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ACRONYMS AND ABBREVIATIONS

Symbols	Description
°C	Degree Celsius
°F	- Fahrenheit
Abbreviation/ Acronym	Description
ACReSAL	Agro Climatic Resilience in Semi- Arid Landscapes
AfDB	African Development Bank
ADP	Agriculture Development Program
AMSL	Above Mean Sea Level
ATA	Agricultural Transformation Agenda
AWF	African Water Facility
BCM	Billion Cubic Metre
CBDA	Chad Basin Development Authority
CCAFS	Climate Change, Agriculture and Food Security
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station.
CJTF	Civilian Joint Task Force
CMCs	Catchment Management Committees.
CN	Curve Number
DEM	Digital Elevation Model
EA	Executing Agency
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
EU	European Union
FAO	Food and Agriculture Organization of United Nations
FDC	Flow Duration Curve
FEPA	Federal Environment Protection Agency
FGD	Focus Group Discussion
FMEnv	Federal Ministry of Environment
FMAFS	Federal Ministry of Agriculture and Food Security
FMWR	Federal Ministry of Water Resources

GBV	Gender-based violence
GCM	Global Climate Model
GEFC	Global Environmental Flow Calculator
GIS	Geographic Information System
GPS	Global Positioning System
GRDB	Global Runoff Data Base
GRDC	Global Runoff Data Centre
Ha	Hectares
IAR	Institute of Agricultural Research
ICRC	International Committee of the Red Cross.
IDPs	Internal Displace Persons
IP	Irrigation Project
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
IWRMD	Integrated Water Resources Management and Development
IWRMP	Integrated Water Resources Management and Planning
JICA	Japan International Cooperation Agency
KCWS	Kano City Water Supply
KII	Key Informant Interview
KRIS	Kano River Irrigation Scheme
KRIP	Kano River Irrigation Project
KSMWR	Kano State Ministry of Water Resources
KYB	Komadugu Yobe Basin
LCBC	Lake Chad Basin Commission
LGP	Length of Growing Period
LUA	Land Use Act
LULC	Land Use Land Cover
M	Metres
masl	Metres above sea level
MCM	Million Cubic Metre
MDG	Millennium Development Goal
MSF	And Médecins Sans Frontières
MSL	Mecon Services Limited
M&E	Monitoring & Evaluation

NCWR	National Council on Water Resources
NDVI	Normalized Different Vegetation Index
NEAZDP	North East Arid Zone Development Programme
NESREA	The Nigerian Environmental Standards and Regulations Enforcement Agency.
NFDP	National Fadama Development Program
NGO	Non-Governmental Organization
NGSA	Nigerian Geological Survey Agency
NIHSA	Nigeria Hydrological Services Agency
NIMET	Nigerian Meteorological Agency
NIP	National Implementation Plan
NIWRMC	Nigeria Integrated Water Resources Management Commission
NNJC	Nigeria-Niger Joint Commission
NRW	Non-Revenue Water
NRCS	Natural Resources Conservation Service
NSE	Nash-Sutcliffe Efficiency
NW	North West
NWRMP	National Water Resource Master Plan
OSGOF	Office of Surveyor General
PET	Potential Evapotranspiration
PIM	Participatory Irrigation Management
PMT	Project Management Team
PPT	Precipitation
PSC	Project Steering Committee
PWD	Projected Water Demand
RBDA	River Basin Development Authority
RRR	Ministry of Reconstruction, Rehabilitation, and Resettlement
RUWASA	Rural Water Supply and Sanitation Agency
SAP	Strategic Action Plan
SAPDWR	Strategic Action Plan for the Development of Water Resources
SCIP	South Chad Irrigation Project
SCS	Soil Conservation Service
SESA	Strategic Environmental and Social Assessment
SHA	Sub Hydrologic Area

SGS	Streamflow Gauging Station
SMA	State Ministry of Agriculture
SME	Small Medium Enterprise
SMM	Soil Moisture Method (<i>Hydrology rainfall-runoff model within WEAP</i>)
SMWR	State Ministry of Water Resources
SUBEB	Small Medium Enterprise
SWA	State Water Agencies
SSEA	Strategic Social and Environmental Assessment
SZCMP	Sokoto-Zamfara Catchment Management Plan
TAP	Technical Advisory Panel
TOR	Terms of Reference
TRIMING	Transforming Irrigation Management in Nigeria
UBE	Universal Basic Education
UNESCO	United Nations Educational Scientific & Cultural Organization
UNICEF	United Nations Children’s Fund
UTM	Universal Traverse Mercator
VAPP	Violence against Persons Prohibition
WASH	Water, Sanitation, and Hygiene
WEAP	Water Evaluation and Planning
WBG	World Bank Group
WHO	World Health Organisation
WMO	World Meteorological Organization
WRA	Water Resources Act
WRM	Water Resources Management
WSS	Water Supply and Sanitation
WSSSRP	Water Supply and Sanitation Sector Reform Programme

EXECUTIVE SUMMARY

The Sokoto-Zamfara Catchment, a vital hydrological region in northwestern Nigeria, spans across Sokoto, Zamfara, and Kebbi States, covering approximately 45,883 km² (4,588,300 hectares). This catchment plays a crucial role in supporting agriculture, water supply, and economic activities, but faces growing environmental and water management challenges. Increasing pressure from climate variability, land degradation, population growth, and unsustainable practices threatens the long-term sustainability of its water resources.

The topography of the catchment varies significantly, ranging from the rugged terrains of Zamfara in the east to the lowland plains of Sokoto and Kebbi in the west. Elevations range from 600 meters to around 180 meters, influencing drainage patterns and water availability. The Sokoto and Zamfara Rivers, along with their tributaries, flow through the catchment, converging into the Rima River, which eventually joins the Niger River. Seasonal flooding is a key feature of the region, supporting wetlands, agriculture, and biodiversity, but also posing flood risks to settlements and farmlands.

Water availability is regulated by several dams and reservoirs, including Goronyo, Bakolori, Jibia, and Lugu, which store and control seasonal water flow. However, increasing demand for irrigation, domestic use, and livestock farming has led to water shortages and competition among users. The catchment's distinct wet and dry seasons create fluctuations in river discharge and groundwater recharge, making effective water resource management essential.

The catchment's vegetation zones range from open Sudan Savannah in the north to denser woodlands in the south, influenced by rainfall patterns and soil characteristics. However, land degradation, deforestation, and intensive farming have led to soil erosion, loss of biodiversity, and reduced soil fertility. Unchecked urban expansion, particularly in Sokoto, Gusau, and Birnin Kebbi, is placing further strain on water resources and land availability.

Security challenges in some parts of the catchment have disrupted farming and herding activities, leading to land use changes, migration, and increased pressure on safer agricultural zones. With a rapidly growing population, expected to significantly expand by 2050, the demand for food, water, and infrastructure will intensify, requiring sustainable planning and intervention strategies.

Geologically, the Sokoto-Zamfara Catchment is divided into two major formations:

- The Precambrian Basement Complex, which dominates eastern Zamfara and parts of Kebbi, is characterized by rocky outcrops and limited groundwater potential.
- The Sokoto Basin Sediments, prevalent in western Sokoto and Kebbi, consist of porous sedimentary rocks that store significant groundwater reserves.

Soil types across the catchment include:

- Arenosols in the drier northern regions, which are prone to wind erosion and poor water retention.
- Vertisols in the floodplains, which are fertile but require careful water management.
- Fluvisols along riverbanks, which support wetland agriculture and fisheries.
- Leptosols in upland areas, which are rocky and less suitable for intensive farming.

The northern part of the catchment is dominated by pastoralism and subsistence farming, while southern regions have more developed agriculture, including irrigated rice, millet, sorghum, and vegetable production. Expanding urbanization and infrastructure development are transforming land use patterns, increasing competition for farmland, water, and grazing areas.

The Sokoto-Zamfara Catchment is characterized by semi-arid and sub-humid climates, leading to high variability in rainfall and temperature. Rainfall is unevenly distributed, with northern areas receiving less than 500 mm annually, while southern parts can exceed 1,000 mm. Temperatures are consistently high, leading to high evaporation rates and water loss from surface reservoirs and soil moisture.

Hydrological studies using CHIRPS precipitation data and SCS Rainfall-Runoff models reveal significant seasonal variations in streamflow across different sub-catchments:

- Gusau Sub-Catchment receives moderate rainfall but faces intense runoff and soil erosion.
- Sokoto-Zamfara Sub-Catchment experiences severe seasonal water fluctuations, requiring enhanced storage and conservation methods.
- Argungu Sub-Catchment benefits from floodplain agriculture, particularly rice farming, but is vulnerable to flood risks.
- Binji Sub-Catchment has limited water retention capacity, making it prone to prolonged dry seasons.

Water quality in the Sokoto-Zamfara Catchment is deteriorating due to agricultural runoff, urban wastewater discharge, and industrial activities. Common pollutants include silt, nitrates, heavy metals, and microbial contaminants, affecting drinking water sources and aquatic ecosystems.

The catchment's groundwater resources vary based on geology, with alluvial aquifers near rivers providing stable supplies, while deeper aquifers in sedimentary formations store large reserves but require sustainable extraction practices. Overexploitation of groundwater and declining recharge rates pose risks for long-term water security, particularly as climate change intensifies dry-season stress.

Climate data analysis indicates that temperatures in the catchment have been rising steadily, with projections showing an increase of 3-5°C by the end of the century. Rainfall trends remain highly variable, increasing the likelihood of droughts, flash floods, and prolonged dry spells. These changes will affect crop yields, livestock survival, and overall water availability, requiring adaptive management strategies such as climate-smart agriculture and improved irrigation systems.

A GIS-based flood vulnerability assessment identified high-risk zones, particularly in low-lying floodplains around Sokoto, Shinkafi, and Argungu. Historical flood events have caused major disruptions to farming, settlements, and infrastructure, emphasizing the need for early warning systems, better drainage networks, and integrated flood management plans.

Key stakeholders, including government agencies, local communities, and environmental organizations, recognize the need for collaborative management of the catchment's water and land resources. The region is rich in natural resources, but unsustainable practices threaten long-term productivity. A comprehensive catchment management plan should integrate:

- Harmonized water policies and stricter environmental regulations.
- Climate-resilient agricultural techniques to improve food security.
- Watershed restoration and sustainable land management to combat soil erosion and deforestation.
- Efficient water governance, including improved dam operations and equitable water allocation.

- Investments in renewable energy and agro-processing industries to strengthen the local economy.

By implementing these strategies, the Sokoto-Zamfara Catchment can move toward a future of improved water security, environmental stability, and economic resilience, ensuring sustainable development for its rapidly growing population.

Past and Ongoing Development Initiatives in the Catchment Area

To put the Plan in proper perspective, Table ES 1 depicts some past and ongoing development initiatives by different partners in the Sokoto-Zamfara Catchment.

Table ES 1: Past and Ongoing Initiatives by Governments and Development Partners in the Catchment

LOCATION	PAST INITIATIVE	ONGOING INITIATIVE
Sokoto State	<p>Project: Goronyo Dam Agency: Federal Government of Nigeria (via the Federal Ministry of Water Resources); managed locally by Sokoto RIMA (Rural Water Supply and Sanitation Agency) Focus: Water supply, irrigation, flood control, and urban consumption</p>	<p>Project: 40 Million Litres Daily Water Project Agency: Sokoto State Government (Ministry of Water Resources); in collaboration with development partners Focus: Urban water supply, infrastructure expansion, water scarcity reduction</p>
		<p>Agency: Sokoto State Government (Ministry of Water Resources); with technical support possibly from UNICEF or other WASH-focused partners Focus: Rural and peri-urban water supply, infrastructure rehabilitation, public health improvement</p>
	<p>Project: Installation of Solar-Motorized Borehole in Kindiru Village Agency: USAID & UNICEF Focus: Rural water access, sustainable energy use, support for livelihoods and small businesses</p>	<p>Project: 40 Water Supply Projects in Sokoto State Agency: Federal Government of Nigeria (Ministry of Water Resources & Sanitation); Sokoto State Government Focus: Clean water access, public health, institutional support, rural development, employment creation</p>

		<p>Project: Restoration of 19 Million Cubic Meters of Water in Lugu Dam</p> <p>Agency: Sokoto State Government (in collaboration with World Bank and ACREsAL Project)</p> <p>Focus: Water restoration, irrigation, agricultural development, environmental sustainability</p>
		<p>Project: Construction of Water Supply Scheme at Kauran Miyo, Bodinga LGA</p> <p>Agency: Federal Ministry of Water Resources; Sokoto RIMA RBDA</p> <p>Focus: Rural water supply, infrastructure development, improving access to clean water in remote communities</p>
Zamfara State	<p>Project: Bakalori Dam</p> <p>Agency: Federal Government of Nigeria (Federal Ministry of Water Resources), Sokoto Rima Basin Development Authority (SRBDA); historical support from the World Bank</p> <p>Focus: Irrigation, domestic water supply, agricultural productivity, flood control</p>	<p>Project: Construction of Bilbis Irrigation Scheme in Zamfara Central</p> <p>Agency: Federal Ministry of Water Resources; Sokoto RIMA RBDA</p> <p>Focus: Irrigation infrastructure, agricultural development, water supply</p>
		<p>Project: Kaura Namoda Water Supply Scheme</p> <p>Agency: Federal Ministry of Water Resources; Sokoto RIMA RBDA</p> <p>Focus: Urban water supply, infrastructure development, clean water access</p>
		<p>Project: Transforming Irrigation Management in Nigeria (TRIMING)</p> <p>Agency: World Bank; Federal Ministry of Water Resources; Zamfara State Government</p> <p>Focus: Irrigation infrastructure, agricultural productivity, water resource management, security issues</p>
Katsina State	<p>Project: Jibia Dam</p> <p>Agency: Federal Government of Nigeria (through the Federal Ministry of Water</p>	<p>Project: Katsina State Water Supply Projects (2025 Budget)</p>

	<p>Resources); managed locally by Katsina State Government Focus Water supply for domestic use, irrigation, and drought mitigation</p>	<p>Agency: Katsina State Government, Katsina State Water Board Focus: Clean water provision, rural and urban water supply, sustainability</p>
		<p>Project: NG-SURWASH (Nigeria Sustainable Urban and Rural Water Supply, Sanitation and Hygiene Programme) Agency: Katsina Small Towns Water Supply and Sanitation Agency (STWSSHA); World Bank Focus: Water supply, sanitation, hygiene, rural and urban development, monitoring, quality assurance</p>
		<p>Project: Danja Dam Construction Agency: Katsina State Government, Ministry of Water Resources Focus: Dam construction, water supply, irrigation, infrastructure development</p>
		<p>Project: Yashe Earth Dam Rehabilitation (Kusada) Agency: Katsina State Government, Ministry of Water Resources Focus: Dam rehabilitation, water supply, irrigation, infrastructure maintenance</p>
<p>Kebbi State</p>	<p>Project: Completion of Bunza Town Water Project Agency: Federal Ministry of Water Resources Focus: Provision of clean and sustainable water</p>	<p>Project: Improved Sustainability of Integrated WASH Services (I-WASH) Agency: USAID & Green Habitat Initiative (GHI) Focus: Provision of sustainable solar-powered water supply & Construction of toilets and handwashing facilities security in Gwandu LGA</p>

	<p>Project: Construction of Earth Dam and Irrigation Scheme at Gwandu Agency: Federal Ministry of Water Resources & Sokoto Rima River Basin Development Authority (SOKOTO RIMA RBDA) Focus: Construction of an earth dam for water conservation, Irrigation support for farming communities & Support for livelihoods and food security in Gwandu LGA</p>	<p>Project: Sustainable Urban and Rural Water Supply, Sanitation and Hygiene (SURWASH) – Kebbi State Assessment Agency: World Bank & National SURWASH Coordination Unit Focus: Upgrade and expansion of both urban and rural potable water systems & Improved hygiene infrastructure and behaviour change promotion</p>
	<p>Project: Dangandu Solar-Motorized Borehole Project Agency: USAID & UNICEF Focus: Clean Water Access</p>	<p>Project: Construction of Water Supply Schemes at Mahuta LGA Agency: Federal Ministry of Water Resources & Sokoto Rima River Basin Development Authority (RBDA) Focus: Development of localized water schemes to improve potable water access & targeted at underserved communities within Mahuta LGA</p>

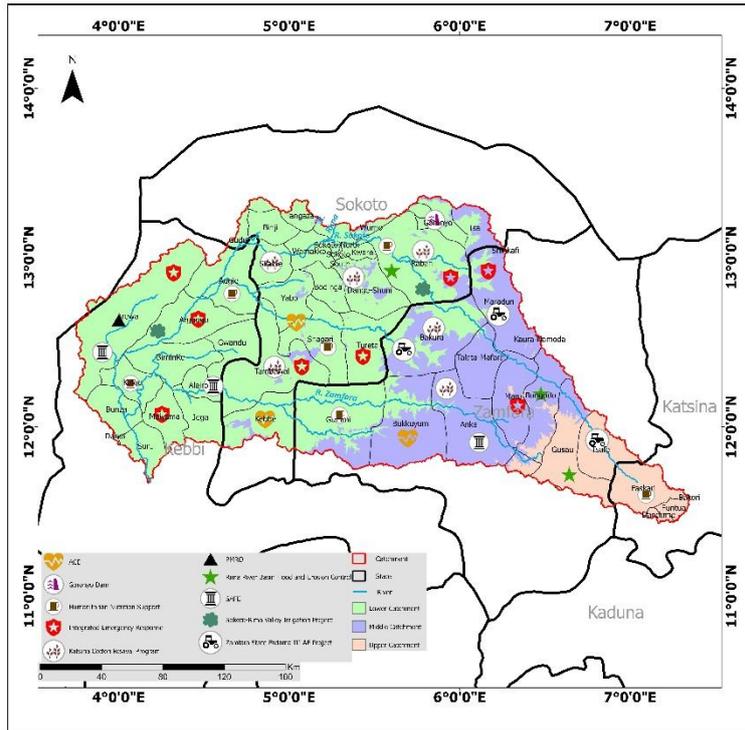


Fig E.S.1: Sokoto-Zamfara Catchment Showing Past Interventions (Source: MSL, 2025)

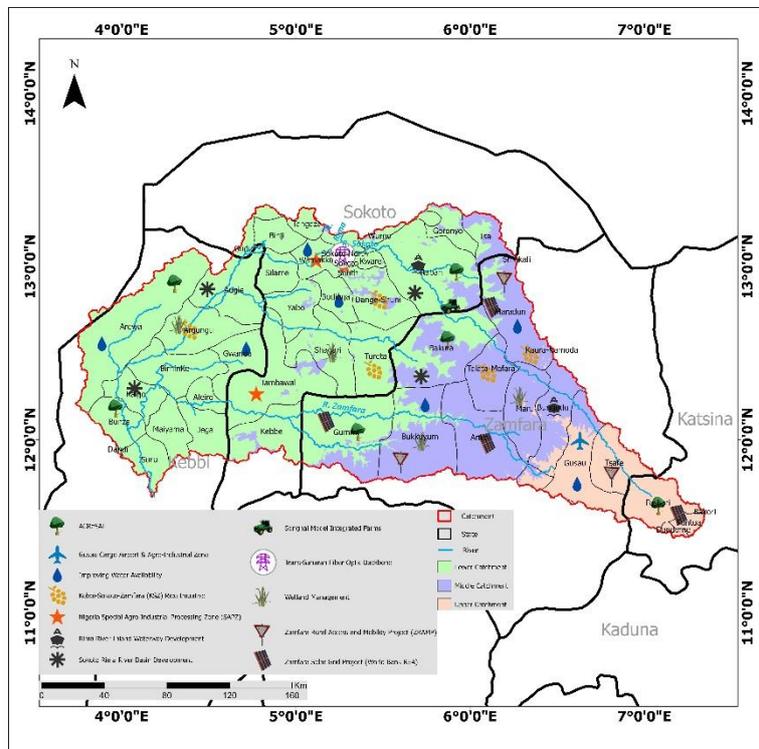


Figure E.S.2: Sokoto-Zamfara Catchment Showing Ongoing Interventions (Source: MSL, 2025)

Despite the numerous initiatives implemented, there remains a widespread concern that many interventions within the Sokoto-Zamfara catchment area have not effectively addressed development challenges in a holistic manner. Numerous projects appear to lack the necessary integrated approach to comprehensively address the interconnected environmental and socio-economic issues. As a result, the catchment continues to face persistent biophysical and social challenges.

Main Biophysical and Socio-economic Challenges

Based on biophysical assessments and stakeholder engagement, the following are the key biophysical and socio-economic issues facing the Sokoto-Zamfara Catchment:

Biophysical Challenges

- i. **Soil Erosion and Land Degradation:** Soil erosion and land degradation are widespread in the Sokoto-Zamfara catchment, driven by factors such as heavy rainfall, deforestation, and unsustainable farming practices. These issues significantly reduce agricultural productivity, contribute to the siltation of water bodies, and heighten the region's vulnerability to flooding.
- ii. **Floods and Water Management:** The Sokoto-Zamfara catchment, particularly the Wurno Local Government Area of Sokoto State, is highly susceptible to severe flooding. Repeated breaches of the Lugu Irrigation Dam have led to significant environmental and socio-economic repercussions. Flooding causes widespread damage to homes, agricultural land, and infrastructure, displacing communities and resulting in the loss of livelihoods.
- iii. **Water Quality and Availability:** Water quality in the Sokoto-Zamfara catchment is declining due to pollution from agricultural runoff, industrial waste, and inadequate sanitation infrastructure. This deterioration of both surface and groundwater quality poses significant health risks to local communities and threatens the long-term sustainability of water resources.
- iv. **Climate Change:** The Sokoto-Zamfara catchment is significantly impacted by climate change, with erratic rainfall patterns, extended droughts, and rising temperatures. These shifts intensify pre-existing environmental issues, further complicating water resource management and undermining agricultural productivity in the region.

Socio-Economic Challenges

- i. **Poverty and Food Insecurity:** Poverty and food insecurity are prevalent in the Sokoto-Zamfara catchment, as much of the population depends on subsistence farming, which is highly susceptible to environmental shocks. Frequent floods and droughts result in crop failures, food scarcity, and heightened poverty, exacerbating the region's socio-economic challenges.
- ii. **Infrastructure Deficits:** The Sokoto-Zamfara catchment faces a severe lack of basic infrastructure, including dependable water supply systems, sanitation facilities, and flood control measures. This infrastructure deficit worsens the impact of environmental challenges, hindering communities' ability to recover effectively from disasters.
- iii. **Health Risks:** The combination of poor water quality and insufficient sanitation facilities facilitates the spread of waterborne diseases, leading to deteriorating public health. High rates of diseases such as malaria and cholera place additional pressure on the already limited healthcare resources in the region.
- iv. **Displacement and Migration:** Frequent flooding and land degradation force numerous communities to relocate, resulting in involuntary resettlement and the breakdown of social networks. This displacement disrupts local economic activities, heightens social tensions, and worsens poverty levels.
- v. **Gender-Based Violence (GBV):** Displacement and resource scarcity heighten the vulnerability to gender-based violence (GBV) and sexual exploitation. This exacerbates social instability and hinders progress toward sustainable development, creating additional challenges for affected communities.

Elements of the Catchment Management Plan

The elements of the Sokoto-Zamfara Catchment Management Plan are captured through the lenses of the following strategic vision and objectives:

Strategic Vision

The strategic vision for the Sokoto-Zamfara Catchment Management Plan is

To build a climate-resilient, inclusive, and sustainable catchment that restores degraded landscapes, secures water and ecosystem services, and improves livelihoods across Sokoto, Zamfara, and Kebbi through integrated resource management and strong local and regional partnerships.

Strategic Objectives

- i. **Integrated Water Resource Management:** Develop and implement a comprehensive water resource management plan that addresses both surface and groundwater resources. Promote sustainable water use practices and improve water allocation efficiency.
- ii. **Environmental Conservation and Rehabilitation:** Combat land degradation and soil erosion through reforestation and sustainable land management practices. Enhance the resilience of ecosystems to climate change impacts.
- iii. **Socio-Economic Development:** Improve agricultural productivity and food security through effective irrigation and water management. Support livelihoods and reduce poverty by creating opportunities for income generation and employment.
- iv. **Stakeholder Engagement and Community Participation:** Foster active participation of local communities and stakeholders in the planning and implementation of catchment management activities. Ensure gender equality and social inclusion in all project interventions.
- v. **Infrastructure Development and Rehabilitation:** Rehabilitate and construct water infrastructure, such as dams and boreholes, to enhance water supply and flood control. Develop and maintain a robust monitoring and evaluation system to track project progress and impact.
- vi. **Policy and Institutional Strengthening:** Strengthen governance structures and regulatory frameworks to support sustainable catchment management. Enhance the capacity of local institutions and stakeholders to effectively manage water resources.

Catchment Policies

For harmonious relationship and engagement of stakeholders regarding equitable utilization of inter-state water resources the following treaties, policies, and laws need to be recognized, and ratified treaties further domesticated.

Treaties

- Vienna Convention on the Law of Treaties on principle of binding nature of treaty once signed, ratified and inforce (*pacta sunt servanda*),
- UN Watercourses Convention on non-navigational use of shared watercourses, application to surface water and connected groundwater,
- UNECE Water Convention on relevance to both surface and ground water as well as application to all uses of the shared watercourse,

- Niger Basin Water Charter as principal treaty of the Niger River Basin,
- Lake Chad Water Charter as principal treaty of the Lake Chad Basin.

International Policies That Affect Water Resources

- 1971 Stockholm Declaration on Human Environment
- 1992 Dublin principles on water and sustainable Development,
- 1992 Rio Declaration on Environment and Development and Agenda 21
- 2008 ECOWAS Water Resources Policy
- Draft Articles on the Law of Transboundary Aquifer

National Laws and Policies

- 1999 Constitution of Federal Republic of Nigeria
- 1993 National Water Resources Act
- 2016 National Water Resources Policy
- 2016 National Policy on Environment
- National Climate Change Policy for Nigeria (2021-2030)
- Nigeria's Agricultural Transformation Agenda (ATA)
- Nigeria's National Forest Policy (2006)

Plan Components

To achieve the outlined goal and objectives to ameliorate the challenges in the Sokoto-Zamfara catchment, the following are the strategic components or intervention areas of the Plan:

Component 1: Sustainable conservation, management, and use of water resources: The focus will be on sustainable water resource use to support socio-economic development, ensuring equitable access to minimize conflicts among communities. Efforts will address environmental degradation and mitigate water-related disasters. Development of water storage infrastructure will support dry-season activities, while monitoring systems for surface and groundwater will promote sustainability and informed decision-making.

Component 2: Preservation and restoration of critical ecosystems and services for sustainable land use; including sustainable agricultural and livestock practices: The ecological integrity is crucial for sustainable development, but human activity is straining land

resources, particularly through unsustainable fuelwood reliance. This leads to tree felling near water sources, causing forest degradation and threatening biodiversity. Such changes increase sedimentation and turbidity in water bodies. The management plan will focus on restoring degraded ecosystems to enhance land quality and protect water resources.

Component 3: Improved diversification for enhanced sustainable livelihoods and well-being: Agriculture is the main livelihood for many in the Sokoto-Zamfara Catchment, but small landholdings and unsustainable practices result in low productivity and income. This economic pressure drives young men to migrate to urban areas, creating labor shortages in agriculture. The plan aims to build capacity for sustainable resource management, diversify economic opportunities, and improve access to resources to boost local resilience.

Component 4: Climate change, disaster risk management, and climate-resilient infrastructure: Agriculture in the Sokoto-Zamfara Catchment is hindered by limited land and unsustainable practices, leading to low productivity and increased reliance on natural resources. This economic strain drives young men to migrate to urban areas, resulting in labor shortages in agriculture and resource management. The Plan aims to build local capacity for sustainable resource management, create economic opportunities, and improve access to resources to reduce dependency, curb migration, and enhance resilience.

