological integrity of the protected forest. It is crucial to conduct more research of this nature to determine whether local communities in Nasarawa State and Nigeria can possess agency in shaping their environment and whether governing bodies are genuinely prepared and intend to incorporate their voices, desires, and aspirations into meaningful policy changes.

5. Conclusions

The comparative analysis presented in this study shows that while all three forest reserves in Nasarawa State face similar challenges, context-specific sociocultural, ecological, and governance dynamics influence the drivers of change and the trajectories of each forest. Odu demonstrates a more hopeful pathway shaped by traditional practices and emerging shifts toward more sustainable land use, offering a foundation for designing localized participatory conservation strategies.

Drivers of forest change across all three gazetted forests included agricultural expansion, lumbering for fuelwood/charcoal production, population growth, poverty, and government policies, although the intensity varied. Risha and Doma showed the highest perceived levels of agricultural expansion of forest degradation, whereas Odu's forest revealed cultural controls of traditional shifting cultivation around the reserve.

The six decades of LULCC in the gazetted forest reserves in Nasarawa State were primarily driven by interactions between direct and indirect drivers. Despite geographical variations, drivers and land use were similar across the three gazetted forests. Local people influenced LULCC dynamics in response to the need to meet their survival and to pursue their livelihoods, with similar patterns expected in other subsistence agriculture areas. Implementing policies that focus on these key drivers is necessary to prevent unfavorable LULCC shifts in forest reserves and other PAs in north-central Nigeria. Forest

protection is crucial for biodiversity, climate goals, and local livelihoods, given limited land resources. Land-use change impacts future generations, making sustainable forest management essential for sustainable societies. Understanding the local contexts that influence forest-cover changes helps to identify interventions that support forest protection and local development. These can be integrated into existing initiatives such as REDD+. It is also imperative to ensure local perspectives are taken into account and that successful traditional practices are integrated into meaningful forest conservation action.

Author Contributions: Conceptualization, B.T.C.; data curation, B.T.C.; formal analysis, B.T.C.; Funding acquisition, B.T.C.; Investigation, B.T.C. Methodology, B.T.C.; Project administration, B.T.C. and R.A.M.; resources, B.T.C.; software, B.T.C.; supervision, R.A.M., E.K.K.J. and L.C.S.; validation, B.T.C., R.A.M., E.K.K.J. and L.C.S.; Visualization, B.T.C., R.A.M., E.K.K.J. and L.C.S.; writing—original draft, B.T.C.; writing—review and editing, B.T.C., R.A.M., E.K.K.J. and L.C.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the Tertiary Education Trust Fund (TETFUND) in Nigeria (award TETF/UNIV/KEFFI/TSAS/2019).

Institutional Review Board Statement: Questionnaire survey data are not publicly available to protect participant privacy, as promised during data collection and detailed in our ethical approval. The authors declare that they have no conflicts of interest.

Informed Consent Statement: Ethics approval for research involving human participants was granted by the Environment Department Ethical Review Committee, University of York, UK, with due consideration for informed consent and data privacy.

Data Availability Statement: The original contributions presented in the study are included in the article, and further inquiries can be directed to the corresponding author.

Acknowledgments: The lead author expresses their gratitude to Nasarawa State University, Keffi, for sponsoring the research project through TETFUND, Nigeria.

Conflicts of Interest: The authors have no competing interests to declare.

