The Impact of Nature-Based Solutions (NbS) On the Local Livelihoods, Security and Income Generation in Northwest Nigeria

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ABSTRACT

This research investigates the socio-economic hurdles posed by climate change and the adoption of Nature-based Solutions (NbS) in Northwest Nigeria. Employing a cross-sectional mixed-methods approach, data were gathered from 700 participants through surveys, focus group discussions (FGDs), and key informant interviews conducted in Sokoto, Zamfara, and Katsina States. The quantitative analysis utilised various statistical methods, including descriptive statistics, chi-square tests, t-tests, ANOVA, logistic regression, and multiple regression, while the qualitative data underwent thematic analysis. The results indicated that 56% of the participants were farmers, with many expressing high levels of vulnerability to climate-related shocks. Chi-square and regression analyses demonstrated that factors such as income, education, and farm size had a significant impact on the adoption of NbS. In contrast, age did not appear to be a significant predictor. Rural households experienced more intense climate effects compared to their urban counterparts, and respondents from Zamfara showed the highest levels of vulnerability. The qualitative findings brought to light themes concerning community resilience, gaps within institutions, challenges in gendered adaptation, and insufficient community ownership of NbS initiatives. The study concludes that vulnerability in Northwest Nigeria is complex, influenced by socio-economic disparities, structural obstacles, and gender factors. Recommendations include enhancing community capacity, promoting policies that are sensitive to gender issues, improving institutional collaboration, and integrating indigenous knowledge with scientific methods to scale up NbS effectively.

Keywords: Climate change; Nature-based Solutions (NbS); Socio-economic vulnerability; Community resilience; Northwest Nigeria; Gender adaptation; Institutional capacity

INTRODUCTION

Climate change continues to present substantial threats to human welfare, ecosystems, and socio-economic progress globally, with its effects particularly pronounced in sensitive and unstable regions like Northwest Nigeria. This area, which includes states such as Sokoto, Zamfara, and Katsina, is marked by elevated poverty rates, significant reliance on agriculture, fragile institutional structures, and ongoing insecurity issues, all of which heighten vulnerability to environmental disturbances. These factors directly threaten local livelihoods, security, and income generation, which are essential for community survival and sustainable development in the region (Olusola et al., 2025).

Nature-based Solutions (NbS) have surfaced as a pioneering and holistic approach to simultaneously tackle these interconnected issues by utilising ecosystems for environmental and socio-economic resilience. NbS refers to actions that protect, regenerate, and sustainably manage ecosystems while delivering various co-benefits, including biodiversity conservation, climate adaptation, livelihood enhancement, and better social cohesion (IUCN, 2021; UNEP/EA, 2022). For instance, practices such as reforestation, watershed management, soil preservation, and climate-smart agriculture can rejuvenate degraded lands, enhance food

security, create green jobs, and mitigate conflicts over resources (Sule et al., 2024). This positions NbS as a crucial instrument for transforming the development landscape of Northwest Nigeria.

The influence on local livelihoods is evident due to their capacity to diversify income streams, improve agricultural productivity, and enhance food security, consequently lessening rural poverty (Magaji & Musa, 2024). By allowing communities to utilise natural resources sustainably, NbS interventions promote resilience against climate disturbances and environmental degradation. Additionally, NbS can bolster security by alleviating competition for scarce natural resources, reducing conflicts between agricultural and pastoral groups, and fostering community unity. Furthermore, the promotion of NbS directly contributes to income generation, not only through increased agricultural outputs but also through alternative income opportunities, such as eco-tourism, renewable energy initiatives, and agro-processing businesses. Therefore, NbS act as both environmental solutions and strategies for socio-economic development.

Despite these prospects, the adoption and expansion of NbS in Northwest Nigeria face limitations due to structural challenges such as insufficient funding, weak institutional capabilities, low awareness levels, insecurity, and gender-related inequities in resource access. Numerous communities lack the necessary technical knowledge to implement ecosystem-based strategies. At the same time, both governmental and non-governmental actors find it challenging to incorporate NbS into policy frameworks and development planning. Additionally, persistent violence and insecurity disrupt local economies, diminish trust in institutions, and threaten the sustainability of long-term interventions.

In light of these challenges, this research examines the effects of Nature-based Solutions on local livelihoods, security, and income generation in Northwest Nigeria. The specific goal is to evaluate how NbS interventions help reduce socio-economic vulnerability, strengthen adaptive capacity, and foster resilience among both rural and urban families. By integrating quantitative analysis with qualitative feedback from communities, key stakeholders, and policy actors, the study offers a comprehensive evaluation of the prospects and obstacles associated with NbS implementation in the region. Ultimately, the research highlights the multifaceted role of NbS in mitigating the effects of climate change while promoting human security and sustainable livelihoods in one of Nigeria's most vulnerable areas.

