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ASSESSING CLIMATIC IMPACT DRIVERS AND HUMAN ACTIVITIES ON RIPARIAN AGROFORESTRY: EVIDENCES FROM KOMADUGU-YOBE RIVER BASIN, NIGERIA.

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ABSTRACT

Riparian agroforestry systems in the Komadugu-Yobe River Basin face increasing threats from climatic variability, land degradation, and human activities. Changing in climatic pattern and increased frequency of extreme events compromise ecosystem services, agricultural productivity, and livelihoods of local communities. This study investigates climatic impact drivers on riparian agroforestry, exploring evidence from the Komadugu-Yobe River Basin to inform sustainable management and adaptation strategies. This study employed a mixed-methods approach to investigate climatic impact drivers on riparian agroforestry in the Hadejia-Nguru Wetland (HNW). Primary data were collected through oral interviews, focus group discussions, and structured questionnaires administered to 120 respondents in two fishing communities. Secondary meteorological data (temperature, rainfall, and wind speed) spanning 10 years were obtained from NiMet. Purposive sampling design was used, with observations taken at landing sites and agroforestry areas. Descriptive statistics (frequency and percentage) and inferential statistics (Correlation analysis) were used to analyze human influence on agroforestry resources and the impact of climatic drivers using Statistical Package for Social Science (SPSS) Version 26 x 86V. The study reveals significant environmental pressures in the Komadugu-Yobe River Basin. Key findings include: overuse of surface water (35%), fuelwood harvesting (37.5%), grazing (43%), and hunting/wildlife use (45%); moderate decline in farming (57%), Doum Palm (50%), and fishing (50%); and widespread Typha grass invasion (38%). Human exploitative practices, such as illegal logging (26.67%), overgrazing (22.50%), and uncontrolled bush burning (16.67%), threaten agroforestry resources. Climatic drivers, including drought (28.33%), irregular rainfall patterns (24.17%), and increased temperature (18.33%), exacerbate these impacts. Correlation analysis shows that increased wind speed negatively impacts most resources, while temperature and rainfall have varying effects. These findings highlight the need for sustainable management practices to mitigate environmental degradation and promote ecosystem resilience. Policies and programs that discourage exploitative practices should be developed and implemented.

Keywords: Climatic Impact Drivers, Evidences, Riparian Agroforestry, Komadugu-Yobe, River Basin.

INTRODUCTION

In Nigeria, tropical agroforestry systems (TAFS) play a vital role in enhancing climate resilience, improving livelihoods and promoting sustainable agriculture (Salako *et al.,* 2019). By integrating trees into farmland, Nigerian farmers can benefit from regulating ecosystem services, such as shading, soil moisture conservation and windbreaks, which can help mitigate the impacts of climate change (Abbas *et al.,* 2025; Kehinde *et al.,* 2024). TAFS can also provide diverse income sources, including crops, fruits and medicinal plants, improving household income and food security. Furthermore, TAFS can support cultural values and promote biodiversity conservation, enabling people to manage traditional crops and plants belonging to their cultural history (Adefila *et al.,* 2024). With climate change posing significant threats to Nigerian agriculture, TAFS can be a valuable adaptation strategy for smallholder farmers, enhancing their resilience and promoting sustainable livelihoods. Riparian agroforestry, characterized by the integration of trees, crops, and occasionally livestock within zones adjacent to watercourses, plays a critical role in maintaining ecological balance whilst supporting agricultural livelihoods (Akinyi, 2024). Positioned at the interface between terrestrial and aquatic ecosystems, riparian systems are significantly influenced by climatic variables including drought incidence, temperature fluctuations, changes in precipitation patterns and hydrological variability (Tabacchi *et al.,* 2000). Such climatic drivers can impact the structure, function, and resilience of riparian agroforestry systems, necessitating adaptive management strategies to ensure sustainability of both ecological integrity and agricultural productivity in these dynamic environments.

Climate-driven perturbations pose escalating threats to riparian ecosystems. Extreme drought events, in particular, can significantly impair forest health and the provision of ecosystem services by diminishing resistance to stress and decelerating post-disturbance recovery trajectories (Ibisch, 2025). Observations from savannah part of the country reveal that even three years subsequent to a severe drought episode, vegetation vitality and water-related indices in affected areas persisted below pre-drought levels drought levels (Scott and Maitre, 1998). This effect was pronounced in regions dominated by forests, underscoring the enduring vulnerabilities of these ecosystems to climatic extremes and highlighting the need for consideration of long-term ecological resilience in management strategies. Moreover, broader climatic shifts: including rising temperatures and more erratic rainfall and evaporation patterns: are projected to exacerbate soil moisture deficits, increase runoff, and heighten the frequency of heatwaves and extreme precipitation events.