Appendix A

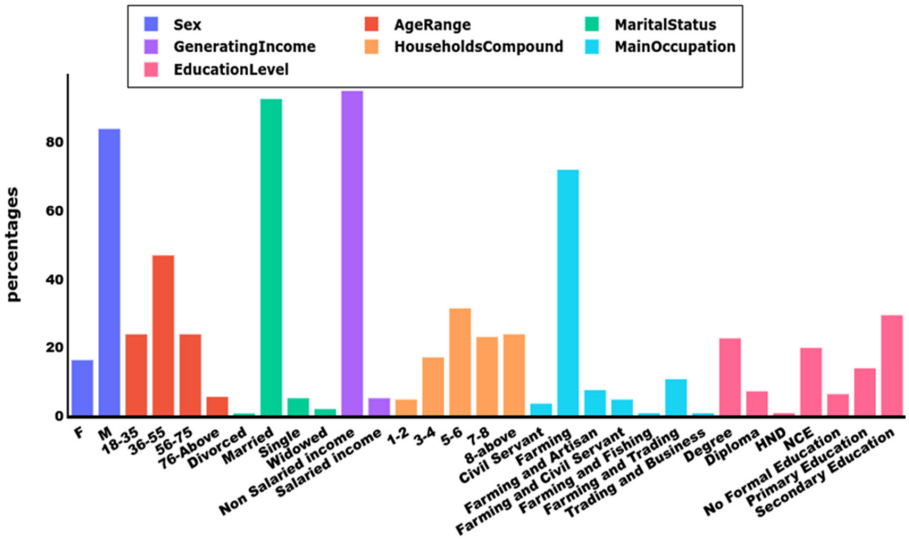


Figure A1. Household Survey on Socioeconomic Variables of the Gazetted Forest Reserves Study Communities in Nasarawa State.

Appendix B

Table A1. Doma key stakeholder quotes identifying perceived drivers of forest change in the study area from 1966 to 2000 (the past) and from 2001 to 2022 (the present), based on data from KII.

Participants' Group	Key Response (s) Agriculture
Local People	*"The forest reserve has undergone substantial changes primarily due to the expansion of agricultural activities, as it has become a site for farming. Local communities cultivate a variety of crops in the area, including yam, groundnut, melon, maize, guinea corn, beans, soya beans, and others. This agricultural activity has contributed to the transformation of the forest landscape, reflecting a shift in land use driven by local livelihoods and subsistence needs."* (Doma Local People KII 001, June 2022)
Local Leaders	*"Agriculture is the major driver for the forest changes in this area because trees have been cut down to give space for farming activities since the 1960s until date; it is the source of livelihood for our communities, which is why we exploit these forest reserve resources and cultivate crops within the area. We, the community, have no alternative sources of income for our livelihoods. We depend on the forest reserve for our source of income and livelihood."* (Doma Local leaders KII 001, June 2022)
	Key response (s) poverty
Local people	*"Poverty is a significant driver of changes in the forest reserve. People exploit this forest to sustain their livelihoods and meet economic needs, with community members often clearing parts of the forest to access and utilize its resources."* (KII Doma Local person 005, June 2022).
	Key response (s) Lumbering
Local people	*"The practice of timber extraction has persisted for thousands of years, focusing on economically valuable tree species like Iroko, mahogany, ebeche, shea butter trees. These trees have been harvested to meet the substantial demand for timber exports, serving diverse applications abroad and within local communities. This industry includes forest-dwelling individuals and private commercial enterprises, generating revenue for governmental bodies. Consequently, these logging operations have significantly altered the designated forest reserve."* (Doma Local People KII 003, June 2022)
	Key response (s) Fuelwood/Charcoal
Local Community Leaders	*"Local communities frequently harvest trees, such as Vitellaria paradoxa* (shea tree), *Daniellia oliveri* (African Copaiba balsam tree), *and Prosopis africana, for firewood and high-quality charcoal due to their dense wood and high calorific value. This targeted harvesting has significantly contributed to the depletion of forest cover and resources in the reserve, driven by domestic use and economic necessities."* (Doma, local community leader K II 004, June 2022)
	Key response (s) Grazing
Local people	*"Grazing by herdsmen contributes to the destruction of the forest reserve; they move into the forestry area and cut down the trees and grasses to feed their animals', this reduces the composition and size of the forest reserves.; Their activities affect forest growth and cover."* (Doma, Community members KII 003, June 2022)
	Key response (s) Population
Local Community Leaders	*"Population growth has significantly impacted forest cover and ecosystem change, interacting with other environmental pressures and direct drivers. For example, the demand for livelihood sources is influenced by population growth. Prior to 1960, the population that led to extraction and degradation remained low. However, since 2000, deforestation has escalated, largely driven by rapid population growth within the state and local community areas."* (Doma, local community leader KII 005, June 2022)
	Key response (s) Government policies/Governance
Local people	*"Before now, government do take good care of the reserves but now less attention is given, so people go into the reserves and cut down trees in the reserve any time without any taken proper permission."* (Doma local people KII 005, June 2022).
	Key response (s) Settlement/Construction
Local Leader	*"Residential building is among other land uses that contribute to the change of the forest reserve because the first need of a man is shelter. Our people build within the forest reserve area before using the resources available on the reserves such as agriculture, timber and with the increasing of human population people clear forest area for more building."* (Doma local leader, 002, June 2022)