Conceptual Review

Nature-Based Solutions (NbS): Multiple scholars and organisations have offered varying definitions of nature-based solutions. Among these definitions, several are highlighted below: The UNEP/EA (2022) describes a nature-based solution as: "Actions aimed at protecting, conserving, restoring, sustainably using, and managing natural or modified terrestrial, freshwater, coastal, and marine ecosystems, which effectively and adaptively address social, economic, and environmental challenges while providing benefits to human well-being, ecosystem services, and resilience."

Another definition from the IUCN (2021) states that a nature-based solution involves: "Actions to safeguard, sustainably manage, and rehabilitate natural or modified ecosystems that effectively and adaptively respond to societal challenges, simultaneously providing advantages for human well-being, ecosystem services, and resilience." This definition also highlights nature-based solutions as efforts to protect ecosystems. The European Commission (2023) defines nature-based solutions as: "Approaches inspired and supported by nature, which are cost-effective, provide simultaneous environmental, social, and economic benefits, and contribute to building resilience."

The UNEP/EA (2022) also considers nature-based solutions as: "A wide range of actions to safeguard, sustainably manage, and restore natural or modified ecosystems that effectively and adaptively address societal challenges while simultaneously delivering human well-being, ecosystem services, and resilience benefits."

Based on these definitions, a nature-based solution can be summarised as any action taken to protect, preserve, conserve, or sustain an ecosystem.

Local Livelihoods: Local livelihoods encompass the various economic and subsistence activities that individuals, households, and communities engage in to maintain their well-being within a particular socio-cultural and ecological framework. They include practices such as farming, livestock raising, fishing, trading, wage labour, and the use of natural resources, often influenced by environmental factors, cultural traditions, and local institutions. Within the context of climate change and development studies, livelihoods extend beyond mere income; they also incorporate access to fundamental resources like food, water, shelter, and social support systems that ensure survival and resilience (Jafaru et al., 2024).

Security: Security refers to the state in which individuals, households, and communities are safeguarded from threats that jeopardise their survival, dignity, and development. It extends beyond the mere absence of conflict. It encompasses aspects of human security (Abiola et al., 2025), including economic stability, food accessibility, environmental sustainability, health security, and freedom from fear and deprivation (Adekoya et al., 2025). In the context of development discourse, security guarantees that individuals have safe access to the resources, opportunities, and institutions necessary for sustainable living and resilience against shocks like climate change, conflicts, or economic downturns (Magaji et al., 2022).

Income Generation: Income generation pertains to the methods and activities through which individuals or groups produce financial resources to meet their immediate needs and long-term welfare (Magaji et al., 2023). This includes both formal and informal economic endeavours, such as farming, wage employment, small-scale commerce, artisanal work, and entrepreneurial projects. Conceptually, income generation transcends mere monetary earnings; it also involves enhancing people's ability to elevate their standard of living (Magaji & Adamu, 2011), develop resilience against socio-economic shocks, and alleviate poverty (Yakubu et al., 2025).

Empirical Review

Evidence from various contexts has illustrated the diverse effects of Nature-based Solutions (NbS) on livelihoods, security, and income generation. For example, Raymond et al. (2017) evaluated NbS initiatives in European cities. They found that green infrastructure, such as urban forests and permeable surfaces, not only mitigates flood risks but also provides social and economic co-benefits by enhancing public health and generating green employment opportunities. Likewise, Frantzeskaki et al. (2019) investigated NbS projects in urban areas across Europe, reporting that the implementation of ecosystem-based adaptation strategies improved community resilience and encouraged inclusive governance models, even though there were still institutional gaps to address.

In the context of developing countries, Mwangi, Ndunda, and Ouma (2020) studied the effectiveness of agroforestry practices in Kenya as an NbS for addressing soil degradation and increasing household incomes. Their results indicated notable improvements in crop yields, household food security, and resilience to droughts, thereby establishing a direct link between NbS and poverty alleviation alongside sustainable livelihoods. Adegun and Olokesusi (2021) focused on flood-affected communities in Lagos, Nigeria. They found that mangrove restoration initiatives boosted both climate resilience and income-generating prospects through eco-tourism and fisheries while also diminishing risks of displacement.