Component 5: Strengthening institutional mechanisms and project coordination mechanisms: Efforts across the Sokoto-Zamfara Catchment are often fragmented due to poor coordination and a lack of collaboration mechanisms. Establishing robust coordination, clearly defining roles, and empowering local leaders are essential for improving governance. This Plan will promote integrated approaches to enhance collective action and drive sustainable development within the basin.

Component 6: Mainstreaming gender equality and social inclusion (GESI) mechanism: In the Sokoto-Zamfara Catchment, shifting gender roles have led to women taking on greater household and agricultural responsibilities as men migrate for work. This shift presents opportunities for supporting women's entrepreneurship, particularly in transitioning to commercial agriculture. However, it's crucial to address the socio-economic implications and prioritize women's economic empowerment and equitable participation in watershed development planning.

Component 7: Research and extension: This component will focus on action-oriented research in the Sokoto-Zamfara Catchment, aiming to develop an evidence-based watershed

management plan. Key areas include Indigenous knowledge, nature-based solutions, soil and water conservation, and integrated water management. Research will also explore climate change impacts and the role of micro-finance in sustainable livelihoods. Insights will drive practical interventions to enhance resilience and sustainability in the region.

Component 8: Effective coordinated monitoring, evaluation, and reporting mechanism and system. The emphasis will be on capacity building to enable effective and regular monitoring of watershed services, as well as the systematic monitoring and evaluation of the overall watershed management plan.

Table ES 2 shows the significant issues in the watershed and the proposed solutions, including the local, state, and national implementing partners.

Table ES 2: Summary of Components and Activities of the Sokoto-Zamfara Catchment Plan

Component	Activities	Key Indicators	Responsibility/ Partners
<p>Sustainable conservation, management and use of water resources:</p>	<p>Rehabilitate existing dams and reservoirs (including the extensive removal of typha grass, to improve water retention and release.</p>	<p>Reports, implementation and supervisions</p>	<p>Three tiers of government encompassing the RBDA's, FMWR and allied agencies</p>
	<p>Construct small-scale water storage facilities and enhance rainwater harvesting techniques.</p>		
	<p>Establish water allocation plans that balance upstream and downstream needs.</p>	<p>Reports on a comprehensive water study, policy enactment, implementation and enforcement.</p>	<p>As above, NIWRMC</p>
	<p>Construct embankments and improve drainage systems in high-risk areas.</p>		
	<p>Develop early warning systems and conduct flood risk assessments regularly.</p>	<p>Reduction in environmental risk and disaster</p>	<p>NHISA, NIMET</p>
	<p>Strengthen the network of groundwater monitoring systems and hydromet stations</p>	<p>Better Socio-economic engagement</p>	
	<p>Enhance public awareness and preparedness for flood events.</p>	<p>Routine Reports</p>	<p>NHISA, The three tiers of government encompassing the RBDA's, FMWR and allied agencies</p>
	<p>Implement integrated water management practices that address seasonal variability, optimize groundwater recharge, and enhance surface water distribution to</p>	<p>Reports</p>	<p>NHISA, NIMET, MOA, CBO's</p>

	<p>meet agricultural, domestic, and industrial demands.</p> <p>Define and operationalize a set of technical standards for water efficiency (conservation, reuse, recycling) for recreation and - other uses based on best practices</p> <p>Assessment of demand and supply of drinking water</p> <p>Construction and maintenance of pipelines and water tanks</p> <p>Construction of recharge structures to rejuvenate drying and dried springs.</p> <p>Roof rainwater harvesting and improved water use efficiency</p> <p>Conservation and preservation of water recharge areas, along with planting of appropriate tree and plant species which assist in increasing the abundance of water sources.</p>		
<p>Preservation and restoration of critical ecosystems and services for sustainable land use (to include sustainable agricultural and livestock practices)</p>	<p>Restoration of 30% to 40% of degraded land through afforestation</p> <p>Restore 25% and improve agricultural degraded land</p> <p>Restore and maintain wetlands to stabilize hydrological cycles and support biodiversity.</p>		

	<p>Enforce the protective boundaries of national parks and valuable reserves such as Nguru</p> <p>Increase agricultural productivity by 40% through climate-smart agriculture, capacity building, and data gathering</p> <p>Improve soil fertility management, and apply soil and water conservation to reduce erosion</p> <p>Support smallholder farmers through training and access to improved technologies</p> <p>Encourage the use of micro-irrigation facilities</p>	<p>Increase in agricultural productivity</p> <p>As above</p> <p>Increase in number of farmers.</p> <p>Increase in agricultural productivity</p>	<p>Federal, state and local government MDA's on agriculture and food security, livestock, water resources and environment</p> <p>As above</p> <p>Bank of agriculture, NGOs and other international agencies. CBOs</p> <p>As above</p>
<p>Improved diversification for enhanced sustainable livelihoods and well-being</p>	<p>Ensure the proper conditions for the effective organization of fish farming in floodplains of rivers, natural and artificial reservoirs;</p> <p>Provide training programs for sustainable farming, fishing, and aquaculture practices.</p> <p>Facilitate access to credit and market opportunities for smallholder farmers and fisherfolk.</p> <p>Develop community-based tourism and eco-friendly economic activities.</p> <p>Improve access to sustainable natural resources, low-cost energy, better sanitation and hygiene practices</p>	<p>Improved quality of living.</p> <p>Improved funding</p> <p>Improved income/job creation.</p> <p>Availability of renewable energy and improved standard of living.</p>	<p>Federal, state and local government MDAs, CBOs</p> <p>Donor agencies, banks and cooperatives</p> <p>CBOs and the three tiers of government</p> <p>As above</p>

	<p>Promote farming of high-value agricultural products such as high yielding climate resilience seeds such as maize, sorghum, SAMNUT-22, millet</p> <p>Providing comprehensive training on irrigation techniques, preparation of compost manure, water ponds for irrigation,</p> <p>Integrated Pest Management (IPM) and other technical skills to women, men, and marginalized communities to reduce the pollution of the main water resources.</p> <p>Promote of multi-year crops to improve the average income of the people living in the catchment.</p> <p>Promote the use of water as an alternative to road transport system</p>		
<p>Climate change, disaster risk management, and climate-resilient infrastructure</p>	<p>Promote the use of local runoff of small rivers to mass-arrange water bodies and provide water measures to combat climate change-induced drought.</p> <p>Expand early warning systems and enhance the capacity for disaster response</p> <p>Construct resilient infrastructure to address flood risks and water distribution challenges.</p>	<p>Reduction in climate change induced disaster</p> <p>Reduction in environmental degradation and climate change disaster</p> <p>Improved agricultural</p>	<p>Federal, State and local Government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs</p> <p>Federal, State and local Government MDAs, NGOs, donor agencies.</p>

	<p>Support the adoption of drought-resistant crop varieties and efficient irrigation technologies.</p> <p>Promote afforestation programs to combat desertification and stabilize soils.</p> <p>Implement community-based initiatives for floodplain management and watershed protection.</p> <p>Prepare risk sensitive Land-use Plan (RSLUP) and implementation for identified degraded areas</p> <p>Revitalise erosion-affected areas, including stream banks and gully stabilization in the upstream micro-catchment vulnerable areas</p> <p>Promote green roads through bioengineering in erosion-prone areas</p> <p>Creating a green infrastructure system to protect ecosystems, ecologic corridors and natural landscapes in the water bodies</p> <p>Focus on both structural (bioengineering, retaining walls) and non-structural (hazard/ susceptibility, vulnerability, risk maps, early warning systems) measures for infrastructure failure mitigation and preparedness</p>	<p>output and increased employment</p> <p>Decrease in soil erosion, improved NDVI</p> <p>Reduction in environmental degradation.</p> <p>Designated livelihood areas and updated reports</p> <p>Increase in land resources available for livelihoods in updated reports.</p> <p>As above</p> <p>Updated reports</p> <p>Updated reports and increase in harmonious engagement with stakeholders</p> <p>Updated reports</p>	
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	<p>Undertake hazard and risk assessment to minimize the risk.</p> <p>Conducting EIA/IEE of major development projects to minimize impact on ecosystem.</p> <p>Undertake effective and timely review and monitoring of infrastructure development projects</p>		
<p>Strengthening institutional mechanisms and project coordination mechanisms:</p>	<p>Establish a regulatory framework for integrated water resource management at the catchment level.</p> <p>Strengthen coordination among federal, state, and local agencies.</p> <p>Ensure community representation in decision-making processes and management committees.</p> <p>Strengthening the watershed management committee to implement the watershed management plan.</p> <p>Implementing production-based incentives and monitoring mechanisms for agricultural land management.</p> <p>Developing mechanisms to ensure effective implementation and management of springshed and recharge areas, particularly on public and private land.</p>	<p>Reduced conflict and equitable distribution of water resources</p> <p>Reduced conflict among stakeholders and better institutional collaboration</p> <p>Increase in agricultural output</p> <p>Policy formulation and Implementation</p>	<p>Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs.</p>

<p>Mainstreaming gender equality and social inclusion (GESI) mechanism</p>	<p>Ensure equitable distribution of roles and responsibilities to women, men and marginalized communities during the planning, implementation and evaluation of any projects/plans/activities</p> <p>Provide training and exposure visits to both women and men in order to enhance their understanding on water conservation technologies and economic development.</p> <p>Identify vulnerable areas and communities (with gender and social disaggregated data) to disaster and climate risk and develop focused projects to address identified challenges</p> <p>Promote women and marginalized communities to leadership positions through participatory approaches.</p> <p>Establishing counseling centers for handling domestic violence, grievances, and psychosocial services for supporting the well-being of women, men, and marginalized communities.</p>	<p>Comprehensive participation of all stakeholders</p> <p>Better outputs of environmental conservation</p> <p>Updated Reports on key social issues within a community</p> <p>More women participation</p> <p>Improved psycho-social status of victims of abuse</p>	<p>Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs.</p>
<p>Research and extension</p>	<p>Undertake action research on pertinent issues such as:</p> <ul style="list-style-type: none"> ✓ accounting of water resources and regulation of their flow ✓ Indigenous knowledge and practices, 	<p>Increased awareness</p>	<p>Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs.</p>

	<ul style="list-style-type: none"> ✓ nature-based solutions, ✓ effectiveness of soil conservation measures, ✓ watershed services for IWM, ✓ sediment yield, ✓ climate change impact on vegetation and land use, ✓ pests, ✓ micro-finance and others for an evidence-based watershed management plan and strategies. 	<p>Increased livelihood output</p>	
<p>Effective coordinated monitoring, evaluation, and reporting mechanism and system</p>	<p>Establish a coordinated and functional watershed management monitoring system (to be institutionalized in a reputable already existing institution in the Catchment) to include:</p> <ul style="list-style-type: none"> ✓ Periodic monitoring of watershed services ✓ Monitoring the work of large hydraulic ✓ Structures and developing rational methods for their operation. ✓ Inclusion of gender and social aspects in projects' development and implementation ✓ Monitoring and evaluation of the plan 	<p>Quarterly reports, updated watershed plans</p>	<p>Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs, NASRDA, NCRS.</p>

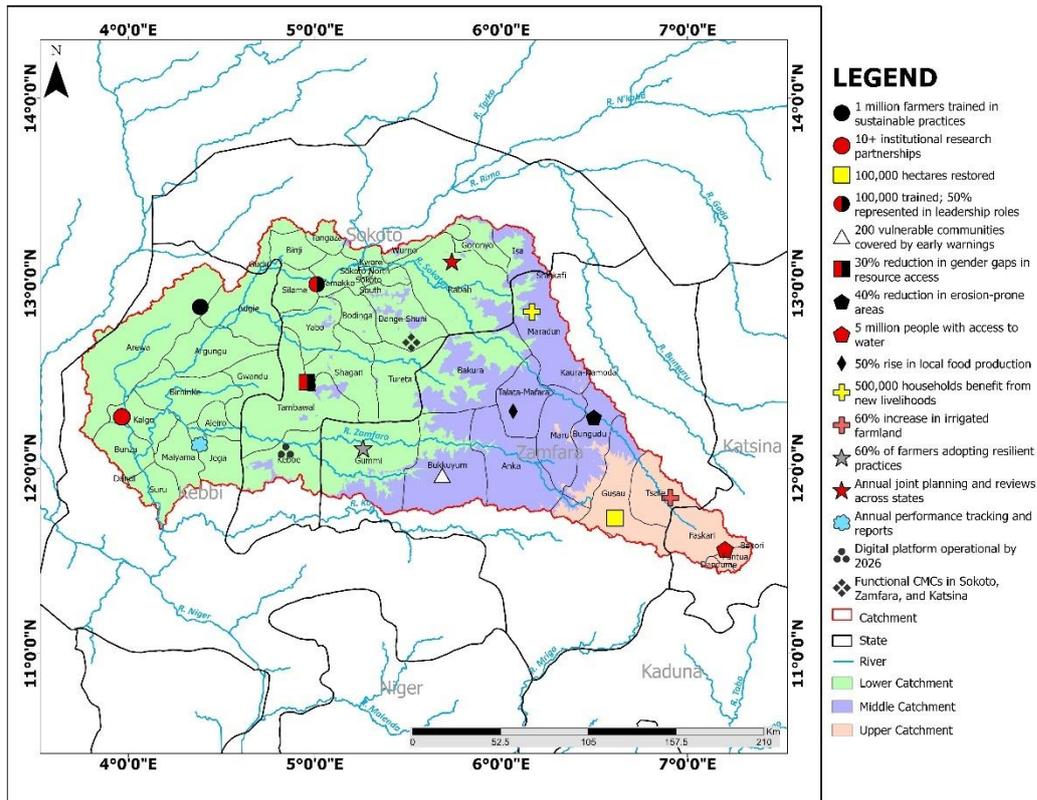


Figure E.S.3: Sokoto-Zamfara Catchment Showing the Recommended Interventions (Source: MSL, 2025)

Table E.S.3: Lower Catchment of the Sokoto-Zamfara Strategic Catchment – Spatial Challenges and Intervention Matrix

Section	LGA/Towns	Identify Challenge	Proposed Intervention	Appropriate Tool(s) For Sustained Monitoring and Evaluation	Responsible Agency	Expected Outcome
Lower Catchment	Arewa, Dandi, Bunza, Suru, Kalgo, Maiyama, Jega, Aleiro, Argungu, Birnin Kebbi	Flooding of farmlands during rainy season	River training, embankment construction, floodplain zoning	River modelling, flood hazard mapping	NIWA, State Ministry of Water Resources, FMEnv.	Reduced flood damage, protected farmlands, secure livelihoods
	Tambuwal, Kebbe, Tureta, Shagari, Yabo, Dange-Shuni, Gummi, Bondiga	Dry season water scarcity, unreliable irrigation water	Rehabilitation of small dams, installation of solar pumps, and drilling of additional Borehole.	Hydrogeological survey, irrigation scheduling	Rural Water Supply Agency, ADP,NIWRMC,FMWR,NIHSA	Improved water access for agriculture and domestic use



	Silame, Augie, Gudu, Binji, Tangaza, Goronyo, Rabah, Wurno	Land degradation and desert encroachment	Shelterbelt development, community afforestation programs	Remote sensing for land degradation, nursery devt	Ministry of Agriculture Forestry Department, NCF, ECN.NGO, ACRoSAL, ,LGA's	Slowed desertification, restored vegetation cover
	Wamakko, Sokoto North, Sokoto South, Kware	Urban flooding, poor drainage	Stormwater drainage system upgrades, urban flood early warning	GIS flood risk mapping, urban drainage design	Urban Planning Authority, SEMA, NEMA, FMEnv. Ministry of water Resources	Reduced urban flood risk, safer city environment

Table E.S.4: Middle Catchment of the Sokoto-Zamfara Strategic Catchment – Spatial Challenges and Intervention Matrix

Section	LGA/Town(s)	Challenge	Proposed Intervention	Appropriate Tool(s) For Sustained Monitoring and Evaluation	Responsible Agency	Expected Outcome
Middle Catchment	Isa, Shinkafi, Kaura-Namoda	Banditry-related land abandonment, disrupted farming	Community security support +	Participatory mapping,	NEMA, State Agric Devt	Restored farming activities, improved security



			rehabilitation of farmlands	community engagement	Programme (ADP), NSCDC	
	Maradun, Bakura, Talata-Mafara	Seasonal flooding of low-lying farmlands	Small-scale flood barriers, canal desilting	Topographic survey, flood risk models	NIWA, State Ministry of Environment	Minimized flood loss, enhanced farm productivity
	Maru, Bungudu, Anka, Bukkuyum	Soil erosion and gully formation on farmlands	Gully erosion control (check dams, reforestation)	Drone survey, erosion hazard mapping	ACReSAL, Forestry Dept, State Ministry of Works	Stabilized soils, reduced erosion, reclaimed farmland

Table E.S.5: Upper Catchment of the Sokoto-Zamfara Strategic Catchment – Spatial Challenges and Intervention Matrix

Section	LGA/Town(s)	Challenge	Proposed Intervention	Appropriate Tool(s) For Sustained Monitoring and Evaluation	Responsible Agency	Expected Outcome



Upper Catchment	Gusau, Tsafe	Gully erosion threatening farmlands and settlements. Outdated Infrastructure	Gully stabilization (check dams, tree planting)	Drone mapping, erosion risk modeling	ACReSAL, State Ministry of Environment	Controlled gully spread, restored land for use
	Faskari, Bakori, Dandume	Deforestation leading to loss of soil fertility	Agroforestry, community woodlots	GIS land use survey, nursery establishment	FMAFS Forestry Dept, State Agric Development Prog	Enhanced soil fertility, sustainable fuelwood supply
	Funtua	Flash floods damaging infrastructure	Urban drainage improvement, flood retention basins	Hydrological modeling, urban flood mapping	NEMA, NIWA, Local Government Councils	Reduced flood risk, safeguarded livelihoods and infrastructure
All the Town	High youth unemployment and limited economic opportunities	Youth agro-enterprise training, off-season farming schemes	CBO feedback	SMEDAN, NDE, Kaduna State Agricultural Development Programme (ADP)	Reduced youth unemployment, increased rural income	

Expected Outcomes

The successful implementation of the interventions in the Sokoto-Zamfara SCMP will result in:

- Restoration of Degraded Lands, Improved Water Resource Management and Enhanced Biodiversity Conservation
- Increased Agricultural Productivity, Livelihood Enhancement and Employment Generation
- Strengthened Governance Structures, Community Engagement and Empowerment and Capacity Building
- Modern Infrastructure, Data and Monitoring and Climate Adaptation
- Community-Led Initiatives, Gender Inclusion and Empowerment Programs

CHAPTER 1 : INTRODUCTION

1.1 Purpose of the Plan

The Sokoto-Zamfara Catchment is a critical ecosystem that supports the livelihoods of millions of people in Northwestern Nigeria. However, the catchment faces numerous challenges, including:

- i. **Environmental Degradation:** Water Scarcity, Land Degradation and Climate Change.
- ii. **Socio-Economic Challenges:** High Poverty Rates, Unemployment and Insecurity.
- iii. **Institutional Weaknesses:** Fragmented Governance, Weak Enforcement and Capacity Gaps.
- iv. **Technical Limitations:** Outdated Infrastructure, Limited Data and Monitoring and Climate Resilience.

1.2 Rationale for a Strategic Catchment Plan

To address these challenges, the Sokoto-Zamfara Strategic Catchment Management Plan proposes a series of strategic interventions:

- i. **Environmental Sustainability:** Enhance environmental sustainability by implementing modern irrigation technologies to reduce water wastage and boost agricultural productivity, launching large-scale reforestation and soil conservation initiatives to combat land degradation and desertification, and developing climate-resilient agricultural practices and infrastructure to mitigate climate change impacts.
- ii. **Socio-Economic Development:** Promotes socio-economic development by supporting alternative income-generating activities like agro-processing and handicrafts, implementing capacity-building and vocational training programs, especially for youth and women, and enhancing security in conflict-prone areas to ensure stable agricultural activities and economic growth.
- iii. **Institutional Strengthening:** Focuses on institutional strengthening by establishing inter-agency coordination mechanisms for cohesive resource management, enhancing regulatory enforcement to protect natural resources, and providing technical and financial support to local institutions to improve their capacity in managing water and environmental resources.

- iv. **Technical Advancements:** Promotes technical advancements by upgrading water management infrastructure, developing robust data collection and monitoring systems, and investing in climate-resilient infrastructure to enhance efficiency, reliability, and adaptive capacity in the face of climate change impacts.

1.3 Expected Outcomes

The Sokoto-Zamfara strategic catchment plan is expected to achieve the following outcomes:

- i. Improved water availability, enhanced ecosystem health and climate resilience.
- ii. Reduce poverty rates, increased agricultural productivity and improved access to services.
- iii. Enhance governance, strengthened enforcement and capacity building.
- iv. Modernized infrastructure, robust monitoring systems and climate adaptation.
- v. Increased community participation, enhanced gender inclusion and empowerment programs.

1.4 Environmental Roles

- i. **Sustainable Water Resource Management:** The SCMP enhances sustainable water resource management by implementing efficient irrigation and rainwater harvesting systems, promoting managed aquifer recharge, and establishing water quality monitoring systems.
- ii. **Land Degradation and Soil Conservation:** Combat land degradation through large-scale reforestation, terracing, contour farming, cover crops, and agroforestry to reduce erosion, improve soil fertility, and minimize chemical fertilizer use.
- iii. **Climate Resilience:** Enhance climate resilience by promoting drought-resistant crops and water conservation, investing in resilient infrastructure, and implementing early warning systems for floods and droughts.
- iv. **Biodiversity Conservation:** Restore degraded ecosystems like wetlands, floodplains, and forests to support biodiversity, and strengthen protected area management and conservation programs for endangered species.
- v. **Community Engagement and Empowerment:** Promote community-led conservation and resource management, implement capacity-building and vocational training for youth and women, and encourage their participation in resource management and economic activities.

1.5 Socio-Economic Roles

- i. **Economic Development:** The plan enhances agricultural productivity through improved water storage and sustainable irrigation, supports agribusiness development for income growth and job creation, and fosters SME growth in related sectors to reduce poverty. It also includes strategies for sustainable exploitation of mineral resources like gold and limestone to boost the local economy.
- ii. **Community Empowerment:** Focuses on community empowerment by offering skill training for women and youth to boost employability and entrepreneurship, supporting vulnerable groups with education and healthcare, and promoting gender equality through policies and programs ensuring equal access to resources.
- iii. **Disaster Risk Reduction:** The plan focuses on disaster risk reduction by establishing early warning systems for floods and droughts, implementing flood and drought management strategies like building small earth dams and promoting water conservation, and enhancing community-based disaster management practices to improve local preparedness and response.
- iv. **Sustainable Resource Use:** Promotes sustainable resource use through regulations for the sustainable extraction of water, minerals, and other natural resources, and encourages sustainable land and water management practices to reduce environmental degradation and ensure long-term resource availability.
- v. **Infrastructure Development:** Enhances infrastructure development by constructing boreholes, water treatment plants, and sanitation facilities to improve access to clean water and sanitation. It also includes initiatives to enhance energy access through renewable sources and improve transportation infrastructure for better connectivity and market access.
- vi. **Policy and Governance:** Strengthen governance and ensure effective policy implementation, promoting transparency and accountability in resource management and project execution. It also emphasizes stakeholder engagement, including local communities, in planning and implementation.

1.6 Governance and Institutional Roles

- i. **Governance Structure**
 - **Federal and State Governments:** The Federal Ministry of Environment plays a key role in overseeing the project, working closely with state governments to implement policies and regulations that support sustainable catchment management. The state

governments of Sokoto, Zamfara, Kebbi, Katsina, and Niger are actively involved in the planning and execution of the SCMP.

- **Stakeholder Engagement:** The plan emphasizes the importance of engaging all stakeholders, including local communities, traditional leaders, and non-governmental organizations. This collaborative approach ensures that diverse perspectives are considered, leading to more effective and sustainable solutions.

ii. Institutional Roles

- **ACReSAL Project Team:** The ACReSAL project team is responsible for coordinating the development and implementation of the SCMP. They work closely with stakeholders to identify intervention areas, assess resources, and develop strategic approaches to managing catchments.
- **World Bank:** The World Bank provides financial and technical support for the project, recognizing the significance of sustainable catchment management in addressing environmental challenges and enhancing resilience to climate change.
- **Local Communities:** Community representatives from the affected regions are invited to participate in the planning process. Their input is crucial in developing a shared vision for an ideal catchment that promotes peace, considers local opportunities and challenges, and is integrated into the catchment management plan.

iii. Implementation and Monitoring

- **Policy Development:** The plan includes measures to strengthen governance structures and ensure the effective implementation of policies and regulations. This involves promoting transparency and accountability in the management of resources and the execution of projects.
- **Capacity Building:** Initiatives are in place to build the capacity of local stakeholders, including training programs and workshops, to enhance their ability to manage catchment areas sustainably.
- **Monitoring and Evaluation:** Continuous monitoring and evaluation mechanisms are established to assess the effectiveness of the implemented strategies and make necessary adjustments. This ensures that the plan remains responsive to changing conditions and achieves its intended objectives.

CHAPTER 2 : CHARACTERISTICS OF THE CATCHMENTS

2.1 Location

2.1.1 Location and Boundary

The catchment covers the larger parts of Sokoto State, Zamfara State and Kebbi States with some parts of Katsina state. The area lies between latitude 11°26'02"N and 13°21'37"N, and longitude 3°43'55"E and 7°20'59"E. It is bounded by the Rima catchment to the North, Gulbin Ka catchment to the south and Hadejia-Jama're catchment to the East.

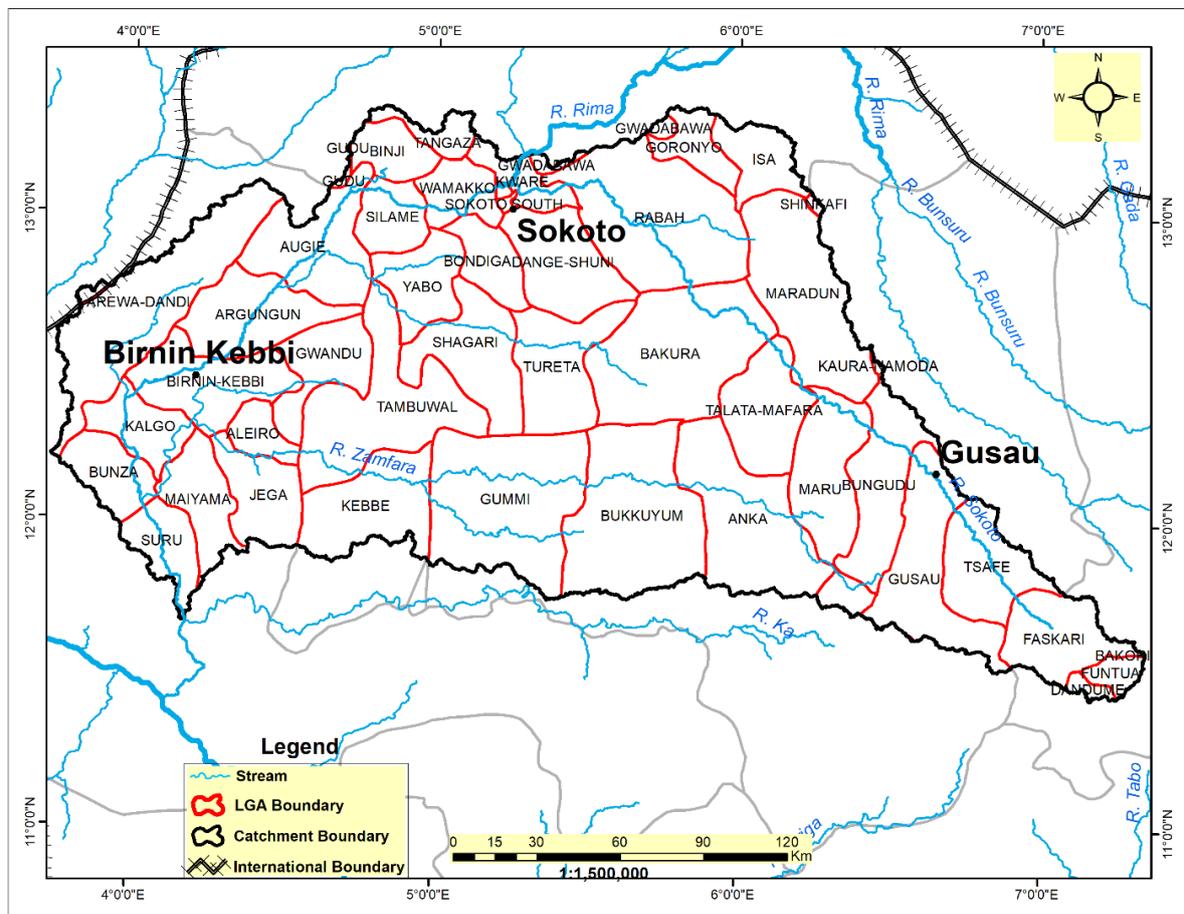


Figure 2.1: Sokoto-Zamfara catchment showing the LGA's (Source: MSL, 2025)

2.2 Precipitation, Temperature, Sunshine and Relative Humidity

The Sokoto-Zamfara Catchment experiences a tropical semi-arid climate characterized by distinct wet and dry seasons. Key climatic parameters including precipitation, temperature, sunshine duration, and relative humidity play a critical role in shaping the region's hydrological behaviour and ecological patterns. These factors influence water availability, agricultural productivity, and natural resource sustainability across the catchment.