Table A1. *Cont.*

Participants' Group	Key Response (s) Agriculture
	Key response (s) Migration
Local People	*"People migrate from rural to rural areas for a greener pasture. For example, people migrate to our community in Doma, and we allow them to live with us, contributing to the pressure we receive on our forest cover and the forest resources for a livelihood. This help in contributing to the change in the forested area."* (Doma local person KII 002, June 2022)
	Key response (s) Corruption
Local leaders	*"The government forest officers assigned to monitor, manage, and enforce the forest laws against encroachments in this forest reserve encourage the community and even foreigners by collecting small bribes from them and then allowing them to enter the forest and degrade it for timber extraction, agricultural, and other uses, which leads to a high rate of cutting forest trees and a change in the forest reserves."* Doma local leader KII 003, June 2022)

Table A2. Risha key stakeholder quotes identifying perceived drivers of forest change in the study area from 1966 to 2000 (the past) and from 2001 to 2022 (the present), based on data from KII.

Participants' Group	Key Response (s) Agriculture
Local People	*"Agriculture activities have been the primary driver of forest changes in this reserve. Since the 1970s, extensive tree cover has been cut down to give space for farming activities. These practices are deeply intertwined with the livelihoods of local communities, as agriculture serves as the primary source of income and sustenance for many families. The community's reliance on forest resources is rooted in a lack of alternative economic opportunities, leading to the exploitation of the forest reserve for both agricultural cultivation and other livelihood needs."* (Risha Local people KII 001, June 2022).
Community Leaders	*"The forest reserve has changed due to agriculture expansion because we are farming there. We farm crops like yam, groundnut, melon, maize, guinea corn, beans, and soya beans and so on."* (Risha Local leaders KII 001, June 2022)
	Key response (s) Lumbering
Local people	*"Lumbering is one of the key contributors to human activities that lead to the degradation of forest reserve in this area. People often felling or cut down trees in and around protected forest areas, particularly to obtain timber for construction materials such as roofing houses. Over time, this persistent practice not only depletes tree populations but also undermines efforts to maintain the ecological balance and biodiversity within this reserve."* (Risha, KII 004, June 2022)
	"Valuable tree species, including mahogany, iroko, and others less commonly recognized, were heavily exploited by the community and the government for timber to meet housing, roofing, and construction demands. This large-scale deforestation significantly reduced forest cover, disrupting the ecological balance. The loss of these trees has had cascading effects on biodiversity, including wildlife displacement and depletion of other valuable species. As a result, these trees are now scarce around the reserve, highlighting the long-term consequences of unsustainable logging practices." (Risha, KII 002, June 2022)
	Key response (s) Charcoal production
Local leaders	*"Most of our people "indigenes" cut down trees to produce charcoal and firewood; also, the trees provide us with construction materials which we construct our houses and also sell to generate income for ourselves and our families, and I think it could be a crucial driver for the gazetted forest reserve changes."* (Risha Community Leader KII 004, June 2022)
	Key response (s) Population growth
Local People	*"Due to population increase, people started claiming ownership of land for farming purposes around 1998 to date of the forest reserves area."* (Risha forest, Local person 003, (Female) KII July 2022)
	Key response (s) Poverty
Local people	*"Poverty is one of the major drivers that led to changes in the forest reserves: we expand our agricultural land in the forest to get our livelihood since we have no good way of getting food or money to survive."* (KII Risha Local people 005, June 2022)

