Land use change around gazetted forest reserves in Nasarawa State, Nigeria

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Thesis Abstract

Protected forest reserves are essential in maintaining ecological balance, preserving biodiversity, mitigating climate change, and providing essential ecosystem services. However, these vital ecosystems are under threat from unsustainable land use practices inside and outside protected areas. Understanding the importance of protected forest reserves in society and land use management is crucial. This study evaluates land use change around three gazetted forest reserves in Nasarawa State, Nigeria. The study's specific objectives are to: assess the extent of how, when and where the gazetted forest has changed since 1966; evaluate the perceived drivers that triggered land cover changes in the gazetted forest and understand community perceptions of the benefits derived from the gazetted forest; examine the existing strategies to safeguard the gazetted forests in Nasarawa State, and explore community perceptions of effective management policy to inform the future suitability sustainability of the gazetted forest reserve. A comprehensive analysis of forest cover and land use change history in the area is carried out using remote sensing data. The key drivers behind forest cover change, such as historical land use driven by human activities are explored. Through a mixed methods approach that engages with a diverse range of local stakeholders, management, ownership and conservation strategies are explored in the context of forest sustainability for forest reserve-dependent communities. The study draws on remote sensing data and participatory methods such as interviews, focus group discussions, and vegetation surveys. ArcGIS 10.8. was used to analyse the historical trends of Land use land cover change (LULCC) from 1986 to 2020, while statistical packages for social science (SPSS), NVivo, and Python 3, were used for further data analyses to generate descriptive statistics, code themes, and conduct linear cross-correlation analyses. The findings reveal that there has been a significant transformation in the land around the gazetted forest reserves, driven by sixteen interconnected social, economic, environmental, policy/institutional, and technological factors, with the expansion of agricultural activities being the primary driver. While findings generally showed forest loss, one reserve, Odu forest, showed a rapid increase in forest cover (45%) in 2020 compared to the other forests. This was found to be linked to the cultural significance the forest holds within the local community. Further findings indicate mixed understandings and awareness regarding who owns and is responsible for the forest reserves. The study highlights the ineffective implementation of forest conservation strategies to maintain the ecological balance and preserve forest resources, even within gazetted reserves. The findings underscore the importance of understanding cultural values and practices in forest management, and the need to gain local support. Incorporating community knowledge and priorities can support sustainable forest development and environmental stewardship in PAs, both within and beyond Nasarawa State.

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List of abbreviations and acronyms

ACReSAL	Agro-Climatic Resilience in Semi-Arid Landscapes
CBD	Convention on Biological Diversity
CFAs	Community Forest Associations
CMS	Convention on Migratory Species
ETM+	Enhanced Thematic Mapper Plus
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus group discussion
FPAs	Forest PAs
GPS	Global Positional System
KII	Key informant interview
LFN	Laws of the Federation of Nigeria
LGAs	Local Government Areas
LULCC	Land use land cover change
NAGIS	Nasarawa State Geographic Information Services
NGOs	Non-governmental organisations
OLI	Operational Land Imager
PAs	Protected areas
RAs	Research assistants
REDD+	Reduced emissions from deforestation and degradation
SDGs	Sustainable Development Goals
TM	Thematic Mapper
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organisation
WWF	Worldwide Fund for Nature

Dedication

To Almighty God, the Alpha and Omega of my life for his grace and mercy, and to my wonderful parents; (Mr and Mrs. Chunwate Thomas Dogo) and my wife's family (Mr/Mrs Sallau Haruna).

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Author's declaration

I declare that this thesis is a presentation of original work, and I am the sole author. This work has not previously been presented for a degree or other qualification at this University or elsewhere. All sources are acknowledged as references. Except where explicitly mentioned, this thesis represents the author's original work. Three empirical chapters of this thesis are under preparation for publication and are primarily authored by the PhD candidate. I can confirm that I am the lead author of these papers; I was responsible for the work, designing the methodology, carrying out all data collection and analysis, developing arguments, interpretation and writing. As supervisors, Rob Marchant, Eleanor Jew and Lindsay Stringer are co-authors who provided guidance and commented on the drafts.

This research designed was approved by the Environment and Geography Ethical Review Committee, University of York, UK.

Chapter 1. Background and justification for the study

1.1. Forest conservation and protected areas

Forests play an essential role worldwide as natural ecosystems, they provide many ecological functions valuable to humans, including crucial ecosystem services that support livelihoods, such as food, fuel, bioproducts, timber, carbon storage, nutrient cycling, water, air purification, and maintenance of wildlife habitat (Payn et al., 2015; Ward et al., 2018; Wulder et al., 2020; Onyekuru, et al., 2021; Klapwijk et al., 2018). In addition, forests provide services such as shelter, raw materials, and spiritual sustenance (Nvenakeng, 2015; Saka-rasaq, 2019; Nesha et al., 2021) alongside other values such as recreation and serve as a symbol of cultural identity (Miller and Hajjar, 2020; Dreyer et al., 2019; Van Der Jagt and Lawrence, 2019). Forest ecosystem services contribute to human welfare at different scales. On a global scale, all people benefit from e.g. crop pollination services of forests and climate change mitigation, as well as from forest-based products such as wooden furniture or timber for housing (Dreyer et al., 2019; Van Der Jagt and Lawrence, 2019). At a more local scale, it is estimated that 350 million rural inhabitants are highly dependent on forests for food security, livelihoods, and energy (Rayner, et al., 2010; Latham, 2013; Wolfslehner et al., 2020).

At the same time, the 21st century, more than any previous period in human history, is witnessing intense competition for natural resources and accelerating rates of change on a global scale, including changes to forests. Increasingly, efforts are being developed to support forest conservation (IUCN, 2019). Forest conservation involves maintaining, protecting, or restoring a forest landscape to preserve biological and cultural values, promoting sustainable use and more equitable distribution of forest goods and services (IUCN, 2019; Andrade and Rhodes, 2012; Pawar and Rothkar, 2015). Restoration is increasingly vital in conservation, though it is a relatively young concept, especially in practices addressing ecosystem services (Tedesco et al. 2023).

Tedesco et al. (2023) assert that ecosystem restoration transcends ecology, serving as a transformative process addressing societal challenges such as inequality, governance, and sustainability. Fischer et al. (2021) similarly highlight the importance of inclusive approaches that integrate ecological and social dimensions, especially in the context of the UN Decade on Ecosystem Restoration (2021-2030). These views underscore that forest

conservation and restoration are both ecological necessities and opportunities for transformational change, contributing to resilient and equitable landscapes.

Often conserving forests involves establishing protected areas (PAs). A PA is a distinct geographic region officially recognised, designated, and administered through legal or other effective measures to ensure the long-term preservation of nature, including its connected ecosystem services and cultural values (Dudley, 2008; Borrini-Feyerabend and Hill, 2015; IUCN, 2019). Establishing PAs is imperative for preserving biological diversity as an intrinsic value and a valuable resource for future generations (IUCN, 2019, Hodder et al., 2014). However, in practice, the efficacy of PAs varies considerably. While well-managed PAs can effectively conserve biodiversity, many fail due to factors such as insufficient resources, inadequate enforcement, and conflicting human interests (Hodder et al., 2014). Therefore, realising their full potential necessitates addressing these challenges to ensure PAs function as intended. Throughout the world, PAs frequently encompass forests, as these ecosystems provide critical habitat for biodiversity and essential ecosystem services and are central to global climate regulation (Leberger et al., 2020; UNEP-WCMC and IUCN, 2021b). Forested PAs not only safeguard species and ecological processes but also serve as carbon sinks, contributing to climate change mitigation. According to the World Database on PAs (WDPA), approximately 20% of the world's forests are within formally designated PAs, underscoring their significant role in forest conservation (UNEP-WCMC and IUCN, 2021b). However, the conservation of PAs is facing significant and escalating challenges from human-induced factors, which are currently being intensified, including the impacts of climate change (Belle et al., 2016; Ward, et al., 2018; Hoffmann, 2022). The establishment of PAs in virtually all countries signifies the dedication of governments to ensuring the preservation of natural resources for the present generation to pass onto future generations a world that is at least as diverse and productive as the current one we are privileged to experience and enjoy today (Richardson et al., 2019; Krause and Nielsen, 2019). Yet, despite these conservation efforts, protected forest ecosystems, national parks, and forest reserves in tropical regions have failed to meet their expected ecological functions, as evidenced by studies from different parts of the world conducted by e.g. Amoah et al. (2022), Aditya and Ganesh (2022), Barlow et al. (2007), and Kusimi (2015). This research seeks to understand human-forest interactions and explain landscape changes around PAs (Owusu and Essandoh-yeddu, 2018; Cabral et al., 2018), focusing on gazetted forests in Nasarawa State, Nigeria.

1.1.2. Vegetation type, tree cover changes and forest conservation in Nigeria

Nigeria's forest cover types range from dense tropical rainforests in the south to open woodlands and savannas in the north (Nzeh and Nweze, 2015). The Guinea savanna is a prominent ecological zone. Located in northern Nigeria, the Guinea savanna is characterized by woodland and grassland vegetation (Adenle and Speranza, 2020). This region is Nigeria's most extensive ecoregion and a major food production area (Adenle and Speranza, 2020). In the Guinea savanna, the forest structure consists of scattered trees interspersed with grasses and shrubs and this mix plays a crucial role in the country's biodiversity and ecosystem services. The vegetation is adapted to seasonal rainfall patterns, with a distinct dry season. Tree species are often drought-resistant and fire-tolerant, as annual burning is common (Hopkins, 1965). Woodland areas within the Guinea savanna have lower tree density and basal area compared to humid forest types (Godlee et al., 2020). Contradictions exist in vegetation trends observed in the region, with some studies reporting decreased woody vegetation cover and others noting increased herbaceous vegetation cover (Liu et al., 2016). These discrepancies may be influenced by factors such as deforestation, latitude, and rainfall variability (Adenle and Speranza, 2020). This suggests complex factors influencing vegetation dynamics, including human activities, climate change, and natural processes, necessitating careful monitoring and sustainable management practices to preserve the forest areas' ecological integrity (Liu et al., 2016; Nwabueze et al., 2023).

Nigeria has faced substantial tree cover loss in recent decades due to deforestation, agricultural expansion, urbanization, and unsustainable logging (Eludoyin and Iyanda, 2019). Studies indicate that Nigeria's deforestation rate is among the highest globally, with forest cover reducing by over 50% since the 1970s (Global Forest Watch, 2021; FAO, 2020). From 2001 to 2020, Nigeria lost about 1.14 million hectares of tree cover, significantly affecting biodiversity-rich and livelihood-dependent forest ecosystems (FAO, 2020). This loss heavily affects lowland rainforests, mangroves, and savanna woodlands (Nzeh and Nweze, 2015).

Tree cover loss is prevalent in areas with weak forest governance and inadequate conservation enforcement (Ujor, 2018; Chiaka et al., 2024). Subsistence farming, commercial plantations, fuelwood collection, and charcoal production are primary contributors, reflecting rural dependence on wood-based energy (Scullion et al., 2019; Scheren et al., 2021). Forest degradation leads to the loss of ecosystem services like carbon sequestration, water regulation, and biodiversity conservation, posing challenges for local

communities and global climate goals (Chiaka et al., 2024; Ujor, 2018). Sustainable outcomes require landscape-oriented approaches that integrate ecological, social, and economic considerations.

1.1.3. Protected areas and Gazetted forests in Nigeria: history, status, and knowledge gaps

Protected Areas are recognized as key conservation tools, but their effectiveness in preventing land-use conversion varies (Olufemi et al., 2020). In some regions, PAs successfully limit deforestation, whereas in others, they fail due to weak governance and economic pressures. The effectiveness of PAs is influenced by several factors, including: proximity to markets and infrastructure- forests near roads and towns experience higher deforestation pressure due to increased accessibility (Eludoyin and Iyanda, 2018) Regarding governance and enforcement, well-managed PAs with active monitoring are more effective than "paper parks" with minimal oversight (Guerra et al., 2019). Socioeconomic factors may resist strict conservation measures, particularly if local communities are dependent on forests for their livelihoods, necessitating community-based conservation approaches (Guerra et al., 2019). While Nigeria's PAs play a critical role in conservation, they face challenges similar to PAs globally, requiring stronger governance and enforcement to prevent deforestation and land-use conversion.

Nigeria's total landmass, as reported by the Federal Ministry of Environment (2015), spans 923,768 km², with 15.15% designated as PAs. These PAs include biosphere reserves, Ramsar wetlands, and national parks aligned with global conservation standards. However, only a limited portion of these areas consists of forested regions. Nigeria's forests, including lowland rainforests, mangroves, and savannas, continue to diminish due to deforestation and land conversion. Cross River State harbors the largest intact rainforest areas, while the country's mangrove forests, covering approximately 10,000 km², represent Africa's most extensive mangrove ecosystem (Abdulaziz et al., 2015).

Gazetted forests in Nigeria are legally designated forest reserves established during colonial and post-colonial periods to regulate timber extraction, land use, and biodiversity conservation (Ujor, 2018). Initiated under British colonial rule in the early 20th century, these reserves became part of Nigeria's conservation framework. By the 1960s, over 1,000 reserves covered approximately 10% of the country's land area (Areola, 1987).

Despite their legal status, many gazetted forests do not align with international standards of PAs as defined by the IUCN (IUCN, 2019; Abdulaziz et al., 2015). Weak conservation management has led to their unsustainable exploitation, particularly through logging and agricultural encroachment. Only select reserves, such as national parks and UNESCO biosphere reserves, receive significant protection and conservation efforts. Nigeria has seven national parks and four PA categories, totaling 994 PAs, including 445 gazetted forest reserves (Olaniyi et al., 2019; Federal Ministry of Environment, 2015; Federal Department of Forestry Nigeria, 2019). However, many reserves have suffered degradation due to population pressures, agricultural expansion, and weak oversight. Although gazetted forests are intended as PAs, their effectiveness is undermined by inadequate conservation status and enforcement (Abdulaziz et al., 2015; Madumere, 2019). Their role within broader national conservation strategies remains unclear, and exclusion from international networks like the IUCN categories or UNESCO World Heritage sites limits their visibility and funding opportunities (IUCN, 2019).

Knowledge gaps exist regarding the ecological and socio-economic aspects of gazetted forests (Belle et al., 2016). Limited empirical data on forest conditions, degradation rates, and community dependence necessitate comprehensive research utilizing remote sensing, ecological surveys, and participatory methods. Conservation initiatives must adopt landscape perspectives and multi-scale data analysis to guide future interventions, ensuring effective forest management that supports both environmental sustainability and human well-being (Leberger et al., 2020).

1.1.4. The need for landscape perspectives in conservation initiatives

Landscape perspectives and data-driven approaches play a key role in designing effective conservation strategies (Belle et al., 2016). Landscape approaches consider the broader spatial context of forest ecosystems, acknowledging the interconnectedness of ecological, social, and economic processes (Olaniyi et al., 2019).

Currently, forest cover is changing rapidly in developing countries, especially in those in Africa. Data from the Food and Agriculture Organization (FAO) underscores the severity of the issue. According to the Global Forest Resources Assessment (2020), Africa experienced the highest rate of net forest loss between 2010 and 2020, losing approximately 3.9 million hectares per year- a significant increase compared to the previous decade. Countries such as the Democratic Republic of the Congo, Nigeria, and Ethiopia have seen some of the steepest

declines in forest cover, largely driven by economic forces, and government policies (Amoah et al., 2020; Mutoko, et al., 2015; Amoah et al., 2020; Cantarello et al., 2014; Meyfroidt and Lambin, 2010; Mutoko et al., 2015). Such losses have limited the benefits of carbon storage and climate regulation, as well as challenging the livelihoods of local communities (Food and Agriculture Organization [FAO], 2020; WWF, 2021; 2022).

In Nigeria's gazetted forests, data-driven approaches can identify forest loss patterns, areas of ecological importance, and restoration opportunities. By integrating remote sensing technologies, GIS analyses (Eludoyin and Iyanda, 2019) and stakeholder participation, conservation efforts can create context-specific interventions balancing conservation goals with local community needs (Oduro Appiah et al., 2021). Successful forest conservation in Nigeria relies on bridging knowledge gaps, strengthening governance, and leveraging landscape-scale data for informed decision-making (Chiaka et al., 2024). Gazetted forests have significant potential for biodiversity conservation and ecosystem services but achieving this requires ongoing efforts to improve their management, recognition, and integration into broader conservation agendas (Phiri and Nyirenda, 2022). These challenges highlight a significant gap between the aspirations associated with PAs and their real-world outcomes (Bongaarts, 2019; FAO and UNEP, 2020). Legally designated PAs play a crucial role in mitigating biodiversity loss and fostering associated benefits, demonstrating their significance in various global regions (Klapwijk et al., 2018; Oduro Appiah et al., 2021; Olaniyi et al., 2019). Recognising the paramount importance of forests, the United Nations recommends that 25% of a country's total land area should be dedicated to permanent forest cover (Phiri and Nyirenda, 2022; Ankomah et al., 2020), however, this does not mean that all of this land should be designated as PAs. This strategic conservation approach is emphasised for its instrumental role in delivering essential ecosystem services and preserving biodiversity at local, regional, and global scales (Frechette, et al., 2014; Ladan, 2014; Federal Ministry of Environment, 2015). For example, local communities often lose access to the benefits provided by forests, including ecosystem services like water regulation, soil fertility, food, medicinal plants, and livelihoods (e.g., through non-timber forest products). Cultural and spiritual connections to the forest may also be disrupted. In relation to biodiversity, forest ecosystems house diverse species, many of which are endemic. Gazetted forest loss leads to habitat destruction, species displacement, and extinction risks. Furthermore, regional and global populations are affected to some extent due to the loss of carbon storage capacity, which exacerbates climate change, and other ecosystem services that forests provide on a broader scale (e.g., weather regulation,

pollination). The loss of gazetted forests often means the loss of these resources. This conservation strategy is crucial for providing essential ecosystem services and preserving biodiversity at local, regional, and global levels (Frechette et al., 2014; Ladan, 2014; Federal Ministry of Environment, 2015).

However, of all the notable forest transition pathways, there has yet to be a consensus on which specific or mix of pathways can best inform efficient regeneration and management of forest resources in Africa (Oduro et al., 2015; Van Der Jagt and Lawrence, 2019) as land use changes influence the changes in the forest area, including the conservation benefits provided by PAs. Findings in this thesis contribute to this debate.

1.2. Land use/ land cover and forest change

Land cover change refers to modifying or converting the biophysical landscape of the Earth's surface and its underlying layers (Kissinger and Herold, 2017; Thasi et al., 2021). This process is frequently linked with land use, which involves the manipulation of the physical features of the land and the reasons behind such alteration, i.e., the intended purpose for which the land is utilized (Muhati et al., 2018; Turner et al., 1995).

Although several factors affect the biophysical makeup of the Earth's surface, research suggests that humans are the primary cause of most changes in modern times (Gong et al., 2020; Rudel et al., 2020; Thasi et al., 2021; Meyfroidt et al., 2013; Guerra et al., 2020). This period, beginning in the late 19th century, is marked by technological, industrial, and societal advancements that have significantly altered land use and cover patterns. Understanding the relationship between land use and land cover change can help policymakers develop appropriate responses to mitigate the environmental impacts of human activities on forest cover (Oduro Appiah et al., 2021; Estoque and Murayama, 2015; Wulder et al., 2020).

1.2.1. Global and regional perspectives on land use and forest change

Land cover change occurs globally, with forest expansion occurring through natural processes such as the re-establishment of forests on abandoned agricultural land, as well as through reforestation and afforestation initiatives (Keenan et al., 2015; Pokorny et al., 2019; FAO, 2017; United Nations Resolution, 2020). However, forest loss is primarily driven by land-use transformations, including agricultural expansion, urban development, fuelwood extraction, and timber harvesting (Eludoyin and Iyanda, 2019; Scullion et al., 2019; Scheren et al., 2021).

Geldmann et al. (2019) conducted a global quantitative analysis of deforestation trends in tropical regions from 2008 to 2019. Using high-resolution satellite imagery and GIS-based mapping, they found that Latin America, Asia, and Africa experienced the highest rates of deforestation. Notably, deforestation rates were lower within PAs than in unprotected areas, except in North Korea, where forest loss within PAs was higher than outside them (Mammides et al., 2022). In Latin America, pasture establishment and shifting cultivation were key deforestation drivers, while in Africa, subsistence agriculture was found to be the primary cause (Addo-Fordjour and Ankomah, 2017). In Northeast Asia, deforestation was driven by logging and timber plantations (Leberger et al., 2020; Dibaba et al., 2020; Elleason et al., 2021). These studies underscore the need for targeted conservation efforts that consider regional variations in land use and forest change dynamics.

1.2.2. Land use and forest change in Nigeria

In Nigeria, Geographic Information Systems (GIS) have been extensively used to map forest cover change, providing insights into deforestation patterns and environmental challenges (Olufemi et al., 2020; Fasona et al., 2020). For instance, a study in southwestern Nigeria used Landsat imagery from 1986 to 2002 to assess land use changes. Using the Maximum Likelihood classification method, it was found that disturbed or degraded forest was the most extensive land cover type in the area (Mengistu and Salami, 2007).

Similarly, a study in northern Nigeria analyzed forest cover dynamics in the Falgore Game Reserve over three decades (1985-2015). Using multi-temporal Landsat imagery, researchers observed significant changes in forest composition, with moderate woodland giving way to open woodland as the dominant cover type (Suleiman et al., 2017). However, while the southwestern study linked deforestation to population growth and economic activities, the Falgore Game Reserve study found no significant correlation between forest cover change and population density (Mengistu and Salami, 2007; Suleiman et al., 2017). This contradiction highlights the complexity of land use dynamics and the need for localized studies to understand specific drivers of deforestation.

In summary, land use and land cover change are complex processes influenced by various anthropogenic and environmental factors. Globally, deforestation is driven by agricultural expansion, urbanization, and resource extraction, while afforestation and reforestation efforts contribute to forest regrowth. In Nigeria, GIS and remote sensing studies have provided crucial insights into forest cover dynamics, revealing regional variations in land-

use pressures and conservation effectiveness. However, the evidence base for land-use change patterns in Nigeria remains limited, highlighting the need for further research. Strengthening forest governance, investing in geospatial technologies, and adopting community-based conservation models will be essential for sustainable forest management in the country. Further research is nevertheless needed to understand these human-environment relationships.

1.3. Forest conservation governance

This section establishes the conceptual foundation for governance in conservation, distinguishing it from management and highlighting how governance structures shape conservation outcomes through legal frameworks, stakeholder engagement, and power dynamics. By outlining key governance challenges such as weak enforcement, resource mismanagement, and political constraints, it contextualizes the broader issues relevant to the PhD research and highlights a failing of the governance around conservation in Nigeria.

Governance refers to the exercise of authority and power through policies, institutions, stakeholders, and decision-making processes that determine conservation outcomes (Nvenakeng, 2015; Worboys et al., 2015; Phiri & Nyirenda, 2022). Stakeholders in forest governance and conservation are individuals, groups, or organizations with an interest or influence in the management, use, and protection of forests. This includes government agencies, local communities and indigenous peoples, Non-Governmental Organizations (NGOs), the private sector and industries, academics and researchers, international organizations and donors (e.g., FAO, UNEP, ACReSAL), civil society and environmental activists and the general public. (Nvenakeng, 2015; Kariuki et al., 2021; Van Der Jagt & Lawrence, 2019). Each stakeholder should theoretically play a crucial role in shaping policies, implementing conservation measures, and ensuring sustainable forest management while balancing ecological, social, and economic interests.

For the purpose of this study, the focus is on government stakeholders agencies responsible for environmental policy and enforcement and community stakeholders, primarily forest users. Formal and informal institutions, including legal frameworks and customary practices, influence how forest governance is structured, while forest tenure arrangements define rights and responsibilities over resources (FAO, 2017; Siry et al., 2015). In contrast, management focuses on the coordination of resources and activities to meet specific conservation objectives within designated areas (Deng et al., 2020; Domínguez & Luoma, 2020).

Effective governance ensures compliance, equitable resource distribution, and biodiversity conservation, whereas weak governance leads to mismanagement and resource depletion (Ujor, 2018; Borokini et al., 2012).

In Nigeria, despite international commitments to conservation such as pledges to afforest 6 million hectares and expand national parks forest governance faces persistent challenges. These include weak regulatory enforcement, resource mismanagement, political constraints, land-use conflicts, illegal timber trade, and rapid deforestation rates estimated at 350,000–400,000 hectares annually (Ujor, 2018; Gutierrez Garzon et al., 2022). Environmental degradation in regions like the Niger Delta further illustrates governance failures, while population growth and policy inertia hinder progress towards ambitious global biodiversity conservation goals such as "30 by 30" and "50 by 50" aimed at addressing the ongoing biodiversity crisis and mitigating the effects of climate change (Li et al., 2023; Parks and Tsioumani, 2023).

National conservation efforts include protected forest reserves managed by government agencies under environmental and agricultural ministries (Federal Ministry of Environment, 2006; Phillips, 2020). These reserves aim to balance biodiversity preservation and sustainable resource use, aligning with international frameworks like the Convention on Biological Diversity (CBD) (Federal Ministry of Environment, 2006; Phillips, 2020). However, achieving conservation goals necessitates improved governance structures, stronger policy enforcement, and the inclusion of indigenous and local knowledge (Orsini & Diallo, 2015; Ningsih et al., 2020). Strengthening governance mechanisms is essential for addressing deforestation, biodiversity loss, and climate change impacts in Nigeria.

The discussion of Nigeria’s forest governance emphasizes the multi-actor landscape, linking institutional frameworks to international conservation commitments while recognizing persistent gaps in implementation. This serves to frame the research objectives by demonstrating how historical governance structures, including gazetted forests, predate contemporary global conservation agendas and often-overlooked local communities. This research explores how governance mechanisms evolved, how historical legacies contribute to current conservation challenges, and how governance structures can be reformed to integrate both environmental and social considerations effectively for conservation and sustainable development.

1.4. Forest conservation and the sustainable development goals

The Sustainable Development Goals (SDGs), adopted by all 193 UN member states on 25 September 2015, emphasize the need for integrated methodologies to enhance forests' contributions to sustainability. These methodologies, including both quantitative assessments and qualitative frameworks, are essential for analyzing forest-related policies and strategies (Baumgartner, 2019; Díaz-López et al., 2021). Forests play a critical role in achieving multiple SDGs, particularly through themes like ecological sustainability, sustainable energy, and social development (Raman et al., 2024). A comprehensive approach is necessary to navigate synergies and trade-offs, ensuring forests contribute effectively to sustainability (Ahrens et al., 2025; Van Zanten and Tulder, 2021). Recognized as central to SDG 15 (Life on Land), forests are deeply interconnected with nearly all SDGs, underscoring their significance in achieving broader sustainability objectives (UN, 2015; United Nations Resolution, 2020; Sonwa, 2017; FAO, 2017). Table 1.1 presents a summary of how SDGs are linked to forests.

Table 1. 1. Summary of sustainable development goals and contributions of forests toward sustainable outcomes.

Sustainable Development Goals	Contributions of forests toward sustainable outcomes	SDGs relevant at a local level (Nasarawa State), Priority/Issues
SDG 1: No Poverty:	Forest-based incomes contribute to poverty alleviation.	High priority: forest resources critical for poverty alleviation
SDG 2: Zero Hunger	Forests serve as sources of essential plant and animal-based products, including medicines and food, which help to end hunger.	High priority: reliance on forests for food, but risks biodiversity loss.
SDG 3: Good Health and Well-being	Forest improves health and well-being for all at all ages.	Moderate priority: Forest degradation threatens traditional medicine and air quality.
SDG 6: Clean Water and Sanitation:	Forests profoundly influence hydrological cycles, which in turn impacts downstream water supplies and contribute to achieving the goal of ensuring access to clean water and sanitation.	Moderate priority: Opportunities for forest-based environmental education.
SDG 8: Decent Work and Economic Growth	Forestry practices generate employment opportunities, aligning with the provision of decent work.	High priority: Forest-based enterprises offer livelihoods, especially in rural areas.
SDG 7: Affordable and Clean Energy	Forests provide a significant means of reducing global dependence on fossil fuels for energy, as they offer a source of biomass.	Conflict: Heavy reliance on firewood/charcoal fuels deforestation
SDG 12: Responsible Consumption and Production	Forests also play a role in responsible consumption and production by providing renewable materials and products as alternatives to non-renewable counterparts.	High priority: Need for sustainable harvesting and management.
SDG 9: Industry, Innovation, and Infrastructure	Forests serve as catalyst in manufacturing innovation and growth.	Moderate priority: Untapped potential in sustainable forest-based industries
SDG 5 and 10: Gender Equality	Many forest communities exhibit notable gender and (empower all women and girls) and equality within and among countries.	High priority: Women play key roles in forest product collection and conservation. Need for inclusive forest governance structures.

SDG 16: Peace, Justice, and Strong Institutions	Participatory forest management strategies are vital in fostering inclusive societies and establishing inclusive institutions.	Important: land-use conflicts between farmers, herders, and loggers
SDG 13: Climate Action	Forests are essential for carbon storage and regulation which addresses climate action and also provide vital supporting services, including nutrient cycling and crop pollination, which are fundamental for sustainable agricultural production.	Critical: deforestation increases vulnerability to climate impacts
SDG 14: Life Below Water	Coastal mangroves offer protective benefits such as marine resources for sustainable development and enhance the resilience of coastal communities to climate-related hazards.	Low priority: Nasarawa is inland; minimal direct impact, but upstream activities affect river ecosystems.
SDG 11: Sustainable Cities and Communities	Forest-related cultural ecosystem services, spanning recreational, spiritual, religious, and non-material benefits, are essential for the well-being of both rural and urban populations and contribute to education, physical and mental well-being, and the development of resilient and sustainable cities.	Moderate priority: Urban expansion threatens peri-urban forests and green spaces
SDG 15: Life on Land	Fundamentally, a significant proportion of global terrestrial biodiversity is harboured within forests underscores the imperative to safeguard, rehabilitate, and advance the sustainable utilisation of land-based ecosystems, implement sustainable forest management practices, counteract desertification, cease and reverse land deterioration, and put a stop to the decline of biodiversity.	At risk: expansion of farming and logging threatens ecosystems

Sources: United Nations Resolution, 2020; Carr et al., 2021; Scherer et al., 2018; Baumgartner, 2019.

Sources: United Nations Resolution, 2020; Carr et al., 2021; Scherer et al., 2018; Baumgartner, 2019.

Although the importance of sustainably managing forest resources is widely recognised, robust evidence on the impacts of specific forest conservation interventions, including PAs such as gazetted forests, remains limited, forcing policymakers to shoot in the dark when designing or implementing interventions effectively (Cuni-Sanchez et al., 2019; Ward, et al., 2018; Mallari et al., 2016). While some forest conservation development strategies' best practices are successful in some parts of the world, forest conservation in many parts of Africa remains challenging (Cetas and Yasué 2017; Nesha et al., 2021; Fasona et al., 2020).

At the local level in Nasarawa State, different stakeholders could lead them to prioritize Sustainable Development Goals (SDGs) differently based on their interests and needs. For

example, local communities and farmers could lead them to prioritize SDG 1 (No Poverty) and SDG 2 (Zero Hunger) due to economic and food security concerns. Government agencies and environmental NGOs may emphasize SDG 13 (Climate Action) and SDG 15 (Life on Land) to address deforestation and biodiversity loss. Meanwhile, energy-related stakeholders often focus on SDG 7 (Affordable and Clean Energy), even though this can conflict with climate goals. Understanding these varying priorities is essential for designing balanced, context-appropriate forest management strategies and multi-stakeholder engagement for long-term sustainability (Carr et al., 2021; Scherer et al., 2018. The research in this thesis adds to the body of evidence that helps to understand how forests can be managed more effectively to support the achievement of the SDGs and initiatives within the CBD and focuses on the gazetted forests in Nigeria.

1.5. Perspectives on forestry development and environmental conservation practices in Nigeria

The development of forestry in Nigeria is strongly linked with the historical trajectory of its people (Kalu and Izekor, 2006; Alo et al., 2014). Pre-colonial Nigeria was characterised by a diverse array of indigenous communities with varying degrees of reliance on hunting, gathering, and agriculture. While not exclusively a nation of hunter-gatherers, many communities engaged in these practices as part of their subsistence strategies. As the population grew, they established a permanent residence, constructed an enclosed area, and assumed the use of some forest lands. The level of exploitation was relatively low, save in certain areas where land was converted for agricultural purposes (Morin-Rivat et al., 2017). The environmental conservation practices during this period were often intertwined with socio-cultural norms and traditional belief systems. These practices, comprising totemism, sacred groves, and taboos, that have been shown to play a significant role in the preservation of the natural resources for conservation were widely practised (Eneji, et al., 2019; Ogwu and Osawaru, 2022).

The areas that were cleared for agricultural purposes involved selective clearing, typically for subsistence farming rather than large-scale and commercial agriculture. This approach led to less environmental degradation in comparison to contemporary practices. Although Nigeria's Bantu agriculture can be traced back approximately 5,000 years, it stands as an exception to this general pattern. However, the situation underwent a significant transformation with the arrival of colonial officials in Nigeria throughout the 19th century (Ujor, 2018; Ayanlade, 2016; Udeagha, et al., 2016). As the establishment of settlements

progressed, there was a corresponding rise in the exploitation of timber resources due to the adoption of Western architectural practices for constructing structures such as offices, trading stations, train lines, and residential areas (Kalu and Izekor, 2006). The need for timber in Europe also grew with Nigeria as a primary supplier of timber for export (Adeyoju, 1975; Ezenwaka, 2018).

The early chainsaw from the late 19th century replaced traditional tools such as the machete and axe, resulting in a significant surge in the extent of exploitation (Abere and Ezenwaka, 2011; Ezenwaka, 2018). Historical documentation dating back to 1822 indicates the presence of forest produce exports, primarily originating from the southern protectorate of Nigeria (Federal Ministry of Environment, 2006; Kalu and Izekor, 2006). These resources played a crucial role as an essential energy source, industrial activities, and railway infrastructure construction during the late 1890s and early 1900s to the British Empire. Nigeria's forest resources were perceived as valuable assets for economic exploitation by the British. The colonial authorities recognised the potential of timber and other forest products to contribute to revenue generation and economic development (Ezenwaka, 2018; Ujor, 2018). As such, the creation of forest reserves was partly driven by the desire to facilitate the controlled exploitation of these resources for the benefit of colonial coffers and industrial interests.

During the early phases of reserve establishment, the primary motivations differed from those prevalent in later periods (Adeyoju, 1975). The impact of colonial legacies on Nigeria, as also exemplified by French colonial policies in West Africa, has led to the establishment of distinct identities and administrative structures that have marginalized traditional authorities and exploited natural resources, including timber, for economic gains (Aigbe, 2012; Nwosu and Nnwana, 2013). This historical context has contributed to the present challenges in regulating timber extraction, where economic interests of Nigeria often clash with conservationist objectives. While conservationist objectives are present in Nigerian society and laws, their realization is often hindered by economic priorities, institutional weaknesses, and a lack of cohesive implementation.

It is noteworthy that while colonial policies have had a lasting effect on resource management, there is also recognition of the importance of integrating traditional practices with modern conservation efforts (Banso et al., 2023). This integration is essential in addressing the socio-economic and environmental challenges associated with timber extraction. Furthermore, the struggles of the Nigerian forestry sector with non-performance and corruption highlight the broader governance issues that can affect the implementation of regulatory policies in the timber industry (Enuoh and Bisong, 2015). The regulation of

timber extraction in Nigeria is a complex issue that is influenced by historical colonial exploitation, the need for economic development, administrative challenges, and conservationist ideals. Addressing these concerns requires a multifaceted approach that respects historical contexts, incorporates traditional practices, and strengthens governance to ensure sustainable management of forest resources (Banso et al., 2023; Benjamin et al., 2024). Objectives are only superficially integrated and vary significantly across regions and contexts. Strengthening the institutional enforcement capacity, increasing public awareness, and aligning local and national interests with conservation goals are critical steps forward.

1.6. PAs and forest governance in Nigeria today

Forest governance in Nigeria involves a complex web of organisational structures and diverse actors designed to manage and regulate the utilisation of forest resources, balancing economic interests with environmental conservation (Federal Ministry of Environment, 2020) as presented in Table 1.2.

Table 1. 2. Summary of the organisational structures and actors of forest governance in Nigeria

Organisation names	Roles
Governmental Bodies:	
Federal Ministry of Environment:	Responsible for formulating policies, regulations, and guidelines related to forestry and environmental management at the federal level.
State Ministries of Environment and Forestry	Implement and adapt federal policies to suit regional contexts, overseeing forestry activities within their respective states.
Forest Regulatory Agencies:	
National Forestry Research Institute (FRIN):	Focuses on research and development to enhance sustainable forestry practices.
Nigerian Conservation Foundation (NCF):	Works towards biodiversity conservation and sustainable forest management.
Civil Society Organizations	
National NGOs:	Act as intermediaries between the government and local communities, advocating for sustainable practices and community engagement.
International NGOs:	Provide support, expertise, and sometimes funding to enhance Nigeria's capacity for effective forest governance.
Local Communities:	
Household Non-Timber Forest Product (NFTP) Extractors and Farmers:	Engaged in the sustainable extraction of forest products for livelihoods.
Legal Timber Operators:	Including concession holders and those with timber utilization contracts, responsible for regulated timber harvesting.
Investors in Commercial Timber Plantations:	Contribute to developing sustainable forestry practices and economic growth.
Individual Tree Growers:	Contribute to afforestation efforts and sustainable wood supply.
Wood Processors, Lumber Sellers, and Buyers:	Involved in the downstream timber industry, influencing market dynamics.
Research and Academic Institutions:	
Universities and Research Institutes:	Contribute to the knowledge base, providing research findings to inform policy and practice in forest governance.

Source: Forest governance organisational structure; Federal Ministry of Environment Nigeria, 2023.

Formally, there is a well-established collaboration between environmental institutions and agencies that evaluate forest activities that impact people's lives in Nigeria. Parties work together in various ways to manage forest resources and carry out administrative duties. The Federal Department of Forestry at the Federal Ministry of Environment is the national coordinator for all forest-related matters in Nigeria (Federal Ministry of Environment, 2020; Federal Ministry of Environment, 2015). Each state has institutions that monitor, measure, and report on forest laws and conservation management. The National Federal Ministry of Environment oversees these state-level institutions and establishes Technical Committees, state-specific working groups, and Stakeholder Platforms to facilitate dialogue among diverse stakeholders. Civil society organisations, including National and International NGOs, also act as intermediaries between the government and local communities (Federal Ministry of Environment 2006, 2015; FREL, 2019). While the governance structures appear well set out on paper, systematic research on the governance and implementation of Nigeria's gazetted forests often reflects tensions between national political priorities and local community needs. National policies tend to emphasize conservation and revenue generation, while local communities rely on forest resources for their livelihoods. This misalignment can lead to conflicts over access, enforcement challenges, and unintended ecological consequences that are largely unexplored, leaving a critical knowledge gap. Despite the importance of these dynamics, systematic research on the governance and implementation of Nigeria’s gazetted forests and the implications for both forest conditions and local livelihoods remains limited. Addressing this gap in knowledge is particularly critical for understanding how governance decisions shape real-world outcomes. While this study does not fully address this gap, it contributes by examining key governance patterns and their localized effects on gazetted protected conservation, providing a foundation for further research.

Although prevailing forestry legislation and regulations in Nigeria (such as those cited by Onyekuru et al., 2021; Federal Department of Forestry Nigeria, 2019) suggest that federal and state governments should adopt proactive approaches to sustainable management, ecological restoration, and biodiversity protection incorporating long-term environmental and social considerations into forest resource exploitation in practice, the extent to which these frameworks are implemented remains limited. Consequently, there is a gap between the intended policy objectives and the actual management practices on the ground. The allocation of concessions for logging activities underwent scrutiny and evaluation by the State Forestry Departments in Nigeria. Subsequently, multiple institutions were established, and legislative reports were published for implementation (Anwadike, 2020). The Land Use

Act, encapsulated in Cap L5 LFN 2004 and promulgated in 1978, further enhances Nigeria's control and administration of forest lands (FAO, 2020b; Ujor, 2018; Abere and Ezenwaka, 2011). According to this act, the Governor of each state is entrusted with the responsibility of managing and administering land within their territories (Agbeja and Ostesila 2011). Moreover, the Endangered Species (Control of International Trade and Traffic) Amendment Act of 2016 serves to facilitate the preservation and administration of Nigeria's wildlife, as well as safeguard certain species that face the imminent threat of extinction due to excessive exploitation or alterations in their natural habitats, which include forests (Isyaku, 2021; Anwadike, 2020). The legislation aligns with Nigeria's contractual obligations delineated in multiple international accords, including the CBD and the Convention on Migratory Species (CMS) of Wild Animals, and Flora, all which Nigeria has ratified (Ite and Adams, 1998). These tools facilitate enforcement of laws and the implementation of guidelines and policies about international commerce in plant and animal species within Nigeria by the Federal Government. Nigeria also formulated its National Biodiversity Strategy and Action Plan (2016 – 2020) to serve as a comprehensive framework aimed at the conservation and sustainable exploitation of biodiversity. This strategic initiative facilitates access to genetic resources and strives for the equitable and just distribution of benefits arising from their utilisation, complementing the National Forestry Policy.

Nigeria has developed a comprehensive set of forest policies over time, including the National Forest Policies (1988, 2006, 2020), the Forestry Law (1999), and the Climate Change Policy (2012; 2020), all of which emphasise sustainable forest management, community involvement and conservation practices, in line with the country’s obligations to the CBD and Nationally Determined Contributions under the Paris Agerement 2015 (CBD, 2019; United Nations Resolution, 2020). The efficacy of forest policy in achieving environmental protection and promoting sustainable resource use, ecosystem preservation, and human health while preventing environmental degradation is paramount (Baumgartner, 2019; United Nations Resolution, 2020). However, considering Nigeria's persistent and extensive forest and environmental issues (Olaniyi et al., 2019; Ogunkan, 2022), it is justifiable to argue that efforts so far have been ineffective (Banso, et al., 2023). The dearth of citizen engagement, direct or indirect, despite stakeholder engagement on paper, has impeded the progress of forest preservation and environmental policy in Nigeria (Mutekwa, 2016; Adeniyi, 2016), while the implementation process has been plagued with challenges. The ongoing degradation and change of Nigeria's forest and environment can, in part, be attributed to the failure of responsible agencies to effectively implement and enforce

regulations and laws aimed at environmental protection (Ujor, 2018; Fasona et al., 2020). This phenomenon can be ascribed to a multitude of factors, including constraints within the legal structure, impediments within institutions, instances of corruption, inadequate financial resources, subpar governance, instances of intimidation, and lack of awareness, among other contributing elements (Ujor, 2018; Fasona et al., 2020). The analysis above indicates that Nigeria's environmental governance has proven ineffective (Eludoyin, and Iyanda, 2019; Adekola, et al., 2023). This study evaluates the current situation from the perspectives of forest-dependent communities and the policymakers as stakeholders, addressing the challenge of stakeholder engagement in practice, with a view to informing more suitable policies for the PA reserves and forest conservation. Regular reviews and adaptations of the policies are essential to address the challenges and opportunities in the dynamic field of forest management. It is hoped this research can contribute to the process and fill this important knowledge gap.

1.6.1. Stakeholder engagement and community participation

Effective forest conservation requires active participation from forest-dependent communities. However, research indicates that engagement remains limited, restricting the inclusion of local perspectives in forest governance (Mutekwa, 2016; Adeniyi, 2016). Despite formal provisions for participation, implementation has been weak, exacerbated by inadequate institutional capacity, corruption, and a lack of financial resources (Fasona et al., 2020; Ujor, 2018).

The lack of community participation undermines conservation efforts. Studies highlight that rural populations, particularly women, rely heavily on forests for sustenance, medicinal resources, and income generation. Adedayo et al. (2010) found that rural women in North Central Nigeria depend on forest resources for household welfare yet have limited access due to restrictive policies and deforestation. This lack of inclusion in decision-making processes perpetuates inequalities and weakens conservation initiatives.

To improve forest governance, there is a need for genuine stakeholder engagement, incorporating local knowledge and community-driven conservation efforts. Regular reviews and adaptations of policies should ensure that forest-dependent populations have an active role in governance. This study contributes to understanding governance patterns and their localized effects, highlighting the necessity for participatory approaches in Nigeria’s forest conservation efforts.

From these well-structured organisations (Table 1.2), this research focuses on actors such as governmental bodies, state ministries of environment and forestry, research and academic institutions, and local communities. These bodies operate at the state level, translating federal policies into actionable programs. Actors operate directly in forest reserves and PAs, influencing their management, including policy, governance, conservation, and uses.

1.7. Statement of the problem

Understanding the patterns and factors contributing to forest loss within PAs is essential (Damnyag et al., 2013; Amoah et al., 2022; Loveridge, 2021) yet is poorly understood in Nigeria. Evidence of historical land cover change is essential to inform efforts to minimise trade-offs and enhance conservation-development synergies in the future (Eludoyin and Iyanda, 2019). Research conducted in Costa Rica and Thailand has shown the potential of PAs to alleviate poverty and provide ecosystem services but has also highlighted ongoing deforestation. Protected areas worldwide have often followed a conventional top-down approach, neglecting social, cultural, political, and governance factors, and the perspectives of forest communities (Watson et al., 2014). This is the case in Nigeria too where stakeholder participation is present on paper but not in practice. Such oversight can lead to conflicts between conservation and other land uses (Oduro Appiah et al., 2021; Alao, 2009).

Africa faces significant environmental challenges, particularly in the context of its projected population growth and land degradation (Soul, 2016; Amoah, et al., 2022). Addressing these challenges requires a shift towards integrated conservation strategies considering social and ecological dynamics (Elleason et al., 2021; Mammides et al., 2022; Liang et al., 2016). This research focuses on the Nasarawa forest reserves in Nigeria, examining the historical context of forest reserves and the impact of changes in land use on these reserves, particularly in the northern central Nigeria region. While existing studies in Nigeria have contributed to addressing forest changes, there needs to be an improved understanding of the current impacts stemming from those past changes and the variability of drivers around gazetted forest communities in north-central Nigeria. Moreover, governance, conservation, and management information for PAs in the study area must be more comprehensive. This necessitates a comprehensive, mixed methods empirical approach to understanding forest and land use change, including both its perceived and empirically identified drivers as well the possibilities it offers for conservation, management, and sustainability. Consequently, this thesis provides crucial information for effective and sustainable development of forest PAs in the region.

1.8. Aim and objectives

This study evaluates the extent and status of gazetted forest reserves and land cover changes around the gazetted forest reserve communities in Nasarawa State, north-central Nigeria. It evaluates their conservation management measures and sustainability using mixed methods (remote sensing (RS) and Geographical Information Systems (GIS), and field surveys). The continued presence of naturally occurring forests offer a vital resource for the government and Nigeria's citizens.

The overall aim is to understand the land use change around the gazetted forest reserves and identify the perceived drivers of this change to inform a better understanding of actions to support forest conservation and sustainability of PAs. The study objectives are to:

(i) assess the extent of how, when and where the gazetted forest has changed since 1966;

(ii) identify and evaluate the perceived drivers that triggered land cover changes in the gazetted forest and understand community perceptions of the benefits derived from the gazetted forest;

(iii) identify and examine existing strategies to protect the gazetted forests in Nasarawa State, and

(iv) explore community perceptions of management policies to inform the future sustainability of the gazetted forest reserve.

The objectives consider the perceptions of forest communities and other stakeholders involved in gazetted forest governance. This is important because the study is also relevant to the different groups working within environmental governance in Nasarawa State and the country and the literature has shown a lack of incorporation of stakeholder voices to date. Findings will provide helpful information to aid policymakers in devising appropriate interventions to improve conservation and support rural livelihoods in gazetted forest-fringe communities, supporting sustainable development locally, regionally, and globally.

Chapter 2. Research design and research methods

2.1. Introduction to the chapter

This chapter examines the study area and the methods employed for collecting and analysing data. Survey map boundaries, remote sensing data, and Geographic Information System (GIS) applications are utilised to determine the spatial changes in land use and the nature of gazetted forest reserve change in the study area, addressing objective i). The fieldwork component was conducted with local communities around the selected reserves in Nasarawa State to understand the driving forces of land cover change, how human activities interact with the forest, and how this has changed, allowing the remainder of the objectives to be tackled.

Objective i) necessitates the utilisation of spatial information and generated maps (as presented in Chapter 3). Accurate and current land cover maps, such as those developed in this study, can be employed to elucidate the temporal changes in protected forests (Gong et al., 2020; Kafy et al., 2020), and to facilitate environmental planning. These maps can further inform appropriate sustainable land management, which is crucial for the survival of the local and urban inhabitants surrounding the forest reserves.

Objective ii) elucidates the perceived drivers of land cover changes and forest change from the forest community through empirical evidence based on qualitative and quantitative information. Furthermore, objectives iii and iv) address existing strategies to safeguard the gazetted forests and community perceptions of effective management and sustainability for the reserves. These objectives are investigated and evaluated through quantitative and qualitative data obtained through household questionnaires, semi-structured interviews and focus group discussions (FGDs) with key community members, including farmers, forest dwellers, local leaders, government officials and experts as detailed in Chapter 3. This participatory process can provide local knowledge and experiences (Munthali et al., 2019) which are integrated into recommendations for future protected forest management strategies. The integration of qualitative and quantitative methods facilitates a more comprehensive understanding of both the physical changes in the forest and the socio-economic drivers underlying these changes (Walters, 2022; Domínguez and Luoma, 2020a).

2.2. Research design

This thesis integrates a top-down assessment of land cover change with bottom-up viewpoints from communities living around gazetted and protected forests and using forest resources, alongside the views of other (government) stakeholders. This integration enables a comprehension of the intricate governance difficulties associated with gazetted and protected forests in Nigeria with broader implications for society. The ability to draw generalisable conclusions is crucial for informing policy and making recommendations at spatial scales extending beyond the study landscape's boundaries. Nevertheless, it is crucial to acknowledge that top-down approaches risk marginalising the significance of local values and context-specific elements, thereby resulting in a lack of local relevance (Woodhouse et al., 2015). In contrast, bottom-up perspectives emphasise local knowledge and contextual explanations, which research findings accurately reflect the empirical observations and experiences of the studied individuals or phenomena (Kihlstrom, 2021). Additionally, these perspectives also promote the local relevance of a study, prioritising the perspectives and interests of the individuals involved. Thus, incorporating both top-down and bottom-up views is essential in comprehensively understanding complex issues (Holleman et al., 2020). The interaction between PA conservation efficacy, and their social benefits are explored in Chapters 4 and 5 by combining top-down detail on forest cover change with insights from bottom-up focus groups.

One notable methodological contribution has been integrating quantitative and qualitative approaches. Top-down and bottom-up approaches are inherently linked to specific academic disciplines and methodological frameworks. Top-down approaches primarily rely on statistical demonstration techniques to empirically evaluate hypotheses. Bottom-up approaches are frequently employed in qualitative social sciences, including political ecology and anthropology (Walters, 2022b; Walters, 2022a; Pfeifer, 2020). These approaches rely on qualitative analyses, such as document and topic analyses (Loveridge 2021).

This study offers a comprehensive examination of the contributions of forest conservation by focusing on multidisciplinary and geographical perspectives. The thesis explores the necessity of integrating mixed methodologies within forest conservation, connecting social and natural scientific ideas and effectively integrating a wide range of academic and regional viewpoints (Rudel et al., 2020; Meyfroidt et al., 2018). The research emphasises the pressing requirement to establish connections between social and natural science perspectives. The interface between governance and management policies is a further crucial area where the knowledge exchange regarding forest conservation occurs (Domínguez and Luoma, 2020; Amoah et al., 2022).

2.3. Positionality

Undertaking a PhD requires examining positionality, which enhances understanding of power dynamics across contexts (Loveridge, 2021). Such reflection ensures ethical research design and interpretation. My academic background spans natural and social sciences, including human geography and environmental resource management. This foundation, with experience in problem-solving and collaboration, has deepened my understanding of conservation challenges from human-environment interactions.

My natural sciences training follows a top-down approach, prioritizing external validity (Loveridge, 2021). Conversely, social sciences, particularly qualitative methods, align with constructivist-interpretivist paradigms. My BSc in Geography and MSc in Environmental Resource Management provided theoretical and methodological grounding. My master's dissertation (2015) analyzed land use change trends and sustainable development in Lafia, Nasarawa State. Knowledge of the region and engagement with communities informed my study, ensuring relevance in addressing land use around gazetted forests.

My research aimed to amplify marginalized voices, acknowledging multiple epistemological perspectives (Creswell, 2017). Integrating biophysical and socioeconomic data in my PhD research, I focus on gazetted reserve changes and conservation sustainability. Field research helps refine methodologies while fostering self-reflection on my influence in the research process.

Born in north-central Nigeria, I understand the region's cultures and engage effectively with stakeholders, including community leaders, farmers, policymakers, and forest management experts. My research contributes to understanding gazetted forest governance, balancing community interests and conservation objectives. The study's location near Abuja motivated my engagement.

Recognizing positionality in fieldwork (Loveridge, 2021), I recruited research assistants from local ethnic groups (Mada, Alago, and Gade), proficient in Hausa and English with Bachelor's degrees. Selection considered literacy, local knowledge, and communication skills. Training emphasized reflexivity, assessing biases to ensure credible outcomes. Evaluating influences on research questions fostered reflective practices, mitigating biases and enhancing validity. The educated RAs familiar with the study area facilitated engagement with male and female community members, ensuring inclusive data collection. Undertaking a PhD requires examining positionality, which enhances understanding of

power dynamics across contexts (Loveridge, 2021). Such reflection ensures ethical research design and interpretation. My academic background spans natural and social sciences, including human geography and environmental resource management. This foundation, with experience in problem-solving and collaboration, has deepened my understanding of conservation challenges from human-environment interactions. My natural sciences training follows a top-down approach, prioritizing external validity (Loveridge, 2021). Conversely, social sciences align with constructivist-interpretivist paradigms. My BSc in Geography and MSc provided theoretical and methodological grounding. My master's dissertation (2015) analyzed land use change trends in Lafia, Nasarawa State. Knowledge of the region and community engagement informed my study, ensuring relevance in addressing land use around gazetted forests. My research aimed to amplify marginalized voices, acknowledging multiple perspectives (Creswell, 2017). Integrating biophysical and socioeconomic data, I focus on gazetted reserve changes and conservation sustainability. Field research helps refine methodologies while fostering self-reflection on my research influence.

Born and raised in north-central Nigeria, I am versed in the region's diverse cultures and skilled at engaging with stakeholders, including community leaders, farmers, policymakers, and forest management experts. My research contributes to understanding gazetted forest governance, balancing community interests and conservation objectives. The study's location near Abuja, my state of origin, motivated my engagement. Recognizing the importance of positionality in fieldwork (Loveridge, 2021), I recruited and trained research assistants (RAs) from local ethnic groups (Mada, Alago, and Gade), proficient in Hausa and English with Bachelor's degrees. Their selection considered literacy, local knowledge, and communication skills. Training emphasized reflexivity, assessing biases to ensure credible and ethical research outcomes. Evaluating influences on research questions fostered reflective practices, mitigating biases and enhancing validity. The involvement of educated RAs familiar with the study area facilitated engagement with both male and female community members, ensuring inclusive and reliable data collection.

2.3.1. My positionality and identity as insider and outsider

Positionality and identity significantly shape the research process, influencing the researcher's perspective and study outcomes (Ferring and Hausermann, 2019; Hausermann and Adomako, 2022). Insider researchers possess understanding of cultural, social, and ecological aspects of studied societies, enabling community integration and access to

traditional knowledge. However, they may face challenges like bias and preconceived notions. Outsider researchers offer fresh perspectives and objectivity, yet their unfamiliarity with local customs and dynamics can hinder communication and data interpretation. To gather comprehensive insights from forest communities, I adopted roles as both an "outsider" and "insider." Despite being native, I faced suspicion due to lacking affiliation with specific dialects within forest community reserves. My "outsider" status emerged from not being part of the dialect and cultural fabric. I faced initial challenges in establishing trust for effective data collection. Using my native background, I assumed an "insider" role to connect with broader cultural experiences. This duality allowed balancing objective observation and empathetic participation. During stakeholder consultations, I introduced myself as an environmental researcher at Nasarawa State University (Nigeria) and PhD researcher with the University of York, UK. This status facilitated relationship negotiations and access to familial connections, providing insights into forest reserves. My Nigerian educational background enhanced belonging within forest communities, increasing stakeholder interactions. Objects like pens, notebooks, maps, and research papers indicated my positionality, establishing professional identity within study communities.

