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Research Article

The Role of Wetlands in Climate Regulation in Daura Local Government Area, Katsina State, Nigeria

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ABSTRACT
This study observed the ecological condition, land use practices, and environmental pressures affecting selected wetland ecosystems in Kwarin Sarki, Unguwar Gabasawa, and Kwarin Lugga. A purposive sampling technique was employed to select 30 respondents (10 per site), comprising farmers, herders, traditional leaders, government officials, and local community members with knowledge of wetland utilization. Primary data were obtained through structured interviews, field observations, GPS, and soil sampling for organic matter (OM%) analysis. Findings reveal strong livelihood dependence on wetland resources, with farmers (46.7%) and herders (26.7%) forming the majority of respondents. Educational attainment was generally low, suggesting reliance on traditional ecological knowledge in resource management. Biophysical assessment showed clear spatial variation in vegetation condition and soil organic matter. Kwarin Lugga recorded the highest OM% (2.276) and relatively intact riparian vegetation, indicating better ecological stability. Kwarin Sarki exhibited moderate ecosystem resilience (OM% = 2.034), while Unguwar Gabasawa recorded the lowest OM% (1.369), reflecting significant degradation associated with flooding, deforestation, and settlement expansion. Natural stressors such as drought (83%), irregular rainfall (67%), and soil erosion (60%) further compound anthropogenic pressures across the sites. All the study site are good environment for animal grazing and fishing if the ecological strategic planning is going to be fully maintain.

Keywords: Anthropogenic Pressure; Climate Change; Ecological control; Soil Organic Matter; Sustainability; Wetland

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INTRODUCTION

Wetlands are among the most productive ecosystems globally, providing essential services such as climate mitigating, biodiversity conservation, and water resource management (Mitsch and Gosselink, 2015). In Nigeria, wetlands are critical for environmental sustainability, particularly in arid and semi-arid regions like Daura Local Government, where climate change impacts are pronounced (Bako and Musa, 2017).

They mitigate flooding by absorbing excess rainwater (Usman and Sadiq, 2019). Carbon Sequestration Wetlands store large amounts of carbon, reducing atmospheric CO_2 levels (Ibrahim and Yusuf, 2022). Biodiversity Support they provide habitats for diverse plant and animal species (Ramsar, 2018).

Wetlands regulate climate by sequestering carbon dioxide, storing water, and mitigating extreme weather events (Ramsar Convention Secretariat, 2018). However, these ecosystems face degradation due to agricultural expansion, deforestation, and poor land management practices (Ahmed et al., 2021).

Wetland has the capacity to retain water during dry season and keeping the water table high and moderately stable (Orimoloye et al., 2018). It has a potential to regulate a microclimate (Simsek and Odul, 2018). Wetlands provide many ecosystem services that are critical to reduce the vulnerability of communities to climate change in general and to extreme weather events in particular. Wetland has a fundamental ecological function that plays an irreplaceable role in serving biological survival and human development (Chen et al., 2019). The total carbon stock in wetlands was more than double as compared to converted cultivated as well as grazing lands (Kassa et al., 2015).

Wetlands are among the world's most important assets, providing the basis for human survival and development. Wetland has the potential to stabilize microclimates, retain and purify agrochemicals, toxicants and sediments minimize the occurrence of drought and floods and recharge ground water. However, wet lands are under threat as the result of over utilization and lack of management strategies that can reduce the negative impact against wetland deterioration.

The over utilization of wetlands directly affects biodiversity conservation. For instance, study conducted in Ethiopia by Gemeda et al. (2016) confirmed that the local communities are converting wetlands for agricultural purpose which threatened the life of Black Crowned crane. Thus, proper management of wetlands is required from various sectors and organization.

Expanding agriculture leads to habitat loss and fragmentation, drainage of wetlands, and impacts on freshwater and marine ecosystems through sedimentation and pollution and is one of the greatest threats to biodiversity worldwide (World Bank, 2008).