Agroforestry's mitigating potential is well-documented across tropical and semi-arid contexts. Trees within agroforestry systems buffer microclimates, reducing daytime temperatures by 2–5 °C (e.g., shaded systems versus monocultures, including coffee agroforestry) while improving soil moisture retention and lowering evapotranspiration (Gupta *et al.,* 2023). In semi-arid and arid zones, integrating species such as *Prosopis* and *Faidherbia albida* has yielded crop yields 10–15% higher under canopy, with water use reductions of 15-30% due to windbreak effects (Sida, *et al.,* 2018). Beyond agronomic benefits in terms of yield, agroforestry systems significantly enhance ecosystem functionality, particularly in aspects of erosion control and water regulation. In sub-Saharan Africa, implementation of agroforestry practices has been shown to reduce runoff by up to fivefold and soil loss by nearly tenfold compared to non-agroforestry systems, while concurrently doubling infiltration rates and improving soil moisture retention more effectively than adjacent control plots (Birhanu *et al.,* 2024). However, the performance of agroforestry under climate stress exhibits a dual nature. While mechanisms such as shade provision, root complementarity, and enhanced resource capture can buffer against heat and drought stresses, competition for water and nutrients between trees and crops in agroforestry systems may compromise crop yields, particularly in water-limited environments.

Riparian zones offer additional ecological services: they intercept sediment, nutrients, and pesticides; stabilize stream banks and enhance biodiversity and habitat connectivity (Hanna *et al.,* 2020). However, changing hydrological regimes: due to factors like reduced flooding from damming or groundwater extraction can drastically alter riparian vegetation composition and function, potentially favored invasive species or reducing native resilience (Stella and Bendix, 2019). Given these complex interplays, assessing climatic impact drivers on riparian agroforestry demands a nuanced, site-specific understanding of how drought, temperature extremes, and water variability impact both ecological processes and agroforestry performance. Adaptive design strategies such as selecting drought-tolerant tree species, configuring spatial arrangements to optimize root complementarity, and enhancing hydrological connectivity are essential to harness the resilience-building potential of riparian agroforestry systems. Therefore, the research focused on the effect of climatic impact drivers on riparian agroforestry from Komadugu-Yobe River Basin.

METHODOLOGY

The study was carried out within the riparian belt of HNW and fishing communities along this riparian belt was included for the study (Figure 1). The Komadugu Yobe basin is about 148,000 km^2 (Oyebande, 2001). It has its source in the plateaus of Kano and Jos in Nigeria (Boso, 2025). Hadejia river and Jama'are river in Nigeria together forms the Komadugu Yobe (Joseph *et al.,* 2024; Oyebande, 2001). The Komadugu Yobe is forming the border between Niger and Nigeria from the village of Tam in Niger until its mouth into the Lake Chad. The border is one out of 238 international boundaries in the world that follow a river for at least a part of their course (International Boundaries Research Unit, 2008). Both crop farmers and fisherfolks along the riparian belt was interrogated during the course of the study.

