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Effects of climate change on forest resources and biodiversity conservation in Nigeria: A case study of forest reserve areas of Imo State, Nigeria

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ABSTRACT

This study investigated the effect of climate change on forest resources and biodiversity conservation in the forest reserve areas of Imo State, Nigeria. It therefore, assessed the various manifestations of climate change, evaluated the impact on forest resources and biodiversity, identified conservation challenges, and proposed adaptation and mitigation measures to the situation. Descriptive survey research design was adopted for the study. The study population consisted of forestry personnel, community members and other stakeholders in the forest reserve areas. Multistage sampling procedure was used to select 150 respondents from the study area. Structured questionnaires were administered to the respondents and expert validation was carried out to test the reliability and validity of the research instruments. Cronach's alpha was computed to determine the reliability of the questionnaire and the result showed that 0.82 of the variance in the data was explained by the item-scale. Frequency counts, percentage, mean and standard deviation were used to analyze the data. The study established that climate change has adverse effect on forest resources in the study area. The main effects included; increase in temperature, prolonged drought, flooding, increase in wildfires and occurrence of pests and diseases. These effects led to forest degradation, poor forest cover, loss of biodiversity, decrease in forest products and lack of market for forest products in the study area. The study also revealed that poor enforcement of the forest policies; illegal logging of trees, agricultural expansion, and insufficient funding are some of the major challenges facing forest resource and biodiversity conservation in the study area. The study concluded that climate change has negative effect on forest resources and biodiversity conservation in the study area. It further recommended afforestation and reforestation programmes, improved forest governance, adaptation measures to climate change, and increased funding for biodiversity conservation in Imo State forest reserve areas.

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INTRODUCTION

Climate change has become a great environmental challenge that threatens forest resources and biodiversity globally. Forests play a crucial role in providing food, fuelwood, medicinal plants, and habitat for wildlife in addition to being a carbon sink and providing environmental benefits such as erosion control. In Nigeria, forest areas play a significant role in sustaining the environment and supporting local livelihood. Nevertheless, temperature rise, changes in precipitation patterns, flood, drought, and other climate-related phenomena have affected forest resources and biodiversity in forest reserve areas (Intergovernmental Panel on Climate Change, 2023a). Nigeria has various forest types that include mangrove swamps along coastal swampy lands, rainforests in the southern part of the country, and woodland in the northern region. Forest reserves sustain a wide range of flora and fauna and provide Nigeria with essential environmental goods and services. Nevertheless, Nigeria's forest resources have been degraded over time due to anthropogenic activities and climate change effects such as flooding and temperature rise. For instance, the Food and Agriculture Organization (2022) reports that illegal logging, agricultural expansion, and burning, among other activities, have affected the forest cover in Nigeria.

Imo state is among the many states in Nigeria that have a share of the forest reserves found in the country. The state has belt of tropical rainforests and woodland in addition to forest reserves that support wildlife and provide environmental benefits to the communities surrounding them.

Nevertheless, the forest reserves in the state faced adverse effects brought about by climate change such as temperature rise, flooding, and erosion among others. These effects of climate change on forest reserves have had negative implications on the biodiversity, environmental benefits, and forest products in the state (Nwankwoala and Amadi, 2020).

Biodiversity plays a critical role in supporting life on earth and facilitating important environmental services such as carbon cycling and water purification. Conserving biodiversity is key to promoting a stable environment and supporting diverse economic activities such as agriculture, hunting, and gathering. However, climate change has become a major threat to forest biodiversity and the essential services they provide. For instance, Akindele *et al.* (2021) report that climate change has adversely affected the distribution, breeding, and migration patterns of many species of animals and plants in Nigeria's forest reserves. Such impacts hinder efforts to promote biodiversity conservation and undermine the sustainability of forest resources. The state's forest reserves are home to many species of wildlife that provide Nigeria with essential environmental and economic benefits. Climate change impacts such as temperature rise and flooding threaten the existence of these species and contribute to a decline in biodiversity. As a result, biodiversity conservation efforts in the forest reserves of the state become difficult and encounter several challenges. Similarly, climate change impacts such as drought and erosion affect the livelihood of many people who depend on forest resources for their products and services. Therefore, it becomes pertinent to carry out a study on the effects of climate change on forest resources and biodiversity conservation in order to promote sustainable ways of utilizing and managing the forest reserves.