Regarding security issues, Yila, Weber, and Neef (2020) examined the farmer-herder conflicts in Northern Nigeria and discovered that environmental degradation and land competition intensified insecurity, proposing that integrating NbS like rangeland restoration and sustainable grazing methods could alleviate conflict triggers and stabilise local economies. In a related study, Adams, Carter, and Nsiah (2021) illustrated how watershed rehabilitation efforts in Ghana enhanced water accessibility, strengthened community bonds, and reduced conflicts over limited resources, showcasing the peace-building advantages of NbS.

From a policy standpoint, Cohen-Shacham et al. (2019) performed a global analysis of NbS projects. They concluded that initiatives incorporating local knowledge and gender-sensitive strategies were more successful in decreasing socio-economic vulnerability. This finding is consistent with the observations of Seddon et al. (2021), who highlighted that the effectiveness of NbS relies on supportive governance structures, sufficient financing, and long-term institutional commitment. Together, these studies confirm that NbS not only provide

ecological advantages but also significantly contribute to improving local livelihoods, enhancing human security, and promoting income generation in at-risk regions.

The research conducted by Sabiu and Magaji (2024) focused on the impacts of oil exploration and climate change in Nigeria's Niger Delta region. The study aimed to outline the socio-economic profiles of participants, evaluate the extent of environmental degradation in the area, and assess the levels of climate change. Data was gathered from primary sources and analysed using both descriptive and inferential statistics. A multi-stage sampling method was employed, selecting two states purposefully. First, the results indicated that a large portion of respondents in the study area were male, aged between 25 and 39, married, Christians, involved in various business activities, and possessed a primary school education. Secondly, the analysis regarding environmental degradation in the region showed that the majority, 45.3% or 120 respondents, acknowledged that oil exploration leads to environmental degradation within the Niger Delta community. Furthermore, the evaluation of climate change impacts revealed that most respondents firmly agreed that it negatively influenced their farming productivity and fishing practices. Lastly, the assessment regarding oil spills in the Niger Delta region showed that 28.3% of all respondents strongly concurred that frequent oil spills continually harm the region. As a consequence, numerous individuals in the area are now participating in various non-agricultural livelihood activities. A significant 41.51% strongly agree that they have encountered an oil spill in their vicinity, while 18.87% strongly agree that human error is responsible for the oil pollution in the surveyed area. Additionally, another 11.32% strongly agree. In a separate study conducted by Ismail, Musa, and Magaji (2019), the authors examine the factors influencing regulatory compliance by utilising traditional deterrent variables alongside potential moral and social factors. They relied on self-reported data to achieve the purpose of their analysis. A subset of habitual offenders shows no response to either normative influences or conventional deterrent variables; instead, they consistently breach regulations and resort to bribery to escape penalties. The findings also indicate that tree poachers modify their rates of violation concerning changes in detection likelihood and penalties. Nonetheless, they are also influenced by social and legitimacy factors. To effectively tackle ongoing deforestation, forest degradation, and depletion, it is crucial to establish proactive and anticipatory policies that consider social, economic, and environmental shifts to inform the development of the forest sector. Social factors significantly influence everyday interactions within society. Empirical research supports the idea that the traditional deterrent model of regulatory compliance, which emphasises the certainty and severity of sanctions as primary factors influencing compliance, only partially explains compliance behaviours. The repercussions of global warming on agriculture, livestock rearing, and fishing—Nigeria's three primary livelihood sectors—highlight the urgent need for targeted strategies to adapt to climate change. Addressing the challenges confronted by rural and coastal communities requires a comprehensive approach that incorporates both short-term and long-term solutions. In the agricultural domain, for instance, it is vital to promote farming practices that are resilient to climate fluctuations, enhance access to irrigation, and advocate for sustainable land management methods. Moreover, investing in research and development is essential to assist farmers in transitioning to crops that are more adaptable to changing climate conditions. Support from governmental and international organisations is also necessary for vulnerable communities, encompassing financial assistance, training initiatives, and improved infrastructure. Furthermore, the escalating tensions between herders and farmers necessitate prompt intervention. Enhanced water management strategies and policies that foster peaceful relationships between agricultural and pastoral communities are critical. Absent a coordinated response, the struggle for limited resources could incite further socio-political turmoil and exacerbate the economic hardships in Nigeria's rural areas. In coastal regions, initiatives to safeguard and rejuvenate mangrove ecosystems and other natural coastal defences will be crucial in mitigating the effects of rising sea levels and coastal erosion. Programs that promote sustainable fishing practices, such as overseeing fishing activities and restoring damaged coastal ecosystems, can help sustain the viability of fishing as a livelihood. Additionally, developing alternative income-generating opportunities in coastal areas, such as eco-tourism or aquaculture, could reduce economic reliance on fishing, thereby bolstering resilience against climate-induced disruptions.