A wetland is a distinct ecosystem that is inundated by water, either permanently or seasonally, where oxygen-free processes prevail (Keddy, 2010). The primary factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation of aquatic plants, adapted to the unique hydric soil (Butler, 2010). Wetlands play a number of roles, sometimes referred to as functions. Among these are water purification, water storage, processing of carbon and other nutrients, stabilization of shorelines, and support of plants and animals.

Despite the ecological significance of wetlands in climate mitigating, limited research has focused on their role in semi-arid areas like Daura. Increasing wetland encroachment, coupled with erratic rainfall patterns, threatens their capacity to regulate the local climate (Usman and Sadiq, 2019). This study addresses the knowledge gap by evaluating the contributions of wetlands to climate stabilization in Daura Local Government and proposing sustainable management practices.

Understanding the role of wetlands in climate mitigating is essential for environmental planning and policy development in arid regions. This study provide valuable insights for environmental policymakers, conservationists, and local communities to enhance sustainable wetland management in Daura Local Government. It also contributes to the global dialogue on climate change mitigation through ecosystem-based adaptation strategies (Ibrahim and Yusuf, 2022).

This Study is design to highlight the Role of wetlands in mitigating climate change in Daura Local Government, Katsina State and to identify the three key wetlands Areas so also to evaluate the climate mitigation services provided by these wetlands together with the examination of the anthropogenic and natural factors affecting wetland sustainability. In each study site and lastly propose conservation strategies for improving wetland functions.

The study adopted a mixed-methods research design, combining both qualitative and quantitative approaches. This design enabled the researcher to collect data through field observation, questionnaire administration, interviews, and the use of Global Positioning System (GPS) tools. The quantitative aspect involved analyzing numerical data obtained from questionnaire responses and field measurements, while the qualitative aspect involved interpreting observational data on vegetation cover and soil organic matter. (Creswell and Plano Clark, 2018).

MATERIALS AND METHODS

Study Area

Geographical Location of Daura LGA

Daura Local Government Area is located in the northern part of Nigeria within Katsina State, close to the border with the Republic of Niger. It lies roughly between latitude 13°06′ N and longitude 08°21′ E and is about 80 km east of Katsina town the state capital forming part of the semi-arid Sudano Sahelian zone. The underlying geology is mainly Cretaceous sedimentary rocks of the Sokoto Basin, with some areas overlain by crystalline Basement Complex formations. This geology influences soil types, drainage, and groundwater availability in the region.

The climate is tropical continental with distinct wet and dry seasons. Most rainfall is concentrated between May and September, and temperatures vary seasonally often exceeding 30 °C during the dry season and dropping to around 18–20 °C in the cooler months.

Agricultural Activities

Dominance of Agriculture

Agriculture is the primary economic activity in Daura LGA. Most households are engaged in crop production and livestock rearing, often relying on both rain fed and limited irrigation sources. Key crops cultivated include:

Cereals: Sorghum and millet, which are well adapted to semi-arid conditions.

Legumes: Groundnuts (peanuts) and beans.

Vegetables and cash crops: Onions and cotton.

These crops provide food security and income for rural families and are also traded in local markets.

Livestock and Pastoralism

Livestock rearing especially of cattle, goats, sheep, donkeys, and sometimes horses is integral to the local economy, supplementing farming income and contributing to cultural identity among Hausa and Fulani communities. During dry spells, pastoral movements often concentrate around wetter areas and river channels where water and grazing are available.

Wet Season Agriculture and Irrigation

Although rainfall is seasonal and sometimes unreliable, farmers try to flag wet-season crop production during rains and, where possible, irrigation farming near water sources and dams. In some parts of northern Nigeria, flood-recession agriculture (cultivation on moist soils after floods) allows farmers to grow crops beyond the usual rainy season. (This pattern is typical of wetland floodplains in the broader Sahel Sudan belt, even if specific data for Daura's wetlands are limited in literature.) makhillpublications.co

Fishing and Wetland-based Activities

Importance of Wetlands

Daura LGA lies in a semi-arid zone, scattered wetlands and reservoirs (such as the Unguwar Gabasawa, Kwarin Sarki and Kwarin Lugga) playing important ecological and economic role. These wetlands are water-retentive features that form during the rainy season and can remain as permanent or semi-permanent (eg, Kwarin Sarki) water bodies. They serve local communities by providing water for domestic use, livestock, fishing, and irrigation.