In Nigeria's Northern region, individuals carrying pens and paper are seen as Yan Boko, representing the educated class often assumed to be government workers or teachers. Some questioned if I was a state official coming to take over their forest, and asked me to report on forest changes and livelihood improvements. Community members were curious about my notetaking, with some examining my notes or checking with research assistants about accurate recording. I trained three male research assistants after the female candidate withdrew following training. The RAs were recruited from within the forest communities for their familiarity with cultural norms, languages, and social structures. As insiders, they could increase trust and gather authentic data, whereas outsiders might be viewed with suspicion. Understanding positionality was crucial for ensuring data validity. Despite shared cultural identity, differences emerged during interviews and discussions. Stakeholders perceived me as not fully integrated into the community, noting my different dialect. My research was recognized as the first of its kind in the community, highlighting its significance. Although my understanding of their cultural practices was limited, I engaged with stakeholders, farmers, leaders, and experts who shared insights on forest history and conservation. Women's representation among stakeholders was limited due to cultural factors, potentially biasing data interpretation given their important role in forest matters. I responded to questions about potential financial benefits, political affiliations, background, cultural heritage, and language proficiency. During interviews and focus groups, I

maintained modesty through traditional clothing to respect participants' diverse cultural and religious backgrounds, including Christians, Muslims, and traditional worshippers. This self-presentation was crucial for securing respondents, particularly where cultural backgrounds are highly significant (Loveridge, 2021). Despite positionality challenges, subjects provided valuable insights into their relationships with forests and land use.

My research aimed to contribute to knowledge on collaborative environmental conservation and governance. My experience demonstrates the value of multidisciplinary approaches to land use and conservation research, offering insights into land cover science and socioeconomic interactions. Reflecting on practices and positionalities is essential for fostering inclusive spaces that explore social differences and natural phenomena. This approach emphasizes integrating scholars and local communities to understand land uses, forest cover changes, and ecosystem service needs to support sustainable forest conservation.

In Nigerian forest research, insider-outsider roles exist on a spectrum. Through reflexivity, I reflected on my background and values to understand their influence on interpreting the local context, including my social, cultural, and professional identity. I journaled thoughts after key interactions and examined power dynamics, particularly regarding representation. This involved ensuring participants had input on how their stories were told. These reflexivity practices aimed to minimize biases and enhance understanding of the local context. By promoting collaboration, valuing local knowledge, and navigating identity dynamics sensitively, researchers can develop sustainable and contextually relevant solutions to the challenges facing Nigerian forests and beyond.

2.3.2. Local ontologies for the use of forest resources

Local communities provide crucial insights into land and natural resource management (Ferring and Hausermann, 2019; Hausermann and Adomako, 2022). In Nasarawa State, North Central Nigeria, a study area with diverse ethnicities, I personally immersed myself in the context of a forested area during my growing-up years, particularly around Akwanga forest. During my development, I acquired a comprehensive understanding of forests that extends beyond the physical realm and encompasses the spiritual, human, and biophysical dimensions, which are intimately interconnected to some extent. This personal immersion has allowed me to appreciate the forest's significance in ways that might parallel the perspectives of those who are more directly part of these forest communities, even as I recognise the limits of my own cultural area. In my native villages, there is a unique cultural

characteristic that stands out. By "native villages," I am referring to the communities where I grew up, which had specific areas of the forest that were considered off-limits. This experience gave me an insider's understanding of how certain areas within forests might be culturally or spiritually significant, and this perspective informed my approach when studying the forests in the current research. Recognizing these culturally protected spaces in my native villages made me more aware of the possibility that similar practices might exist in the forests I studied, helping to shape my research approach.

For example, within the cultural tapestry of my native villages, these delineating certain portions of the forest as off-limits are unpermitted to individuals, especially the conservation areas and secret forest areas, an aspect imbued with the sanctity of taboos. Deviation from these established norms exposes people to severe consequences, ranging from illness to the extreme outcome of death. Consequently, the forest reserves were further designated as sacred shrines, where rituals involving libations and sacrifices are performed in homage to the forest deity to this day. In both the study villages and my native village, the sacredness of designated forests prohibits farming around them. These beliefs deeply influence forest land and resource management, as the communities' practices and spiritual reverence for these areas shape how the land is used and preserved. However, it was not unexpected when stakeholders, during my research fieldwork, began expounding on the spiritual ontologies linked to forests, revealing a characterisation of these spaces as inherently unauthorised people of the society. These interactions helped me understand that traditional beliefs hugely shape forest practices and livelihoods in this research, particularly for one of the forests (Odu). Hence, my research will provide valuable insights that may be applied to positively inform decision-making in site-based conservation studies.

2.4. The study area and scope of the study

The decision to conduct this study in Nigeria was influenced by the country's strategic location within the West African Guinea savanna region (Figure 2.1), known for its natural resource-based economy and rich biodiversity (Inuwa et al., 2022). Nigeria, as the largest economy in Africa (Olaniyi et al. 2019; Inuwa et al., 2022), occupies a significant position within the West African Guinea savanna. Its substantial size and population render it a focal point for ecological and economic studies, the nation faces considerable challenges in the form of rapid population growth, urbanisation, and agricultural expansion, all of which exert substantial pressure on its natural resource base and biodiversity. These factors could potentially have broader regional implications for other countries within the Guinea savanna

zone, which encompasses a diverse array of ecosystems ranging from forests to grasslands, making it an ideal location for investigating ecological patterns and biodiversity conservation (Onyekuru, et al., 2021). These anthropogenic pressures in this region create a unique environment for studying the impact of human activity on savanna ecosystems from the forest areas. The insights gained from Nigeria's management of these forest regions due to pressures could potentially be applicable to other regions of the Guinea savanna facing similar, though perhaps less intense, challenges.

Within Nigeria, I chose to work in Nasarawa State, located in central Nigeria (Mbaya and Hashidu, 2017) within the Guinea savanna vegetation zone, representing the northern central part of the geopolitical zone. This area is noteworthy due to migration driven by farmer-herder conflicts across the north, south, and east, leading individuals to seek refuge and sustenance in Nasarawa State (Atim and Gbamwuan, 2022; Ite and Adams, 1998; Fasona and Omojola, 2005). This migration has bolstered Nasarawa's status as a major national food basket, supporting diverse food and cash crops and attracting those in search of viable livelihoods (Ihemezie et al., 2021), leading to agricultural expansion and deforestation, which comes at an environmental cost in the state. As seen globally, the expansion of farmland remains the leading driver of deforestation (FAO, 2020). The state's proximity to the Federal Capital, Abuja, has also led to significant land-use changes over the past 30 years, driven by human development, ecological services, and economic growth (Mba and Ekpo, 2020; Jeminiwa et al., 2020). These land-use changes often negatively impact natural ecology and future development. Notably, a significant proportion of Abuja FCT's workforce resides in Nasarawa, with estimates indicating 35-40 per cent commutes from Nasarawa State (Adeyinka and Victor, 2019). This makes the naturally occurring forests and land in Nasarawa a crucial resource for the government and residents, necessitating proper land management for the survival of both local and urban populations.

The state's proximity to Abuja, FCT, means it must also respond to external events like development initiatives in Abuja, FCT, suggesting that human activities significantly influence forest productivity and conservation (Ihemezie et al., 2021). Moreover, the desert region in the north is rapidly encroaching on Nasarawa State (Jamala et al., 2013; Suleiman et al., 2017). Given Nasarawa's central location of the country (Figure 2.1) selection of this location for this offers the chance to provide vital insights for both the state and the nation, offering up-to-date and reliable data on land-use change and its impact on forest reserves, which can be applied to other regions for environmental planning and sustainable development. Furthermore, the state's approach to land use and the management of gazetted forests is vital for preserving its natural resources, promoting environmental sustainability,

and supporting the livelihoods of its inhabitants. An accurate and up-to-date land cover database such as that developed in this study, can be used to determine how the landscape has changed over time (Gong et al., 2020; Kafy et al., 2020). This data can aid environmental planning, essential for the survival of local and urban populations near forest reserves.

There is a noticeable difference between the northern and southern Guinea savanna within Nasarawa State. The Southern Guinea zone encompasses local government areas (LGAs) such as Doma, Awe, Keana, Toto, Wamba, and parts of Nasarawa Eggon, Nasarawa, Obi, and Akwanga, whereas the Northern Guinea savanna characteristics are found in LGAs such as Nasarawa Eggon, Akwanga, Kokona, Karu, Keffi, and Nasarawa (Areola, 1983; Akosim, 1999); see, species of grass that occur in northern Guinea are very similar to southern Guinea, with a prevalence of grassland and woody shrubs over trees (Ahungwa et al., 2013). This vegetation is almost annually consumed by human-caused fires during the dry season (Fabolude et al., 2023; Buba, 2015; Ayo and Mr, 2014) and many species, such as *Parkia biglobosa* (African locust bean tree), *Vitellaria paradoxa* (Shea butter tree), *Milicia excelsa* (Iroko tree) *Burkea africana* (wild syringa), *Anogeisses leiocarpa* (African, birch satin wood) *Afromosia*, (African teak) are resistant to fire (Buba, 2015; Federal Department of Forestry Nigeria, 2019) in the State. Also, the area's vegetation is the result of centuries of selective tree harvesting based on the usefulness of the trees to the local population, as well as continuous fire damage (Fabolude et al., 2023; Soule et al., 2016). Some of the trees have long taproots and thick bark to help them survive the long dry season and fire impacts (Saidu and Yahaya, 2020; Buba, 2015). Nasarawa State receives annual rainfall of 1100–2000mm (Agidi et al., 2018; Saidu and Yahaya, 2020; Fabolude et al., 2023). During the wet season, Nasarawa State receives moderate to heavy rainfall, which fosters agricultural activities and supports vegetation growth. The dry season, typically lasting from November to March, is marked by lower humidity and higher temperatures. Harmattan, a dry and dusty trade wind, often blows across Nasarawa State during the dry season, influencing temperature and visibility (Saidu and Yahaya, 2020).

Nasarawa State's vegetation and climate significantly influence the community's agricultural practices, while the State exhibits a variety of land uses, ranging from agricultural activities to urban. Agriculture is the primary economic activity, with a significant portion of the land dedicated to crop cultivation and livestock farming. The predominantly agrarian communities engage in subsistence farming, relying on the seasonal rainfall for their agricultural activities. The state's fertile soils and favourable climate support the cultivation of crops such as yams, maize, rice, and cassava, even within the designated forest reserves.

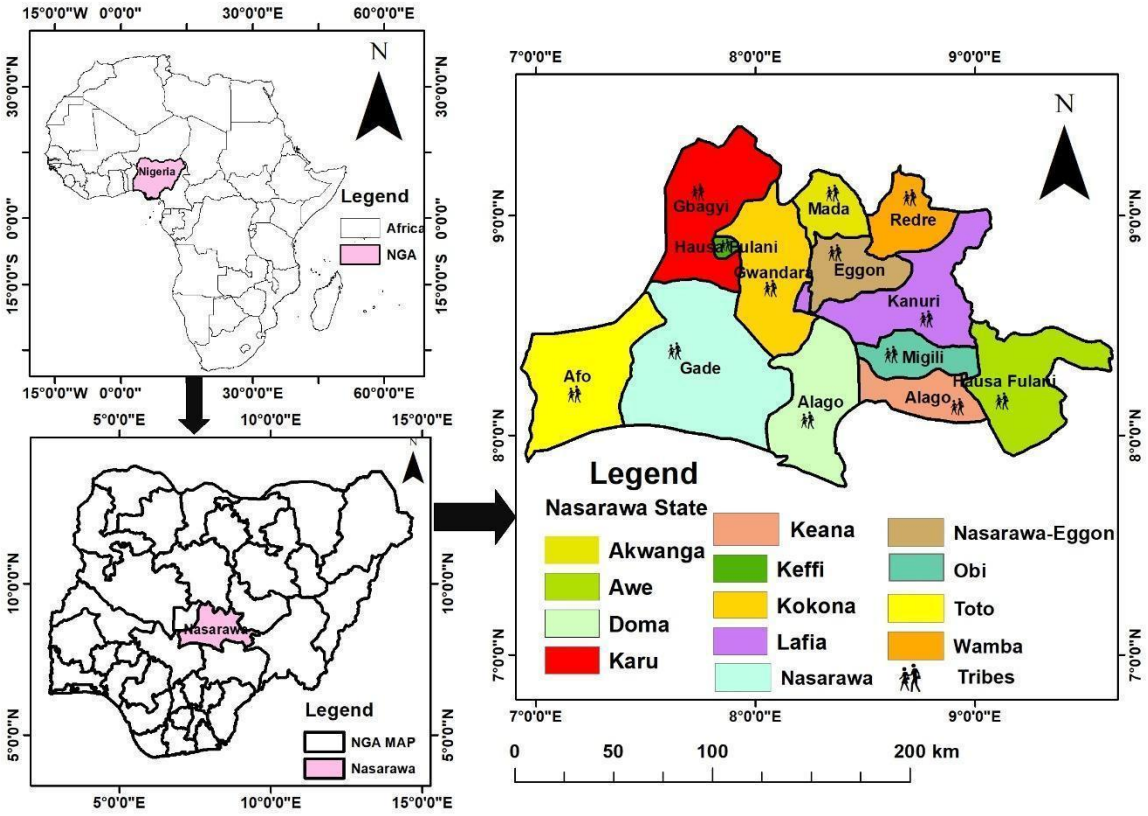

Figure 2. 1. Map of Africa with Nigeria showing the geographical position of Nasarawa State and its administrative subdivisions, showing major tribes across the state**.**

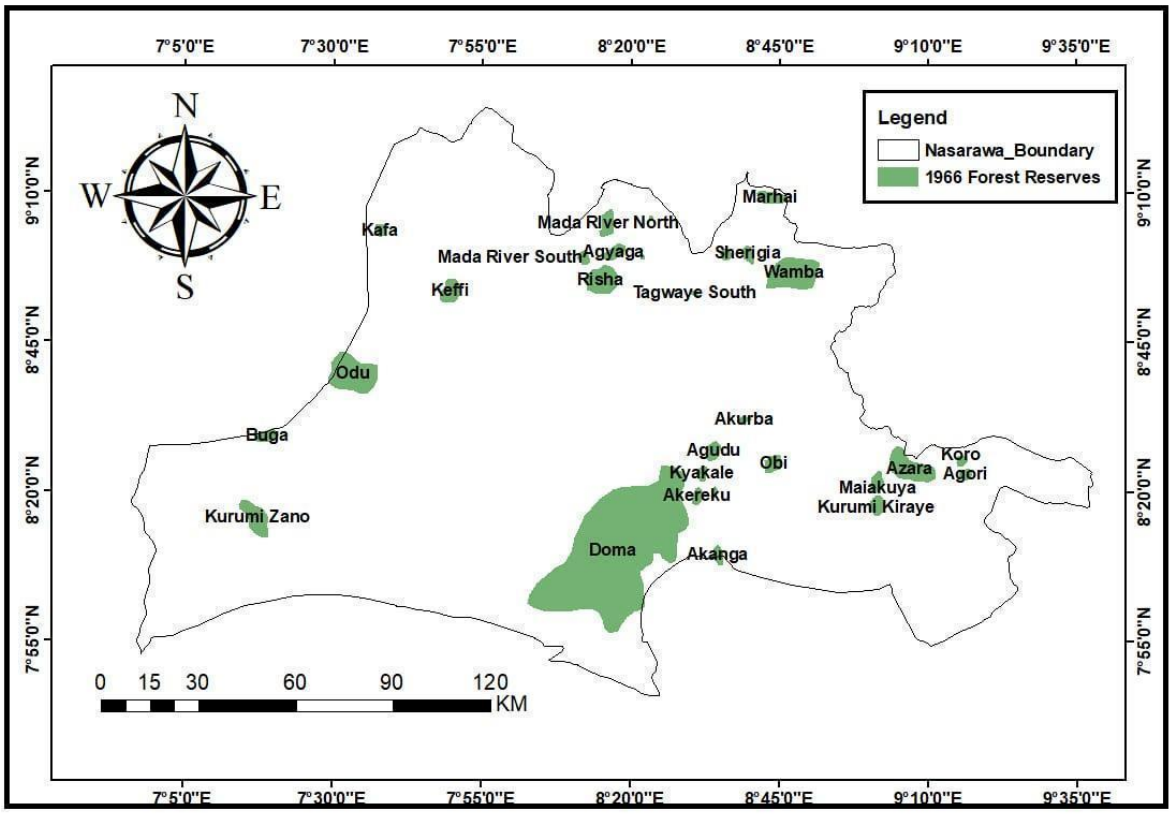

Figure 2. 2. Nasarawa State map showing the gazetted forest reserve distribution for 1966. This was an extraction from the Nasarawa shapefile from the Ministry of Environment, Abuja, and Nasarawa Geographic Information Service, 2020**.**

Nasarawa State has a total of 41 gazetted forest reserves (Figure 2.2) which were established and mapped out in 1966, fully legally backed up with documents, while others were proposed but not fully legally backed up (Forest law B.P.LS, 7 of 1968). Others still were not contained in the maps due to the different years in which they were their gazetted, leaving a rather confusing picture of the area of gazetted forest. The mapped forest reserves are nevertheless spread across all three geo-political zones of the state namely, Nasarawa North, Nasarawa South, and Nasarawa West Senatorial district (Figure 2.1) with most of the reserves situated in the southern zone followed by the northern and western parts respectively. These were gazetted under Benue plateau State of Nigeria gazetted supplement part B to N.R gazetted No.8 vol. 2, 1966.

Although local people were not allowed to clear the vegetation cover, there were rights for the forest community to have access to important resources while preserving the forest cover. The document outlines the rights of gazetted forest communities such as drawing water, collecting thatching grass; dead wood for fuel, stones, fruits, and medical plants trees which are valuable to the culture of the communities. However, the right to large quantities of extraction was restricted, with extraction only for the personal domestic requirements of members of the dependent communities, and not for sale or barter and provided there is no interference with other vegetation cover (Forest law B.P.LS, 7 of 1968; Forest law, 1968).
Three gazetted forests across the state, namely, Doma, Risha and Odu were selected for this study. They were purposely chosen to symbolise each geo-political zone`s forest reserves; Doma gazetted forest reserve is in the south, Risha Akwanga forest reserve in the north, and Odu forest reserve in the west (Figure 2.2; 2.3). The representation of different parts of the state through the selection of forest reserves in the south, north, and west ensures a balanced, inclusive, and comprehensive approach by capturing the full range of ecological zones, cultural landscapes, and socioeconomic activities that define the state. The selection of Doma, Risha, and Odu forests in Nasarawa State reflects the ecological, cultural, and socioeconomic diversity of the region in a more deliberate and structured manner. Doma Forest, located in the southern part of the state, is characterized by rich biodiversity, including tropical tree species and wildlife critical for conservation efforts. It also has cultural significance for indigenous communities engaged in traditional practices and subsistence farming and fishing and features a mix of riverine and lowland forests making it vital for local economies (Agidi et al., 2018; Soul, 2016). The community has an ethnic diversity with Alago speaking tribes people predominant.

Risha Forest, located in the northern part of the study area, represents a transitional zone between savanna and woodland ecosystems. It plays a crucial role in supporting agricultural and grazing activities for pastoralist communities and acts as a natural buffer against desertification, thereby sustaining local economies (Saidu and Yahaya, 2020). The Mada ethnic group is the predominant community inhabiting this area, although other ethnic groups are also present.

In contrast, Odu Forest, situated in the western region, holds significant cultural importance for indigenous communities practicing traditional livelihoods and subsistence farming (Buba, 2015). The Gade ethnic group constitutes the majority in this region, alongside a variety of other ethnic groups. This ethnic diversity across the study area contributes to a rich cultural landscape characterized by different languages, traditions, and festivals.

The varied ethnic composition is closely linked to distinct land-use traditions and agricultural practices, which, in turn, influence community responses to land management initiatives. Cultural perceptions, customary land tenure systems, and historical experiences play significant roles in shaping decision-making processes related to resource use and governance (Saidu and Yahaya, 2020; Audu et al., 2019). Understanding these dynamics is essential for accurately interpreting variations in land use patterns and management strategies within the study area.

The selection process is grounded in several key criteria, including ecological similarity, cultural and historical significance, and geographic as well as environmental distribution. These factors were carefully chosen to represent a wide range of ecological zones. Additionally, attention was given to achieving a balance in forest types, encompassing both small and large areas with comparable levels of biodiversity. This approach ensures a comprehensive representation of forest conditions. Figure 2.3 presents the 1966 forest boundaries that were extracted from the state, the choice of the forest sites also had to account for security concerns in the area. Some of the forest reserves have dynamic security threats such as kidnapping, violence between farmers and herdsmen, inter-community crises, and cultural barriers that all had to be considered when deciding where to focus the work. I contacted the Nigeria security services in the state divisional centre in Lafia, Nasarawa State Capital for security information before travelling to the area and making my final choices.

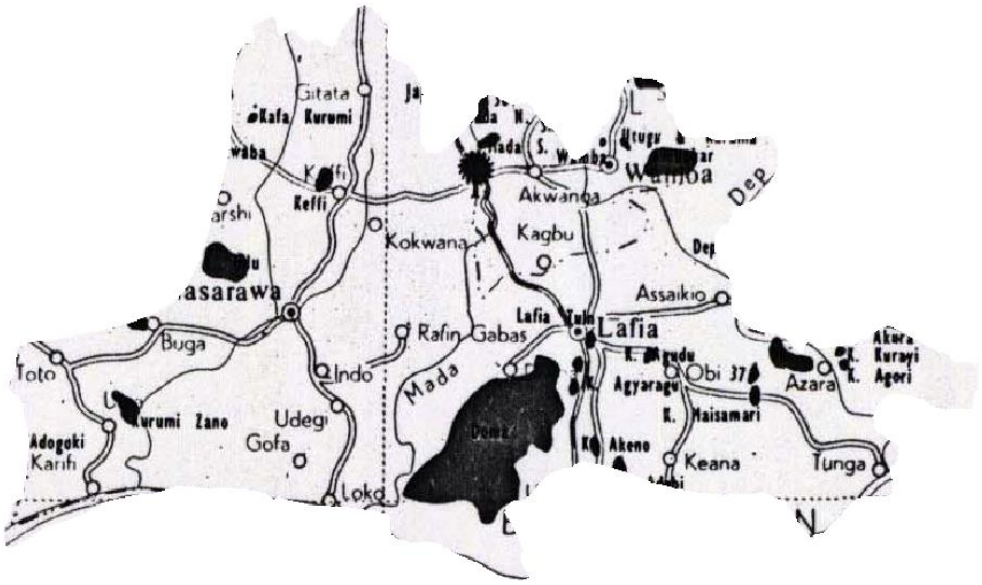

Figure 2. 3. Nasarawa Map showing gazetted forest survey map boundaries of 1966**.**

Source: Department of Forestry, Federal Ministry of Environment and Nasarawa Geographic Information Service, 2020.

2.5. Data sources and methodology

This study adopted a mixed-method approach in which quantitative and context-specific qualitative data were integrated (Figure 2.4).

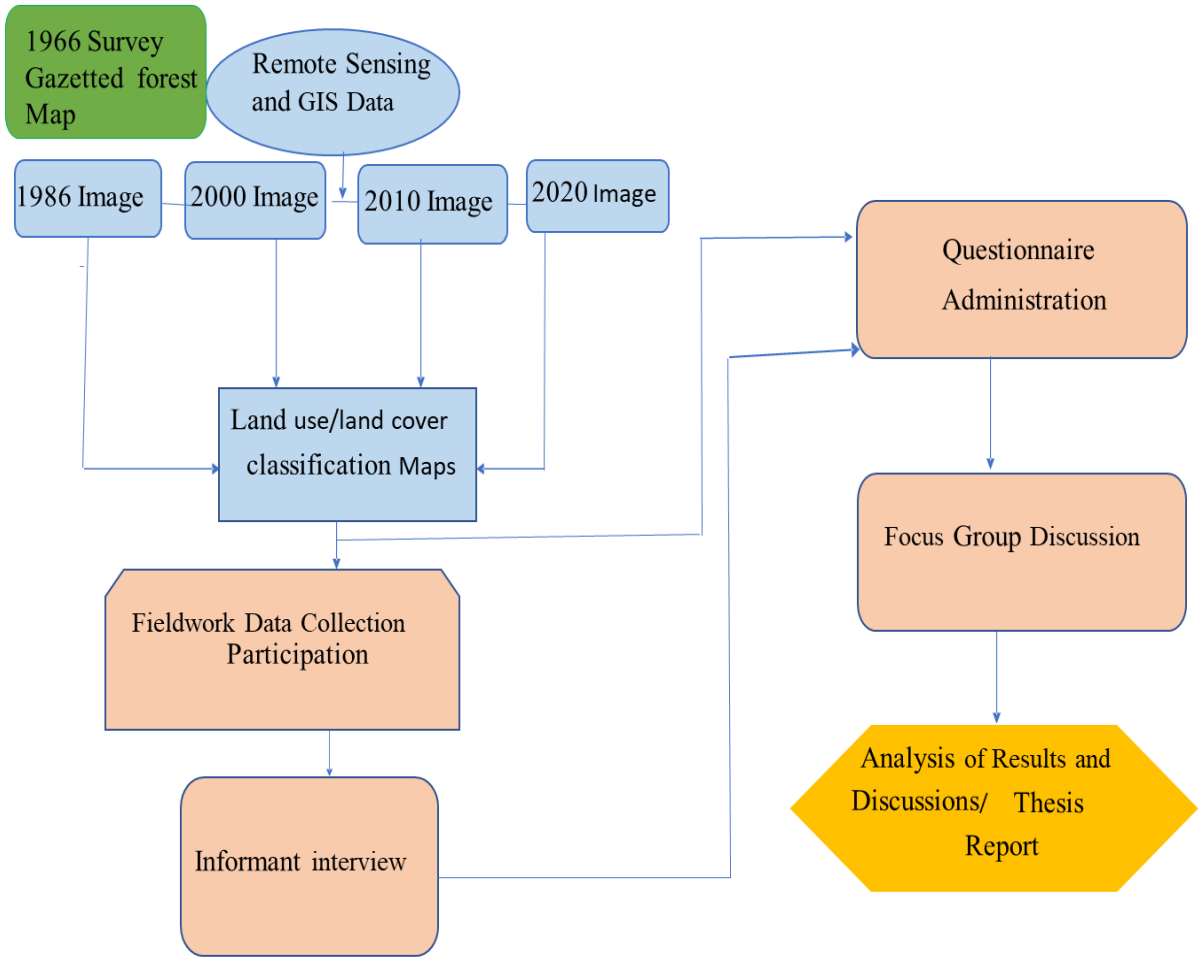

Figure 2. 4. Study research methodology flow chart showing the overall systematic approach and the mixed methods used. Blue Arrows show the flow of information from remote sensing data and fieldwork towards land use classification and analysis**.**

Diagram colours: Light green (Gazetted forest survey map 1966), Blue accent (Remote Sensing and GIS application method), Orange (Field data collection methods), Gold accent (Analysis and discussion on the output of the results).

To understand what, when, and how the gazetted forest areas have changed in line with objective 1, the study used satellite remote sensing imagery data to analyse land use and land cover change maps of Nasarawa State, examining changes in land cover from 1986 to 2020. The outputs were overlaid within a GIS with gazetted forest maps to understand the proportion of changes in forest cover. Ground-truthing was carried out on the selected gazetted forest reserves to understand the actual activities going on in the forest area and to verify some of the classified results of the land use and land cover in the selected forest reserve (Chapter 3). Thirty sample coordinate points were randomly picked using a Global Positional System (GPS) in each of the three gazetted forests in the areas accessible as

advised by the village heads as some of the forest areas were inaccessible for security and traditional reasons. Appendix 2.1. shows the coordinates picked for each of the forest sites. Although remote sensing data and Geographic Information Systems (GIS) applications can quantify the extent of changes in land use and forests, accurately identifying the drivers of these changes remains a challenging task. Remote sensing cannot explain the anthropogenic drivers felt or perceived by the forest communities while the drivers of forest and land cover change are complicated (Munthali et al., 2019; Ihemezie et al., 2021). Three approaches were used to evaluate the perceived critical drivers of forest change: interviews, a household survey and focus group discussions. These methods are ideal for gathering a broad spectrum of viewpoints from respondents within the forest communities (Nvenakeng, 2015; Kuemmerle et al., 2016; Phiri and Nyirenda, 2022) and are described in section 2.7. Three approaches were used to evaluate the perceived critical drivers of forest change: interviews, a household survey, and focus group discussions. These methods are useful for gathering a broad spectrum of viewpoints from respondents within the forest communities (Nvenakeng, 2015; Kuemmerle et al., 2016; Phiri and Nyirenda, 2022) and are described in section 2.7. However, each method has its limitations. Interviews may be subject to interviewer bias or social desirability effects, household surveys can be influenced by non-response bias or misinterpretation of questions and focus group discussions may be dominated by more vocal participants, potentially skewing results. The use of all three methods helps to mitigate these individual weaknesses by allowing for cross-validation of findings, improving the reliability and depth of the data collected. The empirical field data were used to support the findings presented in Chapter 4 on the historical changes to the reserves and provide data to answer questions on why the gazetted forest has changed (Chapter 4) and to understand the perception of the communities on the conservation measures, management and sustainability of the forest (Chapter 5).

2.5.1. Data collection on land use land cover change (LULCC)

To achieve research objective one on the historical change of the gazetted forest reserve change and land use, the study used a surveyed reserve boundaries map for 1966 (Figure 2.2 and 2.3) and Landsat imagery covering the study area for the years 1986, 2000, 2010, and 2020. Landsat imagery was downloaded from USGS website: Global Visualization Viewer (Glovis) for Nasarawa State, Nigeria and used to analyse and generate image maps of LULCC from 1986 to 2020 (Table 2.1; Figure 2.5).

Table 2. 1. Landsat images and their characteristics used from USGS, Glovis, NASA

Path/Row	Date of Acquisition	Sensor	Image Resolution
187/054	10-01-1986	L5 TM	30m
187/055	28-12-1986	L5 TM	30m
188/054	19-12-1986	L5 TM	30m
188/055	19-12-1986	L5 TM	30m
189/054	08-01-1986	L5 TM	30m
187/054	08-11-2000	L7 ETM+	30m
187/055	27-01-2001	L7 ETM+	30m
188/054	17-12-2000	L7 ETM+	30m
188/055	04-03-2000	L7 ETM+	30m
189/054	06-12-1999	L7 ETM+	30m
187/054	04-01-2010	L7 ETM+	30m
187/055	20-01-2010	L7 ETM+	30m
188/054	13-12-2010	L7 ETM+	30m
188/055	13-12-2010	L7 ETM+	30m
189/054	02-01-2010	L7 ETM+	30m
187/054	08-01-2020	L8 OLI	30m
187/055	24-01-2020	L8 OLI	30m
188/054	31-01-2020	L8 OLI	30m
188/055	31-01-2020	L8 OLI	30m
189/054	22-01-2020	L8 OLI	30m

Source: Satellite Images characteristics USGS, Glovis, NASA 2021

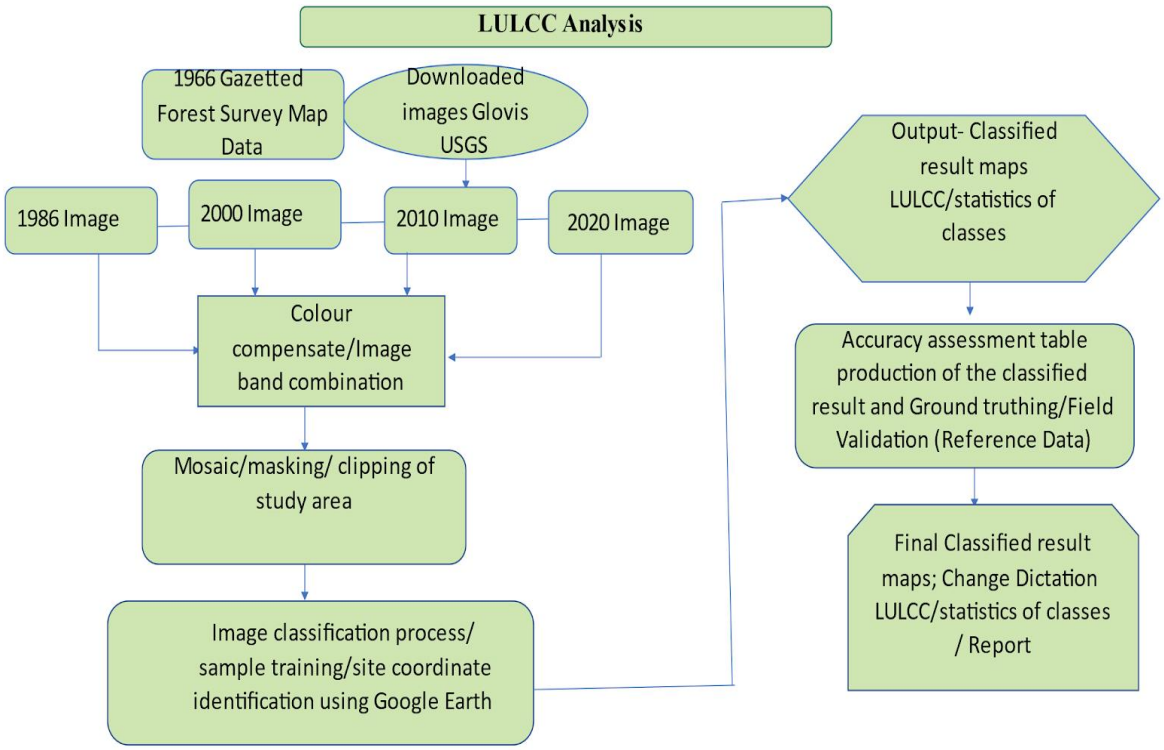

Figure 2. 5. Flow chart showing workflow and steps for LULCC mapping for the study.

The extracted gazetted forest map boundaries of 1966 (Figure 2.6) were overlaid on the classified maps for the LULCC to understand the portion of changes of land use and forest cover across time series.

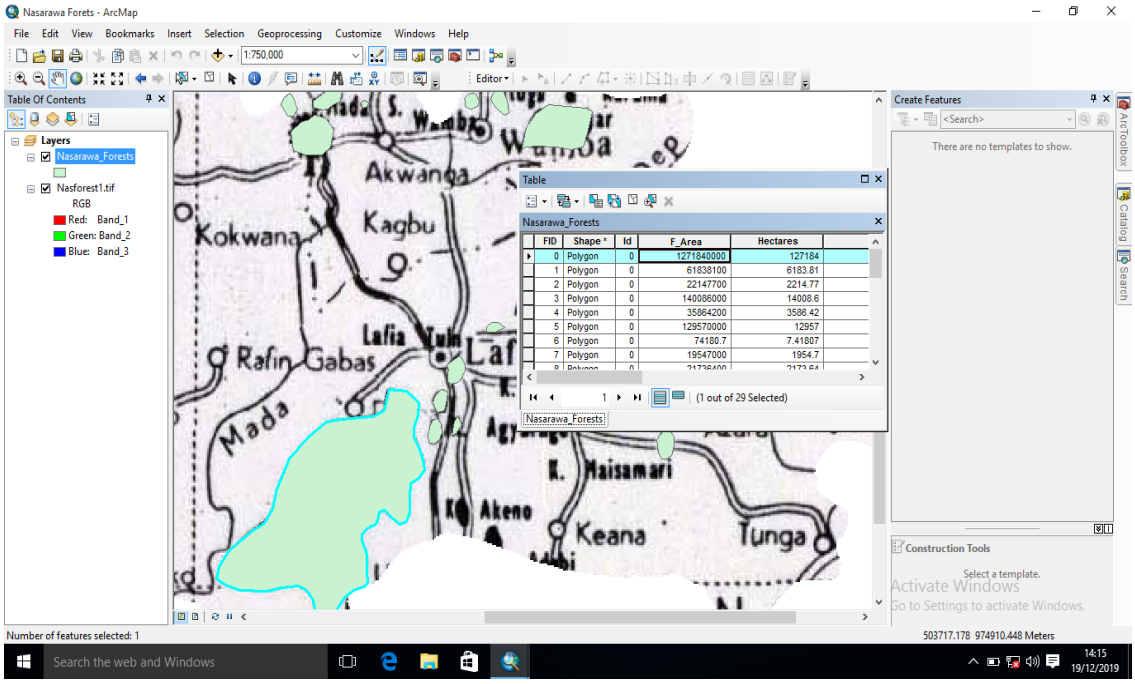

Figure 2. 6. Digitization and extraction of the gazetted forest boundaries for the study reserves.

A reconnaissance survey and ground-truthing process involved on-site verification and data validation to ensure the accuracy of forest maps by exploring and integrating ground-truthing data with remote sensing outputs (details in section 2.5.6.). The reconnaissance survey was carried out in December 2020 while groundtruhing was undertaken in June 2022. This process was carried out for each of the selected gazetted forest reserve areas, to get background information on the forest area and to verify the classified results of the land use and land cover in the selected forest reserves. Ground control point coordinates were taken with a GPS to obtain the coordinates from the gazetted forest areas with the overlay points on the classified maps (Appendix 2.1 and Chapter 3).

2.5.2. Remote sensing and GIS methodology

Data used include a surveyed reserve boundaries map (Figure 2.3), representing the base year of 1966's map of forest reserve boundaries obtained from the Ministry of Environment, Department of Forestry, agriculture unit in Nigeria. The forest reserve boundaries were corroborated with data on the gazetted forest reserve boundaries of Nasarawa State from the Nasarawa State Geographic Information Services that was the first original gazetted survey

boundary map of the reserves. These sources were the appropriate authorities charged with obtaining reliable information on the mapping forest of reserves in Nigeria under their responsibilities of mapping and forest protection. This map was digitized in ArcGIS software 10.8 (Figure 2.6) to extract the forest boundaries and obtain the reserves' initial sizes for the base year 1966. The Landsat images for the study area were obtained for 1986, 2000, 2010, and 2020 from the USGS Global Visualization Viewer (Glovis) website as GeoTIFF data images (Table 2.1) level-1 available for public access on the above website downloaded free of charge. Five scenes were downloaded for each year to cover the entire Nasarawa State boundary. All the downloaded imagery used was for the dry season (Table 2.1). Targeted images captured in December, November, and January were cloud-free images for the analysis, as it was noticed that all the images selected from the selected years and months were cloud-free. This approach also helped to minimise variations that may arise from phenological changes in the forest plants and aimed at maximising stability spectral measurements of the actual changes in the land cover of the forest reserve (Gong et al., 2020; Amoah et al., 2022). Careful consideration was given to the temporal dimensions by encompassing the years 1986, 2000, 2010, and 2020, as well as specific months, with a strategic intent to enhance data quality and minimise cloud cover interference (Gong et al., 2020; Guerra et al., 2020; Phiri and Nyirenda, 2022). A cloud cover of <10% was required for all the images for the study. The study years were chosen due to the quality and availability of satellite data for the area during this period, ensuring accurate analysis. For example, satellite data from the early 1990s have gaps or lower quality compared to other periods. Landsat 6, launched in 1993, failed to achieve orbit, causing a gap in high-quality data until the launch of Landsat 7 in 1999. However, the chosen intervals (1986–2000, 2000–2010, and 2010–2020) may not be perfectly equal, but they are close enough in length (14 years and 10 years) to effectively capture long-term trends and significant changes over time. These gaps make the best use of the available data, especially considering the issues related to the data gap caused by the failure of Landsat 6. This combination offers a comprehensive view of LULCC dynamics over different periods, highlighting gradual and rapid changes, and providing a strategic balance between capturing key changes and maintaining a manageable dataset. Table 2.1 shows the details of the images acquired. The colour composite of bands 1-7 of each of the scenes was performed in ArcGIS 10.8. The images were later mosaiced to join the different five scenes for each year to cover the entire area of interest that was then clipped using the administrative boundary of Nasarawa State.

2.5.3. Development of a classification scheme for LULCC of the study area

Before the generation of the classification, a reconnaissance survey was carried out across the study site to provide information to inform the land cover classification. The survey took place from December 2020 to January 2021. This period corresponds with the typical dry season in the region, ensuring that the conditions observed on the ground matched those captured in the remote sensing data. This temporal alignment helps to accurately identify and classify different land cover types, as seasonal variations that could affect vegetation and other land features are minimised. This reconnaissance survey involved identifying the classes of existing land use features and taking coordinates of the specific location of some land classes in the area to inform pattern, shape, and association. The information gained helped to guide the choice of suitable classes, providing some background knowledge on the study area. For instance, some parts of farmland were seen as associated with a bare surface in the study area. Riverine areas were associated with shrubs and forested areas, while built-up areas mostly were close to cultivation lands in the study area. The classification system adopted was based on Anderson (1976) and the national land use and cover classification scheme developed within a mapping project in Nigeria in 1995 (Federal Ministry of Environment, 2015). This serves a basis of broad classification suitable for the land use and land cover for the study area. Supplementary insights from prior research pertinent to the study area, exemplified by sources like the Federal Department of Forestry Nigeria (2019) and Gong et al. (2020), encompassing comparable classifications deemed applicable to diverse regions within Africa, were taken into consideration, such as cropland, forest, shrubland amongst other LULCC classes.

The information helped to gain the knowledge foundation to inform the grouping of classes of similar features. For example, when remotely sensed data is combined with ground-truthed data from the reconnaissance surveyed, it helps validate and improve the accuracy of the classification. This process allows researchers to identify and group different land features, objects, or areas with similar characteristics into "classes" in the dataset. The research aggregated the classes that can be distinguished with high confidence on satellite imagery (Hansen, 2013; Wulder et al., 2020; Onilude and Vaz, 2020; Gong et al., 2020). Six classes were developed based on their relevance to the research questions of this study (Buba, 2015; Federal Department of Forestry Nigeria, (2019) and Gong, et al., (2020), giving a specific classification system of land use and land cover for the study. The classes and cover used are shrublands, croplands, built-up land, grasslands, bare surface, wetlands, and forests (Table 2.2). However, this classification scheme provides a broad categorization of

land use and cover types. While it is suitable for the level of analysis conducted in this study, it is somewhat limited in scope. Some important subcategories, such as different types of forests (e.g., primary vs. secondary forests) or variations within built-up areas (e.g., infrastructure development industrial vs. residential), are not explicitly distinguished. Additionally, transitional land covers, mixed-use areas, or degraded landscapes may not fit effectively into these categories. In addition, focus on the local community's perception captures the classification types of the landscape based on their lived experiences, ensuring that both scientific data and local knowledge contribute to understanding land use management and decision-making.

Table 2. 2. Description of the classification scheme for the study

Categories of land use/ cover type	**Description**
Shrublands	Mix of plants or woody shrubs, smaller than trees generally <5m tall dispersed across the landscape with exposed soil or rock. Scrub-filled clearings within an area with multiple permanent stems branching from the near ground: moderate to sparse cover of bushes, shrubs and tufts of grass, savannas with very sparse woody or other plants.
Cropland	Area covered with crops, farmlands, and cultivation of arable and non-arable land, irrigated and non-irrigated agricultural farming. Planted cereals, and crops such as maize, wheat, beans, soya beans, yams, cassava, and fallow plots.
Built up area	Areas covered by human made structures, major road and rail networks, large homogenous impervious surfaces including parking structures, office buildings and residential housing; examples being houses, dense villages / towns / cities, paved roads, asphalt in both rural and urban areas.
Grasslands	Open areas covered in homogenous grasses with little to no taller vegetation; and grasses with no obvious human agent; examples include natural meadows and fields with sparse to no tree cover, open savanna with few to no trees, parks/golf courses/lawns, pastures.
Wetlands	Areas covered by water bodies such as dams, ponds, streams, rivers, swamps, and marshes. Areas where water is predominantly present throughout the year. Contains little to no sparse vegetation.
Bare surface	Areas of land covered mainly with bare land, including untarred roads. Areas covered by all different types of rocks including hilly areas, with very sparse to no vegetation for the entire year; examples include exposed rock or soil and sand, lake beds and mines.
Forest	Land area spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 to 20 percent, or trees able to reach these thresholds in *situ*. Any significant clustering of tall (15-m or higher) dense vegetation, typically with a closed or dense canopy. This area of land is covered with trees close together, including all

	natural and artificial forests with tree crown density (crown closure percentage) of 10% or more and are stocked with trees. More than 75% of the tree species shed their leaves in response to seasonal change.

Sources: Description of the classification scheme for the study, Author 2022 and FAO, 2020.

2.5.4. Land use land cover classification use and analysis

A supervised maximum likelihood classification was most suitable for this study in line with Gong et al., (2020) and Radwan (2021), as it is a widely adopted classification system for Landsat images (Radwan, 2021) that considers each spectral class can be explained by a multivariate normal distribution. The supervised classification allows an image classification procedure for identifying spectrally similar areas on an image by identifying 'training' sites of cluster features and then extrapolating those spectral signatures to the actual feature class (Hansen et al., 2013; Ahmed et al., 2020; Radwan et al., 2021). The classification also provides good quality training data needed to instruct the computer to recognise similar patterns in the imagery (Radwan et al., 2021; Mousivand and Arsanjani, 2019; Keenan et al., 2015). The process is controlled by creating, managing, evaluating, and editing signatures (Mousivand and Arsanjani, 2019; Radwan, et al., 2021), which gives the training classes homogeneous appearance in the application of a set of methods or decision rules (Geidam, et al., 2020; Phiri and Nyirenda, 2022). To give a quality appearance for the classes, the images were composed with bands 1–7 of the ETM+, TM, images and bands 2–7 of the OLI images. Since these represent only a small sample of the entire image/region to be classified, the training data from supervision was based on field visits and researcher knowledge of the study area for over 30 years and the identified coordinate points of common land use class around the gazetted forests as reference points from the field (Chunwate et al., 2019; Halefom et al., 2018; Oduro Appiah et al., 2021). The goal of the classification was to select multiple areas of reflectance for each land cover type throughout the images to allow the training data to provide a quantitative description of the appearance of each thematic land use class of interest in the image. The supervised classification shows the best overall number of sample pixels from many small areas around the image rather than just one or two areas (Radwan et al., 2021; Hassan and Ahmed, 2020). For instance, at least ten times the number of spectral bands in the image was picked for training to allow possible variations in the image to be accounted for (Chunwate et al., 2019; Oduro Appiah et al., 2021).

According to a report by the United States Geological Survey (USGS), tier 1 images exhibit high quality owing to geometric and radiometric corrections, thereby facilitating seamless time-series analyses without necessitating additional corrections or pre-processing. However, despite the enhanced quality of tier 1 images, those acquired for Nasarawa State still manifest scan line cover artefacts. In the context of ERDAS IMAGINE, the Atmospheric and Topographic Correction (ATCOR) tool was systematically employed to eliminate scan line artefacts from the images. This corrective procedure resulted in an enhanced visualisation of the images and an improved discrimination capacity between different land classes. To visualise the classification process, small-scale and distinct areas were used as training samples, enabling the algorithm to identify land cover classes based on their spectral signatures as evident in the imagery data. Google Maps (Sentinel) was used to help identify the location and cross-check the coordinate sites to confirm and verify the actual area of doubt of land use or cover types (Amini et al., 2022; Das et al., 2021; Capitani et al., 2019). The training areas for each land cover class were created with the appropriate selection of each pixel in the image for the feature class and were converted into a KML file and opened in Google Earth imagery to verify the feature classes (Gbedzi et al., 2022; Gong et al., 2020). In addition, the classified dataset was polygonised to calculate the areas of each of the classes (Fasona, and Sobanke, 2020; Owusu and Essandoh-yeddu, 2018; Mousivand and Arsanjani, 2019). Area calculation for all the classes was generated through the calculated geometry of the attribute table in ArcGIS software 10.8 (Phiri and Nyirenda, 2022; Fasona et al., 2020). However, some unresolved problems were still encountered such as differentiating between some land use/land cover classes. For example, differentiating between cropland and grassland proved particularly tricky. With the knowledge of remote sensing/GIS experience, the ground truthing data collected was added to the training data sets and used to reclassify the Landsat images to obtain more realistic and accurate classified land use/land cover maps for 1986 to 2020 (Chapter 3). There were only a few portions of the initially classified data that were not aligned with the observed ground conditions and which necessitated a re-evaluation. This was rectified by reclassifying the image map to improve data accuracy, ensuring that subsequent analyses and decisions were based on reliable information. In this study, the classified Landsat images were assessed for accuracy using the 90 geographically referenced points collected from the gazetted forest as detailed in the next section.

2.5.5. Accuracy assessment of LULCC classes

The accuracy of the land use and land cover classification for 1986, 2000, 2010, and 2020 was assessed using ArcGIS and software, following the approach by Forkuo and Frimpong (2012) and Dibaba, Demissie, and Miegel (2020). The assessment involved generating an error matrix, accuracy totals, and a Kappa statistic (Chapter 3). Reference data from the supervised classification module in ArcGIS were used to create the error matrix, based on methods used by Nuhu and Ahmed (2013), Khawaldah (2016), and Fasona et al. (2020).

2.5.6. Field ground truthing

Field validation was done to improve the quality and accuracy of the classified maps (Latham, 2013; Dibaba, et al., 2020) by obtaining ground truth data to verify the classified maps of the gazetted forest reserves. Ground truth points were sampled using random sampling techniques considering the security and accessibility of the forest areas, following an approach like Oliphant et al., (2019) Phiri and Nyirenda, (2022). To maintain consistency and allow for direct comparison between the three forest reserves, a sample size of 30 points was selected for each site. Although Doma Forest Reserve is larger than the others, the decision to use an equal number of sampling points (30) across all three reserves was made to ensure uniform sampling intensity and to prevent sampling bias. 30 ground truth points for each of the three surveyed forests were geographically referenced, with data points collected from study reserves on the ground using GPS (Appendix 2.1). Only areas of the reserve that were accessible without significant risks concern such as rough terrain, terrorism attack around the three forest and cultural restriction, dangerous wildlife (notably in the Odu forest reserve) were included in the assessment. The same sample number of 30 points was chosen across the three forests to maintain a consistent sample size representation across all three forests allowing for direct comparison between them to avoid bias in the data collection. The selecting 30 points provided a balance between sufficient spatial coverage and practical constraints related to fieldwork safety, time, and resource availability. A larger number of points would have posed greater logistical and safety challenges without proportionally improving the robustness of the comparative analysis, while fewer points might have risked insufficient representation of the environmental variability (LULCC) within each reserve. Thus, 30 points per reserve were deemed an optimal and pragmatic choice under these conditions

There was a concerted effort to sample places with different types of land use and forest covers, such as farms, forests, shrublands, grasslands, built-up areas, and bodies of water. Photographs were taken to confirm the land cover classes (Chapters 3 and 4).

The points were imported into ArcGIS 10.8, and georeferenced, using UTM zone 32. These ground truthing points were superimposed onto the classified image map of the forest reserve, providing a visual representation of the accuracy and reliability of the classification process in capturing the actual land use and land cover class. The ground truthing points also allowed authentication of the reality of what is in the real world within the study area forest boundaries, as presented in Chapter 3.

2.6. Perception data collection on forest change and conservation from participants

To understand what is perceived to be happening to forests, data were collected on the direct and indirect drivers of the land use and forest cover history of the gazetted forest, the perceived ecosystem service benefits, management, future conservation and sustainability of the reserves. Three approaches were employed to evaluate the critical drivers of the forest change in the gazetted forest communities and address the research objectives: household questionnaire, key informant interview, and focus group discussions were used (Appendix 2.2; Plate 2.1). These methods are appropriate (suitable, effective, and well-suited) for obtaining varied opinions from forest community members, government officials, and experts as the key stakeholders on forest matters (Dibaba, et al., 2020; Ihemezie, et al., 2022; Phiri and Nyirenda, 2022).

Plate 2.1. presents the fieldwork sample pictures of the various activities and methods applied during the fieldwork, 2022.

Plate 2. 1. A cross-section of participants during the fieldwork activities: a) Ground truthing, b) Key informant interview; c) Household questionnaire, d) Focus group discussion

Household questionnaires, key informant interviews, and group discussions each have specific strengths and weaknesses in research applications. Household questionnaires are effective for collecting quantitative data from a broad base of respondents, crucial for understanding the distribution of as land use and ownership, drivers, and socioeconomic factors among community members (Gautam et al., 2023). However, they may not capture in-depth personal insights or nuanced dynamics. Key informant interviews are valuable for detailed information from individuals with specific knowledge or influence within the communities (Gautam et al., 2023). These interviews can provide in-depth perspectives but may be biased and overlook less influential voices, potentially reinforcing existing power structures (Lokot, 2021). Focus group discussions (FGDs) are effective for exploring complex social interactions and a range of viewpoints within a community (Hennink, 2014; Hennink et al., 2019). If done properly, they foster a participatory environment where diverse opinions can be expressed (Lakshman et al., 2000). However, group dynamics may influence individual responses, with dominant voices potentially marginalizing quieter participants

(Hennink et al., 2019). To address these weaknesses, this study employs a mixed-methods approach, integrating qualitative and quantitative data collection techniques to provide a comprehensive understanding of gazetted forest communities. This approach captures the dynamics of forest reliance by examining drivers, resource use patterns, and perceptions of conservation within gazetted forest reserves. Additionally, it traces historical changes in forest management, and sustainability of the forests (Ganesha and Aithal, 2022; Isaak, 2018). While this methodology offers a holistic perspective, it may have limitations in fully capturing nuanced socio-economic dependencies or informal resource extraction practices, which could be explored further through longitudinal or ethnographic studies. This triangulation balances the quantitative breadth of questionnaires with the qualitative depth of interviews and discussions. The questions used included a mix of closed and open-ended inquiries. Although these two types of questions have unique merits, they are not mutually exclusive. An integrated method of closed and open-ended questions leverages the strengths of each approach, so the questionnaire survey incorporated both types. The closed ended questions provided a response format that can be quantified, making it suitable for statistical analysis and comparison (Geer, 1991; Baburajan, et al., 2022). Closed questions are also less time-consuming to administer and analyse which can be advantageous in large-scale surveys (Agustianingsih and Mahmudi, 2019). On the other hand, open-ended questions allow respondents to express thoughts and concerns more freely in greater detail, uncovering richer details that closed-ended questions miss (Hansen and Świderska, 2023). Open questions can be more difficult expensive to code and due to the variability complexity of responses (Lokot, 2021). Additionally, the sequence of presenting closed and-ended questions may influence how participants respond, although empirical evidence indicates that this effect may not be significant (Hansen and Świderska, 2023). Moreover, open-ended questions can stimulate higher thinking and provide an understanding of respondents' thought processes (Agustianingsih and Mahmudi, 2019). They require more effort from both the respondents in articulating their thoughts and the researchers in interpreting the data (Septiani, et al., 2022). An integrated approach that combines closed and open-ended questions can offer a comprehensive view of the subject matter, so this was adopted in this thesis. However, there may be potential biases and challenges in coding and analysis but efforts to reduce this can benefit from the strengths of both question types (Covell, et al., 2012; Hansen and Świderska, 2023). To span both breadth and depth, in this study I utilised closed-ended questions as initial responses for data collection, followed by open-ended inquiries to explore those initial responses further. The closed questions related to the demography of the household respondent, land use on gazetted forest change, forest resources use and drivers

of land use and forest change for the household questionnaires. Open-ended questions generated details on the drivers of forest change from a historical perspective (Appendix 2.2), and were also useful for triangulating information to support achievement of research objectives three, four and five. The details of the instruments used for data collection are shown in the next sections.

2.6.1. Household questionnaire

The questionnaire used for the study was a set of structured questions (Appendix 2.2), specifically designed to capture the views of the local community residing in proximity to the forest reserves (refer to Appendix 2.2). The household questionnaire was purposefully designed to survey a large population of 252 respondents, aiming to capture comprehensive perspectives from the selected gazetted forest communities (Makunga and Misana, 2017). The questionnaire was structured to gather information on the key drivers of forest change, demographic data, education, size of households, and income. Other focal areas were on human activities, forest ecosystem importance, management, and conservation as well perceptions of future concerns and the sustainability of the gazetted forest (Appendix 2.2).