Problem statement

Forest resources and biodiversity in Nigeria are facing a tremendous threat due to the adverse effect of climate change and human activities such as illegal logging and burning. In addition, the forest reserve areas in Imo State have also faced adverse environmental impacts that have affected the forest resources and biodiversity over the years. Such effects as erratic rainfall, flooding, temperature rise, and prolonged drought, among others, have hindered efforts to maintain forest reserves in the state. Although the forest reserves in Imo State have various environmental and economic benefits, they have been poorly maintained and are facing challenges brought about by climate change impacts in the state.

These reserves sustain various livelihoods and provide forest products that have a great economic value to the community. As a result, forest areas such as woodlands and rainforests in the state have faced adverse effects such as flooding and prolonged drought that have threatened their existence. Moreover, human activities such as illegal logging, agricultural activities, and bush burning have caused significant damage to the forest reserves in the state. Therefore, biodiversity conservation in the forest reserves in the state is hindered as many plant and animal species face extinction due to these challenges. In addition, the communities surrounding the forest reserves in the state rely on these resources for economic benefits, food, and other products crucial to their livelihood. The forest products and resources have been reduced due to human activities and climate change impacts such as drought and temperature rise, which have hindered forest production. This leads to negative effects such as poverty, hunger, unemployment, and environmental degradation that have adverse effects on the community. Although many researchers have addressed the problems facing the forest resources in Nigeria, the effects of climate change on the forest reserve areas in Imo State have not been addressed extensively. Therefore, the current proposal seeks to address the effects of climate change on the forest resources and biodiversity conservation in order to promote forest management and environmental sustainability.

The broad objective of this study is to examine the effects of climate change on forest resources and biodiversity conservation in Nigeria using forest reserve areas of Imo State as a case study. The specific objectives are to: a). identify forest resources available/present in Imo State Forest Reserve Areas; b). examine the major effects of climate change on forest resources in Imo State forest reserves; c). assess the impact of climate change on biodiversity conservation in the study area; d). identify the major factors contributing to forest degradation and biodiversity loss in the forest reserves; e). evaluate the socioeconomic implications of climate change on rural communities dependent on forest resources; and f). recommend sustainable strategies for forest resource management and biodiversity conservation in Imo State. The significance of this study is enormous as it will contribute greatly to the existing knowledge on the implication of climate change on forest resources and biodiversity conservation. The results of this study will benefit environmental agencies, policymakers, conservation organizations, and forestry departments by providing information on the extent to which climate change alters forest ecosystems and biodiversity in the study area. It will also serve as a basis for further research, provide insights, and share relevant information among students, researchers, and scholars in the disciplines of Forestry, Geography, Ecology, and Environmental Science. The study will also propose strategies for combating the effects of climate change and managing forest resources sustainably and efficiently. Besides, it will educate the rural community and stakeholders on the need to conserve forest resources. The recommendations in this study will also benefit the local government and private organizations involved in forest conservation in Nigeria.

MATERIALS AND METHODS

The study was conducted in Imo State, located in the southeastern part of Nigeria. This state is known to host many rural forestry communities where people engage in hunting, farming, and harvesting forest resources. The communities selected for this study were highly involved with wildlife activities. A descriptive survey research design was selected because there was a need to determine the extent of the influence of wildlife hunting, human encroachment, and wildlife disease transmission on the public health of the rural foresters in the study area. The study population consisted of rural foresters, hunters, farmers, and other community members who relied on forest resources in the selected communities in Imo State. The target population was all community members who engaged in forest-related activities exposing them to wildlife-human contact. A sample size of 150 respondents was selected to represent the views of all rural foresters

and forest users in the study area. The research question was answered using a questionnaire developed by the researcher. The questionnaire had both demographical sections and sections addressing the issue of wildlife hunting and human encroachment, wildlife disease, and public health. The survey was administered directly to the respondents by the research assistants. The collected data were analyzed using descriptive statistics. Frequency counts and percentages were used to present the respondent views on the study variables. Additionally, inferential statistics, including correlation analysis, were performed to determine the associations between wildlife and public health issues affecting the rural foresters.