Fishing Activities

Fishing in wetlands and reservoir areas is a subsistence and livelihood activity in many northern Nigeria communities. These inland waters support a diversity of fish species (e.g., catfish, tilapia, and others adapted to inland freshwater) and provide critical protein sources for rural households. Wetland fishing is often carried out alongside farming, with many people engaging in both activities seasonally in Daura communities.

Irrigation and Wetland Management

Reservoirs and wetland systems especially within Daura LGA (e.g., Unguwar Gabasawa, Kwarin Sarki and Kwarin Lugga) are utilized for irrigation farming, especially in the dry season. This allows farmers to grow vegetables and other crops outside the rainy season, improving food supply and income opportunities. Additionally, wetlands may support benthic biodiversity, which is essential for aquatic food webs and fish production.

Vegetation and Environmental Setting

The natural vegetation is primarily savanna open grasslands with scattered shrubs and trees reflecting the semi-arid climate. Around wetlands, however, hydrophilic plants and grasses occur, which improve soil moisture and support animal rearing as well as biodiversity.

Population of the Study

The target population of this study comprised residents living within and around the identified wetland areas in Daura LGA. These include farmers, herders, fishermen, and community members whose livelihoods are directly or indirectly linked to wetland resources. The total population was not determined due to limited demographic data, but a representative sample was drawn from each study site.

Sample size and Sampling Techniques

A total of 30 respondents participated in the study, with 10 respondents selected from each of the three sites: Kwarin Sarki, Unguwar Gabasawa, and Kwarin Lugga. Purposive sampling was employed to select individuals who possess relevant knowledge and experience about wetland use and management in the area. This approach ensured that the data collected were rich and context specific (Etikan et al., 2016).

Research Equipment

The primary instruments used for data collection were structured questionnaires, interviews, and field observation guides. The questionnaire was divided into sections addressing demographic information, perceptions of wetland importance, human activities, and environmental conditions. Field observations were conducted to assess vegetation cover, soil conditions, and human-induced changes. In addition, GPS coordinates were recorded at each site to determine geographical positioning, and soil samples were analyzed to determine organic matter content.

Method of Data Collection

Data collection was conducted in three phases. In the first phase, questionnaires were administered to respondents at each site. The second phase involved conducting semi-structured interviews with selected community members to gain deeper insights into the local understanding of wetlands and their climatic role. The third phase involved direct field observation, where vegetation cover, deforestation patterns, and organic matter content were examined and recorded using GPS technology.

The data collected from the field and questionnaires were analyzed using descriptive statistics, including frequencies and percentages. The responses were summarized in tables for easy interpretation. The formula used for calculating the percentage of responses is given as:

$P = (F / N) \times 100$

Where:

P = Percentage of responses
F = Frequency of a given response
N = Total number of respondents

Qualitative data obtained from interviews and field observations were analyzed thematically, while spatial data from GPS and soil organic matter tests were interpreted to complement the quantitative findings. (Kothari, 2004).

RESULTS

Sample Characteristics and Respondent Allocation

A total of 30 respondents were purposively selected across the three study sites: Kwarin Sarki (A), Unguwar Gabasawa (B), and Kwarin Lugga (C), with 10 respondents drawn from each location. The sampling approach targeted individuals who are living around the area and those who has knowledge of wetland use and management, which include farmers, herders, traditional leaders, government officials, and local community members.

The occupational structure reveals that farmers (46.7%) and herders (26.7%) constitute over 73% of respondents, indicating a strong livelihood dependence on wetland ecosystems. The dominance of primary resource users suggests that wetland management decisions are largely influenced by subsistence and income generating needs.