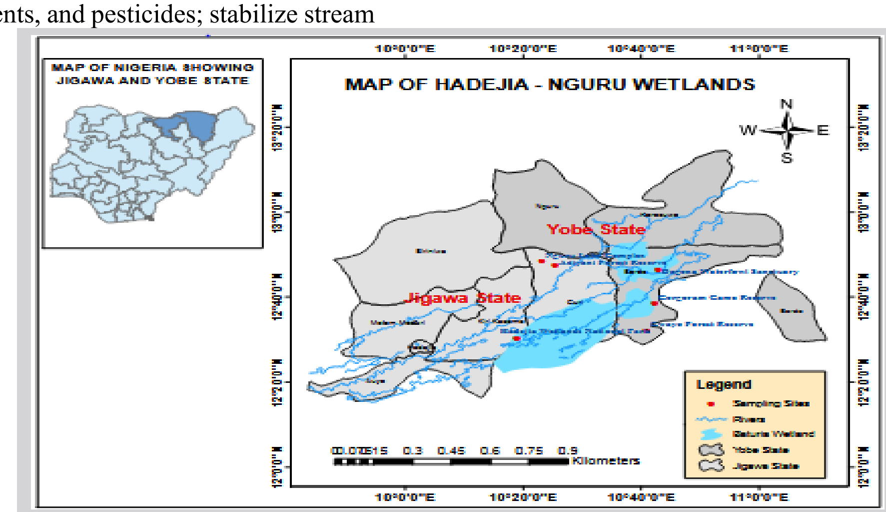

Figure 1: showing map of Hadejia and Nguru Wetland
Source: Field survey 2024

Data Collection
Meteorological secondary data was collected for this study. The following secondary meteorological data: temperature, rainfall, and wind speed were collected throughout the duration of the study. Further to the above, secondary meteorological data dating back to 10 years was obtained from Nigerian. Similarly, oral interview, focus group discussions (FGDs), structured questionnaire was used to obtain secondary data such as climatic information, agroforestry resources, composition and distribution present within HNW.
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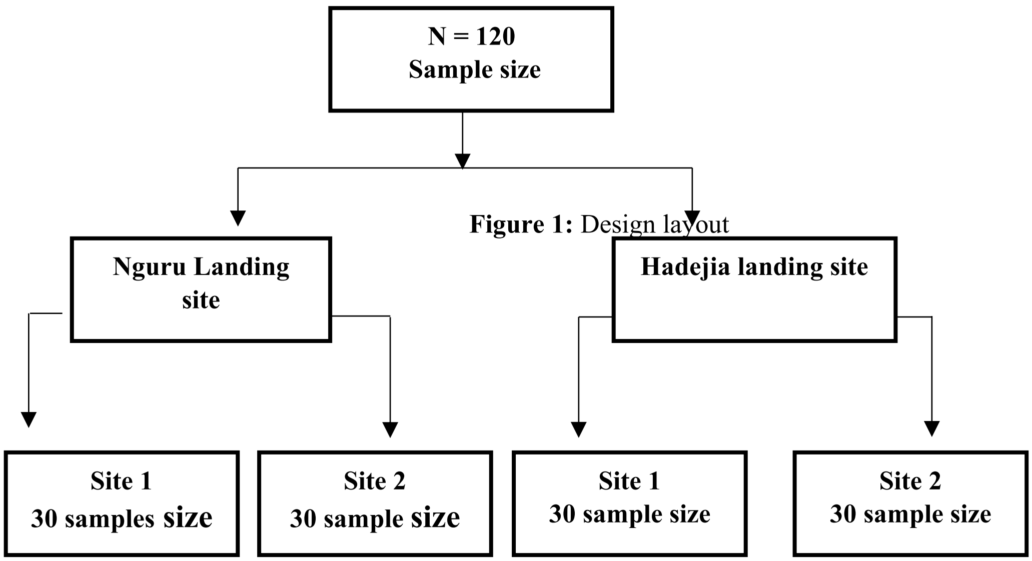

Figure 1: Design layout

Sampling Design and Data analysis
Purposive sampling design was employed which was one hundred and twenty (120) questionnaires were distributed in two fishing communities such as (two landing sites from each community) Nguru and Hadejia. The exploitative practices by crop farmers, lumbers and fishermen within HNW were collected to analyses their consequences on forest sustainability and conservation. Human exploitative practices such as logging activities, livestock grazing, fuel wood consumption, road construction, water pollution, overfishing, bad agricultural practices and industrialization were studied. Descriptive statistic such as frequency and percentage was used to analyse rate of utilization, the impact of human influence on agroforestry resources, impact of climatic drivers on resources and Pearson's correlation was used to check the relationship between available resource and climatic drivers.