Theoretical Framework

Vulnerability Theory

Vulnerability theory serves as a comprehensive framework for understanding the varied effects of environmental hazards, including climate change, on different populations, regions, and systems. Within the context of climate change, vulnerability refers to the susceptibility of a system, community, or nation to the adverse effects of climate change. This encompasses the extent to which these entities are unable to cope with, withstand, or recover from the impacts of climate-related stressors.

Vulnerability is typically characterised by three elements: exposure, sensitivity, and adaptive capacity. Exposure refers to the degree to which a system or population is vulnerable to climate-related risks. For instance, in Nigeria, certain regions are more vulnerable to climate hazards, including droughts, floods, and heatwaves. The northern parts of Nigeria are particularly vulnerable to droughts due to their arid and semi-arid climate. At the same time, areas along the coast are threatened by rising sea levels and increased flooding. Sensitivity refers to how much a system or population is impacted by changes related to climate. This sensitivity is shaped by factors such as socioeconomic conditions, health, infrastructure, and reliance on resources that are affected by climate, including agriculture. In Nigeria, where a significant segment of the population depends on agriculture for their livelihoods, climate change poses a serious threat to food security and economic stability.

Adaptive capacity denotes the capability of a system or population to adjust to climate change, lessen potential harm, seize opportunities, or manage its effects. In Nigeria, adaptive capacity is limited by poverty, lack of access to technology, weak institutional frameworks, and insufficient infrastructure. Vulnerability theory in Nigeria clarifies why specific regions, like the northern and coastal areas, are at a higher risk of the negative impacts of climate change. For instance, the northern regions are experiencing growing desertification and diminishing agricultural output, which worsens food insecurity and poverty. The vulnerability of these communities is increased further by their limited adaptive capacity, characterised by poor infrastructure, insufficient access to clean water, and inadequate governmental support.

Research indicates that rural populations in Nigeria are especially vulnerable due to their heavy reliance on subsistence farming, which is very sensitive to fluctuations in weather patterns. A study conducted by Oyekale (2014) highlighted that the growing unpredictability of rainfall and elevated temperatures in northern Nigeria have resulted in a significant drop in crop yields, intensifying poverty and food insecurity in these areas. Likewise, coastal populations face risks from rising sea levels, which jeopardise homes, livelihoods, and infrastructure.

Vulnerability theory also emphasises the role of social determinants like gender, age, and socioeconomic status in understanding the repercussions of climate change. Women and children in Nigeria are especially impacted because they rely on natural resources, have limited educational opportunities, and have decreased decision-making authority. This situation necessitates a gender-sensitive approach to climate adaptation strategies within the country.

METHODOLOGY

Research Design

The study employed a cross-sectional research design, which effectively assesses the prevalence of socioeconomic challenges and evaluates the effectiveness of interventions within a specific timeframe. This design facilitated the identification of correlations and predictive factors that influence community reactions to climate change in Northwest Nigeria. To ensure a comprehensive perspective, the study employed a mixed-methods approach that integrated both quantitative and qualitative techniques. The quantitative segment aimed to identify measurable patterns, trends, and statistical connections between socio-economic factors and vulnerabilities linked to climate change, including the uptake of Nature-based Solutions (NbS). Conversely, the qualitative component, which involved Focus Group Discussions (FGDs) and key informant interviews,

provided more profound insights into the experiences, perceptions, and adaptation methods of the affected communities.

Study Area

The research was carried out in Northwest Nigeria, which consists of seven states: Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara. This region is primarily characterised by the West Sudan savanna eco-region, encompassing an area of roughly 216,065 km² and home to over 49 million people, representing about 23% of Nigeria's population (NPC, 2022). The region's economy is mainly reliant on agriculture, with key crops including millet, sorghum, maize, cotton, rice, and groundnuts, in addition to livestock farming, small-scale trading, and artisanal mining. The focus of the research was particularly on Sokoto, Zamfara, and Katsina States, selected due to their vulnerability to climate change impacts, relevance for the application of NbS, and diversity in socio-economic, ecological, and political contexts.

Population and Sample Size

The target population for the study included individuals aged 18 and older residing in Northwest Nigeria. A total of 700 respondents were selected using the Taro Yamane (1967) formula, ensuring a representative sample with a 95% confidence level and a 5% margin of error.