It was difficult to obtain precise figures and data on the villages and communities surrounding the forest reserves, which resulted in challenges in establishing what was a valid sample. Since the study area's population is unknown, multi-stage sample approaches were used to choose questionnaire respondents (Muhati, Olago and Olaka, 2018; Munthali et al., 2019). First, one LGA with a gazetted forest reserve was purposefully picked from each of the State's three geopolitical zones, ensuring a balanced and comprehensive coverage of the State. The inclusion and exclusion criteria were carefully designed to select representative, accessible, and legally recognised forests, providing a robust basis for analysing ecological and socio-economic dynamics. Covering all three zones enhances the relevance and applicability of the study's findings, contributing valuable insights for forest conservation and management across Nasarawa State. Second, three communities and villages within each of the selected forest reserve areas were selected from the list of communities in the LGA. The selected communities have a link and right to the gazetted forest for each of these reserves. Distance from the forest reserves was considered likely to affect the frequency of forest resource access and level of reliance on forest resources, therefore, the distance of the communities from the gazetted forest boundary was set between 1 and 5 km. Figure 2.7

shows three villages in each of the forest areas where questionnaire surveys were administered.

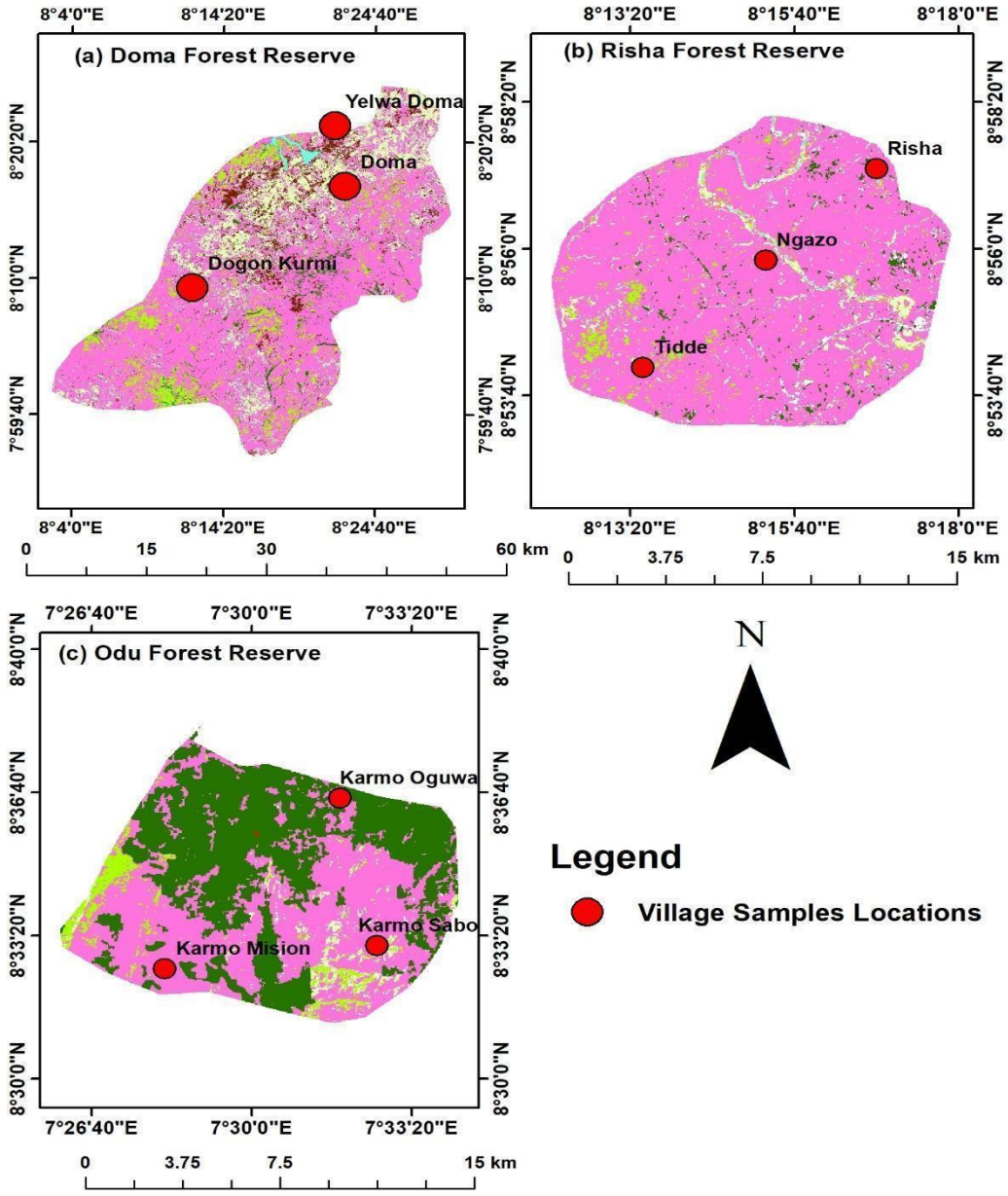

Figure 2. 7. Gazetted forest map showing case study sampling villages' locations in the three forest reserves, 2022. From top left: a) Doma forest villages b) Risha forest villages and c) Odu forest villages.

The selected villages were also areas with stable security conditions. This was a necessary consideration to minimise risks during the study and for the research team to conduct

fieldwork both efficiently and safely. Households were randomly selected, by choosing every second household by walking around the village from the identified villages. The traditional and village heads of each of the selected forest communities were approached initially and gave permission to administer a questionnaire to the head of households or an adult person in their absence to represent their household's views. Households that declined or were unavailable were skipped by applying non-response technique. The village chiefs and elders confirmed that the study area encompassed all remote village regions with historical connections to the reserves. Therefore, in each of the three forests an equal number of questionnaires (84) was administered comprising three communities' villages in each of the three gazetted forests (28). This gave a total sample size of 252 respondents (Table 2.4) across nine villages (Figure 2.7). The household questionnaires were conducted by the researcher and the three trained research assistants hired for the purpose of data collection. This was to ensure that administration of the questionnaire was possible within a reasonable time, also considering security concerns in the area. As stated earlier in the positionality section during early visits, the researcher recruited and trained research assistants from forest reserve-dependent communities. The research assistants had deep knowledge of the community members as well as high levels of education (BSc) and skills relevant to the study as recognised by their community leaders. Indeed, community leaders suggested individuals from the communities who possessed relevant background information and knowledge about the subject matter and who were educated in the local dialect of the specific community, Hausa, and English. This followed similar method to that used by Fasona, et al. (2020) and Ward, et al. (2018). The researcher assessed their interest, availability, and core skills such as literacy, local knowledge, and communication abilities, after which, training took place. Time was taken during the training to explain the purpose of the research to the research assistants for all the community data collection, including the surveys, KII and FGD. Care was taken to ensure that the research assistants did not influence, edit, or censor participant responses (Laws et al., 2013; Withers et al., 2014). The researcher encouraged them to explain the questions several times in different ways to confirm that the questions and responses were adequately understood before recording the answers.

The first task of the trained field assistants was to administer the pilot survey of the forest reserve communities. A set of 15 questionnaires was systematically tested in a pilot study to evaluate their clarity and length before the commencement of formal data collection. This pre-test was conducted to provide the opportunity to improve the questionnaire and minimise response errors, identifying questions that respondents struggled to answer (Makunga and Misana, 2017; Munthali et al., 2022). This process aimed to enhance the validity and

reliability of the questionnaires, ensuring a successful formal data collection phase. Pilot questionnaires were tested at two forest sites, Risha and Doma. Participant feedback on clarity, length, and overall experience was documented, leading to necessary revisions. For instance, additional questions about the crops cultivated and challenges within gazetted forests were added based on the pilot study insights. The pilot data were excluded from the final analysis. Ethics approval was obtained from the University of York, UK. A copy of the final questionnaire is in Appendix 2.2.

As some of the participants could not adequately communicate (read and write) in English, questions were translated to the Hausa language with assistance from the field research team. The household questionnaire was administered using the face-to-face approach, and data responses for the respondents were recorded in hard-printed copies of the questionnaire written in English.

The activities of the research assistants were supervised by the researcher (coordinator). Since some of the respondents agreed to be contacted by giving their phone numbers, a random sample of participants across six villages were called to verify if they participated. The responses from the participants tallied with the hardcopy questionnaires completed by the research assistants. The research field team met together every day both before and after the data collection, to reconcile, back up, and discuss any challenges that arose in the field activities. The household survey was conducted in Nigeria during June and July 2022 in the wet season.

2.6.2. Key Informant Interviews: identification and selection of the stakeholders

In this study, stakeholders refer to individuals or groups with a direct or indirect interest in the management and conservation of forest resource use. In this context, direct stakeholders are those who use, manage, or depend on forest resources for their livelihood**,** while indirect stakeholders influence, benefit from, or support forest conservation without direct involvement in resource use (Ezenwaka, 2018)**.** These individuals provide knowledge, experience, and insights related to LULCC, forest use, and ecosystems, contributing to understanding drivers, impacts, and solutions in forest management and conservation. However, the extent and applicability of their knowledge may vary, as highlighted by studies such as Muhati and Olaka (2018) and Ihemezie et al. (2021). Therefore, while local knowledge is valuable, it should be assessed critically alongside other information sources.

The stakeholder groups selected for this research encompass a wide range of perspectives of participants from local people, local leaders, government officials, and experts, as detailed

in Table 2.3. The local community groups were selected based on their experience with forest resource use, their understanding of land use change, and their active involvement in forest-related activities. The stakeholders were selected based on the aforementioned involvement in conservation, land use management, or community-based forestry and also forest dependency, whereby participants rely on forests for their livelihoods (e.g., fuelwood collection, non-timber forest products harvesting, farming) (Muhati and Olaka, 2018). The stakeholders were selected based on their involvement in conservation, land use management, or community-based forestry, as well as their dependency on forests for their livelihoods (e.g., fuelwood collection, non-timber forest products harvesting, farming) (Muhati and Olaka, 2018). Information regarding their forest reliance was obtained through preliminary consultations, local knowledge, and prior engagement with relevant institutions and stakeholders working in the areas.

In this study, efforts ensured inclusivity and balanced representation across gender, age, and socioeconomic groups. Participants were eligible if they were aged 18-75 years, residents of the study area, able to provide informed consent, and interacted with forest activities for livelihood. Individuals were excluded if they were below 18 or above 75 years, unable to communicate in the primary interview language, declined participation, or had cognitive impairments preventing meaningful engagement. Despite attempts to encourage female participation, female respondents remained lower than male participants. This was attributed to cultural norms and time constraints, which limited women's availability and willingness to participate. Although strategies were used to address this imbalance through flexible scheduling and female community leaders, female participants remained underrepresented. This disparity introduces potential bias and may influence the findings and generalizability of results.

The local leaders (Table 2.3) were chosen based on their leadership role, involvement in land use decision-making, and influence in enforcing forest conservation measures or policies in the community while the government officials participant group were identified based on their official role and responsibilities in managing forest reserves, enforcing environmental policies, or monitoring LULCC processes. As experts were chosen based on their academic professions, the research focus on LULCC and forest-related issues, and their familiarity with relevant policies and regulations.

Table 2. 3. 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 with the forest for resources frequently to derive immediate benefit 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, including forest use, land ownership and disputes, and local regulations. **Traditional Rulers and Village Heads:** They play a key role in land governance, ensuring that customary laws and traditions are upheld in forest use and ownership. Their authority helps manage disputes over land and guide sustainable resource allocation. **Youth Leaders**: Representing the younger generation, they are essential in conservation efforts, enforcing environmental policies, and promoting sustainable practices. They also help in preventing illegal activities such as deforestation. **Women Leaders**: As key users of forest resources for livelihood activities such as farming, gathering firewood, and herbal medicine, women leaders ensure that their community's needs are met while advocating for responsible land use and conservation. **Market Leaders**: Being responsible for trade and commerce related to forest products, they help regulate sustainable harvesting and distribution of forest resources to prevent overexploitation and ensure long-term benefits.
Government officials	These are government custodians who monitor and analyse 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 Nasarawa State Ministry of Environment and Natural Resources
Experts	These are independent experts, which in this context refers to specialists who are not directly affiliated with government agencies, corporate entities, or other organizations that might have a vested interest in specific land-use policies. They advocate for forest and land use for sustainability and advise the government, and people to understand forest policy implementation strategies, considering their impact on the environment, and particularly the importance and role of forests in environmental sustainability. Their expertise spans multiple disciplines, and includes land-use planners, environmentalists, geographers, and foresters in academic and forestry institutions. They bridge the gap between scientific research and practical policy implementation, guiding decision-makers toward solutions that balance ecological health with human needs.

2.6.3. KII Identification and selection for the stakeholder's interviews

After identifying the key stakeholder groups, specific individuals were selected to participate in each of the stakeholder KIIs groups. The selection was guided by the following: Individuals were chosen for their in-depth knowledge of LULCC processes, forest ecosystems, and relevant policies, ensuring they could provide informed perspectives and reliable data. Moreover, to ensure equitable representation, efforts were made to include participants from different geographic regions and backgrounds within the forest reserve communities, government officials and experts. This provided a more comprehensive understanding of the forest-related issues under study. Furthermore, given logistical challenges, such as time constraints and the need to coordinate movement between locations, the number of participants was carefully balanced to ensure meaningful and productive discussions while remaining feasible for the research team. The stakeholders were identified in three selected forest reserve communities between the 14th and 20th of June 2022.

Following the recommendations of Muhati and Olaka (2018), Etikan (2016), and Munthali et al. (2019), the idea of selecting a smaller number of participants who are representative of the larger population can be a practical and efficient way to gather in-depth insights from participants who share common characteristics, making it easier to analyse and draw conclusions. Therefore, five participants from each of the four identified stakeholder groups with similar socioeconomic backgrounds on land use and forest matters were purposely selected for this study (Tables 2.3 and 2.4) while a snowball was used to identify individual participants. Other dimensions such as age, education, gender, occupation, geographic location, and cultural or ethnic background were considered to ensure comprehensive representation across the stakeholder groups. For instance, each stakeholder group has a diverse mix of participants based on these factors aiming for balanced representation across these dimensions to ensure the findings reflect a broad range of perspectives and experiences.

Table 2. 4. Sampling sizes for the KII and FGDs and household surveys for the three forest sites with government and expert groups for the study.

Variables	Nature of the respondent	Sample size and number of participants	Gender		Method
Doma			**Male**	**Female**	
Interviews and Focus groups discussion	Four themes'/ groups Stakeholders	Local leaders stakeholders 5 Local people stakeholders 5	4 4	1 1	Snowball sampling method
Risha					
Interviews and Focus groups discussion	Four themes'/ groups Stakeholders	Local leaders stakeholders 5 Local people stakeholders 5	4 4	1 1	Snowball sampling method
Odu					
Interviews and Focus groups discussion	Four themes'/ groups Stakeholders	Local leaders stakeholders 5 Local people stakeholders 5	4 4	1 1	Snowball sampling method
Government Official and expert					
Interviews and Focus groups discussion	Four themes'/ groups Stakeholders	Government official (Policy maker) 5 Expert 5	4 4	1 1	Snowball sampling method
Total		**40**	**32**	**8**	
Household Questionnaire	Local Community Household survey	Doma Forest Reserves 84 Risha Forest Reserve 84 Odu Forest Reserve 84 **Total 252**			multi-stage sample method

Sources: Computation of sample size for household survey, KII and FGD and selection, 2021.

According to Palinkas et al. (2013), Oribhabor and Anyanwu, (2019), Alan (2019), and Sandham et al. (2019), the number of participants and the size of the sample should be determined by the nature of the issue being studied and the experience and expertise of the stakeholder to provide meaningful information on the subject. Snowball sampling is a useful choice of sampling strategy when the population you are interested in studying is hidden or hard to reach and for cost-effectiveness since initial participants can help in recruiting others,

helping researchers save time and resources that would otherwise be spent on locating eligible individuals through broader sampling techniques (Etikan, 2016; González-Val, 2021). This helps researchers to select a sample of the population interested in being studied from which they can make inferences. It is impossible to determine the possible sampling error and make statistical inferences from the sample as the population being studied is widely generalence in the relevant field, or those without direct engagement with the study's focus area.

Initially, specific inclusion and exclusion criteria were established to guide participant selection. Firstly, I identified potential participants aligned with the research objectives by defining these criteria, which were based on relevant characteristics such as demographics, expertise, experience, and other attributes essential to the study. Demographic attributes, including age, professional background, and years of experience, were critical in determining eligibility. These characteristics were selected to ensure that participants possessed the maturity, contextual knowledge, and experiential insight necessary for meaningful contributions to the research topic. The inclusion criteria specified that participants should be aged between 18 and 75 years, represent a household, possess a minimum of 10 years of experience as forest users in communities that frequently interact with the forest for resources, and hold relevant educational qualifications or non-formal education, such as primary, secondary, or bachelor's degree, or have local experience on the subject matter. Additionally, participants were required to have direct involvement with or exposure to the phenomenon under investigation. Exclusion criteria eliminated individuals outside the specified age range, those with less than 10 years of experience in the relevant field, or those without direct engagement with the study's focus area.

Secondly, the initial recruited respondent was asked to refer us to other potential participants who met the same criteria relevant to the research, such as shared experiences or perspectives.

I engaged with gatekeepers where access to participants was restricted and contacted relevant authorities or individuals to facilitate connections. This approach presents challenges associated with gatekeeping. Gatekeepers like community leaders or authority figures control access to certain populations, introducing bias in sampling and limiting representation. Their influence may reinforce existing power dynamics (Kathlene, 1994); for example, in communities with restrictive gender norms, women were significantly underrepresented. For instance, the consultation began with the village leaders of each of the study communities. This played a key role in connecting with other stakeholders in their local areas, facilitating a broader outreach. The policy makers were addressed by writing to

the Commissioner of the Environment through the Ministry of Environment who then contacted the Director of Forestry, which enabled contact to be made with other potential stakeholders from the government, while the experts come from an academic environment and have a wealth of experience in their respective fields. I contacted the Deputy Vice Chancellor, Nasarawa State University, Keffi who is a biogeographer, who provided links to other academic stakeholders who were interviewed.

Due to the cultural background associated with the forest communities in this study, women are often not given opportunities to speak or participate much in their communities on forest conservation matters, while some women were unwilling to be interviewed. However, to address this challenge, the composition of the groups, gender and age groups were considered in the selection process for the interviewed stakeholders, and eight women were interviewed as well as 32 male counterparts (Table 2.4). In each of the identified groups, at least one female was involved.

To address this challenge, the composition of the groups specifically gender and age was carefully considered in the selection process for the interviewed stakeholders. In total, 40 stakeholders were interviewed, comprising eight women and 32 men. The inclusion of only eight women raises important questions regarding power dynamics and representational balance. The selection of female participants was based on their roles in the community, availability, and expertise in the subject matter. This approach aimed to ensure diverse perspectives while acknowledging potential constraints in gender representation.

Selected individuals were invited to interviews via formal letters, including the researcher's telephone and WhatsApp contact details. Upon acceptance, they received advance notice of the date and location. Participants were briefed beforehand on the interview objectives, research ethics, and data protection measures. The participating stakeholders gave verbal consent, following a similar method by Ward, et al. (2018) and Kariuki et al., (2021a). A total of 40 key informant interviews were conducted across the four different groups as presented in Table 2.4.

To avoid interference from a third person, the interviewees were interviewed separately in face-to-face conversations (Dibaba, et al., 2020). A mix of languages (English, Hausa, and local dialects) was used for the interviews. The same research assistants employed to administer the survey helped in conducting the KIIs and FGDs, assisting with local language interpretation, when prompted or necessary during interactions with the respondents as some of them preferred. However, Hausa and English were the primary languages used throughout the fieldwork exercise. The researcher facilitated the interaction while the critical points were noted down by the research assistants (Oduro Appiah et al., 2021). Participants'

permissions were granted before the voice audio recording and taking of group photographs was carried out. The procedure for collecting data was the same for all the different types of stakeholders.

2.6.4. FGD Identification and selection for the stakeholders

According to Philip et al. (2019) and Boateng, (2012), a focus group discussion involves a limited number of individuals, typically ranging from five to 12, who gather to discuss a specific topic of interest to the moderator. The purpose is to understand the group's perspectives on the direction of forest change. In this study, FGDs were used to provide additional insights to complement the key informant interviews, household questionnaire, and remote sensing data and to see the extent of a group's consensus or differences, particularly regarding their perceptions of forest change and historical drivers of land use, as well conservation and sustainable issues in the study area (Kariuki et al., 2021; Nganro et al., 2021).

The composition of the groups, including participants' gender and age were considered in the selection process. The same participants in the KIIs were invited to the FGD. This harnessed their willingness to engage in the research and was also considered appropriate due to time frame covering the project work and financial implications (logistics) in recruiting a new set of participants for the study. Participants familiar with the topic from the interviews engaged deeply and thoughtfully during the FGDs, building on their previous reflections, while discussions also yielded information for validation and triangulation purposes. Some of the invited participants needed to assign replacements who had knowledge on the subject matter to represent them in the focus group meeting as their tied schedules meant they would not be available for the FGD. The representatives were also asked if they were willing to participate and all agreed to participate. See Appendix 2.2 for the focus group topics. Consequently, eight focus groups were conducted, each comprising five individuals, giving a total of forty participants in the FGDs across all groups (Table 2.3).

These FGDs were distributed across different forest sites, with two FGDs held in each of the three forest communities (Doma, Risha and Odu) and one with each for the government officials and experts respectively. Each FGD was composed of participants selected based on their roles and knowledge related to forest use, conservation and management who are the relevant stakeholders (Table 2.3 and 2.4). Some FGDs were mixed groups incorporating individuals from diverse backgrounds, while others were homogenous, focusing on specific groups such the local leaders, local community, government officials and experts Table 2.4

provides further details on the composition and distribution of FGDs across the study sites. Having five participants in each focus group enabled in-depth discussion and the ability to manage group dynamics effectively. Smaller group sizes can create a more intimate atmosphere, giving each participant ample opportunity to contribute, which is particularly beneficial when dealing with complex topics (Cortini et al., 2019). Additionally, the smaller group size is appropriate based on the research scope, the specific characteristics of the participant population and the research context (Cortini et al., 2019; Mishra, 2020). Prior to the FGDs, stakeholders were informed of the aims, research ethics, and personal data protection and provided verbal consent. To reduce the effects of power imbalances, and ensure freedom of expression during the FGDs, participants were arranged according to their stakeholder groups, and FGDs were held in different sessions, times, venues and dates; first with local community leaders, second with the local community people, third with the government officials, and finally with the experts. All participants felt at ease responding within the group. To facilitate communication, the researcher and research assistants helped in interpreting some of the unclear topics and translating them to local languages, particularly Hausa, during the FGDs in each of the communities. FGDs with government officials and experts were conducted in English. Overall, the FGDs involved in-depth and qualitative exchanges where the researcher functioned as an "investigator." The research assistants adopted the roles of "facilitator" or "moderator" in this context, facilitating or moderating participant group discussions (Chirwa et al., 2017; Kuemmerle et al., 2016). This technique helped to confine participants to the research topic. Sometimes the researcher allowed participants to address issues deemed particularly relevant to them rather than restricting the topics. This was done to provide flexibility and leverage group dynamics to freely explore issues in context, depth, and detail without imposing a preconceived framework. Such dynamics and the process of sharing and comparing understandings and perspectives imply that the FGDs provide additional insights that were not obtained through the other methods. The primary outputs derived from FGDs include both explicit findings and the deeper insights gained from group dynamics and discussions. The most valuable aspect of FGDs was not just the answers given, but how those answers emerged through group interactions, debates, and consensus-building. This makes FGDs a powerful tool for exploring complex human interactions with forests and environmental issues.

The procedure for collecting data was the same for all the different groups in the study. An audio digital recorder was used to record the conversations during the FGD, note-taking of critical points was taken during the discussion, as well coordination of the process by the two research assistants who were natives of the study area as the researcher facilitated the

discussions (Phiri and Nyirenda, 2022; Chirwa and Kowero, 2017). Each FGD lasted 35-60 minutes. Participants' permission was granted before the audio voice recording and taking of group photographs.

The methodology design was reviewed and approved by the ethics committee at University of York, UK, ensuring compliance with ethical considerations, including informed consent, data confidentiality, and participants' rights. All necessary permits and approvals for conducting research in Nigeria were obtained from appropriate regulatory bodies and institutions (Nasarawa State University Keffi and Ministry of Environment and Natural Resources Nasarawa State). The project adhered to national and institutional ethical standards, ensuring that data collection, analysis, and dissemination complied with ethical and legal frameworks.

2.7. Analysis of quantitative and qualitative data

The LULCC maps were generated in ArcGIS 10.8, and classification statistics of each land use and forest cover were generated through the calculated geometry of the attribute table in ArcGIS software (Gong et al., 2020; Thasi et al., 2021). The calculation of the area trend of each land use and land cover type percentage and km^2 of change was derived from the same software.

For the fieldwork data, Microsoft Excel 2010 version was used to create spreadsheets to facilitate the creation of a structured database of variables, allowing for the systematic entry of information. This included entering the quantitative data collected from the questionnaires. The data was then entered into IBM SPSS version 21 and Python 3 to be coded and further analysed. These were analysed using libraries in Python 3 programming language. The libraries used for the data analysis, manipulation, and plotting comprise Numpy, Pandas, Matplotlib, Seaborn, Sklearn, Graphviz, Dtreeviz, Plotly, cufflinks, StatsModels, and Scipy (Stancin and Jovic, 2019). Each of these libraries played a crucial role in different stages of the data analysis process, for instance, allowing efficient handling, analysing, and visualising of the data. For example, in this study a combination of Pandas and Seaborn was used to explore data, generate descriptive statistics, and create visual relationships (allowing assessment of relationships between drivers and human activities) following Prasai et al., (2021). Additionally, the Matplotlib library was used to generate basic plots and bar charts. A cross-correlation table was constructed using the Plotly module, displaying only values with a correlation coefficient of values ranging from -1 to +1, indicating varying degrees of correlation strength. Descriptive plots were also created using

the Python Plotly module. The descriptive statistics were summarised in tables and charts, providing a comprehensive report of all quantitative information.

The qualitative data from KIIs and FGDs were transcribed, coded, and analysed using NVivo software. This process involved two stages. First, initial coding generated numerous categories without restricting the number of codes, following the approach of Charmaz (2006) and Kuemmerle et al. (2016). Emerging ideas were listed, relationship diagrams drawn, and frequently mentioned keywords were used to highlight key themes aligned with the research objectives. The second stage refined the initial codes by eliminating, combining, or subdividing categories, focusing on recurring ideas and broader themes (Charmaz, 2006). The final codes were grouped into broader themes. For example, direct and indirect drivers of change were identified, with sub-themes such as agriculture, charcoal production, population growth, government policies, and poverty (Makunga and Misana, 2017; Wahabu and Nyame, 2015). For example, throughout the coding process, the researcher compared information from multiple data sources to identify commonalities and discrepancies which were revisited in the coding process to ensure consistency and accuracy. For instance, discrepancies in this context refer to any inconsistency, contradiction, or unexpected difference between data sources which some of these were re-examined to check for errors in data collected or interpreted and refine coding criteria to ensure consistency in classification and seek additional data or use triangulation (cross-checking with multiple sources) to verify accuracy.

Qualitative analysis was complemented by content analysis, grouping data from the analysed (KIIs) and FGDs themes based on frequency, context, and relevance to the research questions (Appendix 2.3: Table 1 and Table 2). Selected quotes supported key findings, reflecting broader community discussions and providing insights into participant perspectives following Boldy et al. (2021), Khawaldah (2016) and Kariuki et al. (2021). Codes were refined to ensure diverse viewpoints were captured, reducing bias and aligning with the study's objectives. For example, objective two on the historical perceived drivers and patterns of land use and forest change in gazetted forest reserves were analysed, the analysis compared two time periods: 1966-2000 (past) and 2000-2022 (present). The year 1966 marks the initial (Reference year) delineation of the gazetted forests, while 2022 represents the current state. This defined period was established by the researcher and stakeholders to assess past and present perspectives on forest boundaries and to address the research questions. For instance, using the NVivo software, the stakeholders code emerging themes identified primary drivers, such as agriculture, lumbering, charcoal production, and government policies following similar methods by Boldy et al. (2021), Khawaldah, (2016),

and Kariuki et al., 2021). Direct quotes data from participants extracted through the Nvivo were used to support key issues relevant to the narrative of the research storylines or related research questions from the themes categories (Appendix 2.3, Figure 1). Additionally, insights from KIIs and FGDs analysed were extracted from the relevant information to support the research findings in Chapters 3, 4, and 5.

In summary, the utilisation of fieldwork, GIS and remote sensing methods offered complementary strengths and limitations in assessing land use and forest cover change. Fieldwork provided detailed, on-the-ground data, ensuring high accuracy and serving as ground truthing in validating remote sensing and GIS data. It allowed for a better understanding of local conditions, human activities, and socio-economic factors that contribute to land use changes and forest use history and conservation measures from the local perspective and enabled the collection of detailed qualitative and quantitative data, including socio-economic drivers, land use characteristics, forest management and conservation practices, and future sustainability for the gazetted forest, which could not be captured through remote sensing and GIS alone. However, fieldwork is time-consuming and labour-intensive, often making it impractical in large or remote areas. The scope is limited to specific locations, which may not represent larger patterns or trends. Data collection can also be subjective and prone to human error, which might affect consistency and reliability. Remote sensing data facilitates the analysis of changes over time with frequent data acquisition, useful for time-series analysis while GIS can be used to integrate various data types (spatial, temporal, statistical) from different sources, providing a comprehensive view of land use and forest cover changes. This helps in visualising complex spatial data through maps, aiding interpretation and decision-making. However, the spatial and temporal resolution of satellite imagery can limit the detection of small-scale changes and detailed analysis and data quality can be affected by atmospheric conditions (e.g., clouds, haze) and sensor limitations. Remote sensing data also requires significant expertise to process and interpret accurately, with the potential for misclassification or errors in automated analysis. The accuracy and reliability of GIS analysis are highly dependent on the quality and resolution of the input data.

Integrating these various approaches has enhanced the robustness, comprehensiveness, and reliability of research findings, enhancing the contextual understanding of landscape dynamics and improving the accuracy of interpretations of the research findings. This ensures that findings are well-supported and balanced, and reduces the likelihood of errors and biases, providing a stronger foundation for conclusions and recommendations. By

combining different methods with empirical data from fieldwork with the experiential knowledge of local communities, researchers can create more accurate, holistic, and actionable land use assessments. This integrative approach not only improves the scientific validity of the findings but also enhances their relevance and applicability in real-world contexts.

2.8. Conclusion

Mapping and analysing spatial patterns within gazetted forest areas using remote sensing and GIS methods provided powerful tools for forest region analysis. GIS allows researchers to quantify forest attributes, assess biodiversity, and evaluate landscape connectivity through spatial analysis functions. By integrating remote sensing imagery, forest boundary maps, and field surveys, GIS creates comprehensive and precise maps depicting the spatial extent of forested areas. These tools assisted in delineating and analysing forest boundaries and classifying and identifying LULCC. Fieldwork, which involved on-site data collection, observations, and interactions with stakeholders served as a fundamental approach to unravelling the intricate dynamics within these protected forest ecosystems and environments. These were combined to understand the relationship between the biophysical changes in forest cover and the socioeconomic drivers behind forest change from the local perspective. Information obtained from household questionnaires, FGDs, and KIIs provide a clear picture of the situation of gazetted forest activities and management in the study area. These methods provide information about the past and present trends of LULCC and gazetted forest change and evaluate and identify the root driving factors of the changes and implications of LULCC on the socio-economic activity of the community and the environment. The mixed methods provide a better understanding and adequate information around the gazetted forests change, resources use changes, management, biodiversity, conservation, and sustainability of the forest reserves from the key stakeholders in the forest communities and very importantly, highlight people's relationship with the forest and how this has changed. As we strive to balance biodiversity conservation with human well-being, a comprehensive research approach such as that used here, which acknowledges both qualitative and quantitative dimensions, is paramount for the sustainable management of PAs.

Chapter 3. Forest cover and land use change history around the gazetted forest reserves in Nasarawa State, North Central Nigeria

Abstract

The rapid losses of Protected Areas (PAs) and forest reserves has had negative environmental, social, and economic impacts globally. This study examines land use and land cover change (LULCC) in Nasarawa State, North Central Nigeria, evaluating the timing and patterns of change in the gazetted forest reserves since 1966, and comparing the changes across the three gazetted forest reserves in the study area. Systematic and purposive techniques were used to select three forest reserves for the study, one in each geopolitical zone. A temporal sequence of Landsat remote sensing imagery was used to analyse the historical trends of LULCC from 1986 to 2020. The land use map outputs were contrasted with the gazetted forest reserve polygon maps from 1966, which were used as a basis to quantify land cover changes in the three reserves. The results showed almost complete loss of forest cover in two of the three gazetted forests, with cultivated land increasing and forest areas decreasing throughout the study period of 1966-2020. The analysis showed that degradation was highest in the Risha forest reserve, where 88% of the forest was cleared. In the Odu forest reserve, 55% of the forest was lost in 2020, while the Doma Forest Reserve lost 83% of its forest cover between 1966 and 2020. The transformation has shown cropland expansion into the reserves, which is highest in the Risha forest reserve, accounting for 87% of the reserve land, followed by the Doma forest reserve (65%) and the Odu forest reserve. Odu forest is characterised by 45% forest cover in 2020, with lower losses attributed to its strong cultural significance within the local community. This study recommends an urgent need to assess current tree cover across the gazetted forest areas, particularly in light of shifting agriculture. The government and forest communities should take practical action for immediate and long-term planning for sustainable forest management by monitoring the remaining forest cover in forest reserves to preserve what is left and maintain the reserves' conservation potential. The current condition and land use change in the forest would make restoration work challenging. There is a need to implement the 2020 National Forest Policy to reduce the rate of rapid degradation and deforestation in north-central Nigeria so that the development potential of professionally managed and functioning forest reserves can be realised.

3.1. Introduction to land use/land cover change

Evaluating natural resources requires a comprehensive approach, emphasizing the role of land-use and land-cover mapping in sustainable environmental management (Capitani et al., 2019; Phiri & Nyirenda, 2022; Kafy et al., 2020). Land use and land cover change (LULCC) encompasses human-induced alterations with ecological, hydrological, and socioeconomic impacts, including biodiversity loss, habitat fragmentation, and economic shifts (Ellis et al., 2013; Dibaba & Miegel, 2020; Chunwate et al., 2019).

Nigeria's growing population, from 208 million in 2020 to 223 million in 2023, with projections of 375 million by 2050, intensifies pressure on land and forest resources (Salisu et al., 2024; NPC & ICF, 2019). Despite its vast population, Nigeria's land area is only slightly larger than Texas, increasing reliance on forests for energy, timber, and agriculture (Ankomah et al., 2020). Over 70% of Nigerians engage in farming, a trend expected to rise, further straining biodiversity conservation efforts (Ekpo and Mba, 2020; Ojeh, 2012). Land demand and fuelwood shortages exacerbate deforestation, including in gazetted forest reserves, driven by agricultural expansion, population growth, and resource exploitation (Adedeji et al., 2015; Nesha et al., 2021).

LULCC insights are critical for environmental planning, particularly in forest conservation and PA management (Gong et al., 2020; Latham, 2013). Forest reserves, managed by Nigeria's State Forestry Department, face challenges of weak enforcement and degradation, despite official forest demarcation (Anwadike, 2020; Federal Ministry of Environment, 2006; 2015). The 2018 IPCC report underscores the importance of preserving these areas for climate regulation and ecosystem services (IPBES, 2018). However, from 2000 to 2016, Nigeria’s protected forest cover declined by over 33%, significantly impacting the country’s overall forest resources (FAO, 2017; Scheren et al., 2021). As a result, the depletion of both protected and unprotected forests led to a severe shortage of locally available lumber, forcing Nigeria to import 75% of its wood supply (FAO, 2017; Scheren et al., 2021).

The instability of Nigeria’s forests, especially in north-central regions, highlights a knowledge gap regarding historical transformations and current status. Many reserves, originally gazetted during colonial times, remain poorly managed (Aloa, 2015; Soul, 2016). Developing an accurate land cover database is essential for monitoring landscape changes (Gong et al., 2020). This study examines historical spatial changes in three gazetted forest reserves in Nasarawa State, a hotspot for deforestation, by analyzing transformations since

their original demarcation in 1966 (Ladan, 2014; Ekpo and Mba, 2020). The chapter explores the timing, character, and extent of these changes, comparing patterns across the study area.

The historical survey of the gazetted forest reserves was digitised, georeferenced and overlaid on current spatial data to assess changes in the forest boundaries from 1966. Satellite images from 1986, 2000, 2010, and 2020 were obtained and analysed to capture degree of change over time using supervised classification techniques using ArcGIS software, categorizing the land cover into distinct classes such as forest, agriculture, water bodies, and urban areas. Detailed information on the method is presented in Chapter 2. Ground truthing involved collecting GPS coordinates and taking photographs of various land cover types to validate the classification. Change detection techniques were applied to identify trends and quantify changes in land cover types, and area statistics and currency assessment for each land cover type were calculated using spatial geometric in GIS tools for all study years. Temporal trends in land cover change were analysed using descriptive statistics and graphical representation using Python software. The results were presented in tables, maps, and charts, illustrating the extent and nature of land cover changes and were compared between 1986 and 2020.

3.2. Results

This section presents the results of the analysed gazetted forest boundaries from 1986-2020, ground truthing checking of the classified LULCC, an accuracy assessment of the land cover classification results from ArcGIS and the classified result of LULCC classification for the gazetted forest change for 1986, 2000, 2010, and 2020. The findings overall reveal trends in land use and land cover around the gazetted forest reserves in the study area.

Doma, Risha and Odu reserves were officially gazetted in 1966 and were intact according to the Federal Ministry of Environment, Nigeria and Nasarawa Geographic Information Service, Nigeria (2020), suggesting that the gazetted forest boundaries indicated complete forest cover for all three forests under study in 1966. However, the accuracy of these boundaries might be questionable due to potential issues in their definition or mapping by the Federal Ministry of Environment, Nigeria. This raises concerns about the accuracy of the 1966 data for this study, as it may not accurately represent the true forest boundaries at that time. Furthermore, the absence of remote sensing data from 1966 limits the ability to verify or analyse these boundaries comprehensively for this first epoch. Despite these limitations, the survey boundaries of the gazetted forest provide a crucial baseline for understanding the

initial forest cover within the gazetted forest reserves. This baseline is essential for assessing subsequent changes in forest cover and for managing and conserving these forest areas over time. The historical context established by the 1966 boundaries allows for a more informed analysis of deforestation, forest degradation, or other land-use changes that have occurred since then.

3.2.1. Accuracy assessment of land cover classification result

To enhance the quality and accuracy of the LULCC classified maps, ground-truthing was carried out at all three gazetted forests for an accuracy assessment. This method verifies the correspondence between land cover maps and actual land cover in situ, typically by comparing the classified map to reference data collected in the field. The field ground-truthing results are presented in Figure 3.1, providing validated or verified information on the classified results for land cover maps. The sampled points of the classes of the LULCC generated on the classified maps of the study area forests (Appendix 2.1) showed 30 points for each of the forest reserves; the cropland class had 10 points in each of the reserve's samples, while other classes such as forestland, bare surface, shrublands, built-up land, and wetland had three to seven sample points. These points were overlaid on the overall classification maps to ascertain the classification maps' accuracy for 2020 as shown in Figure 3.1. Table 3.1 also presents the accuracy for the classified maps. The accuracy of the user refers to the certainty that a pixel categorised on the map accurately depicts the corresponding ground feature, while the producer accuracy relates to the probability of correctly classifying a reference sample (Beland et al. 2006; Ding et al., 2021). The ArcGIS analysis showed a classification map accuracy of 93.33% for 2020, with a Kappa coefficient of 0.98 implying a very strong agreement between the predicted and actual classifications. These results are presented in Table 3.1. and the classified maps are shown in Figures 3.2, 3.4 and 3.6.

Table 3. 1. ArcGIS generated accuracy (%) of the classified image analysis result assessments of 1986, 2000, 2010, and 2020 images using an error matrix.

LULCC Class	1986 Producers' accuracy (%)	Users' accuracy (%)	2000 Producers' accuracy (%)	Users' accuracy (%)	2010 Producers' accuracy (%)	Users' accuracy (%)	2020 Producers' accuracy (%)	Users' accuracy (%)
Croplands	84.2	88.1	85.6	92.2	93.2	94.6	94.1	95.2
Shrublands	89.9	92.4	88.7	93.4	90.3	91.7	91.2	94.1
Forest lands	89.6	94.2	87.5	89.4	88.2	93.5	90.1	96.4
Grasslands	80.2	84.7	85.6	93.6	87.6	94.2	88.5	93.8
Wetlands	86.5	87.2	82.8	86.3	90.1	90.5	90.1	90.7
Bult-up land	86.8	88.3	88.4	90.7	89.4	92.8	91.4	94.2
Bare urface	87	88.2	88.6	90.7	83.3	91.2	81.8	92.9
Overall Accuracy assessment	**86.90%**		**87.50%**		**90.48%**		**93.33%**	
Kappa coefficient	**0.85**		**0.87**		**0.89**		**0.98**	

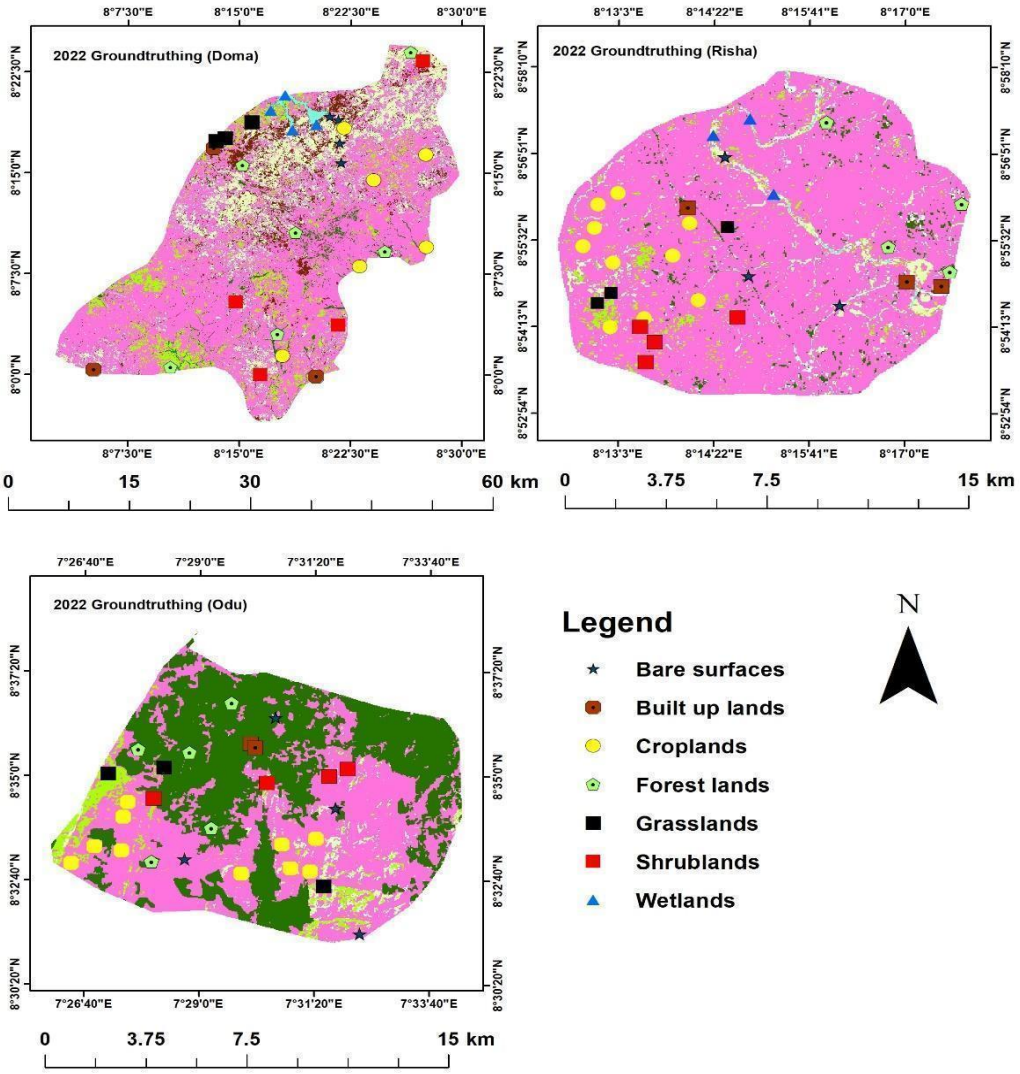

Figure 3.1. Spatial overlay ground truthing points corresponding to LULCC classes from the fieldwork on the classified image map of the three forest reserves

3.2.2. Trends of LULCC around Doma gazetted forest reserve

Figures 3.2 and 3.3 show the analysed image and results of the LULCC for the years 1986, 2000, 2010, and 2020 for Doma. These figures demonstrate that the forest cover experienced a substantial decline between the periods 1986, 2000, 2010, and 2020. In 1986, forests dominated the region, covering a significant portion of the area. There was minimal presence

of croplands and built-up lands, indicating a natural landscape with limited anthropogenic intervention. A notable decline in forests was observed, with increasing croplands in 2000. The year 2000 witnessed an expansion of built-up lands and bare surfaces (Figures 3.2 and 3.3). The major transformation was that croplands became the dominant land cover, covering the larger portion of the region. Substantial loss of forest lands and grasslands was evident, indicating high deforestation rates. Further expansion of built-up areas and bare surfaces was observed, demonstrating settlement expansion and land degradation. Shrublands and natural vegetation were substantially reduced. In 2010, trends revealed a further reduction in forest lands, which had become highly fragmented. Significant expansion of croplands continued to dominate the landscape with marginal increases in built-up areas and bare surfaces, reflecting continued forest cover loss and land degradation. Wetlands were observed predominantly in the northern part of the region with other minor occurrences across the areas. From 1986 to 2020, the extent of wetlands fluctuate erratically (Figure 3.2, 3.3), appearing minimal in 1986, increasing between 2000 and 2010, and decreasing towards 2020.

In summary, the progression from 1986 to 2020 highlights a steady decline in natural vegetation, particularly forests and grasslands, as croplands and built-up areas expanded. Croplands and shrublands are prevalent in this region, covering significant portions of the area on the map. Built-up lands and wetlands are dispersed, mainly concentrated toward the northern and southern parts fluctuating over the study years (Figure 3.3), while bare surfaces and forest lands have limited coverage, particularly in 2020.

Overall trends and patterns indicated that forest cover has drastically declined over the 34-year period, with croplands established as permanent fields of the reserve and built-up expansion in the area. Croplands have steadily increased, becoming the dominant land use by 2020 taking over the forest area. Built-up areas, though relatively small, have gradually expanded over time indicating expansion of human activities. The increase in bare surfaces indicates land degradation and unsustainable land practices.

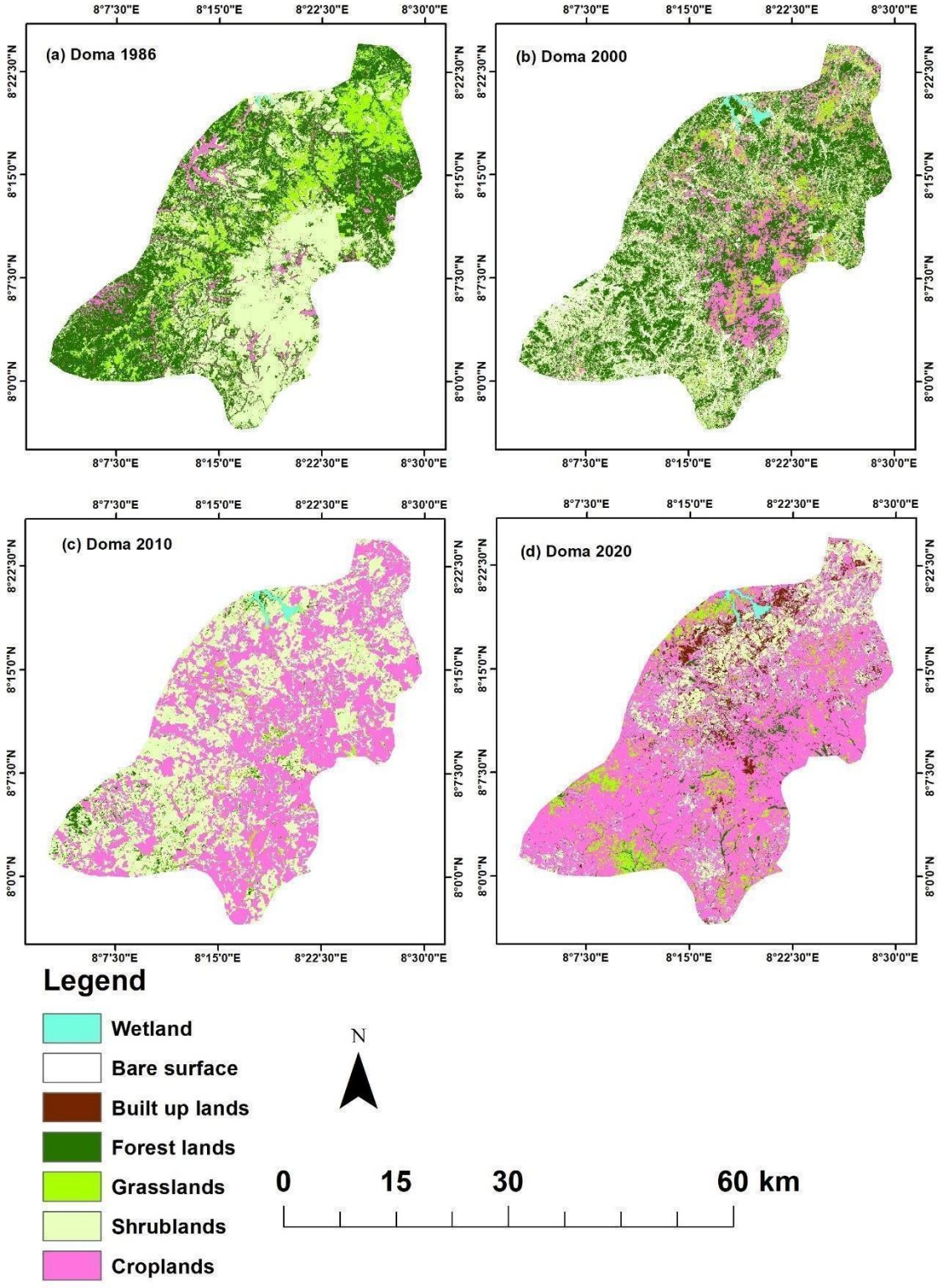

Figure 3.2. Classified Image Map of LULCC for the Doma gazetted forest area from 1986 to 2020.

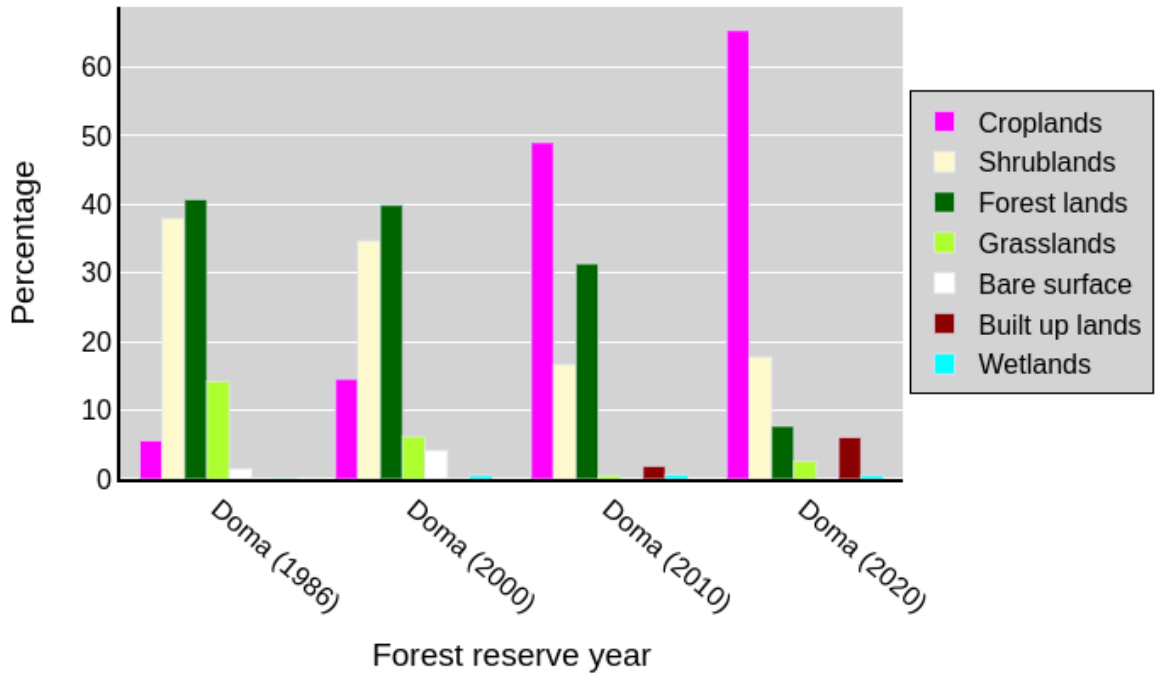

Figure 3.3. LULCC for the Doma Gazetted Forest areas from 1986 to 2020

3.2.3. Trends of LULCC around Risha gazetted forest reserves

Figures 3.4 and 3.5 show the classified maps of land use and land cover results for the years 1986, 2000, 2010, and 2020 for Risha. It is evident from these figures that the forest cover experienced a substantial decline between these periods. Forest lands occupied a significant portion, constituting the most prominent feature in 1986. Grasslands and shrublands were also widespread, with a minimal presence of croplands, built-up areas, and bare surfaces similar to that of the Doma reserve map for 1986. The landscape in 1986 reflected a natural forest cover with limited anthropogenic interference. These forests provide vital ecosystem services, including biodiversity support and climate regulation. However, the 2000 map for Risha demonstrated a dramatic reduction in forest lands, replaced largely by shrublands and croplands. An increase in bare surfaces was observed, indicating deforestation or land degradation, as well as expansion of built-up lands, although still relatively small compared to other categories (Figure 3.5). This period marked the onset of intensified human activity, such as agriculture and infrastructure development, evidenced by cropland expansion and shrubland around the reserve. The deforestation trends suggested a growing demand for farmland and forest resources. In 2010, trends indicated a continued reduction in forest lands, which had become severely fragmented. Further expansion of croplands spread across the

reserve became the dominant land cover type. Furthermore, there was a slight increase in built-up areas and bare surfaces, indicating settlement increases, and an increase in land degradation in the forest cover area was observed around this area. In 2020, croplands overwhelmingly dominated the landscape, occupying almost all parts of the area, which was observed to occupy the permanent landscape of the forest reserve. Forest lands were nearly non-existent, with only small, isolated patches remaining. There was a further increase in bare surfaces and built-up areas (Figure 3.4, 3.5). The year 2020 reflected the culmination of decades of deforestation and agricultural expansion; the dominance of croplands indicated that subsistence or commercial agriculture had become the primary land use. Wetlands, which were significant in 1986 with a river feature observed across the forest area, experienced a decrease in extent between 1986 and 2000, increased in 2000 and 2010, and were observed to have decreased substantially by 2020 (Figure 3.5). This change suggests environmental impacts of deforestation, such as reduced biodiversity and ecosystem disruption from this reserve.

Overall trends and patterns: Forest lands experienced a dramatic decline over the 34-year period, primarily due to cropland encroachment. Croplands steadily expanded, becoming the dominant and occupied permanent land cover observed by 2020 from the trend (Figure 3.4, 3.5). While built-up lands remained a minor land use type, they gradually increased over time. The increase in bare surfaces highlighted issues such as soil erosion, overgrazing, and land degradation.