Table A2. *Cont.*

Participants' Group	Key Response (s) Agriculture
Local leaders	*"We can say poverty serves as a key driver of changes in forest reserves, as economically disadvantaged communities often resort to clearing forests to meet immediate needs. This includes expanding agricultural land to grow crops for subsistence and income generation, as well as extracting resources from forests to support livelihoods. These activities are frequently undertaken to ensure economic survival in the face of limited alternatives."* (KII Risha Local leader 005, June 2022)
	Key response (s) Government policies/Governance
Local people	*"The government forest officers assigned to monitor, manage, and enforce the forest laws against encroachments in this forest reserve encourage the community and even foreigners by collecting small bribes from them and then allowing them to enter the forest and degrade it for timber extraction, agricultural, and other uses, which leads to a high rate of cutting forest trees and a change in the forest reserves."* (Risha local people KII 004, June 2022)

Table A3. Odu key stakeholder quotes identifying perceived drivers of forest change in the study area from 1966 to 2000 (the past) and from 2001 to 2022 (the present), based on data from KII.

Participants' Group	Key Response (s) Agriculture
Local People	*"Agriculture has contributed to forest changes here since the 1970s, as we depend on farming and forest resources for income and survival, with no alternative livelihoods."* (Odu, Local Community members, KII 003, June 2022)
Community Leaders	*"Agriculture is the major driver for the forest changes in this area because trees have been cut down to give space for farming activities since the 1960s until date; it is the source of livelihood for our communities, which is why we exploit these forest reserve resources and cultivate crops within the area. We, the community, have no alternative sources of income for our livelihoods. We depend on the forest reserve for our source of income and livelihood."* (Doma Local leaders KII 001, June 2022)
	Key response (s) Lumbering
Local Community Members	*"Trees like mahogany, iroko and so on I don't know their names, were selected and massively cut out for timbers for houses, roofing and other constructions, affecting trees cover in the forest and even wild animals and other valuable trees, now hardly you seem them in the forest."* (Odu, Community members, KII 002, June 2022)
Local Community leaders	*"There was an extensive exploitation of forest resources particularly trees such as mahogany, iroko, Parkia biglobosa, Gmelina, opepe and others whose names I cannot recall were selectively and extensively harvested for timber used in housing, roofing, and other construction purposes. This has significantly reduced tree cover in the forest, adversely affecting wildlife and other valuable tree species. Today, these trees are scarcely found in the forest."* (Odu, Local People, KII 002, June 2022)
	Key response (s) Fuelwood/Charcoal
Local Community Members	*"Some of our people cut down trees for firewood and charcoal, targeting specific trees, which has depleted forest covers and resources from this reserve. For instance, tree species such as* Vitellaria paradoxa *(commonly known as shea tree),* Daniellia oliveri *(African Copaiba balsam tree), and* Prosopis africana *are frequently harvested for high-quality charcoal due to their dense wood and high calorific value. The widespread cutting and burning of these trees for charcoal for domestic use and economic gain."* (Odu, Local Community members K II 005, June 2022)
Community leaders	*"Our people cut and burn some of the tree species for charcoal; there are specific trees that we have for producing charcoal, and this may have contributed to the reduction of the forest."* (Odu, Community leader K II 003, June 2022)
	Key response (s) Grazing
Local people	*"Animals have been grazing around the reserve by Fulani [Herdsmen] over the parcel of land within the forest reserve area. The cattle and cows' footsteps are overstepping the forest by feeding on the grass within the reserve area and cutting down branches of trees for their animals to feed on, and at times they even cut down the trunks for grazing purposes. Again, they cut down the trees to build their camps (houses), and now they are even going to the roots to uproot the trees."* (Odu, Local people KII 001, June 2022)
Local leaders	

Table A4. Government and expert KII key stakeholder quotes identifying their perceived drivers of forest change in the study area from 1966 to 2000 (the past) and from 2001 to 2022 (the present), based on data from KII.