2.2.1 Precipitation

The catchment experiences a unimodal rainfall pattern, influenced primarily by the northward movement of the Intertropical Convergence Zone (ITCZ). Annual precipitation across the catchment varies between 500 mm and 1,200 mm, with the rainy season occurring from late May or early June through September or early October. Rainfall intensity is highest between July and August, which typically account for the majority of the annual total. The southern and eastern parts of the catchment (closer to Kebbi and eastern Zamfara) receive relatively higher rainfall compared to the northern sections.

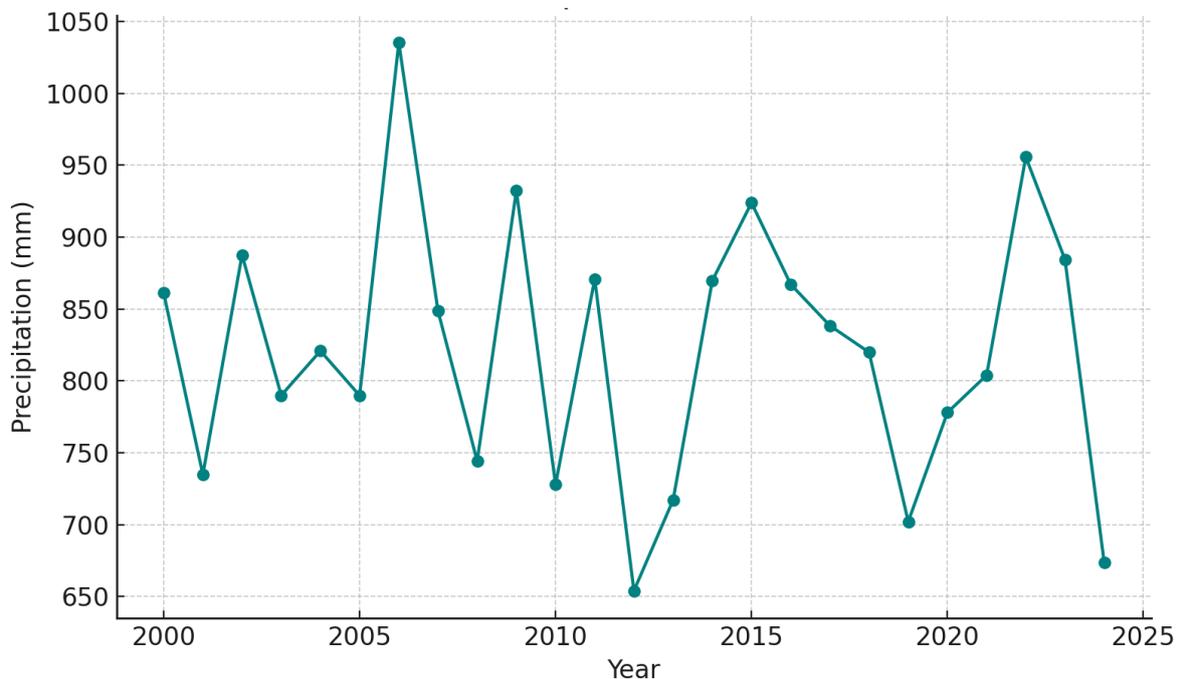


Figure 2.2: Annual Precipitation of the Catchment (2000 - 2024) (Source: MSL, 2025)

2.2.2 Temperature

The Sokoto-Zamfara Catchment, experiences a tropical semi-arid climate. Annual temperatures range between 20°C and 42°C. During the dry season (November to April), daytime temperatures often rise sharply, reaching peaks of up to 45°C, especially between March and May, which are typically the hottest months of the year. In contrast, during the rainy season (May/June to September/October), temperatures moderate, averaging between 25°C and 30°C due to increased cloud cover and rainfall. Nighttime temperatures during the dry season can drop significantly, particularly during the Harmattan period (December to February), occasionally falling to as low as 15°C.

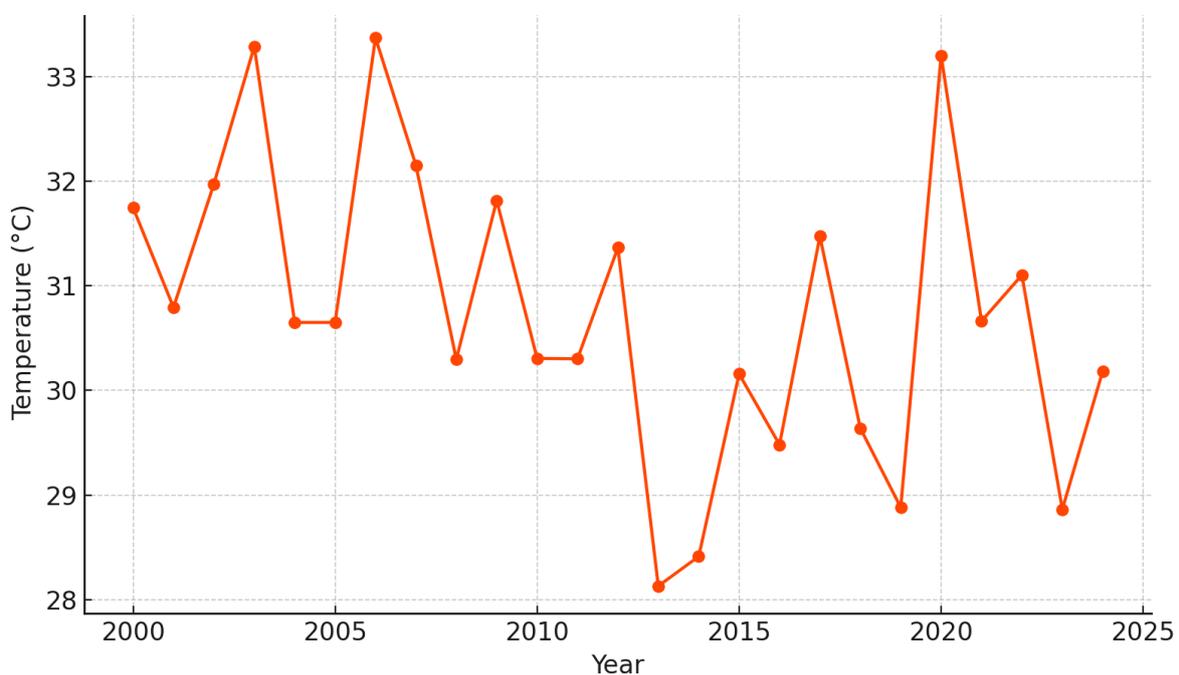


Figure 2.3: Annual Temperature of the Catchment (2000 -2024) (Source: MSL, 2025)

2.2.3 Sunshine Duration

The Sokoto-Zamfara Catchment receives abundant sunshine throughout the year, with average annual sunshine duration estimated between 3,000 to 3,900 hours. During the dry season (November to April), daily sunshine can exceed 9 to 11 hours per day, with March to May being the sunniest months. Sunshine hours reduce during the rainy season, particularly in July and August, due to cloud cover and more frequent rainfall, though the region still averages 5 to 7 hours of sunshine per day during this time. The high solar radiation has implications for evapotranspiration and also presents a significant potential for solar energy development.

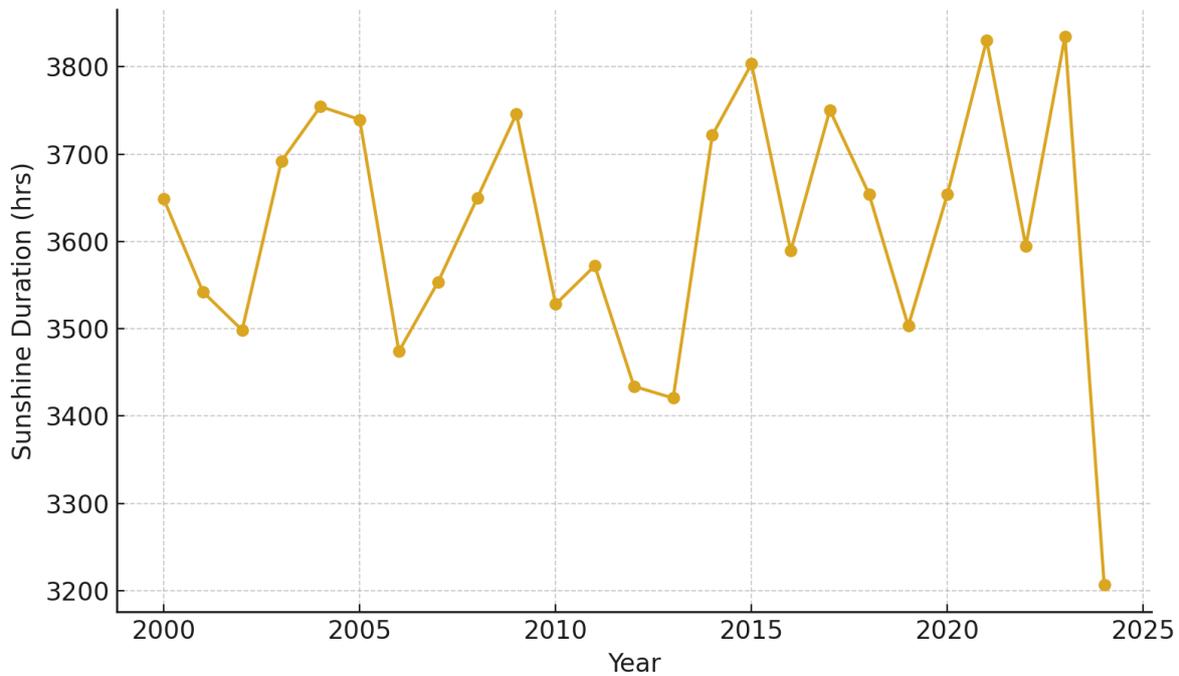


Figure 2.4: Annual Sunshine Duration (2000 - 2024) (Source: MSL, 2025)

2.2.4 Relative Humidity

Relative humidity in the catchment shows strong seasonal variation. During the dry season, especially in the Harmattan period (December to February), humidity levels can fall below 20%, contributing to the harsh, arid conditions typical of that period. In contrast, during the rainy season (June to September), relative humidity increases significantly, often ranging between 60% and 80%, peaking in August when rainfall is highest. The increased humidity during this period enhances agricultural productivity but also elevates risks related to pest outbreaks and waterborne diseases.

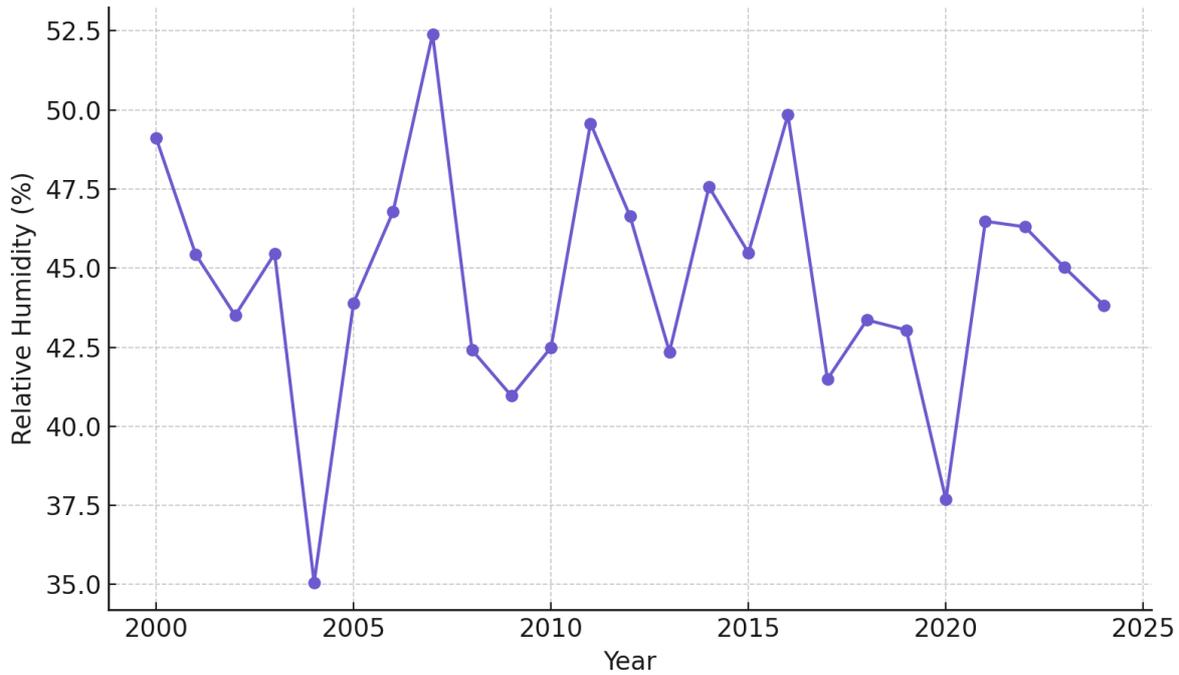


Figure 2.5: Annual Relative Humidity of the Catchment (2000 - 2021) (Source: MSL, 2025)

2.3 Topography, Drainage, Geology and Soils

2.3.1 Topography

The Sokoto-Zamfara Catchment includes Sokoto, Zamfara, and Kebbi states, alongside parts of Katsina.

- It features low to moderate relief, with elevations ranging from about 550 meters to 200 meters.
- The landscape includes flat plains and scattered hills, especially in the southern areas.
- Northern sections have expansive floodplains prone to seasonal flooding.
- The Sokoto-Rima River system is the primary drainage network, with significant water availability fluctuations between wet and dry seasons. This variability presents challenges for water resource management and necessitates effective conservation strategies.
- The interplay of topography and hydrology within the Sokoto-Zamfara Catchment is crucial in shaping land use, settlement patterns, and agricultural productivity in the region. Figure 2.6 depicts the digital elevation model of the catchment, which severally determines the catchment's general disposition.

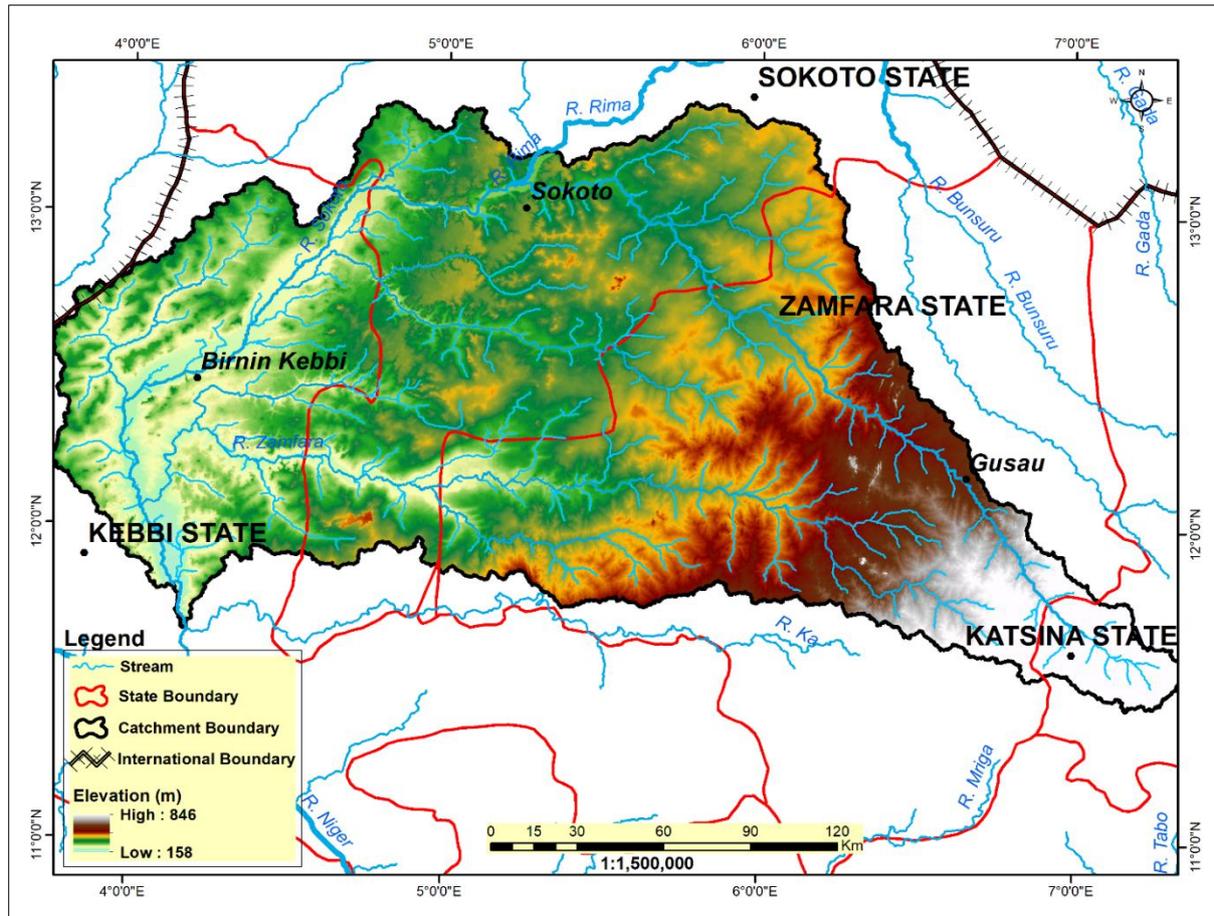


Figure 2.6: Digital Elevation Model (DEM) of the catchment (Source: MSL, 2025)

2.3.2 Drainage

The catchment is primarily defined by the Sokoto-Rima River System (consisting of the Rima, Sokoto) and Zamfara Rivers, which eventually drain into the Niger River.

The Rima River originates from the Gusau region in Zamfara State and flows through Sokoto, serving as a vital watercourse for irrigation, fishing, and floodplain agriculture. It forms a network of distributaries that contribute to seasonal floodplains, supporting local biodiversity and livelihoods.

The Sokoto River, the main river in the catchment, rises from the Funtua highlands in Katsina State and follows a northwesterly course before merging with the Rima River near Sokoto. It plays a critical role in regional hydrology, particularly in sustaining water supply for agriculture and domestic use.

The Zamfara River, another key tributary, originates from the elevated regions of Zamfara State and contributes significantly to the hydrology of the catchment. It provides an essential water source for agricultural activities and supports riparian ecosystems along its course before joining the Rima River.

The rivers in the catchment are highly influenced by seasonal rainfall patterns, with peak flows occurring during the rainy season (June to September). Hydrological conditions are further shaped by both natural and man-made factors, including reservoirs, irrigation schemes, and climate variability. Notable infrastructures such as the Goronyo Dam on the Rima River regulate water flow, impacting downstream hydrology and water availability for agricultural activities.

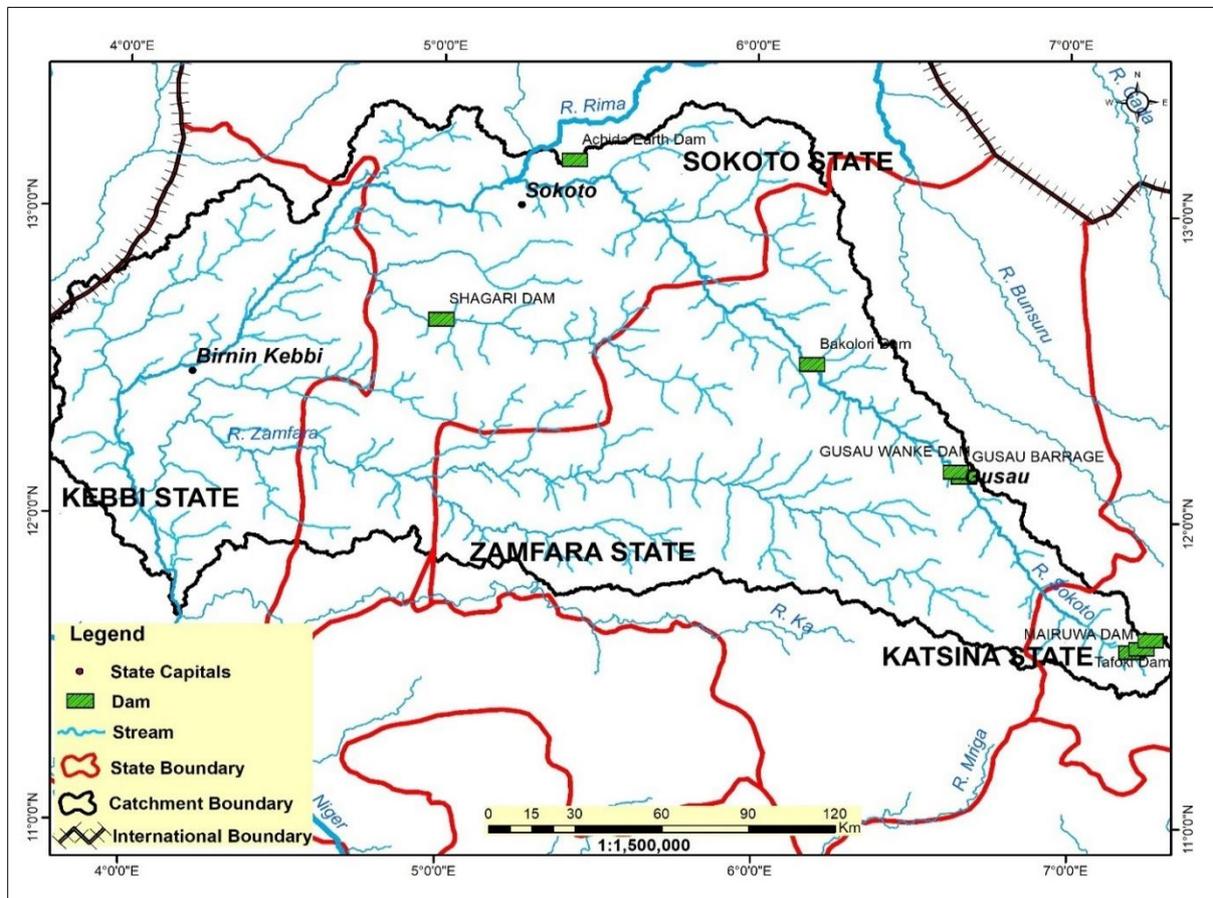


Figure 2.7: Drainage Map of Sokoto-Zamfara Catchment showing dams (Source: MSL, 2025)

STATES OF INFLUENCE

1. Sokoto state
2. Zamfara State
3. Kebbi state

4. Katsina State

Table 2.1: Morphometric Analysis of Sokoto-Zamfara Catchment

Morphometric Parameters		
Area(sq.km)	A	45,883.443223
Perimeter(km)	P	1,704.615141
Drainage Density(km/sq.km)	$D = Lu/A$	0.1156
Stream Frequency	$F_s = Nu/A$	0.0127
Texture Ratio	$T = N1/P$	0.1725
Basin Length(km)	L_b	407.9686
Elongation Ratio	$R_e = 2\sqrt{(A/\pi/L_b)}$	11.9696
Circulatory Ratio	$R_c = (4 \pi A) / P^2$	0.1984
Form Factor Ratio	$R_f = A/L_b^2$	0.2757

Stream Order (u)	Number of Streams (Nu)	Total Length of Streams in km (Lu)	Log (Nu)	Log (Lu)
1	294	2,659.460139	2.4683	3.4247
2	120	1,056.986047	2.0791	3.0236
3	99	923.163985	1.9956	2.9652
4	30	299.090023	1.4771	2.4756
5	43	369.866101	1.6334	2.5670

Bifurcation Ratio (R _b)				Mean Bifurcation Ratio
1 st order/2 nd order	2 nd order/3 rd order	3 rd order/4 th order	4 th order/5 th order	
2.45	1.2121	3.3	0.6976	1.9149

2.3.3 Geology and Soils

The Sokoto-Zamfara Catchment, spanning Sokoto, Zamfara, Kebbi, and parts of Katsina states, is underlain by diverse geological formations that influence soil development, water retention, and land use potential.

- The geology of the region is primarily composed of sedimentary formations, while the soils exhibit variations ranging from fertile alluvial deposits to arid sandy types.
- These geological and soil characteristics play a crucial role in shaping the agricultural and hydrological dynamics of the catchment.

2.3.3.1 Geology

The geological framework of the Sokoto-Zamfara Catchment can be categorized into two major provinces: the Precambrian Basement Complex and the Sokoto Basin sediments.

1. Precambrian Basement Complex (Southern Area)

The southern part of the catchment, covering Katsina, Zamfara, and Kebbi States, features Precambrian Basement Complex rocks like granites and gneisses. This elevated, rugged terrain has shallow, less fertile soils due to weathering and limited groundwater recharge from the low permeability of the bedrock.

2. Sokoto Basin Sediments (Northern Area)

The northern catchment, including Sokoto and Kebbi States, is part of the Sokoto Basin, characterized by Tertiary and Quaternary sediments like sandstones and claystones. These sediments, formed through fluvial processes, create a gently undulating landscape. The basin's porous sandstones play a significant role in groundwater storage and recharge.