Sampling Technique

The study utilised a multi-stage sampling approach. Simple random sampling was used to guarantee that every individual had an equal opportunity to be chosen, thus minimising bias. Cluster sampling was implemented to consider the geographical distribution of respondents across various villages, towns, and Local Government Areas (LGAs). Additionally, purposive sampling was used to select participants for focus group discussions (FGDs) and interviews, specifically targeting community leaders, members of farmers' associations, women's groups, and government entities involved in implementing NbS.

Research Instruments

Data collection involved a combination of structured questionnaires, guides for FGDs, and protocols for interviews. The questionnaires gathered information on socio-demographic aspects, awareness and uptake of NbS, experiences related to climate change, and associated economic effects. The FGD guides were crafted to prompt in-depth dialogues about community resilience, obstacles to NbS implementation, and local adaptation techniques. In a similar vein, key informant interviews were conducted with state officials, NGOs, and community leaders to obtain expert insights on the impacts and responses to climate change in the area.

Methods of Data Analysis

Quantitative data were coded and analysed using SPSS Version 27. The analysis was divided into two phases. Initially, descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarise socio-demographic information, the impacts of climate change, and the levels of NbS adoption. Next, inferential statistics were applied to test hypotheses and identify significant associations. Specifically, Chi-square tests (χ^2) were utilised to explore relationships between categorical variables such as education level and NbS awareness, as well as gender and the uptake of adaptation strategies. Independent t-tests compared mean differences in climate change impacts between rural and urban households. One-way ANOVA was employed to evaluate differences in socio-economic vulnerability across states, including Sokoto, Zamfara, and Katsina. Logistic regression analysis was conducted to determine predictors of NbS adoption, focusing on factors such as age, income, education, and farm size. Multiple regression analysis was used to investigate the relationship between socioeconomic factors and indices of climate change vulnerability.

For the qualitative section, data from FGDs and interviews were evaluated using thematic content analysis. Responses were transcribed, coded, and categorised into emerging themes, including obstacles to NbS, livelihood resilience, and institutional challenges. The triangulation of qualitative findings with quantitative data reinforced the validity and provided a comprehensive understanding of the studied issues.

Validity and Reliability

To ensure the validity and reliability of the study, a pilot test of the questionnaire was conducted with 30 respondents in Kaduna State, which assisted in fine-tuning any ambiguous items. Cronbach's alpha (α) was calculated to assess the internal consistency of multi-item scales, with values exceeding 0.7 regarded as reliable. Furthermore, triangulation among survey data, FGDs, and interviews ensured convergence and bolstered the credibility of the findings.

RESULTS AND DISCUSSION

Socioeconomic and Demographic Characteristics of Respondents

The study included responses from 700 individuals across Sokoto, Zamfara, and Katsina States. Table 1 outlines their socio-demographic characteristics.

Table 1: Socioeconomic and Demographic Characteristics of Respondents (N = 700)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	420	60.0
	Female	280	40.0
Age Group	18–30 years	196	28.0
	31–45 years	280	40.0
	46 years and above	224	32.0
Education Level	No formal education	210	30.0
	Primary	154	22.0
	Secondary	182	26.0
	Tertiary	154	22.0
Occupation	Farming	392	56.0
	Trading	168	24.0
	Civil service	98	14.0
	Others	42	6.0
Household Income (₦)	<50,000	280	40.0
	50,001–100,000	266	38.0
	>100,000	154	22.0

The findings indicate that a significant proportion of participants identified as male (60%) and were mainly involved in agriculture (56%), emphasising the deep dependence of the Northwest Nigerian community on farming for their livelihoods. This reliance heightens their vulnerability to climate-related challenges such as droughts, floods, and desertification. The age demographics show that the largest group of respondents (40%) was situated in the economically active age range of 31–45 years, while 32% were aged 46 and above, suggesting that heads of households tend to be older adults who are actively involved in economic activities. Regarding education, 30% of respondents did not have any formal education, and merely 22% achieved a

tertiary qualification. This relatively low level of educational attainment may restrict knowledge and uptake of innovative adaptation strategies like Nature-based Solutions (NbS). The income distribution further underscores their vulnerability, as 40% of households earn under ₦50,000 monthly, which is significantly below Nigeria's average living expenses, limiting their ability to invest in adaptive technologies or sustainable farming methods. Overall, these characteristics indicate substantial socioeconomic vulnerability to climate effects and underline the necessity for focused interventions.

Chi-Square Test (χ^2) Results

Chi-square analysis was conducted to determine associations between socio-demographic variables and awareness/adoption of NbS.