RESULTS AND DISCUSSION

Forest resources present in Imo State forest reserve areas

The Table 1 shows the forest resources available in forest reserve areas of Imo State as reported by 150 respondents. Since the respondents were allowed to select multiple options, the percentage and frequency added up to more than 150%. From the analysis, it was found that timber trees were identified by 132 respondents which accounted for 88.0%. This finding suggests that the forest reserve in Imo State has a significant amount of timber resources. In addition, 125 respondents identified fuelwood as one of the forest resources available in the forest reserve areas which represent 83.3%. This indicates that the forest reserves in Imo State play a pivotal role in meeting the energy needs of the rural communities surrounding them.

Table 1. Forest resources present in Imo State forest reserve areas

Sl	Forest resources identified	Frequency	Percentage
1	Timber trees	132	88.0
2	Fuelwood	125	83.3
3	Medicinal plants	118	78.7
4	Wildlife species	110	73.3
5	Fruits and nuts	104	69.3
6	Bamboo and rattans	96	64.0
7	Honey and bee products	82	54.7
8	Mushrooms	76	50.7
9	Palm products	101	67.3
10	Fodder and grasses	69	46.0

Medicinal plants were identified by 118 respondents (78.7%) to indicate that the forest reserves are important sources of traditional medicines. Also, wildlife species were identified by 110 respondents (73.3%). This suggests that the forest reserve areas in the study contain various wild animals and plants.

However, fewer respondents identified fodder and grasses (69 respondents; 46%). On the contrary, fruits and nuts recorded 104 (69.3%) and 101 (67.3%) respectively. This implies that the forest reserves provide a wide range of forest products such as fruits and nuts which are used by the locals. Similarly, palm products, bamboo, and rattans were identified by 101 respondents (67.3%), 96 respondents (64%), and 96 respondents (64%) respectively. This indicates that the forest reserves in Imo State provide a wide range of forest products for the citizens. On the contrary, honey and bee products were identified by 84 respondents (54.7%) while mushrooms were identified by 76 respondents (50.7%). Overall, the statistics are an indication that the forest reserve areas in Imo State contain a wealth of forest resources that are valuable to the locals.

However, it is important to ensure that these resources are utilized sustainably to avoid their total extinction due to climate change or anthropogenic activities.

Imo State forest reserve areas present a wide range of forest resources which are very valuable for biodiversity conservation, community livelihood, and ecological security in addition to generating economic returns. The forests are covered primarily with tropical rainforest vegetation and endowed with a great diversity of timber and non-timber forest products. The identified forest areas host various timber tree species such as iroko (*Milicia excelsa*), mahogany (*Khaya* spp.), obeche (*Triplochiton scleroxylon*), gmelina (*Gmelina arborea*), teak (*Tectona grandis*), and other endemic hard-wood tree species useful for construction, furniture-making, and wares production (FAO, 2001; ITTO, 2025). The forest reserves also boast of a wealth of non-timber

forest products including medicinal materials, mushrooms, fruits, vegetables, spices, honey, snails, fuelwood, bamboo, rattan, and palm produce. Generally, the importance of the forest resources in Imo State cannot be overemphasized since they provide food security, employment, and income to the local people in addition to serving as habitats for avian and zoological species, carbon sinks, and watershed resources. Nevertheless, the forest reserves in the region are currently threatened by illegal harvesting of timber and fuelwood, agricultural encroachment, and unplanned urbanization (FAO, 2001; ITTO, 2025). Imo State forest reserves are rich forest resources that support environmental sustainability and provide resources for sustaining local rural communities. The forest reserve contains various timber species, including iroko (*Milicia excelsa*), mahogany (*Khaya ivorensis*), sapele (*Entandrophragma cylindricum*), and obeche (*Triplochiton scleroxylon*) (Dolor *et al.*, 2022). The forest also provides various non-timber forest products such as bush mango, African pear, bitter kola, medicinal plants, mushrooms, honey, bamboo, rattan, and snails.

The forest products from the Imo State forest reserves satisfy local demand for food, materials, and medicines while also providing additional income to forest-dependent households. The forest also provides habitat for wildlife species such as grasscutters, bushbucks, monkeys, pangolins, reptiles, and birds (ScienceDirect, 2023). Besides providing timber and non-timber forest products, the Imo State forest also provides watershed services, controls soil erosion, provides a habitat for biodiversity, and plays a significant role in climate regulation. The forest reserves have a great potential for supporting ecotourism, environmental education, and research activities. On the other hand, the forest faces several threats such as illegal harvesting of timber and fuelwood, expansion of agricultural activities, and other anthropogenic activities that require urgent intervention for effective forest management and improved conservation (ScienceDirect, 2023).