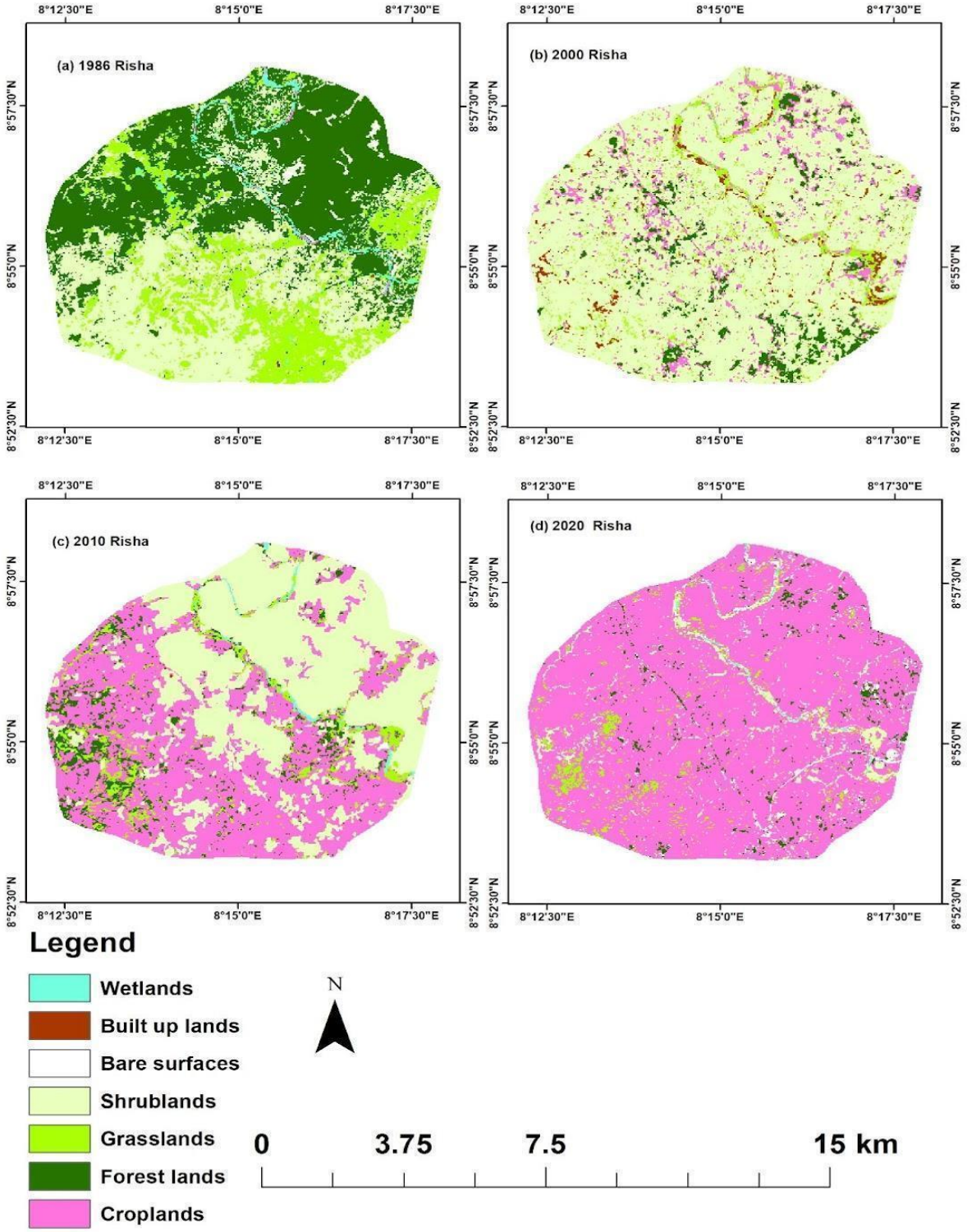

Figure 3.4. Classified Image Map of LULCC for Risha gazetted forest area for 1986 to 2020.

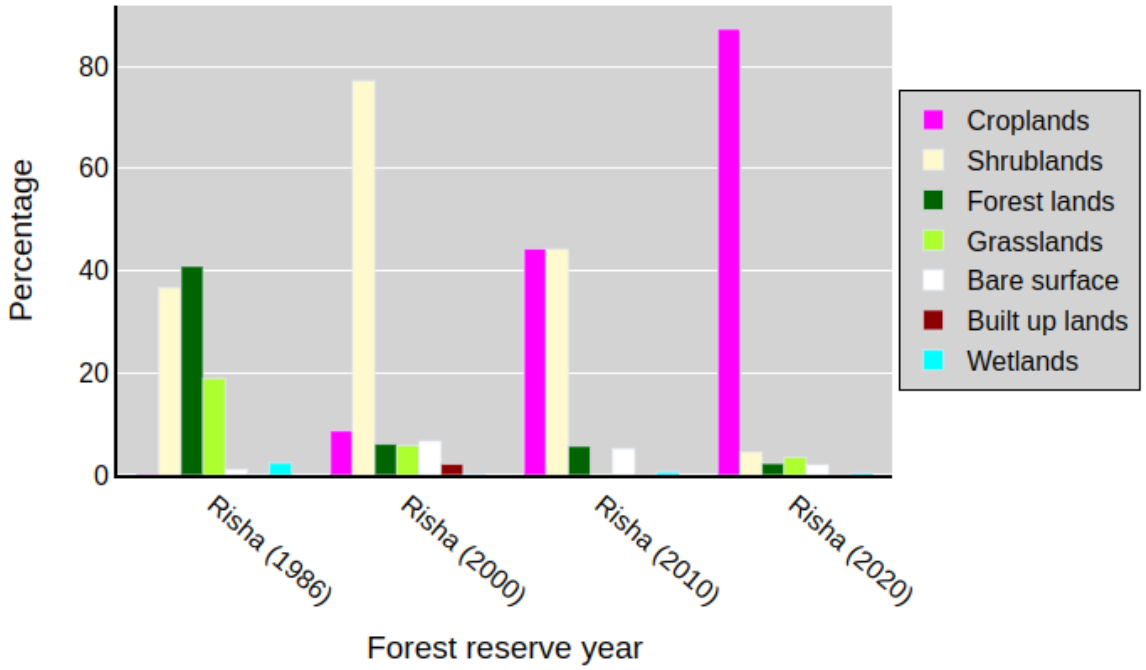

Figure 3. 5. LULCC for the Risha gazetted forest areas from 1986 to 2020.

3.2.4. Trends of LULCC around Odu gazetted forest reserves

Figures 3.6 and 3.7 illustrate and present the image map of land use and land cover results for the years 1986, 2000, 2010, and 2020 for Odu. These figures demonstrate that the forest cover experienced substantial changes between the years 1986, 2000, 2010, and 2020. The observed result in 1986 indicates that forestlands dominated much of the area, with grasslands and shrublands also scattered across the forest region (Figure 3.6). Croplands and built-up areas were minimal, reflecting a predominantly natural landscape with limited anthropogenic interference. Built-up lands and bare surfaces were nearly absent, suggesting minimal settlements or infrastructural developments at this time. However, in 2000 forestland cover and grassland noticed a decline, while shrubland increased and other parts of the area increasingly converted to croplands in 2000 (Figure 3.7). This can be observed from the map that the expansion of cropland became more prominent, particularly in the southeastern and southwestern parts of the region while forest cover is observed to change appearance observed in the northern part of the area (Figure 3.7). The expansion of croplands reflects intensified agricultural activity pressures in the area. In 2010, forest lands further diminished, with significant areas transitioning to croplands and shrublands. The change in conversion between croplands and shrublands is observed, possibly due to an increased focus on agriculture, suggesting a shifting cultivation pattern. Grasslands increased slightly while

shrublands expanded, potentially indicating land degradation or abandonment of certain cropland areas. For 2020, the forest land class exhibited a dramatic substantial increase, and grassland also increased, suggesting improved preservation of vegetation compared to Risha and Doma. However, the croplands continued to expand at the expense of shrubland, which declined significantly as observed from the classified map. The cropland expanded more from the southeastern and western parts of the area. Built-up areas in Odu showed only an increased trend around the reserves in the classified map of 2020, suggesting population growth and infrastructure development that could increase the settlement around the forest reserve area. Some settlements are observed inside the core forest area and appear towards the southeastern and western parts of the region signifying cropland expansion was far from their settlement, which could indicate that shifting cultivation has been taking place. This system involves extensive cropland use followed by a fallow period to allow nutrient regeneration before returning to the same lands in subsequent years. This is evidenced by the classified map as the shrublands, and cropland were fluctuating within the proportion of land cover type. In the classified maps of the reserve, all years reveal an absence of wetlands (Figure 3.6.3.7). However, the research observed some river courses along this during the ground truthing fieldwork around the forest boundary in the area in 2022.

The overall results indicate dynamic changes in land use and land cover within the forest reserves, with shifts towards croplands, variations in forest cover with an increase in forest land cover type to 45% for 2020, and fluctuations in shrublands, wetlands, and built-up areas.

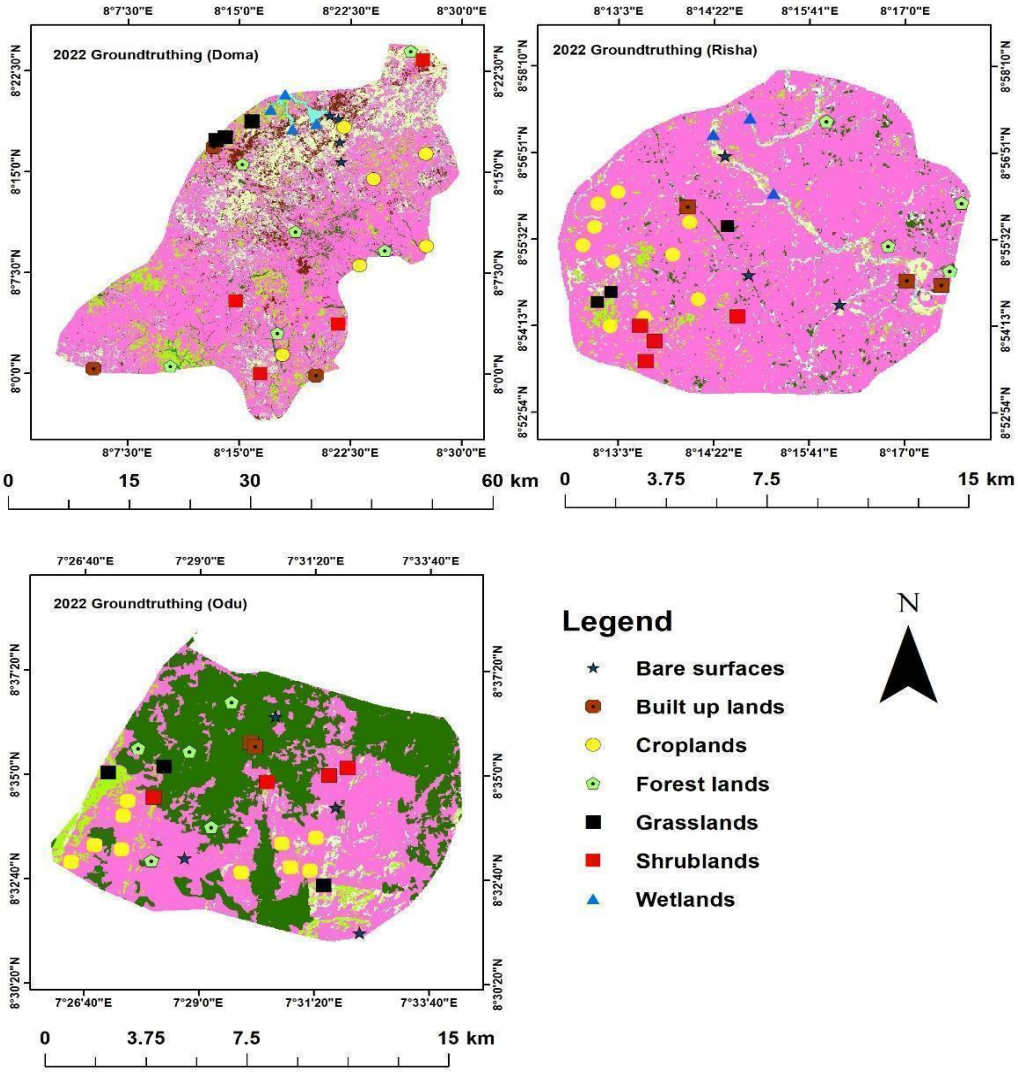

Figure 3.1. Spatial overlay of ground truthing points corresponding to LULCC classes from the fieldwork on the classified image map of the three forest reserves

3.2.2. Trends of LULCC around Doma gazetted forest reserve

Figures 3.2 and 3.3 show the analysed image and results of the LULCC for the years 1986, 2000, 2010, and 2020 for Doma. The forest cover experienced a substantial decline between the periods 1986, 2000, 2010, and 2020. In 1986, forests dominated the region, covering a significant portion of the area. There was minimal presence of croplands and built-up lands, indicating a natural landscape with limited anthropogenic intervention. A notable decline in forests was observed, with increasing croplands in 2000. The year 2000 also witnessed an

expansion of built-up lands and bare surfaces (Figures 3.2 and 3.3). The major transformation was that croplands became the dominant land cover, covering the larger portion of the region. Substantial loss of forest lands and grasslands was evident, indicating high deforestation rates. Shrublands and natural vegetation were substantially reduced. In 2010, trends revealed a further reduction in forest lands, which had become highly fragmented. Significant expansion of croplands continued to dominate the landscape with marginal increases in built-up areas and bare surfaces, reflecting continued forest cover loss and land degradation. Wetlands were observed predominantly in the northern part of the region with minor occurrences across the other areas. From 1986 to 2020, the extent of wetlands fluctuated erratically (Figure 3.2, 3.3), appearing minimal in 1986, increasing between 2000 and 2010, and decreasing towards 2020.

In summary, the progression from 1986 to 2020 highlights a steady decline in natural vegetation, particularly forests and grasslands, as croplands and built-up areas expanded. By 2020, bare surfaces and forest lands have limited coverage. Overall trends and patterns indicated that forest cover has drastically declined over the 34-year period, with croplands established as permanent fields inthe reserve and built-up expansion in the area. Croplands have steadily increased, becoming the dominant land use by 2020 taking over the forest area. Built-up areas, though relatively small, have gradually expanded over time indicating expansion of human activities. The increase in bare surfaces indicates land degradation and unsustainable land practices.

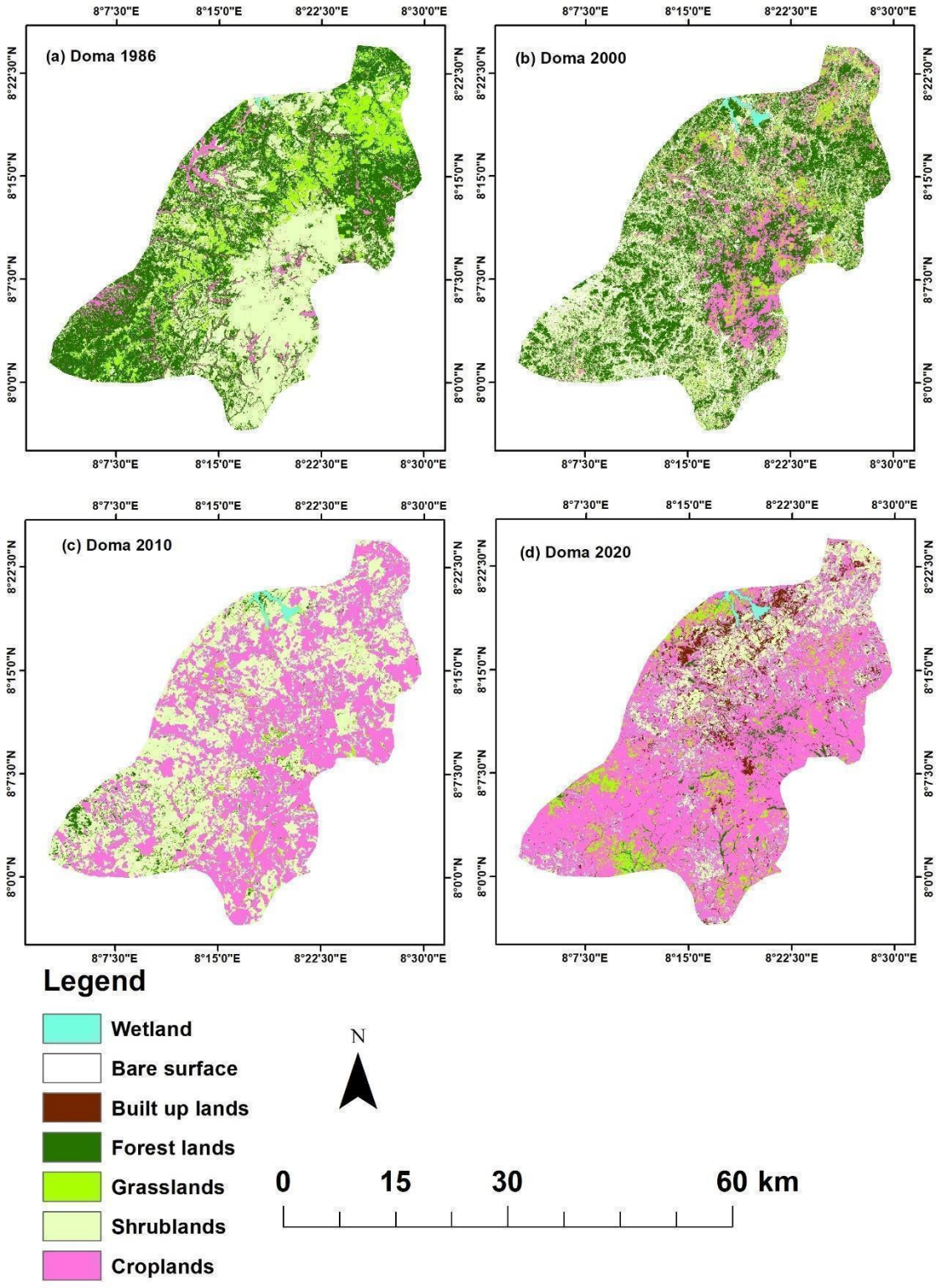

Figure 3.2. Classified Image Map of LULCC for the Doma gazetted forest area from 1986 to 2020.

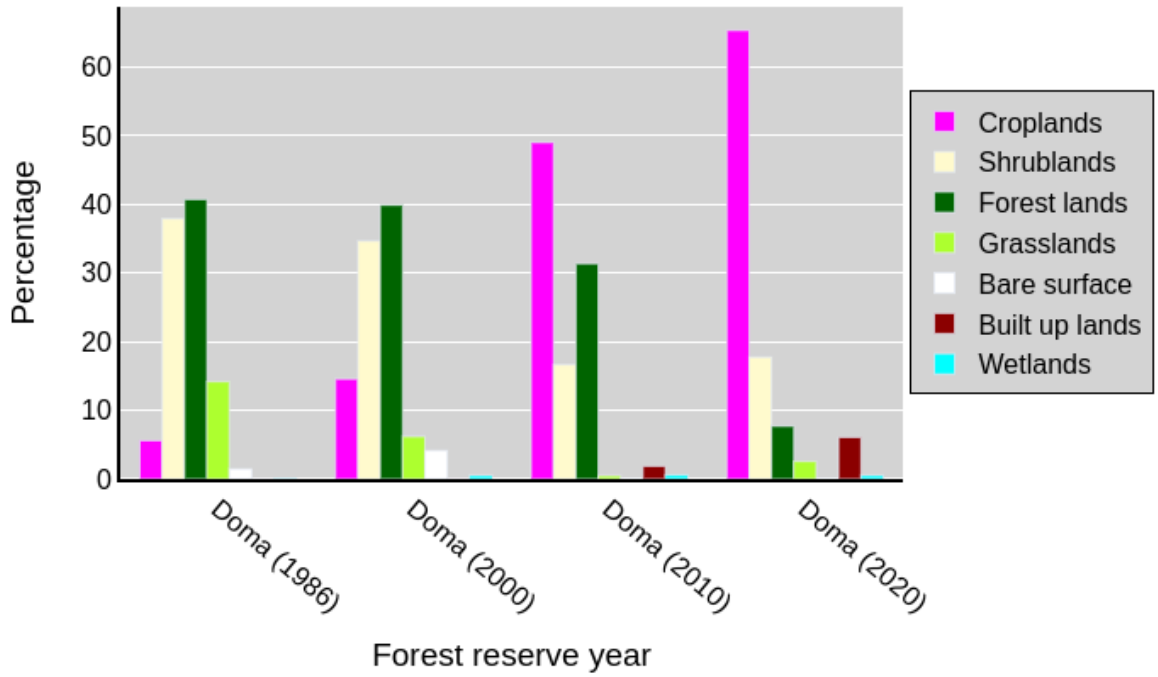

Figure 3.3. LULCC for the Doma Gazetted Forest areas from 1986 to 2020

3.2.3. Trends in LULCC around Risha gazetted forest reserve

Figures 3.4 and 3.5 show the classified maps of land use and land cover results for the years 1986, 2000, 2010, and 2020 for Risha. It is evident from these figures that the forest cover experienced a substantial decline between these periods. Forest lands occupied a significant portion, constituting the most prominent feature in 1986. Grasslands and shrublands were also widespread, with a minimal presence of croplands, built-up areas, and bare surfaces similar to that of the Doma reserve map for 1986. The landscape in 1986 reflected a natural forest cover with limited anthropogenic interference. These forests provide vital ecosystem services, including biodiversity support and climate regulation. However, the 2000 map for Risha demonstrated a dramatic reduction in forest lands, replaced largely by shrublands and croplands. An increase in bare surfaces was observed, indicating deforestation or land degradation, as well as expansion of built-up lands, although still relatively small compared to other categories (Figure 3.5). This period marked the onset of intensified human activity, such as agriculture and infrastructure development, evidenced by cropland expansion and shrubland around the reserve. The deforestation trends suggested a growing demand for farmland and forest resources. In 2010, trends indicated a continued reduction in forest lands, which had become severely fragmented. Further expansion of croplands spread across the

reserve became the dominant land cover type. Furthermore, there was a slight increase in built-up areas and bare surfaces, indicating settlement increases, and an increase in land degradation in the forest cover area was observed around this area. In 2020, croplands overwhelmingly dominated the landscape, occupying almost all parts of the area, which was observed to occupy the permanent landscape of the forest reserve. Forest lands were nearly non-existent, with only small, isolated patches remaining. There was a further increase in bare surfaces and built-up areas (Figure 3.4, 3.5). The year 2020 reflected the culmination of decades of deforestation and agricultural expansion; the dominance of croplands indicated that subsistence or commercial agriculture had become the primary land use. Wetlands, which were significant in 1986 with a river feature observed across the forest area, experienced a decrease in extent between 1986 and 2000, increased in 2000 and 2010, and were observed to have decreased substantially by 2020 (Figure 3.5). This change suggests environmental impacts of deforestation, such as reduced biodiversity and ecosystem disruption from this reserve.

Overall trends and patterns: Forest lands experienced a dramatic decline over the 34-year period, primarily due to cropland encroachment. Croplands steadily expanded, becoming the dominant and occupied permanent land cover observed by 2020 from the trend (Figure 3.4, 3.5). While built-up lands remained a minor land use type, they gradually increased over time. The increase in bare surfaces highlighted issues such as soil erosion, overgrazing, and land degradation.

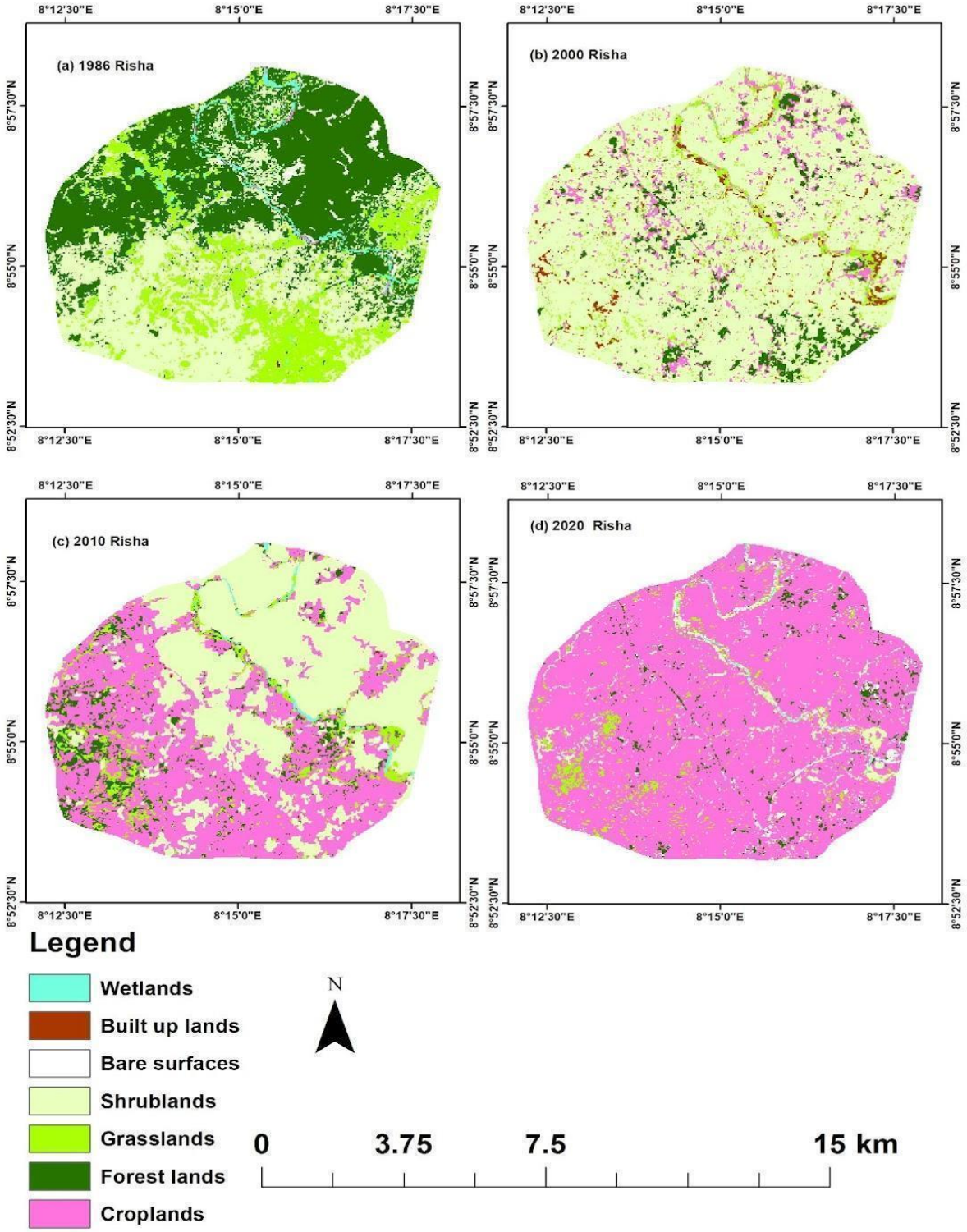

Figure 3.4. Classified Image Map of LULCC for Risha gazetted forest area for 1986 to 2020.

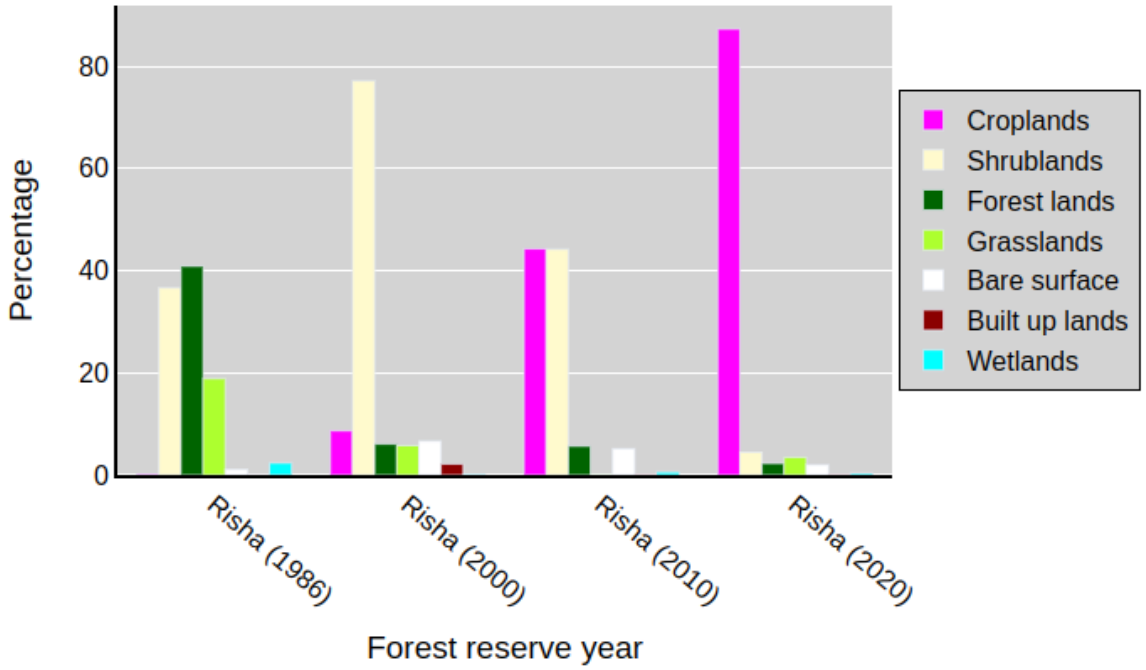

Figure 3. 5. LULCC for the Risha gazetted forest areas from 1986 to 2020.

3.2.4. Trends in LULCC around Odu gazetted forest reserve

Figures 3.6 and 3.7 illustrate and present the image map of land use and land cover results for the years 1986, 2000, 2010, and 2020 for Odu. These figures demonstrate that the forest cover experienced substantial changes between the years 1986, 2000, 2010, and 2020. The observed result in 1986 indicates that forestlands dominated much of the area, with grasslands and shrublands also scattered across the forest region (Figure 3.6). Croplands and built-up areas were minimal, reflecting a predominantly natural landscape with limited anthropogenic interference. The near absence of built-up land and bare surfaces further suggests minimal settlement activity and infrastructural development during this period. However, in 2000 forestland cover and grassland noticed a decline, while shrubland increased and other parts of the area increasingly converted to croplands in 2000 (Figure 3.7). This can be observed from the map that the expansion of cropland became more prominent, particularly in the southeastern and southwestern parts of the region while forest cover is observed to change appearance, as observed in the northern part of the area (Figure 3.7). The expansion of croplands reflects intensified agricultural activity in the area. In 2010, forest lands further diminished, with significant areas transitioning to croplands and shrublands. The change in conversion between croplands and shrublands is observed, possibly due to an increased focus on agriculture, suggesting a shifting cultivation pattern.

Grasslands increased slightly while shrublands expanded, potentially indicating land degradation or abandonment of certain cropland areas. For 2020, the forest land class exhibited a dramatic substantial increase, and grassland also increased, suggesting improved preservation of vegetation compared to Risha and Doma. However, the croplands continued to expand at the expense of shrubland, which declined significantly, as observed from the classified map. The cropland expanded more from the southeastern and western parts of the area. Built-up areas in Odu showed only an increased trend around the reserves in the classified map of 2020, suggesting population growth and infrastructure development that could increase the settlement around the forest reserve area. Some settlements are observed inside the core forest area and appear towards the southeastern and western parts of the region signifying cropland expansion was far from settlements, which could indicate that shifting cultivation has been taking place. This system involves extensive cropland use followed by a fallow period to allow nutrient regeneration before returning to the same lands in subsequent years. This is evidenced by the classified map as the shrublands, and cropland were fluctuating within the proportion of land cover type. In the classified maps of the reserve, all years reveal an absence of wetlands (Figure 3.6.3.7). However, the research observed some river courses during the ground truthing fieldwork around the forest boundary in the area in 2022.

The overall results indicate dynamic changes in land use and land cover within the forest reserves, with shifts towards croplands, variations in forest cover with an increase in forest land cover type to 45% for 2020, and fluctuations in shrublands, wetlands, and built-up areas.

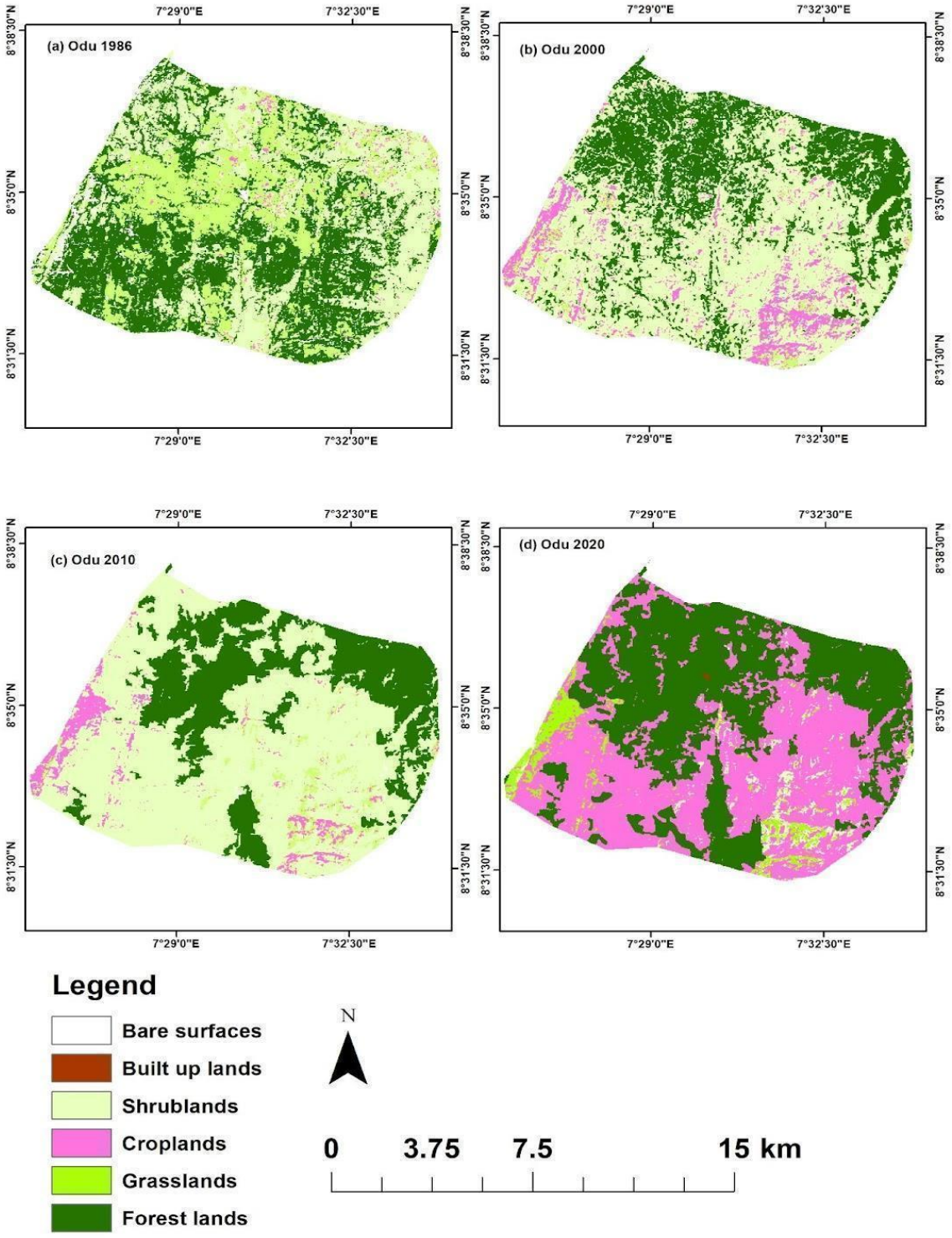

Figure 3.6. Classified Image Map of LULCC for Odu gazetted forest area for 1966 to 2020.

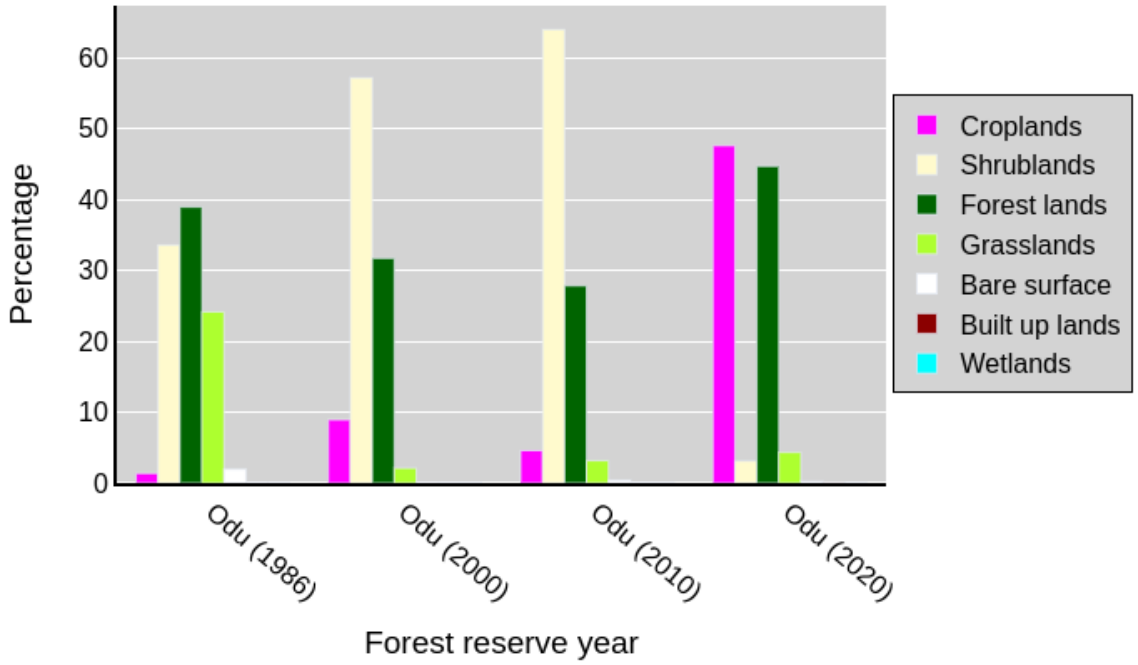

Figure 3.7. LULCC for the Odu gazetted forest areas from 1986 to 2020.

3.2.5. Comparative analysis of LULCC around the three gazetted forest reserves.

Figure 3.8 shows the comparative results for the three forest reserves (Doma, Risha and Odu).

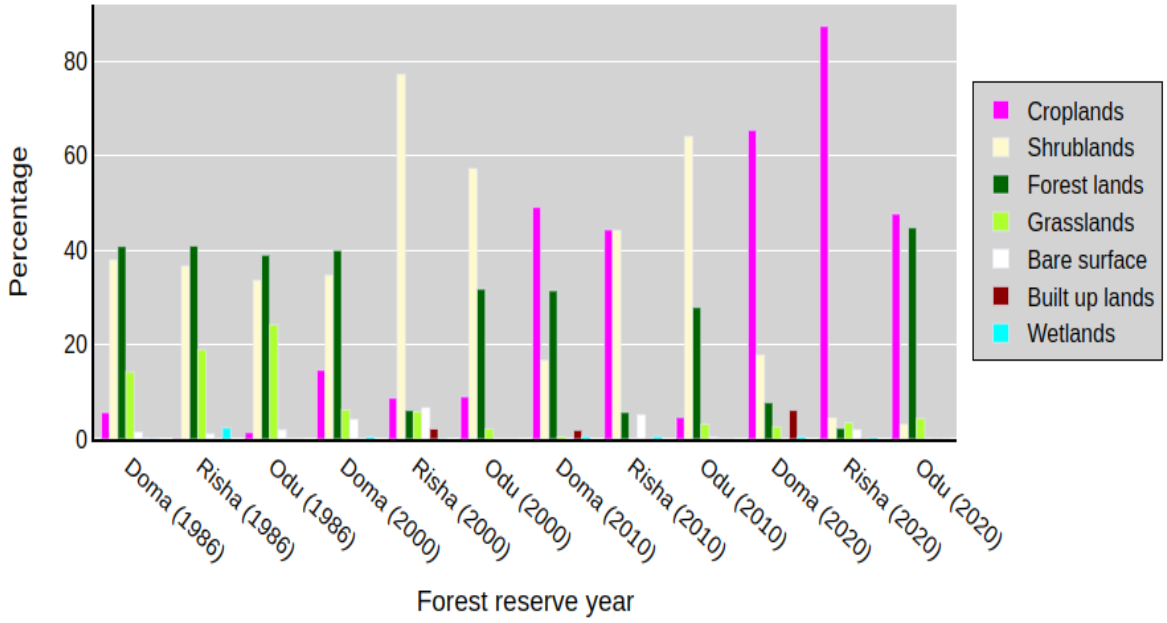

Figure 3.8. LULCC for the three gazetted forest areas from 1986 to 2020

The findings revealed that the rate of land use and land cover change (LULCC) varied significantly among the three forest reserves, although all three displayed a substantial

change in LULCC classes. The Doma forest reserve has experienced a change in all the land cover and a decrease in forest cover between 1986 and 2020 (Figure 3.8). The forest cover declined steadily from 1986 to 2020, with croplands becoming the dominant land cover by 2000. The region's forests were particularly vulnerable to cropland expansion and settlement growth, with minimal forest patches remaining by 2020. The trends indicate continuous loss of forest cover class established to occupy permanent landscapes without any sign of substantial recovery. Similarly, Risha's forest lands experienced a severe decline over the 34-year period. The extent of forest cover within the Risha forest reserve diminished from 40% in 1986, and by 2020, the forest class had just 2%, with croplands largely occupying the permanent landscape of the region by 2020. The forest cover loss and degradation were particularly intense, leading to a near-complete loss of forest cover by 2020 without recovery. The lack of substantial forest remnants suggests unsustainable land-use practices. Unlike Doma and Risha, Odu showed a more dynamic pattern. Although the Odu forest reserve displayed a distinct change trend compared to the other study regions, the forest cover experienced a decrease from 1986 to 2010. However, between 2010 and 2020, there was a substantial 45% increase in forest cover, as shown in Figures 3.6-3.8, Notably, areas classified as shrubland in 2010 have transitioned to agriculture by 2020, while former agricultural land has become grasslands. Between 2010 and 2020, there was a substantial increase of 45% in the forest cover (Figures 3.6-3.8), reflecting possible conservation or natural regeneration efforts. This rebound sets Odu apart as a region with fluctuating but potentially recoverable forest conditions.

From this results comparison, croplands occupied the largest area of the two forest reserves by 2020, with Risha having the highest (87%), followed by Doma and Odu forests (Figure 3.8). This expansion, in Doma particularly after 2000, indicates intensive agricultural pressures (likely subsistence farming), while in Risha cropland encroachment was the most dramatic, where croplands permanently replaced nearly all classes of land cover by 2020. This reflects the high demand for farmland, exacerbated by population pressures and limited conservation initiatives. Although croplands also expanded in Odu, the region demonstrated a more dynamic balance between cropland expansion and other land cover classes such as shrublands and forests. These suggest the evidence of shifting cultivation and land fallow systems, highlighting a different agricultural approach compared to Doma and Risha.

In the Risha reserve, grassland and bare surfaces fluctuated similarly to those of the Doma and Odu forest reserves, although the percentages varied (Figure 3.8). The Doma shrubland cover declined between 1986 and 2000, whereas the shrublands in the Risha forest area rose between 1986 and 2000 but decreased between 2010 and 2020, which could have contributed

to a reduction in these natural vegetation types. The Odu shrublands fluctuated over the same periods (Figures 3.8). This reflects a shifting pattern of land use, potentially tied to land fallow systems or environmental conservation. From 1986 to 2020, the extent of wetlands fluctuated erratically, with the wetland cover in the Doma reserve increasing between 2000 and 2010 and decreasing towards 2020. In Risha, wetlands experienced an extent of decline between 1986 and 2000, increased between 2010 and 2000, and decreased significantly by 2020. Overall, a sharp decline was observed between 1986 and 2020. In the Odu reserve, all years reveal an absence of wetlands (Figure 3.6 -3.8). The dynamics of wetland extents in the Doma and Risha reserves may be primarily influenced by rainfall and temperature changes. Higher rainfall and moderate temperatures may promote wetland expansion, whereas lower rainfall and higher temperatures can cause decline. The lack of wetlands in the Odu reserve suggests consistently unfavourable climatic conditions for wetland formation during the studied period, or vegetation plays a crucial role in water regulation by capturing water and enhancing soil porosity and organic matter content. Consequently, a reduction in vegetation cover can result in increased surface water accumulation, commonly referred to as ponding. The Doma forest area experienced a doubling in built-up area between 2010 and 2020. Risha experienced an increase in built-up areas between 1986 and 2020, reflecting settlement growth and infrastructure development around the forest area which could lead to more encroachments on forest cover for resource exploitation. However, Odu Forest showed no portion of the built land in the reserve, except in 2020. The presence of settlements inside the core forest region in Odu 2020 reflects unique spatial pressures, likely tied to shifting cultivation practices.

In summary, the three reserves exhibited varying trends in land use and cover changes over the studied periods. In 1966, all three forest reserves were largely forest class covered according to the historical boundaries survey map of the study reserve. Doma forest reserve cover experienced a decrease between 1986 and 2020. Risha forest reserve cover decreased to 2% in 2020, while Odu forest reserve cover showed a declining trend from 1986 to 2010 but saw a substantial increase to 45% in forest cover between 2010 and 2020.

The analysis highlights the dynamic nature of LULCC within the three gazetted forest reserves. Doma and Risha show persistent loss of forest cover over cropland expansion in the permanent fields with no recovery, while Odu demonstrates more dynamic land use patterns with potential for regeneration. These findings suggest the need to understand the drivers of change in these reserves (Chapter 4), as well as targeted conservation and

management strategies (Chapter 5) tailored to the specific dynamics observed in each reserve. Overall, the comparative analysis provides valuable insights into the evolving landscape dynamics and underscores the importance of ongoing monitoring and conservation efforts within these forest reserves.

3.3. Discussion

3.3.1. Geospatial analysis of gazetted forest reserves: Key implications

3.3.1.1. Remote sensing and GIS methodology

Remote sensing data and GIS results showed that the forest reserve area has been significantly depleted over the years (1986-2020). According to the classified results, there was considerable agreement between all LULCC class types in the image classifications, as demonstrated by the user and producer's accuracy. User's and Producer's Accuracy are common measures used in remote sensing to evaluate the accuracy of image classification. These terms come from the error matrix (also known as the confusion matrix), which compares the classified image data with reference data. This study's classification results indicate a strong correlation similar to multiple studies, including those conducted by Yesuph and Dagnew (2019) as well as Latham (2013) and Dibaba and Miegel (2020). The accuracy values indicate a strong correlation for all the classified images, exceeding the standard overall classification accuracy limit of 86% (Anderson, 1976; MacLean and Congalton, 2012), with no class falling below 80% (Thomlinson, Bolstad, and Cohen, 1999; Radwan et al., 2021), confirming that the classification accurately reflects ground reality for all the classification years for this study. Although GIS has some limitations (Chapter 2) in terms of the 30-m resolution that covers the study area for instance, further deeper classification analysis was impossible to analyse to show more specific detail of vicinity features within the reserve. The accuracy of the classification results and ground-truthing information nevertheless show a good correspondence and level of agreement (see Figure 3.1).

3.1.1.2. Findings on LULCC

The geospatial results over 34 years showed a significant change in LULCC across the three forest reserves. This study reported that croplands experienced the most significant increase in all three forest reserves (Doma, Risha and Odu) (Figure 3.8), where most of the reserve was converted to agricultural farmland cultivation between 2010 and 2020 in all three forests of the study. Much higher and occupied permanent areas were observed in Risha and Doma while Odu noticed a shift in cultivation in land use between shrubland and cropland around

the forest boundary. According to the classification results (Figures 3.2-3.8), forest and shrubland largely changed to cropland for agricultural purposes (both farming and shifting cultivation). This could be most likely that closed forest was selectively impacted leading to shrubland, this land was then more intensively cleared to form agricultural land. Also, abandoned farmland may have been left fallow allowing bush vegetation to return. This same land may then have been used for agriculture after many years of natural regeneration. Transformation of shrublands into cropland and vice versa particularly occurred in Odu. Moreover, the changes in forestland marked by rapid forest cover loss in Risha and Doma which changed between 2000, 2010 and 2020 and the reappearance of forest cover area in Odu in 2020. This pattern indicates that human activities have significantly influenced the transformation in these three reserves, as elaborated upon in Chapter 4. The observed changes in each forest were not uniform across the three gazetted forests from the classified results, suggesting localised factors associated with the anthropogenic activities that influenced the disappearance and subsequent reappearance of these patches of forested areas particularly the Odu forest among the three reserves covered for this study, an important finding that sets the stage for the discussion on the drivers in the next chapter (Chapter4).

In summary, Doma and Risha forests have transitioned to permanent agriculture within reserve boundaries, whereas farmers within the Odu forest still practice shifting cultivation observed from the classified maps. Map observations indicate ongoing deforestation and land abandonment for recovery, but with rising population pressures (Chapter 4), this system is unsustainable. Without urgent intervention, the Odu forest is likely to follow the same trajectory as other forests, making immediate conservation efforts crucial.

Mohajane et al. (2018) examined the Azrou Forest in Morocco using Landsat data and found that forest cover remained stable between 1987 and 2017, maintaining its ecological role. However, in contrast to this stability, studies across sub-Saharan Africa indicate a widespread decline in forest cover due to agricultural expansion. For instance, research in Ghana by Janssen et al. (2018) and Appiah et al. (2021) highlights significant forest-to-agriculture conversions in the Tano-Offin and Kogya forest reserves. Similarly, Fasona et al. (2020) report that 75% of forest reserves in southwest Nigeria have been degraded, predominantly for cropland use. This pattern extends beyond West Africa. In Ethiopia, Dibaba et al. (2020) and Halefom et al. (2018) observed increasing settlement expansion within the Finchaa Catchment area, leading to forest loss for farming. In Malawi, Phiri and Nyirenda (2022) documented a decline in forest shrublands and a corresponding rise in

cropland within the Thuma Forest Reserve. These findings align with broader trends in tropical regions, where forest losses are driven by agricultural pressures (Ankomah et al., 2020).

Nevertheless, some strategies have been identified to mitigate deforestation. In Ghana, systems integrating crops and trees have been found to reduce local communities' reliance on forest reserves and curb encroachment (Akamani et al., 2016; Akamani and Hall, 2019). Such approaches highlight the potential for sustainable land-use practices to balance conservation and agricultural needs. Overall, the evidence suggests that agricultural expansion remains a major driver of forest loss across sub-Saharan Africa. Recognizing these trends is crucial for informing conservation strategies that address both environmental sustainability and local livelihoods.

Moreover, during the fieldwork, the researcher observed that more substantial patches of the forest remained in Odu compared to that of Doma and Risha. Forest increases could be due to the establishment of forest plantations or the reversal of agricultural to forest land cover through natural regeneration using bush fallow and shifting in cultivation lands. Kusimi's (2015) study provides an assertion that abandonment of certain land cover types, including agricultural land and bare land, can result in recovery of the biophysical attributes of the land cover, potentially transforming them into different land cover categories naturally in the vicinity of forested areas. While the restoration of forests is expected to enhance the ecological health of the forested region, it is recognised to pose challenges to food security, as continuous food cultivation by farmers may be limited (Oduro Appiah et al., 2021; Wulder et al., 2020; and Cai et al., 2022).

Odu forest classification results showed the absence of wetlands throughout the study period. This could mean that some water bodies were covered by vegetation (this is possible, even though there were dried-up river courses along the forest edge, as observed from the field validation by the researcher) which may have had a climatic influence on the water bodies because the remote sensing data used for the analysis were from the dry season (Ashaolu et al., 2020; Ashaolu et al., 2019). Furthermore, if parts of the water bodies were covered by trees, it makes it impossible for the satellite sensors to obtain their exact spectral signature for the area, which might result in their overestimation or underestimation. This can affect the composition and forest cover and other biodiversity within the study area. Moreover, a reduction in forest cover would affect the waterbodies, and an increase in rainfall may influence the pattern and availability of water bodies across the forest region in the study

area (Ashaolu et al., 2020). In addition, the presence of more trees may reduce the waterbodies as the trees need water. This scenario may be similar as documented by Baffour-At et al. (2021) for Bobiri Forest Reserve in Ghana; to better understand the fluctuations in temperature and rainfall patterns over time, the researchers analysed the data collected from 1960 to 2016 and identified variations in the trends. Their study indicates that the climatological extent of change of climatic variables has influenced the forest cover types, as well as the wetland biodiversity and human livelihoods in the forest-dependent communities of the area. Such changes may influence wildlife's access to water in all three forest reserve areas, which may lead to the migration of these animals out of the area in search of water. Water loss may also reduce tree species endemic to water sources. Consequently, changes in forest cover and wetland reduction may have exacerbated soil erosion and increased sedimentation in rivers, reducing rivers or increasing evaporation (Vargas and Omuto 2016).

This result matches Phiri and Nyirenda's study of the Thuma Forest Reserve in Malawi, East Africa, in 2022, which has ecological characteristics similar to Nigeria's forest reserve and PA. They noticed a decline in water bodies, such as rivers, which affected the game reserve of wild animals and the survival of diverse tree species around the forest. They also observed the difficulty in tracing the river course's boundaries in the study's PA. These findings illustrate the interconnectedness of climate, vegetation, water bodies, and wildlife within forest reserves. The degradation of one component can have cascading effects on the entire ecosystem. Therefore, comprehensive and integrated conservation strategies are essential to address the complex challenges posed by climatic variability and human activities. By understanding and mitigating these impacts, we can better preserve the ecological integrity and biodiversity of forest reserves and wetlands.

This study noticed that the built-up area in these reserves consistently increased during the period covered by this study, particularly for Doma and Risha reserves (Figure 3. 4). This is linked to the increased demand from the area's growing population and because people built around the reserves. Bare surfaces decreased around Doma and Risha indicating that bare ground was converted into settlements (houses) and road construction (Chapter 4). However, built-up areas in Odu showed a different trend around the reserves in the classified map until the 2020 built-up area appeared. This could mean that previous years' build-ups were not established or were covered by vegetation because they could be minor, and thick forests or

shrubs could cover the area where satellite sensors could not capture the reflectance of the built-up areas.

The decreasing forest areas in Doma and Risha necessitate the formulation of both social and biophysical/ecological remedies by policymakers and natural resource managers, as the communities surrounding these areas rely on forest reserves for their daily agricultural resources and energy needs. Loconto et al. (2018) argue that the traditional conventional land use strategy, which involves designating specific areas for specific uses, including forest reserves to protect forests, is becoming less effective. Therefore, these reserves are under threat, particularly from agricultural encroachments, and other social, economic, cultural, and political factors that change land use and cover around the forest. Addressing increasing agricultural land demands may require alternative livelihoods for people reliant on subsistence farming in Doma, Risha and Odu gazetted forests. More details on the drivers of the gazetted forest cover change for the study area are in Chapter 4. Encouraging farmers to adopt large-scale agroforestry practices is crucial in achieving this goal. Such practices involve managing both targeted and naturally regenerating tree species at the farm level, which should serve as a source of fuelwood energy for communities (particularly where no greener and cleaner sources of energy are accessible). The Taungya system, which involves mixing crops and trees, has been reported to have reduced the reliance on communities and the level of encroachment in forest reserves in Ghana, as indicated by Acheampong et al. (2016) and Akamani and Hall (2019). This system ensured that the amount of agricultural land gained was equal to that of agriculture between 2002 and 2017, as documented by Appiah et al. (2021). Other options could involve subsidising agricultural inputs to increase per-unit production, strict bylaws, enforcement of national laws, and co-management (Skole et al., 2021). Such an approach will provide time for the recovery of deforested forest reserves.

3.3.2. Implications for other gazetted forests and forest policy in Nigeria

Gazetted forests, including Doma, Risha, and Odu, were initially established to safeguard natural ecosystems and foster their sustainable use, with profound implications at both local and global scales (Onilude and Vaz, 2020; Eludoyin and Iyanda, 2019). However, unsustainable land-use practices threaten these forests, degrading cover (Risha and Doma), reducing biodiversity and climate regulation roles, and affecting livelihoods (Otokiti et al., 2019; Onilude and Vaz, 2020). Studies show gazettement alone is inadequate without enforcement and local stakeholder participation (Fasona et al., 2020; Onyekwelu et al.,

2016). Risha's forest cover decline from 40% in 1986 to 2% in 2020 highlights the need for better governance (Onilude and Vaz, 2020). Addressing deforestation drivers like agricultural encroachment and population pressures is crucial (Adeoye et al., 2018; Eludoyin and Iyanda, 2019). The inability to control cropland expansion in Risha and Doma shows current management inadequacies. Conversely, Odu's improved cover by 2020 shows the potential of targeted restoration (Otokiti et al., 2019). Success depends on enforcing boundaries and addressing unsustainable practices (Fasona et al., 2020). Strengthening policies through collaboration with communities, NGOs, and agencies is key (Onyekwelu et al., 2016). Policies promoting agroforestry, zoning, and sustainable agriculture could mitigate degradation in reserves like Odu. Balancing agricultural needs with conservation is vital for preserving the functions of gazetted forests in Nigeria and globally (Adeoye et al., 2018).