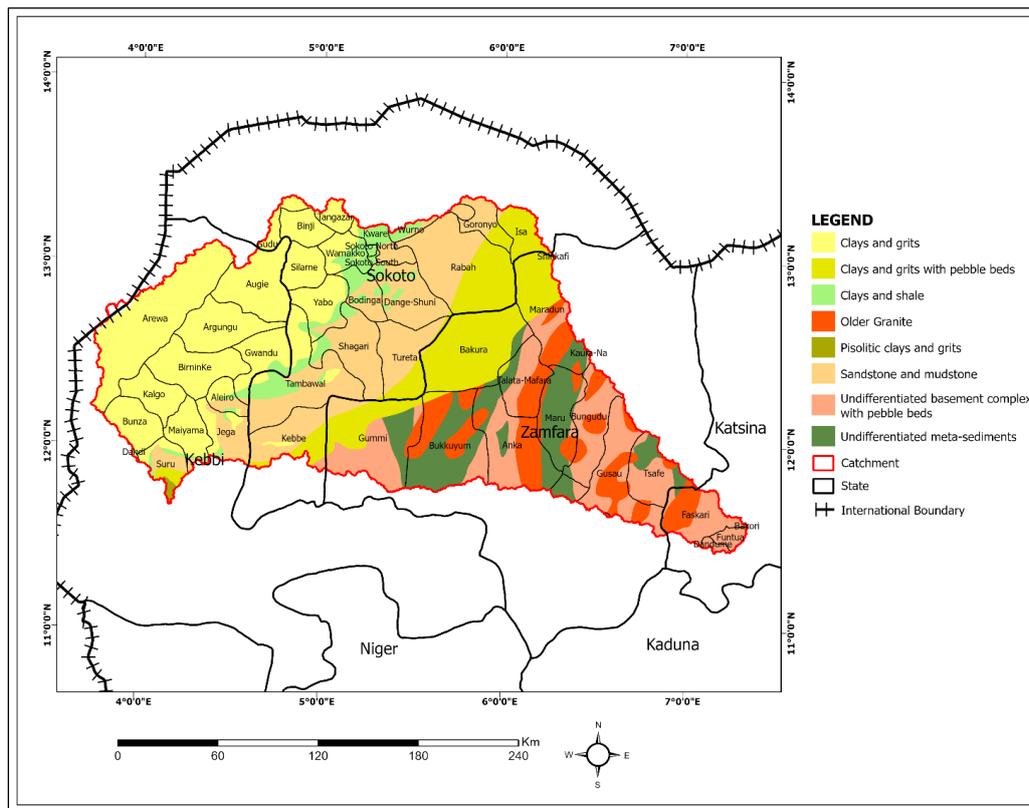


Figure 2.8: Geological Map of Sokoto-Zamfara Catchment (Source: MSL, 2025)

2.3.3.2 Soil Types

In the Sokoto-Zamfara Catchment, soils have been systematically classified following the FAO soil classification framework, which considers essential factors such as formation processes, underlying parent materials, and specific landscape positions. The primary soil types identified include Arenosols, Vertisols, Gleysols, Fluvisols, and Leptosols, each characterized by distinct physical and chemical properties that influence water retention, nutrient availability, and suitability for various vegetation and crop types.

1. Arenosols

Location: Found mainly in the northern catchment, especially Sokoto and Kebbi States.

Characteristics: Sandy, coarse-textured soils in arid regions, low water-holding capacity, and high permeability. **Agricultural Use:** Suitable for drought-resistant crops like millet and sorghum, needing fertilizers and irrigation for better yields.

2. Vertisols

Location: Found in floodplains and depressions across the catchment.

Characteristics: Clay-rich soils that shrink and swell with moisture changes. They are highly fertile but prone to waterlogging.

Agricultural Use: Ideal for rice and other crops that tolerate wet conditions but require careful management to avoid soil cracking.

3. Gleysols

Location: Found in waterlogged areas, particularly near floodplains.

Characteristics: Hydromorphic soils with poor drainage and prolonged water saturation.

Agricultural Use: Suitable for paddy rice cultivation but require drainage improvements.

4. Fluvisols

Location: Common along riverbanks and floodplains.

Characteristics: Young soils formed from recent river deposits with high fertility.

Agricultural Use: Used for flood-recession agriculture, supporting crops like rice, maize, and vegetables.

5. Leptosols

Location: Found in the rugged, elevated areas of Katsina, Zamfara, and Kebbi States.

Characteristics: Shallow, stony soils on hard rock substrates with limited agricultural potential.

Agricultural Use: Primarily used for grazing and forest land with minimal cultivation potential.

Sustainable agricultural practices and soil conservation measures are essential to maximizing productivity while mitigating environmental risks such as erosion, desertification, and waterlogging. Fig 2.9 is a map of the soil characterisation of the catchment.

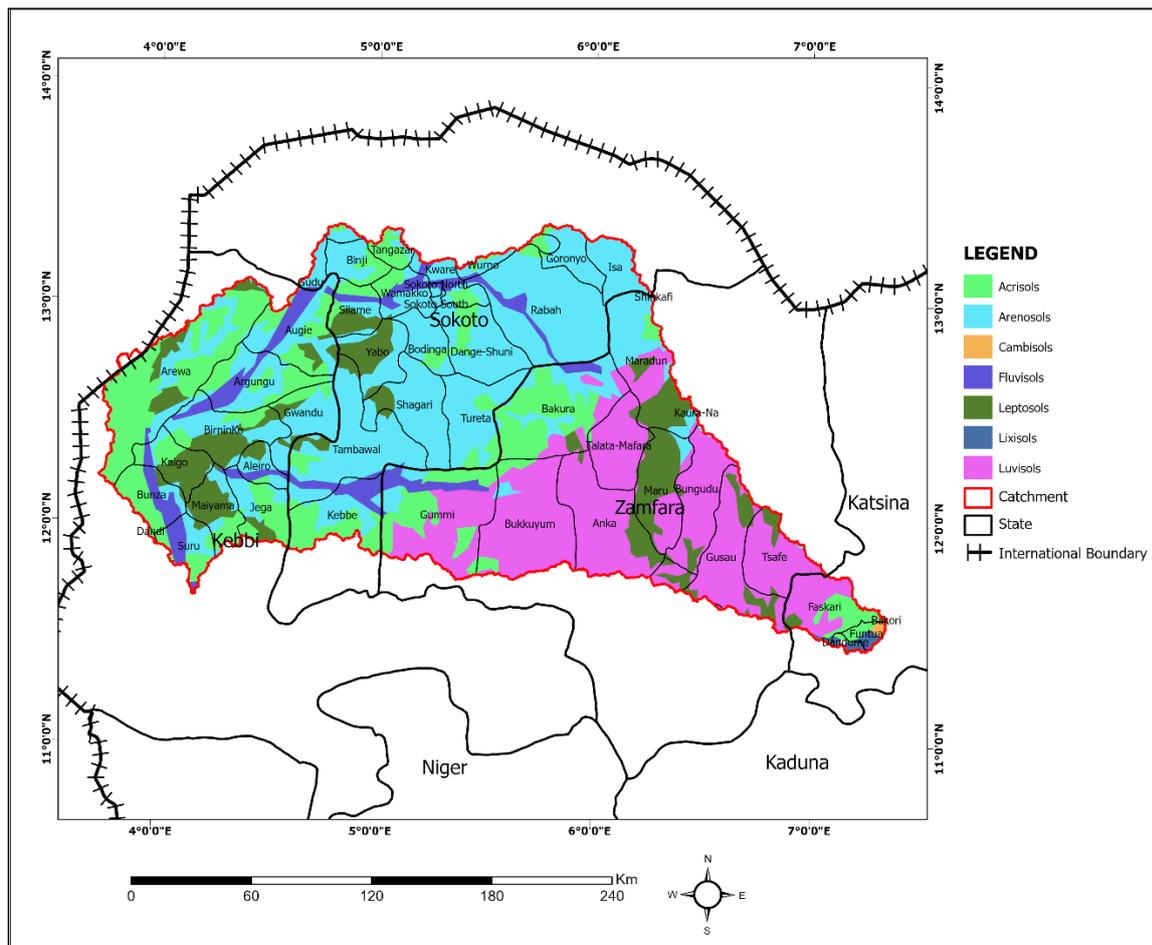


Figure 2.9: Soil Map of Sokoto-Zamfara Catchment (Source: MSL, 2025)

The varied geology and soil types in the catchment influence land use, were fertile alluvial soils support agriculture, while sandy soils in the north pose cultivation challenges. Effective land and water management, particularly irrigation, is crucial to optimize productivity and prevent soil degradation. Groundwater in the Chad Basin offers irrigation opportunities, but over-exploitation raises sustainability concerns amid climate change.

2.4 Land Use and Land Cover

The Sokoto-Zamfara Catchment features a diverse landscape shaped by natural processes and human activities. Key land uses include agriculture, livestock grazing, and wetlands. Human-induced changes like deforestation and land cultivation have significantly impacted the environment and water resources.

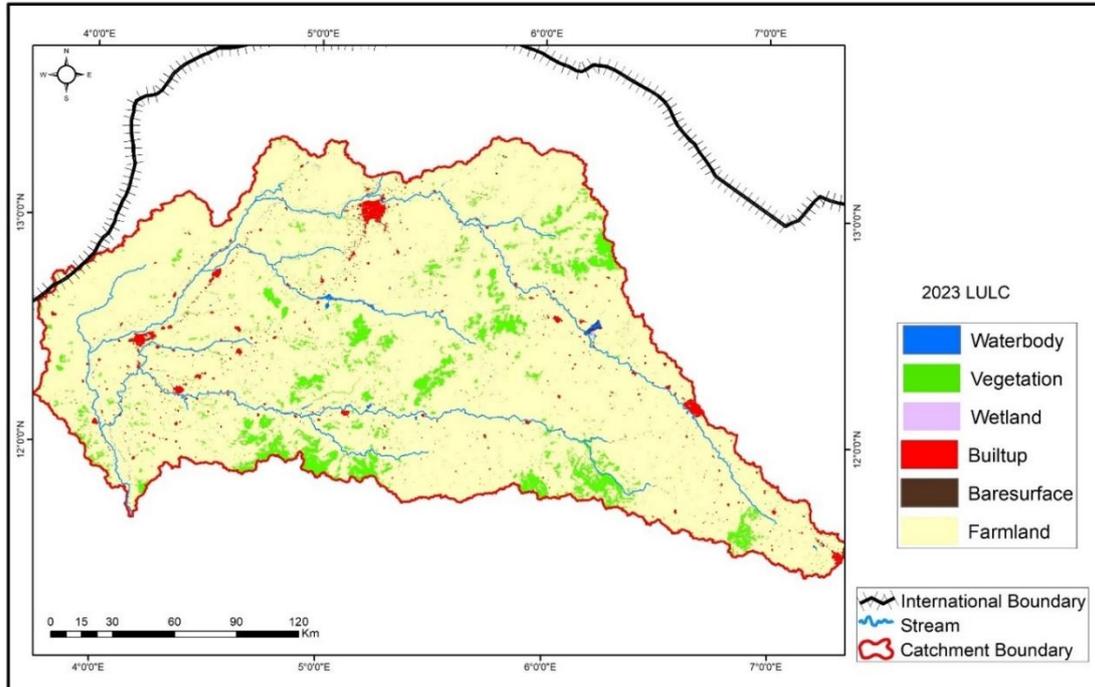


Figure 2.10: Land Use and Land Cover of Sokoto-Zamfara Catchment 2017 and 2023 (Source: MSL, 2025)

2.4.1 Natural Vegetation

The natural vegetation cover of the Sokoto-Zamfara catchment varies across different areas due to climatic conditions and soil characteristics.

- **Northern Area (Sokoto State)**

The northern part of the catchment in Sokoto State is characterized by Sudan savannah vegetation. This semi-arid region features scattered drought-resistant trees such as Acacia and Baobab, interspersed with short grasses. The vegetation is adapted to the dry climate and sandy soils, making it suitable for pastoral activities. However, human activities like overgrazing, fuelwood harvesting, and desertification have led to a gradual decline in vegetation cover.

- **Central Area (Kebbi State)**

The central portion of the catchment, covering Kebbi State, represents a transitional zone between the Sudan and Guinea savannas. The vegetation includes a mix of grasslands and scattered trees such as locust bean, shea butter, and tamarind. The moderate rainfall in this area supports a more diverse plant cover than the northern region, but agricultural expansion and deforestation continue to impact the natural vegetation.

- **Southern Area (Zamfara State)**

The southern part of the catchment, particularly in Zamfara State, falls within the Guinea savannah zone, which is characterized by a denser tree population and taller grasses. Dominant tree species include neem, shea butter, and locust bean. The relatively higher rainfall and fertile soils make this area favorable for farming, but increasing agricultural activities have contributed to deforestation and habitat loss.

2.4.2 Agricultural Land Use

Agriculture is the primary land use in the Sokoto-Zamfara catchment, with extensive farming activities shaping the landscape. The expansion of cultivated land, especially in fertile floodplain areas, has significantly influenced the region's environment and economy.

- **Rainfed Agriculture (Kebbi and Zamfara States)**

The majority of agriculture in the catchment is rainfed, particularly in Kebbi and Zamfara States, where relatively fertile soils, including Alfisols, support crop cultivation. Farmers in these areas grow staple crops such as millet, sorghum, maize, groundnuts, and cowpeas. However, dependence on seasonal rainfall makes agriculture vulnerable to climatic fluctuations, particularly in drier areas where droughts periodically reduce crop yields.

- **Irrigated Agriculture (Sokoto and Zamfara States)**

The floodplains of the Sokoto River and its tributaries in Sokoto and Zamfara States provide favorable conditions for irrigated farming. Irrigation systems support the cultivation of water-intensive crops such as rice, onions, vegetables, and wheat. While irrigation has boosted

agricultural productivity, it has also led to increased pressure on water resources, particularly in the dry season, contributing to conflicts over water use between farmers and pastoralists.

- **Fallow and Shifting Cultivation (Northern Sokoto and Parts of Zamfara State)**

In areas with less fertile soils, particularly in northern Sokoto and parts of Zamfara State, traditional fallow and shifting cultivation practices are still employed. Farmers leave land uncultivated for regeneration before resuming farming. However, rising population pressure has led to shorter fallow periods, resulting in soil degradation, reduced fertility, and declining agricultural yields over time.

2.4.3 Wetlands

The wetlands of the Sokoto-Zamfara catchment are significant land cover features, particularly in Sokoto, Zamfara, and Kebbi States. These wetlands, sustained by the Sokoto River and its tributaries, play a crucial role in supporting biodiversity, regulating water flow, and sustaining local livelihoods.

- **Ecological Significance (Sokoto, Zamfara, and Kebbi States)**

The wetlands provide essential habitats for various bird species, aquatic plants, and fish populations, serving as critical breeding and feeding grounds. They also function as natural flood regulators, absorbing excess water during the rainy season and gradually releasing it in the dry season. This process helps maintain water availability for surrounding communities, supports groundwater recharge, and reduces the risk of flooding.

- **Agricultural Use (Sokoto, Zamfara, and Kebbi States)**

Wetland agriculture, especially rice farming, thrives in the Sokoto River floodplains due to seasonal flooding that enhances soil nutrients. In Kebbi State, large-scale rice farming has grown thanks to these favorable conditions. However, unsustainable practices and water diversion jeopardize the wetlands' long-term sustainability, highlighting the need for better management.

2.4.4 Grazing Land and Pastoralism

Livestock grazing is a major land use in the Sokoto-Zamfara catchment, particularly in the northern and central regions, where pastoralism serves as a key livelihood. Nomadic and semi-nomadic herders move across the area in search of pasture for their cattle, sheep, and goats. Grazing lands include the natural grasslands of the savannah and marginal lands unsuitable for crop cultivation.

- **Pastoralism in Northern Areas (Sokoto and Kebbi States)**

The drier northern parts of Sokoto and Kebbi States support a significant number of pastoralists. However, overgrazing has contributed to land degradation and vegetation loss in some areas. This problem is further intensified by climatic factors such as reduced rainfall and more frequent droughts, leading to declining pasture availability.

- **Conflict with Agricultural Land (Sokoto, Zamfara, and Kebbi States)**

The expansion of cropland into traditional grazing areas has led to increasing competition for land and resources between farmers and herders. As both groups struggle to access fertile land and water—especially during dry seasons—disputes over land use have become more frequent. This ongoing competition highlights the need for improved land management and conflict resolution strategies to balance the needs of both agricultural and pastoral communities.

2.4.5 Human Settlements

Human settlements in the Sokoto-Zamfara catchment are primarily concentrated around river systems and fertile agricultural zones. Population density is higher in the southern parts of the catchment, particularly in Sokoto, Zamfara, and Kebbi States, where both urban and rural settlements thrive.

- **Urban Areas (Sokoto, Zamfara, and Kebbi States)**

Major urban centers such as Sokoto, Gusau, and Birnin Kebbi serve as economic hubs, supporting trade, manufacturing, and services. The expansion of these urban areas is exerting pressure on surrounding agricultural and grazing lands. In recent years, urban sprawl has led to the conversion of peri-urban farmland into residential and commercial developments, reducing available land for food production and livestock grazing.

- **Rural Settlements (Sokoto, Zamfara, and Kebbi States)**

Most rural settlements in the catchment consist of small villages and hamlets closely tied to agricultural activities. These settlements depend on farming and livestock rearing for their livelihoods. However, many rural areas face challenges such as limited access to essential infrastructure, including roads, schools, and healthcare facilities. This lack of infrastructure hinders socio-economic development and contributes to rural-urban migration.

2.4.6 Forest and Woodland Areas

Small patches of forests and woodlands are present in the southern parts of the Sokoto-Zamfara catchment, particularly in Zamfara, Kebbi, and parts of Sokoto State. These areas are mainly found in protected reserves or as remnants of the original savannah woodlands.

- **Deforestation (Zamfara, Kebbi, and Sokoto States)**

Deforestation has been widespread across the catchment due to agricultural expansion, overgrazing, and high demand for firewood and charcoal production. This has led to biodiversity loss, increased soil erosion, and the degradation of water catchment areas, making the land more susceptible to desertification.

- **Reforestation Efforts (Sokoto, Zamfara, and Kebbi States)**

To combat deforestation, various reforestation and afforestation projects have been introduced, particularly in areas at risk of desertification, such as northern Sokoto and parts of Zamfara and Kebbi States. These initiatives focus on restoring degraded lands, improving soil fertility, and enhancing water retention through tree-planting campaigns and sustainable land management practices. Fig 2.11 shows the vegetative map of the catchment.

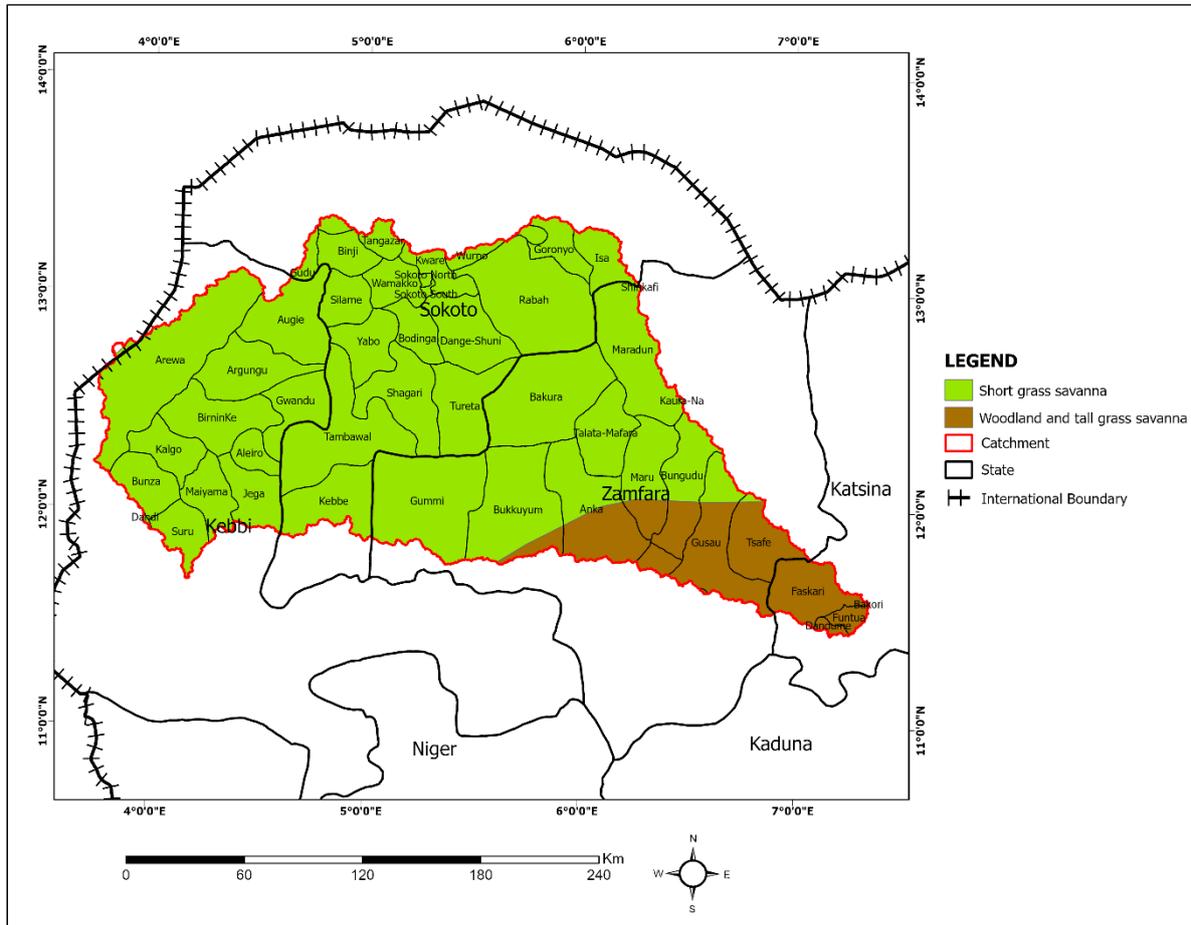


Figure 2.11: Vegetation Map of Sokoto-Zamfara Catchment (Source: MSL, 2025)

2.4.7: Biodiversity

Ecosystem Type / Zone	Representative Flora	Representative Fauna	Ecosystem Services	Key Biodiversity Challenges
Sudan & Sahel Savanna	<i>Acacia senegal</i> , <i>Acacia nilotica</i> , <i>Vitellaria paradoxa</i> , <i>Parkia biglobosa</i> , <i>Adansonia digitata</i> , grasses (<i>Andropogon</i> , <i>Pennisetum</i>)	Patas monkey, Roan antelope (now rare), warthogs, African civet, rodents	- Livestock grazing- Fuelwood- Soil fertility & erosion control- Medicinal & food products	- Deforestation- Overgrazing- Habitat loss- Firewood exploitation
Riparian Forests & Riverbanks	<i>Khaya senegalensis</i> , <i>Ficus spp.</i> , <i>Tamarindus indica</i> , <i>Dum Palm</i> (<i>Hyphaene thebaica</i>)	Crocodiles, otters, fish e.g., tilapia, catfish; birds like pied kingfisher, African fish eagle	- Water purification- Erosion control- Biodiversity corridors-	- Sand mining- Riparian degradation- Agrochemical runoff

			Livelihoods from fisheries	
Wetlands & Floodplains	<i>Typha domingensis</i> , <i>Nymphaea lotus</i> , <i>Echinochloa spp.</i> , <i>Oryza longistaminata</i>	Black-crowned crane, white-faced whistling duck, Nile crocodile, frogs, West African mud turtle	- Flood buffering- Dry season grazing- Fish breeding habitats- Migratory bird refuge	- Typha invasion- Wetland encroachment- Water abstraction
Aquatic Ecosystems (Rivers, Dams)	Aquatic macrophytes, wild rice	Tilapia (<i>Oreochromis niloticus</i>), Catfish (<i>Clarias gariepinus</i>), <i>Labeo</i> species	- Fisheries & food- Water supply- Economic trade- Aquatic biodiversity	- Dam impacts- Pollution- Declining fish stocks
Inland Forest Patches	<i>Anogeissus leiocarpa</i> , <i>Daniellia oliveri</i> , <i>Vitellaria paradoxa</i>	African civet, parrots, small monkeys	- Non-timber products- Cultural values- Carbon sequestration	- Charcoal production- Fragmentation- Poaching
Agro-ecological Systems	Millet, sorghum, cowpea, groundnut, rice	Sokoto Gudali cattle, Red Sokoto goats, West African dwarf sheep, local poultry	- Food & nutrition- Seed & breed conservation- Soil fertility- Livelihood diversity	- Genetic erosion- Agrochemical use- Climate stress on crops and livestock

2.5 Hydrology and Water Resources

2.5.1 Hydrology

The hydrology of the Sokoto-Zamfara catchment is shaped by its river network, seasonal flooding, groundwater systems, and wetlands. The primary rivers in the basin are the Rima, Sokoto, and Zamfara Rivers. These play a crucial role in the region’s water dynamics, influencing agriculture, water supply, and floodplain ecosystems.

2.5.2 Hydrograph/Water Budget of The Catchment

The hydrographs and water budgets of this strategic catchment are characterized by a semi-arid climate with high temperatures and low rainfall. Rainfall is seasonal, concentrated between June and October, with the majority of precipitation occurring during this wet season. As

illustrated in Figures 2.12, 2.13 2.14 and 2.15, the catchment's hydrographs and water budget graphs exhibit homogeneous hydrologic characteristics. Key features include:

- Peak flows in August.
- High evapotranspiration rates (Figure 5)
- Seasonal runoff patterns

The catchment experiences a peak flow time of four months, with a dry season almost as long as the rainy season. Evapotranspiration consistently exceeds precipitation, leading to a low average water budget of 103.00mm and water surplus for only four months. Table 1 summarizes the hydrologic catchment parameters. In general, there is a need for alternative water supply solutions.

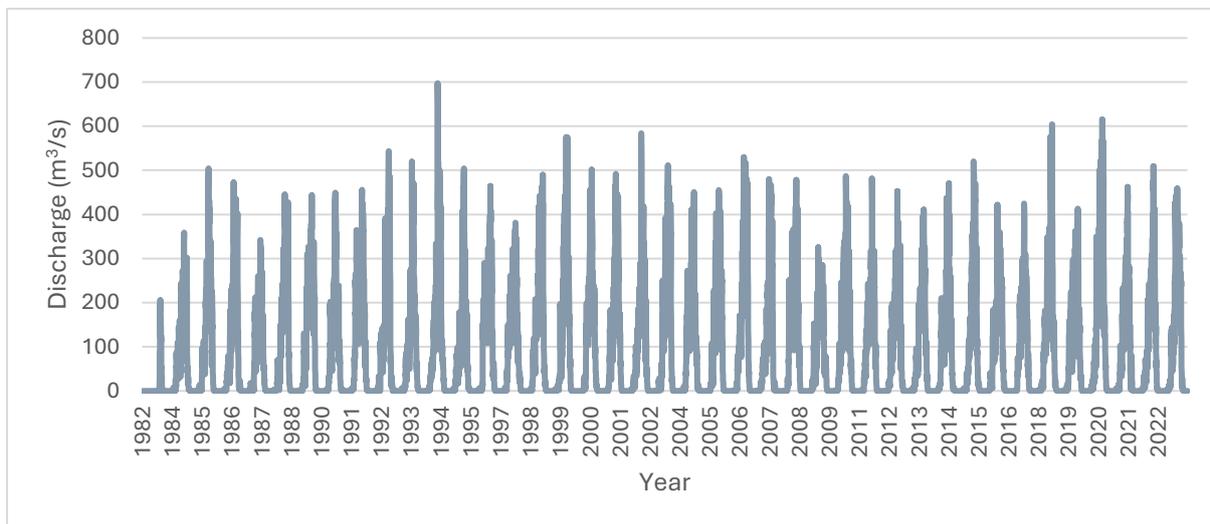


Figure 2.12: Hydrograph of Sokoto-Zamfara Strategic Catchment (Source: MSL, 2025)

Based on HEC-HMS modelling for Strategic catchment.