Table 2: Chi-Square Tests of Socio-Demographic Factors and NbS Awareness/Adoption

Variable	χ^2 Value	df	p-value	Decision
Gender × NbS adoption	6.72	1	0.010	Significant
Education × NbS awareness	18.54	3	0.001	Significant
Income × NbS adoption	12.31	2	0.002	Significant
Age × NbS adoption	2.85	2	0.240	Not Significant

Clarification: The findings indicate that education and income are significant factors affecting the awareness and adoption of Nature-based Solutions (NbS). Individuals with higher educational qualifications were notably more likely to be informed about climate adaptation strategies, while households with greater income had more resources to implement NbS interventions. Additionally, gender played a role in adoption rates, with men exhibiting higher levels of adoption compared to women, likely due to disparities in access to land, extension services, and resources. In contrast, age did not appear to impact adoption significantly, indicating that the decision to embrace NbS is influenced more by economic and educational factors than by generational differences.

Results from Independent t-Tests

Independent t-tests were conducted to compare the average climate change impact scores between households in rural and urban areas.

Table 3: Independent t-Test Comparing Rural vs. Urban Households on Climate Change Impacts

Location	N	Mean Impact Score	Std. Dev.	t-value	p-value
Rural	420	3.85	0.62	4.27	0.000*
Urban	280	3.45	0.58		

*Significant at $p < 0.05$

Rural households have reported significantly higher average impact scores (M = 3.85) compared to their urban counterparts (M = 3.45). This indicates that rural communities experience greater vulnerability to climate shocks such as unpredictable rainfall, droughts, and soil degradation. In contrast, urban households benefit from diverse income sources and improved infrastructure, which provide some protection against severe climate fluctuations. This finding underscores the need for targeted interventions in rural areas, particularly in relation to agricultural adaptation and sustainable land management.

One-Way ANOVA Results

ANOVA tested socio-economic vulnerability differences across Sokoto, Zamfara, and Katsina States.

Table 4: ANOVA Results on Socio-Economic Vulnerability across States

Source	SS	df	MS	F-value	p-value
Between Groups	15.62	2	7.81	6.42	0.002*
Within Groups	842.73	697	1.21		
Total	858.35	699			

*Significant at $p < 0.05$

Explanation: There were notable differences in vulnerability among the three states ($p = 0.002$). Subsequent comparisons (not included in the table) indicated that respondents from Zamfara had the highest vulnerability index, followed by those from Sokoto, whereas Katsina had comparatively lower vulnerability scores. This disparity could be linked to Zamfara's greater levels of insecurity, pervasive poverty, and weaker institutional support, which intensify the effects of climate change on livelihoods.4.5 Logistic Regression Results

Logistic regression identified predictors of NbS adoption.

Table 5: Logistic Regression on Predictors of NbS Adoption

Predictor	B	SE	Wald	Exp(B)	p-value
Age	-0.12	0.08	2.25	0.89	0.134
Income	0.48	0.11	19.02	1.62	0.000*
Education	0.35	0.10	12.48	1.42	0.001*
Farm Size	0.29	0.07	17.11	1.34	0.000*

*Significant at $p < 0.05$

Income, education, and the size of the farm were significant factors influencing the adoption of Nature-based Solutions (NbS). Households with higher income were 1.62 times more likely to embrace NbS, while those with an education were 1.42 times more likely to adopt these solutions compared to those without formal education. Additionally, larger farms showed a higher likelihood of adopting NbS, as farmers with more land were inclined to explore methods such as tree planting, agroforestry, and water conservation. Age was not identified as a significant factor, suggesting that the decisions to adopt are more influenced by available resources and knowledge than by differences across generations.

Multiple Regression Analysis

Multiple regression analysis examined socio-economic factors that predict climate change vulnerability.

Table 6: Multiple Regression on Socio-Economic Factors and Climate Change Vulnerability

Predictor	Beta	t-value	p-value
Education	-0.28	-6.10	0.000*

Income	-0.32	-7.25	0.000*
Farm Size	-0.19	-4.32	0.001*
Household Size	0.14	3.05	0.002*

*Significant at $p < 0.05$. $R^2 = 0.41$

The regression analysis accounted for 41% of the variation in vulnerability to climate change ($R^2 = 0.41$). Households with higher levels of education, income, and larger farm sizes exhibited reduced vulnerability, indicating greater resilience to climate impacts among these groups. In contrast, larger household sizes significantly heightened vulnerability, as larger families tend to strain household resources and coping abilities more. These results underscore the intertwined influence of socio-economic conditions and family structure in determining climate resilience.