Educational attainment is generally low to moderate, with 40% having no formal education and only 6.7% attaining tertiary education. This distribution implies that traditional ecological knowledge likely plays a significant role in shaping wetland use practices. The data further suggest that awareness based environmental interventions may need to be tailored to local literacy levels to achieve effective community participation across the study area.

The below section presents the GPS coordinates, vegetation condition, and soil organic matter (OM %) obtained across all field from field work.

Table 1: Shows Demographic Information of the Respondents across all sites.

Variable	Category	Frequency (n)	Percentage (%)
Occupation	Farmers	14	46.7
	Herders	8	26.7
	Traditional leaders	3	10.0
	Government officials	3	10.0
	Local community members	2	6.6
Education	No formal education	12	40.0
	Primary	10	33.3
	Secondary	6	20.0
	Tertiary	2	6.7

Source: Field survey, 2025

Table 2: GPS, Vegetation and Organic Matter of the study area

Site	GPS	Vegetation Description (Field Observation)	Soil Organic Matter (OM%)
Kwarin Sarki (A)	N 13°2'38.97708", E 8°19'43.63248"	Vegetation covers fairly dense despite some deforestation and settlement expansion.	2.034
Unguwar Gabasawa (B)	N 13°1'54.68988", E 8°29'46.0212"	Vegetation scattered; effects of flooding, deforestation, and settlement; low groundwater availability.	1.369
Kwarin Lugga (C)	N 13°0'2.67012", E 8°21'48.68388"	Vegetation covers extensively low deforestation; healthier riparian vegetation.	2.276

Source: GPS readings and field soil tests, 2025

Soil organic matter (OM%) serves as a good indicator of soil fertility, carbon storage potential, and ecosystem stability. Clear spatial variation exists among the three sites:

Kwarin Lugga (C) recorded the highest OM% (2.276) and exhibited healthier riparian vegetation, suggesting relatively stable ecological conditions and stronger carbon retention capacity.

Kwarin Sarki (A) showed intermediate OM% (2.034), indicating moderate resilience but evidence of growing anthropogenic pressure.

Unguwar Gabasawa (B) recorded the lowest OM% (1.369), consistent with visibly degraded vegetation, recurrent flooding impacts, and groundwater stress.

The pattern demonstrates a positive relationship between vegetation integrity and soil organic matter levels. Sites with reduced vegetation cover correspondingly show lower soil carbon status, indicating ecosystem degradation.

Land Use Practice and Anthropogenic Pressures

Field interviews and questionnaires recorded common land use practices and human impacts at each site. The table below summarizes major activities and local consequences.

Site Specific Observations

Kwarin Sarki (A)

Mixed irrigated and rain-fed cropping dominates land use. Grazing along wetland margins contributes to patchy vegetation loss. Although vegetation remains moderate, settlement expansion and soil erosion are emerging pressures. The intermediate OM% suggests that the site still retains ecological resilience but may decline if pressures intensify.

Unguwar Gabasawa (B)

This site exhibits the highest level of ecological stress. Respondents consistently reported flooding events that destroy crops and remove topsoil. Vegetation is sparse, groundwater levels are reportedly declining, and deforestation for construction is common. The low OM% (1.369) reflects reduced soil fertility and weakened carbon storage capacity. The combination of environmental stress and socio-economic vulnerability (e.g., farm produce theft) compounds the degradation pattern.

Kwarin Lugga demonstrates comparatively stable ecosystem characteristics. Vegetation cover is relatively intact, and soil organic matter is highest among the sites. While farming intensification is present, land use practices appear relatively controlled. This site currently maintains better hydrological function and ecological balance compared to the others.

Natural Challenges and Seasonal Constraints

Respondents and field observations identified natural stressors affecting wetland function

Drought and heat stress reported by many respondents as causing crop failure and reduced water availability during dry months.