3.3.3. Implications for conservation

The findings reveal a contrast in conservation success among the reserves. Notably, Odu showing a positive trend in forest cover, indicating conservation efforts. In contrast, Doma and Risha face severe degradation, nearing complete forest loss for declining trends.

This disparity underscores the challenges and opportunities in conservation within gazetted forest reserves. In Doma and Risha, minimal conservation interventions result in seemingly irreversible forest loss. The analysis highlights significant cropland encroachment, settlement expansion, and ineffective conservation measures, as shown by forest cover loss maps. The shift from conservation to restoration adds complexity, with entrenched land-use patterns complicating efforts (Crouzeilles et al., 2019). Restoring forests within historical reserve boundaries necessitates displacing agricultural activities, posing challenges given current land-use dynamics. This emphasizes the need for integrative conservation strategies considering socio-economic constraints and local practices. The conversion of forest reserve areas into non-forest land has several consequences (Deng et al., 2020), including a decline in conservation levels, environmental changes, biodiversity loss, habitat destruction, and fragmentation, affecting species of flora and fauna within and around protected reserves (Domínguez and Luoma, 2020). This has a considerable impact on forest resources and other ecosystem services, which could be adversely affected by this decline for both local communities and the wider environmental community.

3.3.4. Implications for restoration

The distinct LULCC trajectories across the three reserves offer insights into forest restoration potential under varying conditions. The forest cover increase in Odu by 2020 exemplifies possibilities for restoring degraded forests. Restoration strategies, particularly afforestation and reforestation, hold promise for reversing forest loss in Doma and Risha (Stanturf et al., 2014). However, addressing forest decline in Risha and Doma requires extensive efforts, including reforestation, afforestation, and agroforestry integration (Chazdon & Uriarte, 2016). The high cropland proportion in Risha, 87% by 2020, highlights the challenge of large-scale restoration without affecting agricultural lands, a concern noted by Zomer et al. (2016). Effective programs must align ecological goals with social and economic sustainability. Techniques like Farmer-Managed Natural Regeneration (FMNR), a low-cost, scalable, community-driven approach, are promising. FMNR regenerates trees from existing root systems and has succeeded in the Sahel, improving soil, water retention, and biodiversity while aiding local livelihoods (Chomba et al., 2020). Restoration is costlier than conservation, making forest degradation prevention more economical (Chomba et al., 2020). Conservation strategies like PAs, sustainable land management, and incentivizing forest stewardship should be prioritized to reduce large-scale restoration needs. Drawing from Odu's forest cover increase, natural regeneration should be emphasized where feasible. This involves rehabilitating lands with native tree species and soil and water conservation techniques (Chazdon and Uriarte, 2016). Incorporating traditional ecological knowledge and engaging local communities in restoration are vital for long-term stewardship (Tedesco et al., 2023). Multi-stakeholder approaches balancing agriculture and reforestation offer sustainable restoration pathways (Fischer et al., 2021). Agroecological systems can reduce cropland expansion demand while ensuring food security near reserves (Appiah et al., 2021). Traditional practices like Odu's shifting cultivation highlight sustainable land-use transitions aligning with local contexts (Hecht, 2014). Similarly, the Taungya system, mixing crops and trees, has reduced reliance on communities and encroachment in forest reserves in Ghana (Acheampong et al., 2016; Akamani and Hall, 2019). This system ensured agricultural land gained equaled agriculture between 2002 and 2017 (Oduro Appiah et al., 2021). Other options include subsidising agricultural inputs, strict bylaws, law enforcement, and co-management (Skole et al., 2021).

This study emphasizes using 1966 boundaries as reference points for restoration planning. Comparing current patterns to historical cover can prioritize areas most affected by degradation (Crouzeilles et al., 2019), aligning with global commitments like the Bonn

Challenge to restore landscapes worldwide (Crouzeilles et al., 2019). Long-term success requires community participation, sustainable agroforestry, and biodiversity conservation (Aronson et al., 2011).

3.3.5. Implications for forest management

The findings suggest that current management practices in gazetted forests are insufficient to curb deforestation and land degradation that affect forest cover. The transformation of forest lands to croplands, as observed in all three reserves, indicates the need for a paradigm shift in forest governance.

The decreasing forest areas in Doma and Risha necessitate social and biophysical/ecological remedies by policymakers and natural resource managers, as surrounding communities rely on forest reserves for agricultural resources and energy needs. Loconto et al. (2018) argue that the traditional land use strategy of designating specific areas for specific uses is becoming less effective. These reserves are under threat from agricultural encroachments and other factors that change land use and cover. Addressing agricultural land demands may require alternative livelihoods for those reliant on subsistence farming in Doma, Risha and Odu gazetted forests. More details on the drivers of forest cover change are in Chapter 4. Encouraging large-scale agroforestry practices is crucial, involving managing targeted and naturally regenerating tree species at the farm level as a source of fuelwood energy. The Taungya system, mixing crops and trees, has reduced reliance on communities and encroachment in forest reserves in Ghana (Acheampong et al., 2016; Akamani and Hall, 2019). This system ensured agricultural land gained equaled agriculture between 2002 and 2017 (Oduro Appiah et al., 2021). Other options include subsidising agricultural inputs, strict bylaws, law enforcement, and co-management (Skole et al., 2021). A comparative analysis suggests forest management strategies should be tailored to each area's unique dynamics. Doma reserve management should prioritize alleviating subsistence farming pressures through agricultural extension services, sustainable farming practices, and alternative livelihoods (Ankomah et al., 2020). Risha reserve requires these measures plus stronger enforcement mechanisms and conservation initiatives while addressing population pressures. Odu reserve demonstrates natural regeneration potential and should explore replicating these successes elsewhere. The observed fluctuations in shrublands, wetlands, and grasslands underscore the dynamic nature of LULCC, necessitating continuous monitoring. Remote sensing technologies and participatory land management tools can inform adaptive forest management strategies (Amoah et al., 2022). Effective forest

management should prioritise sustainable practices, integrating forest management plans with broader rural development policies. Additionally, it should encourage agroforestry as an alternative land-use practice that combines agricultural productivity with forest conservation. Furthermore, adopting a landscape-level approach to forest management that acknowledges the interconnectedness of forests, agricultural lands, and surrounding settlements is essential for fostering sustainable land-use practices.

The findings presented in this study would be relevant to local communities in understanding the change and the implications of the change in the forest reserves, as well as to all those working within the environmental sector in Nasarawa State and the country at large. The findings underscore the need for the integration of land use planning for proper, effective policy decision making and implementation. Through analysis of Landsat images over the study period, this research contributes important new knowledge on the study area's land cover/land use in terms of its protected forests, providing insights that can inform management in advancing towards achieving UN Sustainable Goals 13 and 15. Goal 13 seeks climate change mitigation initiatives, whereas Goal 15 aims to prevent desertification and restore and protect land-based resources by 2030 (UN, 2015) including the sustainable management of forest reserves and PAs. In addition, this research presents fresh insights for developing nations, particularly those where deforestation remains prevalent. Specifically, the findings on forest cover modifications in this study can aid these countries in formulating and executing more efficient conservation measures, thus decreasing the speed of forest loss. Hence, this should be a wake-up call to policymakers regarding the management of the PAs and gazetted forest reserves, as encroachment is increasing and taking over the forest reserves across the forest regions in Nigeria. Reserves are currently not protecting the forest in the way that they were originally intended. The change in the forest has negative implications in diverse ways, such as the loss of genetic resources, unsustainable food production and the loss of potentially valuable medical and other forest products in this area. The loss of forests which are essential for environmental functions, encompassing biodiversity, climate regulation, and preserving water catchment areas, poses a significant threat to societies. In addition, this could reduce opportunities for livelihood and income generation but also hampers efforts that seek to preserve the cultural values of society.

3.4. Conclusion

The LULCC trends observed in Doma, Risha, and Odu gazetted forest reserves provide critical insights into the dynamics of forest change in Nasarawa state, Nigeria. This research represents the first quantification of the failure of the forest reserve approach in these areas, providing unprecedented insights into the extent of deforestation in Doma and Risha. Doma and Risha showed nearly complete forest loss to cropland expansion, with the establishment of permanent fields. Continued trends in this direction will eventually lead to the complete loss of forest in the area. However, Odu forest reserve retained substantial forest cover increases in 2020 despite that the cropland increased as a result of shifting cultivation around the reserve. The comparative analysis of LULCC in the Doma, Risha, and Odu forest reserves highlights the varied impacts of human activities and environmental factors on forest ecosystems. A comprehensive understanding of the changing patterns of LULCC within forest reserves is crucial for formulating effective management strategies. Assessing these changes using multi-temporal remote sensing data is vital for making well-informed decisions at local, national, and international levels. The divergent trends observed underscore the need for tailored conservation, restoration, and forest management strategies that account for local dynamics. Lessons learned from Odu's recovery trajectory and the failures in Risha and Doma offer valuable insights for guiding national forest policy and management. It is essential to focus on and learn from this reserve and collaborate with the communities involved in maintaining and preserving the forest cover.

Chapter 4. Understanding local perspectives on the trajectory and drivers of gazetted forest reserve change in Nasarawa State, North Central Nigeria.

Abstract

Understanding forest cover change and its drivers has become vital to global forest management as it helps in decision-making and policy development. This study analysed perceptions of the historical drivers behind the land use land cover change (LULCC) and forest change in the gazetted forests from 1966 to 2020 and evaluated the human activities around the gazetted forest reserves, comparing three forests in Nasarawa State, North Central Nigeria. Data were sourced through a household questionnaire, stakeholder interviews, and focus group discussions. Three gazetted forests were sampled to represent the three senatorial districts of the state. Statistical packages for social science (SPSS), NVivo, and Python 3 were used for data analyses to generate descriptive statistics and code themes. The results show that the changes in the gazetted forest were perceived to be triggered by the interplay of sixteen drivers (direct and indirect) related to social, economic, environmental, policy/institutional, and technological elements. Agricultural expansion (cultivated lands), lumbering, and charcoal production were the most frequently reported direct drivers. Population growth, poverty, and government policies were the most frequently perceived indirect drivers. The results indicate similarities and differences in human activities and the perceived drivers across the three forest sites. For example, agricultural expansion, lumbering, and grazing were more widespread while construction and settlement activities differed between forests. Risha saw agriculture expansion ahead of other drivers, Doma saw population growth above other drivers, and Odu saw lumbering aiding other drivers that led to change. Development of forest areas should consider how much people depend on forests for livelihood resources and services. Hence, it is critically necessary to implement policies and strategies focusing on these key drivers and ensure that they match local 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.

4.1. Introduction

Human-caused alteration of the Earth's surface, as described by Makunga and Misana, (2017) and Dibaba et al. (2020), frequently leads to the destruction of forest and woodlands and the degradation of forested areas. The primary issues around forest conservation and livelihood change issues are attributed to land use and human interactions (Oduro Appiah et al., 2021; Plata-Rocha et al., 2021). These human activities are linked to deforestation and forest degradation which work against the protection of forests and their management systems (Syed Ajijur et al., 2016). Assessing these are vital for effective local, regional, and global development of environmental settings (Meijaard et al., 2013; Amoah et al., 2022). The impact of land use change and the factors that drive it have been shown to affect forest cover and biodiversity negatively, which has important implications as biodiversity sustains the livelihoods that people depend on to survive (Keenan et al., 2015a; Ahammad et al., 2019).

It is important to evaluate drivers that contribute to changes and degradation in forest cover and protect areas from the local perspective (Meijaard et al., 2013; Amoah et al., 2022). 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 the local people who depend on them, often directly, for their livelihoods (Li et al., 2018; Moutouama et al., 2019; Rasmussen et al., 2016). Incorporating a local perspective enables the consideration of both environmental and human aspects of forest management. Forests play a crucial role as a valuable resource, providing a diverse array of ecosystem services, including timber, food, fuel, and non-timber bioproducts. Additionally, they contribute to the maintenance of ecological functions, including carbon storage, nutrient cycling, water and air purification, and the preservation of wildlife habitat; services that are essential for promoting human well-being and supporting life (Capitani et al., 2019; Sotirov et al., 2020; Scullion et al., 2019). Human activities have led to a 60% decrease in ecosystem services globally, according to the Millennium Ecosystem Assessment (2005), reiterated by Meijaard et al. (2013) and Yang et al. (2015). As the primary means of subsistence for people living in poverty, they rely heavily on these services, so often lose the most in terms of ecosystem service losses (Carpenter and Peponis, 2010; Carpenter, et al, 2006).

According to the Millennium Ecosystem Assessment (2005), when a driver 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 the 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 (Fasona et al., 2020; Dibaba et al., 2020; Lim et al., 2017). Indirect drivers encompass complex political, socio-economic, cultural, and technological interactions (Guerra et al., 2020; Dibaba, Demissie and Miegel, 2020; Endri et al., 2023). Further indirect drivers contributing to deforestation include corruption, inadequate governance, population growth, climate change, and ambiguous land tenure arrangements (Domínguez and Luoma, 2020; Wehkamp et al., 2015; Mutekwa, 2016). Geist and Lambin, (2020) and the Millennium Ecosystem Assessment (2005) indicate that changes in these drivers influence not only the land cover but also change the forest although the drivers and their impacts differ regionally.

In most developing nations of 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 and forest fires and livestock grazing (Hosonuma et al., 2012; Chirwa et al., 2017; Amoah et al., 2022).

In Nigeria, research has been conducted on LULCC, and the drivers it of using remote sensing and survey data (Orimoogunje, 2014; Soul, 2016; Fasona et al., 2020; Olorunfemi et al., 2020), but there has been limited research on the current drivers of protected and forest reserves changes, particularly in North Central Nigeria (Geidam et al., 2020; Adedeji et al., 2015; Soul, 2016). Although remote sensing data and GIS applications have been used in quantifying the extent of changes in land use and forest change in many regions (Gong et al., 2020; Thasi and Gueguim, 2021; Walters, 2022) including in this study (Chapter 3), it cannot explain the rationale behind the anthropogenic drivers that are felt or perceived by the stakeholders in the forest communities. Understanding perceptions is important as it affects how people behave and their attitudes towards the forest. Gaining this understanding demands quantitative and qualitative approaches for detailed understanding beyond just the observation of the change. This chapter aims to evaluate the perceived drivers of forest change using an empirical perspective at the local community level including those populations living close to the gazetted forest reserves explored in Chapter 3. The study assesses the socio-economic activities in the gazetted forest-dependent community, evaluates direct and indirect drivers that influence the gazetted forest reserves change and compares the drivers and human activities across the three forest regions in the state.

This chapter utilised various methods, such as household questionnaires, KIIs, and FGDs, to gain insights into the primary direct and indirect effects of land use, as well as the human

activities that impact the gazetted forest changes within the study area. Mixed methods were used to triangulate information from the forest-dependent community across stakeholders, as outlined in Chapter 2. A total of 252 structured and semi-structured questionnaires were distributed, and 40 KIIs and 8 FGDs were conducted with forest-dependent local people, local leaders, government officials, and forest experts. The identified categories of stakeholders reflect diverse interests, goals, impacts, and knowledge of forest use, historical drivers, and human activities around the conservation forest, as detailed in Chapter 2. The data was analysed using a mixed methods approach with software such as IBM SPSS version 21 and Python 3. Descriptive statistics were used to analyse the data. Qualitative data was analysed using NVivo software, employing content analysis to extract pertinent codes from themes identified through coding, thematic and content analysis. Data from KIIs and FGDs were systematically categorised into key themes based on frequency, context, and relevance to the research questions to support the narratives (Appendix 2.3: Table 1 and Table 2). Selected quotes were chosen for their representativeness, clarity, and content relevance, reflecting broader patterns observed in community discussions.

4.2. Results

This section presents the results of the community household survey, KII and FGD on perceived historical drivers of gazetted forest changes and human activities around the three forest reserves (Doma Risha and Odu) in Nasarawa State.

4.3. Households' perceived responses of the drivers and human activities that affect the gazetted forest change in the three forests (Doma, Risha and Odu) in Nasarawa State.

The results of the household survey of the community perceptions of the drivers and human activities that contribute to the gazetted forest reserve change in their community are shown in Figure 4.1 and 4.2. Multiple options were given to the respondents so they could select any number of possible drivers of the change (Appendix 2.1). In terms of direct drivers, all respondents identified agricultural expansion and lumbering across the three forests. Fuelwood/charcoal production was another top driver of forest change. Other drivers were natural disaster/ climate change, grazing, settlement, and construction across the three forests (Doma, Risha and Odu (Figure 4.1, 4.2).

To understand more details on the human activities that led to the change of the gazetted forest in the study area, the household survey further evaluated local community activities around the gazetted forest communities (Figure 4.2). This also was to relate their perception of the drivers and human activities in the area. Respondents identified agriculture, grazing,

hunting, residential, mining, fishing, and infrastructural development as human activities around the gazetted forest area which influence the drivers that cause the changes in the gazetted forest across the three forests in the study area.

4.3.1. Comparison of (households') perceived responses of the drivers and human activities that for the gazetted forest change in the three forests in Nasarawa State

The comparative result of drivers of the LULCC in the three gazetted forests is shown in Figure 4.1 and that of human activities is presented in Figure 4.2. All the respondents (100%) in the three gazetted forests indicated agriculture expansion as the major driver of change, while 99% of the respondents identified agriculture as human activities (Figure 4.2 and plate 4.1). As revealed earlier, that the classified map in Chapter 3 shows that croplands keep increasing to occupy forest land with 65%, 87% and 45% in 2020 (Doma, Risha and Odu) for the three forest reserve areas respectively. From the household survey sample, respondents also identified grazing, hunting, residential, mining (quarry), fishing, and infrastructural development as key human activities around the three gazetted forest areas (Figure 4.2). However, construction and settlement were perceived by far fewer people as driving the forest change across the three reserves. Doma had the highest construction response (47%) with Risha followed while Odu had the least (Figure 4.1). 76% of respondents in Doma identified settlement as one of the major drivers while only a few in Risha and Odu considered it as a driver for forest change in the area (Figure 4.1). Over 90% of respondents in all three forest reserves identified lumbering as one of the major drivers of the gazetted forest change in their communities (Figure 4.1, 4.2). Fuelwood and charcoal production were similar in the three forest reserves with over 90%, however, this was slightly higher in Doma, with Risha next and Odu being the least among the three reserves. In terms of respondents' perceptions of disaster and climate change, more than 70% of respondents in the three forest communities (as shown in Figure 4.1) agreed that these drivers had contributed to changes in their gazetted forest reserves. Grazing was a commonly identified driver across the three forest reserves noted by 81% of respondents in Risha and 79% in Doma and 69% in Odu (Figure 4.1). Similarly, grazing activities were common over the three reserves, over 60% identified grazing as human activities in the survey (Figure 4.2). Other findings comparing results linked to perceptions of hunting, mining, fishing are presented in Figure 4.2.

This comparative analysis sheds light on the multifaceted nature of human activities and the drivers within the three gazetted forest reserves in Nasarawa State. The findings provide valuable insights into the varying degrees of engagement in agriculture, residential living,

grazing, mining, hunting, fishing, and infrastructural development across the surveyed areas, contributing to a more comprehensive understanding of the human-environment dynamics in these forest reserves (Figure 4.1 and 4.2).

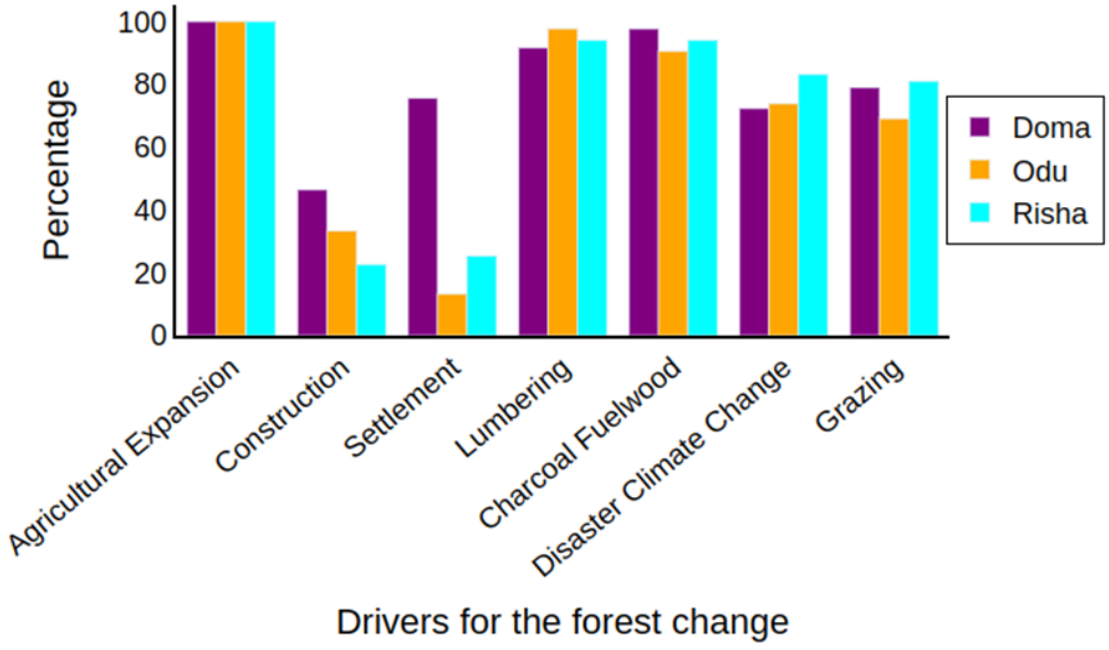

Figure 4.1. Comparative responses on the perceived major direct drivers of gazetted forest change in the three gazetted forests in Nasarawa State.

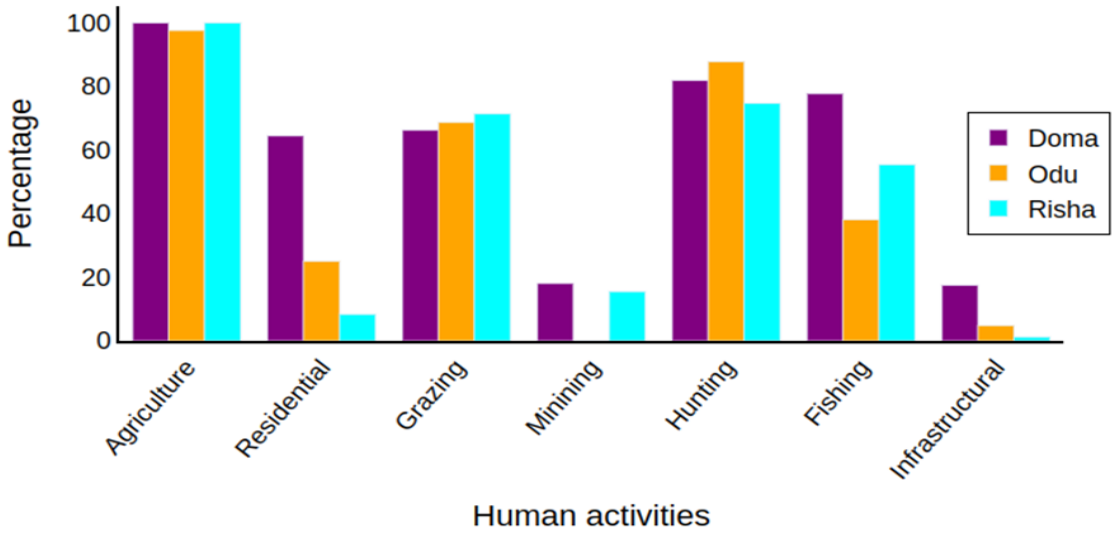

Figure 4. 2. Comparative responses analysis of human activities around the three gazetted forest reserves in Nasarawa State.

Plate 4. 1. Evidence of identified land use activities around the gazetted forest reserves in the study sites. From top right: ai, ii) 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) show grazing activities in Doma and construction along Risha forest reserves. Sources: Fieldwork July, 2023.

4.4. Underlying (indirect) drivers of the gazetted forest change in Nasarawa

Themes derived from quantitative data analysis, as mapped through NVivo project coding based on KII and FGD indicate interconnected factors such as population increase, poverty, climate change, corruption, governance, government policies, insecurity, land grabbing, and migration.

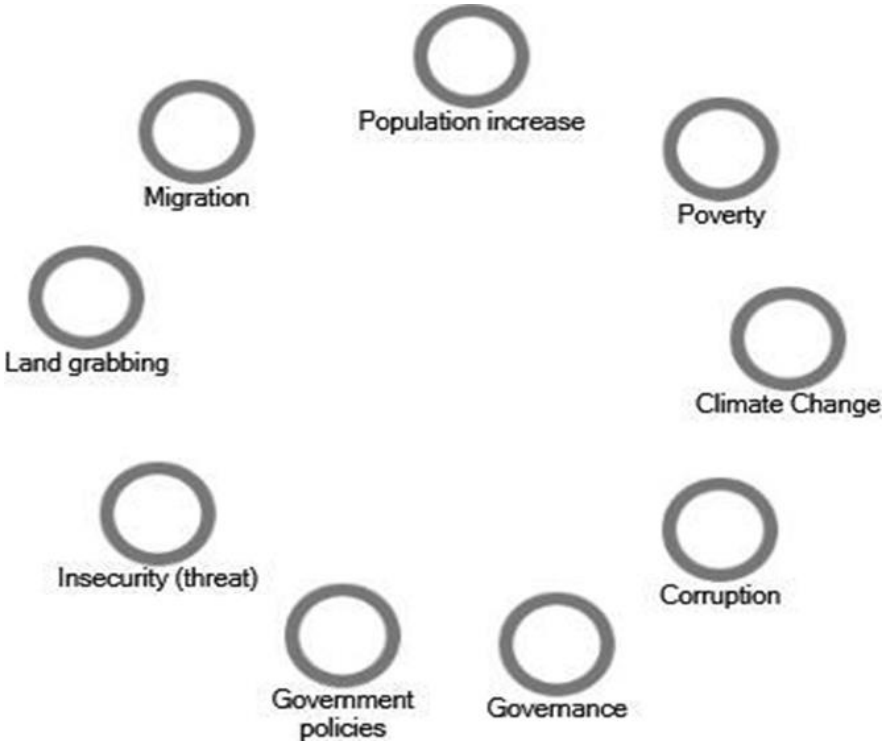

Figure 4.3. Nvivo mapping codes from all stakeholders across the forest sites, showing perceived underlying drivers of forest change, as collected using KII and FGDs.

These codes represent the perceived underlying drivers of forest change identified during data collection. These drivers encapsulate the multifaceted and dynamic pressures contributing to forest degradation and alterations in surrounding communities. This analysis emphasizes the systemic nature of the challenges and provides a framework for understanding stakeholder perspectives on the underlying causes of forest changes.

4.5. Community perceived historical drivers of gazetted forest changes and human activities around the forest in Nasarawa State: Insights from Stakeholders (1966–2022) across the three forests (Doma, Risha and Odu)

Understanding the variety of factors driving forest changes over time is critical for informed forest management and conservation strategies. This section examines stakeholders' perceptions of the historical and contemporary drivers of forest change in Nasarawa State, Nigeria, between two distinct timeframes: 1966–2000 (the past) and 2001–2022 (the present) and the trajectories for the perceived drivers, and processes of change. This section also sheds light on the interplay of socio-economic, political, and environmental factors influencing forest cover, biodiversity and ecosystem change in the three gazetted forests. Appendix 2.3: Tables 3-6 show relevant quotes from the key stakeholders' KII identifying perceived drivers while section 4.5.1- 4.5.5. show the FGD summaries of stakeholders' perceptions of the historical drivers of forest change trajectories and processes of change for gazetted forest reserve change.

4.5.1. Summary of Stakeholder FGD comparative content analysis on the trajectories, perceived drivers, and processes of change in the Doma gazetted forest reserve community

The local people and leaders FGD revealed that from the 1960s to 2000, Doma forest reserves were dense, biodiverse ecosystems with tall trees, vital wildlife, and minimal degradation. Between 2000 and 2022, deforestation intensified, resulting in significant biodiversity loss, wildlife extinction, and reduced forest cover. By 2022, the reserves had nearly disappeared, leaving degraded ecosystems and diminished community benefits. Both groups highlighted population growth as a major driver, leading to forest encroachment. Logging and timber extraction were significant factors, fueled by urbanization and state revenue policies. Agricultural expansion took a large permanent portion of the forest reserve mentioned by the two stakeholder groups. Community leaders pointed to charcoal production and commercial logging as key contributors, while community people mentioned government-issued orders for timber extraction. Leaders noted bushfires and overgrazing as major contributors, less emphasized by the local community. Both FGDs acknowledged extensive wildlife and biodiversity loss due to habitat destruction and hunting and emphasized neglect of management including inadequate enforcement of forest policies. On change processes, both groups agreed that population pressure and economic activities directly fueled forest clearing without reforestation. Leaders added that unsustainable grazing practices introduced invasive species and degraded the ecosystem further. Lack of enforcement, combined with local and state policy gaps, allowed extensive degradation to

continue. Overall, the Doma forest reserve's decline is rooted in population pressure, agriculture expansion, economic exploitation, and policy failures, with nuanced variations between the two groups. Both acknowledged the urgent need for sustainable management to reverse the trend in the study area.

4.5.2. Summary of stakeholder FGD comparative content analysis on the trajectories, perceived drivers, and processes of change in the Risha gazetted forest reserve

From the 1960s to 2000, the Risha gazetted forest had dense vegetation, abundant wildlife, and flowing streams. Agricultural activities and human settlement were minimal, with government control preserving biodiversity. Species included lions, baboons, crocodiles, pythons, and tree species like mahogany and Terminalia spp. By 2001 to 2022, rapid forest degradation occurred due to agricultural expansion, deforestation, and near-total loss of forest cover. Biodiversity significantly declined, with many species disappearing or retreating. Open spaces replaced dense vegetation, streams dried up, and ecosystems were disrupted. Local community and leaders FGD identified key drivers: population growth and increased settlement driven by agricultural expansion into forest reserves. Deforestation for crop production converted forests into farmland. Economic pressures led to timber extraction, charcoal production, and firewood harvesting. Bush burning contributed to hunting, land clearing, and farming, causing forest destruction. Overgrazing by Fulani herders caused soil compaction, tree damage, and loss of tree cover and grassland as revealed in the two FGDs. However, it is noteworthy that Fulani herders were not included as participants in these FGDs due to their inaccessibility, which precluded the opportunity to gain insights into their perspectives regarding the impact of their activities on forest degradation.

The local community FGD revealed deforestation from logging, agricultural expansion, and firewood/charcoal extraction led to habitat destruction and biodiversity loss. This displaced wildlife, with animals fleeing and species like crocodiles, pythons, and buffalo disappearing. Cultural and economic shifts transformed forests from traditional conservation areas to sources of short-term economic gains. The transformation of the Risha forest reserve is attributed to direct and indirect interconnections such as social, economic and environmental factors that have altered the forest reserve cover, ecosystem, and biodiversity.

4.5.3. Summary of Stakeholder FGD comparative content analysis on the trajectories, perceived drivers, and processes of change in the Odu gazetted forest reserve

For Odu between 1960–2000, the local community FGD revealed that forests remained largely intact due to low population density, strict traditional laws, and minimal economic reliance on forests. Wildlife and valuable tree species thrived under traditional regulation. However, community leaders noted that forest size began to reduce gradually from logging for local and commercial use, additionally driven by agricultural expansion and bushfires, while fauna and flora species started depleting due to weak enforcement. 2001-2022, the local community explained that forest degradation accelerated due to economic pressures. Deforestation was driven by timber operations, agricultural expansion, charcoal production, and bush burning, leading to habitat loss, reduced wildlife, and insecurity. Community leaders attributed the change to rapid forest degradation from population growth, poverty, and weak forest management. Overexploitation for fuel, farming, and urbanisation led to forest cover and biodiversity loss, soil erosion, and a decline in forest resilience. The community revealed that processes of change between the 1960s and 2000 were characterised by traditional forest protection systems giving way to unsustainable practices, leading to significant forest cover change and biodiversity loss. Community leaders pointed out weak governance and lack of reforestation led to unsustainable exploitation, while rapid urbanisation and reliance on forest resources due to poverty further accelerated degradation. The local community focused on unregulated timber extraction (sawmills) and shifting cultivation as key drivers, while community leaders highlighted urbanisation and population growth, poverty, and lack of effective forest governance as critical causes, also noting climate change's influence on forest change.

4.5.4. FGD content analysis for Government Officials and expert stakeholder groups on the trajectories, drivers, and processes of change in gazetted forest reserves in the study area

During the period from the 1960s to 2000, both Government and Expert Focus Group Discussions (FGDs) noted gradual deforestation, driven by population growth, agricultural expansion, and timber extraction. Infrastructure development contributed to forest degradation, albeit slower compared to subsequent years. Experts highlighted bushfires as a significant contributor. Biodiversity loss commenced, with declining flora (e.g., Parkia) and fauna (e.g., primates, elephants). From 2001 to 2022, both groups emphasised accelerated deforestation driven by rapid population growth, agricultural expansion, urbanisation, and economic pressures. Charcoal production, commercial timber harvesting, and mining were identified as major drivers. Experts highlighted rising energy costs leading to increased

firewood and charcoal use. Both groups noted the impact of climate change, policy inconsistencies, and inadequate reforestation efforts. Faunal extinction became more pronounced, with large mammals and valuable tree species experiencing drastic declines. In summary, government officials and experts revealed that processes of change between the 1960s and 2000 were characterised by gradual degradation due to farming, timber harvesting, and infrastructure development, while 2001-2022 processes exhibited accelerated deforestation caused by expanded agricultural activities, unsustainable resource exploitation, and urbanisation. Both groups identified the interplay of population growth, economic need, and policy failures as primary drivers of forest degradation. Experts provided additional ecological insights and highlighted specific socio-economic factors as contributors to the change. Tables 4.1-4.3 present the overview comparison, similarities and differences in stakeholder FGD insights and perspectives.

Table 4.1. Overview of stakeholder perspectives for the FGD content analysis of findings 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, climate change.	Shift from traditional conservation to unsustainable exploitation, changing cultural attitudes towards conservation, population pressure, and economic reliance on forest resources

Table 4. 2. Comparative analysis of the trajectories, drivers, and processes for the government and expert FGDs

Time Period	Government and Expert Observations	Key Drivers	Processes of Change
1960-2000	Gradual deforestation due to farming, timber harvesting, and infrastructure development. Biodiversity loss began.	Population growth, agricultural expansion, timber extraction, charcoal/ fuelwood extraction, infrastructure projects, bushfires.	Slow but steady degradation, early signs of habitat and species decline.
2001-2022	Accelerated deforestation, faunal extinction, and significant ecological decline.	Rapid population growth, agriculture expansion, urbanization, economic pressures, increased reliance on firewood/charcoal, mining, weak governance, and reforestation efforts.	Unsustainable resource exploitation, policy failures, climate change impacts.

Table 4.3. Similarities and differences among stakeholders' FGDs on the perceived drivers, impacts and process of change of the gazetted reserves

Aspect	**Similarities**	**Differences**
Time Period	**Government and Expert Observations**	**Key Drivers**
Perceived Drivers	All stakeholders identify population growth and urbanization, agriculture, logging, and weak governance as primary drivers.	Local communities emphasize immediate livelihood needs, while the government and experts highlight policy failures and economic exploitation.
Impact on Biodiversity	All agree on significant biodiversity loss and ecosystem disruption.	Experts provide detailed ecological insights, while local stakeholders focus on visible wildlife disappearances.
Processes of Change	Generally, the consensus socio-economic (livelihood) activities accelerate deforestation.	Government officials acknowledge policy gaps, whereas communities highlight economic survival needs.
Solutions & Management	Recognition of the need for sustainable management, reforestation, and policy enforcement.	Experts advocate scientific conservation approaches, while local leaders stress traditional conservation methods.

The comparative stakeholder analysis highlights the stakeholder perspectives on forest reserve changes, and the narratives from FGDs across stakeholder groups underscore diverse perspectives on forest reserve trajectories, drivers of change, and processes shaping forest ecosystems across the three gazetted forest communities. Each group's viewpoint is rooted in their interaction with and reliance on the forests, as well as their capacity for control over forest resources.

Local communities and leaders depicted dense, biodiverse forests in the 1960s, gradually transforming into degraded landscapes due to population growth, economic pressures, and weak enforcement. Their perspectives blend personal experience and direct reliance on forest resources, emphasizing agricultural expansion, charcoal production, and timber extraction as primary drivers of deforestation. Community leaders also highlighted policy failures and urbanization as accelerants of forest loss, with nuanced variations in emphasis on issues like overgrazing and bushfires.

Government officials and experts provided a broader policy-oriented and ecological perspective. They aligned with local accounts of deforestation drivers but enriched the analysis with insights into the interplay between climate change, energy demand, and governance challenges. Experts, in addition, highlighted the ecological consequences of forest degradation, including biodiversity loss and species extinction, offering a systems-level understanding of socio-economic and environmental transformations.

Consistent themes emerged across all FGDs: population pressure, economic exploitation of forest resources, and governance failures were identified as central drivers of deforestation and biodiversity loss. However, the analysis revealed the need for disaggregating perspectives. Local communities emphasized immediate livelihood challenges, while experts provided more long-term and systemic analyses of forest degradation. This divergence underscores the importance of considering each group's unique vantage point to design inclusive and sustainable forest management strategies (Chapter 5). The findings emphasize the urgency of integrating local knowledge, expert insights, and governance reforms to reverse forest decline. Effective management must address underlying drivers such as poverty, urbanization, and policy gaps while promoting reforestation and sustainable resource use. An integrated approach that combines policy reform, community engagement, and scientific conservation is essential for the sustainable management of the Doma, Risha, and Odu forest reserves and beyond (details are in Chapter 5).

4.6. Population growth and climate change variable (Temperature and precipitation) of Nasarawa state

To evaluate the population growth and climate variable of the study area as consistently revealed across stakeholder perceptions, figures 4.4, 4.5 and 4.6 indicate that over the years covered in this study (1986-2020), Nasarawa State has experienced significant climate variability with an overall trend of increasing temperatures and fluctuating rainfall. Simultaneously, the population has seen substantial growth, more than tripling from 1986 to 2020. These changes may have implications for the region's forest cover, agriculture activities, ecosystem services and overall sustainability of the gazetted forest reserve, and indeed, were noted by stakeholders.

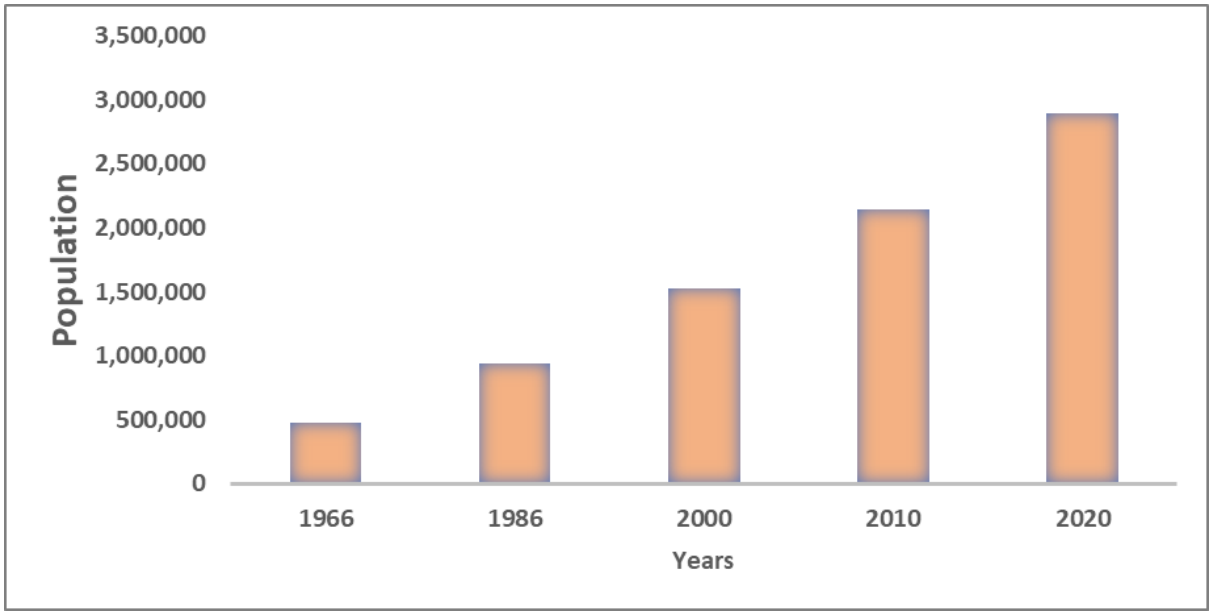

Figure 4.4. Population trends for the study area (Nasarawa state) for the study years, 1966-2020.

Sources: website: https://www.nationalpopulation.gov.ng

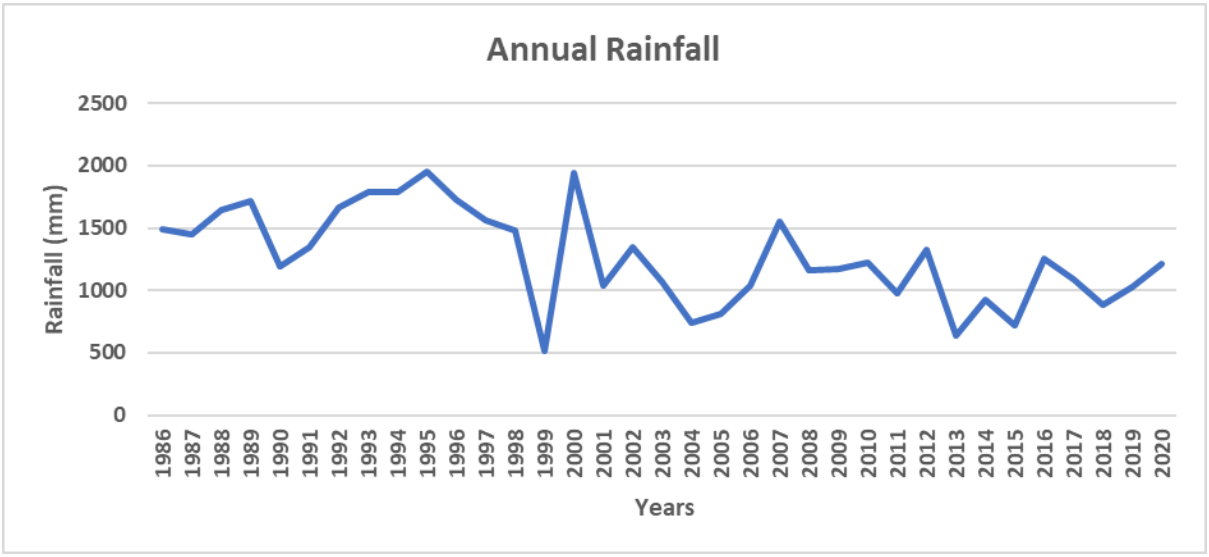

Figure 4. 5. The study area's annual rainfall trend for 1986-2020 (Lafia Station).

Source: Nigeria Meteorological Agency, Abuja, 2022.

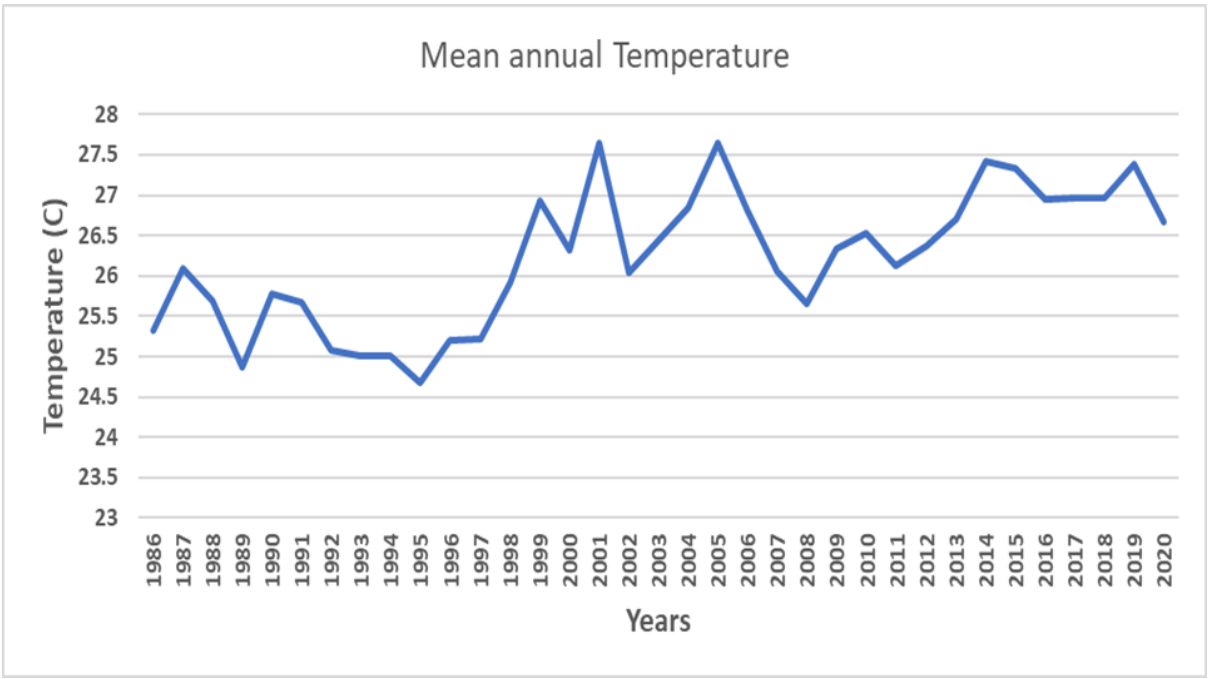

Figure 4.6. The study area's annual temperature trend for 1986-2020 (Lafia Station).

Source: Nigeria Meteorological Agency, Abuja, 2022.

4.7. Community evaluation of key drivers and human activities behind changes in the gazetted forest reserves across the three study areas.

This section examines and evaluates the perceived primary factors (key drivers and human activities) identified and recognised by local communities and stakeholder participants across the three (Doma, Risha and Odu) forest reserves (Figures 4.1 and 4.2). Data from KIIs are in Appendix 2.3: Table 1-5; FGD Section 4.5.1- 4.5.5 and Table 4.1- 4.3.

4.7.1. Doma forest reserve

a) Agricultural Expansion

In Doma forest reserve's household survey, agricultural expansion was perceived by most of the respondents as the largest driver of forest cover changes, as highlighted by the LULCC analysis (1986-2020) where cropland occupied 65% of reserve land cover by 2020 in Chapter 3. Qualitative insight from content analysis of Doma stakeholder KIIs (Appendix 2.3: Table 2 and section 4.5.1) revealed that farming activities, initiated in the 1970s, have led to widespread deforestation, with trees felled to create farmland for crops like yam, maize, guinea corn and beans (Appendix 2.3: Figure 2 and section 4.5.1). FGDs and KIIs confirmed this trend, with participants noting that the increasing demand for farmland and settlements has driven deforestation in Doma (Table 4.1, 4.2). Moreover, field observations in 2022 by the researcher further revealed ongoing agricultural activities in and around the reserve, contributing to deforestation (plate 4.1.).

Overall, household surveys and remote sensing data support the qualitative findings, indicating that agricultural expansion is the principal driver of forest loss in Doma as perceived by the community. This perception by the community is supported by the maps presented in Chapter 3, which show a significant conversion of land to agriculture. The community describes a situation where people on the agricultural frontier actively clear land to make room for farming.

Stakeholders also observed that land is initially cleared because of valuable resources, particularly timber. Agriculture then gradually follows, degrading the forest over time. Eventually, agricultural activities rapidly occupy the cleared space permanently.

Stakeholders also noted that land is first cleared because it contains a valuable resource (timber) and the agriculture moves in behind on the processes gradually degrade the forest and agriculture moves in rapidly to occupied permanent space on the reserve between 2001 and 2020 corroborate with the classified map result of the reserve in Chapter 3 that shows

cropland which is the agricultural activities influence the substantial change to the reserve area.

b) Lumbering

Lumbering is another key driver and human activity of the gazetted forest change in Doma, as shown in the household survey (Appendix 2.3: Table 2 and section 4.5.1). The KII and FGD revealed that the primary activity of lumbering is timber extraction, which is carried out through non-commercial and commercial logging by the community people and government. The extraction of selected important tree species for both commercial and non-commercial timber purposes has targeted species such as Iroko, Obeche, and mahoganies found in the forest reserves. This has impacted forest quality, composition, and size, leading to a decrease in forest cover.

Clear-cutting practices contribute directly to forest degradation, with agricultural expansion taking over areas previously degraded by timber extraction. Qualitative data (Appendix 2.3: Table 2-5) and sections 4.5.1–4.5.4 reveal this trend.

KIIs and FGDs noted that increasing population pressures have led to higher demand for timber for construction purposes, further exacerbating deforestation within the reserve. Participants reported that clear-cutting practices and selective logging of valuable tree species have significantly altered the forest composition in Doma. For example, within the KII, a participant explained that; "*The practice of timber extraction has persisted for decades of years, focusing on economically valuable tree species like Iroko, mahogany, obeche, shear 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).

c) Fuelwood/Charcoal Production

Fuelwood/charcoal production was identified and perceived as one of the primary drivers and anthropogenic activities contributing to forest change and degradation in Doma, according to 94% of survey respondents. These activities are essential for household energy and income generation. In the qualitative results from FGD, the local people confirmed that specific tree species are harvested for fuelwood and to produce charcoal, resulting in a reduction of forest cover over time (Appendix 2.3: Table 2 and section 4.5.1). One of the

leader participants from Doma KII further elaborated: *"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). Observations during fieldwork confirmed the ongoing exploitation of the forest for fuelwood, which aligns with household survey, KII and FGD findings.

d) Grazing

Grazing by livestock, particularly cattle and cows was perceived to be a driver that contributed to forest degradation in Doma as identified by 81% of respondents (Figure 4.1 and Figure 4.2). FGDs revealed that herdsmen 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 grassland composition. Cattle trampling and cutting of branches for fodder further exacerbate the problem. Additionally, herders have been reported to clear forested areas to build camps, adding to deforestation pressures noted by both the local people and leader stakeholders (Appendix 2.3: Table 2 and section 4.5.1). The KII participants from the local community in Doma elaborated and further 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 people KII 003, June 2022) Table 4.1.

4.7.2. Risha forest reserve

The results of the household survey in Risha considering perceptions of the drivers and human activities that contribute to the gazetted forest reserve change in their community are presented in Figure 4.1 and 4.2.

a) Agricultural Expansion

In Risha forest reserve, agricultural expansion was perceived by most of the respondents as one of the substantial drivers that influence the forest cover change in the area. By 2020, croplands accounted for 87% of the reserve area, as per LULCC analysis in Chapter 3. This was cropland expansion observed to expand and cover permanent areas of the reserve in Chapter 3. Qualitative insight from the stakeholders (Appendix 2.3: Table 3 and section

4.5.2) revealed that by 2001 to 2022, rapid forest degradation had occurred due to agricultural expansion and near-total loss of forest cover in this forest reserve (Chapter 3 forest map figure 3.4). Local community and community leaders participating in KIIs and FGDs reported that agricultural expansion began several decades ago and remains a critical driver of deforestation and the forest cover change in Risha. Agricultural expansion is a primary driver of major changes in forest areas, directly leading to the permanent conversion of forests into agricultural land. This process involves communities clearing forests to create new cropland and expand settlements. This result confirms findings in Chapter 3, which showed that cropland expansion was the primary driver of forest loss, with cropland almost entirely replacing the reserve's original forest cover before other factors contributed to further changes."For example, one of the participants further reiterated that *"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) (Appendix 2.3: Table 3 and section 4.5.2). This trend was observed during field visits in 2022 (Plate 4.1) and is also evident in the forest cover map in Chapter 3. The local community stakeholders' insights from the FGD further elaborated on how cropland expansion on the forest reserve was observed from the initial stage and the characteristics behind the change (Table 4.3, 4.4 and section 4.5.1.)

b) Lumbering

The household survey identified lumbering is perceived as a major contributor to forest decline in Risha (Figure 4.1). The qualitative data from the content analysis revealed that a large number of trees were degraded for timber extraction for construction and other uses, leading to significant forest loss in Risha. Selective logging of valuable species like Gmelina, Obeche, Mahogany and Iroko has reduced forest quality and composition. These species are selectively logged due to their economic and commercial value, though they cause excessive exploitation that leads to deforestation and loss of biodiversity in the reserve. FGD participants (Appendix 2.3: Table 3 and section 4.5.2) further noted that as the population grows, the demand for timber increases, driving unsustainable logging practices in the reserve- one of the key contributors to forest decline in Risha. One of the local stakeholders 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 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, Local people KII 004, June 2022) (Appendix 2.3: Table 3 and section 4.5.2)

c) Fuelwood/Charcoal Production

Fuelwood/charcoal production was perceived as one of the critical drivers and human activities for livelihoods in Risha, with 90% of household survey respondents acknowledging their role in forest cover change and degradation. The qualitative results from FGD elaborated that the communities cut down trees from the reserves which are the sources of their energy use at home and also they sell them for their economic gain as a source of income for their families. Community leaders confirmed that tree cutting for fuelwood/charcoal production is a common practice, reducing the forest's ecological integrity (Appendix 2.3: Table 3 and section 4.5.2). A KII participant reiterated this perspective, stating; *"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) (Appendix 2.3: Table 3 and section 4.5.2). Observations during fieldwork in 2022 revealed active woodlot and charcoal production sites around the reserve (Plate 4.1).

d) Grazing

Grazing activities in Risha were perceived to have notably impacted the forest reserve as identified by a large proportion (90%) of the respondents (4.1-4.2). Qualitative insight from the FGDs for both the local people and the community leaders highlighted that cattle graze on remaining cropland stalks and grasslands within the reserve, which diminishes forest cover, trees and grassland cover. Livestock overgrazing causes new trees not to regenerate and compacts the soil, while tree cutting for fodder further reduces forest composition. Both the stakeholder groups emphasized the challenges posed by herdsmen clearing trees for grazing purposes and building camps within the reserve, which trigger the fast loss of forest cover within the reserve areas. For example, one of the stakeholders from the community in Risha KII further added that*: "Fulani herdsmen's livestock grazing practices, including overgrazing causes overgrazing on grasslands and damages regenerated trees, trampling on soil by compaction and destruction of tree roots by trampling and cutting down trees for fodder and camp construction, significantly contribute to forest degradation within this forest reserve*" (Risha, Local people KII 002, June 2022) (Appendix 2.3: Table 3 and section 4.5.2)

4.7.3. Odu forest reserve

The results of the household survey for Odu gazetted forest community perceptions for the drivers and human activities that contribute to the gazetted forest reserve change are shown in Figures 4.1 and 4.2 and the qualitative results are presented in (Appendix 2.3: Table 3 and section 4.5.3. The respondents perceived agricultural expansion, lumbering, and fuelwood/charcoal production as higher among the other drivers (100%, 90% and 80%) respectively, however they also perceived natural disasters/ climate change, grazing, settlement, and construction to contribute to the change (Figure 4.1, 4.2).

a) Agricultural Expansion

Agricultural expansion was perceived as the prevalent driver influencing forest change in the Odu forest reserve by most respondents from the surrounding forest communities (Figure 4.1. 4.2). Although forest cover increased as observed from the LULCC map in Chapter 3, cropland accounted for 48% of the reserve area by 2020. While this proportion is lower than in Doma and Risha, the trend remains notable. Forest cover showed a significant increase in 2020 from the classified map Chapter 3, indicating a shift within agricultural cultivation land and shrubland. According to qualitative information from FGD (Appendix 2.3: Figure 3 and section 4.5.3) farmers were practising shifting agriculture as a traditional way of agriculture by increasing farmland on existing established farms left over the years that followed, cultivating crops such as yam, maize, beans, and cassava, contributing to forest clearing and change in the reserve. Furthermore, the FGDs for both the local community and local leaders revealed that agricultural land expansion, with shifting cultivation (agriculture) driven by population growth and livelihood needs, influences changes in the reserves, including biodiversity loss (Appendix 2.3: Table 3 and section 4.5.3). Morealso, in a KII, one of the participants further that: *"Agriculture has contributed to forest changes here since 1970s, as we depend on farming and forest resources for income and survival, with no alternative livelihoods"* (Odu, Local Community People, KII 003, June 2022 (Appendix 2.3: Table 3)

b) Lumbering

Timber extraction and logging has also contributed to deforestation and forest cover loss in Odu as a driver (Figure 4.1 and 4.2). The qualitative data revealed the trend, with participants reporting extensive logging of species like Obeche, opepe, African Copaiba, Iroko and Mahogany for construction and furniture making (Appendix 2.3: Table 4 and section 4.5.3). KIIs and FGDs highlighted that increased demand for timber in the growing population has intensified forest exploitation. This has reduced the availability of valuable tree species and

altered the reserve's ecological balance. Community leaders in FGDs (Figure 4.6) noted that the forest size began to reduce gradually from logging for local and commercial use, additionally driven by agricultural expansion and other drivers. In a KII, another participant from the local community added that "*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 tree cover in the forest and even wild animals and other valuable trees, now hardly you seem them in the forest"* (Odu, Community People, KII 002, June 2022).

c) Fuelwood/Charcoal Production

Fuelwood/charcoal production contributed a considerable role in the gazetted forest degradation and change perceived by a substantial numbers of household survey respondents in Odu (Table 4.1. and 4. 2). Community leaders in FGD confirmed that many residents rely on these activities for energy and income generation. Specific tree species are targeted for charcoal production, which has further reduced the forest's size and composition (Appendix 2.3: Table 4) and section 4.5.3. In a KII, one of the participants further elaborated that: *"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 People K II 005, June 2022).

d) Grazing

Grazing was perceived as one of the key drivers and human activities that affected change in forest cover in the Odu forest by over 69% of household survey respondents (Table 4.1), although the impact appears less severe compared to Doma and Risha from the community stakeholders' narrative. FGDs reported that Fulani herdsmen rearing livestock such as cattle and cows overgraze the land, trampling of soil and young regenerating trees, and the cutting of trees for fodder contribute to forest degradation. Focus Group Discussions (FGDs) reported that Fulani herdsmen, while rearing livestock such as cattle, contribute to forest degradation through overgrazing, trampling of soil and young regenerating trees, and the

cutting of trees for fodder.One of the participants from the KII (Appendix 2.3: Table 4) further revealed that *"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) (Appendix 2.3: Table 4 and section 4.5.3)

4.8. Evaluation of underlying (indirect) drivers of the gazetted forest change in Nasarawa State

In addition to direct drivers that lead to the forest change, the KII and FGD revealed underlying (indirect) drivers of land use and gazetted forest reserves change in the study area, identifying population growth, poverty, government policies, poor governance, and corruption which are similar across the three forest reserves (Figure 4.3 (Appendix 2.3: Table 2-5 and section 4.5.1-5). Other indirect drivers are climate change and disasters (unreliable rainfall and temperature). The results are shown in Figure 4.3, from the NVivo mapping across the themes. The details of some of the key indirect drivers are discussed as follows.

a) Population growth

The majority of the KII and FGD participants from the local people, leaders, government officials and experts perceived the population of the area had increased over the studied period, thereby influencing human activities, particularly agricultural land expansion on the reserves, with the interaction of other drivers such as settlement which led to high demand for timber and other forest resources in the area. The population trend of the state had shown a significant increase for the period covered by this study (Figure 4.4). The increasing population pressure leads to increased demand for farmland, placing increasing demands on forest resources and increasing activities that lead to forest change. FGDs and KIIs confirmed that population increase in the area influences the direct drivers that led to a significant change in the forest reserves (Appendix 2.3: Table 2-5 and section 4.5.1- 4.5.4). For example, a stakeholder participant stated that "*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) (Appendix 2.3: Table 2-5 and section 4.5.1- 4.5).