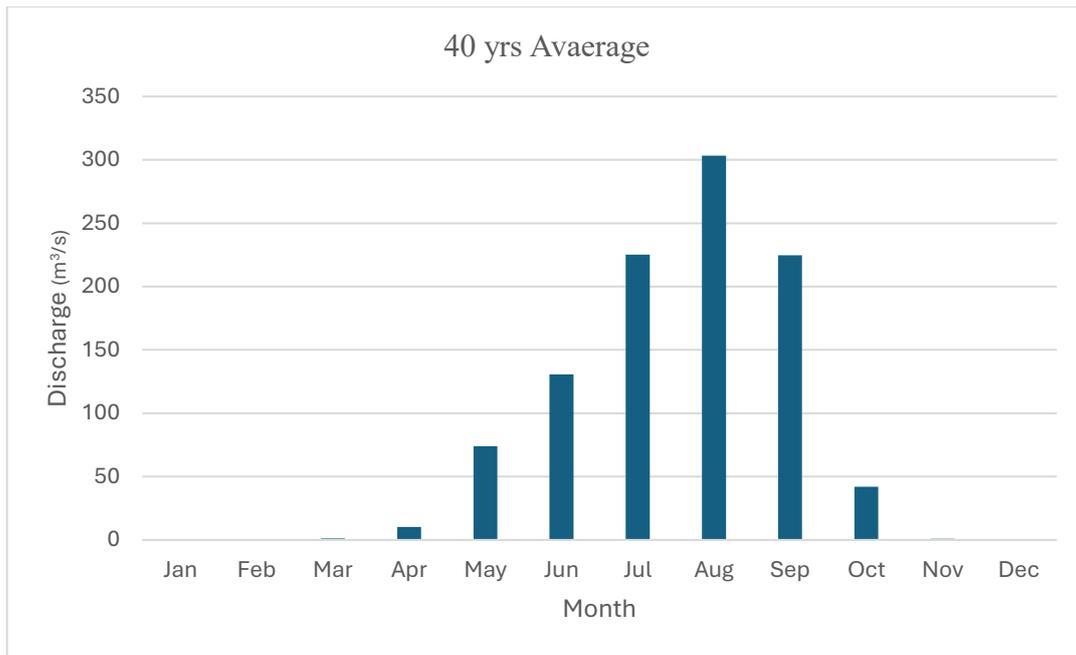


Figure 2.13: 40 - Year Summary Hydrograph of Sokoto-Zamfara Strategic Catchment (Source: MSL, 2025)

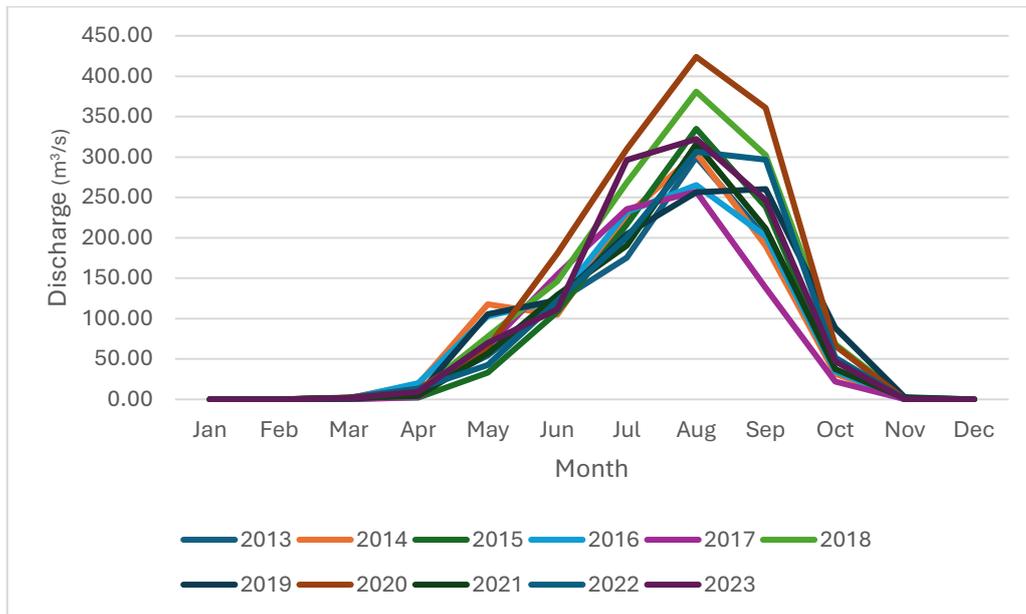


Figure 2.14: Hydrograph of Gulbin Strategic Catchment for Specific Year (Source: MSL, 2025)

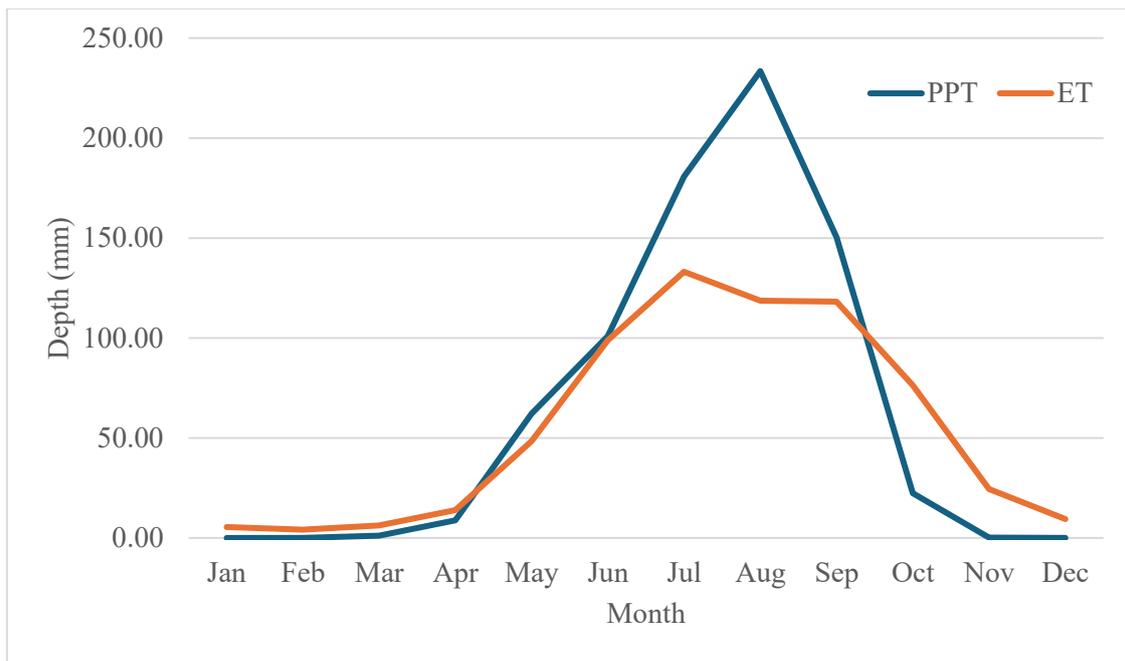


Figure 2.15: Water Budget for Sokoto-Zamfara Strategic Catchment (Source: MSL, 2025)

2.5.2.1 The Sokoto Zamfara Strategic Catchment

The Sokoto-Zamfara Strategic catchment consists of the Sokoto and Zamfara sub-catchments, influenced by a complex river system and seasonal flooding. The Sokoto River, a key tributary of the Niger, flows through Gusau, where the Gusau Dam creates a reservoir. The Sokoto Dam further alters the flow, impacting water availability downstream. The Zamfara River supports local agriculture, emphasizing the importance of these waterways for livelihoods.

2.5.2.2 Water Resources Assessment Concept in the Catchment

Water demand in the Sokoto-Zamfara Catchment exceeds supply, posing challenges for sustainable management.

- Factors like climatic variability, population growth, and weak regulations contribute to this pressure.
- Declining flow from the Sokoto and Zamfara Rivers results from siltation, sedimentation, and water regulation from reservoirs. Invasive aquatic weeds, especially Typha grass, further disrupt water flow.
- Conflicts arise among agriculture, domestic use, and industry, highlighting the need for an integrated water resource management strategy.

2.5.2.3 Stream Flow and Seasonal Variability

Stream flow in the Sokoto-Zamfara Catchment exhibits strong seasonal variations, largely influenced by rainfall distribution. The hydrological regime is characterized by distinct wet and

dry season fluctuations, which impact river discharge, groundwater recharge, and floodplain dynamics.

a) Wet Season Flow

The wet season (June to September) marks the peak of river discharge within the catchment, driven by monsoonal rainfall and surface runoff contributions. Rainfall is more intense in the upstream areas of Zamfara and Kebbi States, where runoff from elevated terrains feeds into the Sokoto and Zamfara Rivers and their tributaries. Peak flows typically occur between July and September, supporting floodplain agriculture and replenishing groundwater reserves.

Sokoto River: The Sokoto River experiences a sharp rise in discharge during the wet season, with flow rates ranging between 50 and 200 cubic meters per second (m^3/s), depending on rainfall intensity. Flooding is common along its lower courses, particularly in Sokoto State, where extensive floodplains temporarily store excess water.

Tributary Contributions: The Ka, Zamfara, and Gagere Rivers serve as important seasonal tributaries to the Sokoto River system, providing short-lived but intense water inflows. These tributaries support rain-fed agriculture, local fisheries, and wetland ecosystems.

b) Dry Season Flow

From October to April, river discharge declines significantly as rainfall ceases. Water availability becomes dependent on groundwater contributions, wetland residual storage, and controlled releases from major reservoirs. Flow rates can drop below $15 \text{ m}^3/\text{s}$ in smaller tributaries, raising concerns about irrigation water shortages and livestock water access.

Bakolori and Goronyo Dams: These major hydrological structures play a crucial role in regulating dry-season flows by storing and gradually releasing water. However, increased upstream water withdrawals for irrigation and domestic use have led to reduced downstream water availability, affecting farming communities.

Floodplain Reservoirs: The floodplains of Sokoto and Zamfara States act as natural seasonal reservoirs, providing essential moisture for dry-season farming and livestock grazing. However, changing rainfall patterns, increasing water abstraction, and sedimentation are reducing their storage capacity over time.

2.5.2.4 Discharge Measurements

Continuous monitoring of river discharge is crucial for effective water resource management, especially in a catchment with high seasonal variability like Sokoto-Zamfara. Discharge measurements provide insights into:

- Water availability trends
- Flood risks and mitigation strategies
- Long-term hydrological changes

The Nigeria Hydrological Services Agency (NIHSA) and state water management bodies conduct periodic river flow assessments. These measurements guide irrigation scheduling, reservoir operations, and flood control planning to optimize water use.

2.5.2.5 Surface Water Resource Potential

Nigeria's average annual precipitation is about 1,150mm, with Hydrological Area 1 (HA-1) receiving 767mm/year. Only 24% contributes to surface runoff, resulting in 10.7 BCM of internal surface water generation. Approximately 71.4% of Nigeria's surface water resources rely on transboundary inflows, totalling 26.7 BCM/year.

The total renewable groundwater recharge in HA-1 is estimated at 5 BCM/year, reinforcing the need for sustainable groundwater management strategies. Fig 2.16 shows the entire HA 1 area encapsulating the Sokoto-Zamfara strategic Catchment.

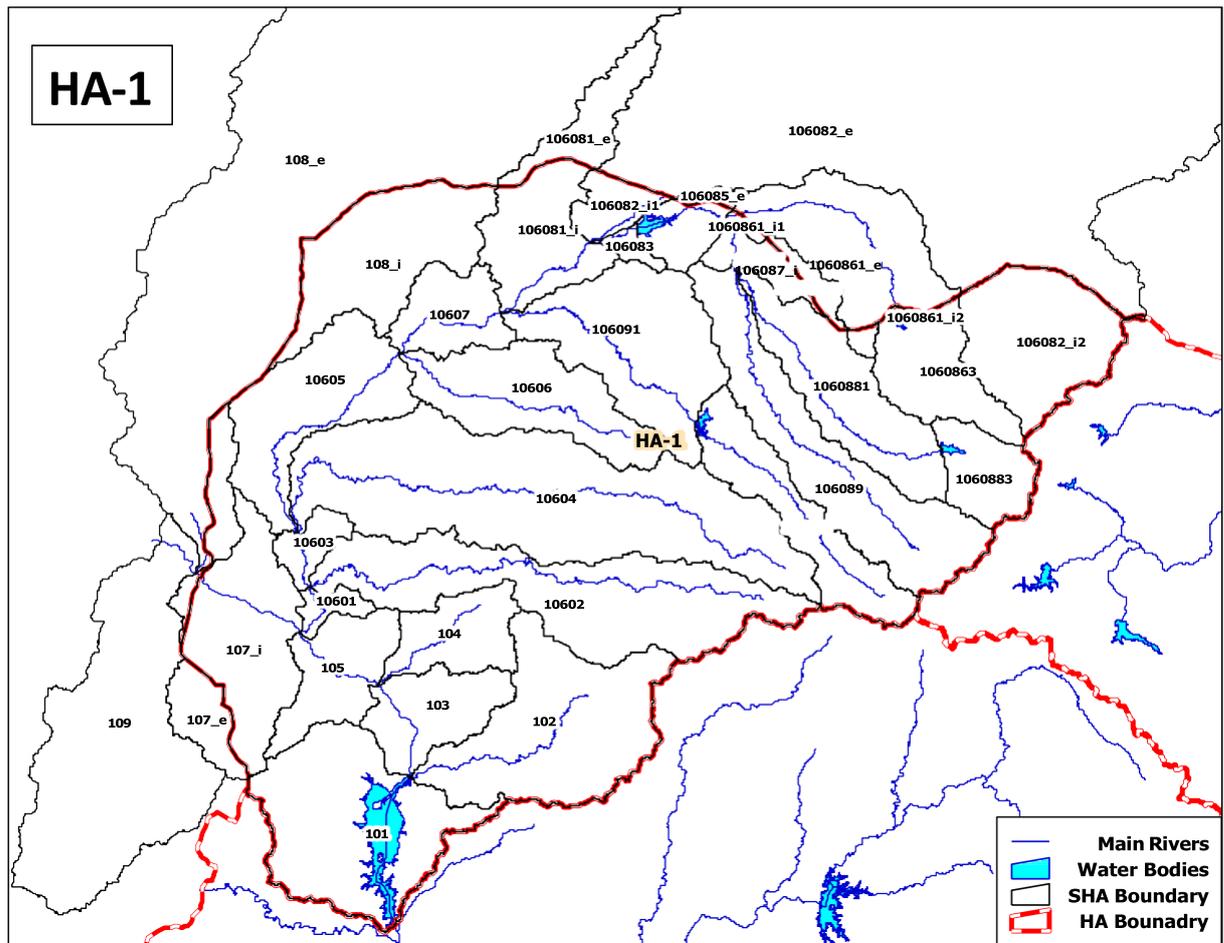


Figure 2.16 Water Resources of the catchment

Table 2.2: Table below shows the water resource potential for HA-1

		HA-1
Water Resources Potential		
Total Water Resources Potential		
Including inflow from outside Nigeria	(BCM /year)	37.4
Only internal generation in Nigeria	(BCM /year)	10.7
Surface Water Resources Potential		
Including inflow from outside Nigeria	(BCM /year)	35.1
Only internal generation in Nigeria	(BCM /year)	8.4
Groundwater Resources Potential		
Groundwater Recharge	(BCM /year)	5
Runoff Condition (Only internal generation in Nigeria)		
Precipitation (P)	(mm/ year)	767

Total Runoff (RO)	(mm/year)	62
Groundwater Recharge (GRE)	(mm/year)	37
Loss of Recharge (LOS)	(mm/year)	18
Runoff Rate (RO/P)	(%)	8.1
Recharge Rate (GRE/P)	(%)	4.8
Loss Rate (LOS/P)	(%)	2.3
Total Water Res. Rate ((RO+LOS)/P)	(%)	10.4

Source: JICA Project Team

2.5.3 Hydrogeological Disposition of the Catchment

The hydrogeological disposition of the catchment and its hydrogeological units and aquiferous layers make up part of the water resources of the catchment, as seen and explained in figure 2.17.

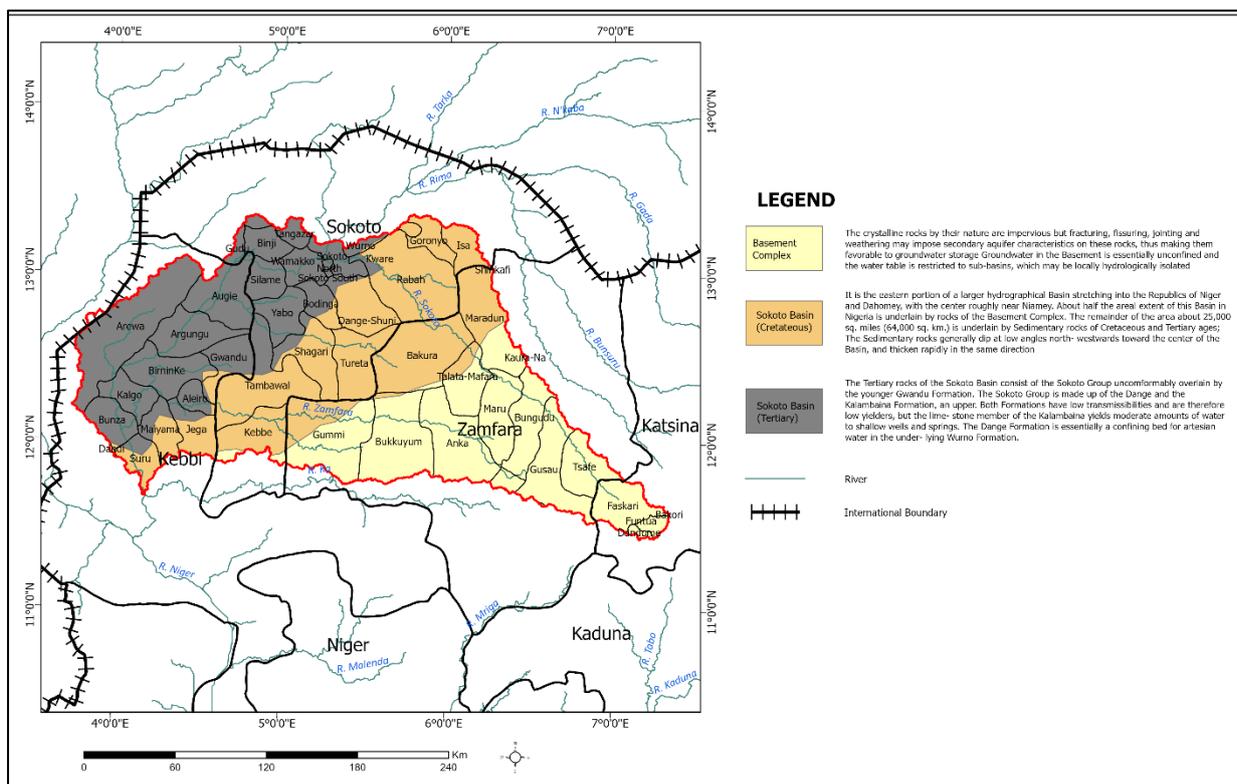


Figure 2.17: Hydrogeological province Map of the Catchment (Source: MSL, 2025)

2.5.3.1 Groundwater Recharge

Groundwater recharge in the Sokoto-Zamfara Catchment is declining due to climate change, increased water use, and land-use changes. Areas with shallow aquifers and high evapotranspiration are particularly vulnerable. The impact of reduced recharge is more severe in regions with low natural recharge rates.

Groundwater depletion is less severe near rivers due to subsurface flow, while inland areas like Zamfara, Kebbi, and Sokoto States face greater risks due to minimal recharge and reliance on seasonal rainfall. Tailored climate adaptation strategies are essential for these regions. While interventions may include:

- Enhancing artificial groundwater recharge through floodplain storage and managed aquifer recharge (MAR) techniques.
- Implementing water conservation practices to reduce over-extraction for irrigation and domestic use.
- Strengthening monitoring networks to track groundwater trends and inform sustainable management strategies

2.6 Water Demand for Sokoto-Zamfara Catchment

2.6.1 Water Availability by Sub-Basin

The water resources availability (cumulative annual flow volume) under natural conditions, by sub-basin are as follows:

Sokoto Sub basin : 1600, - 2100MCM/year

Zamfara Sub-basin: 1100 – 1700MCM/year

Bakalori dam: Reservoir capacity 450MCM

2.6.2 Water Use and Demands

Current and future water demand for Sokoto-Zamfara Catchment were estimated utilizing the methodology adopted in the NWRMP (JICA Team, 2014). The demand-related data obtained was based on the State level. The States considered are Sokoto, Zamfara, kebbi and part of Katsina.

The water demand is divided into the following categories:

- Municipal water demand (including domestic, commercial, and industrial).
- Irrigation water demand.
- Livestock water demand.
- Aquaculture water demand.

2.6.2.1 Municipal water demand

Municipal water consists of drinking, cooking, bathing, flushing, and washing water, and also other water usage in our daily lives. Municipal demand increases by not only increase in population served but also with improvement in living standards.

Daily average domestic water consumption is calculated by multiplying the population served by per capita consumption (lit/cap/day).

Municipal water use within the catchment area is mostly met by groundwater scheme, though there exist surface water treatment facilities in major state capitals, but areas of coverage is low.

2.6.2.2 Livestock Indices and Water Demand

The north of the country has a significantly larger number of livestock than the south due to frequent droughts that limit crop farming. Scant annual precipitation results in low surface water availability, forcing livestock to rely on well water. Livestock water consumption depends on atmospheric temperature, weight, and available grazing.

- Because 80% of the weight of grazing grass is nothing but water, and if a cattle graze and browse 20 kg/day, it is equivalent to drink 16 liter of water that can maintain a day of an adult cow with her live weight of 240kg (0.15 l / kg live weight).
- In an extreme drought year, with an annual rainfall of 400mm or less, grass cover becomes so thinner over grazing field that adult cattle cannot graze more than 5kg a day. In such a case it should drink at least 11 liter of water at watering spots a day to maintain its body.
- Moreover, moving/ walking livestock require more water, about double as much as the staying one. That the reason why adult cattle needs 25 ~ 35 liter of water per day on average depending on its live weight and its activities.
- As to other ruminants like goats and sheep. The situations are similar to the case of cattle. The following table shows a standard of livestock water requirement in the tropical zone shown in one of livestock guidebook published by FAO in 1960s. Of course, domestically kept livestock and nomadic one has different standard in a strict sense:

Table 2.3: Water requirement per head of livestock

Livestock specie	Live Weight (kg)	Maintaining* need (L/day)	Uptake from grazing Grass/ feeds (L/day)	Gross water Drink (L/day)	Annual (m ³) requirement
Cattle	250	60	38.4	21.6	
Goat	30	6.6	4.3	2.3	
Sheep	40	8.8	6.8	2.0	
Pig	90	20	16.7	3.3	
Donkey	110	24	15.6	8.4	
Camel	350	80	55.4	24.6	
Horse	300	70	47.8	22.2	
Fowl					

Source: FAO Livestock Guide-book in Tropical African Countries, 1960

Table 2.4: Number of livestock heads/ fowls in 2009 / 2010

Livestock Heads	Cattle	Goats	Sheep	Pigs	Poultry	Donkeys	Camels	Horses
Kebbi	440,469	1,974,189	1,063,894	140,500	3,598,760	14,726	18,057	4,174
Sokoto	1,427,080	3,155,584	3,194,837	35,000	3,848,501	73,107	20,162	0
Zamfara	458,720	2,334,979	2,115,105	12,975	6,941,239	13,748	44,421	96,285
Total	2,326,269	7,464,752	6,373,836	188,475	14,388,500	101,581	82,640	100,459

Source: Jica Team

Table 2.5: Estimated growth rate of livestock heads during the period 2010 ~ 2030

Specie	Formula of linear regression	Annual growth rate
Cattle:	Y= 121.3 X + 15,470.2	0.681%/year
Goats:	Y= 1352.2 X + 41,466.8	2.011%/year
Sheep:	Y= 1372.3 X + 20,327.7	3.000%/year
Pigs:	Y= 268.3 X + 7,411.7	2.154%/year
Fowls:	Y= 1265.9 X + 79,006.1	1.227%/year

Table 2.6: Corresponding livestock water requirement projected in 2050

WATER DEMAND (M3) FOR EACH LIVESTOCK IN THE SOKOTO-ZAMFARA CATCHMENT PROJECTED TO 2050									
	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cattle	18314716	18946884	19600872	20277434	20977349	21701422	22450489	23225411	24027081
Goats	6330109	6992721	7724693	8533285	9426518	10413250	11503271	12707390	14037552
Sheep	4729386	5482655	6355899	7368229	8541797	9902284	11479461	13307842	15427436
Pigs	225039	250907	279748	311904	347757	387731	432299	481991	537395
Poultry	561152	613947	671709	734905	804047	879695	962459	1053010	1152081
Donkeys	312565	346792	384767	426900	473647	525514	583059	646906	717745
Camels	742025	823279	913431	1013455	1124432	1247562	1384174	1535746	1703916
Horses	806686	895021	993029	1101769	1222417	1356276	1504793	1669573	1852398
TOTAL	32,021,678	34,352,206	36,924,149	39,767,883	42,917,965	46,413,734	50,300,006	54,627,870	59,455,603

Source: JICA 2014 MP

Table 2.7: Breakdown of water requirement into hydrological area (HA)

Water Demand (MCM)			
HA	2010	2030	2050
1	49.2	63.9	78.6

2.6.2.3 Aquaculture water demand

Basic Data for 2030 projection: Area of farm ponds by Fishery Statistics of Nigeria, Inventory of Private and Government Fish Farm and Hatcheries (Dec. 2004) published in 2007

Table 2.8: Fish Farm Pond

State	Number of Fish Farm	Water Area of Farm Pond (ha)	Brackish Water Area of Farm Pond (ha)
KEBBI	56	57.7	0
SOKOTO	9	14.2	0
ZAMFARA	9	37.5	0
TOTAL	74	109	0

Annual water supply per hectare is calculated based on groundwater replacing the bottom 50cm of spoiled water with fish excretes and feed, totalling 0.03 MCM per ha per year. About 75-85% of pond water comes from shallow wells, with the rest from surface runoff and stagnant water. Water quality must meet requirements: free from detergents and chemicals, neutral pH, and dissolved oxygen above 4 ppm. Groundwater is preferred due to its colder temperatures, which result in higher oxygen content.

The inland fish farming is projected to supply 1.73 kg/year/person by 2030, slightly above the current consumption of 1.62 kg. With a target yield of 10 t/ha, it surpasses rice yields. However, high initial investments and marketing challenges limit production, expecting less than 500,000 tons/year from the feasible 1.4 million ha available in Nigeria.

Table 2.9: Projected Water Demand for Inland Aquaculture

Realistic Aquaculture Water Demand Allocation Based on Catchment Area Covering State	State	Water Demand for Aquaculture 2010	Water Demand for Aquaculture 2015	Water Demand for Aquaculture 2020	Water Demand for Aquaculture 2025	Water Demand for Aquaculture 2030	Water Demand for Aquaculture 2035	Water Demand for Aquaculture 2040	Water Demand for Aquaculture 2045	Water Demand for Aquaculture 2050
40%	KEBBI	2.74	3.86	4.14	4.26	4.39	4.53	4.66	4.79	4.92
65%	SOKOTO	1.10	1.54	1.66	1.70	1.76	1.81	1.86	1.92	1.97
60%	ZAMFARA	2.67	3.76	4.04	4.16	4.28	4.41	4.54	4.67	4.80
10%	KATSINA	0.34	0.49	0.52	0.54	0.55	0.57	0.59	0.60	0.62
Total Aquaculture Water Demand		6.86	9.65	10.35	10.66	10.99	11.32	11.65	11.98	12.31

Source: JICA 2014 MP

2.6.2.4 Irrigation water demand

Several small-scale irrigation systems, either formal or informal, exist in the Sokoto-Zamfara Catchment. Local people take the initiative to develop the Fadama irrigation schemes, mostly utilizing surface water, either diverted from streams by gravity or lifted with small diesel pumps. The irrigation water demand was extracted from the Nigeria National Water Resources Master Plan (NNWRMP 2013). Table 2.1 shows the irrigation water demand for Sokoto-Zamfara Catchment area by Sub-Basins. The irrigation water demands in this table are for rice only (the most conservative estimate) and vegetables only, which is the most optimistic water demand requirement for irrigation.