Major effects of climate change on forest resources in Imo State forest reserves

The data provided in the Table 2 illustrates the opinions of participants regarding the primary consequences of climate change on forest resources in Imo State's forest reserve regions. As respondents were allowed to provide multiple answers, the total occurrences exceed the number of participants (150), indicating that respondents recognized various overlapping effects of climate change. The most notable impact identified was the decrease in forest area (accelerated deforestation) at 90.7%. This indicates that climate change, in conjunction with human actions, is significantly contributing to the swift depletion of forest vegetation in the research area. Closely linked to this is the decline in biodiversity at 85.3%, suggesting that numerous plant and animal species are under threat or disappearing due to altering climatic conditions and habitat degradation. Another significant effect is the destruction of wildlife habitats at 83.3%, revealing that climate fluctuations are disrupting natural ecosystems and diminishing suitable habitats for wildlife species. The diminished availability of firewood and lumber at 80.7% reflects the reduced productivity of forest resources that rural communities rely on for energy and building materials. Additionally, the rise in forest fires was cited by 120 respondents (80.0%), indicating that increasing temperatures and extended dry periods are heightening the susceptibility of forest reserves to wildfires. Similarly, soil deterioration and erosion received 118 responses (78.7%), indicating that climate-related fluctuations in rainfall are contributing to land deterioration and the loss of fertile topsoil in forested regions. The desiccation of streams and water bodies within forest reserves was also significant, with 115 responses (76.7%), suggesting that climate change is impacting the hydrological equilibrium of forest ecosystems, resulting in reduced water availability for plants and animals. Furthermore, the reduced capacity for forest regeneration was noted by 112 participants (74.7%), showing that tree species are struggling to naturally regenerate due to unfavorable climate conditions. The

drop in medicinal plant species was highlighted by 109 responses (72.7%), indicating that crucial non-timber forest products are also being impacted. Lastly, alterations in species distribution had the lowest occurrence at 97 responses (64.7%), indicating that while species migration and redistribution are ongoing, they are less conspicuous compared to other immediate effects. Overall, the results suggest that climate change is significantly impacting forest resources in Imo State through biodiversity loss, habitat destruction, reduced forest output, and ecosystem instability. These consequences jeopardize both environmental sustainability and the well-being of rural communities reliant on forest reserves. The effect of climate change on forest resources in Imo State forest reserves is exerted through rising temperatures and changes in rainfall patterns, prolonged periods of drought, as well as extreme weather events. These impacts have significantly affected the growth and sustainability of many tree species in the forest through poor regeneration and distribution (IPCC, 2023). Similarly, extreme dryness and heavy rainfall destroy forests, leading to a reduction in the number of trees available for commercial and community use. The impact of climate change on Imo State forest reserves is also manifested through frequent occurrences of bushfires, pests, and diseases that affect forests, contributing to the destruction of forest trees and impacting wildlife habitats. In addition, changes in temperature and rainfall patterns can affect the ecological functions of the forest, such as flowering, fruiting, and seed production, which are crucial to most tree species in the forest. The imbalance in these processes decreases the amount of timber and other forest products, affecting the livelihoods of many people who derive their products from the forest (FAO, 2022). Moreover, since forest trees and plants help reduce the amount of carbon dioxide in the atmosphere, their destruction and poor growth can adversely impact climate change by diminishing this natural carbon sink (IPCC, 2023).