Irregular rainfall and flooding Flooding was specifically highlighted at Gabasawa as causing loss of vegetation and land at other sites flooding is episodic.

Soil erosion and desert encroachment observed in Kwarin Sarki and Gabasawa where vegetation cover is reduced.

Table 3: Land Use Practice and Anthropogenic Pressure

Site	Dominant Land Use	Primary Anthropogenic Pressures
Kwarin Sarki (A)	Both irrigated and seasonal farming; grazing	Overgrazing in some patches, soil erosion, settlement expansion, moderate deforestation.
Unguwar Gabasawa (B)	Farming and grazing on wetland margins	Recurrent flooding leading to land loss, deforestation for construction, settlement expansion, theft of farm produce.
Kwarin Lugga (C)	Farming with livestock watering; some irrigation	Limited deforestation; relatively sustainable use but pressure exists from farming intensification.

Source: Field survey and interviews, 2025

Table 4: Frequency of natural Challenges mentioned

Natural challenge	Frequency (mentions across interviews)	% (approx.)
Drought / heat stress	25	83
Irregular rainfall	20	67
Soil erosion	18	60
Flooding (site-specific heavy impact at Gabasawa)	10	33
Desert encroachment	15	50

Source: Field interviews, 2025.

DISCUSSION

Drought and heat stress were the most frequently reported challenges (83%), highlighting the vulnerability of wetland-dependent livelihoods to climate variability. Irregular rainfall (67%) and soil erosion (60%) further reduce agricultural reliability and ecosystem stability.

Flooding, although mentioned by 33% overall, had a concentrated and severe impact at Unguwar Gabasawa. The findings suggest that natural stressors do not operate independently; rather, they interact with anthropogenic activities to amplify degradation. Where vegetation cover is already reduced, flooding and drought effects become more destructive, accelerating soil nutrient loss and ecosystem instability.

Revised and Expanded Discussion

This research concern with the climate-mitigating functions of wetlands in Daura Local Government Area of Katsina State, Nigeria. Using a mixed methods approach that combined questionnaire surveys, semi-structured interviews, GPS mapping, direct field observation of vegetation cover, and laboratory analysis of soil organic matter (OM%), the research generated both quantitative and qualitative evidence on wetland condition and ecosystem functioning. Three wetland locations Kwarin Sarki, Unguwar Gabasawa, and Kwarin Lugga were examined. The findings reveal significant spatial differences in ecological integrity, hydrological stability, and carbon storage potential across the study sites.

Spatial Differences in Soil Organic Matter and Carbon Sequestration

The laboratory results indicate clear variation in soil organic matter among the three wetlands. Kwarin Lugga recorded the highest OM% (2.276%), followed by Kwarin Sarki (2.034%), while Unguwar Gabasawa showed the lowest value (1.369%). Soil organic matter is a widely accepted indicator of ecosystem health because it enhances soil structure, nutrient availability, water retention, and carbon storage capacity. Higher OM% generally reflects improved carbon sequestration potential and reduced vulnerability to erosion and drought.

These findings align with established ecological literature which emphasizes that wetlands act as long term carbon sinks due to slow organic matter decomposition under saturated conditions (Mitsch and Gosselink, 2015). According to the Intergovernmental Panel on Climate Change (IPCC, 2022), conserving and restoring wetlands significantly contributes to climate change mitigation by preventing the release of stored soil carbon. Similarly, the Food and Agriculture Organization (FAO, 2017) highlights that soil organic carbon is central to ecosystem-based climate strategies.

The relatively low OM% observed at Unguwar Gabasawa suggests intensive land disturbance, which accelerates oxidation of organic matter and reduces soil carbon reserves. Degraded wetlands may shift from carbon sinks to carbon sources, thereby contributing to greenhouse gas emissions (Davidson, 2014). This reinforces the urgency of targeted restoration strategies in highly disturbed areas.