Public irrigation schemes mostly utilize surface water, whereas Fadama farming and some small-scale private irrigation systems in floodplains mainly use groundwater flows that occur after flood recession. The small-scale private irrigation systems outside floodplains mostly utilize groundwater for irrigation purposes

2.6.2.5 Water Demand of Existing Irrigation Schemes in Sokoto-Zamfara Catchment

Table 2.10: Water Demand of Existing Irrigation Schemes in Sokoto-Zamfara Catchment

Catchment	Water Source	Irrigated Area (ha)	Wet Season Water Demand (MCM)	Dry Season Water Demand (MCM)	Total Water Demand (MCM)
Sokoto-Zamfara	Surface Water	23,862	137	92	229
	under flow	7,817		29.5	29.5
	Ground Water	3827	14.4	14.4	28.8
Total					287.3

Source: Jica Team

Table 2.11: Net Irrigation Requirement (for Existing Irrigation scheme)

Hydrological Area: HA-1 Wet Season

	Unit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1) Rice														
ETo (Potential Evapotranspiration)	mm	81	92	133	161	175	155	137	123	118	120	96	82	
Kc						0.17	0.69	1.04	0.99	0.61	0.15			
① Etcrop (ETo×Kc)	mm					30	107	142	122	72	18			
② Percoration	mm					30	30	60	60	30	30			
③ Land Preparation	mm					75	75							
④ =①+②+③	m					135	212	202	182	102	48			
⑤ Effective rainfall	mm	0	0	2	4	18	40	82	100	56	6	0	0	
⑥ Net Irrigation Requirement	mm					117	172	120	82	46	42			
2) Other Cereal														
ETo (Potential Evapotranspiration)	m	81	92	133	161	175	155	137	123	118	120	96	82	
Kc						0.11	0.41	0.75	0.85	0.54	0.14			
① Etcrop (ETo×Kc)	mm					19	64	103	105	64	17			
② Pre-Irrigation	mm					30	30							
③ =①+②	mm					49	94	103	105	64	17			
④ Effective rainfall	mm					13	28	57	70	39	4			
⑤ Net Irrigation Requirement														

Hydrological Area: HA-1 Dry Season

	Unit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1) Rice														
ETo (Potential Evapotranspiration)	mm													
Kc														
① Etcrop (ETo×Kc)	mm													
② Percoration	mm													
③ Land Preparation	mm													
④ =①+②+③	mm													
⑤ Effective rainfall	mm													
⑥ Net Irrigation Requirement	mm													
2) Other Cereal														
ETo (Potential Evapotranspiration)	mm	81	92	133	161	175	155	137	123	118	120	96	82	
Kc		0.88	0.85	0.39	0.05							0.15	0.52	

① Etcrop (ETo×Kc)	mm	71	78	52	8								14	43	
② Pre-Irrigation	mm												30	30	
③ =①+②	mm	71	78	52	8								44	73	326
④ Effective rainfall	mm	0	0	1	3								0	0	
⑤ Net Irrigation Requirement	m	71	78	51	5								44	73	322

2.6.2.6 Water Demand of Existing Irrigation Schemes in Sokoto-Zamfara Catchment

Table 2.12: Water Demand of Existing Irrigation Schemes in Sokoto-Zamfara Catchment

Catchment	Water Source	Irrigated Area (ha)	Wet Season Water Demand (MCM)	Dry Season Water Demand (MCM)	Total Water Demand (MCM)
Sokoto-Zamfara	Surface Water	23,862	137	92	229
	under flow	7,817		29.5	29.5
	Ground Water	3827	14.4	14.4	28.8
Total					287.3

Source: Jica Team

Table 2.13: Net Irrigation Requirement (for Existing Irrigation scheme)

Hydrological Area: HA-1 Wet Season

	Unit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1) Rice														
ETo (Potential Evapotranspiration)	m	8	9	13	16	17	15	13	12	11	12	9	8	
Kc	m	1	2	3	1	5	5	7	3	8	0	6	2	
						0.1	0.6	1.0	0.9	0.6	0.1			
						7	9	4	9	1	5			
① Etcrop (ETo×Kc)	m					30	10	14	12	72	18			
② Percoration	m					30	30	60	60	30	30			
③ Land Preparation	m					75	75							
④ =①+②+③	m					13	21	20	18	10	48			
						5	2	2	2	2				

⑤ Effective rainfall	m m	0	0	2	4	18	40	82	10	56	6	0	0	
⑥ Net Irrigation Requirement	m m					11	17	12	82	46	42			
2) Other Cereal														
ETo (Potential Evapotranspiration)	m	8	9	13	16	17	15	13	12	11	12	9	8	
Kc						0.1	0.4	0.7	0.8	0.5	0.1			
① Etcrop (ETo×Kc)	m m					19	64	10	10	64	17			
② Pre-Irrigation	m m					30	30							
③ =①+②	m m					49	94	10	10	64	17			
④ Effective rainfall	m m					13	28	57	70	39	4			
⑤ Net Irrigation Requirement														

Hydrological Area: HA-1 Dry Season

	Unit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1) Rice														
ETo (Potential Evapotranspiration)	m m													
Kc														
① Etcrop (ETo×Kc)	m m													
② Percoration	m m													
③ Land Preparation	m m													
④ =①+②+③	m m													
⑤ Effective rainfall	m m													
⑥ Net Irrigation Requirement	m m													

2) Other Cereal														
ETo (Potential Evapotranspiration)	m	81	92	13	16	17	15	13	12	11	12	96	82	
Kc		0.88	0.85	0.39	0.05							0.15	0.52	
① Etcrop (ETo×Kc)	m	71	78	52	8							14	43	
② Pre-Irrigation	m											30	30	
③ =①+②	m	71	78	52	8							44	73	326
④ Effective rainfall	m	0	0	1	3							0	0	
⑤ Net Irrigation Requirement	m	71	78	51	5							44	73	322

2.6.3 Water Demand under Climate change

Table 2.14: Water Demand under Climate change

Catchment	Water Source	Irrigated Area (ha)	Wet Season Water Demand (MCM)	Dry Season Water Demand (MCM)	Total Water Demand (MCM)
Sokoto-Zamfara	Surface Water	23,846	193.5	87.6	281.1
	under flow	14,731		72	72
	Ground Water	8334	46	41	87
Total					440.1

Source: JICA Project Team

Table 2.15: Net Irrigation Requirement (under Climate Change)

Hydrological Area: **HA-1** **Wet Season**

	Unit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1) Rice		81	92	133	161	175	155	137	123	118	120	96	82	
ETo (Potential Evapotranspiration)	m	95	107	155	188	204	181	160	144	138	140	112	96	

Kc						0.17	0.69	1.04	0.99	0.61	0.15		
① Etcrop (ETo×Kc)	m					35	125	166	143	84	21		
② Percoration	m					30	30	60	60	30	30		
③ Land Preparation	M					75	75						
④ =①+②+③	M					140	230	226	203	114	51		
⑤ Effective rainfall	M	0	0	2	4	18	40	82	100	56	6	0	0
⑥ Net Irrigation Requirement	m					122	190	144	103	58	45		
2) Other Cereal													
ETo (Potential Evapotranspiration)	m	95	107	155	188	204	181	160	144	138	140	112	96
Kc						0.11	0.41	0.75	0.85	0.54	0.14		
① Etcrop (ETo×Kc)	m					22	74	120	122	75	20		
② Pre-Irrigation	m					30	30						
③ =①+②	m					52	104	120	122	75	20		
④ Effective rainfall	m					13	28	57	70	39	4		
⑤ Net Irrigation Requirement													

Source: JICA Project Team

Hydrological Area: HA-1 Dry Season

Unit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1) Rice													
ETo (Potential Evapotranspiration)	m												
Kc													
① Etcrop (ETo×Kc)	m												
② Percoration	m												
③ Land Preparation	m												

④ =①+②+③	m													
⑤ Effective rainfall	m													
⑥ Net Irrigation Requirement	m m													
2) Other Cereal														
ETo (Potential Evapotranspiration)	m m	95	10	15	18	20	18	16	14	13	14	11	96	
Kc		0.8	0.8	0.3	0.0							0.1	0.5	
① Etcrop (ETo×Kc)	m	84	91	60	9							17	50	
② Pre-Irrigation	m											30	30	
③ =①+②	m	84	91	60	9							47	80	
④ Effective rainfall	m	0	0	1	3							0	0	
⑤ Net Irrigation Requirement														

Source: JICA Project Team

2.6.4 Total Water Demand

Table 2.16: Water Balance analysis of the Catchment

WATER BALANCE ANALYSIS FOR SOKOTO-ZAMFARA CATCHMENT		
WATER DEMAND (CUBIC METER)	2025	2050
MUNICIPAL	273,666,051	495,130,684
LIVESTOCK	39,767,883	59,455,603
AQUACULTURE	10,658,056	12,307,985
IRRIGATION	287,300,000	440,100,000
TOTAL	611,391,990	1,006,994,271
AVAILABLE WATER RESOURCES (CUBIC METER)	2,167,093,800	2,167,093,800
WATER BALANCE (CUBIC METER)	1,555,701,810	1,160,099,529

SOURCE: JICA 2014 MP AND GHI Water and Watershed Management 2022

2.6.5 Infrastructure and Assets

Table 2.17: Catchment Infrastructure and Assets

Infrastructure	Location	Importance	Risk Factor
Zobe Dam	Katsina State, Dutsin-Ma LGA	Irrigation, water supply, flood control	Drought, sedimentation
Jibia Dam	Katsina State, Jibia LGA	Domestic & industrial water supply, irrigation	Sedimentation, insecurity
Bakolori Dam	Zamfara State, Maradun LGA	Major irrigation dam, domestic/industrial water supply	Erosion, climate variability
Goronyo Dam	Sokoto State, Goronyo LGA	Irrigation, domestic/industrial water supply, flood control	Sedimentation, flooding
Sabke Irrigation Project	Katsina State, Mai'Adua LGA	Year-round farming, improved food production	Infrastructure degradation
Bakolori Irrigation Scheme	Zamfara State, Bakura & Talata Mafara LGAs	Large-scale food production, multiple cropping seasons	Flooding, management issues
Wurno Irrigation Scheme	Sokoto State, Wurno LGA	Year-round farming, food security	Drought, inadequate maintenance
Kware Irrigation Scheme	Sokoto State, Kware LGA	Irrigation, improved food security	Drought, poor funding
Goronyo Irrigation Scheme	Sokoto State, Goronyo LGA	Large-scale irrigation, crop productivity	Sedimentation, climate risks
Zauro Polder Irrigation Project	Kebbi State, Birnin Kebbi LGA	Year-round cultivation, rural livelihoods	Climate variability
Funtua Silo	Katsina State, Funtua LGA	Grain storage for food security	Vandalism, poor maintenance
Gusau Storage Facility	Zamfara State, Gusau LGA	Grain preservation, food availability	Pest infestation, management
Sokoto Agricultural Storage	Sokoto State, Sokoto North LGA	Post-harvest grain stability	Storage capacity limitations
Kebbi Grain Reserve	Kebbi State, Birnin Kebbi LGA	Grain storage, price stabilization	Market volatility, access challenges
Katsina Grain Reserve	Katsina State, Katsina LGA	Food security, price control	Storage degradation
Bakolori Hydroelectric Power Plant	Zamfara State, Maradun LGA	Regional electricity generation	Maintenance, hydrological risks
Goronyo Hydropower (Potential)	Sokoto State, Goronyo LGA	Undeveloped but viable hydropower source	Feasibility challenges
Kainji Hydroelectric Station (Shared asset)	Kebbi State (Ngaski LGA) / Niger State	Major regional power source	Water level fluctuations
Kuyambana Game Reserve	Zamfara State, Maru LGA	Conservation, eco-tourism	Deforestation, poaching

Kwiambana Forest Reserve	Katsina State, Safana LGA	Biodiversity, eco-tourism	Logging, encroachment
Gashaka-Gumti National Park (extension)	Kebbi State, Ngaski LGA	Biodiversity, eco-tourism, research	Insecurity, low funding
Sokoto Forest Reserve	Sokoto State, Sokoto South LGA	Eco-tourism, biodiversity preservation	Urban encroachment
Argungu Fishing Festival Site	Kebbi State, Argungu LGA	UNESCO-recognized cultural site, economic boost via tourism	Pollution, seasonal flooding
Emir of Katsina Palace	Katsina State, Katsina LGA	Cultural heritage, tourism	Urban pressure
Gobir Kingdom Ruins	Sokoto State, Sabon Birni LGA	Archaeological and heritage site	Neglect, erosion
Sokoto Museum and Sultan’s Palace	Sokoto State, Sokoto North LGA	Cultural landmark, Islamic history preservation	Urban development pressures
Gidan Sarki (Old Prison)	Sokoto State	Colonial-era structure, heritage attraction	Dilapidation
Kurmi Market	Sokoto State	Traditional trade hub, cultural tourism	Modernization pressures
Gusau Emir’s Palace	Zamfara State	Cultural events, governance symbol	Neglect, limited tourism infrastructure
Kwiambana Ruins	Zamfara State	UNESCO tentative site, historical value	Erosion, lack of tourism facilities
Sokoto-Rima Wetlands	Sokoto & Zamfara States	Biodiversity, fishing, flood control	Invasive species (e.g., Typha grass)
Flood Control Embankments/Levees	Sokoto-Rima River Basin	Seasonal flood mitigation	Structural deterioration
Katsina City Walls and Gates	Katsina State, Katsina LGA	Historic defense infrastructure, tourism	Weathering, vandalism

2.7 Water Quality

2.7.1 Surface Water Quality

The Sokoto-Zamfara Catchment faces increasing risks of surface water pollution due to agricultural runoff, industrial activities, urban wastewater discharge, and natural sedimentation processes. The catchment is home to major agricultural irrigation schemes and growing urban centers, both of which contribute to surface water contamination.

Key sources of pollution in the catchment include:

- **Agricultural Runoff:** Fertilizer and pesticide-laden runoff from irrigation schemes such as Bakolori and Jibiya Irrigation Projects significantly impact water quality. Crops like

rice and cotton require heavy fertilizer application, leading to an accumulation of nitrogen and phosphorus in water bodies.

- **Urban Wastewater Discharge:** Many towns in the Sokoto-Zamfara Catchment, including Sokoto, Gusau, Funtua, and Kaura Namoda, have poorly regulated sewage disposal systems. Untreated wastewater from households and businesses drains into rivers, increasing microbial contamination.
- **Industrial Pollution:** Urban centers such as Sokoto and Gusau host tanneries, textile industries, and slaughterhouses. These industries release pollutants like heavy metals (chromium, cadmium, and lead) into nearby rivers. Many industrial waste treatment systems are non-functional or inadequate, resulting in direct discharge of toxic effluents into waterways.
- **Siltation and Vegetation Encroachment:** The Sokoto River and its tributaries are increasingly affected by siltation from deforestation and soil erosion, while invasive aquatic plants like typha grass further degrade water flow and quality.

Studies indicate that heavy metal concentrations in some surface water sources exceed WHO permissible limits, posing risks to human health and aquatic ecosystems. In particular, water quality deterioration in the Sokoto River and its tributaries has been linked to industrial and domestic waste disposal upstream. Addressing these issues requires stricter pollution control measures and improved waste management strategies.

2.7.2 Groundwater Quality

Groundwater quality in the Sokoto-Zamfara Catchment varies across different aquifer systems, with major concerns including salinity, fluoride contamination, nitrates, and heavy metal presence. Given the region's reliance on groundwater for drinking, agriculture, and industry, maintaining groundwater quality is critical for sustainability.

i. Groundwater Electrical Conductivity

Electrical conductivity (EC) is a key indicator of dissolved salts in groundwater. In the Sokoto Basin Aquifer System, groundwater tends to have higher salinity levels compared to other regions due to natural mineralization of the sedimentary rock formations.

- Areas with shallow aquifers near urban centers, such as Sokoto, Gusau, and Birnin Kebbi, exhibit higher EC values ($>1,000 \mu\text{S}/\text{cm}$) due to anthropogenic pollution and over-extraction.

- In contrast, groundwater in more remote rural areas tends to have lower salinity and better overall quality.

ii. Fluoride distribution

Fluoride concentrations in groundwater within the Sokoto-Zamfara Catchment show spatial variations, with some areas exceeding the WHO-recommended limit of 1.5 mg/L. High fluoride levels are particularly observed in the deeper aquifers of the Sokoto Basin, leading to potential risks of dental and skeletal fluorosis among communities that rely on deep boreholes for drinking water.

iii. Nitrates distribution

Nitrate contamination is increasingly becoming a challenge due to poor sanitation practices, agricultural activities, and livestock waste disposal.

- Urban areas such as Sokoto, Gusau, and Funtua have recorded higher nitrate concentrations due to leaking septic tanks and open waste dumping.
- Fertilizer use in irrigated farmlands around Bakolori and Goronyo dams contributes to nitrate leaching into shallow aquifers, raising concerns about drinking water safety.
- WHO and Nigerian standards set a maximum allowable limit of 50 mg/L for nitrates in drinking water, but some locations within the catchment have exceeded this threshold, indicating the need for better groundwater protection measures.

iv. Heavy metals and other metals

Groundwater in the Sokoto-Zamfara Catchment is vulnerable to contamination from heavy metals, particularly in areas downstream of industrial and mining activities.

- Tanneries in Sokoto and other industrial areas discharge chromium, cadmium, and lead, which can seep into groundwater.
- Informal gold mining activities in Zamfara State have led to mercury and lead contamination, posing severe health risks, especially for children.
- While heavy metal concentrations remain within safe limits in some areas, localized contamination hotspots have been identified near industrial zones and mining sites.

Table 2.18: Health risks of heavy metals in ground water

Heavy metal	Recommended Limits (mg/l)	Impacts on Humans (Long-term exposure)
Arsenic	0.01	Cancer of the bladder, lungs, skin, kidney, liver and more Death
Cadmium	0.003	Renal dysfunction, lung disease and lung cancer, bone defects, and high blood pressure
Chromium	0.05	Skin irritation, ulceration, liver and kidney damage, Damage to circulatory and nervous tissue
Lead	0.01	Problems in the synthesis of hemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system.
Mercury	0.002	Kidney damage Permanent nervous system damage
Nickel	0.02	Decreased body weight, heart and liver damage, and skin irritation

Source: SAP by SMEC 2019

2.7.3 Surface Water Resources

The Sokoto-Zamfara Catchment in northwestern Nigeria is part of the Sokoto-Rima River Basin and features a semi-arid climate.

- About 80% of annual rainfall occurs from June to September, supporting rain-fed agriculture. However, the long dry season from October to May leads to reduced surface water availability, causing many tributaries to dry up.
- The Sokoto-Zamfara Catchment's hydrology is shaped by the Sokoto River and its tributaries, including the Ka, Bunsuru, and Zamfara Rivers.
- These rivers create floodplains and wetlands vital for agriculture and livestock. Seasonal flooding recharges groundwater, supporting local communities during dry months.

Groundwater recharge in the Sokoto-Zamfara Catchment mainly occurs through seasonal flooding and localized rainfall in depressions. Alluvial deposits along riverbanks enhance water retention, supporting agriculture and fisheries. However, rising water demand for irrigation, urban, and industrial use strains both surface and groundwater resources.

The Sokoto-Zamfara Catchment features key water management infrastructure, such as the Bakolori and Goronyo Dams, which aid irrigation but alter natural river flows. Climate variability, land use changes, and unsustainable groundwater use have led to reduced water availability, impacting livelihoods and increasing water scarcity risks.

To ensure sustainable water resource management in the Sokoto-Zamfara Catchment, it is essential to implement integrated water management strategies that balance water supply with demand while preserving the ecological integrity of the river system.

2.7.3.1 River flow patterns

The Sokoto-Zamfara Catchment, part of Hydrological Area 1, has a seasonal river flow influenced by rainfall variability and human activities.

- Peak discharge occurs from June to September during the wet season, while flow declines sharply in the dry season from October to May as many tributaries dry up.
- The Sokoto-Zamfara Catchment's river system is primarily rain-fed, making it sensitive to precipitation changes.
- The southern region has more consistent flow due to higher rainfall, while the north faces greater seasonal variability.
- Over-extraction of groundwater for various uses has decreased dry-season flows, leading to water scarcity.

The Bakolori Dam in the Sokoto-Zamfara Catchment regulate river flow for agriculture and urban water supply, but they disrupt natural hydrological cycles. This reduces downstream flows, alters sediment transport, and impacts aquatic ecosystems, further limiting groundwater recharge and water availability.

As climate variability intensifies and water demand increases, maintaining sustainable river flows in the Sokoto-Zamfara Catchment requires integrated water resource management strategies. These include promoting efficient irrigation techniques, improving watershed

conservation efforts, and developing policies that balance water use with ecological preservation.

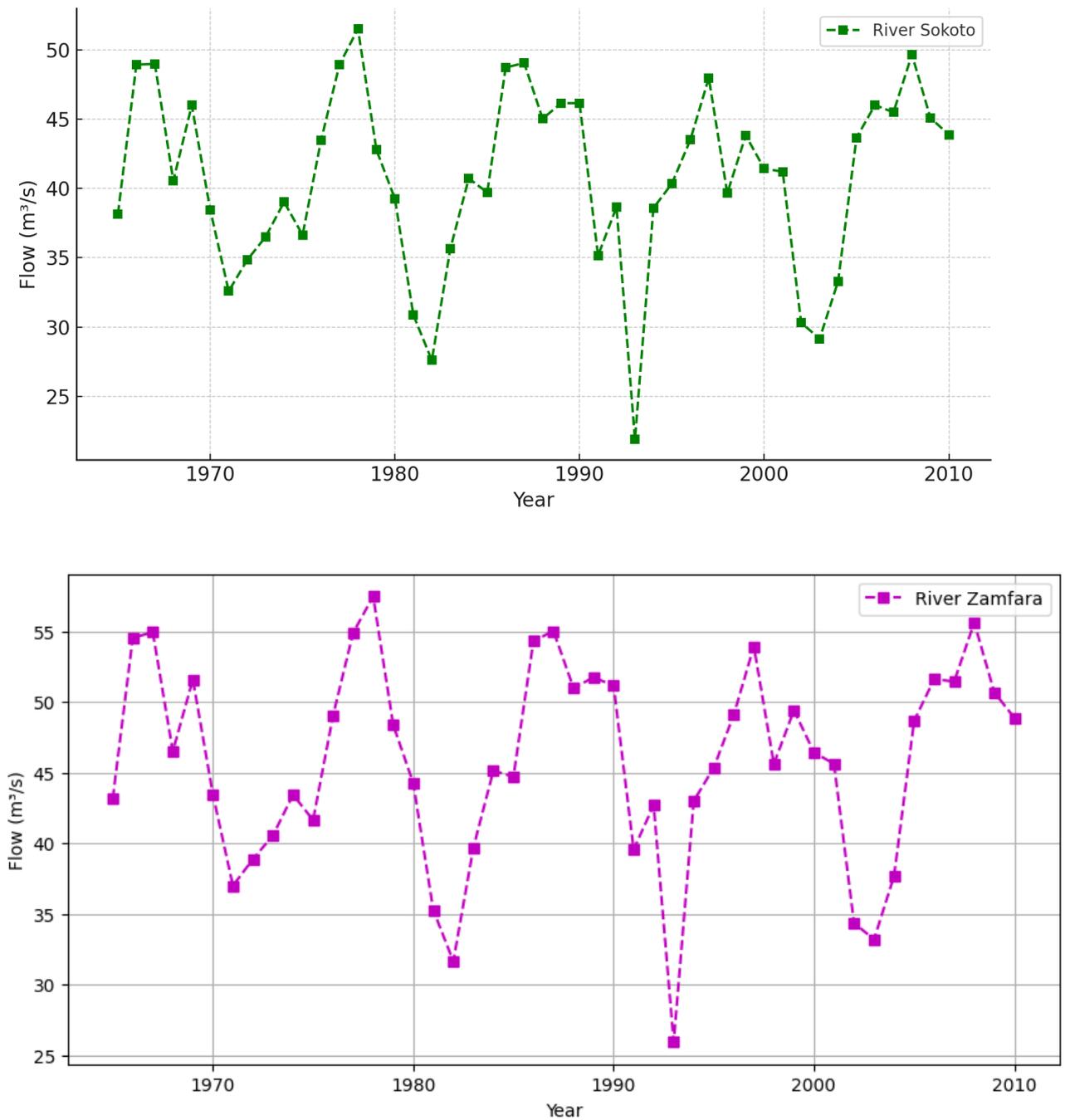


Figure 2.18: River flow graphs for the catchment (Source: MSL 2025)

2.7.3.2 Relation between flows and floodplain infiltration

Floodplains in the Sokoto-Zamfara Catchment are vital for groundwater recharge and ecosystem sustainability. During the wet season, floodwaters spread across these areas,

allowing water to infiltrate aquifers. This recharge is crucial for maintaining groundwater levels, supporting agriculture and domestic needs during the dry season.

The efficiency of floodplain infiltration in the Sokoto-Zamfara Catchment is influenced by soil type, vegetation cover, and sediment dynamics.

- Sandy and loamy soils allow higher infiltration rates, while clayey soils lead to surface runoff.
- Land degradation from deforestation and overgrazing has reduced infiltration capacity. Human interventions, like dam construction, have disrupted natural floodplain connectivity, impacting groundwater recharge. Although some irrigation systems support dry-season agriculture, they alter natural hydrology.
- Prioritizing the restoration of floodplain areas through soil conservation and sustainable practices is crucial to ensure long-term water sustainability.

2.7.3.3 Impact of changed flow patterns

Shifts in river flow patterns within the Sokoto-Zamfara Catchment have led to significant environmental and socio-economic consequences. Various factors, including climate variability, land use changes, and hydrological infrastructure developments, have contributed to these alterations, disrupting natural hydrological processes and affecting water availability.

Key Impacts of Changing Flow Patterns:

- **Increased Flow Variability:** Climate change has intensified rainfall fluctuations, leading to prolonged droughts followed by extreme flood events. This unpredictability poses challenges for agriculture, livestock management, and domestic water supply, making water resource planning more difficult.
- **Reduced Dry-Season Baseflow:** Unsustainable groundwater extraction, combined with deforestation and soil degradation, has reduced river baseflow during dry months. This has exacerbated water scarcity, particularly in rural areas that rely on river-fed wells and boreholes for water.
- **Flooding and Erosion:** The increase in surface runoff due to land degradation has heightened flood risks in low-lying areas, leading to soil erosion, loss of fertile farmland, and damage to settlements and infrastructure. Uncontrolled urban expansion along riverbanks has further worsened these problems.

- **Impact of Dams and Water Diversion:** Reservoirs such as the Goronyo and Bakolori Dams play a crucial role in storing water for irrigation and municipal use. However, these structures have significantly altered downstream hydrological regimes by reducing seasonal flooding, disrupting sediment transport, and affecting aquatic ecosystems.

Addressing these challenges requires the adoption of adaptive water management strategies, such as regulating groundwater extraction, implementing soil conservation measures, and promoting sustainable irrigation practices. Reforestation and afforestation programs can also help stabilize soil conditions, reduce runoff, and restore natural hydrological processes in the Sokoto-Zamfara Catchment.

2.7.3.4 Groundwater Resources

Groundwater that flows across the boundary is called as trans-boundary groundwater. Groundwater flows following regional topography and aquifer structure. If aquifer extends beyond boundary, there is a possibility that groundwater can flow through the boundary. In case of Nigeria, trans-boundary groundwater is limited in sedimentary rock area because:

Aquifer system in Basement Complex is divided into isolated small aquifers. Therefore, groundwater cannot flow in regional scale passing through boundary within small aquifers.

Aquifers extend in large area in sedimentary rock area. Therefore, groundwater can flow passing through the boundary in large scale.

Table 2.19: Ground water recharge;

Item	Hydrological area
	HA-1
Area(km ²)	135,128
Average precipitation (mm/year)	768
Average groundwater recharge (mm/year)	37
Percentage of precipitation to recharge (%)	4.8

Source: JICA Project Team

Table 2.20: Groundwater Recharge by Aquifer;

Age	Formation	Groundwater Recharge (mm/year)
HA-1		
Eocene	Gwandu Formation	24
Paleocene	Kalambaina Formation Sokoto group)	1
	Dange Formation (Sokoto group)	1
	Wurno Formation (Rima Group)	18
Maestrichtian	Dukamaje Formation (Rima Group)	34
	Taloka Formation (Rima Group)	6
	Ill Formation	10
	Gundumi Formation	10
Pre-Cambria	Basement complex	40

Source: JICA 2014 MP

2.7.4 Sokoto Basin (HA-1)

Situation on trans-boundary groundwater is explained below on Sokoto basin and Chad basin where groundwater is flowing in large scale.