Qualitative Insights from FGDs and KIIs

The qualitative aspect of the research, derived from Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs), offered more profound insights into the experiences of communities and stakeholders in Sokoto, Zamfara, and Katsina States. These findings complemented the quantitative analysis and provided context-specific narratives regarding the challenges and opportunities related to Nature-based Solutions (NbS). Several sub-themes were identified:

(a) Community Resilience and Local Adaptation Approaches

Participants identified a variety of indigenous strategies employed to cope with climate shocks. Farmers mentioned diversifying their livelihoods through small-scale commerce, artisanal mining, and migrating to urban areas during extended drought periods. Traditional methods such as water harvesting, utilising indigenous drought-resistant seeds, and community-driven tree planting efforts were highlighted as relevant local strategies.

FGD participants in Zamfara stressed the importance of social networks and collective labour groups (“gayya”) in pooling resources to assist vulnerable households. Although these local mechanisms are under pressure, they remain vital for maintaining food security and enhancing resilience.

(b) Institutional Challenges and Policy Limitations

KIIs with state officials and NGO representatives revealed deficiencies in climate governance. Inconsistent financial support, a shortage of technical skills, and fragmented collaboration among ministries and agencies obstructed the expansion of NbS initiatives. Officials in Sokoto recognised that while NbS projects were initiated through donor-funded programs, the lack of sustainable funding arrangements restricted their continuity post-donor involvement.

NGO representatives pointed out a disconnect between national climate adaptation frameworks and the capacity for local implementation, highlighting that policies often overlook the input of local communities. This gap in institutional support erodes trust between communities and government, diminishing the effectiveness of NbS efforts.

(c) Gender-Specific Adaptation Challenges

Gender was identified as a significant factor influencing vulnerability and resilience. Women, especially in rural areas, struggle with limited access to land, financial resources, and extension services, which impedes their ability to adopt NbS practices like agroforestry or soil conservation.

Discussions in Katsina revealed that women disproportionately experience the impacts of climate shocks, often assuming responsibility for water collection, gathering fuelwood, and providing food for their households.

Participants also noted that women's expertise in traditional food preservation and water management techniques is frequently underutilised in formal adaptation initiatives. This highlights the necessity for gender-responsive policies that acknowledge and empower women as key players in climate adaptation.

(d) Views on the Effectiveness of NbS

While some participants recognised the advantages of NbS projects like community woodlots, shelterbelts, and wetland restoration, others expressed doubts stemming from inadequate maintenance, limited reach, and a lack of community involvement. Farmers in Sokoto argued that tree planting efforts often fell short because seedlings were given out without proper follow-up support or irrigation systems.

Experts involved in the KIIs suggested that community engagement and ownership are critical for the sustainability of NbS, recommending that projects incorporate traditional governance structures (village heads, religious leaders) to boost their legitimacy and acceptance.

(e) Obstacles to Execution

Commonly mentioned obstacles from the focus group discussions (FGDs) included:

i. Conflicts over land tenure, particularly between farmers and pastoralists, hinder nature-based solutions (NbS) like rangeland management.

ii. Economic hardship and insecure livelihoods, compelling families to focus on immediate survival (for example, selling firewood) rather than the long-term benefits of NbS.

iii. Low levels of awareness, especially in communities with minimal formal education, make it challenging to expand technical NbS interventions.

(f) Suggestions from Stakeholders

Participants from the FGDs and Key Informant Interviews (KIIs) offered several strategies for improving NbS:

i. Training and capacity building for local farmers and women's cooperatives.

ii. Combining indigenous knowledge with scientific methods for climate-smart agriculture.

iii. Enhanced funding for community-led projects with clear monitoring systems.

iv. Platforms for conflict resolution to tackle disputes between farmers and herders that hinder NbS efforts.

Integration with Quantitative Findings

The qualitative insights supported the statistical findings:

i. The link between education, income, and the adoption of NbS (as indicated by Chi-square and logistic regression results) was echoed in FGDs, where low awareness and poverty were frequently mentioned as hurdles.

ii. The elevated vulnerability scores in Zamfara (according to ANOVA results) corresponded with accounts of weak institutions and ongoing conflicts in the region.

iii. The gender disparities highlighted in qualitative data reinforced quantitative findings indicating significant differences in NbS adoption among socio-economic classifications.

Validation of Findings

Validation was used to enhance the trustworthiness and reliability of the research by merging quantitative results (surveys, chi-square, regression, ANOVA, and t-tests) with qualitative insights (FGDs and KIIs). For example, quantitative analysis showed that income, education, and farm size were vital predictors of NbS adoption. Concurrently, qualitative findings indicated that poverty, a lack of awareness, and insufficient extension services restricted community engagement.