Field observations showed that Kwarin Lugga maintains relatively dense riparian vegetation compared to Unguwar Gabasawa, where deforestation and settlement expansion are widespread. Vegetation plays a critical role in climate regulation by facilitating evapotranspiration, shading the soil surface, reducing temperature extremes, and enhancing carbon uptake.

Studies have shown that vegetation loss in wetlands weakens flood regulation capacity and groundwater recharge (Adekola and Mitchell, 2011). The recurrent flooding reported at Unguwar Gabasawa may reflect hydrological imbalance rather than ecological strength. Wetlands with intact vegetation slow surface runoff and promote infiltration, thereby reducing flood intensity (Junk et al., 2013). In contrast, removal of plant cover and soil compaction from grazing increase runoff and sedimentation, degrading wetland resilience.

The examined relationship between vegetation density and soil organic matter in this study supports the assertion by Bridgham et al. (2006) that plant biomass input is a primary driver of soil carbon accumulation in wetland systems. Thus, the healthier condition of Kwarin Lugga can be partly attributed to sustained vegetative cover and lower anthropogenic disturbance.

Anthropogenic Pressure and Environmental Change

Human activities emerged as the dominant factor influencing wetland condition in Daura LGA. Agricultural expansion, overgrazing, wood harvesting, and settlement encroachment were consistently identified across interviews and field observations. These pressures are consistent with regional trends reported in northern Nigeria and other semi-arid parts of West Africa (Akpabio et al., 2018).

Population growth and livelihood dependence intensify resource exploitation, particularly during dry seasons when wetlands serve as critical sources of water and fertile soil. According to Davidson (2014), global wetland loss is primarily driven by land conversion for agriculture and infrastructure development. The findings from this study confirm that similar dynamics operate at the local scale in Daura.

Climatic stressors including irregular rainfall patterns, prolonged dry spells, and episodic flooding further compound anthropogenic impacts. The Intergovernmental Panel on Climate Change (IPCC, 2022) notes that semi-arid regions are particularly vulnerable to climate variability, making ecosystem-based adaptation essential. In this context, degraded wetlands become less capable of buffering climatic extremes, thereby increasing community vulnerability.

The study also documented local coping strategies such as small-scale tree planting, application of organic manure, informal grazing control, and community based by laws. These efforts indicate environmental awareness among residents. However, their impact remains limited due to weak enforcement, inadequate funding, and absence of coordinated institutional support.

Nyong, Adesina, and Osman Elasha (2007) emphasize that indigenous adaptation strategies in the African Sahel are valuable but require policy backing to achieve sustainability. Strengthening local governance structures and integrating wetland conservation into formal land-use planning could enhance effectiveness. Ecosystem-based adaptation approaches, as promoted by the Food and Agriculture Organization (FAO, 2017), provide a practical framework for aligning community initiatives with broader climate objectives.

The findings confirm that wetlands in Daura LGA contribute to climate mitigation primarily through carbon sequestration and hydrological regulation. However, the degree of contribution varies significantly depending on ecological condition. Kwarin Lugga represents a relatively stable system with strong mitigation potential, while Unguwar Gabasawa requires urgent restoration intervention.

Restoration strategies may include reforestation of riparian zones, controlled grazing systems, enforcement of land use regulations, and continuous monitoring of soil organic carbon. According to Bridgham et al. (2006), even moderately degraded wetlands can regain substantial carbon storage capacity if hydrology and vegetation are restored. Therefore, early intervention is more cost-effective than delayed rehabilitation.

From a policy perspective, site specific management plans are necessary. A uniform management strategy may not adequately address the varying degrees of degradation observed across the three wetlands. Integrating scientific monitoring with community participation will enhance long-term sustainability and climate resilience.

CONCLUSION

The study concludes that wetlands in Daura Local Government Area of Katsina State perform significant climate mitigating functions, including carbon sequestration, microclimate regulation, groundwater recharge, and flood attenuation. However, their capacity to sustain these ecosystem services is increasingly threatened by human activities such as deforestation, overgrazing, agricultural encroachment, and settlement expansion, alongside the growing influence of climatic variability.