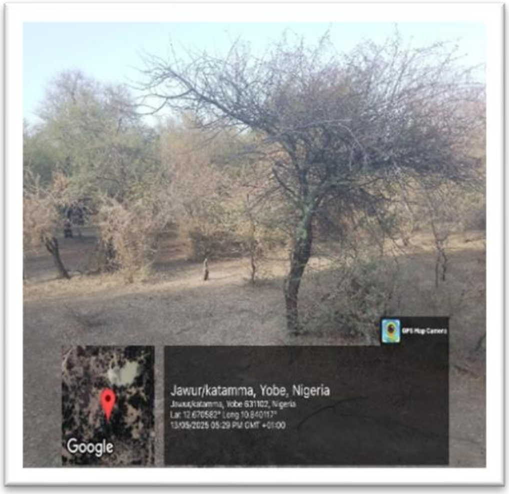

Plate 1: *Acacia nilotica*

Plate 2: *Balanities eagypti*a

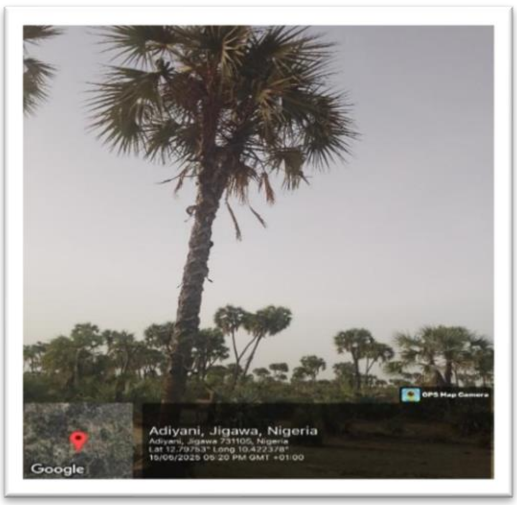

Plate 3: *Borasus eatiopica*

Plate 4: *Adansonia digitata*

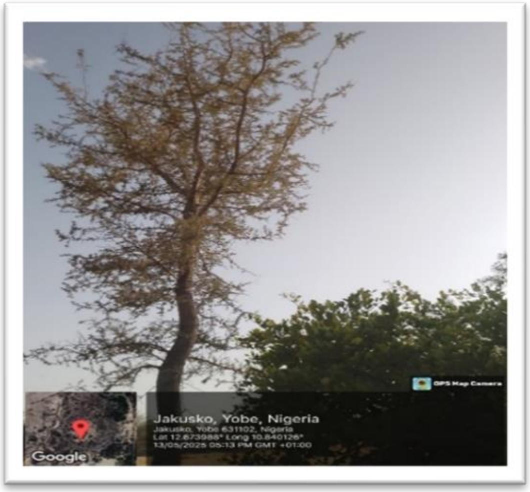

Plate 5: *Borasus eatiopica*

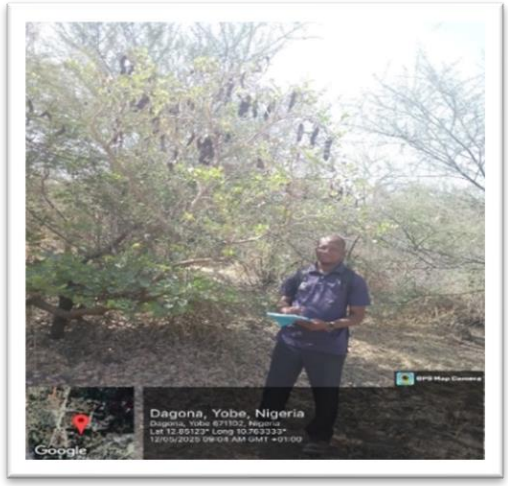

Plate 6: *Boehevia ruvensa*

Plate 7: Human activity (Burning)

Plate 8: Researcher and Taxonomist

Plate 9: ***Typha species***

Plate 10*:* Showing people engaging in fishing activities in the Hadejia Nguru Wetlands

RESULTS AND DISCUSSION

The Komadugu-Yobe River Basin showcases diverse tropical agroforestry systems tailored to its ecological conditions. In semi-arid and arid farmlands, agrisilviculture, silvopastoral, and agrosilvopastoral systems thrive, integrating crops, trees, and livestock to enhance soil fertility, livestock performance, and drought resilience. Windbreaks, shelterbelts, and multipurpose trees on farmland protect against erosion and improve microclimates. Parkland agroforestry and improved fallow systems leverage scattered trees and nitrogen-fixing hedgerows to boost soil fertility and crop yields. In seasonal wetlands, home gardens and agroecological buffer zones offer opportunities for multilayered, multipurpose tree systems. Indigenous techniques like zaï pits and stone bunds optimize rainwater harvesting and soil-water retention, supporting vegetation regeneration. These agroforestry systems demonstrate adaptability and effectiveness in addressing environmental challenges and improving livelihoods in the region. By adopting these practices, farmers can enhance ecosystem services, increase crop yields, and build resilience to climate variability.

Table 1: Trend of The Major Types of Tropical Agroforestry Systems Based on Supporting Ecological conditions in Komadugu-Yobe River Basin