To confirm the community's perception of population growth, the study area population data from 1986 to 2020 was analysed (Figure 4.4). The population experienced a substantial growth of 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). The consistent rise in the population depicted in Figure 4.4 over time demonstrates this growth trend, remaining apparent despite the unavailability of precise statistical population data for the gazetted forest community.

b) Poverty

Poverty was one of the underlying drivers mentioned in the study area that influenced the land use and forest change in both the KII and FGDs across the three forest reserve areas. This was corroborated with demographic characteristics from the household survey (Appendix 2.3: Table 1**).** Many of the gazetted forest communities are farmers and villagers living in low socioeconomic conditions, which made them dependent on forest resource as a means of attaining a livelihood, which in turn, exerts pressure on the resource and leads to changes in the forest reserves. The KII and FGD participants explained this underlying driver in detail (Appendix 2.3: Table 2-5 and section 4.5.1- 4.5.5). For example, in Risha forest reserve, one of the participants stated that *"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). Moreover, a community leader in Doma emphasised 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) (Appendix 2.3: Table 2-5 and section 4.5.1- 4.5.4). One of the participants further explained

the government's understanding: *" 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 resources access and use"* (KII Government official 005, June 2022) (Appendix 2.3 Table 2). In addition, the household survey (Appendix 2.3: Figure 1) showed that the individual households in the study communities rely predominantly on non-salaried sources of income, with a substantial proportion earning insufficient income. The study's findings indicated that many of the respondents were farmers who did not have reliable sources of income to supplement their monthly earnings and sustain their livelihoods. This is consistent with the participants' statements, who highlighted that poverty in the study area is a contributing factor to the overexploitation of forest resources in the absence of alternative means of subsistence. This conclusion is supported by the KII and FGD content analysis presented in Appendix 2.3: Table 2-5 and sections 4.5.1- 4.5.4. Poverty has also increased the rate of deforestation and forest degradation in the study area due to increased demand for fuelwood and other domestic uses in the study area as reported by the local community findings in this study. This is because these communities are heavily dependent on natural resources to meet their daily needs. The forest is therefore frequently subject to unsustainable exploitation due to the heightened demand for woodfuel for use and generating income and other forest resources that are essential for their immediate survival and economic stability.

c) Poor Governance/policies and corruption

Poor governance was among the hurdles limiting the success of conserving forests and their associated biological diversity in the study area and contributed to the decline in forest reserves as identified by many participants from the KII and FGD across the three forest communities (Appendix 2.3: Table 1-5, Section 4.5.1- 4.5.5). Poor governance includes issues such as corruption and embezzlement of funds, which have adversely affected 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 among others, which greatly influence the changes in the forest reserves of the area. This was particularly the case in Doma where community leaders reiterated this problem. For example, one of the stakeholders revealed that *"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) (Appendix 2.3: Table 2).

Poor governance for instance can affect the policy implementation that contributed to the change of the gazetted forest in the study area. Government policies governed the establishment of the PAs and forest reserves which were intended to help reduce the overall forest loss and degradation, limiting the areas in which concessions could be granted. However, many of the PAs and reserves were poorly managed and limited in resources and capacity due to the policy's failure in terms of implementation. This affects other drivers that interplay and that contribute significantly to the gazetted forest reserves in the study area, as explained by the participants in the KII and FGD (Appendix 2.3: Table 2-5 and section 4.5.1-4.5.4) across the stakeholder groups. For example, a government participant stated: "*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). Appendix 2.3: Table 1-4; Section 4.5.1- 4.5.5 gives other details of some of the KII and FGD insights on policy as a driver for the forest change.

Poor governance and policies were also perceived to influence corruption by some of the forest officials in the study area. For instance, when it comes to obtaining permits or documents, bribes were reportedly necessary. This includes using bribes 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, and members of local communities and government officials are involved affecting the governance for the protection of the forest particularly noted in the Risha forest community (Appendix 2.3: Table 2.5). A participant in one of the forest communities, the Risha revealed that: *"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) (Appendix 2.3: Table 3).

Furthermore, the stakeholders for both the KII and FGD expert and government official groups perceived similarly driver emphasised accelerated deforestation to change around this gazetted forest driven by rapid population growth, urbanisation, and economic pressures such

as agricultural expansion, lumbering and fuelwood/fuel across around the forest reserve. Additional underlying (indirect) factors contributing to changes in the forest reserve in the area, as identified in the KII, include migration and insecurity (terrorism threats). However, they do not seem to have as much impact as other drivers on the gazetted forest change according to the stakeholders' perceptions.

When you compare across the communities, make sure you are only focusing on those aspects that differ substantially. In some places you say that responses "vary between communities" but the differences between them are not substantial and just a small % in some instances. Be more discerning and draw out those differences that are notable and explain them. rewrite in a very short way for academic written report for this three forest from this result.

4.9. Correlation of the key insights for the household survey KIIs and FGD for the study

In Doma Forest, a significant number of local community members and leaders identified agricultural expansion, lumbering, fuelwood collection/charcoal production, and grazing as the primary direct drivers of forest change. Similarly, in Risha, local households, community members, and leaders perceived these same direct drivers as being closely linked to livelihood needs (Appendix 2.3: Table 1-5). In contrast, in Odu, while similar direct drivers were identified, lumbering was perceived as the first most influential driver, followed by agriculture, fuelwood/charcoal collection, and grazing.

Across all three forests, a substantial number of participants and stakeholders recognized human population growth, poor forest governance, and poverty as the key underlying drivers of forest degradation. These factors emerged as dominant concerns among local community members including the government and experts KIIs, and FGDs.

Notably, while most respondents from Doma, Risha, and Odu were farmers, they primarily linked forest change to economic necessity. On the other hand, stakeholders with higher education, including government officials and experts, shared a similar perception of the drivers but also emphasised policy failures and weak enforcement as critical factors influencing forest degradation.

In summary, the analysis reveals that while all three forest reserves in Nasarawa State face similar drivers of forest change, the qualitative data shows that their perceived intensity, trajectories and scale vary. 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 has remained relatively intact, largely due to cultural controls of the traditional land use pattern of shifting cultivation. In Risha and Doma reserves, individuals on the agricultural frontier actively cleared land for permanent agriculture. In Odu, the land was initially cleared for valuable timber, with agriculture subsequently encroaching, later, 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 in some decades. However, Odu is currently experiencing gradual to rapid recovery according to the forest cover map in Chapter 3 due to a shift in traditional agriculture.

Stakeholders from expert and government officials KII and FGD perceived similar drivers and human activities, noting agricultural expansion driven by population growth and timber extraction as gradual or fast causes of deforestation and forest cover change around the reserves. Underlying drivers such as population growth, poverty, poor governance, and corruption are perceived to be common across all reserves. Population growth has increased pressure on forest resources, while poverty has driven communities to exploit forests for livelihoods. Poor governance and weak policy implementation have exacerbated deforestation in all reserves. However, these underlying drivers are perceived to manifest more severely in Risha and Doma, where forest degradation is more extensive compared to Odu (Appendix 2.3: Table 2-5 and section 4.5.1- 4.5.4). Addressing these drivers requires targeted interventions for conservation and management, including improving governance, providing alternative livelihoods, and promoting sustainable land use practices.

4.10. Discussion and implications

4.10.1. Interplay between social and biophysical drivers of forest change

The intricate relationship between social and biophysical processes that drive land-use changes, particularly those impacting forest cover, is influenced by a combination of direct and underlying factors, often stemming from human activities (Imanda, 2022; Phiri and Nyirenda, 2022). This dynamic was evident in the current research, where most participants from gazetted forest communities attributed forest change primarily to this interplay between socio-economic factors and biophysical processes. Most of the historical drivers and human activities that drive the gazetted forest change were similar across the three gazetted forests (Figure 4.1 and 4.2). However, perceptions differed of construction and settlement drivers in terms of their contributions to change in the forest across the three sites surveyed. Each

group's viewpoint is rooted in their interaction with and dependence on the forests, as well as their capacity for control over forest resources.

4.10.2. The impact of forest loss on livelihoods and socioeconomic dynamics

Understanding socioeconomic drivers and forest change reveals how incentives and constraints shape human interactions with forest ecosystems. The research highlights those socioeconomic drivers of forest change in the studied areas, with findings consistent with those of previous studies, such as Sahuri et al. (2023), which reported on changes in the Bukit Suligi Protected Forest Area. Communities around the forest reserves in the study area experience economic challenges (poverty), which may impact 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. Activities like agricultural expansion, fuelwood/charcoal production and lumbering, driven by poverty and population growth, create a deforestation cycle in the PAs in the three study reserves. However, Wibowo et al. (2021), suggest that socioeconomic activities, when managed properly, can have positive outcomes, suggesting a dual nature of these activities in protecting forests.

Agricultural expansion remains a leading driver of deforestation, particularly in Risha and Doma as shown in Chapter 3, consistent with studies across Africa and globally. Studies by Phiri and Nyirenda (2022), Kayombo et al. (2020), and Oduro Appiah et al. (2020), echoing similar findings in Malawi, Tanzania, and Ghana report high rates of protected forest conversion to agricultural land. This pattern, noted by Lim et al. (2017) and Kissinger and Herold (2017), impacts biodiversity and ecosystem services. These patterns highlight the need to balance food production with conservation through strategies like buffer zones and integrated national policies. Alternative livelihoods, agroforestry, and tree farming could reduce reliance on forest resources and support sustainable development (Martini et al., 2023).

Lumbering activities was perceived as one of the key drivers of forest cover change, as identified in this study and supported by research in Ghana, Kenya, and Malawi (Ankomah et al., 2020; Kimutai & Watanabe, 2016; Phiri and Nyirenda, 2022). More also, my findings also align with previous research by Kimutai and Watanabe (2016) in Western Kenya, which found that demand for timber and building poles has led to illegal chainsaw logging of indigenous tree species, causing forest degradation in the protected area. The consistency with other studies suggests that lumbering is a pervasive issue across different geographical locations, emphasizing its widespread impact on forest reserves and PAs. However,

promoting sustainable wood products through tax incentives, stricter import regulations, and public awareness campaigns could foster market demand for certified timber and encourage eco-friendly practices aligned with the SDGs.

The findings show charcoal and fuelwood use significantly contributes to forest degradation in the study area, a trend reported across Africa. Studies by Orimoogunje and Asifat (2015), Munthali et al. (2019), Jeminiwa et al. (2020), Sedano et al. (2016), Ekpo and Mba (2020), and Phiri and Nyirenda (2022) demonstrate that fuelwood and charcoal demand are significant drivers of forest cover change. Their study highlighted the negative impact on forest cover and biodiversity in protected areas. While communities recognize the negative impacts, poverty and lack of alternatives drive continued reliance on these practices (Alhassan et al., 2023). The introduction of improved charcoal technology in Nepal has shown reduced fuelwood consumption and positive forest conservation impacts (Kattel, 2015). Transitioning to clean cooking fuels and subsidizing alternatives are crucial steps to protect forest reserves (Felix, 2015; Salisu, et al.,2024). Subsidies for cookstoves and gas cylinders can minimize tree-cutting (Salisu, et al.,2024). Expanding energy options and creating forest reserves for biodiversity conservation and community livelihood sustainability can help preserve forests and vegetation cover (John et al., 2020; Socorro, 2023).

Grazing practices were found to exacerbate forest degradation in this study, as also documented by Oduro Appiah et al. (2021), Phiri and Nyirenda (2022), Rotich (2019), and Kariuki et al. (2021b) research. 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 (Antoneli, et al., 2019; Chen et al., 2023; Wang et al., 2019). Implementing strict grazing control, quotas, and monitoring programs is crucial for biodiversity conservation and sustainable forest management (Chen et al., 2023; MacKinnon, et al.,2020; Laurance et al., 2012).

4.10.3. Infrastructure development and settlement expansion

Infrastructure development and settlement expansion contribute to forest change, aligning with studies across Africa and Asia documenting forestland loss due to urbanization (Matlhodi et al., 2019; Mucova et al., 2018; Jellason et al., 2021; Dibaba et al., 2020; Makunga & Misana, 2017; Ahammad et al., 2019). Urban expansion leads to encroachment into forest reserves (Ojija et al., 2024). Infrastructure in forest-dependent communities must be provided while implementing land-use strategies that minimize environmental impacts.

These activities cause habitat fragmentation and biodiversity loss, requiring environmental assessments in development projects (Alamgir et al., 2019; Häkkilä et al., 2017; Siqueira-Gay et al., 2020; Ojija and Nicholaus, 2023). Effective land allocation and promotion of non-timber forest products can support conservation amid urbanization (Fisher, 2010; Ryan et al., 2016; Joppa & Pfaff, 2011).

4.10.4. Governance and policy challenges

Research across Africa, Asia, and Latin America links weak governance and poor policy implementation to illegal logging in PAs (Robson & Klooster, 2019; Tegegne et al., 2016; Fasona et al., 2020; Domínguez & Luoma, 2020; Bertzky et al., 2012). In African contexts, corruption among officials contributes to forest resource exploitation (Duguma et al., 2018; Olaniyi et al., 2019; Lim et al., 2017; Plata-Rocha et al., 2021). These challenges are worsened by poverty and inadequate monitoring (Makunga and Misana, 2017; Erickson and Brase, 2019; Munthali et al., 2019; Nerfa & Zerriffi, 2020). These findings emphasize the need for integrated conservation approaches considering environmental and socio-political factors. While Morales-Hidalgo et al. (2015) reported growth in PAs, declining primary forests in tropical regions indicate designation alone is insufficient without effective governance. Despite legislative efforts (Banuri and Eckel, 2015), conservation success requires addressing fundamental governance challenges. Detailed strategies are discussed in Chapter 5.

4.10.5. Security threats and forest degradation

One finding was that forest communities face security threats, leading to vegetation clearing around protected forest reserves for defence purposes, as mentioned in FGDs. This aligns with Ladan's (2014) study in northern Nigeria, where protected forests in Falgore, Rumah/Kukar Jangarai, Idu, and Gwagwa were cleared due to security threats from criminals, armed groups, and terrorists. Lunstrum and Ybarra (2018) in South Africa reported similar PA decline. These threats restrict conservation activities, reduce protection effectiveness, and damage forest reserves, resulting in biodiversity loss and ecosystem degradation. Implementation of official policies may displace local protection forms, increasing resource exploitation within protected forests and sacred areas. Addressing security threats is essential for PA sustainability and biodiversity conservation (Brandt et al., 2015; Izah and Seiyaboh, 2018).

4.10.6. Climate change and forest dynamics

Climate change threatens biodiversity and protected forest areas, though not the primary driver of gazetted forest change in the study area. The area shows climatic variability with decreased rainfall and increased temperature, potentially impacting forest reserves and biodiversity. While no extreme weather events occurred during the study period, research shows climate change could cause over 70% species loss in PAs (Miranda et al., 2019). It intensifies habitat fragmentation and affects species distribution (MacKinnon et al., 2011; Ranius et al., 2023). Though vital for conservation, PAs may inadequately buffer climate change impacts (John et al., 2020; MacKinnon et al., 2020). Adaptive strategies and expanded conservation efforts are essential (Milad et al., 2011; Socorro, 2023; Senganimalunje et al., 2016). The Nigeria Forest Policy (2020) implementation and Collaborative Forest Management will support sustainable practices and enhance resilience against climate impacts (Akanwa and Joe-Ikechebelu, 2019; Bhatt, 2022, 2023; Socorro, 2023).

4.10.7. Broader implications of forest change

The relationship between the number and complexity of proximate and underlying drivers and forest decline is complex and debatable. However, researchers have conducted numerous studies using various indicators to establish clear cause-and-effect linkages between these factors and human activities in the protected forest areas (Dibaba, et al., 2020; Socorro, 2023). This resonates with the case in this study around these specific forest reserve communities' evidence, as shown in plate 4.1.

Generally, the implications of this study's findings on the reasons for the gazetted forest change suggest that there is a loss of forest cover, with implications for forest composition, biodiversity, and related ecosystems, while the impact of climate change will increase these effects. As the population grows and human activities such as deforestation, urbanization, and other activities rise, these would continue to have many negative impacts on forests (Munthali et al., 2019; Amoah et al., 2022; Härtl and Knoke, 2013). The ongoing human activities and these drivers of change create more impacts which can include the extinction of plant and animal species in the study area, as also reiterated by other scholars' (Dibaba, et al., 2020; Indarto and Mutaqin, 2016).

Continuing LULC dynamics due to human activities and the drivers in the gazetted forest reserves and landscape nevertheless have different implications. For instance, the significant

loss of forest cover in the area has led to increased pressure on the remaining forest patches due to human activities such as agricultural expansion, lumbering, charcoal/fuelwood production, and animal grazing, which hinder natural regeneration and forest sustainability (Klapwijk et al., 2018; Jew et al., 2019; Tesfaye et al., 2010). Ongoing forest conversion could directly or indirectly contribute to the loss of high-conservation priority indigenous tree species of the study landscape in forest reserve areas (Chapters 3 and 5) (Scheren et al., 2021; Tesfaye et al., 2010). The continued conversion of forests or transformation of woodlands within these designated forest reserve areas may result in the loss of these crucial vital tree species. Such loss could occur through direct means, such as the physical removal of trees from their habitats, or indirectly, by modifying the surrounding environment in ways that render it unsuitable for these species to thrive. These indirect effects might include shifts in the local climate, degradation of soil conditions, or the encroachment of non-native species.

This research finding indicates that individuals in the Nasarawa forest reserve communities continue to use forest resources, even in a protected area where there is no longer any closed-canopy forest. This suggests that degraded forest stands are essential to these individuals' livelihoods, and the prevailing perception among the stakeholders, local communities, and policymakers of these lands as worthless is a key driver of deforestation. As local drivers and human activities continue to increase their impact on these protected gazetted forest-dependent communities, the consequences become more severe. Clearly, intervention strategies are necessary to safeguard forest areas from the change and prevent negative environmental and socio-economic consequences in the long term. Although international agreements such as the 2030 Agenda on Sustainable Development and the Paris Agreement on Climate Change address land use and forest change, signatory countries are required to prioritize land use and forest conservation in their national policies and development planning processes. The governmental bodies in charge of the gazetted forest in Nasarawa State of Nigeria need to acknowledge the key drivers and human activity patterns that led to the degradation of this gazetted forest, as revealed in this research, to develop policies that incorporate the forest use needs of the local population. For example, Indonesia has implemented various policies related to the 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 (Akiefnawati et al., 2010) that help reduce the forest cover loss and to retain the ecological integrity of the protected forest. It is crucial to conduct more research of this nature to determine if local communities in Nasarawa State and Nigeria can possess agency in shaping their environment and if

governing bodies genuinely intend to incorporate their desires and aspirations into policy-making processes.

4. 11. Conclusion

Most studies investigating LULCC rely on remote sensing to identify patterns of change over time. However, additional approaches, such as field observations, focus groups, interviews and stakeholder surveys, are essential for accurate fact-checking. These methods are particularly important because they can reveal the perceived magnitude and socioeconomic factors that indirectly drive change and were employed in this study to examine the direct and underlying drivers of LULCC and forest reserve change in the three forest reserves of Nasarawa State's three geo-political zones over a 34-year period.

The study found that drivers of LULCC included agricultural expansion, lumbering for fuelwood/charcoal production, population growth, poverty, and government policies similar in all three forest reserves, though intensity, process and scale vary. Risha and Doma show the highest levels of agricultural expansion and forest degradation, as evidenced by all data sources, while Odu's forest has remained relatively intact due to cultural controls of traditional shifting cultivation. In Risha and Doma reserves, individuals clear land for permanent agriculture; in Odu, land was initially cleared for timber, with agriculture subsequently encroaching. Additionally, a range of drivers (e.g., population growth, poverty, and grazing) gradually influenced the degraded forest, leading to rapid agricultural expansion and now shifting cultivation, which allows gradual to rapid recovery of forest cover experienced in Odu forest, as evidenced in Chapter 3. Agricultural expansion and lumbering for fuelwood/charcoal production were the most cited direct drivers linked to human activities, while population growth, poverty, and government policies were the main underlying drivers from community stakeholders in Doma, Risha and Odu, including experts and officials.

The study concluded that the four decades of LULCC in the gazetted forest reserves in Nasarawa State were primarily driven by the direct and underlying interactions around these 16 drivers. Despite geographical variations, drivers and land use were similar across the three regions, with minor differences in respondents' perceptions. Agriculture activities and population emerged as primary drivers, with increased household participation in farming. Local people influenced LULCC dynamics in response to drivers for survival and livelihood, with similar patterns expected in subsistence agriculture areas. Implementing policies focusing on these key drivers is necessary to prevent unfavorable LULCC shifts in forest

reserves and PAs in north-central Nigeria. Forest reserves and PAs depend on governance, management, socioeconomic factors, and human pressures for sustainability. Forest protection is crucial for biodiversity, climate goals, and local livelihoods, given limited land resources. Land use changes impact future generations, making sustainable forest management essential for sustainable societies. Understanding local contexts that influence forest cover changes helps identify interventions supporting forest protection and local development. Assessing forest resources is crucial for evaluating sustainable forest management practices and informing policy and management initiatives, as well as guiding investments from both the public and private sectors. Securing sufficient forest resources for future generations to fulfil social, economic, and environmental roles is vital for sustainable development.

Chapter 5. Community perceptions on conservation management and sustainability around the protected areas reserves in Nasarawa State, North Central Nigeria

Abstract

The participation of communities in conserving forests and biodiversity in developing countries is crucially important. This study evaluates community involvement in forest conservation around three gazetted forest reserves in Nasarawa State, North Central Nigeria. The study examined the community's perceptions of forest ownership and management in the study area, explored the extent of community involvement in forest conservation, and assessed the community's perception of the future sustainability of forest management. The study employed a mixed methods approach, including household surveys, key informant interviews, and focus group discussions to obtain information from forest-dependent communities. A multistage sampling technique was used to select three forest reserves from the three geopolitical zones of the state, considering also their accessibility and security. Descriptive statistics and content analysis were performed using SPSS, NVivo, and Python 3. Findings indicate mixed understandings and awareness regarding the government's ownership of the forest reserves. Most participants indicated that they were involved in conservation strategies, such as planting trees and that they protected desirable trees, mostly for economic reasons. This is despite shrinking forest cover in the reserves. However, they were concerned about the loss of biodiversity, including animal extinction and environmental impacts. The study found that utilizing community and government laws and governance processes, physically demarcating zones within protected areas, including buffer zones, and establishing alternative sources of livelihood could offer potential as effective strategies for advancing towards sustainability within these reserves. Integrating local knowledge with government institutions, such as the Forestry Commission, in collaboration with local administrative authorities, is crucial for promoting tree planting, implementing policies, and increasing surveillance and security in protected forest areas. These actions can help to ensure effective management and the conservation of these regions for the benefit of communities, society at large, and future generations.

5.1. Introduction

Conservation of forests and biodiversity is an essential aspect of society and has economic, aesthetic, moral, philosophical, and political implications (Brian et al., 2020; Willcock et al., 2017; Ihemezie et al., 2022). Humans depend on forests for their survival due to the numerous ecosystem services and functions that forests deliver (Anwadike, 2020; De Vries and Snep, 2019). Due to the exponential rise in demand for natural resources from a growing population and the growing impacts of detrimental human activities, forests and their biodiversity are nevertheless declining at an alarming rate (Ahammad et al., 2019; Lim et al., 2017). Given the global scope of forest loss, various institutions, environmental organisations, and government bodies, are intensifying their efforts to implement strategies aimed at conserving PAs, including forests, to safeguard biodiversity and the ecological functions of the planet (Walters, 2022; Brady et al., 2019). While they vary in their approaches, community conservation efforts are increasingly common for preserving and conserving biodiversity and natural resources (Sodhi et al., 2010; Ward et al., 2018). This chapter focuses on community perceptions and actions in protected forest conservation.

Forest change processes in Africa are influenced by a wide range of factors, including socioeconomic, environmental, political, and psychological factors that shape conservation outcomes (Chiaka et al., 2024a; Federal Ministry of Environment, 2015). Consequently, the practices and policies adopted by various African nations are distinct, given the substantial diversity that exists among individuals and communities across the African continent (Philips, 2020; Oduro Appiah et al., 2021). The persistent deforestation rates, despite interventions, suggest that numerous policies are either ineffectively implemented or fail to address key drivers of deforestation that affect forest conservation (Van Der Jagt and Lawrence, 2019). These policies often neglect to consider local contexts, such as cultural or socio-economic factors that influence human interactions with forests (Ahammad et al., 2019). In some locations, restoration efforts are needed, as the degradation has gone so far that there is little left to conserve. Despite the implementation of various global and national intervention programmes in different regions of Africa, the effectiveness of these policies could be improved through a comprehensive assessment of the preferences and experiences of different stakeholders, as these also differ from place to place (Phiri and Nyirenda, 2022).

Acharya and Cockfield (2019) have reiterated a distinct ineffectiveness in assessing African forest resources, which can be linked to economic ineffectiveness and an information imbalance. For example, in Bwindi Impenetrable Forest, Uganda, after the national park was gazetted in 1991, several fires were deliberately set, burning 5% of the forest because people

did not understand why the protected area had been established and had not been adequately engaged in the process (Hamilton et al., 2000). Watts and Faasen (2009) showed that within Tsitsikamma National Park in South Africa, local populations engaged in illicit activities to retaliate against command-and-control conservation strategies. Countering these negative experiences, available evidence indicates that including local populations' knowledge and perspectives in decision-making processes about PAs (PAs)PAs increases the likelihood of their compliance and long-term commitment to conservation strategies (Loveridge, 2021; Ankomah et al., 2020; Andrade and Rhodes, 2012).

This chapter considers these issues about community perceptions and actions relating to forest conservation in Nigeria. In Nasarawa State, North Central Nigeria, managing these PAs faces several challenges, including insufficient resources, inadequate stakeholder involvement in current conservation management, and institutional and governance issues (Soul, 2016; Isyaku, 2021). Forest conservation in Nigeria (and in some locations, forest restoration too) is therefore an environmental imperative and vital to the nation’s sustainable development. This chapter aims to evaluate community perceptions of forest conservation measures and their participation in activities to manage natural PAs within forest reserves. Specifically, the objectives

1) to assess community perceptions regarding ownership and management of gazetted forests in the study area,

2) to examine the degree and nature of community involvement in forest conservation activities in Nasarawa State, and,

3) to evaluate community perceptions regarding the sustainability of future forest management practices in their locality.

The chapter makes an important contribution, going beyond the problem of forest depletion as presented in the previous chapter to reveal local perspectives on forest management. In doing so, the chapter provides insights relevant to community conservation practices in developing countries and the kinds of support needed by other stakeholders in delivering co-management, especially where forest depletion is still endemic, and conservation issues remain around the future sustainability of PAs.

The methodology utilised in this chapter is outlined in Chapter 2 and involved gathering quantitative and qualitative data from households and other stakeholders. The study employed a rigorous and systematic approach to data collection and analysis to ensure the

validity and reliability of the findings. A total of 252 structured and semi-structured questionnaires were distributed, and 40 key informant interviews (KIIs) and eight focus group discussions (FGDs) were conducted with forest-dependent local people, local leaders, government officials, and forest experts. The data was analysed using a mixed-methods approach. Using IBM SPSS version 21 and Python 3, descriptive statistics were employed to code and analyse the data. Qualitative data was analysed using NVivo software, and content analysis was used to extract relevant content and codes from the KIIs and FGDs.

5.2. Results and discussion

This section presents household survey respondents' perceptions and evaluates the qualitative insights from the KII and FGD on perceived ownership and management of gazetted forests in the study area, examines the community perceptions of the conservation strategies, reason for the conservation of forest, concerns about the change and future change in the gazetted forests and evaluates community perceptions regarding the sustainability of future forest management practices.

5.2.1. Community perception on the ownership and management of the forest reserves in the study area

Analysis of the 252 household surveys provided an overview of the communities' perceptions of the ownership and management of the forest reserves in the study area (Table 5.1), while KIIs provided qualitative insights (Table 5.2).

Table 5. 1. Community perceptions of the ownership and management of the forest reserves in the study area (as collected during the household survey)

Variables with responses	**Doma**		**Risha**		**Odu**		**Total**	
Awareness of gazetted reserves	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Yes	83	99	84	100	84	100	251	99
No	01	01	00	0	00	0	01	01
Ownership								
Community ownership	20	24	82	98	68	81	170	67
State Government	64	76	02	02	16	19	82	33
Permission to enter the Forest								
Community leaders	15	18	84	100	52	62	151	60
Government	68	81	00	0	31	37	99	39
Nil	01	01	00	0	01	1	02	1
Effectively Managed								
Strongly Agree	18	21	08	10	27	32	53	21
Agree	29	35	12	14	06	07	47	19
Disagree	19	23	52	62	17	20	88	35
Strongly Disagree	18	21	12	14	34	41	64	25
Neither Agree Nor Disagree	00	0	00	0	00	0	00	0
Sources for Livelihood								
Strongly Agree	40	48	54	64	45	54	139	55
Agree	22	26	19	23	17	20	58	23
Disagree	08	09	05	06	18	21	31	12
Strongly Disagree	14	17	06	7	04	5	24	10
Neither Agree Nor Disagree	00	0	00	0	00	0	00	0
Use by people Closer to the Reserve								
Strongly Agree	69	82	71	95	80	85	220	87

Agree	15	18	13	5	04	15	32	13
Disagree	00	0	00	0	00	0	00	00
Strongly Disagree	00	0	00	0	00	0	00	00
Neither Agree Nor Disagree	00	0	00	0	00	0	00	0
Future Safety of the Gazetted Forest								
Strongly Agree	01	1	11	13	39	46	51	20
Agree	17	20	06	7	07	8	30	12
Disagree	25	30	46	55	20	24	91	36
Strongly Disagree	41	49	21	25	18	21	80	32
Neither Agree Nor Disagree	00	0	00	0	00	00	00	0

Table 5.2. KII qualitative insights and perceptions of the ownership and management of the forest reserves in the study area

Participants' Group	**Key response (s) on ownership**
Local People (Doma Reserve)	*"This reserve is owned by our community as our ancestral forest land, passed down from our great-grandparents. However, the government later took control and managed the resources within the forest. Therefore, ownership can be seen as shared between the government and the community, as the community remains the primary user of these resources."* (Doma Local leader, KII 005, June 2022)
Community Leaders (Doma Reserve	*"The gazetted forest reserve is owned by the community and is controlled by the government"* (Doma Local leader, KII 002, June 2022)
	Key response (s) ownership

Local People (Risha Reserve)	*"The reserve originates from ancestral forest land passed down from great-grandparents. However, the government later assumed control and managed the forest's resources without adequately compensating our present generations. Consequently, the reserve is now considered jointly owned by the community and government* (Risha Local people, KII 001, June 2022)
Local leader (Risha Reserve)	*"This Doma gazetted forest reserve was designated by the state government, meaning it is legally recognized as government-owned reserve,but on the other way round it is also owned or belongs to the community and is controlled by both the government and community people"* (Risha Local leader, KII 004, June 2022)
Participants' Group	**Key response (s) ownership**
Local People (Odu Reserve)	*"The gazetted forest reserve is owned by the community; however, the government seeks to assert control over it. The reserve originates from ancestral forest land passed down from great-grandparents. Without missing words, this reserve is now considered community-owned, although some individuals believe it belongs to the government."* (Odu Local People, KII 002, June 2022)
Community Leaders Odu Reserve	*"This reserve is owned by our community, as our ancestral forest land from our great grandparents, we control any resources from the forest, not the government"* (Odu Local People, KII 002, June 2022)
Experts	"*Over 90% of reserves are controlled by the government. However, some reserves are controlled by an ethnic group or community, and then some reserves are controlled by the closest communities that are utilising them… Other reserves are still owned by the government" (*Expert, KII 003 June 2022).
Government Official	"*The forest reserve belongs to the government, before a forest reserve is gazetted, affected landowners in the community are compensated, and agreements are established. While communities retain rights to water, worship, and resource collection, activities like farming and wood cutting are restricted. Agroforestry is allowed under regulated conditions, ensuring sustainable coexistence with the forest ecosystem".* (Government Official, KII 003 June 2022).

When asked about the ownership and management of the gazetted forest in the study area, Analysis of the survey responses reveals notable differences in perceptions and practices among the three forest communities (Table 5.1). One of the clearest contrasts is in perceived ownership: while Doma respondents largely identify the state government as the owner and manager of the forest reserve, communities in Risha and Odu overwhelmingly regard the reserves as community-owned. This distinction is mirrored in the processes for obtaining permission to use forest resources. In Risha, for instance, all respondents report seeking permission from community leaders, whereas in Doma, the vast majority rely on government authorization. Odu presents a mixed approach, with permissions sought from both community leaders and government authorities, suggesting a more hybrid governance perception.

Perceptions of management effectiveness also vary substentially. Doma stands out as the only community where a majority view management as effective, yet even here, concern about the forest's future remains high. In contrast, respondents from Risha and Odu express substantial dissatisfaction with reserve management. Despite this, a majority in Odu believe the forest has a secure future, indicating a disconnect between current management evaluations and long-term outlook.

Finally, the degree of dependence on the forest for livelihoods is strongly affirmed across all sites, but especially in Risha, where almost nine in ten respondents report reliance on forest resources. This high level of dependence may partly explain the community’s strong support for community ownership and management structures, reflecting a desire for local control over critical resources.

By focusing on these key contrasts ownership perceptions, permission structures, views on management effectiveness, and future outlooks this analysis highlights the complex and varied relationships communities have with forest reserves, going beyond the statistical summary provided in the table 5.1.

Key Informant Interviews (KIIs) revealed significant discrepancies in perceptions regarding the ownership and management of gazetted forest reserves, reflecting a complex and often contested socio-political landscape. While these reserves are legally owned and managed by the state government, local stakeholders frequently articulated contrasting interpretations of this arrangement.

Participants from expert and governmental backgrounds consistently emphasized that the vast majority of forest reserves are under state control. For example, the experts noted that

over 90% of reserves are controlled by the government, while acknowledging that certain reserves are also claimed by ethnic groups or local communities depending on proximity and historical usage (Table 5.2). This view highlights the formal legal framework but also hints at overlapping and informal claims.

In contrast, responses from local community members presented varied and sometimes contradictory understandings. For instance, the local leader in Doma reveal that the gazetted forest reserve is owned by the community and is controlled by the government (Table 5.2), indicating a duality in perceived ownership. Meanwhile, the participants from Odu community firmly asserted ancestral ownership, claiming the forest as their ancestral forest land from their great grandparents and explicitly rejecting government control (Table 5.2)

The close split in perceptions suggests confusion or ambiguity about the roles of the government and the communities. The legal frameworks governing gazetted forests in the area, typically are officially designated by the government, which implies that the state holds ownership and management responsibilities. However, communities might also have traditional rights or co-management roles based on the specific legal arrangements for the gazetted forest governance status. The conflicting responses highlight the need for clearer communication or education about the governance structure of the forest reserves to align local perceptions with the actual legal situation. However, chapter one clarifies the legal situation regarding gazetted forests in Nigeria's specific forest governance framework, indicating that when a forest is "gazetted", it becomes legally designated as a PA under state authority, implying that the government holds primary ownership and management responsibility. This designation is formalised in legal documents such as forest laws and policies, and the national constitution. For instance, Nigeria has developed a comprehensive set of forest policies over time (Chapter One), including the National Forest Policies (1988, 2006, 2020) and the Forestry Law (1999) that outline the state's role in protecting and managing these forests.

5.2.2. Community perceptions of the conservation strategies in the study area

This section considers the communities' perceptions of conservation strategies in the study area, with results summarised in Table 5.3. Qualitative KIIs and FGDs are shown in Table 5.4. Each of these concepts plays a role in community perceptions of conservation strategies. The effectiveness of these strategies depends on whether they align with local priorities, respect community needs, and involve the community in decision-making and implementation.

Table 5. 3. Summary data showing community perceptions of the conservation strategies in the study area

Variables Responses (%)	**Doma**		**Risha**		**Odu**		**Total**	
Planting Trees	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Yes	71	85	77	92	71	85	219	87
No	13	15	07	08	13	15	33	13
Protect Desired Trees								
Yes	80	95	73	87	81	96	234	93
No	4	05	11	13	03	04	18	07
Protecting Areas Forest								
Yes	81	96	84	100	84	100	165	99
No	3	04	00	0	00	0	87	01
Clear Use Rights								
Yes	64	76	68	81	77	92	209	83
No	20	24	16	19	07	08	43	17
Forest Management								
Yes	82	98	76	90	76	90	234	93
No	2	02	8	10	8	10	18	07
Local Rules								
Yes	82	98	78	93	84	100	244	97
No	2	02	6	07	00	00	8	03
Protective Mechanism								
Yes	83	99	75	89	83	99	241	96
No	01	1	09	11	1	01	11	04
Enacted Enforce Law								
Yes	82	98	82	98	84	100	248	98
No	2	2.38	2	02	00	0	4	02
Mapping Inventory								
Yes	76	90	78	93	78	93	232	92
No	8	10	6	07	6	07	20	08

Table 5.4. KII qualitative insight for community perception on conservation strategies of the forest reserves in the study area

Participants' Group	**Key response (s) conservation strategies**
Doma Local people	*"There have been no robust conservation strategies in this area since the 1990s. While stakeholders and the government once relied on local rules to restrict the cutting of specific trees, these measures are no longer effective in addressing conservation efforts." (*Doma Local people KII 002, June 2022).
Doma Local leaders	*"We have community hunter guards attached with forest guards to safeguard the forest reserve. We don't have a concrete measure in the community for conservation and tree planting. However, we encourage not cutting down economy trees and practice tree planting. We call farmers and advise them not to cut down or burn economy trees like shear trees, locust beans, mangoes, and other valuable tree plantations* (Doma local people KII 005, June 2022)
Local People (Risha Reserve)	"*We always conserve economy trees in the forest. We don't cut down economy trees- valuable species that give us things such as shea butter, locust beans, and mango trees. Additionally, we plant trees in our homes, not in the forest, such as mangoes, baobab, cashews, oranges, and more, to provide edible fruit and other benefits to the community and beyond"* (Risha local people KII 005, June 2022).
Risha Community leaders	*"Frankly speaking, I don't see any tangible conservation strategies in this forest area. The forest cover has been depleted, and the only replanting efforts seem to involve mango trees and other edible fruits"* (Risha local people KII 001, June 2022).
Odu Local Local people	*"We have community hunter guards attached with forest guards to safeguard the forest reserve and we cut only section of the forest areas and leave some desired part of the forest to regrowth"* (Odu Local people KII 003, June 2022). "*There is no conservation measure in the gazetted forest reserve; we only plant valuable trees at home*" (Odu Local people KII 005 June 2022).
Odu Community leaders	"We have*, a shrine called 'buka' is inside the forest reserve to stop people from cutting down trees. Anyone who violates it will face consequences such as a beating, striking and so on. Again, our traditional security guards are around the reserve to protect it"* (Odu Local Leaders KII 002, June 2022).

When asked about the conservation strategies they are involved in within the study area (see Table 5.3), participants highlighted several key concepts that shape community perceptions of these strategies. The effectiveness of conservation efforts depends on how well they align with local priorities, respect community needs, and involve local people in both decision-making and implementation. Across the three forest reserves studied, respondents overwhelmingly expressed support for various conservation activities, as reflected in the quantitative data. However, notable differences emerge when examining specific community responses. For instance, while Risha reported the highest involvement in tree planting, this contrasts sharply with the near-total forest cover loss observed in the area (see Chapters 3 and 4). This discrepancy suggests a gap between stated intentions and actual environmental outcomes. Similarly, although support for forest management was high overall, only 10% in Risha and Odu reported active involvement, raising questions about the depth of engagement despite declared support.

Another key difference lies in the use of local conservation rules. The Odu community showed unanimous support for locally driven regulations, in contrast to Risha, where a notable minority did not recognize or apply such rules. This may indicate stronger community cohesion or more established traditional governance structures in Odu.

Moreover, while protective mechanisms such as gazettement were broadly supported, Risha again lagged slightly behind Doma and Odu, possibly reflecting different perceptions of state-led conservation or enforcement challenges. By focusing on these areas of divergence between stated behavior and observed outcomes, between communities, and between regulatory frameworks this section adds context and analytical depth to the numerical findings presented in Table 5.3.

The qualitative findings shed light on the underlying motivations and strategies driving individual and collective participation in forest conservation across the study sites (Table 5.4). Stakeholders widely recognised the importance of forest protection, highlighting activities such as the enforcement of community laws, reduction in tree felling, and efforts to preserve forest boundaries. A key motivator was the increased awareness of forest biodiversity and its role in sustaining both environmental and community wellbeing.

Several recurring conservation strategies emerged from the interviews and focus group discussions. One prominent approach was the establishment of community-based monitoring systems, including the use of local security guards and hunters to patrol forest areas. Tree planting also featured strongly across all communities, with a distinction made between trees planted within domestic spaces and those preserved in forested areas. So-

called “economy trees” species such as mango, baobab, teak, mahogany, cashew, and eucalyptus were seen as especially valuable due to their economic utility. These trees contribute to local livelihoods through the provision of food, timber, fuelwood, and materials for furniture-making and construction industries. However, while valued, their cultivation was often directed towards home environments rather than forest reserves, partly to avoid overexploitation of the forest ecosystem.

A key difference across communities related to the role of cultural and spiritual practices in conservation. In some areas, such as Odu forest, traditional institutions and beliefs played a more formalised role in safeguarding forest areas. These included shrines (e.g., the *buka*) and masquerade rituals, which act as both spiritual deterrents and community-enforced governance mechanisms. Such practices were said to confer sacred status on certain forest zones, discouraging unauthorised activities through fear of supernatural retribution or community-imposed sanctions. In contrast, participants from other communities, such as Risha, placed less emphasis on spiritual governance and more on practical conservation, particularly the domestication of valuable tree species for private use.

Despite these efforts, inconsistencies in governance were noted. While some communities implemented clear conservation measures within forest reserves, others reported the absence of formal strategies in gazetted forests. This disconnect points to differing levels of institutional support and community engagement in forest management and highlights the need for targeted interventions that consider local values, governance systems, and forest tenure dynamics.

Overall, these findings suggest active community involvement in forest conservation activities. However, the decline in forest area presented in Chapter 3 suggests that these efforts have not been delivering the intended benefits, particularly for the Doma and Risha reserves. This raises concerns about the effectiveness of these efforts, although the Odu forest appears to show more positive results, with noticeable improvements in forest cover suggesting local conservation practices are more successful in conserving the forest (Chapter 3). The gap between reported community involvement and actual outcomes indicates underlying factors undermining conservation efforts, such as the effectiveness of government and local regulations and enforcement, monitoring and evaluation, external pressures, capacity and resources, and the community's socioeconomic context. Economic pressures may drive individuals to harm the forest despite a communal commitment to conservation, especially when alternative livelihoods are not provided to reduce reliance on

forest resources. People can be simultaneously involved in activities that cause both deforestation and conservation.

These results offer valuable insights for policymakers, conservationists, and researchers working on sustainable conservation strategies, highlighting the need to manage diverse viewpoints and understandings. Findings revealed both the conservation strategies and barriers to effective conservation governance.

5. 2.3. Community perceptions on drivers and reasons for forest conservation in the study area

This section presents further findings linked to community understandings and perceptions, regarding the drivers and reasons for forest conservation in three study areas (Table 5.5 and 5.6).

Table 5. 5. Community perceptions on drivers and reasons for forest conservation in the study area

Variables Responses in Percentage	Doma			Risha		Odu		Total
Community perceptions on the reason for the conservation	**n**	**%**	**n**		**n**	**%**	**n**	**%**
Conserve for Local Development								
Strongly Agree	76	91	84	100	84	100	244	96
Agree	07	08	00	0	00	0	07	03
Disagree	01	01	00	0	00	0	01	01
Strongly Disagree	00	0	00	0	00	0	00	0
Neither Agree Nor Disagree	00	0	00	0	00	0	00	0
Conserve for Income								
Strongly Agree	63	75	83	99	68	81	214	85
Agree	21	25	01	01	16	19	38	15
Disagree	00	0	00	0	00	0	00	0
Strongly Disagree	00	0	00	0	00	0	00	0
Neither Agree Nor Disagree	00	0	00	0	00	0	00	0
Conserve for Local Participation								
Strongly Agree	62	74	84	100	71	85	217	86
Agree	22	26	00	0	13	15	35	14
Disagree	00	0	00	0	00	0	00	00
Strongly Disagree	00	0	00	0	00	0	00	00
Neither Agree Nor Disagree	00	0	00	0	00	0	00	00
Conserve for Natural Environment								
Strongly Agree	66	79	83	99	70	83	219	86
Agree	18	21	01	01	13	16	33	13
Disagree	00	0	00	0	01	01	01	01
Strongly Disagree	00	0	00	0	00	0	00	0

Neither Agree Nor Disagree	00	0	00	0	00	0	00	0
Conserve for Community Land Rights								
Strongly Agree	59	70	82	98	66	78	207	82
Agree	23	28	2	02	15	18	40	16
Disagree	02	2	0	0	00	0	02	01
Strongly Disagree	00	0	00	0	03	04	03	01
Neither Agree Nor Disagree	00	0	00	0	00	0	00	0
Conserve for Carbon Stock								
Strongly Agree	60	72	79	94	73	86	212	84
Agree	24	28	05	56	10	11	39	15
Disagree	00	00	00	0	01	01	01	01
Strongly Disagree	00	0	00	0	00	0	00	0
Neither Agree Nor Disagree	00	0	00	0	00	0	00	0
Conserve for Solution Land Conflict								
Strongly Agree	59	70	73	86	73	87	205	81
Agree	25	30	08	10	09	11	42	17
Disagree	00	0	00	0	02	2	02	01
Strongly Disagree	00	0	03	04	00	0	03	01
Neither Agree Nor Disagree	00	0	00	0	00	0	00	0

Table 5.6. KII qualitative insights on drivers and reasons for forest conservation of the forest reserves in the study area

Participants' Group	**Key response (s) Conservation driver reason**
Doma Local People	*"Because it provides and protects biodiversity such as valuable plants and animal species for both the community and wider society resources use and it regulates climate change such as reduce heat and prevents desertification for our benefit and for the future generations"* (Doma Local people KII 005 June 2022).
Doma Local Leader	*"Our forests are the only place where our carbon is stored. For example, the forest influences the climate by regulating the micro-climate of an area where you have a lot of trees, and that is the only place where you still find water; ecosystem services are always available there. It protects biodiversity and serves as a means for the economy and livelihood of people; you can see how our forest is important in all these things"* (Doma Local leader KII 002, June 2022).
Risha Local Reserve	*"Conserving the reserve is essential for safeguarding biodiversity, sustaining ecosystems, reinforcing governance, preserving cultural heritage, supporting local livelihoods, and promoting eco-tourism, making it a cornerstone of sustainable development"* (Risha Local leader KII 003, June 2022).
Risha Local leader	*"Conserving forest is important for livelihood opportunities and sustaining ecosystem and biodiversity for both the local communities and for the society development"* (Risha Local leader KII 003, June 2022).
Odu Local people	*"It is important to conserve forests to sustain the environment, such as preserve the wildlife there and the biodiversity too. Some of our people use it as a shrine for traditional rituals and ceremonies, protecting us from enemies who want to fight against our ancestral land. It can also serve as a tourist centre, especially if the wildlife is seriously conserved. It can act as a holiday resort, and people can visit for educational purposes. Therefore, I think the gazetted forest is conserved for political, social, cultural and tourist use with sources of livelihood"* (Odu Local People KII 005, June 2022).
Odu Local leaders	*The conservation of this forest greatly helps for the preserving our cultural heritage, supports local livelihoods and biodiversity, and promotes faith for future generations.* (Odu Local leader KII 001, June 2022).

Responses regarding the extent to which the forest should be conserved and for the change in the forest in the area (Table 5.5) indicated a strong perceived link between conservation and development. The responses across the three forest reserves (Doma, Risha, and Odu) revealed a shared recognition of the role of forest conservation in supporting local development. However, notable differences emerged in the strength and uniformity of that perception. While Risha and Odu demonstrated unanimous or near-unanimous strong agreement that conservation contributes to local development, responses from Doma were slightly more varied, with a portion of respondents expressing agreement rather than strong agreement. This suggests that while the link between conservation and development is recognized across all sites, in Doma it may be perceived with slightly less intensity potentially due to different local development trajectories or experiences with forest-related interventions.

Perceptions around conservation as a source of income also varied. Risha again showed the highest level of strong agreement, while Doma exhibited a more even distribution between strong agreement and agreement. Odu, although supportive overall, had the lowest proportion of strong agreement and a small but notable group of respondents who only agreed rather than strongly agreed. These variations may reflect differing levels of direct economic benefit from conservation initiatives, such as eco-tourism or forest-based enterprises, which may be more established or accessible in Risha than in the other two sites.

Environmental motivations for conservation were widely acknowledged, Risha stood out for its near-unanimous strong support. Doma and Odu showed greater variation, with some respondents selecting agreement rather than strong agreement, and a very small proportion in Odu expressing disagreement. These differences may be attributed to local variations in environmental degradation or ecological awareness, which could influence how communities perceive the importance of conserving natural ecosystems.

Regarding the right to community-led conservation and carbon stock preservation, Risha consistently showed the strongest consensus, whereas Doma and Odu revealed more mixed views. In Doma, a significant number of respondents agreed rather than strongly agreed on both counts, while in Odu, a small minority even expressed disagreement concerning land rights and carbon stock conservation. This suggests that while these values are generally supported, local governance issues or contested land tenure arrangements particularly in Odu might shape how these conservation goals are received.

Furthermore, while all three communities recognized conservation's role in mitigating land conflicts, disagreement was more apparent in Risha and Odu than in Doma, where no

disagreement was reported. This could reflect active or historical land disputes in Risha and Odu, which may influence how residents view the effectiveness of conservation in resolving such tensions.

Overall, while broad consensus exists on the value of forest conservation, whic shows that all three reserves exhibit strong support for conservation as a tool for local development and participation, reflecting a shared perception that it contributes to economic and social benefits. The differences across the reserves point to local factors such as economic conditions, governance structures, environmental awareness, and land tenure dynamics that shape community-specific conservation narratives.

Qualitative insights from KIIs across the three study communities consistently emphasized the multifunctional importance of the gazetted forest, highlighting a wide range of environmental, ecological, social, cultural, political, and economic reasons for its conservation Table 5.6.

A key environmental theme across the responses was the forest's role in regulating local climate and maintaining ecosystem services such as water availability and carbon storage. Ecological concerns were similarly prominent, with frequent references to biodiversity protection and the forest's role as a habitat for wildlife. Social and economic perspectives also emerged strongly, particularly the forest's contribution to local livelihoods, both directly through resource use and indirectly through tourism potential.

Notably, cultural and spiritual values were especially emphasized in some communities. For example, respondents from Odu highlighted the forest's use as a site for traditional rituals and as a symbol of ancestral protection. This contrasts with Doma, where the emphasis leaned more towards the forest's ecological functions and its contribution to local microclimate and livelihoods.

Differences also emerged in how conservation was linked to development. While all communities acknowledged the forest's economic potential, only some explicitly connected conservation to broader political or strategic concerns, such as territorial protection or future tourism infrastructure. This suggests varying priorities and conceptions of conservation across local contexts.

This section reveals a connection between forest conservation and local development, demonstrating that communities view conservation as essential for both the environment and their livelihoods. This understanding is crucial for integrating conservation efforts into broader development plans and promoting sustainable livelihoods. It also highlights the cultural significance of forests in local communities, including their role in traditional rituals and ceremonies to preserve forest areas. In summary, the section insights further emphasize the multifunctional importance of forests, ranging from environmental and economic benefits to cultural, social, and political significance. Together, these perspectives reinforce the critical need for continued conservation efforts tailored to the unique contexts and priorities of each community.

5.2.4. Community perceptions on concerns for the change and the future forest conservation in the study area

This section presents both quantitative and qualitative insights into community perceptions regarding forest changes and their future concerns. Tables 5.7 and 5.8. summarize community responses on their concerns about forest changes and the future conservation of gazetted forest reserves across three regions.