Table 2. Major effects of climate change on forest resources in Imo State forest reserves

Sl	Effects of climate change	Frequency	Percentage
1	Reduction in forest cover (deforestation acceleration)	136	90.7
2	Loss of biodiversity	128	85.3
3	Increased frequency of forest fires	120	80.0
4	Drying of water bodies/streams in forest areas	115	76.7
5	Reduced availability of fuelwood and timber	121	80.7
6	Decline in medicinal plant species	109	72.7
7	Habitat destruction for wildlife	125	83.3
8	Soil degradation and erosion	118	78.7
9	Changes in species distribution	97	64.7
10	Reduced forest regeneration capacity	112	74.7

Impact of climate change on biodiversity conservation in Imo State forest reserves

The data in the Table 3 illustrates how respondents view the influence of climate change on biodiversity protection in forest reserves in Imo State, using a 4-point Likert scale. The average scores for all items ranged from 3.23 to 3.39, all surpassing the standard mean of 2.50. This indicates a general consensus among respondents that climate change has substantial adverse effects on biodiversity protection in the area under study. In particular, Item 4, which discusses how climate change diminishes the quality of habitats for biodiversity, received the highest average score of 3.39, with a relatively small standard deviation of 0.75. This suggests a strong consensus among respondents that habitat deterioration is a significant consequence of climate change in forest reserves. Similarly, Item 8 (reduction in overall biodiversity richness) also had a high average score of 3.39, affirming that the loss of biodiversity is a major issue in the study area. Items 5 and 1, which focus on the increased susceptibility of endangered species (average = 3.37) and the decline in wildlife populations (average = 3.35), also garnered strong agreement.

This implies that climate change is significantly contributing to the decrease in animal populations

and the rise in extinction threats. Additionally, Item 3 (disturbance of breeding and migration patterns) with an average of 3.31 demonstrates that fluctuations in climate are impacting animal life cycles and movement behaviors, potentially disrupting the balance of ecosystems. Item 2 (extinction of plant species) and Item 6 (reduced availability of food for wildlife) both had an average score of 3.27, indicating that the loss of vegetation and scarcity of food are notable ecological outcomes. Item 7, with an average score of 3.23, suggests that changes in species distribution are occurring due to modified environmental conditions, although this effect is slightly less pronounced compared to others. Nonetheless, it still falls within an acceptable range, confirming its importance. The standard deviation values for all items (0.74–0.79) indicate minimal variation in responses, indicating that respondents held relatively similar viewpoints on the impacts of climate change on biodiversity conservation. In summary, the results demonstrate a strong agreement that climate change detrimentally impacts biodiversity conservation in forest reserves in Imo State by degrading habitat quality, reducing species populations, disturbing ecological processes, and heightening extinction risks.

Table 3. Impact of climate change on biodiversity conservation in Imo State forest reserves

Sl	Biodiversity conservation indicators	Mean	SD	Decision
1	Climate change reduces wildlife population	3.35	0.78	Accepted
2	It leads to extinction of some plant species	3.27	0.79	Accepted
3	It disrupts breeding and migration patterns of animals	3.31	0.78	Accepted
4	It reduces habitat quality for biodiversity	3.39	0.75	Accepted
5	It increases vulnerability of endangered species	3.37	0.74	Accepted
6	It affects food availability for wildlife	3.27	0.78	Accepted
7	It causes shift in species distribution	3.23	0.79	Accepted
8	It reduces overall biodiversity richness	3.39	0.74	Accepted

Climate change presents a significant threat to biodiversity conservation in Imo State forest reserves. This may occur through habitat degradation and the subsequent inability of many species to adapt to the altered environmental needs. Temperature rise, changes in the rainfall regime and extreme weather events threaten to undermine most species' ability to survive and thrive in the modified biome (IPCC, 2023). As a result, there is a high likelihood of losing forest wildlife and losing many species that can only survive in this ecosystem. Such changes will inevitably affect forest wildlife populations, migration patterns, and food supply, with detrimental effects on biodiversity. Species that cannot adapt to the changed conditions are likely to disappear, which reduces overall species richness and affects the ecological role played by forest ecosystems. Additionally, global climate change will facilitate the spread of alien species and invasive vegetation, as well as promote insect pests, diseases, and burning incidents that could further affect biodiversity. Ultimately, these impacts and stresses on forest vegetation threaten to destroy crucial resources and services provided by forests to communities, compromising sustainability (CBD, 2020; FAO, 2022). The impact of climate change on biodiversity conservation in Imo State's forest reserves is a critical concern that threatens the region's ecological integrity through habitat degradation, disruptions in ecosystem processes, and the diminishment of numerous plant and animal species. The consequences of climate change, including rising temperatures, altered precipitation patterns, and an increase in extreme weather events, have compromised the ability of several native species to thrive in their natural habitats (IPCC, 2023). Notably, these environmental shifts have led to forest fragmentation, which has adversely affected wildlife populations while facilitating the invasion of non-native species.