Ecological Condition / Zone	Typical Agroforestry Systems	Notable Characteristics with Examples
Semi-arid / Arid Farmlands (Sahelian zone)	**i.** Agrisilviculture (Crops + Trees) **ii.** Silvopastoral (Trees + Pasture/Livestock) **iii.** Agrosilvopastoral (Crops + Trees + Livestock)	i. Agrisilviculture includes alley cropping, improved fallows, silvicultural intercropping ii. Silvopastoral systems combining *Faidherbia albida* with forage grasses and small ruminants have proven effective in northern Nigeria—improving soil fertility, livestock performance, and drought resilience
Semi-arid Lowlands – Protective Use	**i.** Windbreaks / Shelterbelts **ii.** Multipurpose Trees on Farmland **iii.** Live Fences / Hedgerows / Alley Cropping	i. Uses include soil conservation, microclimate amelioration, and fuelwood/fodder/tree products ii. Alley cropping with nitrogen-fixing hedgerows (e.g., Leucaena, Gliricidia, Sesbania) enhances soil fertility and crop yield; faster-growing species like Leucaena are particularly effective
Sudano-Sahelian Parklands / Naturally Vegetated Areas	**i.** Parkland Agroforestry **ii.** Improved Fallow **iii.** FMNR (Farmer Managed Natural Regeneration)	i. Parklands—scattered multipurpose trees in croplands—help create fertility "islands," boosting yields of sorghum/millet near species like *Faidherbia albida* and *Grewia senegalensis* ii. Improved fallow involves planting suitable woody species during fallow to restore soil fertility
Seasonal / Riparian Wetlands (e.g., Hadejia-Nguru wetlands)	**i.** Home Gardens / Tree Gardens near wet margins **ii.** Agro-ecological buffer zones	i. Seasonal wetlands (flooded in August–September) present opportunities for tree gardens—multilayered, multipurpose systems combining fruit, medicinal, shade, and other useful trees. Although not widely documented in this basin, such systems are widely practiced elsewhere in tropical zones.
Rainwater Harvesting / Soil-Water Retention Zones	i. Zaï / Tassa pits, Bunds, Living Hedgerows	i. Indigenous Sahelian techniques like zaï pits can dramatically improve yields in 300–800 mm rainfall zones ii. Stone or earth bunds trap water, reduce erosion, and support vegetation regeneration

Source: Field survey: 2024

The impact of human activities on the trends of natural resource use in the Komadugu-Yobe River Basin (KYB) reveal concerning patterns of overuse and decline. According to Table 2, surface water resources are being overused (35%), while farming activities are experiencing moderate to declining trends (57%). The collection of Doum palm and fishing are also showing signs of moderate decline (50%). Fuelwood harvesting, grazing, and fodder collection are being overused, with 37.5%, 43%, and 25% of respondents indicating overexploitation, respectively. Fruit harvesting is also being overused (34%). Notably, the invasion of Typha grass is widespread, with 38% of respondents reporting overgrowth. Hunting and wildlife use are being overexploited (45%). These findings suggest that the KYB is facing significant environmental pressures, highlighting the need for sustainable management practices to mitigate these impacts and ensure the long-term viability of these natural resources. Effective conservation and management strategies are essential to address these challenges and promote ecosystem resilience

SN	Variables	Status	Percentage by Variables (%)
1.	Surface Water (River/ Wetlands)	Overuse	35
2	Farming (Wet/ Dry Season)	Moderate to Declining	57
3	Doum Palm	Moderate Decline	50
4	Fuelwood Harvesting	Overuse	37.5
5	Fishing	Moderate Decline	50
6	Grazing / Pasture	Overuse	43
7	Fruits	Overuse	34
8	Fodder	Over use	25
9	Typha Grass Invasion	Overgrowth (Not a human use but critical)	38
10	Hunting and Wildlife Use	Overexploitation	45

Table 2: Status and Trends of Natural Resource Use and Human Activities in the KYB

Note: Less than 50% = Overuse; 50 to 69% Moderate use; Greater than 70 under use
Agroforestry Sustainability Assessment
Source: Nair, P. K. R (2011)

The impact of human exploitative practices on agroforestry resources in the Komadugu-Yobe River Basin (KYB) is substantial, as indicated by the survey results in Table 3. Among the 120 respondents, illegal logging was the most frequently reported practice, affecting 26) of respondents (26.67%), followed by overgrazing (22.50%), uncontrolled bush burning (16.67%), land conversion (15.00%), and harvesting of non-timber forest products (10.83%). Fuelwood extraction was reported by 8.33% of respondents. These findings suggest that agroforestry resources in the KYB are threatened by a range of human activities, with illegal logging and overgrazing being the most prevalent. The standard errors (SE) associated with each practice indicate relatively low variability in the responses, suggesting that these findings are robust. These results highlight the need for effective conservation and management strategies to mitigate the impacts of these exploitative practices and promote sustainable use of agroforestry resources in the KYB.

Table 3: Impact of Human Exploitative Practices on Agroforestry Resources in KYB **(n = 120)**

Exploitative Practice	Frequency (f)	Percentage (%)	Standard Error (SE)
Illegal logging	32	26.67	4.12
Overgrazing	27	22.50	3.91
Uncontrolled bush burning	20	16.67	3.53

Exploitative Practice	Frequency (f)	Percentage (%)	Standard Error (SE)
Land conversion (e.g., housing/farming)	18	15.0	3.31
Harvesting of non-timber forest products	13	10.83	2.87
Fuelwood extraction (deforestation)	10	8.33	2.50
Total	**120**	**100.00**	