Table 5.7. Community perceptions and concerns for the change and the future of forest conservation in the study area

Variables Responses in Percentage	**Doma**		**Risha**			**Odu**		**Total**
Community perceptions on concern for the change and the future of the gazetted forest conservation	**n**	**%**	**n**		**n**	**%**	**n**	**%**
Concern about the Forest Change								
Being concerned	20	24	19	23	09	11	48	19
Being very concerned	64	76	65	77	75	89	204	81
Not concerned	00	0	00	0	00	0	00	0
Future Concerns of the Forest Change								
A Fair amount	17	21	10	12	03	04	30	12
A lot	67	79	73	87	81	96	221	87
Not at all	00	0	01	01	00	0	01	01

Table. 5.8. KII qualitative insight for community perception on their concern for the change and about the future conservation of the forest reserves in the study area

Participants' Group	**Key response (s) Concern about the future conservation**
Doma Local people	*"I am seriously concerned because I am seeing desertification coming towards us here, an increase in heat, and a loss of biodiversity…this would affect future generations"* (Doma Local people KII 005 June 2022)
Doma Local leaders	*"We have concerns about the loss of forest cover vegetation and forest resources such as biodiversity, including important plant and animal species which are our sources of livelihood. This is a danger to our children since the future generation in this area will have no forest, given the rate of degradation that has occurred in this forest reserve"* (Doma Local people KII 004 June 2022)
Risha Local people	*"We worry about the loss of vegetal cover and loss of forest resources such as loss of important plants and animal species which are our sources of livelihood, showing us that there will be no vegetation soon for the future generation in this area"* (Risha Local people KII 005 June 2022)
Risha Local leader	*"Our primary concern is the depletion of forest cover and consequent loss of resources, which previously provided essential benefits to our local community. This depletion has placed livelihoods at risk, affecting agricultural productivity. The decline in forest cover and soil fertility, attributed to the absence of organic manure from trees, poses a significant threat to future generations in the region"* (Risha Local leader, KII 005, June 2022)
Odu Local people	*"My concern for the change in the reserve covers is the exposure of our secret traditional worship places, which is dangerous for future generations to connect spiritually with our ancestors through the forest cover in our area"* (Odu Local people KII 005 June 2022).
Odu Local leader	*"Our concern regarding the change in the reserve covers in this area is not only the exposure of our sacred traditional worship sites, but also the economic loss it may bring. This endangers future generations' ability to connect spiritually with our ancestors through the forest cover, while also diminishing the potential economic benefits these reserves provide to our community."* (Odu Local People, KII 005, June 2022).

When the participants were asked about their concerns regarding the change of the state of the gazetted forest reserves and concern for the future generation, the data presented in Table 5.7 indicate widespread concern among respondents across all three forest reserves regarding ongoing changes to the forest landscape. Over 85% of participants expressed apprehension, suggesting a broadly shared recognition of the negative implications of these changes for the forest's preservation and sustainability.

Notably, concern levels vary across the three communities. Odu demonstrates the highest level of immediate concern, with a strong majority of respondents indicating a heightened sense of urgency regarding the forest's condition. This contrasts slightly with Doma and Risha, where concern remains high but marginally less intense. The distribution of concern highest in Odu, followed by Risha and Doma may reflect differing local dependencies on the forest or varying degrees of perceived vulnerability due to environmental or cultural factors. Clearly, these results suggest that the community's future concerns are aligned with current concerns, but they are more acute in Odu, possibly due to the cultural and traditional value of and perceived vulnerability of the change to the forest.

In summary, while all three communities exhibit substantial concern about both current and future changes to the forest reserves, Odu consistently reports the most intense levels of worry. This pattern underscores the importance of place-based perceptions and cultural values in shaping environmental attitudes. This comparative analysis highlights the differences in perception and suggests possible contextual explanations for the observed patterns.

When asked why they were very concerned about the change to the reserves, also considering future generations KIIs insights (Table 5.8). Community members expressed strong concerns about gazetted forest reserves' degradation, particularly regarding future generations' wellbeing. These concerns highlighted biodiversity loss, climate change, and critical resource depletion, with variations across communities. A key theme was biodiversity loss, with references to species vital for livelihood, culture, and ecology. Risha and Doma communities emphasized the loss of forest-dependent species, linking this to food insecurity and reduced livelihood options. Odu participants focused on cultural and spiritual losses, noting forest degradation's impact on traditional worship sites and cultural transmission.

Climate-related concerns were prominent, with Doma respondents connecting forest loss to rising temperatures, desertification, and altered weather patterns, which threatened agricultural sustainability. Communities highlighted declining ecosystem services, including

fuelwood and lumber availability. Risha stakeholders noted reduced forest materials for construction and energy, affecting poorer households particularly. While environmental degradation, climate vulnerability, and cultural disruption were consistent themes, emphasis varied by location. Risha prioritized resource depletion, Doma emphasized climate and biodiversity, and Odu focused on cultural heritage, suggesting conservation interventions must be locally tailored.

This section reveals a profound and widespread concern among community members regarding the ongoing changes to the gazetted forest reserves and their implications for future generations. This concern stems from the perceived threats to biodiversity, environmental stability, and cultural traditions, as well as the anticipated impacts of climate change and the loss of vital forest resources. Stakeholders overall showed a good degree of awareness, revealing concerns about the impact of climate change on forests and future generations, and providing valuable insights into the relationship between environmental conservation and climate change. Recognising community perceptions of climate change risks and vulnerabilities is crucial for developing resilience-building measures and adaptive strategies and provides an additional driver of forest conservation efforts. Moreover, the alignment of current and future concerns underscores the communities' deep recognition of the forest's critical role in their livelihoods, environment, and heritage, emphasizing an urgent need for sustainable conservation efforts to address these pressing issues.

5.2.5. Community perceptions of forest management and sustainability in the study area

This section presents the options considered by the community to support forest sustainability, with results summarised in Tables 5.9-5.15

Table 5. 9. Community perceptions of options for forest sustainability in the state.

Variables **Responses (%)**	**Doma**		**Risha**		**Odu**		**Total**	
Community perception options for forest sustainability in the state	**n**	**%**	**n**	**%**	**n**	**%**	**n**	%
Tree Planting Campaigns								
Very important	67	80	75	89	81	96	223	88
Important	17	20	09	11	03	04	29	12
Less important	00	0	00	0	00	0	00	0
Not important	00	0	00	0	00	0	00	0
Individual Tree Plantation								
Very important	58	69	78	93	79	94	215	85
Important	25	30	6	7	05	06	36	14
Less important	01	01	00	0	00	0	01	01
Not important	00	0	00	0	00	0	00	00
Private NGO Plantation								
Very important	60	71	81	96	80	95	221	88
Important	24	29	03	04	04	05	31	12
Less important	00	0	00	0	00	0	00	0
Not important	00	0	00	0	00	0	00	0
Stop Deforestation								
Very important	66	79	79	94	79	94	224	88
Important	17	20	05	06	05	06	27	11
Less important	01	01	00	0	00	0	01	01
Not important	00	0	00	0	00	0	00	0
Alternative Fuelwood								

Very important	63	75	79	94	78	93	220	87
Important	19	23	05	06	05	06	29	12
Less important	01	01	00	0	01	1	02	01
Not important	01	01	00	0	00	0	01	0
Alternative Source of Livelihood								
Very important	50	59	60	72	65	77	175	70
Important	22	26	20	24	14	17	56	22
Less important	08	10	02	02	03	04	13	05
Not important	04	05	02	02	02	02	08	03
Community Forest Security								
Very important	66	80	81	96	80	95	227	90
Important	18	20	03	04	03	04	24	09
Less important	00	0	00	0	01	01	01	01
Not important	00	0	00	0	00	0	00	0
Inputs Loan to Farmers								
Very important	58	69	82	98	73	87	213	84
Important	25	30	02	02	08	09	35	14
Less important	01	01	00	00	03	04	04	02
Not important	00	0	00	00	00	0	00	0

Table 5.10. KII qualitative insight for community perception on management and sustainability in the study area

Participants' Group	Key response (s) Gazetted forest management and sustainability
Doma Local people reserve	*"The government, community and even individuals should encourage tree planting particularly the indigenous tree species for multiple benefits while district heads should help in safeguarding the forest" (*Doma Local people KII 005, June 2022).
Doma leaders reserve	*"The stakeholders regarding gazetted forest management must wake up to emphasise the necessity of inclusive governance, community engagement, and stringent enforcement of sustainability practices to ensure long-term forest health and equitable resource utilization* (Risha Local People KII 002, June 2022).
Risha Local people	"*Government should provide employment opportunities that will benefit the people in the forest community areas. Such employment will reduce the rate of farming activities in the forest area. This will lead to generating income for the community as another alternative livelihood and the gazetted forest will be sustained"* (Risha Local People KII 001, June 2022)
Risha Local leaders	*" The government should create initiatives that will contribute to generating income for the community, providing an alternative means of livelihood that can enhance their economic stability. This can ensure the gazetted forest preservation and sustained for future generations, striking a balance between development and environmental conservation"* (Risha Local leader KII 004, June 2022)

Odu Local people	*"The community laws should be enforced more by the traditional ruler while Government should come and build a fence to cover the forest boundaries and promote them into a zoo, this would enhance their sustainability for now and for the future"* (Risha Local People KII 002, June 2022). "G*overnment and community should add security men to safeguard the forest for our future generation"* (Odu Local People 005, June 2022).
Odu Local leader	"*A shrine should be allowed inside the forest reserved by the community; this will stop people from cutting trees in the reserves. Any person that goes into the forest reserve area intending to destroy the trees in the reserve shall be revealed to the security guard, and the punishment will follow"* (Odu local leader, KII 002, June 2022)
Expert	*"Yes, creating awareness, sensitising the communities on tree planting campaign, teaching the community how to plant trees, lecturing them about environment law, and getting them involved in planting a tree will go a long way in sustaining this forest for their use and for the future people"* (Expert KII 004, July 2022). *"Non-Governmental Organizations can also help in organising seminars, free lectures, even free tree planting campaigns. They can help to sensitise people on how to minimise the poaching in the forest or destruction of the forest products and support the sustainable use of the forest resources"* (Expert KII 003, June 2022).
Government Official	"*the community people should be provided with alternative sources of cooking energy and incentives such as electric cookers, stoves, or gas cylinders and taught how to use and sustain them, with proper monitoring and programmes for the protection of the gazetted forest, by adequately funding the monitoring of the forest"* (Govt. Official KII 005, June 2022).

When asked their opinion on forest management and sustainability, participants expressed that sustainable options for the forest include tree planting campaigns, individual tree planting, private or NGO plantations, alternative sources of fuelwood and alternative energy, input loans to farmers, stopping deforestation, and community forest security (forest guards).

The household questionnaire results (Table 5.9) show broad consensus across Doma, Risha, and Odu communities regarding forest conservation strategies, though with meaningful differences in responses to specific measures. A key divergence concerns alternative energy sources to reduce fuelwood dependence. While Risha and Odu communities view this as crucial, Doma shows less enthusiasm, possibly reflecting limited access to alternatives or skepticism about feasibility. Attitudes toward private and NGO-led plantations also vary. Risha and Odu show strong support, indicating higher trust in external forestry initiatives, while Doma maintains a more reserved stance. Regarding deforestation, Risha and Odu demonstrate near-unanimous support for halting it, while Doma residents appear less alarmed, possibly due to differences in forest pressure or economic dependence.

Risha shows strongest endorsement on provision of loans to farmers, with nearly all respondents rating it very important. Odu shows varied responses, while Doma shows moderate perceived importance. These variations in loan perception likely reflect local economic contexts and agriculture's role in forest management. While there is overall agreement on community forest security importance in the response. This suggests that community forest security is universally regarded as crucial for Doma, Risha and Odu. This suggests a generally strong consensus on the need for forest security for the management and sustainability of this forest.

KIIs revealed strong support among the stakeholders for multiple forest conservation strategies (Table 5.10) inline with household surveys. Key insights included community-based security, tree planting, awareness campaigns, and alternative livelihoods, with variations between communities in emphasis and approaches.

Community stakeholders emphasized local security measures. In Odu, traditional belief systems were seen as deterrents: for example community leaders proposed establishing a shrine within the reserve to discourage illegal logging. Additionally, there were calls for increased community security personnel to monitor reserves.

Doma and Risha participants focused on formal state involvement, advocating for forest boundary fencing and integration of traditional rulers into enforcement mechanisms. Tree planting emerged as a widely endorsed sustainability strategy, with differences in scale and

focus. Doma and Risha stakeholders prioritized indigenous species and district head involvement (Table 5.10), while Odu emphasized community sensitization and training.

Expert stakeholders stressed civil society's role in providing technical support and long-term engagement. Alternative livelihoods were a shared concern, particularly in Risha, where leaders proposed government employment to reduce protected area farming. Participants supported alternative energy promotion to reduce fuelwood dependence. While Odu and Doma endorsed government-led equipment distribution, experts emphasized community training and financing mechanisms, proposing micro-loans to reduce charcoal production. Government official focused on systemic reform and institutional development, emphasizing policy frameworks for green solutions and enforcement. Community stakeholders supported legal enforcement through traditional institutions. In Risha, a leader suggested converting forest reserve sections into a zoo with fencing to promote conservation.

Odu communities rely on traditional practices and moral authority for conservation, while Doma stakeholders emphasize indigenous species and district heads' leadership in reforestation, and Risha stakeholders focus on livelihood diversification and infrastructure. Experts and officials promote education, funding, and facilitation to support local efforts. This analysis shows shared priorities and contextual differences in forest conservation strategies, highlighting the need for a tailored approach combining traditional knowledge, community participation, government policy, and NGO support for sustainable outcomes.

5.2.6. Comparison of stakeholders analysis summary of Key Informant Interviews (KII) on forest reserves management and sustainability for the study area

Table 5.10 revealed the stakeholders' key insights regarding the perceived management and sustainability of gazetted forests, as derived from the comprehensive data obtained across the KII groups.

Local Perspective: The Doma reserve community advocates for the afforestation of indigenous species with community and governmental involvement, while Risha residents propose employment opportunities as an alternative to mitigate over-dependence on forest resources. The Odu community **c**alls for the enforcement of community laws, security personnel deployment and improving livelihood, and fencing of forest boundaries.

Community Leaders' Perspective: Doma reserve people emphasise inclusive governance, community engagement, and sustainability enforcement. Risha reserve community leaders encourage government-initiated programmes for community income generation and forest conservation while Odu Reserve community leaders were propose using cultural elements (shrines) to deter tree felling, reinforcing traditional conservation methods.

Expert Perspective: Experts emphasize community sensitisation and awareness campaigns as essential for promoting environmental conservation. They argue that a well-informed public can enhance community engagement in sustainable environmental practices. They advocate for environmental law enforcement through both government authorities and community participation to ensure accountability and stewardship. The involvement of NGOs is highlighted as key, particularly in delivering educational programmes and implementing sustainable forest management initiatives.

Government Official Perspective: Government officials view reducing population reliance on forest resources as crucial. They propose alternative cooking energy sources, such as electric stoves and gas cylinders, to curb deforestation and promote energy sustainability. Officials emphasize the need for effective monitoring and adequate funding mechanisms to support forest protection programmes. These measures are considered essential for the long-term success of conservation policies and forest ecosystem preservation.

This analysis provides a comprehensive view of KII stakeholder perspectives on forest management, highlighting actionable steps for ensuring the long-term sustainability of the Doma, Risha, and Odu forest reserves.

Table 5.11. Doma FGDs content analysis summary of the key stakeholder insight on forest reserves management and sustainability of the study area

Participants' Group	**Doma Key Insight from FGDs Content Analysis** **Gazetted forest management and sustainability**
Doma Local people	The community emphasized the urgent need to protect, and manage forests for future generations. Key suggestions include: Employing Forest Workers and Guards: Employ workers and enforce laws to prevent indiscriminate logging, ensuring only mature trees are cut while allowing younger ones to regenerate. Replanting Efforts: For every tree cut, replanting should be mandatory to sustain forest cover. Alternative Livelihoods: Provide alternative income sources (e.g., training in sustainable practices) and affordable cooking alternatives (like gas cookers) to reduce dependency on wood and forest exploitation. Government Support: The government must take proactive steps to reserve forests for future generations by implementing these measures effectively.
Doma Local Leaders	To promote sustainable forest management, it is recommended that individuals who cut down trees for fuelwood or timber should replace each tree with the planting of two or three new trees, as stipulated in the forest policy. This practice should be actively encouraged and enforced in forest-dependent communities. Another approach involves engaging community members to reflect on the environmental changes within their localities and collaboratively explore solutions. For instance, in Doma, large trees that once dominated the landscape are now absent, prompting the need for collective action to restore forest cover. This could involve consultation with key stakeholders, including women, youths, and farmers, to

	develop actionable recommendations for the state government. The government is urged to initiate awareness campaigns and implement sustainable forest conservation programs, starting with communities in Doma, Obi, Keana, Lafia, and Awe local governments, and expanding to other areas. Additionally, lessons can be drawn from northern states such as Katsina, Jigawa, Kano, and others, where annual tree planting programs are effectively carried out. Conversely, Nasarawa State lacks adequate forest conservation programs despite its rich natural environment. The inclusion of local communities in policymaking is deemed essential for achieving sustainable outcomes. Furthermore, providing alternative cooking technologies, such as gas cookers, could significantly reduce reliance on forest resources and mitigate deforestation in forest-dependent communities.

Table 5.12. Risha FGDs content analysis summary of the key stakeholders insight on forest reserves management and sustainability for the study area

Participants' Group	**Risha Key Insight from FGDs Content Analysis** Gazetted forest management and sustainability
Local people	The community emphasized the need for government intervention to improve welfare by establishing industries, providing livelihoods, and initiating tree-planting campaigns. They highlighted challenges such as elderly parents struggling with farming, women lacking economic opportunities, and insufficient access to capital or loans. These measures, they argued, would enhance quality of life, reduce reliance on reserve lands, and support health and economic stability.

Local Leaders	The community emphasized the need for government support to provide tree seedlings, such as oranges, mangoes, and indigenous species, to benefit the community and promote sustainable livelihoods. Participants linked forest degradation to hunger, stating that lack of food forces individuals to exploit forest resources for survival. They highlighted that addressing hunger and providing alternative livelihoods are crucial for safeguarding forest reserves. Additionally, they called for the establishment of legal frameworks to protect planted trees from destruction, including measures to regulate Fulani herders' grazing practices. Ensuring long-term sustainability requires a focus on relief measures for future generations through livelihood support and environmental conservation.

Table 5.13. Odu FGDs content analysis summary of the key stakeholders insight Stakeholders on forest reserves management and sustainability for the study area

Participants' Group	**Odu Key Insight from FGD Content Analysis** Gazetted forest management and sustainability
Local people	The community highlighted the need for afforestation and agroecology systems to address environmental challenges caused by deforestation. Participants emphasized that replanting efforts should be spearheaded by the government and community rather than individuals to prevent ownership disputes. Suggestions included the government providing seedlings, promoting tree planting, fencing forest reserves, and employing personnel to monitor and protect forests. Compensation for affected community members was proposed, with a transparent, inclusive system to distribute benefits fairly. Examples of effective policies, such as those in Benue State, were

	cited as models for achieving sustainable forest restoration and management. The importance of long-term solutions over temporary measures, such as providing gas or stoves, was also stressed
Local Leaders	The local community members proposed several points for the gazetted forest management protection sustainability such as; Fencing: Installing fences around the forest to prevent unauthorized entry. Security Guards: Deploying security personnel to monitor and enforce forest protection laws, with strict consequences for violators. Government Laws: Establishing robust government-enforced laws to deter illegal activities, as local laws are often ignored. Violators of government laws could face imprisonment, which would discourage others. Outsourced Guards: Hiring guards from outside the community to ensure impartial enforcement of forest protection, avoiding biases arising from local relationships. Infrastructure Development: Building camps and facilities near the forest to support security and foster monitoring efforts. Reforestation: Encouraging tree planting by both the government and individuals to restore and preserve the forest ecosystem. These suggestions reflect a combination of physical barriers, law enforcement, and community-driven restoration efforts to safeguard the forest

Table 5.14. Expert and Government Official key stakeholders FGDs insight content analysis summary on the forest reserves management and sustainability for the study area

Participants' Group	**Odu Key Insight from FGD Content Analysis**
	Gazetted forest management and sustainability

Expert	The expert's discussion highlights recurring challenges in environmental sustainability, particularly in Nigeria's policy implementation for energy and forest conservation. Despite existing policies and laws, enforcement remains weak. Government efforts in providing alternative energy sources are acknowledged but not widespread. Participants emphasise that Nigeria is effective in policy formulation but lacks proper execution strategies. They suggest the need for public awareness of efficient energy use. For example, proper gas usage techniques can extend fuel lifespan, reducing household costs. Sensitisation and education on energy efficiency are crucial for sustainable consumption. Perceived sustainable forest conservation strategies include protective measures such as fencing, surveillance, and forest guards. However, they added that sustainability requires community involvement alongside government efforts. Overall, the discussion underscores the gap between policy and implementation, emphasizing the need for government intervention, public sensitization, and stronger enforcement mechanisms to ensure sustainable energy use and forest conservation.
Government Official	The FGD highlights the importance of livelihood and protecting forest reserves through physical barriers such as fences and wires, alongside technological measures and other security mechanisms that were suggested to safeguard the forest reserve. The stakeholder participants emphasised the role of forest guards and the need for proper enforcement of existing policies and laws. Emphasis on a key concern in the implementation process, ensuring sustainability in line with the national policies and laws that exist, and international frameworks such as the United Nations Earth Summit. The discussion underscores the necessity of collaborative

	efforts between the community and the government for effective and sustainable forest conservation and management with emphasis on joint responsibility in conservation efforts through both local and institutional frameworks.

Table 5.15. Comparison of stakeholders content analysis summary insight FGDs on forest reserves management and sustainability for the study area

Stakeholder Group	Doma	Risha	Odu
Local People	Need for forest guards, regulated logging, replanting, and alternative livelihoods.	Need for government support in welfare, alternative income, and tree-planting campaigns.	Demand for afforestation, agroecology, fencing, and fair compensation.
Local Leaders	Promote tree planting policies, community involvement, and government awareness programs.	Address hunger as a root cause, provide seedlings, and establish legal frameworks for protection.	Strong focus on security (fencing, guards), strict government laws, and reforestation programs.
Government & Experts	Weak policy implementation, need for law enforcement, alternative energy sources, and community inclusion.	Need for stronger regulations, policy enforcement, and livelihood support.	Stress on policy execution, community-government collaboration, security enforcement, and legal backing.

5.2.7. Comparison of similarities and differences in FGDs insight stakeholder perspectives perceived on forest management and sustainability in the study

Tables 5.11-15 presents FGD insights from across the three forest reserves including from experts and government officials, on the management and sustainability of the gazetted forest. The discussions emphasised key themes, including livelihoods, forest security and conservation efforts, policy implementation, government intervention, and enforcement approaches for forest management and sustainability for the study area.

All participants emphasise replanting, tree-planting campaigns, and conservation efforts. Furthermore, there is an emphasis on the need for government intervention across all reserves; stakeholders highlight the necessity of government support through funding, policies, and enforcement. These suggest a strong consensus on the necessity of government intervention in the form of funding, policy formulation, and stringent enforcement mechanisms to support these initiatives across all reserves.

Fundamentally, issues of alternative livelihoods were recognised as crucial in reducing dependency on forest resources across all the stakeholder communities. For example, hunger and economic support mentioned in Risha uniquely link deforestation to food insecurity, emphasising livelihood creation to combat deforestation, stressing that economic hardships drive communities to exploit forest resources unsustainably.

Both the stakeholders in these forest communities emphasise the weak policy implementation, while experts and government officials consistently highlight the gap between policy formulation and execution. This gap was particularly evident in enforcement inconsistencies and the lack of financial and technical support for local conservation programs. Furthermore, alternative livelihood programs were identified as crucial in reducing local communities' dependence on forest resources.

For the approach to enforcement, Odu suggests local engagement and enforcement. This suggests they rely on community-based policing or locally recruited forces, which could foster trust and familiarity with community people but might also lead to bias or corruption due to personal ties; however, in addition, they outsource enforcement to external, impartial guards. Doma and Risha, on the other hand, prefer to outsource enforcement to external, impartial guards. This means that instead of relying on local forces, they bring in third-party security personnel who are neutral and likely more professional but may not have a deep understanding of local dynamics.

In terms of differences in security measures, there are divergent approaches to security and enforcement across various locations. The Odu stakeholders' FGD strongly advocates for fencing and strict local measures and government law enforcement, whereas Doma and Risha focus more on livelihood and community involvement and government law enforcement. For example, hunger and economic support mentioned in Risha uniquely link deforestation to food insecurity, emphasising livelihood creation.

5.3. Discussion and implications of findings

5.3.1. Community perceptions of forest reserve ownership and management

The findings from household surveys and qualitative interviews reveal diverse community perceptions of forest reserve ownership and management in the study area. While many community members were aware that the government-owned the forest reserves, a substantial proportion lacked awareness of this, reflecting a disconnect between legal ownership and community understanding. This finding is corroborated by Brian and Moses (2020), who looked at communities' attitudes and perceptions towards the status, use and management of Kapolet Forest Reserve in Kenya, which was created by the government for conservation purposes. Their study found that most community members understood that the forest belonged to the government, while a minority of individuals lacked awareness and insisted that the gazetted forest reserves belonged to their community. This indicates a complex relationship where both community and government entities regulate and permit resource extraction from the forest reserves and potentially reveals a gap in terms of the legal ownership and management and the practice of accessing the forest reserves.

The results from this study align closely with Nvenakeng's (2015) research on the Mount Cameroon National Park Conservation Project, which explored the involvement of the local community as co-managers. Their study revealed that state ownership, control, and decisions over forest policies have led some community members not supporting forest projects, and this has likely had a substantial impact on participation in gazetted forest conservation activities in this area. Creating a governance mechanism that supports the protected reserve so it can deliver both co-benefits and equitable conservation management purposes is crucial.

5.3.2. Role of communities in forest conservation and co-management

Community members must be given meaningful governance roles in co-management, such as becoming forest guards, and should be given chances to participate in decision making. They can also engage in forest monitoring by helping to identify species and measure trees, gaining valuable new skills and capacities in the process, rather than just being labourers or

observers. This finding supports other literature that underscores that securing the tenure rights of communities and involving them in decision-making processes in forest-dependent areas is crucial in achieving the objectives of gazetted forests (Hajjar and Oldekop, 2018). Above all, it is essential to recognise the rights of local people in PAs rather than the government claiming ownership or control over their land. The results show indigenous/local communities can play a significant role in effective management, while also, they oversaw forest management before the present institutions.

The qualitative interviews and household surveys in this study highlighted the concerns about degradation of the forest reserves, and the links between forests, development and livelihoods, suggesting that effective management is lacking. According to Measham and Lumbasi (2013), community-based natural resource management (CBNRM) initiatives that are initiated, owned, and managed by communities have been able to better withstand negative impacts on livelihoods than complex governance strategies that resulted from influential actors' management strategies in state-controlled initiatives. However, a community forest ownership and co-management model may be a better option to enable communities to claim ownership of the protected reserve, manage it based on local perspectives, and enhance their benefits and livelihoods while providing global benefits such as biodiversity and climate change mitigation. A co-management model offers a chance for the local community to support forest conservation but may need to be supported by relevant training and capacity building. Overall, incorporating local communities can play an essential role in ensuring more effective management through information sharing and motivation of both managers and the institutions responsible for conservation (Measham and Lumbasi, 2013).

5.3.3. Conservation strategies and challenges in gazetted reserves

Conservation strategies were generally not implemented within Gazetted Reserve areas, despite strong community awareness and concern. Instead, efforts focused on preserving economic trees such as shea, mango, baobab, and cashew on private lands and in home gardens, with limited forest planting. Hassen et al. (2023) similarly found that local communities relied on traditional customary regulations and indigenous beliefs for conserving natural resources. In some areas, additional techniques such as terracing, gully prevention, and hillside planting with native trees were used to rehabilitate degraded forest land. Although restoration efforts were not systematically applied across the reserves, some this study area communities could engaged in specific land rehabilitation techniques, including terracing, gully erosion prevention, and hillside planting with native species. These

activities, while limited in scale, represent local attempts to restore degraded areas and mitigate further environmental degradation.

The evidence shows that forest conservation is influenced not just by ecological science but also by societal values, informal rules, and traditional knowledge systems (Winkel & Jump, 2014; Quevedo et al., 2020). This intersection of cultural context and governance significantly affects local engagement in conservation. Despite community-led efforts, these have had limited impact within the reserves, a trend also noted in studies from Tanzania (Kizigo et al., 2019; Linuma and Tang'are, 2018) and Indonesia (Harbi et al., 2018). The persistent ecological decline suggests that lack of motivation, weak enforcement, and conflicting interests may hinder active conservation.

While local initiatives were largely ineffective in reversing forest degradation, other contexts show more promising results. Amoah et al. (2022) in Ghana, and Brian and Moses (2020) in Kenya, observed that when supported by effective policy enforcement, community efforts led to improved forest cover. These cases highlight the potential for integrating local knowledge with legal and institutional frameworks to enhance conservation outcomes.

In this study, there was strong consensus on the importance of forests for economic, ecological, and cultural reasons. Community members recognised benefits such as income generation, environmental protection, and cultural heritage preservation. Concerns were raised about the declining availability of forest resources like fuelwood and construction materials, and broader environmental threats such as erosion, biodiversity loss, and climate change. The exposure of sacred sites and traditional worship areas further underlined the cultural implications of forest degradation.

Quantitative findings confirmed that conservation effort are mainly occurred at their homes land, with community-driven efforts largely absent in the reserves. This underscores the need to integrate traditional knowledge systems with formal conservation frameworks to achieve more effective and inclusive forest governance. Current policies lack this integration, limiting their potential impact. Addressing these challenges requires a holistic, community-based approach that reflects local realities and enhances both environmental and livelihood outcomes.

5.3.4. Integrating community and institutional efforts (NGOs and multi stakeholder partnerships)

Effective forest conservation depends on collaboration among government agencies, NGOs, and local communities. This consensus emerges from community leaders, experts, and government officials involved in the study. Tanvir and Afroze (2016) highlight that community-based forest management and co-management have been practiced in six South Asian countries, yielding improvements in forest conditions and biodiversity.

Such collaboration is vital for the effective management of PAs (PAs), integrating traditional practices like sustainable harvesting and community governance (Munthali et al., 2019; Nvenakeng, 2015; Andrade & Rhodes, 2012). The government's central role lies in shaping policy and regulatory frameworks to guide forest management. However, policy effectiveness requires co-development with communities, engaging them as co-designers and implementers (Scheba and Mustalahti, 2015; Adusei and Dunyah, 2016).

Management plans should articulate objectives for production, conservation, and environmental services, with clear enforcement and monitoring systems. While enforcement remains a government responsibility, involving communities enhances compliance and cultural sensitivity (Amoah et al., 2022; Andrade and Rhodes, 2012).

NGOs contribute by advocating, raising awareness, and building community capacity (Kizigo et al., 2019). Their research and innovation support biodiversity conservation and climate change mitigation (Sodhi et al., 2010; Ward et al., 2018). Inclusive engagement from the outset helps align conservation strategies with local perceptions, fostering shared responsibility and reducing resistance to external regulations (Bayrak and Marafa, 2016; Loveridge, 2021; Martínez-López et al., 2021).

Resource pooling among stakeholders through funding, expertise, and technology can improve conservation outcomes (Van Der Jagt and Lawrence, 2019; Carr et al., 2021). However, institutional perspectives often marginalize communities, viewing them as threats rather than partners. This perpetuates a top-down approach that undermines motivation and performance among local managers (Quevedo et al., 2020; Hassen et al., 2023).

5.3.5. Addressing climate change and global conservation goals

An overwhelming majority (99%) of respondents strongly agreed that forest conservation is essential for carbon stock preservation, reflecting a high level of awareness of forests' role in climate change mitigation (Measham and Lumbasi, 2013; Olaniyi and Omowale, 2022;

United Nations Resolution, 2020). This awareness presents an opportunity to align local actions with global climate and conservation goals. Respondents identified key strategies for improving forest sustainability in Nasarawa State, including community forest security, tree planting campaigns, NGO-led plantations, alternative energy adoption, farmer support through input loans, and stricter enforcement of anti-deforestation laws. These initiatives not only support local environmental management but also contribute to the achievement of multiple Sustainable Development Goals (SDGs), as discussed in Chapter 1.

5.3.6. Challenges and opportunities to sustainable forest management

Key barriers to effective forest conservation include institutional constraints, conflicting interests, and limited integration of local knowledge systems with scientific approaches which was one of the findings revealed across the stakeholders in this study. Community decisions to conserve and sustainably manage forest resources are impacted by various socio-economic, environmental, and psychological factors that support the security of PAs (Nath and Magendran, 2021; Ezenwaka, 2018). According to the household findings in the study, 90% of the respondents considered community forest security to be one of the most effective approaches for managing and ensuring sustainability. This view was also expressed by the community KII and FGD. Achieving forest security involves empowering local communities living in or around forested areas and implementing traditional measures to safeguard their forests, which can prevent illegal logging, encroachment, and other activities that may harm the ecosystem and the forest and support sustainability (Harbi et al., 2018; Amoah et al., 2022; Andrade and Rhodes, 2012). The approach has shown some evidence of success in sustaining the gazetted forests in one of the study areas (Odu) (see Chapter 3), which managed to keep or preserve a significant portion of its forest despite potential threats like deforestation activities (Chapter 4). Sustainability success was attributed to the traditional security management and conservation strategies used by the community, along with the shrines and masquerades that helped protect and sustain their remaining forest reserve. Such community forest security can thus be considered an effective approach for gazetted forest sustainability. In addition to protecting existing forests, stakeholders emphasised the importance of tree-planting campaigns and increasing awareness, as seen in Kizigo et al. (2019) and Andrade and Rhodes (2012).

5.3.7. Role of traditional practices and cultural values

Community conservation measures, such as protecting sacred sites and using traditional regulations, were significant in sustaining forest reserves in Odu. These practices align with findings from Kizigo et al. (2019) and Andrade and Rhodes (2012), who emphasize the

importance of integrating cultural values into conservation strategies. Combining traditional and modern approaches can enhance conservation outcomes and strengthen community involvement. Interestingly, there is a growing recognition of the importance of integrating traditional knowledge with scientific approaches in protected area management. The Papahānaumokuākea Marine National Monument exemplifies this biocultural approach, incorporating Native Hawaiian values and practices into policy, management, education, and research (Kikiloi et al., 2017). This integration has led to more effective conservation outcomes and serves as a model for other PAs worldwide. In conclusion, PAs can play a crucial role in preserving traditional ecological knowledge and cultural landscapes, particularly in developing countries where rapid transformation threatens these practices (Gómez-Baggethun et al., 2010). However, it is essential to strike a balance between strict protection and allowing traditional resource use to maintain cultural identity and ensure the continued transmission of valuable ecological knowledge (Harrop, 2007)

5.3.8. Enhancing livelihoods and alternative income sources

The lack of alternative livelihoods significantly increases pressure on protected forests, a concern consistently highlighted across the three forest communities, as well as in Chapter 4. This scarcity of income options renders rural survival strategies unsustainable and contributes to forest degradation in North Central Nigeria. Addressing this challenge is essential for both forest conservation and community well-being (Cuni-Sanchez et al., 2019; Carney, 1998).

Despite the clear need, government intervention has been limited, leaving forest-dependent populations without viable alternatives. Provision of alternative livelihoods, alongside financial support such as subsidies for seeds, fertilizers, and equipment, can enhance agricultural productivity without encroaching on forest lands (Ihemezie et al., 2021; Kyere-Boateng et al., 2023). Such assistance is especially critical for smallholder farmers lacking capital for sustainable investments.

Diversification strategies including eco-tourism, agroforestry, and non-timber forest product development have proven effective in reducing forest dependence and promoting conservation (Derkyi et al., 2013; Ahammad et al., 2019; Lepetu and Garekae, 2019; Olaniyi et al., 2019). Training in sustainable agriculture can further deter practices like slash-and-burn cultivation (Munthali et al., 2019). These findings reinforce the importance of policy frameworks that support alternative income generation and livelihood development to ensure the sustainability of PAs.

5.3.9. Policy implications and enforcement

Ensuring the enforcement of both community and government laws and policies is also vital Lockwood, (2010); Sotirov et al. (2020); Loveridge (2021), and Amoah et al. (2022). These studies highlight the importance of aligning traditional and government regulations to maintain the sustainability of PAs. Strengthening law enforcement mechanisms within protected regions is essential to deter illegal activities and can be achieved by imposing penalties and providing incentives, such as implementing strict consequences for unlawful behaviours and offering rewards for adhering to sustainable conservation practices. Such measures are expected to encourage compliance and reinforce sustainability efforts within protected forests (Damnyag et al., 2013; Ding et al., 2020; Amoah et al., 2022).

Additionally, setting clear boundaries can play a significant role in the community's perceptions: the construction of physical barriers to delineate the boundaries of protected regions could be effective in regulating access to the PAs and reduce human-wildlife conflict and conflicting land use around the reserves. As well as physical demarcation, the designation of distinct zones within PAs, including buffer zones, emerges as a viable strategy for managing human activities while safeguarding core ecological zones for long-term sustainability. However, fencing can be effective in protecting forests, but it also brings challenges, such as restricting wildlife movement, disrupting ecosystems, and causing conflicts with local communities (Lindsey et al., 2011; Osipova et al., 2018).

Sustainable logging practices like selective and reduced-impact logging should be encouraged and implemented over slash and burn or clear felling, to maintain the integrity of the forests while still fulfilling the demand for timber and wood products. Moreover, the utilisation of alternative and renewable energy sources, such as solar, wind, and biogas, lessens dependence on fuelwood for cooking and heating, while efficient stoves and cooking technologies can also decrease the need for fuelwood, reducing the pressure on forests and PAs (Amoah et al., 2022; Houghton and Nassikas, 2018).

This study documents the importance of integrating community-driven approaches, traditional practices, and institutional frameworks to achieve sustainable forest management. In essence, the grassroots community forms the seedbed upon which sustainable practices should be nurtured and developed to sustainability of the forest. In this research a combination of ineffective governance mechanisms, limited enforcement of policies, and socioeconomic pressures encourage unsustainable practices (see also Olalekan et al., 2019). Failure in conservation management and sustainability efforts in PA reserves in Nasarawa

State, have far-reaching implications for biodiversity and ecosystem services, community development, cultural preservation, and climate resilience for sustainable development both at the local scale and beyond. However, by integrating these approaches discussed in this study and working closely with local communities, forest restoration, management and sustainability could be improved.

Bringing together the community perspectives with those of the other stakeholders has identified several areas of common ground and shared perceptions amongst the different groups, as well as the need for a diverse range of solutions to tackle forest loss. The sustainability of the gazetted forests in Nasarawa State will depend on the collaboration between government agencies, non-governmental organisations, and local communities, so the similarities in some of their views provide a useful starting point for discussions. Moreover, by fostering a sense of ownership and responsibility among the local population, Nasarawa State can work towards a harmonious coexistence between human communities and their forest environments, ensuring a sustainable future for all. Many communities around the protected forests in Nasarawa State have traditional forest management practices passed down through generations. These traditional practices often involve sustainable harvesting, rotational farming, and community-based governance systems. Recognising and integrating these traditional methods into modern forest management plans could enhance sustainability and community engagement.

People of Nasarawa State have long-standing relationships with their forests, as they rely on them for various resources such as timber, non-timber forest products, and traditional medicines by examining how these several key aspects of these forests are utilized and integrated into their livelihood, economy, and cultural practices (in this chapter 5), chapter 4 and Chapter 1. However, the increasing pressure on these resources has led to concerns among the local communities and a recognition of the need for conservation. Several stakeholders suggested strengthening the enforcement of existing forest laws (including both Government and Traditional regulations) is essential to curb the deforestation practices and their drivers identified in Chapters 3 and 4. Such efforts include enhancing monitoring and surveillance mechanisms, imposing strict penalties for illegal activities, and ensuring the active involvement of local communities in law enforcement for the PAs.

The emphasis on traditional practices, such as community forest security, and the suggestion of integrating cultural practices, like shrine establishment, within forest reserves highlights the importance of blending modern conservation strategies with local approaches. This finding reinforces suggestions in the literature advocating the incorporation of traditional

ecological knowledge into contemporary conservation practices. It also aligns with the principles of participatory management, emphasising the need for inclusive decision-making processes involving local communities. Together, the calls for stronger enforcement of forest conservation laws, community involvement in forest management, and the establishment of institutional frameworks for sustainable forest management that integrate perspectives, highlight the importance of putting the right governance in place to achieve conservation objectives.

The chapter makes an important contribution, going beyond the problem of forest depletion as presented in the previous chapter to reveal local perspectives on forest management. In doing so, the chapter provides insights relevant to community conservation practices in developing countries and the kinds of support needed by other stakeholders in delivering co-management, especially where forest depletion is still endemic, and conservation issues remain around the future sustainability of PAs.

5.4. Conclusion

This study has evaluated community perceptions of the ownership and management of the gazetted forest in the study area, understood the conservation efforts underway in the gazetted forest communities, and examined perceptions of the sustainability of forest management for future generations. The results indicate a lack of clarity regarding the ownership roles and responsibilities in managing these reserves, where legal possession, ancestral claims, and government control intersect. Moreover, while a substantial proportion of individuals in the study indicated that they are involved in the conservation measures, empirical evidence showed that the community conservation measures undertaken in the forest reserves lack any significant impact on the gazetted forest region, despite community concerns about the decline of the forest. Community emphasis on alternative sources of livelihood particularly in Risha, traditional practices for forest security, and the integration of cultural practices, like shrine establishment, within forest reserves specifically in Odu, highlights the importance of blending modern conservation strategies with local systems of forest conservation prominent in Doma. Similarly, traditional practices, such as sustainable harvesting and community-based governance can yield a better outcome for protected and gazetted forests, despite that the effectiveness of this remains to be tested in the forest reserves in this study. It is imperative to promote the implementation of community-based participatory forest co-management, underpinned by an understanding of the local community perspectives on effective conservation and management of forests. Furthermore, tree planting campaigns using native and threatened tree species in restoring and revitalising

degraded PAs can be beneficial. Fundamentally, decision-makers and managers need relevant data for the long-term preservation and management of forest resources. Improved local engagement in forest conservation can also help to build locally relevant monitoring systems and data. These measures are crucial in enhancing rural livelihoods while ensuring the long-term sustainability of the PAs, so they continue to deliver benefits both locally and globally.

Chapter 6. General discussion and conclusion

6.1. Introduction and synthesis of the thesis

In this thesis, I aimed to understand historical land use change around three gazetted forest reserves and perceived drivers of forest change, to provide a better understanding of actions supporting forest conservation and sustainability of PAs. I applied robust interdisciplinary analysis combining multiple viewpoints to integrate different perspectives to understand the situation on the ground. In this final chapter, I integrate essential findings and contributions from preceding sections and discuss the relevance of research designed to address land use change, drivers, conservation, and future management sustainability. I discuss the consequences and implications for the protected gazetted forest, delve into potential limitations and highlight areas for future research for the protected area's conservation, governance, and management, and present my key conclusions.

My thesis provides a progressively deeper insight into land use around gazetted forest reserves and conservation management and their sustainability. Chapter 1 established a foundation by providing context, background, and justification for the study of forest conservation and PAs. It set out components such as forest conservation and PAs, management and governance, land use and local livelihoods within forested landscapes. It identifies conceptual data gaps pertaining to governance, land use change, conservation, management, and sustainability, guiding the focus of ensuing chapters. The conceptual framing integration necessitates a balance between explanatory relevance and practical applicability to real-world scenarios, incorporating ideas from distinct social and scientific concepts in understanding empirical phenomena.

Chapter 2 details methods employed to gather comprehensive information on the complex relationship between biophysical and socio-economic data. Survey map boundaries, remote sensing data, and Geographic Information System (GIS) applications were used to determine spatial change in land use and nature of gazetted forest reserve change. Fieldwork components were used to understand driving forces and human activities interacting with the gazetted forest reserve and local communities.

Chapter 3 focused on how and when the gazetted forest reserves changed over time, emphasizing spatial change of land use and land cover. Chapter 4 evaluated perceived drivers and human activities triggering land use changes in the gazetted forest. These are supported by findings from Chapter 3 showing significant forest cover degradation in the study areas, confirmed by gazetted forest study communities. Chapter 5 explored community

perceptions of conservation management and sustainability of PA reserves in Nasarawa State, North Central Nigeria to provide insights for policymakers to effectively manage future sustainability of PAs.

Objective i) revealed how the gazetted forest changed in three study forests in Nasarawa state, providing historical evidence through spatial information and maps (Chapter 3). The findings showed nearly complete forest cover loss in two of three gazetted forests, with cultivated land increasing and forest areas decreasing during 1966-2020. Analysis revealed degradation was most severe in Risha Forest Reserve, where 88% of forest was cleared. In Odu Forest Reserve, 55% of forest was lost by 2020, while Doma Forest Reserve lost 83% between 1966 and 2020. Permanent cultivation was established in Risha and Doma, while shifting cultivation occurred in Odu (Chapters 3 and 4). These maps can inform sustainable land management, crucial for local and urban inhabitants surrounding forest reserves to achieve conservation goals.

Objective ii) identified drivers that triggered land cover changes and examined community perceptions of benefits from gazetted forests (Chapter 4) through empirical evidence from local people, government and expert stakeholders. Findings showed similarities and differences in human activities across forest sites. Agricultural, lumbering, and grazing activities were similar, while construction and settlement activities differed. Trajectories and processes for reserve change varied. Risha experienced agriculture expansion leading to other drivers, Doma saw population growth leading other drivers, and Odu observed lumbering facilitating other drivers. Agricultural expansion, lumbering for fuelwood/charcoal production, population growth, poverty, and government policies were common in all reserves, though intensity and scale varied. Risha and Doma showed highest agricultural expansion and forest degradation, while Odu's forest remained relatively intact due to traditional shifting cultivation. Local participants perceived forest change driven by interactions of 16 drivers (Chapter 4).

Objectives iii and iv) addressed strategies to safeguard forests and community perceptions of management (Chapter 5). Findings indicated mixed awareness of government forest ownership. Most participants were involved in conservation strategies, planting and protecting trees for economic reasons, despite shrinking forest cover in Risha and Doma.Most of the Odu community indicated increased forest cover (Chapter 3), acknowledging community ownership and engaging in shifting cultivation (Chapter 4). The

forest holds cultural and traditional values contributing to conservation in the area. Stakeholders in these communities emphasize weak policy implementation, while experts and officials highlight the gap between policy formulation and execution Chapter 5. Regarding forest sustainability perceptions, most participants mention security measures. Security approaches vary across locations; Odu stakeholders' FGD advocates fencing, strict traditional measures, and government enforcement, while Doma and Risha prioritize livelihood, community involvement, and government enforcement. Hunger and economic support mentioned in Risha link deforestation to food insecurity, highlighting the importance of livelihood creation.

6.2. General discussion and implication of the findings

The thesis explores the necessity of integrating interdisciplinary methodologies within forest conservation, connecting social and na’tural scientific ideas to comprehend complex socio-economic systems, and effectively integrating a wide range of disciplinary and regional viewpoints. The thesis explores the necessity of integrating interdisciplinary methodologies within forest conservation, connecting social and natural scientific ideas to comprehend complex socio-economic systems, and effectively integrating a wide range of disciplinary and regional viewpoints.

Chapter 2 utilized remote sensing, GIS, and participants' perspectives to create a detailed history of forest change, blending land cover change analysis with the experiences of those living near the forests. This yielded a comprehensive and reliable outcome in this study. This methodological approach facilitated a more holistic interpretation that combined biophysical ecological data with the authentic experiences of those living in the study area. Adopting this study methods approach ensured equal consideration of perspectives from various stakeholders, including conservation practitioners, community members and leaders, government officials, NGOs, and academic researchers.

The analytical framework for the study was developed using multiple perspectives, focusing on the linkages between practice and research. This was achieved by integrating various perspectives and methodologies into the research process and engaging in critical reflection (Walters, 2022b). This integration ensured that the research not only captured the complexity of land-use change on the protected gazetted forest but also aligned with broader theoretical understandings of management and sustainability in forest conservation.

For example, the use of base maps, remote sensing data, and GIS techniques provided invaluable insights into critical land change dynamics in the studied forests by offering

precise and reliable data. Systematically assessing forest loss in these systems, where management maps do not exist, provided the first comprehensive evaluation of these changes. The precision and reliability of the data were reinforced through ground-truthing, establishing a strong foundation for informed decision-making. Fieldwork complemented these methods by providing detailed observations that remote sensing alone could not offer. It helped address limitations such as ground truthing, identifying and distinguishing similar land cover features, understanding processes, and determining historical change drivers.

This thesis' research techniques emphasized the integration of biophysical and socioeconomic applied research with local knowledge, which is essential for understanding the perceptions and attitudes of local communities and stakeholders toward conservation efforts. This approach informs management practices by assessing both the ecological aspects and the human dimensions of conservation, ensuring that management strategies are guided by a holistic view of the area's dynamics and challenges. For instance, the findings of the study provide empirical evidence demonstrating the interplay between human actions, policy changes, and ecological processes (Chapter 4 and 5). By emphasizing these interactions, conservation efforts could shift to place more weight on participatory governance, empowering local communities, and integrating traditional knowledge. This recognizes human communities not just as external pressures but as integral parts of the ecological system, capable of contributing to its sustainability.

The findings likely offer practical lessons that could be generalized to other socio economic contexts. For example, the study suggests that successful forest conservation requires a combination of top-down policy enforcement and bottom-up community involvement. These lessons can be used to refine the conceptual approach presented here, enhancing its relevance to real-world contexts and strengthening its utility for informing policy and management decisions. In summary, the findings not only support the human with forest perspective but also contribute to its development as a more effective tool for understanding and managing complex human environment interactions.

The findings of this study significantly contribute to the current understanding of forest reserve management and its implications on ecological, economic, social, and cultural impacts. Unlike previous research that generalizes land cover change effects, this study offers a detailed analysis of specific forest reserves in Nigeria. It advances the literature by revealing localized perspectives on forest change, linking socio-economic activities to ecological degradation in context, examining forest and cover loss, and exploring cultural

services. The study highlights the specific challenges faced by individual forest reserves, moving beyond the generalized impacts typically discussed in the literature. Additionally, data from this study have shown the local-level changes and pressures that contribute to the overall picture of global environmental change. The study also offers empirical data on the impact of human activities (LULCC) in the gazetted forest, which affect ecosystems and habitats, informing more targeted conservation strategies.

Understanding the land use forest change interplay is critical, as it could contribute to the attainment of the United Nations' Sustainable Development Goal (SDG) 15, which seeks to protect, restore, and promote the sustainable use of terrestrial ecosystems, manage forests sustainably, combat desertification, and halt biodiversity loss by 2030. The "30 by 30" initiative, introduced in Chapter 1, represents a significant opportunity to protect and restore forests, directly contributing to SDG 15. By conserving 30% of land and ocean areas, the initiative addresses the complex interplay between land use and forest change, offering a pathway to halt biodiversity loss, combat desertification, and promote sustainable ecosystem management by 2030 (Li et al., 2023; Li, Ge, and Sayer, 2023).

Forest reliant communities often manage lands with rich biodiversity, and their local knowledge can be invaluable in designing effective conservation strategies. These strategies are crucial as a cornerstone of global conservation efforts in the coming decade. For example, according to Global Forest Watch, Nasarawa State's tree cover was around 50.9 thousand hectares, covering just 1.9% of its land area, indicating that the region has limited forest cover to work with when trying to meet conservation goals. If local forest management strategies are not integrated with broader land-use policies that consider local communities' needs and knowledge, it can be difficult to meet both conservation and development objectives.

The findings of this study significantly contribute to the current understanding of forest reserve management and its implications on ecological, economic, social, and cultural impacts. Unlike previous research generalizing land cover change effects, this study provides detailed analysis of specific forest reserves in Nigeria. It advances literature by revealing localized perspectives on forest change, linking socio-economic activities to ecological degradation, examining forest cover loss, and exploring cultural services. The study highlights specific challenges faced by individual forest reserves, moving beyond generalized impacts typically discussed. Data from this study shows local-level changes and pressures contributing to global environmental change. The study provides empirical data

on human activities' (LULCC) impact in gazetted forest, affecting ecosystems and habitats, informing targeted conservation strategies. Understanding land use forest change interplay is critical for achieving the United Nations' Sustainable Development Goal (SDG) 15, which seeks to protect, restore, and promote sustainable terrestrial ecosystem use, manage forests sustainably, combat desertification, and halt biodiversity loss by 2030. The "30 by 30" initiative represents an opportunity to protect and restore forests, contributing to SDG 15. By conserving 30% of land and ocean areas, the initiative addresses land use and forest change interplay, offering a pathway to halt biodiversity loss, combat desertification, and promote sustainable ecosystem management by 2030 (Li et al., 2023; Li, Ge, and Sayer, 2023). Forest reliant communities manage lands with rich biodiversity, and their knowledge is invaluable for designing effective conservation strategies. These strategies are crucial for global conservation efforts. According to Global Forest Watch, Nasarawa State's tree cover was around 50.9 thousand hectares, covering 1.9% of its land area, indicating limited forest cover for conservation goals. If local forest management strategies are not integrated with broader land-use policies that consider local communities' needs and knowledge, it can be difficult to meet both conservation and development objectives.

The reality on the ground is that forest reserves in Nasarawa State, North Central Nigeria, have undergone substantial depletion over the study period. Field surveys show gazetted forest reserves have mostly turned into farmlands. These findings were validated through ground-truthing, as shown in Chapter 3's classified map. Some areas, like the Odu Reserve, retained forest cover in 2020 due to traditional community conservation strategies, including cultural traditions like shrines and masquerades (Chapter 5). Community forest security is an effective approach for forest sustainability. Key informant interviews and focus group discussions revealed the community used the reserves for religious purposes. Sacred natural sites, often better protected for their spiritual value, can be rich in biodiversity, sometimes surpassing officially PAs. However, they face anthropogenic threats and may be too small for extensive forest cover. The effectiveness of PAs, including forest reserves, is influenced by legal, ecological, cultural, and socio-economic factors (Dudley and Stolton, 2022; Izah and Seiyaboh, 2018).

Gazetted forest reserves in this study, as highlighted in Chapters 3 and 4, have undergone significant changes due to human activities, leading to degradation and fragmentation. These land cover changes impact ecological services, including biodiversity conservation and the delivery of provisioning, regulating, supporting, and cultural services (Payn et al., 2015; Ahmed et al., 2020; Hassen et al., 2023). The reduction in forest cover in Doma and Risha

reserves has led to a decline in species richness, particularly for tree species like mahogany (Terminalia spp.), shea (Vitellaria paradoxa), and locust tree (Parkia biglobosa). This loss affects biodiversity and ecosystem services like carbon sequestration, soil fertility, and water regulation (FAO, 2016; Ahmed et al., 2020; IPCC, 2021). These changes illustrate the deep interconnections between ecological integrity and human well-being, reaffirming the need for strategies that align conservation with sustainable development.

Furthermore, the socio-economic activities around these reserves, including agricultural expansion, have been shown to provide short-term economic benefits, as discussed in Chapters 4 and 5. However, the findings reveal that these benefits are often outweighed by the long-term ecological costs, such as soil degradation, loss of ecosystem services, and increased vulnerability to climate change (Oduro Appiah et al., 2021; Woldeyohannes et al., 2020).

For example, the alteration of vegetation cover in these reserves has disrupted natural ecosystem services due to changes in the forest cover, leading to a reduction in forest resources available for local communities' livelihoods, as highlighted in Chapters 3 and 5. Additionally, the study reveals that changes in forest cover have not only threatened biodiversity but have also undermined the cultural services provided by these reserves (Chapters 4 and 5). The degradation of these forests has diminished the aesthetic and recreational value of these areas, potentially reducing opportunities for ecotourism and other forms of nature-based recreation that could benefit local economies (Joseph and Olufemi, 2019; Loveridge, 2021).

This phenomenon is evident in all three forest reserves but is particularly pronounced in Odu reserve, where communities lamented the implications of forest cover loss on their cultural values. Communities that ascribe higher cultural value to their local forests potentially have the most to lose from continued degradation.

The findings from this study also underscore the global implications of local land cover changes. The conversion of forest land within these reserves to agricultural or urban uses could have contributed to greenhouse gas emissions, exacerbating climate change on a global scale (Hassan, 2020; Ahmed et al., 2020; IPCC, 2021). The study’s results reinforce the urgent need for more effective conservation and management strategies to preserve the ecological integrity and ecosystem services provided by these forest reserves, as discussed in Chapters 3, 4, and 5, and to curb their contribution to global GHG emissions.

Findings on why the gazetted forest has changed are complex, with multifaceted and intertwined drivers. The quantitative and qualitative findings in Chapter 4 revealed sixteen interconnected drivers from the local perspective, shedding light on the intricate interactions influencing forest change in the study area. Among the direct drivers that emerged prominently were agricultural expansion, logging, and charcoal production activities driven by economic incentives that encourage communities to exploit forest resources for their livelihoods.