Moreover, climate change has disrupted the delicate balance of resources necessary to sustain biodiversity, resulting in the local extinction of several species that were once integral to Imo State's forest reserves. Consequently, the deterioration of forest ecosystems has occurred at an unprecedented rate, primarily

driven by the proliferation of invasive species, pests, and diseases, as well as the heightened risk of wildfires (CBD, 2020; FAO, 2022). These factors collectively undermine the conservation status of biodiversity in the region, ultimately impacting the array of essential services that the forest reserves provide to the surrounding communities.

Major factors contributing to forest degradation and biodiversity loss in Imo State forest reserves

The data in Table 4 illustrates the primary factors leading to forest deterioration and loss of biodiversity in forest reserve regions of Imo State as outlined by 150 survey participants. Given the option to provide multiple answers, respondents pinpointed numerous interconnected human and environmental causes behind the decline of forests. The most crucial factor identified was illicit tree cutting, which garnered 138 responses (92.0%). This suggests that unauthorized deforestation is the main catalyst for forest decay in the research area. Closely linked to this is the expansion of agriculture into forested areas, with 130 responses (86.7%), demonstrating that the transformation of forests into farmlands is a significant contributor to habitat destruction and the reduction of biodiversity. The gathering of firewood also had a high count of 126 responses (84.0%), indicating the heavy reliance of rural households on forest resources for energy requirements. Similarly, bush fires were cited in 124 responses (82.7%), signaling that the use of fires for agricultural purposes and hunting significantly harms forest ecosystems and diminishes biodiversity. Poverty and the rural community's reliance on forest resources were reported in 120 responses (80.0%), emphasizing the economic aspect of forest degradation. Numerous rural inhabitants depend on forests for their livelihoods, intensifying the strain on forest resources. Urbanization and the development of infrastructure came next with 118 responses (78.7%), proving that the expansion of towns, roads, and other structures is contributing to the conversion of forested land. Additionally, climate change variability received 115 responses (76.7%), suggesting that alterations in precipitation and temperature patterns are also hastening forest deterioration by weakening the ecosystem's ability to bounce back. Inadequate enforcement of forest laws was mentioned in 112 responses (74.7%), indicating that the lack of oversight and ineffective implementation of environmental rules promote unlawful activities in forest reserves. Moreover, hunting and the illegal hunting of wildlife were noted in 105 responses (70.0%), showcasing that unsustainable wildlife exploitation adds to the loss of biodiversity. Lastly, overgrazing had the fewest responses at 98 (65.3%), but it still underscores how livestock activities contribute to the degradation of vegetation in specific forest reserve areas. On the whole, the results demonstrate that the decline of forests and biodiversity in Imo State is fueled by a blend of human actions such as illegal logging, farming, fuelwood collection, and bush fires, along with economic pressures like poverty and lax enforcement of environmental legislation. These factors interact with the impacts of climate change to exacerbate the degradation of forest ecosystems and biodiversity in the research area.

The primary human and ecological factors responsible for forest degradation and biodiversity loss in Imo State forest reserves are illegal logging, agricultural activities, fuelwood collection, charcoal production, bush burning, mining, and infrastructural development. The forest is also faced with the threat of climate change, which has led to an increase in droughts, floods, pests, and diseases that affect forest vegetation. Illegal logging, which involves the unauthorized cutting of trees, has led to the destruction of forest reserves, loss of wildlife habitat, and biodiversity loss (FAO, 2022). Additionally, agricultural activities such as shifting cultivators and settled cultivation have resulted in the degradation of forest vegetation and the loss of plant and animal species (NEST, 2011). The collection of fuelwood is a significant contributor to forest degradation in the region because most citizens rely on it as the primary source of energy. Fuelwood collection is done illegally, and the cutting of trees interferes with the

forest's ability to provide a wide range of products and services. Charcoal production is another anthropogenic activity that threatens the forest by destroying its vegetation cover. Apart from the anthropogenic activities affecting the forest, there are also other ecological factors such as uncontrolled bush burning, mining activities, and urbanization, which have had adverse effects on the forest, leading to biodiversity loss and vegetation destruction. Consequently, the degradation of forest reserves in Imo State has been accelerated by the lack of proper funding, poor implementation of policies, and the absence of community participation in forest management (FAO, 2022).