The results from the 120 respondents indicate a high level of awareness and adoption of conservation strategies in the area, reflecting community responsiveness to climate impacts and human-induced degradation. Community awareness and training programs recorded the highest adoption rate (75%), showing that sensitization efforts have significantly contributed to behavior change toward riparian agroforestry management. Agroforestry integration in adjacent farms (68.3%) and riparian buffer-strip planting (62.5%) also showed strong acceptance, highlighting the community's recognition of tree-based systems in controlling erosion and supporting productivity. Controlled grazing (50%) and soil conservation techniques (45.8%) suggest moderate uptake, possibly due to constraints such as land tenure issues or lack of technical support. Assisted natural regeneration had the lowest response rate (40%), likely due to limited knowledge of the method or preference for more visible interventions like tree planting. These findings emphasize that while awareness is growing, targeted support especially in funding, policy enforcement, and technical guidance is necessary to increase adoption of less common but equally vital conservation methods like assisted natural regeneration.

Table 4: Conservation Strategy on Agroforestry Resources in KYB (n = 120)

SN	Conservation Strategy	Number of Respondents	Percentage (%)	Description
1	Riparian buffer-strip planting	75	62.5	Planting trees/shrubs along river banks to reduce erosion, intercept runoff
2	Assisted natural regeneration	48	40	Encouraging regrowth of native species in degraded riparian zones
3	Controlled grazing / livestock exclusion	60	50	Restricting livestock access to riverbanks to reduce bank trampling and erosion
4	Agroforestry in adjacent farms	82	68.3	Integrating trees into agricultural systems near riparian zones
5	Soil conservation techniques (terracing, mulching)	55	45.8	Practices to reduce surface runoff and increase infiltration
6	Community awareness / training programs	90	75	Education on riparian conservation, climate impacts, and sustainable practices

A recent survey conducted in the Komadugu-Yobe River Basin (KYB) assessed the impact of climatic drivers on agroforestry resources, involving 120 respondents. The results, presented in Table 4, show that drought is the most significant climatic impact driver, affecting 28.33% of respondents (n = 34, SE = 4.15), followed by irregular rainfall patterns (24.17%, n = 29, SE = 3.96), increased temperature (18.33%, n = 22, SE = 3.64), flooding (15.00%, n = 18, SE = 3.31), windstorms (8.33%, n = 10, SE = 2.50), and pest and disease outbreaks (5.83%, n = 7, SE = 2.19). These findings suggest that agroforestry resources in the KYB are vulnerable to various climatic stressors, with drought and irregular rainfall patterns being the most critical threats. The relatively low standard errors indicate that the estimates are precise, and the results can be generalized to the study population. These climatic drivers are crucial for developing effective adaptation and mitigation strategies to promote resilience in agroforestry systems and ensure the long-term sustainability of these resources.

Table 5: Impact of Climatic Drivers on Agroforestry Resources in KYB (n = 120)

Climatic Impact Driver	Frequency (f)	Percentage (%)	Standard Error (SE)
Drought	34	28.33	4.15
Irregular rainfall pattern	29	24.17	3.96
Increased temperature	22	18.33	3.64
Flooding	18	15.00	3.31
Windstorms	10	8.33	2.50
Pest and disease outbreaks	7	5.83	2.19
Total	**120**	**100.00**	**-**

The climatic data for the Komadugu-Yobe River Basin (KYB) from 2015 to 2024 reveals trends in average wind speed, temperature, and rainfall patterns. According to Table 5, the average wind speed ranged from 10.1 to 13.3 kmh^{-1}, with fluctuations observed over the years. The annual average temperature remained relatively stable, ranging from 29°C to 32°C. In contrast, the mean annual rainfall pattern showed a consistent increase, rising from 755 mm in 2015 to 808 mm in 2024. This upward trend in rainfall suggests a potential shift in the region's hydrological cycle, which could have implications for agricultural practices, water resource management, and ecosystem dynamics in the KYB. Further analysis and monitoring of these climatic variables are necessary to understand their impacts on the region's environment and livelihoods.

Table 6: Monthly Average Wind Speed, Annual Average Temperature, and Mean Annual Rainfall Pattern in KYB (2015–2024)

Month	Average Wind Speed (km/h)	Avg Temp (°C)	Mean Annual Rainfall (mm)
2015	11.5	32	755
2016	12.6	30	760
2017	12.2	31	766
2018	12.6	31	772
2019	13.3	30	778
2020	13.0	30	784
2021	12.6	29	790
2022	11.2	30	796
2023	10.4	32	802
2024	10.1	31	808

Source: NiMet, 2024

The correlation analysis reveals distinct patterns between climatic variables and resource utilization in the study area. Temperature exhibits positive correlations with various resources, including surface water (0.01), farming (0.03), Doum Palm (0.045), fuelwood harvesting (0.05), and fruits (0.06), indicating that increased temperatures may enhance these resources. Rainfall shows positive correlations with farming (0.018), fuelwood harvesting (0.012), fruits (0.02), and fodder (0.005), suggesting that increased rainfall benefits these resources. In contrast, wind speed exhibits strong negative correlations with most resources, including surface water (-0.62), Doum Palm (-0.61), fuelwood harvesting (-0.73), grazing (-0.85), fruits (-0.58), and hunting/wildlife use (-0.56), indicating that increased wind speed may adversely impact these resources. Notably, Typha grass invasion shows a strong negative correlation with wind speed (-0.94), suggesting that wind may play a role in controlling its spread. These findings highlight the complex relationships between climatic variables and resource utilization, emphasizing the need for nuanced management strategies to mitigate the impacts of climate variability.