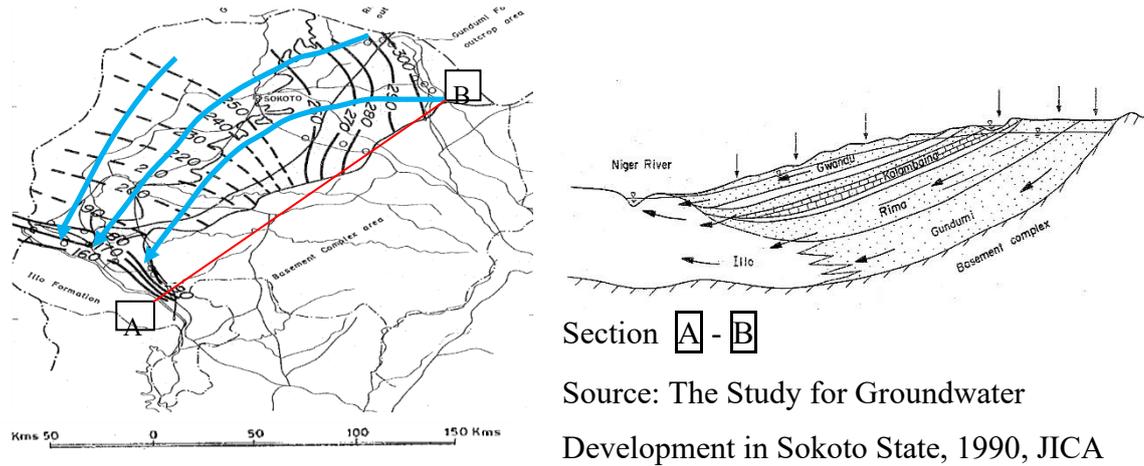
Sokoto Basin

There is multiple aquifer system in Sokoto Basin as shown in Table 2.21.

Table 2.21: Aquifer of Sokoto Basin

Period	Formation	Lithology
Tertiary	Gwandu Formation	Partially consolidated sand and clay
	Kalambaina Formation (Sokoto Group)	Limestone and volcanic shale
	Wurno Formation (Rima Group)	Fine sandstone, silt
Cretaceous	Illo Formation	Sandstone, conglomerate
	Gundumi Formation	Sandstone, conglomerate

Source: JICA Project Team



Section **A** - **B**

Source: The Study for Groundwater Development in Sokoto State, 1990, JICA

Figure 2.19 Groundwater Flow in Sokoto Basin

Table 2.22: Aquifer Model

Model	Symbol	Aquifer type	Thickness of aquifer	Permeability coefficient (k or K)	Static groundwater level	
Weathered aquifer	Weathered High permeability	WH	Weathered Basement rock and weathered part of the other type rocks	50m	0.86 m/day	GL-10m
	Weathered Middle permeability	WM		0.17 m/day		
	Weathered Low permeability	WL		0.086 m/day		
Multiple aquifer	Multiple High permeability	MH	Sandstone or sandy formation within alternation of sandstone and shale	200m	0.43 m/day	GL-50m
	Multiple Middle permeability	MM		0.086 m/day		
	Multiple Low permeability	ML		0.043 m/day		

Source: JICA Project Team

Table 2.23: Relation between Aquifer Type and Aquifer Model

Age	Permeability	Aquifer scale	Aquifer model
Quaternary	Large	Large (sand/clay alternation of coastal plain)	MH
	Middle	Middle (sand/clay alternation of coastal plain)	MM
	Middle	Small sand layer (alluvial plain along river)	WH-WM
	small	Small (silt/clay alternation)	WL
Tertiary	Large	Large (sandstone/claystone alternation)	MH
	Middle	Middle (sandstone/ claystone alternation)	MM
	Middle	Small (sandstone)	WH-WM
	Small	Small (claystone)	WL
Cretaceous	Large	Large (sandstone/shale alternation)	MM
	Middle	Middle (sandstone/shale alternation)	ML
	Middle	Small (sandstone)	WH-WM
	Small	Small (shale)	WL
Basement	Middle	Weathered rock	WM
Volcanic	High	Small	WH

Source: JICA Project Team

Table 2.24 Groundwater Development Potential by Aquifer

Age	Formation	Lithology	Aquifer Characteristics	Groundwater recharge (mm/year)	Aquifer Model
HA-1 : Niger North					
Eocene	Gwandu Formation	Sand and clay.	Aquifer with large outcropping area of maximum thickness of 300m. Basal sandstone form good aquifer.	24	MM
	Kalambaina Formation	Limestone, calcareous shale.	Sandstone form perched aquifers, which provide groundwater to shallow wells.	1	ML

Paleocene	(Sokoto group)				
	Dange Formation (Sokoto group)	Shale and limestone at bottom.	Aquitard confining underlying aquifer.	1	WL
	Wurno Formation (Rima Group)	Fine sandstone and Dukamaje clay stone at the top.	Confined aquifer of medium to coarse sand with recharge area of 330 km ² .	18	MM
Maestrichtian	Dukamaje Formation (Rima Group)	Shale, limestone, clay stone.	Aquitard with thickness of less than 20m.	34	WL
	Taloka Formation (Rima Group)	Sandstone and claystone.	Argillaceous aquifer with low capacity of 1 ~ 5m ³ /hours. Maximum thickness is 180m.	6	ML
	Ill Formation	Sandstone	Unconfined and confined aquifer with wide recharge area.	10	MM
	Gundumi Formation	Sandstone and conglomerate.	Unconfined and confined aquifer with wide recharge area.	10	MM
Pre-Cambria	Basement complex	Granite, gneiss, schist, phyllite, quartzite.	Meta-sedimentary rock form better aquifer than gneiss and migmatite	40	WM

Source: JICA 2014 MP

Table 2.25 Optimum Yield of Borehole Field

Aquifer type	Urban/small urban/small town	
	Motorized pump	
	Optimum yield of boreholes field (m ³ /day)	Population to be supplied (persons)
WH	1,000	10,000
WM	500	5,000
WL	400	4,000
MH	1,500	15,000
MM	1,000	10,000

ML	900	9,000
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Source: JICA Project Team.

Where **First letter**:

W = Water Table (Unconfined aquifer)

M = Mixed (Semi-confined aquifer)

Second Letter:

H = High permeability

M = Medium permeability

L = Low Permeability

2.7.4.1 Numbers of Boreholes in States Covering Sokoto-Zamfara Catchment

Figure 2.20 shows an image of borehole field distribution. Density of dots shows density of distribution of borehole fields.

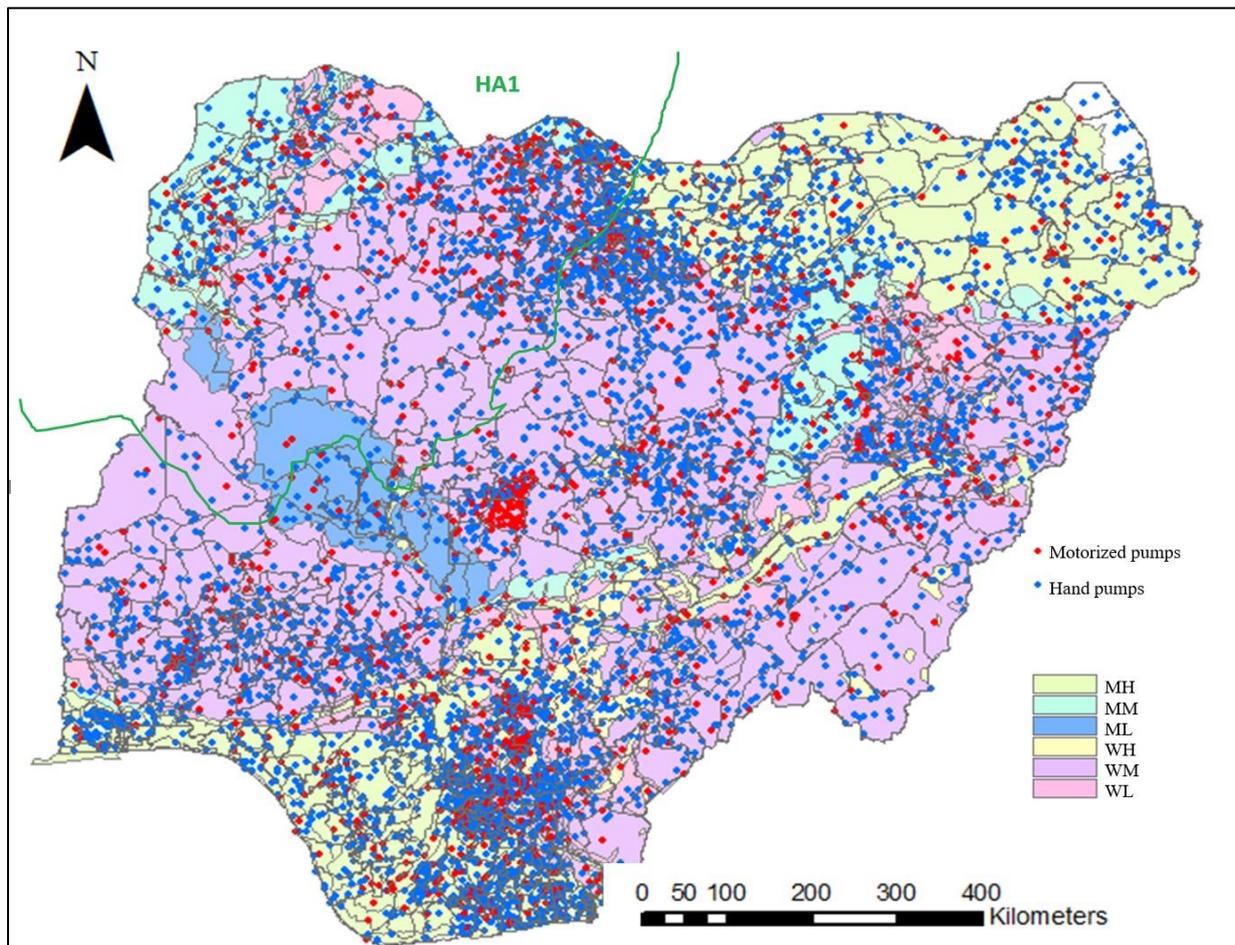


Figure 2.20 Density of Distribution of Borehole Fields (2030) by LGA (Source: JICA Project Team)

2.7.4.2 Groundwater Recharge and Demand Balance

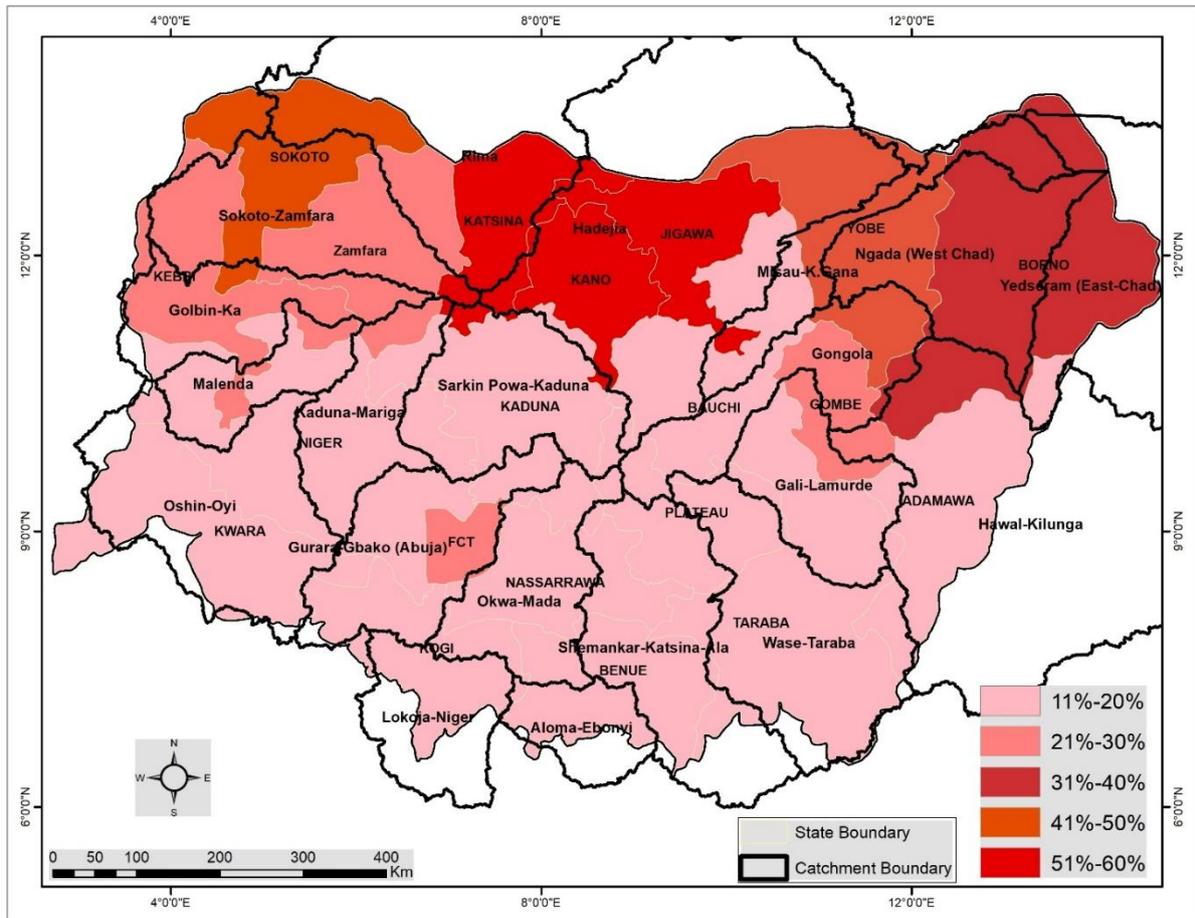


Figure 2.21: Balance of Groundwater Demand and Recharge in 2030 (Modified: MSL, 2025)

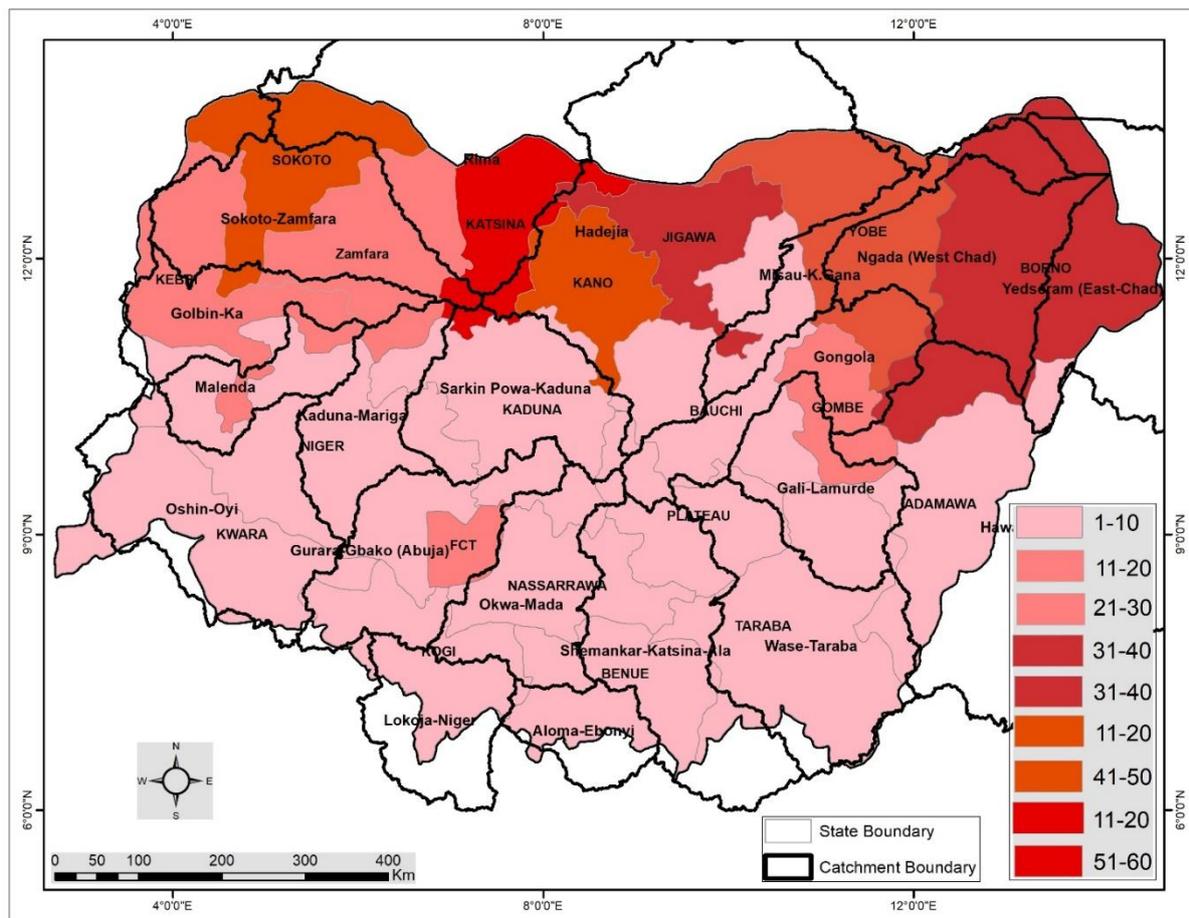


Figure 2.22: Balance of Groundwater Demand and Recharge in 2030 by Effect of Climate Change (Modified: MSL, 2025)

2.8 Climate Change Impact On Water and Land Resources

2.8.1 Historical and Future Climatic Trends

Temperature and rainfall trends for the Sokoto-Zamfara catchment were forecast (projected) from 2023 to 2050 based on the monthly and annual data from 1981 to 2022 (for temperature and rainfall) and 1990 to 2022 (for evapotranspiration), deploying the growth rate schema in Excel. It is of the following specifications:

$$\text{Growth Rate} = (\text{ending value} - \text{beginning value} / \text{beginning value}) \times 100.$$

This above rate is then used to extrapolate for each of the projected periods by multiplying it with the ending value. The formula is thus able to explore the data generation process by linking each value to the previous period, which aids a graphical depiction of trends over time. It needs to be noted that growth may be of different forms, including simple growth and exponential growth. What has been used, however, is the simple growth projection, given the nature of the data when explored from the point of view of period to period.

Excel was used to plot the trends indicated by the projection, just to indicate the annual increase in temperature and not for the projection.

The temperature and rainfall data were sourced from the National Aeronautics and Space Administration data-access-viewer. These are comparable with existing local data from the Nigerian Meteorological Society.

2.8.2 Annual Rainfall and Temperature for Sokoto-Zamfara Catchment

2.8.2.1 Rainfall Trends

Figure 2.23 is the annual rainfall trend for the Sokoto-Zamfara Catchment (1981-2050). From the figure, the slope of -1.3387 indicates a declining trend in annual rainfall over time (1981-2050). On average, rainfall decreases by 1.34 mm per year during the rainy season.

An R^2 of 0.0596 indicates a very weak correlation between the year and annual rainfall. This means that while there is a slight declining trend, year-to-year variability is high, and other factors may influence rainfall patterns. This decline could be due to climate change, which is often associated with reduced rainfall in semi-arid regions like the Sokoto-Zamfara Catchment.

Comparison of Historical and Projected Periods

- The Historical Period (1981-2022) shows natural variability in rainfall, with some wetter and drier years.
- The declining trend suggests that rainfall may have already started to decrease during this period. During the projected Period (2023-2050) the declining trend continues, leading to lower average annual rainfall. Increased variability and more frequent extreme events (e.g., droughts or heavy rainfall) may occur due to climate change.
- A declining trend in rainfall could lead to water scarcity, affecting rain-agriculture, ecosystems, and human populations in the Sokoto-Zamfara Catchment.
- The high variability and declining trend highlight the need for climate adaptation strategies, such as improved water management, drought-resistant crops, Shift to early-maturing and drought-resistant crops, Introduction of irrigation support systems, Climate-smart agricultural practices, and infrastructure to handle extreme weather events.

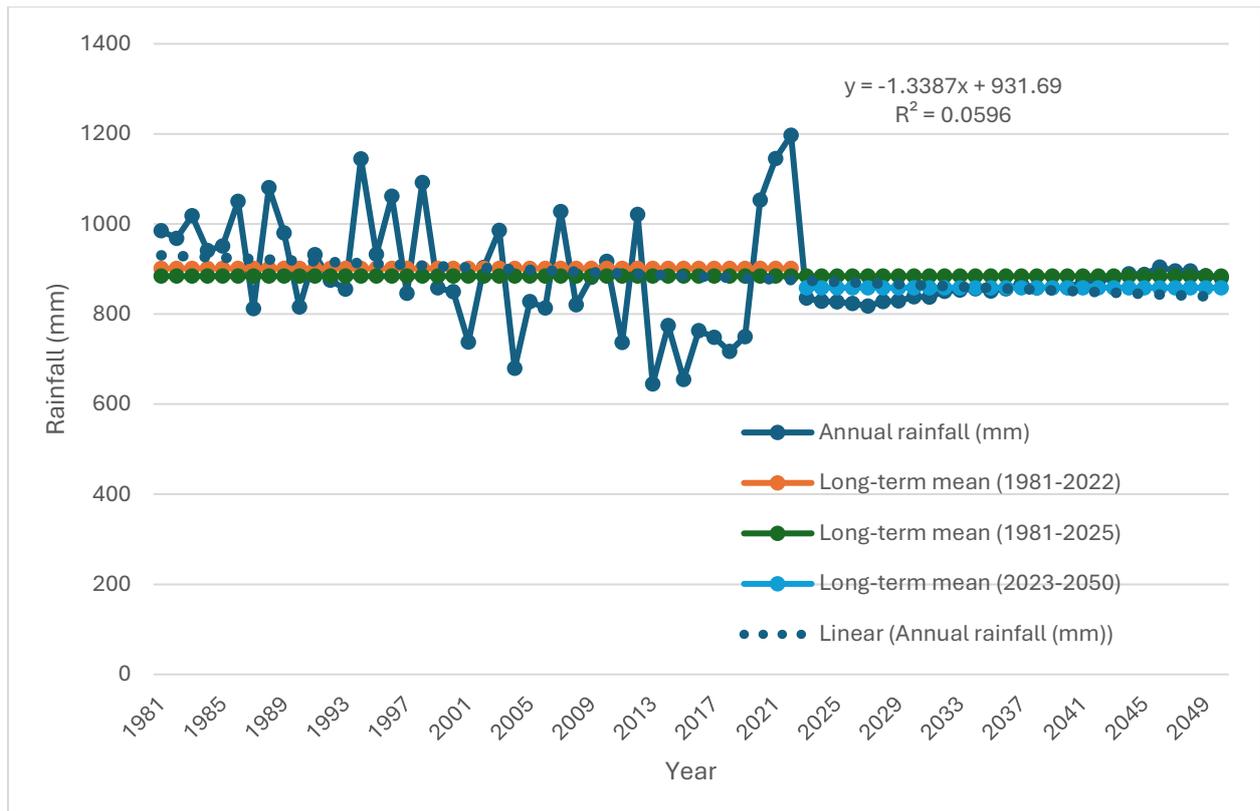


Figure 2.23 Annual rainfall trend for Sokoto-Zamfara Catchment (1981-2050) (Source: MSL, 2025).

2.8.2.2 Temperature Trends

Figure 2.24 presents a time series analysis of temperature trends from 1981 to 2022, with projections extending to 2050.

The long-term mean temperature for the historical period (1981-2022) is 27.14°C. The linear trend line indicates a warming trend with a slope of 0.0262°C per year. The coefficient of determination ($R^2 = 0.656$) suggests that this linear trend can explain approximately 65.6% of the temperature variations, implying a significant warming pattern. The long-term mean for the projected period (2023-2050) is 28.04. This shows that the projected long-term mean for 2023–2050 (28.04° C), which is noticeably higher than the 1981–2022 mean, indicates expected continued warming. The overall long-term mean (1981-2050) of 27.50° C lies between the two earlier periods, reinforcing the trend of increasing temperatures over time. This will lead to higher average temperatures. Increased variability and more frequent extreme heat events may occur due to climate change.

- The steady temperature rise can impact climate-sensitive sectors like agriculture, water resources, and human health.

- Higher temperatures could exacerbate heat stress, particularly during the hottest months, increasing the risk of heat-related illnesses. Crop yields, especially for heat-sensitive crops, will be affected negatively.
- There would be reduced soil moisture due to high evaporation rates, impacting rain-fed agriculture. Water demand for irrigation, livestock, and human consumption. This will put stress on the local ecosystems, affecting biodiversity and species survival.

The projected increase in mean temperature indicates the need for adaptation and mitigation strategies, especially in regions vulnerable to heat stress.