Similarly, the ANOVA results showed that respondents from Zamfara faced greater socio-economic vulnerability, which aligns with FGD discussions mentioning ongoing conflicts, institutional deficiencies, and limited governmental support in the state. The independent t-test outcomes revealed that rural households experienced more intense climate impacts, which was corroborated by FGDs where rural residents reported diminished crop yields, deforestation, and dwindling water resources as everyday challenges.

This method of triangulation confirmed the alignment of statistical evidence and community stories, thereby bolstering confidence in the study's findings.

Interpretation of Findings

The results of this research indicate that socio-economic and demographic factors significantly influence vulnerability to climate change and the adoption of NbS in Northwest Nigeria.

Firstly, the prevalence of farming as an occupation (56%) highlights the reliance on natural resources, rendering households susceptible to climatic disturbances. This supports earlier research suggesting that agriculture-dependent economies in sub-Saharan Africa are more exposed to threats from drought, unpredictable rainfall, and land degradation.

Secondly, chi-square and regression results confirm that income and education are essential factors promoting NbS adoption. Participants with higher income and education levels were more inclined to implement practices such as agroforestry, soil conservation, and community woodlots. This observation aligns with evidence indicating that literacy and financial means enhance adaptive capacity by allowing households to utilise new technologies and climate-related information.

Thirdly, the gap between rural and urban communities was pronounced, with rural households experiencing significantly larger climate impacts than their urban counterparts. This disparity reflects variations in infrastructure, employment prospects, and access to social services. It underscores the necessity for policies tailored to address vulnerability in rural hotspots.

Fourthly, disparities at the state level (as indicated by ANOVA results) identified Zamfara as the most vulnerable state. Qualitative findings attributed this vulnerability to ongoing conflicts, inadequate governance, and frail institutional support. This implies that, in addition to individual socio-economic traits, structural and political factors also intensify vulnerability.

Finally, qualitative findings pinpointed institutional weaknesses, gender-specific adaptation challenges, and limited community ownership of NbS projects as primary barriers.

CONCLUSION

This research examined the socio-economic obstacles related to climate change and the implementation of Nature-based Solutions (NbS) in Northwest Nigeria by utilising a mixed-methods approach. The quantitative analysis revealed that factors such as income, education, and farm size were significant predictors of NbS adoption, with rural households and those in Zamfara State showing greater vulnerability. The qualitative data revealed various challenges, including poverty, weak institutional structures, land disputes, and gender disparities.

The alignment of quantitative and qualitative insights emphasises that climate change vulnerability in Northwest Nigeria is complex and influenced by both socio-economic and structural elements. Although NbS

can enhance resilience, their effectiveness relies on rectifying institutional deficiencies, fostering community involvement, and advancing inclusive adaptation strategies.

RECOMMENDATIONS

In light of the findings, the study proposes the following recommendations:

1. Empower community capacity for NbS: Offer training and extension services to farmers and women's groups regarding sustainable land and water management approaches.

2. Advocate for gender-sensitive adaptation policies: Guarantee equal access for women to land, credit, and decision-making opportunities in climate adaptation efforts.

3. Improve institutional coordination and funding: Create explicit inter-ministerial frameworks and sustainable financing models to support extended NbS initiatives beyond donor contributions.

4. Focus on rural and high-vulnerability areas: Prioritise investments in rural populations and states with high vulnerability, like Zamfara, through specialised NbS interventions.

5. Merge indigenous knowledge with scientific methods: Integrate traditional techniques, such as water harvesting and community labour mobilisation, with contemporary climate-smart agriculture practices.

6. Implement conflict-sensitive NbS programming: Tackle farmer-herder disputes and land tenure insecurity through dialogue platforms to ensure NbS efforts are not compromised.

Contribution to Knowledge

This research makes a significant contribution to knowledge by providing context-specific evidence on the socio-economic issues posed by climate change and the adoption of Nature-based Solutions (NbS) in Northwest Nigeria. The region has been largely underrepresented in existing research. By adopting a mixed-methods framework and correlating quantitative findings with qualitative perspectives, this study identified critical determinants of NbS adoption—namely, income, education, and farm size—while also shedding light on gender-specific adaptation hurdles, institutional shortcomings, and disparities at the state level, with Zamfara identified as the most vulnerable. Unlike many purely descriptive analyses, this investigation combines rigorous statistical evaluation with real-life community experiences, enhancing the understanding of vulnerability factors and strategies for resilience. Additionally, by linking NbS adoption to broader development impacts, the study enriches the existing discourse on climate adaptation. It offers actionable, policy-oriented recommendations that resonate with the Sustainable Development Goals, particularly SDGs 2, 5, and 13.

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