Table 7: Correlation coefficient of climatic elements with Riparian Agroforestry Resources

Climatic /Resources	Surface Water	Farming	Doum Palm	Fuelwood Harvesting	Fishing	Grazing	Fruits	Fodder	Typha Grass Invasion	Hunting Wildlife Use
Temp	0.01	0.03	0.045	0.05	0.02	0.1	0.06	0.5	0.02	0.5
Rainfall	0.00	. 0.02	0.01	. 0.01	0.01	0.02	0.01	0.00	0.01	0.01
Wind	-0.62	-0.55	-0.61	-0.73	0.60	-0.85	-0.58	-0.62	-0.94	-0.56

% Resource decreases when wind speed increases. This moderate negative correlation means higher wind speeds may be linked to lower percentage of resources (or the other way around), suggesting wind speed might influence resource availability. Temperature and rainfall do not seem to have a strong relationship with % resource here.

DISCUSSION

The Komadugu-Yobe River Basin (KYB) in Nigeria is a vital ecosystem supporting riparian agroforestry, which plays a significant role in local livelihoods and biodiversity conservation. Climatic impact drivers such as changing rainfall patterns, rising temperatures, and increased evaporation rates pose threats to this agroforestry system. Human activities like deforestation, overgrazing, and unsustainable agricultural practices further exacerbate degradation (Salami *et al*., 2020). These factors interplay to affect water availability, soil health, and tree species composition. For instance, altered hydrology can disrupt natural regeneration of key tree species like *Faidherbia albida* and *Acacia nilotica,* impacting ecosystem services. Adaptation strategies integrating local knowledge and sustainable land-use practices are crucial for resilience in this fragile basin. Effective management can enhance biodiversity and support communities.

The KYB is experiencing pronounced environmental degradation, underscored by the pervasive overuse and decline of its natural resources. Analysis of resource use trends reveals alarming patterns: surface water resources are being overused (35%), indicating potential strain on aquatic ecosystems and water availability for agroforestry and local communities. Farming activities show moderate to declining trends (57%), likely reflecting challenges such as soil degradation, erratic rainfall, and possibly reduced fertility, which could compromise food security and livelihoods. Non-timber forest products like Doum palm collection and fishing exhibit moderate decline (50%), signaling dwindling resource bases possibly due to overharvesting and habitat alteration. Fuelwood harvesting (37.5%), grazing (43%), and fodder collection (25%) are being overexploited, pointing to unsustainable pressures on vegetation cover, contributing to deforestation, soil erosion, and reduced biodiversity. Fruit harvesting is also overused (34%), affecting both ecosystem services and income streams for communities reliant on these products. The proliferation of invasive Typha grass (38% reporting overgrowth) poses significant ecological and economic threats, likely altering habitats, reducing water flow, and impacting biodiversity. Hunting and wildlife use are notably overexploited (45%), raising concerns about species decline and ecosystem imbalance. These trends collectively depict a basin facing multifaceted environmental stressors driven by human activities, echoing findings by scholars emphasizing anthropogenic pressures on tropical river basins (Adeniyi *et al.,* 2023; Salami *et al*., 2020; Ayanlade *et al.,* 2020; Ogbanje e*t al.,* 2021). Effective conservation and management interventions are imperative to mitigate these impacts. Strategies might include promoting sustainable agroforestry practices, community-led natural resource management, restoration of degraded habitats, and control of invasive species like Typha grass. Integration of local knowledge with scientific approaches could enhance resilience (Ebele and Emodi, 2016). Policymakers should prioritize stakeholder engagement and incentives for sustainable practices to ensure long-term viability of KYB's ecosystems.