Unguwar Gabasawa emerges as the most severely degraded site. The marked reduction in vegetation cover, low soil organic matter (OM%), and recurrent flooding collectively indicate a substantial decline in ecological functionality. This degradation heightens community exposure to soil erosion, declining agricultural productivity, and loss of ecosystem services. Such trends are consistent with documented cases of wetland degradation across semi-arid regions of West Africa, where anthropogenic pressure and climate stress interact to weaken ecosystem resilience.

Kwarin Sarki demonstrates moderate resilience but remains vulnerable due to expanding human activities, particularly grazing and settlement growth. Without timely and targeted management interventions, this wetland may experience further ecological decline, potentially reducing its carbon storage and hydrological regulation capacity.

Kwarin Lugga currently retains relatively stronger ecological characteristics, reflected in its higher soil organic matter content and denser vegetation cover. Consequently, it exhibits greater climate regulatory potential compared to the other sites. Nevertheless, even relatively intact wetlands require proactive conservation strategies to prevent future degradation and ensure long-term sustainability.

Overall, the research emphasizes that safeguarding wetland vegetation and enhancing soil organic matter are fundamental to sustaining climate mitigation services in Daura LGA. Strengthening community-based management, enforcing land use regulations, promoting restoration initiatives such as riparian reforestation, and establishing continuous ecological monitoring mechanisms will be essential steps toward improving wetland resilience. Integrating wetland conservation into local development planning can further support climate adaptation efforts while preserving critical ecosystem services for present and future generations benefit.

Informed by empirical findings and the literature on wetland conservation and climate adaptation, the following recommendations are proposed:

Institutionalize Community Based Wetland Management: Establish and empower local wetland management committees that include traditional leaders, farmers, herders, women's groups, and representatives of the local government. Community stewardship has been shown to improve compliance with conservation measures and enhance restoration outcomes.

Targeted Restoration of Degraded Sites: Prioritise Unguwar Gabasawa for immediate restoration actions reforestation of wetland margins, re-establishment of native grasses and riparian shrubs, and soil conservation measures to rebuild OM and reduce erosion. Restoration should be matched with livelihood-support options to gain local buy-in

Implement Flood and Erosion Control Infrastructure: Combine nature-based solutions (buffer strips, vegetative barriers) with appropriate structural measures (drainage improvements, small berms or check dams) to reduce flood damage and sediment mobilization in Gabasawa and other susceptible locations.

Promote Sustainable Land-Use Practices: Provide training and extension support for agroecological practices (controlled grazing, crop rotation, mulching, organic manure application) that protect soil structure and OM while sustaining local livelihoods.

REFERENCES

Adekola O., and Mitchell, G. (2011). The Niger Delta wetlands: threats to ecosystem services, their importance to dependent communities and possible management measures. *International Journal of Biodiversity Science, Ecosystem Services and Management*, **7(1)**, 50–68.

Adekola, O., Morardet, S., De Groot, R., and Grelot, F. (2017). Evaluating environmental management strategies: participatory wetland assessment in Nigeria. *Environmental Management*, **60(1)**, 102–117.

Ahmed, M., Bello, A., and Yusuf, I. (2021). Wetland degradation and its environmental impacts in Northern Nigeria. *Journal of Environmental Studies*, **15(2)**, 45-62.

Akpabio, E. M., Okaba, B. O., and Udo, E. A. (2018). Human–environment interactions and the sustainability of wetlands in northern Nigeria. *Journal of Environmental Management,* **210(2)**, 271–283.

Bako, S. and Musa, T. (2017). Climate change and water resource management in Nigeria: The role of wetlands. *Nigerian Journal of Environmental Sustainability*, **10(1)**, 34-48.

Bridgham, S. D., Megonigal, J. P., Keller, J. K., Bliss, N. B., and Trettin, C. (2006). The carbon balance of North American wetlands. *Wetlands*, **26(4)**, 889–916.