Participants' Group	**Key Response (s) Agriculture**
Government officials	*"Farmlands are expanded in the reserve areas, and even the government has allowed Tungiya farming in the reserve, which was supposed to be protected. As such, most people begin to farm again around the area. Before the farm, they clear trees by cutting off trees' vegetation cover and even burning them, which degrades the forest cover and also destroys soil organisms on the forest lands, which affects the growth of the forest trees in this forest reserves area."* (Government official KII 003,) June 2022)
Experts	
	Key response (s) Lumbering
Government official	*"As forest communities population increases, people are erecting structures, they fell trees to produce timber to roof their houses, so this has contributed to the decline of the forest reserve in this area."* (Government official, KII 002, June 2022)
Experts	*"Logging activities have been there for thousands of years now, targeting some particular economic trees. They have been cut down due to high demand for these timbers' export for different uses and for the communities' uses. This activity involves both the individual in the forest communities and the private commercial that generate revenue for the government, which has a significant impact on the gazetted forest change in these areas."* (Expert KII 001, June 2022)
	Key response (s) Poverty
Government official	*"The one major activity for the forest reserve change is just poverty and that is the fact, the community members need money for livelihoods and economic means which result to clear forest around them for the resources uses."* (KII Government official 005, June 2022)
	Key response (s) Population growth
Experts	*"Population around this forest reserve areas has changed from 1959 till today in the forest communities. For example, the increased expansion and urbanization comes in; as a result, some of the villages that are used to be 300 square meters now will be 3000 square meters, also likely 500 people then, but today the population of the same place may be like 3500 persons, so as such, with human population increases, settlements growth is bound to occur, and settlements growth means encroaching into other land uses that were not residential, because the first need of a man is shelter, and in a shelter and then production which is within the forest reserve to extract raw material for the production of housing, timbers and leading to other activities as increasing human population results to increasing demand from people for other land use and human activities for livelihood which is the key driving forces of the forest change."* (Expert KII 004, June 2022)
	Key response (s) Government policies/Governance
Government Official	*"Government policies are often contributing to deforestation in forest reserves. This is because these policies are not always implemented in a manner that aligns with the needs of the people for conservation. For instance, Nigeria's high cost of natural gas, cooking gas, and kerosene has led to a situation where poor residents in forest communities are forced to resort to forests for their energy needs. This has resulted in the degradation of the ecosystem and a change in the forest cover."* (Government official KII 002, June 2022)
	Key response (s) Settlement/Construction
Government official	*"Road construction and housing development, particularly around forest reserves like Doma and Risha, has increased due to growing socio-economic activities requiring infrastructure. This has led to significant degradation of these reserves through logging and timber use, causing extensive deforestation and heavily degrading parts of the forest for settlement and infrastructure development."* (KII Government official 005, June 2022)
Expert	*"Recently, road construction in Nasarawa State has tended to increase around some forest reserves linked to socio-economic activities that lead to the demand of facilities such as stores, houses, and built-up products to help with socio-economy activities. This utilization of wood logs and timbers for construction affects our forest reserves. For Example, Doma road opens to Yalwa, which passes through the forest reserves, and massive destruction of forest for the road construction was done. This has greatly affected some portion of the forest in this area."* (Expert KII 002, June 2022).
	Key response (s) Insecurity thread
Expert	*"Some of these forests are the hiding place for criminals in the hiding zone. These people cut down vegetation cover around their communities to see their surroundings clearly for defence purposes."* (Expert KII 001 June 2022)

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