The KYB in Nigeria is facing significant threats to its agroforestry resources due to prevalent human exploitative practices. According to survey results from 120 respondents (Table 3), illegal logging emerges as the most frequently reported detrimental practice, affecting 26.67% of respondents, underscoring the vulnerability of tree species and forest cover in the basin. Overgrazing follows closely, reported by 22.50% of respondents, likely contributing to vegetation degradation, soil compaction, and reduced regenerative capacity of woody species. Uncontrolled bush burning (16.67%) and land conversion (15.00%) further exacerbate ecosystem disruption, potentially altering species composition and reducing biodiversity. Harvesting of non-timber forest products (10.83%) and fuelwood extraction (8.33%) also contribute to pressure on agroforestry resources, impacting both ecological balance and livelihood dependencies. The relatively low standard errors (SE) associated with these practices suggest consistency in respondent perceptions, lending robustness to these findings. These human-induced pressures mirror broader patterns observed in tropical ecosystems where unsustainable practices jeopardize ecosystem services (Salami *et al*., 2020; Agbaje *et al.,* 2022; Olagunju *et al.,* 2023). Addressing these challenges necessitates multifaceted approaches including community engagement, enforcement of regulatory frameworks, and promotion of alternative livelihoods. Agroforestry interventions integrating indigenous species like *Parkia biglobosa* and *Vitellaria paradoxa* could enhance sustainability (Onyekwelu *et al*., 2019). Capacity building and awareness campaigns are critical to curtail practices like illegal logging and overgrazing. Effective conservation strategies must reconcile local livelihood needs with ecological preservation, potentially through Payment for Ecosystem Services (PES) schemes or community-led forest management (Mustapha *et al.,* 2021). Climate-smart agroforestry practices may bolster resilience in the face of changing environmental conditions (Adeyemi *et al.,* 2020).

The findings reflect similar trends observed in riparian conservation literature across sub-Saharan Africa. High adoption of agroforestry and community awareness aligns with studies by Tranchina *et al.,* (2024), which emphasize the role of education in driving sustainable land-use practices. Moderate adoption of grazing control and soil conservation echoes challenges identified by Neina *et al*. (2024), particularly around resource access and policy enforcement. The low uptake of assisted natural regeneration aligns with findings by Hill *et al*., (2020), which highlight knowledge gaps and community preferences for more tangible interventions. Targeted training and institutional support remain essential to scale up sustainable conservation strategies.

Agroforestry systems in KYB are significantly vulnerable to climatic stressors, as revealed by the survey of 120 respondents. Drought emerges as the predominant climatic impact driver, affecting 28.33% of respondents, highlighting the pronounced water stress likely impacting tree growth, species composition, and overall ecosystem productivity. Irregular rainfall patterns (24.17%) further compound these challenges, disrupting natural regeneration cycles and agricultural calendars critical for local livelihoods. Increased temperature (18.33%) exacerbates evapotranspiration, potentially intensifying drought effects and altering species distributions. Flooding (15.00%) poses additional risks, likely causing soil erosion, nutrient leaching, and habitat disturbance. Windstorms (8.33%) and pest and disease outbreaks (5.83%) represent further disturbances threatening agroforestry resilience. The low standard errors associated with these estimates underscore the robustness of these findings, suggesting generalizability within the study population. These climatic drivers necessitate context-specific adaptation strategies like climate-smart agroforestry incorporating drought-tolerant species (e.g., *Faidherbia albida, Acacia senegal*) and water-harvesting techniques (Adeyemi *et al.,* 2020; Muthuri *et al.,* 2022). Strengthening local capacities for climate forecasting and promoting diversification can bolster resilience (Ogunniyi *et al.,* 2021). The Komadugu-Yobe River Basin climatic data (2015-2024) indicates fluctuating average wind speeds (10.1-13.3 kmh^{-1}) and relatively stable temperatures (29°C - 32°C). Notably, mean annual rainfall shows an increasing trend, rising from 755 mm (2015) to 808 mm (2024), suggesting shifts in the hydrological cycle. This uptrend could impact agricultural planning, water management, and ecosystem services in KYB. Increased rainfall might enhance water availability but also pose flood risks, affecting agroforestry and livelihoods. Understanding these dynamics is vital for climate-resilient strategies (Abaje *et al.,* 2022; Oguntunde *et al.,* 2023). Monitoring is crucial for adapting practices like water harvesting and drought-tolerant cropping.

CONCLUSION

The Komadugu-Yobe River Basin faces significant environmental degradation due to human activities and climatic stressors, threatening agroforestry systems and local livelihoods. Unsustainable practices like illegal logging, overgrazing, and land conversion aggravate ecosystem disruption, while drought, irregular rainfall, and increased temperatures further compound challenges.

RECOMMENDATIONS

Effective conservation strategies must integrate local knowledge with scientific approaches, promoting climate-smart agroforestry, community-led natural resource management, and restoration of degraded habitats. Policymakers should prioritize stakeholder engagement, incentives for sustainable practices, and capacity building to ensure long-term viability of the basin's ecosystems and support resilient communities.

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