Butler, S., ed. (2010). Macquarie Concise Dictionary (5th ed.). Sydney, Australia: *Macquarie Dictionary Publishers.* ISBN 978-1-876429-85-0.
Chen, Y., Liu, J., Wang, Q., and Li, X. (2019). Wetland ecosystem services and their role in ecological sustainability. *Ecological Indicators*, **98,** 123–131.
Creswell, J. W., and Plano Clark, V. L. (2018). Designing and Conducting Mixed Methods Research (3rd ed.). *Sage Publications*.
Davidson, N. C. (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. *Marine and Freshwater Research*, **65(10)**, 934–941.
Etikan, I., Musa, S. A., and Alkassim, R. S. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, **5(1)**, 1–4.
FAO. (2017). Soil organic carbon: The hidden potential. *Food and Agriculture Organization of the United Nations, Rome.*
Gemeda, DO; Minstro, AA; Feyssa, DH; Sima, AD; Gutema, TM. (2016). Community knowledge, attitude and practice towards black crowned crane (Balearica pavonina L.) conservation in Chora Boter district of Jimma Zone, Ethiopia. *Journal of Ecology and Natural Environment.* **8 (4)**:40-48.
Ibrahim , L., and Yusuf, R. (2022). Carbon sequestration potential of wetlands in Northern Nigeria. *Nigerian Journal of Environmental Sciences*, **16(1)**, 89–97.
IPCC. (2021). Climate Change 2021: The Physical Science Basis. *Cambridge University Press.*
IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. *Cambridge University Press.*
Junk, W. J., An, S., Finlayson, C. M., Gopal, B., Květ, J., Mitchell, S. A., Mitsch, W. J., and Robarts, R. D. (2013). Current state of knowledge regarding the world's wetlands and their future under global climate change. *Aquatic Sciences*, **75**, 151–167.
Kassa, H., Dondeyne, S., Poesen, J., Frankl, A., and Nyssen, J. (2015). Impact of land use changes on carbon stocks in wetlands of Ethiopia. *Agriculture, Ecosystems and Environment,* 213, 72–81.
Keddy, P.A. (2010). Wetland ecology: principles and conservation (2nd ed.). New York: *Cambridge University Press*. ISBN 978-0521519403.
Kothari, C. R. (2004). Research Methodology: Methods and Techniques (2nd ed.). *New Age International Publishers.*
Mitsch, W. J., and Gosselink, J. G. (2015). Wetlands (5th ed.). *John Wiley and Sons.*
Nwankwoala, H. O. (2012). Case studies on wetland degradation in Nigeria: causes, consequences and solutions. World Environment, 2(1), 30–36.
Nyong, A., Adesina, F., and Osman-Elasha, B. (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in Africa. *Mitigation and Adaptation Strategies for Global Change,* 12(5), 787–797.
Odada, E. O., Oyebande, L., and Oguntola, J. A. (2006). Lake Chad: Experience and lessons learned. *Lake and reservoir Research and Management*, 11(3) 191-206
Orimoloye, IR; Kalumba, AM; Mazinyo, SP; Nel, W (2018). Geospatial analysis of wetland dynamics: Wetland depletion and biodiversity conservation of Isimangaliso *Wetland, South Africa. J. King Saud Univ. Sci*... https:// doi.org/ 10.1016/ j.jksus. 2018.03. 004 (in press).
Ramsar Convention Secretariat. (2018). The Ramsar Convention on Wetlands: *A Global Treaty for Wetland Conservation and Wise Use. Ramsar.*
Simsek, CK; Odul, H (2018). Investigation of the effects of wetlands on micro-climate. *Appl. Geog.* 97:48-60.
Usman, A. and Sadiq, H. (2019). Assessing wetland functions in climate adaptation strategies in Nigeria. African Journal of Environmental Science, 21(1), 89-101.
World Bank. (2008). Biodiversity, climate change, and adaptation: Nature-based solutions from the World Bank portfolio. World Bank.