Additionally, indirect drivers such as population growth and poverty were found to exacerbate pressure on forest resources. Government policies also play a crucial role in shaping the institutional framework within which forest management decisions are made. The interconnections among these drivers highlight the need for integrated approaches to addressing forest conservation challenges and underscore the importance of using a socio-ecological lens to understand and solve these issues.

The study's findings on the influence of socio-economic and underlying factors on changes to forest reserves in the study area support and expand upon existing scholarship regarding the drivers of deforestation and forest degradation in protected regions. The changes in these forests are often driven by a complex interplay of socio-economic, institutional, and environmental factors rather than a single cause. Research has consistently shown that population growth and urbanization exert significant pressure on forest resources (Ankomah et al., 2020; Ojiija et al., 2024).

The results from Chapter 4 reveal that 81% of respondents have shifted towards agricultural activities, aligning with findings from other regions where agricultural expansion encroaches on forested areas (Hosonuma et al., 2012; Phiri and Nyirenda, 2022). This trend is exacerbated by rural poverty, compelling communities to rely on forest resources for subsistence (Alhassan et al., 2023). This study contributes new insights by linking socio-economic pressures to specific policy failures and governance issues, such as land use, agriculture, and environmental policies factors less frequently addressed in the literature for this region.

The study highlights political factors, including weak governance and corruption, in facilitating illegal logging and land-use activities. These issues are well-documented (Alhassan et al., 2023; Ankomah et al., 2020) and confirmed in Chapters 4 and 5. The findings contribute to existing work by providing new empirical evidence from Nasarawa

State, where socio-economic activities, government policies, and inadequate enforcement have created opportunities for unchecked exploitation of forest reserves.

Scholars argue that weak governance, inadequate law enforcement, and corruption hinder conservation efforts and contribute to deforestation in PAs worldwide (Robson and Klooster, 2019; Tegegne et al., 2016; Fasona et al., 2020; Ward et al., 2018a). This study explores these dynamics in Nigerian gazetted forests, adding to the knowledge on governance and environmental degradation in Africa.

The study contributes to the debate about poverty's role in deforestation around gazetted forests. While some argue poverty is the primary driver (e.g., Robson and Klooster, 2019), others contend poverty alleviation can exacerbate deforestation (Nerfa et al., 2020). Some believe the relationship is mediated by factors like land tenure insecurity and access to alternative livelihoods (Nerfa and Zerriffi, 2020; Brockington and Wilkie, 2015). This study presents a nuanced perspective: poverty contributes to deforestation, but its combination with weak governance and inadequate alternative livelihoods exacerbates the situation (Makunga and Misana, 2017; Cheng et al., 2019).

The socio-economic consequences of deforestation and its link to climate change through greenhouse gas emissions are critical issues underscored by the IPCC (2019; 2021). This research contributes to the global understanding of deforestation around PAs by confirming these impacts in Nasarawa State. The IPCC also highlights the need for climate-resilient development integrating climate change mitigation and adaptation without hindering socio-economic progress. Therefore, integrated strategies that combine environmental protection with socio-economic development in forest-dependent communities are crucial. Successful conservation initiatives must involve local stakeholders and address their livelihoods. Policies aimed at promoting sustainable agriculture should consider the implications for forest conservation and the well-being of forest-dependent communities.

The study’s findings in Chapter 5 highlight that although the community is aware of the need to preserve the forest ecosystem, there is a noticeable disparity between this awareness and the implementation of conservation actions. This gap may be influenced by socio-economic constraints, lack of resources, insufficient education on practical conservation methods, and unclear roles and responsibilities. Additionally, confusion over forest ownership and governance, along with a sense of powerlessness among community members, may further discourage conservation efforts (Nath and Magendran, 2021).

External factors such as inadequate governmental support, lack of incentives, and competing economic priorities may also inhibit action despite widespread recognition of the need for conservation (Amoah et al., 2022). Bridging this gap requires sustainable land-use policies, active community engagement in conservation activities, and financial and technical support for restoration projects.

Despite efforts by local communities, the study identifies several challenges that hinder effective conservation, including ineffective governance mechanisms, limited policy enforcement, and socio-economic pressures that encourage unsustainable practices. Conservation failures in Nasarawa State's PAs could have far-reaching implications for biodiversity conservation, community development, cultural preservation, and climate resilience.

Moreover, the absence of functional legal protections and enforcement mechanisms encourages illegal activities that drive deforestation, making it difficult for government agencies, NGOs, and local communities to collaborate effectively. This lack of cooperation could undermine eco-tourism initiatives, sustainable harvesting of non-timber forest products, and community-based conservation programs. Conflicts between conservation goals and local community needs, such as access to land and forest resources, further complicate the management of these forests.

PAs in Nasarawa State hold cultural significance for local communities. Engaging elders and custodians in decision-making can integrate traditional knowledge into conservation. Sacred forests and ancestral sites can be designated as conservation areas, reinforcing sustainable practices like controlled harvesting and seasonal hunting restrictions. Eco-cultural tourism can showcase local traditions and conservation ethics, preserving heritage while supporting biodiversity.

A key finding of the study is that integrating community-led initiatives with government support structures could enhance conservation outcomes. The establishment of collaborative governance frameworks, incorporating both local community knowledge systems and formal government institutions, emerges as a promising approach for sustainable forest management. This approach would empower communities and ensure conservation efforts align with national policies, leading to more effective results (Pienaah et al., 2024).

Integrating local knowledge, such as traditional ecological practices and community conservation techniques, with institutions like the Forestry Commission can create culturally

appropriate, science-based management strategies. This ensures conservation policies align with community values while enhancing forest resilience. Indigenous fire management and sustainable harvesting can support biodiversity and prevent resource depletion (Hu et al., 2023).

The study underlines the importance of diversifying livelihood options for forest-dependent communities to alleviate pressure on natural resources. Communities revealed that alternative livelihood options need to accompany forest management and conservation. By promoting activities like eco-tourism or agroforestry, governments can incentivize sustainable practices while enhancing local livelihoods.

Non-Governmental Organizations (NGOs) play an important role in fighting deforestation and promoting sustainable forest management in Nasarawa State (Chapter 5). The state has several NGOs, such as the Global Initiative for Food Security and Ecosystem Preservation (GIFSEP), Green Renaissance Africa (GRA), Sustainable Environmental Development Initiative (SEDI), and Environmental Rights Action/Friends of the Earth Nigeria (ERA/FoEN). Many work alongside large-scale programs and collaborate with extensive initiatives such as international forest conservation and carbon reduction programmes (Federal Ministry of Environment, 2020; Bosibori and Otieno, 2021). These organizations contribute to forest protection and community livelihoods through advocacy, capacity building, community engagement, and conservation activities (Federal Department of Forestry Nigeria, 2019). However, challenges underscore the need for greater support from the government, international donors, and other stakeholders (Bosibori and Otieno, 2021).

Gazetted forest reserves provide ecological and economic benefits to local, national, and international stakeholders. To ensure long-term conservation, it is important to establish an integrated institutional framework that considers all stakeholders' concerns by linking engagement with improved planning. Effective management in Nasarawa requires a strategy balancing local resource utilization with biodiversity preservation. Success depends on stakeholders' active engagement in management activities. An integrated approach, such as the Biosphere Reserve model proposed by UNESCO in 2017, is necessary for the sustainable use of forest resources for both economic and socio-cultural benefits.

Although the forestry policy and master plan outline a multiple-use zoning management strategy for indigenous forests, its full implementation remains a challenge. Through engaging local communities in the planning process, formulating regulations for extraction, and making management decisions regarding forest reserves, their empowerment can be

enhanced, and they can better appreciate the significance of conservation initiatives. Furthermore, implementing environmental education initiatives in adjacent communities and schools can help reduce human disturbances in core zones. These efforts are ongoing in select regions of the Nasarawa gazetted forest, with support from the Nasarawa State Ministry of Environment and Natural Resources, the NGO Environmental Education Programme, and the local Community Forest Association. However, these efforts need to be expanded and strengthened to cover a wider geographic area and engage more households near the forest.

A combination of reducing disturbances, reforesting degraded areas, and increasing forest patrols can help improve the natural regeneration of indigenous trees for non-extractive purposes. Large plantations can be primarily used for extractive purposes, ensuring sustainability while meeting local resource requirements. Promoting agroforestry practices and tree farming projects at the individual and community levels may provide households with opportunities to reduce their dependence on the resources in gazetted forests. For example, incorporating exotic, native, or mixed species trees into agricultural practices around these areas can help sustain both farming and conservation efforts.

Encouraging community members to engage in income-generating activities such as eco-tourism, butterfly and silkworm farming, beekeeping, and on-farm tree nurseries can also alleviate pressure on forests (Farrukh et al., 2024; Nguyen et al., 2023; Hardaker et al., 2021). To successfully implement a comprehensive forest management approach that encompasses these elements, a supportive policy and institutional framework is necessary. The current national forestry strategy in Nigeria, as outlined by the government in 2020, includes a structured approach to involving local populations in the management and conservation of forests, utilizing their valuable local expertise.

Implementing eco-management arrangements that involve the community and its leaders in forestry activities can contribute to sustainable conservation in two ways. First, it can promote the adoption of appropriate farm forestry technologies, alleviating population pressure on forests. Second, it can regulate and mitigate destructive activities within protected core areas, as per the Forests Act (Nigeria Government Forest Policy 1999, 2006, 2020). However, in the study regions, the local communities lack or have weak Community Forest Associations (CFAs), leading to confusion regarding forest ownership, management responsibilities, and weak enforcement of conservation laws. Establishing CFAs or similar community-led bodies is essential for enhancing forest governance.

Although forests are legally protected, limited resources for conservation management hinder effective enforcement. This lack of resources also contributes to the scarcity of comprehensive data on the forest's carbon sequestration capacity, making it difficult to assess and optimize its role in mitigating climate change (Liu et al., 2024; Li et al., 2023; Al-Nadabi and Sulaiman, 2018). Securing adequate funding is crucial for strengthening conservation efforts and supporting the livelihoods of local communities (Liu et al., 2024; Chiaka et al., 2024). Innovative financing mechanisms and public-private partnerships can help generate sustainable funding streams for conservation initiatives (Maksanova et al., 2020).

Restricting local access to important natural resources without adequate consultation or compensation can lead to hostility toward conservation efforts (Amoah et al., 2022). Effective conservation strategies must consider active community participation, capacity building, outreach programs, and efficient governance, including the consistent enforcement of penalties. Strengthening law enforcement and enhancing surveillance technologies can help regulate human activities around reserves. However, forming partnerships with local communities and PA authorities could be beneficial for all parties involved.

My study established that the existing management system was ineffective in ensuring sustainable forest conservation. More efforts from both the community and the government are needed to encourage sustainable conservation considerations and offer valuable insights into the trade-offs involved in managing gazetted forest reserves in Nigeria. Conservation strategies must consider the lived experiences of local people and their changing perceptions of forest management over time.

Since these perceptions evolve with social, political, and economic changes, ongoing engagement from managers and researchers is necessary. Similarly, PA management plans must be continuously modified to account for new ecological understandings and local knowledge regarding biodiversity and climate change. These plans should also address changes in a PA's social, political, and economic context. Although responsive management is costly and time-consuming, it is essential for consistently protecting both human and ecological security, ensuring long-term sustainability importance.

6.3. Thesis contribution

Understanding the changes in gazetted forests from human perspectives necessitated a mixed method approach, integrating insights from biophysical and socio-economic aspects with the

use of remote sensing and GIS and field surveys. In this thesis, such an approach ensured that the analysis captured the multifaceted nature of human-environment interactions, in line with the socio-ecological lens applied to the study. It provided a better understanding and adequate information about the gazetted forests, resource use changes, biodiversity, conservation, and sustainability of the forest reserves from the perspectives of critical stakeholders in the forest communities. The study contributes to the field of research through the combined methods used in understanding the extent and evaluating forest reserves in north-central Nigeria. No study was found that used this combined method in the same period in the forest reserves in North Central Nigeria.

The study's contributions include new and current maps that show the extent of change in gazetted forest reserves. This research has generated fresh insights and knowledge about the processes of land conversion within designated protected zones. Particularly, it has illuminated how other land categories increase at the expense of forests, as well as the methods by which forests recover in these regions, both naturally and through human efforts, with a focus on quantifying and analysing forest change in PAs where livelihood and other anthropogenic activities are the primary reason for the degraded forest cover. For instance, the research found that there was a reduction in the forest cover in the study reserves due to significant agricultural land expansion between 1966 and 2020 in north-central Nigeria.
The research findings go beyond presenting evidence of forest depletion; they shed light on how the local community perceives the reasons behind forest change in this specific context, emphasizing their views on sustainable forest conservation. In addition, it revealed how a community's traditional way of life has helped in forest preservation, as seen for Odu gazetted forest.
Also, the research provides unique insights into the ownership and management wherein the gazetted forest communities of the study area held divergent views. Some perceived that the state government owns and manages the gazetted forest reserves, while others asserted that the communities themselves own and manage these reserves (Chapter 5). The split in perceptions suggests confusion or a degree of ambiguity about the roles of the government and the communities, which could be relevant to the policy of other developing countries, especially where forest depletion is still widespread.

The study contributes to understanding better protection and management of forest reserves through community forest security, in which traditional use of shrines and secret areas are safeguarded. Use of this approach more widely involves empowering local communities

living in or around forested areas to safeguard their forests. This approach has proven effective in Odu forest, where it leverages the local community's cultural practices and knowledge, which were not fully utilised in previous forest management strategies. Traditional practices, such as the use of shrines and secret areas, should be formally recognised and incorporated into forest management strategies.

This research project further contributes to knowledge exchange activities given the engagement and interaction with critical stakeholders on forest matters who provided evidence from their experience, allowing me to obtain practical insights through KIIs and FGDs. For example, the gazetted forest-dependent community shared their experience on how and why the gazetted forest has changed, revealing their efforts in forest conservation to the forestry in their communities to the researcher. By fostering these exchanges, this project contributes to bridging gaps in understanding local perspectives on protected gazetted forest design. Insights could be used by the government for conservation purposes to improve implementation of conservation efforts, ultimately leading to more effective and collaborative forest management practices for this region, informed also by scientific research and global best practices. The transition towards implementation of policies can be changed from the current sectorial and unjust ones towards achieving future sustainability of the gazetted PAs. By adopting new techniques and embracing this collaboration with through institutional and forest community partnerships, it is possible to develop contextually appropriate blueprints that could enhance understanding of complex socioeconomic and governance processes, as well as help reduce scientific uncertainties related to protected area sustainability.

6.4. Limitations and future research directions

For the biophysical component of this research, I faced limitations in the ability to classify land types (e.g., dense forest, open forest, degraded and non-degraded forest) and other details such as infrastructural development for this study location, due to the spatial resolution of the Landsat images. Considering this, I would suggest that future studies could utilise high-resolution images such as SENTINEL to gain a deeper understanding of other changes in sub-forest types and the loss of significant ecological variables in the protected forest reserves. Due to security challenges such as kidnapping, violence between farmers and herdsmen, inter-community crises, and cultural barriers for safety considerations around the three study reserves, no transect walk was conducted within the forests to obtain primary observations and/or records of resource types and availability. Most of the fieldwork was

carried out within and around the gazetted forest in communities' accessible areas. It would be useful to obtain more first-hand information on resource types and availability by taking a transect walk into the forests covering the entire distance of the gazetted forests, recognising also the security situation and avoiding danger.

Furthermore, future research should extend analyses of the stakeholders' perspectives regarding the values underpinning forest conservation in forest communities. Nasarawa State is one of the pilot survey areas in several regions of Nigeria that is participating in the REDD+ programme, an initiative launched by the World Bank to reduce deforestation and protect the livelihoods of forest communities. Further research is required to assess the status and progress of the programme from the perspective of the local population living around the forest to understand and evaluate its impact on the preservation and reduction of human activities that contribute to forest changes in these study areas.

Given these observations, it became clear that further research should evaluate the effectiveness and equity in the benefit-sharing mechanism of forest ecosystem services within the forest reserves, considering the government and the forest-dependent communities. Understanding these dimensions will help identify where the current system fails and how it can be improved. This research is crucial for ensuring that forest-dependent communities are not just merely passive recipients but active participants in managing and benefiting from forest resources, thereby leading to more sustainable and equitable outcomes. Future research could use a more explicit socioecological and theoretical lens associated with the gazetted forest community. Undertaking sociological research to identify the needs and aspirations of rural communities is necessary with a focus on communities' attitudes or behaviour toward the use and conservation management of the gazetted and non-gazetted forest areas recommended for further studies.

This research faces important limitations regarding the representation of women in the sampling methods (Chapter 2). Due to background cultural practices in the study area, women were not extensively involved. Future research should aim to include a larger number of female participants if improved strategies and opportunities for their engagement become available and at minimum be aware of gender biases in sampling. Women play a substantial role as forest users, often participating in agricultural activities and collecting fuel and other forest resources for livelihood around this forest reserve, so their views and perspectives are important.

In addition, the current forest structure and composition need to be assessed in these protected reserves in the study area for a deeper understanding of the impacts of conservation. Some of the insights from this research can be used to inform future management of this forest. Due to the significant change in the forest reserves lost in this study, there is a need for further research to investigate the potentially significant amount of carbon sequestered lost from the gazetted forest. This could help us to understand the local effects of degradation on carbon stocks.

6.4.1. Strengths and weaknesses of positionality in data analysis and interpretation

Understanding the researcher's positionality is crucial for assessing the reliability and validity of data analysis and interpretation in land use and conservation studies. A key strength of my positionality was combining insider and outsider perspectives, which facilitated access to local communities and critical distance for objective analysis. As an insider, my familiarity with the region, culture, and historical context enabled rapport with stakeholders, leading to insights into community perceptions of land use challenges. My knowledge of gazetted forests and environmental governance strengthened the research design, ensuring contextual data collection. Engaging with stakeholders, including policymakers, farmers, and traditional leaders, provided multiple viewpoints that enriched the study's foundation.

However, my positionality introduced potential biases that may have influenced analysis and interpretation. While my insider status provided access, it carried the risk of unconscious assumptions about local dynamics, affecting neutrality. Linguistic and cultural differences between myself and certain communities created barriers that shaped participant responses. Some viewed me as an outsider due to dialect differences or perceived government affiliations, leading to initial distrust. These perceptions could have influenced responses, particularly regarding land tenure and conservation policies. The underrepresentation of women in stakeholder discussions due to cultural norms may have resulted in gender-biased interpretations. This highlights the challenge of achieving gender inclusion in culturally sensitive research settings, as noted in Chapter 2. Future research should expand sample representation to involve more women in forest matters if cultural background allows their participation, as they interact with forests more often for livelihoods.

To mitigate these challenges, I employed reflexivity throughout the research, assessing how my background and methodological choices influenced findings. Including research assistants from diverse ethnic groups helped bridge communication gaps and enhance credibility. Methodological triangulation combining qualitative and quantitative approaches ensured comprehensive understanding of land use dynamics. Despite these efforts, some limitations persisted, highlighting the need for more inclusive participatory approaches in conservation decision-making.

This study shows how researcher positionality evolves throughout the research process. Recognizing these dynamics was crucial in producing findings that were rigorous and embedded in community realities. Future research should continue to incorporate reflexivity for ethical knowledge production.

Further research work should consider this thesis as baseline information, as there is no other known work such as this in North Central Nigeria. This work was limited in scope, focusing on only three gazetted forest reserves land use and communities. This was a realistic number of communities and people that could be sampled, largely due to cost constraints and security concerns during the fieldwork. It would be useful to carry out this work over a larger geographic area and other gazetted forest reserves.

6.5. Recommendations and conclusions

Understanding changes in land use of the forest reserve using remote sensing data and GIS application at regular intervals, is necessary to understand the relationship between the change in biophysical and socioeconomic variables and the implications for the environment from local to global scales. The study revealed that water bodies that are necessary to life drastically changed in all the reserves over the period covered by the study. This indicates to the government and relevant institutions the need to put in place strategies that will buttress successful forest conservation management in Nasarawa State, Northern Nigeria. There is inadequate published research in the literature on the gazetted forests in North Central Nigeria. As such, it is essential to share the substantial body of research conducted in these domains to offer a foundation of baseline data, for both local and national PA conservation.

There is a need for change in land use that can support tree growing, farming practices that support the environment, to restore forests and reverse losses, and encourage agroforestry, particularly in the local communities. Based on this study, management of Doma, Risha, and Odu Forest Reserve has been unable to meet the standards of IUCN for sustainable forest

reserve management. Given the existing management framework and the continuing and rapid rate of forest loss and vegetation conversion, the forest reserves' viability is questionable. An improved policy and legislative framework on forests and forest reserves is required if the government intends to improve the reserve's deplorable condition. Supportive logistics, human resources, and financial support for the management of the forest reserve should be considered in the reserve area. Efforts by the government and community specifically should make available programmes for reforestation, tree regeneration efforts for effective protection of forest landscape restoration on the reserves and other PAs areas in the state.

Furthermore, the approaches utilised for forest protection and regeneration in this tropical region of the world have been called into question. It is crucial to prioritize forest monitoring and safeguarding. Silviculture can be detrimental to the preservation of tropical forests if foresters fail to address the issues at hand. Urgent measures are necessary to address the following needs: (i) clearly demarcating and maintaining the boundaries of protected forest reserves on the ground and ensuring everyone knows who has ownership and management responsibility (ii) strengthening the protection and patrolling staff to enforce laws against encroachment on these reserves and PAs (iii) improving the efficiency and discipline of the forestry department (iv) implementing reforestation efforts in areas under threat from encroachment (v) developing management plans that integrate the different objectives for each reserve, taking into account the interests of the nation, the state, and local communities, in order to ensure sustained and improving conservation for global benefits (vi) enhancing public education, both nationally and locally, as well as collaboration with law enforcement agencies for forest monitoring and safeguarding. Consequently, proper land use planning, legal backing, and institutional integration are essential recommendations to support the preservation of protected forest reserves and resources for the study area and beyond for global sustainable development. Conservation, management, and sustainability of protected forests must consider the dependence of people on forest products (such as building materials, food, medicine, etc.) and the cultural, economic, and general health and welfare benefits that forests provide. Conservation policies and activities should align with local priorities to engage people in conservation and preserve forests.

6.5.1. Key concluding messages 1. Key conclusion messages in my thesis

One of the key messages from this research is that two gazetted forests have gone in terms of forest cover (Risha and Doma) in chapter 3 which this study is the first to recognise and quantify. The findings highlight a critical concern: the restoration of these forests may be

extremely challenging, if not impossible. However, there is strong evidence that forests have the potential to recover, reseed, and regenerate naturally if left undisturbed. Additionally, reforestation efforts, including assisted regeneration and afforestation programmes, have successfully restored degraded forests in various contexts. While the specific environmental conditions, soil degradation, and anthropogenic pressures in Risha and Doma may complicate restoration efforts, targeted conservation strategies and reforestation initiatives could offer pathways to partial or full ecological recovery. Further research is needed to assess the feasibility of these interventions and to develop site-specific restoration plans. This is one of the significant messages from my PhD and should be used by policymakers to undertake an urgent inventory of the remaining gazetted forests in Nigeria and beyond. This research work should be considered as baseline information, as there is no other known work such as this in North Central Nigeria.

The study identified agricultural expansion, lumbering for fuelwood/charcoal, population growth, poverty, and government policies as key drivers of LULCC as perceived by the community across all three study forest reserves in Nasarawa State, though varying in intensity and scale. Risha and Doma experienced the highest levels of agricultural expansion and forest degradation, while Odu remained relatively intact due to cultural controls on shifting cultivation. In Risha and Doma, the land was actively cleared for permanent agriculture, whereas in Odu, initial timber extraction led to later agricultural encroachment. Over time, factors like population growth, poverty, and grazing also contributed to forest degradation, with Odu now showing a rapid forest cover increase through shifting cultivation, as evidenced in Chapters 3 and 4 on the classified maps and human activities.

Moreover, while a substantial proportion of individuals in the study indicated that they are involved in the conservation measures, empirical evidence showed that the community conservation measures undertaken in the forest reserves lack any substantial impact on the gazetted forest region, despite community concerns about the decline of the forest as evidenced in chapter 5. Traditional practices for forest security, and the integration of cultural practices, like shrine establishment and shifting cultivation within forest reserves have a positive impact on the increase in forest cover specifically in Odu, highlighting the importance of blending modern conservation strategies with local systems of forest conservation (chapter 3, 4 and 5).

A Key finding reveals diverse community perceptions of forest reserve ownership and management in the study area. While many community members were aware that the

government owned the forest reserves, a substantial proportion lacked awareness of this, particularly in Odu forest community, reflecting a disconnect between legal ownership and community understanding. This indicates a complex relationship where both community and government entities regulate and permit resource extraction from the forest reserves and potentially reveals a gap in terms of the legal ownership and management and the practice of accessing the forest reserves for effective conservation evidence (Chapter 5).

In this thesis, I have presented evidence showing that the gazetted forest cover has changed significantly between 1966 and 2020, identifying the reasons behind this change from the perspectives of the forest-dependent community. I have also evaluated community perceptions of ownership and management, conservation strategies, and sustainability opinions for the protected forest reserve. This study demonstrates that no 'silver bullet' exists to understand the challenges of the area's governance and management. It is essential to acknowledge the complexity of these challenges and develop equitable evidence-based solutions that combine local perceptions and sound science. Quantitative and qualitative methods represent different approaches to scientific research and provide complementary information, supporting advances in forest conservation science by providing robust and novel insights. By promoting shared learning between researchers, local communities, and practitioners, the research process can contribute to the co-creation of actionable knowledge and bridge the gap between research and practice. This thesis integrated different perspectives and research methods to enhance the understanding of spatial changes in land use and land cover, answering when, how, where, and why the forest PAs have changed. This allowed a more holistic understanding of the drivers and factors that influence these changes. Protected areas are critical for preserving biodiversity, ecosystems, and ecosystem services, and effective management of these areas requires the collective efforts of multiple stakeholders, including governments, civil society, local communities, and the private sector. To enhance the resilience and effectiveness of PA management, we must implement innovative strategies, foster collaboration, and integrate diverse knowledge systems. Considering this, partnerships with local communities and PA authorities could promote a win-win outcome, with more active local participation in PA decision-making processes so that financial resources can be better invested in improving governance, local capacity building, participation, and outreach. Leveraging evidence on forest cover change and knowledge on their drivers can help ensure the long-term conservation of Nigeria's natural heritage, for the benefit of those communities who live close to forests and to support future generations in the sustainability of invaluable ecosystem services of local, national, and global importance.

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Appendices

Appendix 2.1: A table showing ground truthing coordinate points from the gazetted forest reserve sites for the study area.

	Doma Forest points			Risha forest Points			Odu forest Points		
S/N	**X**	**y**	**Class Name**	**X**	**y**	**Class Name**	**x**	**y**	**Class Name**
1	8°15'46.77"	8°21'51.54"	Bare surface	8°56'48.14	8°14'31.28"	Bare surface	8°32'56.74"	7°30'51.57"	cropland
2	8°17'13.40"	8°21'45.93"	Bare surface	8°54'59.52"	8°14'51.11"	Bare surface	8°33'19.83"	7°27'25.98"	cropland
3	8°18'57.96"	8°21'39.19"	Bare surface	8°54'32.85"	8°16'6.56"	Bare surface	8°33'2.83"	7°26'25.06"	cropland
4	8°19'12.28"	8°21'4.39"	Bare surface	8°54'54.50"	8°17'1.87"	Built up land	8°32'49.44"	7°29'51.53"	cropland
5	8°16'52.10"	8°13'15.44"	Built up land	8°54'50.53"	8°17'30.26"	Built up land	8°32'52.45"	7°31'15.21"	cropland
6	8° 0'22.52"	8° 5'11.93"	Built up land	8°56'1.56"	8°14'0.46"	Built up land	8°33'28.22"	7°30'40.94"	cropland
7	7°59'53.83"	8°20'12.50"	Built up land	8°54'12.51"	8°12'56.47"	Cropland	8°33'36.09"	7°31'22.45"	cropland
8	8°14'29.68"	8°24'2.32"	Cropland	8°54'20.84"	8°13'24.78"	Cropland	8°34'5.19	7°27'27.96"	cropland
9	8° 8'5.45"	8°23'6.61"	Cropland	8°55'18.01"	8°13'48.31"	Cropland	8°33'25.30"	7°26'53.12"	cropland
10	8° 9'30.09"	8°27'35.73	Cropland	8°55'11.70	8°12'58.55"	Cropland	8°34'24.59"	7°27'33.33"	cropland
11	8° 1'23.82"	8°17'55.54"	Cropland	8°55'26.38"	8°12'33.96"	Cropland	8°34'51.01"	7°30'22.33"	cropland
12	8°18'30.65"	8°26'59.23"	Cropland	8°55'43.02"	8°12'43.41"	Cropland	8°35'10.08"	7°32'0.56"	cropland
13	8°19'25.39"	8°24'50.49"	Cropland	8°56'4.56"	8°12'46.07"	Cropland	8°34'17.00"	7°31'46.00"	Bare surface
14	8°16'23.62"	8°27'32.92"	Cropland	8°56'14.83"	8°13'2.84"	Cropland	8°31'28.72"	7°32'15.67"	Bare surface

15	8°15'31.62"	8°23'58.94"	Cropland	8°55'47.49"	8°14'1.92"	Cropland	8°33'8.23"	7°28'42.60	Bare surface
16	8°18'22.39"	8°22'3.16"	Cropland	8°54'37.30"	8°14'9.25"	Cropland	8°36'18.46"	7°30'32.64"	Bare surface
17	8°17'56.21"	8°23'2.23"	Cropland	8°55'26.04"	8°16'46.50"	Forestland	8°35'43.89"	7°30'2.60"	Built up land
18	8°17'34.37"	8°14'4.32"	Forestland	8°55'3.59"	8°17'37.58"	Forestland	8°35'38.32"	7°30'7.92"	Built up land
19	8°17'22.40"	8°13'26.98"	Forestland	8°56'5.42"	8°17'47.13"	Forestland	8°33'4.70"	7°28'2.38"	Grassland
20	8°18'46.42"	8°15'50.56"	Forestland	8°57'19.86"	8°15'55.15	Forestland	8°33'49.99"	7°29'14.88"	Grassland
21	8° 9'9.83"	8°24'49.48"	Grassland	8°55'44.23"	8°14'33.10	Grassland	8°35'31.52	7°28'48.08"	Grassland
22	8°10'34.66"	8°18'48.14"	Grassland	8°54'34.87"	8°12'45.66"	Grassland	8°35'35.79"	7°27'45.98"	Grassland
23	8°23'59.90"	8°26'32.29"	Grassland	8°54'43.90"	8°12'56.82"	Grassland	8°36'37.82"	7°29'39.31"	Grassland
24	8° 5'25.02"	8°14'46.15"	Shrubland	8°53'59.33"	8°13'33.26"	Shrubland	8°36'38.39"	7°31'42.58"	Shrubland
25	7°59'59.80"	8°16'25.92"	Shrubland	8°53'40.70	8°13'25.96	Shrubland	8°32'39.67"	7°31'32.47"	Shrubland
26	8° 3'41.67"	8°21'41.01"	Shrubland	8°54'12.84"	8°13'21.26"	Shrubland	8°32'56.91"	7°29'34.12"	Shrubland
27	8°23'20.78"	8°27'22.05"	Shrubland	8°54'21.70"	8°14'41.90"	Shrubland	8°33'42.10"	7°26'24.21"	Shrubland
28	8°18'35.77"	8°20'11.10"	Wetland	8°56'14.16	8°15'11.56"	Wetland	8°35'10.86"	7°28'17.10"	Forest land
29	8°18'11.85"	8°18'34.94"	Wetland	8°57'7.81"	8°14'21.46"	Wetland	8°34'39.47"	7°30'19.27"	Forest land
30	8°19'40.24"	8°17'7.41"	Wetland	8°57'22.69"	8°14'51.66	Wetland	8°36'58.98"	7°28'5.11"	Forest land

Sources: Authors field exercise on ground truthing coordinate points from the gazetted forest reserve sites for the study are

Appendix 2.2: Sample of a Fieldwork Questionnaire.

HOUSEHOLD QUESTIONNAIRE SURVEY

INTRODUCTION

This research is undertaken to collect data as part of a PhD degree programme at the University of York, UK, titled: ***Anthropogenic impact on gazetted forest reserves and implications for forest sustainability in Nasarawa State, Nigeria***. The research is conducted by **Chunwate Banki Thomas,** a PhD student at the Department of Environment and Geography, University of York, along with research assistants from Nigeria. The research assesses land use change in forest reserves considering their implications for people. This research is funded by TETFUND Nigeria. The information is for academic and learning purposes only.

As part of this research work, we are conducting a household survey in three geo-political zones of Nasarawa State: Doma gazetted forest reserve in the southern district, Risha in the north and Odu in the western part of Nasarawa State. We would like to ask you to participate. It will take around 40 minutes.

We need to point out the following information so you can make an informed decision about whether you want to be involved:

- All your answers will be kept confidential and anonymous, so you cannot be identified from your answers
- Your participation is entirely voluntary. We are unable to pay you for your participation in the questionnaire survey
- The information you provide in your answers will be put together with the answers provided by other people and after analysing the data, we will publish the results in reports and scientific journals, as well as sharing the findings with policymakers
- All information you provide will be treated in compliance with the UK General Data Protection Regulation (GDPR) which we are required to follow by the funders. Only the project researchers will have access to the raw data
- If there are any particular questions in the interview that you do not want to answer you can skip them.
- You can withdraw from the research at any time during data collection, up to the point that we start analysing the data. If you do decide to withdraw, we will delete all your answers. We will leave you our contact details in case you want to withdraw after we have left your area

Please can you confirm that you have understood the information that has just been read to you and let us know if you are willing to proceed with answering the questions?

Section A:

Ethical issues

Q1) Do you consent to participate in this survey?

- Yes
- No

Q2) If No, do not continue

……
…

Would you agree to be contacted by one of the members of the research team following analysis of your answers to this survey, if there are opportunities for further participation in the project?

- Yes
- No

If Yes, state preferred contact details:

…….

SECTION B: -

DEMOGRAPHY OF THE HOUSEHOLD RESPONDENT: -

Q3) Name……

(Q4) Which tribe/ethnic group do you come from?

. Hausa [ ]
a. Mada [ ]
b. Alago[ ]
c. Gade [ ]

d. Other [ ], please specify ……

Q5) Contact details i.e (Settlement, Village and Local Government area)
……

Q6) Phone Number ……

Q7) Sex: (a) Male [ ] (b) Female[ ]

Q8) Age: (a) 18-35 [ ] (b) 36-55 [ ] (c) 56-75 [ ] (d) 76- above [ ]

Q9) What is your marital status

Q10) Single [ ] (b) Married [ ] (c) Separated [ ] (d) Widowed [ ] (e) Divorced [ ]

Q11) What is the household's main way of generating income in your area?

Salaried income [ ] Non salaried income [ ]

Q12) How many households are living in the compound?

. 1-2 [ ] (b) 3-4 [ ] (c) 5-6 [ ] (d) 7-8 [ ] (e) > 8 [ ]

(f) Other [ ] If other please specify **……**

Q13) What is your household's monthly income range?

. Less than N20,000 [ ]
a. N21,000 – N40,000 [ ]
b. N41,000 – N60,000 [ ]
c. N61,000 – N80,000 [ ]
d. N81,000-N100,000 [ ]
e. Above N100,000 [ ]
f. Variable [ ]

Q14) What is your main occupation? Farming [ ] Trading/business [ ] Artisan [ ] Civil service [ ] Government official [ ] Others [ ]. You may tick more than one option

Q15) What is the highest level of education in the household (a) No formal education [ ] (b) Primary education [ ] (c) Secondary education [ ] (d) Diploma [ ] (e) NCE [ ] (f) Degree [ ] (g) Other [ ] If Other, please specify …….

SECTION C: LAND USE AND GAZETTED FOREST CHANGE IN NASARAWA

Q16) Are you aware of the gazetted forest reserve in your community?

Yes [ ] No [ ]

Q17) The Gazetted Forest reserved in your community is owned by who?

. Communities [ ] b) State Government [ ] c) private owners d) [ ] anybody [ ]

Q18) The gazetted forest reserve is Managed by;

Community [ ] b) State Government [ ] c) private owners [ ] d) individual [ ]

Q19). What land use activities going on the gazetted forest reserved in your community? You may tick more than one option.

a) Agriculture [ ] b) Residential use c) Grazing [ ] d)Mining [ ] e) Hunting [ ] f) Fishing [ ] g) Infrastructural Development [ ] h) [ ] others specify…….

Q20) Forest cover in the gazetted forest reserve in your community since 1966 has;

. Decrease [ ] b) Increased [ ] c) stayed the same [ ] d) don't know [ ]

Q21) If the forest decreases what are the major drivers of forest change in your area? You may tick more than one option.

a) Agriculture expansion [ ] b) Construction c) Settlement [ ] d) lumbering [ ] e) charcoal/fuel wood [ ] f) Natural disaster or Climate Change [ ] g) Grazing [ ] h) [ ] Others specify……..

Q22). If the forest is increases what do think is the reason for the increased in your area? You may tick more than one option.

a) individual tree planting [ ] b Tree planting campaigns by the government [ ] Private NGO plantation [ ] Community participation in forest security and decision making [ ] Enforcing regulations to stop deforestation [ ] sustainable Agriculture practices [ ] Non of the above [ ]

Q23) Do the people in your area require any permission to harvest in the forest reserve? Yes [ ] No [ ]

Q24). If yes who give the permission? a) Government [ ] b) Community leaders [ ] c) Non of the above

Q25) If no why

……
….

……
….

Q26) What type of crops do you cultivate in your area? You may tick more than one option

a) Yam [ ] Cassava b)[ ] Maize [ ] c) Guinea corn [ ] d)Melon e)Millet [ ] Groundnut [ ] beniseed [ ] others [ ] Specify…….

SECTION E. FOREST RESOURCES USE AND DRIVERS OF CHANGE

For the following questions please Indicate your answers by choosing an appropriate response to each statement using the formats below.

(1) SA= Strongly Agree	**(2) A= Agree**	**(3) D= Disagree**	**4) SD= Strongly Disagree**	**(5) NAD= Neither Agree Nor Disagree**

	SA	**A**	**D**	**DS**	**NAD**
Q27) Gazetted forests in Nasarawa State are effectively managed					
Q28) People in Nasarawa State rely on forests resources for livelihood					
29)People who live closer to the forests use forest resources more					
Q30)The future of Gazetted forests in Nasarawa State is safe					

Q31) How important is the forest in terms of the following benefits to you and your household?	**5**	**4**	**3**	**2**	**1**
a) Provision of Edible food (fruit, yam, green leaves)					
b) Source of income (fuel wood/charcoal production, lumbering)					
c Conversion for agriculture					
d) Medicinal plant					

e) Bush Meat					
f) Traditional Worship					
g) Regulate Climate Change					
h) Other specify……					

Indicate by scoring the under-listed options on importance of forest to you and society. (Please, find the key for scoring; 5 = of very importance; 4= of importance; 3 = less importance 2= Not importance; 1= No idea) You may tick more than one option as you perceived.

Q28) What do you think is the importance of forests to wider society?	**5**	**4**	**3**	**2**	**1**
a) Source of rain					
b) Resource for maintaining the fertility of the land					
c) Is worth protecting for biodiversity (plants and animals)					
d) Supplement income					
e) Has no importance					
f) Hardwood for construction					
h) Medicinal plant					
i) Bush Meat					
j) Edible items from the forest (fruit, yam, green leaves)					
k) Fuelwood/Charcoal					
l) fires					
m) Religious purpose					
n) Climate Change					

o) Educational purpose					
p) Recreational					
q) Others (specify)					

Q33) Do you face any challenges in terms of forest resources harvesting in the forest?

. Yes [ ] (b) No [ ] (c) Don't know [ ] (d) N/A [ ]

Q34**)** If Yes, what type of challenge do you face?

a) Govt. enforcement of forest law by forest guard [ ] b) Traditional forest law restriction [ ]

c) fear of dangerous wild animals [ ] d) ancestral spiritual calamity from the forest [ ] e) fear of criminal hide out g) others [ ] specify……..

Q35) If no
why……

……

Q35) To what extent do you think the change in the gazetted forest reserve have impacts on the environment for the following statement;	**SA**	**A**	**SD**	**D**	**NAD**
a) loss of biodiversity (plants and animals species)					
b. increased bare surfaces (erosion, flooding)					
c. increases GHG emission to the atmosphere (heat)					
d. influence climatic change (rainfall, sunshine)					
e. reduces crop production (soil fertility, food security)					
f. Others specify……					

SECTION F. FOREST CONSERVATION MEASURE AND MANAGEMENT IN THE COMMUNITY

Indicate by choosing the appropriate response to the questions below

Q36) Do you participate in the following conservation measures for forest management: -

a) Planting of trees Yes [ ] No [ ]

If yes, why? (add explanation

……
……

If no, why not? (add explanation
……
……

b. Protecting certain desired (patches of) tree in the forest to promote natural regeneration Yes [ ] No [ ]

If yes, why? (add explanation

……
……

If no, why not? (add explanation

……

……

c. Protecting areas of forest for environmental services, like water catchment Yes [ ] No [ ]

If yes, why? (add explanation

……
……

If no, why not? (add explanation

……
……

e. Establishing clear use rights for a limited number of people to particular forest products (e.g. honey) trees Yes [ ] No [ ]

If yes, why? (add explanation

……
……

If no, why not? (add explanation

……
……

f. Extension/education about forest management Yes [ ] No [ ]

If yes, why? (add explanation

……
……

If no, why not? (add explanation

……
……

g. Use of local rules guiding conservation Yes [ ] No [ ]

If yes, why? (add explanation

……
……

If no, why not? (add explanation)

……
……

h. Use of protective mechanism Yes [ ] No [ ]

If yes, why? (add explanation

……
……

If no, why not? (add explanation

……
……

i. Enacted and enforce law (e.g. no bush burning in or near the forest) Yes [ ] No [ ]

If yes, why? (add explanation

……
……

If no, why not? (add explanation

……
……

j. Mapping/inventory forest resources Yes [ ] No [ ]

If yes, why? (add explanation

……
……

If no, why not? (add explanation

……
……
……

Q37) To what extent do you think forests should be conserved for the following reasons;	**SA**	**A**	**SD**	**D**	**NAD**
a. Promotion of local development					
b. Generation of income					
c. Promotion of local participation					
e. Improvement of the natural environment					

f. Enhance community land rights					
g. Enhance carbon stock (more trees)					
h. Solution for land ownership conflict					

SECTION G. **A Sustainable Forest /Vegetation option in Nasarawa State.**

Indicate by scoring the under-listed options on importance of forest to you and society. (Please, find the key for scoring; 5 = of high importance; 4= of importance; 3 = less importance 2= Not importance; 1= No idea)

Q38) How important are the following options for forest sustainability in the State	**5**	**4**	**3**	**2**	**1**
a. Tree planting campaigns by the Government					
b. Individual tree plantation					
c. Private NGO plantation					
d. Enforcing regulations to stop deforestation					
e. Provision of alternative source of cooking fuelwood					
f. Alternative Source of Livelihood					
g. Community participation in forest security and decision making					
h. Provision of farm inputs and loan to the farmer by the Government					

Indicate by ticking the under-listed options on the concerned on the change to the forest 5= being very concerned; 4= being concerned; 3= being less concerned; 2=Not being concerned; 1= No idea

Q39) How concerned are you about any changes to the gazetted forest ?	**5**	**4**	**3**	**2**	**1**

why? (add explanation)

……

…….

Why…….

Indicate by ticking the level of future concerned of the forest in the study are using the following scale; 5=A lot; 4=A fair amount; 3=Not very much 2=Not at all; 1=N/A

Q40) How concerned are you about the future of the forest in the state?	**5**	**4**	**3**	**2**	**1**

why? (add explanation)

……
……
……

This is the end of the questionnaire exercise. Please, do you have any questions to ask us or comments? If not, thank you so much for participating and your precious time.

SECTION I: INTERVIEW PROTOCOL AND QUESTIONS

INTRODUCTION

This research is undertaken to collect data as part of a PhD degree programme at the University of York, UK, titled: ***Anthropogenic impact on gazetted forest reserves and implications for forest sustainability in Nasarawa State, Nigeria***. The research is conducted by **Chunwate Banki Thomas,** a PhD student at the Department of Environment and Geography, University of York, along with research assistants from Nigeria. The research assesses land use change in forest reserves considering their implications for people. This research is funded by TETFUND Nigeria. The information is for academic and learning purposes only.

As part of this research work, we are conducting interviews survey in three geo-political zones of Nasarawa State: Doma gazetted forest reserve in the southern district, Risha in the north and Odu in the western part of Nasarawa State. We would like to ask you to participate. It will take around 40 minutes.

We need to point out the following information so you can make an informed decision about whether you want to be involved:

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- ✓ Your participation is entirely voluntary. We are unable to pay you for your participation in the questionnaire survey
- ✓ The information you provide in your answers will be put together with the answers provided by other people and after analysing the data, we will publish the results in reports and scientific journals, as well as sharing the findings with policymakers
- ✓ All information you provide will be treated in compliance with the UK General Data Protection Regulation (GDPR) which we are required to follow by the funders. Only the project researchers will have access to the raw data
- ✓ If there are any particular questions in the interview that you do not want to answer you can skip them.
- ✓ You can withdraw from the research at any time during data collection, up to the point that we start analysing the data. If you do decide to withdraw, we will delete all your answers. We will leave you our contact details in case you want to withdraw after we have left your area

- ✓ Do you have any questions you would like to ask us about the study before you decide whether to go ahead?

INTERVIEW QUESTIONS FOR COMMUNITY PEOPLE

1. Where do you live and how long have you lived here?
2. What is your occupation?
3. Are you aware of the gazetted forest reserve?
4. Have you noticed any changes to the gazetted forest reserve in your area over the past 20 years?
5. What benefits does the forest provide to you?
6. What benefits do you think the forest provides to the community?
7. What do you think is the importance of gazetted forests to society?
8. Do you think there are any environmental impacts from cutting down trees? If so, what?
9. Do you think there are any environmental impacts from cutting down trees? If so, what?
10. Can you tell me about any traditional laws that safeguard the forest in this area?
11. Can you also tell me about any government laws that safeguard the forest in this area?
12. Can you tell me about any community conservation measures for the forest reserve?
13. Do you have any concerns about any changes to the forest and why?
14. What do you think needs to be done to address the major concerns you have about the future of the forest?

INTERVIEW QUESTIONS FOR GOVERNMENT OFFICIALS

1. Do the Ministry of Environment legally bound to protect the gazetted forest reserve?
2. What laws do the ministry have to manage and protect the gazetted forest reserve?
3. Are these laws being apply and enforce on the gazetted forest reserves area?
4. Do you think the gazetted forest reserve has changed over the last 20years ago?
5. What do you think caused these changes?
6. Why do you think the gazetted forests reserve should be conserve?
7. What is the role of state forestry department on the gazetted forest reserve?
8. What are the main three challenges in managing and conserving forest reserves in the state?
9. Do you think the budget allocation to the state forestry department is adequate to allow you to manage these challenges?
10. Does the state forestry conduct an annual survey and boundary demarcation on the gazetted forest reserves?

11. Are these laws being apply and enforce on the gazetted forest reserves area?
12. What do your ministry doing to safeguard the gazetted forest reserves in the state?

INTERVIEW QUESTIONS FOR EXPERT

Can you tell me about gazetted forests in Nigeria?

1. What do you think about the ownership and tenure system of the gazetted forest reserve in Nasarawa State?
2. Do you think this forest has changed in the last 20years and if so, how has they changed?
3. What do you think are the activities that may cause the change in the gazetted forest reserve in the State?
4. What do you think are the impacts of these activities on the forest change and on the environment?
5. Can you tell me about any traditional laws that safeguard the forest in Nasarawa state?
6. Can you also tell me about any government laws that safeguard the forest in this area?
7. Do you think these rules and regulations are enforced effectively in the communities of the state and if so why?
8. As an Expert or NGO what role do you play in Environmental conservation?
9. Do you think conservation of the forest is important to society and why?
10. Can you tell me about conservation measures to put in place for the forest reserve in the state?
11. Do you think the gazetted forests reserves in Nasarawa State are effectively managed? if not why?
12. Tell me about what needs to be done to safeguard the forest for the future generation

SECTION I: FOCUS GROUP DISCUSSION PROTOCOL AND QUESTIONS

INTRODUCTION

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research is funded by TETFUND Nigeria. The information is for academic and learning purposes only.

As part of this research work, we are conducting FGD in the three geo-political zones of Nasarawa State: Doma gazetted forest reserve in the southern district, Risha in the north and Odu in the western part of Nasarawa State. We would like to ask you to participate. It will take around 40 minutes.

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- ✓ Do you have any questions you would like to ask us about the study before you decide whether to go ahead?

FOCUS GROUP DISCUSSION QUESTIONS FOR COMMUNITY PEOPLE

1. Have forest reserves changed in your area between the 1960s and 2000? What about between 2000-2022? How have they changed in terms of (Size, quality/quantity, and composition)?

2. What do you think are the drivers that cause the forest the changes between these years?

3. Do the change affect trees and animal species on the forest reserve? If so, how?

4. Can you tell me about trees and animal species in the forest between the 1960s and 2000, what about 2000-2022?

5. What do you think are the effects of forest changes on the environment?

6. Are there challenges that affect implementation of the extant strategies and regulations? How might these be addressed?

7. What policy do you think is needed to address the forest conservation challenges and why?

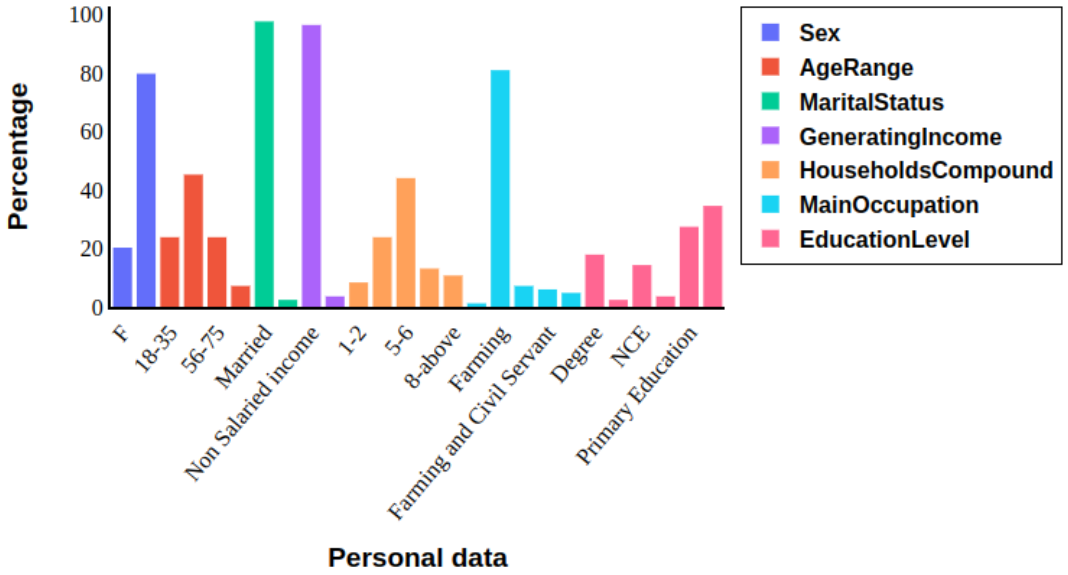
8. What do we need to be doing for the sustainability of these forest reserves for future generations?

FOCUS GROUP DISCUSSION QUESTIONS FOR GOVT. OFFICIAL AND EXPERT

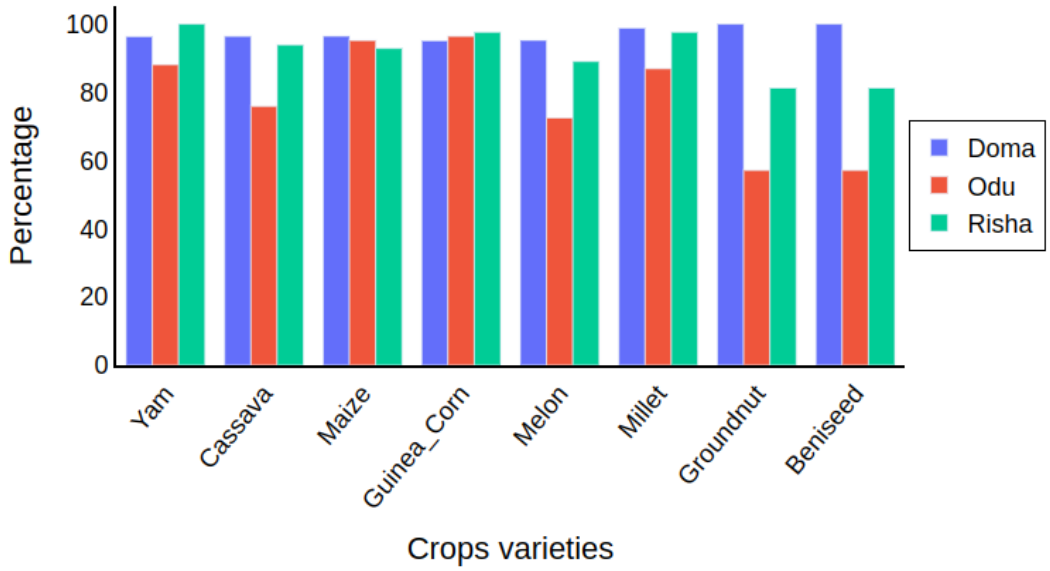
1. Do you think gazetted forest reserves have changed in Nasarawa state between the 1960s and 2000? How about between 2000-2022? How did it change in terms of (Size, quality/quantity, and composition)?
2. What do you think are the drivers that might have caused the gazetted forest change between the 1960s -2000? How about 2000-2022?
3. How does the change affect tree and animal species on the forest reserve? between the 1960s and 2000, what about 2000-2022?
4. Do you think trees and animal species in the forest between the 1960s and 2000 have also been affected? What of 2000-2022?
5. Can you tell me about the environmental impacts of the forest change?
6. what do you think are the challenges that affect the implementation of the extant strategies and regulations? How might these be addressed?
7. Can you tell me about the policy you think is needed to address the forest conservation challenges and why?
8. What do we need to be doing for the sustainability of these forest reserves for future generations?

Appendix 2.3: Part of the analysed Qualitative and Quantitative data.

Appendix 2.3: Figure 2. Household survey socioeconomic responses from the gazetted forest communities in Nasarawa State.



Appendix 2.3: Figure 3. Types of crops reported to be cultivated around the forest reserve communities in the study.



Appendix 2.3: Table 1. Identified LULCC drivers for the study area from 1966–2000 (the past) and 2001–2022 (the present) and their ranking in order of importance from (FGDs) as analysed in NVivo.

Driver of past land use and forest Change (1966-2000)	**Ranking Code mention**	**Driver of present land use and forest (2001-2022**	**Ranking Code mention**
Agricultural activities	1	Agricultural Activities	1
Lumbering	2	Government policies and Governance	2
Grazing	3	Population increase	3
Population increase	4	Fuelwood/Charcoal production	4
Infrastructure development and Settlement	5	Lumbering	5
Climate change/ Disasters	6	Grazing	6
		Infrastructure development and Settlement	7
		Economic gain (poverty)	8
		Climate change/ Disasters	9
		Technologies/Education	10
		Migration	11
		Insecurity threat	12

Sources: Fieldwork FGD, July,2022.

Appendix 2.3: Table 2. Doma key stakeholders quotes identifying their perceived drivers of forest change in the study area from 1966–2000 (the past) and from 2001–2022 (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, shear 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 people 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)
	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)

Appendix 2.3: Table 3. Risha key stakeholders quotes identifying their perceived drivers of forest change in the study area from 1966–2000 (the past) and from 2001–2022 (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)
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).

Appendix 2.3: Table 4. Odu key stakeholders quotes identifying their perceived drivers of forest change in the study area from 1966–2000 (the past) and from 2001–2022 (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 People, 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 People	"*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 People, 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 People	*"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 People 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	

Appendix 2.3: Table 5. Government and Expert KII key stakeholders quotes identifying their perceived drivers of forest change in the study area from 1966–2000 (the past) and from 2001–2022 (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 people 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 defend purposes" (Expert KII 001 June 2022)"*