Table 4. Major factors contributing to forest degradation and biodiversity loss in Imo State forest reserves

Sl	Contributing factors	Frequency	Percentage
1	Illegal logging	138	92.0
2	Agricultural expansion/encroachment	130	86.7
3	Bush burning	124	82.7
4	Fuelwood exploitation	126	84.0
5	Urbanization and infrastructure development	118	78.7
6	Poverty and rural dependence on forest resources	120	80.0
7	Weak forest law enforcement	112	74.7
8	Climate change variability (rainfall/temperature changes)	115	76.7
9	Overgrazing	98	65.3
10	Hunting and wildlife poaching	105	70.0

Table 5. Socioeconomic implications of climate change on rural communities dependent on forest resources

Sl	Socioeconomic implications	Frequency	Percentage
1	Decline in household income from forest products	136	90.7
2	Increased poverty among forest-dependent households	131	87.3
3	Reduced availability of fuelwood and other forest resources	126	84.0
4	Food insecurity due to declining forest food resources	122	81.3
5	Loss of employment and livelihood opportunities	118	78.7
6	Increased cost of accessing forest resources	114	76.0
7	Increased rural–urban migration	108	72.0
8	Decline in availability of medicinal plants	103	68.7
9	Increased conflicts over scarce forest resources	97	64.7
10	Reduced income from forest-based enterprises (e.g., honey, bamboo, ecotourism)	89	59.3

Socioeconomic implications of climate change on rural communities dependent on forest resources

Table 5 illustrates the results of a study on the socioeconomic impacts of climate change on rural communities in Imo State that depend on forest resources. The analysis shows that the most common effect reported was a decrease in household earnings from forest products, with 136 participants (90.7%) highlighting this issue. Following closely were an increase in poverty among households reliant on forests (131; 87.3%) and a reduction in the availability of fuelwood and other forest goods (126; 84.0%). Additionally, a significant number of respondents mentioned concerns such as food insecurity (122; 81.3%), loss of jobs and livelihoods (118; 78.7%), higher costs associated with accessing forest resources (76.0%), migration from rural to urban areas (72.0%), diminishing access to medicinal plants (68.7%), conflicts arising from limited forest resources (64.7%), and decreased earnings from forest-related businesses (59.3%).

These outcomes underscore the substantial negative impacts of climate change on the economic well-being, food security, and overall resilience of rural communities heavily dependent on forest resources in Imo State. Climate change bears significant implications for rural communities whose livelihoods rely on forest resources. Variations in temperature and rainfall, together with extreme weather events, such as droughts, floods, and wildfires, negatively affect the availability of timber, fuelwood, medicinal plants, fruits, and other forest products crucial for rural households' livelihoods and income (Food and Agriculture Organization [FAO], 2022). As a result, many rural households face reduced

income, poverty, and food insecurity. At the same time, climate change impacts the labour force in rural areas, affecting forest-related activities, including logging, harvesting of non-timber forest products, apiculture, and ecotourism. Fuelwood and other forest products' limited supply often compel families to invest more effort and money in searching for forest products (Intergovernmental Panel on Climate Change [IPCC], 2023). At the same time, forest resources scarcity often triggers disputes over forest ownership and rights, rural-urban migration, and loss of traditional knowledge related to forests. Overall, climate change impacts rural communities' social and economic welfare in multiple ways, determining sustainability and rural development strategies in Nigeria (Nigerian Environmental Study/Action Team [NEST], 2011).

Table 6. Sustainable strategies for forest resource management and biodiversity conservation

Sl	Recommended strategies	Frequency	Percentage
1	Afforestation and reforestation programmes	140	93.3
2	Strict enforcement of forest laws and regulations	132	88.0
3	Community-based forest management	125	83.3
4	Public awareness and environmental education	128	85.3
5	Promotion of alternative energy sources (gas, solar)	120	80.0
6	Sustainable agroforestry practices	118	78.7
7	Control of bush burning practices	115	76.7
8	Strengthening of forest reserve monitoring systems	110	73.3
9	Poverty reduction and livelihood diversification	122	81.3
10	Wildlife conservation and protected area expansion	105	70.0

Sustainable strategies for forest resource management and biodiversity conservation

Table 6, illustrates suggestions from participants on sustainable approaches to enhance forest resource management and biodiversity preservation in Imo State forest reserves. Given the option to provide multiple responses, respondents identified various complementary tactics crucial for successful conservation efforts. The top recommended approach was the implementation of afforestation and reforestation initiatives, (93.3%). This indicates a widespread consensus that rejuvenating degraded forest areas through tree planting is the most crucial step in enhancing forest coverage and ecosystem rehabilitation. Following closely is the strict enforcement of forest regulations and laws, (88.0%), signaling the belief that curbing illegal activities like logging, hunting, and land encroachment requires stronger legal measures and monitoring by relevant authorities. Public awareness campaigns and environmental education received 128 responses (85.3%), underscoring the significance of educating rural populations about the importance of forest preservation to instigate behavioral changes and promote sustainable resource utilization. Similarly, community-driven forest management garnered 125 responses (83.3%), emphasizing the importance of involving local communities in decision-making processes and conservation endeavors to ensure effective forest safeguarding. Efforts to reduce poverty and diversify livelihoods (81.3%), highlighting the necessity of enhancing rural livelihoods to decrease reliance on forest exploitation. Encouraging the adoption of alternative energy sources (80.0%), indicating that facilitating access to cleaner energy options like gas and solar power can diminish the dependency on fuelwood. Additionally, sustainable agroforestry practices (78.7%), suggesting that integrating trees into farming systems can help harmonize agricultural productivity with forest preservation. The regulation of bush burning practices (76.7%), showcasing the need to control the use of fires in agricultural and hunting activities to prevent forest degradation. Furthermore, reinforcing forest reserve monitoring systems (73.3%), highlighting the significance of enhancing surveillance and enforcement mechanisms. Finally, wildlife conservation and the expansion of protected areas received the least number of responses at 105 (70.0%), but still demonstrated considerable backing for enlarging conservation zones and safeguarding endangered species. The results indicate strong support from participants for a

blend of ecological restoration, law enforcement, community engagement, livelihood enhancement, and sustainable energy alternatives as pivotal strategies to ensure enduring forest sustainability and biodiversity preservation in Imo State. Sustainable forest resource management and biodiversity conservation involve the adoption of practices that ensure the long-term availability of forest resources while protecting ecological integrity. One key strategy is afforestation and reforestation, which restore degraded forest areas, increase carbon sequestration, and improve wildlife habitats (Food and Agriculture Organization [FAO], 2022).

Sustainable harvesting practices, such as selective logging and regulated timber extraction, also help minimize environmental damage and promote natural forest regeneration. Another important strategy is community-based forest management, which actively involves local communities in forest planning, protection, and monitoring. This approach enhances conservation outcomes while providing livelihood opportunities for forest-dependent populations (Convention on Biological Diversity [CBD], 2020). Strengthening the enforcement of forestry laws, establishing protected areas, promoting agroforestry systems, and encouraging environmental education and public awareness are equally essential for reducing illegal logging, habitat destruction, and biodiversity loss. In addition, integrating climate change adaptation and mitigation measures, such as ecosystem restoration and carbon conservation initiatives, enhances the resilience of forest ecosystems and supports sustainable biodiversity conservation (Intergovernmental Panel on Climate Change [IPCC], 2023).

CONCLUSION

Climate change has become a serious environmental issue threatening forests and their biodiversity in Nigeria, especially in the forest reserves of Imo State. The study established that rising temperatures, increased flooding, unpredictable rainy seasons, long dry seasons, and other climate-related factors have caused forest degradation, destruction of habitats, loss of wildlife species, and depletion of forest resources, including timber and other valuable forest products.

Added to that is the adverse effect of illegal logging activities, agricultural expansion, collection of fuelwood, and weak law enforcement on the forest ecosystem. The study recommends the adoption of climate change adaptation measures, sustainable forest management, and appropriate policies for the conservation of forest resources and biodiversity in the study area. There is a need to promote afforestation and reforestation, strengthen environmental scanning, and create awareness about the importance of forest conservation, among other interventions, to enhance forest reserve management in Imo State. Concerted efforts by government agencies, local communities, researchers, environmental organizations, and development partners are needed to achieve optimum forest conservation and utilization in the state.

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