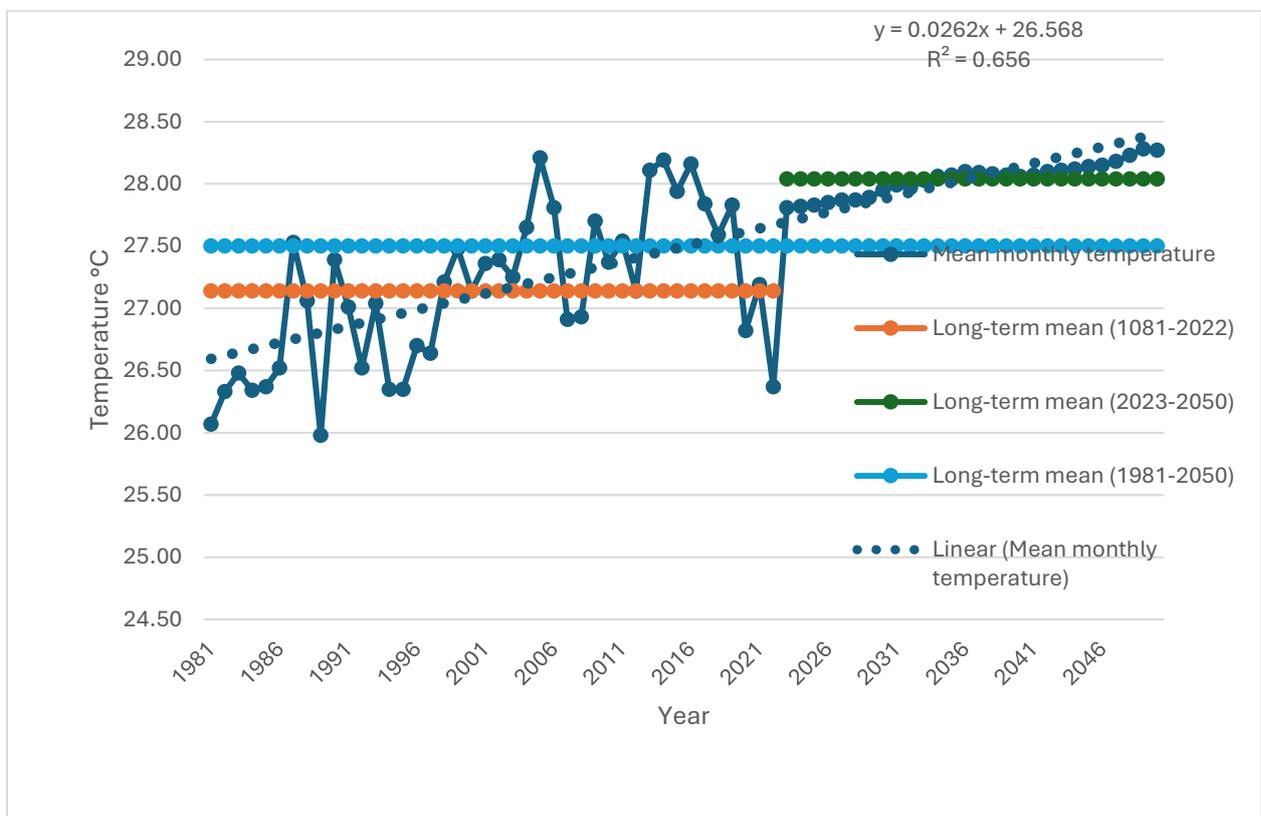


Figure 2.24 Trends in mean annual temperature for Sokoto-Zamfara Catchment (1981- 2050)

(Source: MSL, 2025)

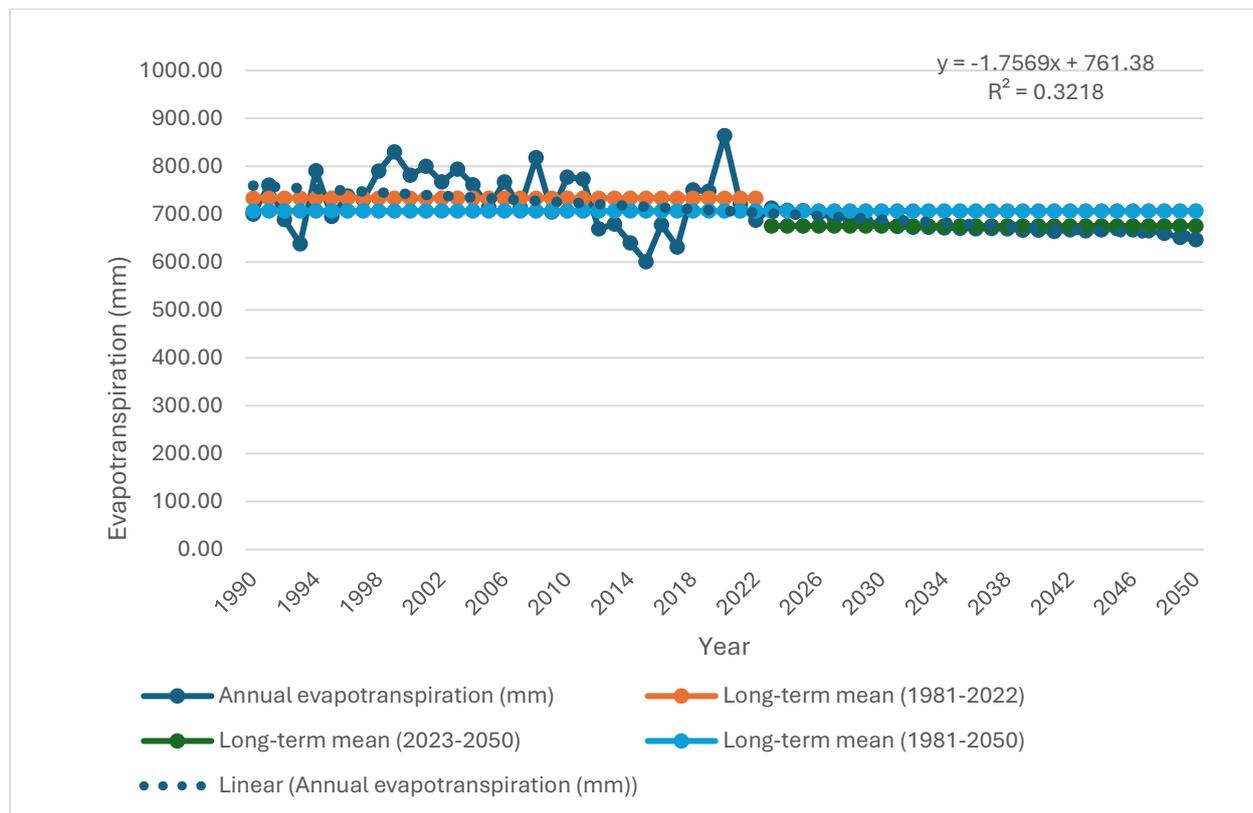


Figure 2.25 Annual evapotranspiration trend for Sokoto-Zamfara Catchment (1981-2050) (Source: MSL, 2025).

2.8.3 Projected Mean Annual Temperature for Sokoto-Zamfara Catchment

Figure 2.26 presents a time series analysis of temperature trends from 1981 to 2022, with projections extending to 2050.

The long-term mean temperature for the historical period (1981-2022) is 27.14°C. The linear trend line indicates a warming trend with a slope of 0.0262°C per year. The coefficient of determination ($R^2 = 0.656$) suggests that this linear trend can explain approximately 65.6% of the temperature variations, implying a significant warming pattern. The long-term mean for the projected period (2023-2050) is 28.04. This shows that the projected long-term mean for 2023–2050 (28.04° C), which is noticeably higher than the 1981–2022 mean, indicates expected continued warming. The overall long-term mean (1981-2050) of 27.50° C lies between the two earlier periods, reinforcing the trend of increasing temperatures over time. This will lead to higher average temperatures. Increased variability and more frequent extreme heat events may occur due to climate change.

The steady temperature rise can impact climate-sensitive sectors like agriculture, water resources, and human health.

Higher temperatures could exacerbate heat stress, particularly during the hottest months, increasing the risk of heat-related illnesses. Crop yields, especially for heat-sensitive crops, will be affected negatively. There would be reduced soil moisture due to high evaporation rates, impacting rain-fed agriculture. Water demand for irrigation, livestock, and human consumption. This will put stress on the local ecosystems, affecting biodiversity and species survival.

The projected increase in mean temperature indicates the need for adaptation and mitigation strategies, especially in regions vulnerable to heat stress.

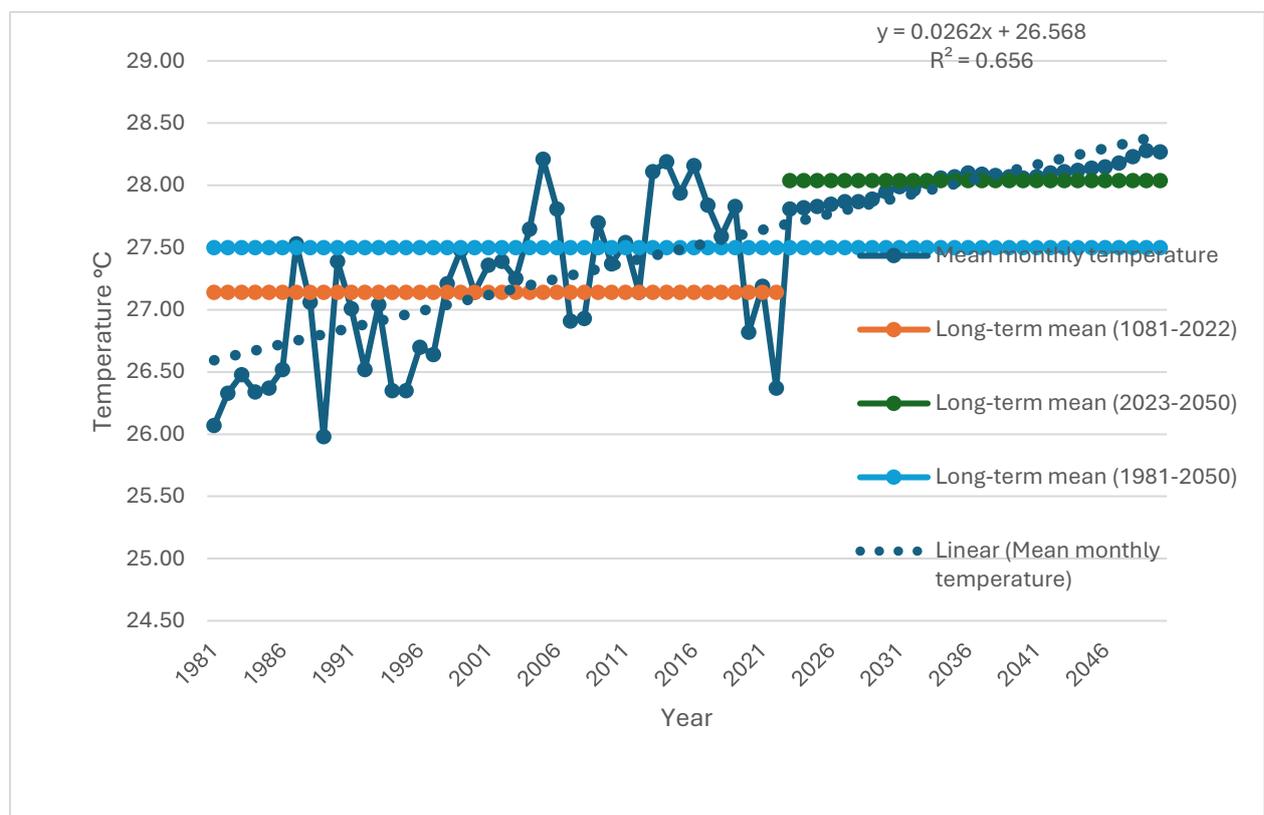


Figure 2.26 Trends in mean annual temperature for Sokoto-Zamfara Catchment (1981- 2050)
(Source: MSL, 2025)

2.8.4 Analysis of Downscaled Output of GCMs

In order to explore the possible change in climate conditions in future, the statistically downscaled output of GCMs, which is provided by CCAFS, are analyzed. The statistical downscaling as well as bias correction was conducted utilizing the spatial distribution of

parameters provided by Worldclim³ dataset. The available dataset by CCAFS includes the average monthly precipitation and air temperature with 30 year running averages from 2020s to 2080s. As for the emission scenarios, the followings are available.

- A1B: High economic growth with globalization utilizing balanced energy sources
- A2: High economic growth with globalization
- B1: Low economic growth with globalization

At this moment, the down scaled output of the following seven (7) GCM are available for download.

- CCCMA-GCM3.1
- CRIRO-MK3.0
- IPSL-CM4
- MPI-ECHAM5
- MRI-CCSM3.0
- UKMO-HADCM3
- UKMO-HADGEM1

The down scale data for A1B scenario with grid scale of 10 minute are spatially averaged for each HA and other related catchment areas outside Nigeria for further analysis.

- In general, the average change among the different outputs from the GCMs is much smaller than the standard deviation. This indicates that there is a lot of uncertainty on the change in precipitation.
- For all HAs, the precipitation tends to decrease during MAM (March, April, May) and increase during JJA (June, July, August) and SON (September, October, November).
- The rate of change increases gradually with time in general, which amplifies the initial direction of change.

In order to explore the possible change in climate conditions in the future, the statistically downscaled output of seven Global Climate Models (GCMs) has been analysed using emission scenario A1B. This scenario assumes high economic growth with globalization utilizing balanced energy sources. The change in precipitation and temperature averaged over the 7 GCM results for three-time horizons are shown in Figure 2.27 and Figure 2.28 respectively.

The approach used in NWRMP for identifying the representative 30 year running average time frame is also followed in this study. The target years of this study are 2035 and 2065. Considering that the project life time is usually 50 years for civil works, it means that 2035 plus 50 years should be the longest time frame to be considered. For the average condition of the time horizon between 2015 and 2085(=2035+50), the results for 2050s from the output of the GCMs can be applied. These GCM results describe the 30-year running average of 2040 to 2069. Similarly, for the average condition of the time horizon between 2015 and 2115 (=2065+50), the results for 2080s from the output of the GCMs can be applied. These results describe the 30-year running average of 2070 to 2099.

This study assumes that the change in precipitation for each season is set at the average value of the output of the GCMs. The change in annual mean air temperature is set at the annual average value of the output of the GCMs. The change factors are summarized in below Table 2.26.

Table 2.26: Overview of change factors for the two target years

Parameter	Season	2035	2065
P (%)	DJF	+12.3	+17.1
	MAM	-0.5	-2.1
	JJA	+7.9	+12.0
	SON	+7.6	+11.7
T (°C)	Annual	+2.5	+3.9

Source: JICA 2014 MP

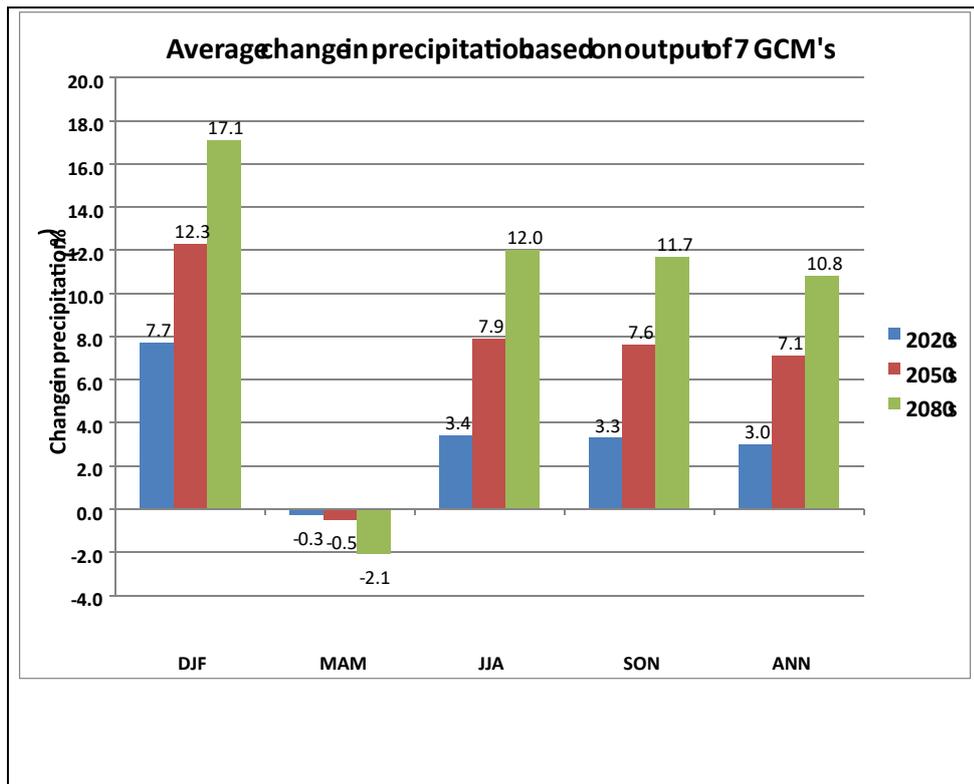


Figure 2.27: Average changes in precipitation derived from outputs of 7 GCMs (source: JICA, 2014)

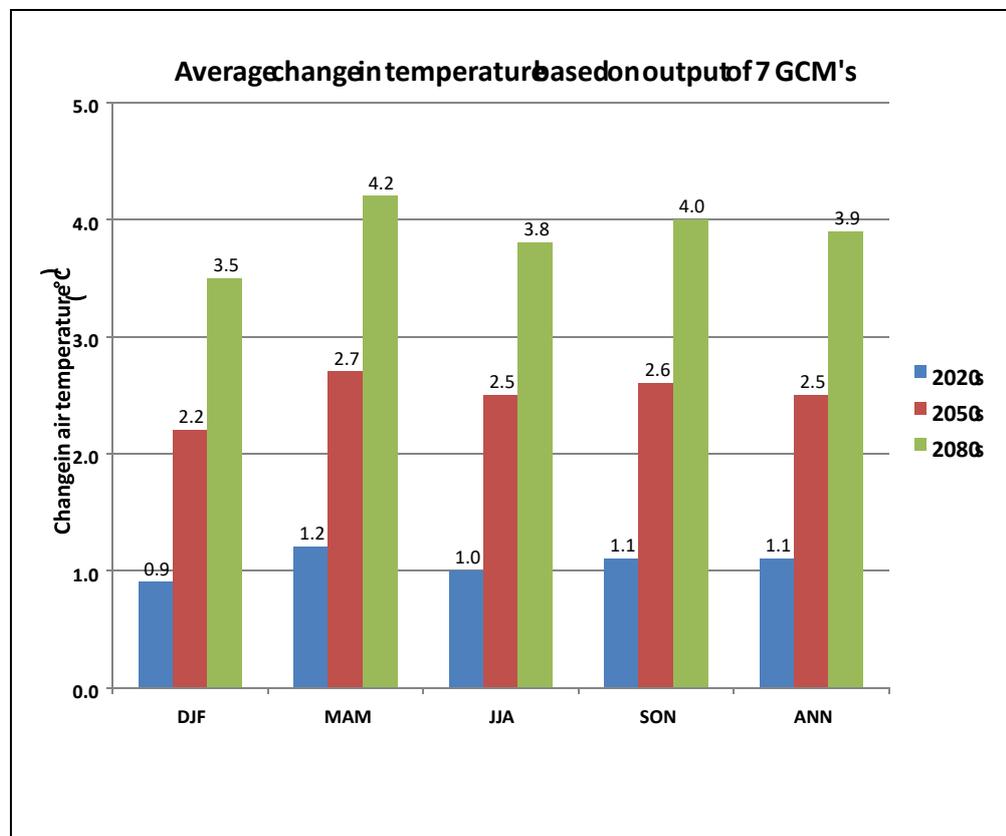


Figure 2.28: Average changes in temperature derived from outputs of 7 GCMs (source: JICA 2014),

2.8.5 Evapotranspiration

Figure 2.29 depicts the annual evapotranspiration (ET) trend for the Sokoto-Zamfara Catchment from 1981 to 2050.

Figure 2.29 shows a negative slope of -1.7569 , indicating a gradual decline in annual evapotranspiration over time. On average, evapotranspiration decreases by 1.76 mm per year. This decline could be due to reduced rainfall, increased temperatures, or changes in land use. An R^2 of 0.3218 indicates a weak to moderate correlation between the year and annual evapotranspiration. This explains 32.18% of the variation in annual evapotranspiration, indicating the influence of other climatic and environmental factors.

The long-term mean for the historical Period (1981-2022) is 733.65 mm, which is higher than the long-term mean; this drops to 675.42 mm during the projected period (2023-2050). By the projection, evapotranspiration will continue to decline during the projected period.

The declining evapotranspiration has implications for agriculture, water resources, and the local ecosystem.

Reduced evapotranspiration may affect crop yields, particularly for rain-fed agriculture, which relies on natural water availability. Lower evapotranspiration could reduce the recharge of groundwater and surface water bodies, impacting water availability for human consumption, livestock, and ecosystems. Reduced evapotranspiration could stress local ecosystems, affecting plant growth and biodiversity. Changes in water availability may alter the composition and distribution of plant and animal species.

Farmers may need to adopt irrigation and water conservation practices to mitigate the impact of reduced evapotranspiration, and water management strategies will be crucial to address potential water scarcity.

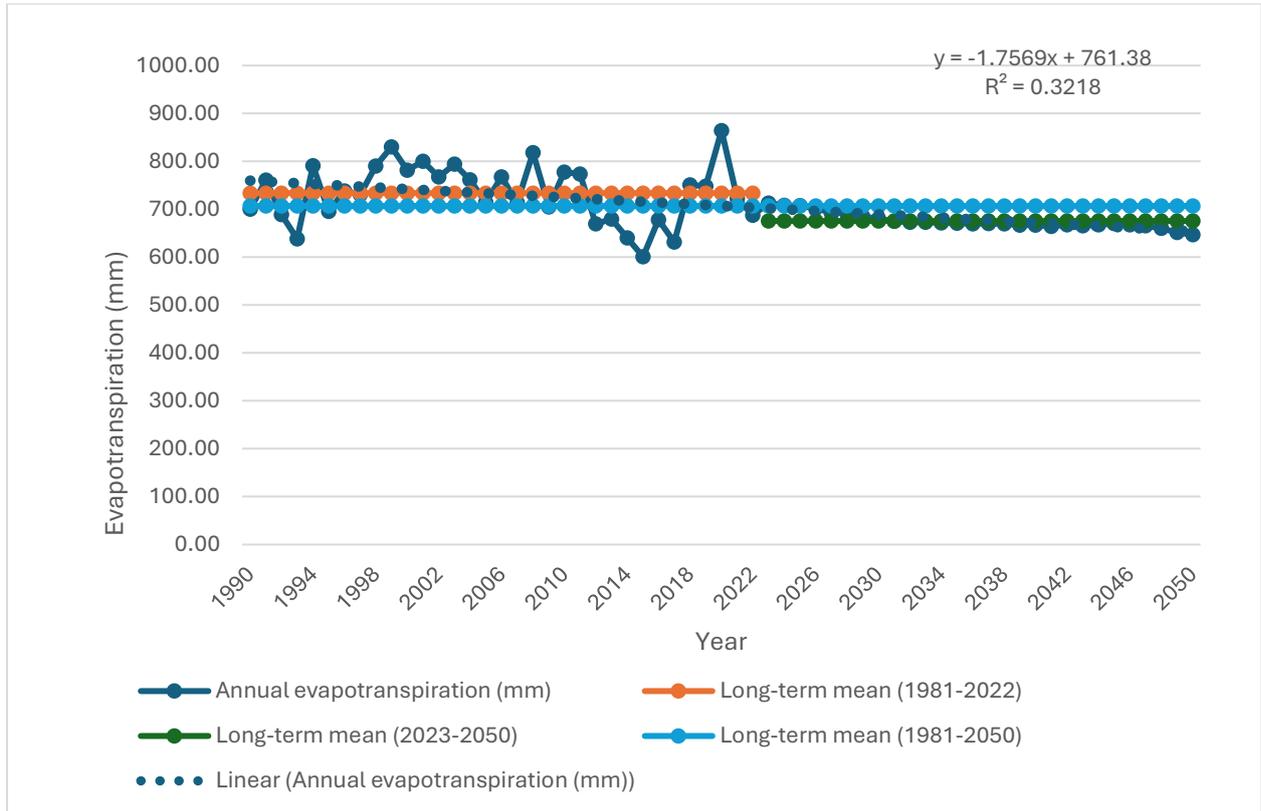


Figure 2.29 Annual evapotranspiration trend for Sokoto-Zamfara Catchment (1981-2050).

2.8.6 Major Impacts of Climate Change

Climate change poses severe and far-reaching challenges across multiple sectors within the Sokoto-Zamfara Catchment, significantly impacting the socio-economic fabric, public health, and critical infrastructure. These effects are increasingly evident through disrupted agricultural productivity, heightened vulnerability of communities, and strain on essential services. **Table 2.27** outlines key climate-related impacts observed and projected in the catchment area, drawing attention to the urgent need for integrated and adaptive management strategies.

Table 2.27: Key Impacts of Climate Change

S/No.	Impacts	Details
1	Economic	<ul style="list-style-type: none"> - Agricultural losses due to erratic rainfall, rising temperatures, and soil degradation reduce crop yields (e.g., rice, sorghum, millet). - Fishing and livestock income drop during drought/flood years. - Higher food prices affect affordability.
2	Social	<ul style="list-style-type: none"> - Increased migration from degraded areas to urban centers or safer zones. - Rising tension between farmers and herders over shrinking water and grazing resources. - Livelihood insecurity pushes rural populations into poverty.
3	Environmental	<ul style="list-style-type: none"> - Desertification encroaching from the north, degrading forests and pastures. - Wetland shrinkage (e.g., Sokoto-Rima floodplains) reduces biodiversity and ecosystem services. - Deforestation accelerates due to fuelwood dependence.
4	Health Impact	<ul style="list-style-type: none"> - Heat-related illnesses rising due to increased average temperatures (projected +3–5°C). - Flooding leads to outbreaks of waterborne diseases (cholera, diarrhea) and vector-borne diseases (malaria). - Drought reduces water access, affecting hygiene.
5	Infrastructure & Services	<ul style="list-style-type: none"> - Urban flooding in cities like Sokoto and Argungu damages roads, housing, and drainage systems. - Irrigation infrastructure (e.g., Bakolori, Goronyo) stressed by low inflows and sedimentation. - Energy services affected by declining hydropower potential.

2.8.7 National and International Climate Change Frameworks/Agreements

The NWRMP (JICA,2014) investigated the climate change effects on Nigeria. The long-term trend of rainfall and air temperature in the past in Nigeria has been considered based on meteorological datasets collected from NIMET and was summarised as follows:

- ❖ There is a linear tendency of increase in air temperature in the last 50 years;
- ❖ There is a linear tendency for a decrease in rainfall in the last 50 years. However, the variation by decades is much larger than the linear decreasing rate;
- ❖ Generally, most parts of the country show evidence of long-term temperature increase;
- ❖ Annual rainfall showed a decrease of 2 to 8mm/ year across many parts of the country.

According to JICA studies 2014, it was found that the annual rainfall does not change over the coming 35 years. However, the temperature changes by 2.6°C over the time frame.

2.8.7.1 Climate Change Scenarios

For the possible future climate conditions, climate change scenarios in Nigeria have been discussed as shown below.

According to the 4th IPCC report (2007), it is expected that the increase of air temperature in West Africa area in 2100 would be about 3-5 degree Celsius in the case of A1B scenario, which is about 1.5 times higher than the average in the world.

As for the precipitation, the predictions of precipitation by different GCM models vary very much. It is difficult to conclude the general tendency for the change in precipitation.

2.8.7.2 Nigeria's First National Communication on Climate Change

In the Nigeria's First National Communication (2003), the climate change scenarios in Nigeria have been discussed based on several GCM model output. The following findings were noted.

- The most significant changes are with respect to temperature and temperature-related parameters.
- There has been an observed trend towards aridity in Sub-Saharan West Africa. This trend will be put on hold or reversed as the century progresses. There are possibilities, however, that the additional water need created by higher temperatures may not be met by the increases in precipitation.
- The difference in climate conditions from coastal areas to the northern part of the country could become more significant.

2.8.7.3 Nigeria's Second National Communication on Climate Change

Nigeria's Second National Communication (SNC) on Climate Change is a key step in addressing climate impacts in line with the Paris Agreement and UNFCCC. It offers a thorough analysis of greenhouse gas emissions, climate vulnerability, and adaptation and mitigation strategies relevant to Nigeria's unique context.

The findings of the SNC highlight the escalating risks posed by climate change to Nigeria's ecosystems, economy, and communities, particularly vulnerable populations. Some of the key findings are listed below;

- i. Greenhouse Gas (GHG) Inventory and Emissions Trends
- ii. Vulnerability and Impacts of Climate Change

- iii. Adaptation Measures and Challenges
- iv. Mitigation Strategies and Potential
- v. Barriers to Climate Action
- vi. International Cooperation and Support Needs

Some of the outcomes and Future Steps are also presented below;

- i. Strengthening Policy Frameworks
- ii. Public Awareness and Community Engagement
- iii. Focus on Renewable Energy Expansion
- iv. Capacity Building and Research Development

2.8.7.4 Nigeria's Third National Communication on Climate Change

The Third National Communication on climate change showcases Nigeria's commitment to addressing greenhouse gas emissions and climate vulnerabilities. It highlights that the Agriculture, Forestry, and Other Land Use (AFOLU) sector accounts for 60.1% of emissions, with projections of a 58% increase by 2035. Nigeria faces risks such as drought, desertification, flooding, and reduced agricultural productivity.

Key findings and outcomes were similar to the second National Communication with some improvement such as;

- i. Capacity Building, Technology Transfer, and Financial Needs
- ii. Enhanced Policy Framework and Institutional Coordination
- iii. Scaling Up Renewable Energy and Green Economy Initiatives
- iv. Strengthening Community Engagement and Resilience Building
- v. Research, Innovation, and Monitoring Systems

2.8.7.5 The Paris Agreement

Since becoming a member of the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, Nigeria has ratified the Kyoto Protocol in 2004 and the Paris Agreement in 2007.

The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on the 12th of December, 2015. It came into effect on the 4 of November, 2016

Its overarching goal is to cease “the increase in the global average temperature to well below 2°C above pre-industrial levels” and pursue efforts “to limit the temperature increase to 1.5°C above pre-industrial levels.”

2.9 Flood and Drought Vulnerability

The Flood Vulnerability was performed through GIS analysis to determine the vulnerable locations using the weighted Overlay process. Weighted vulnerability analysis allows us to answer questions that are impacted by many factors and assign varying weights to each of the factors. The result gives more information than binary analysis, as it ranks locations based on the vulnerability rather than giving only a vulnerable/not vulnerable result.

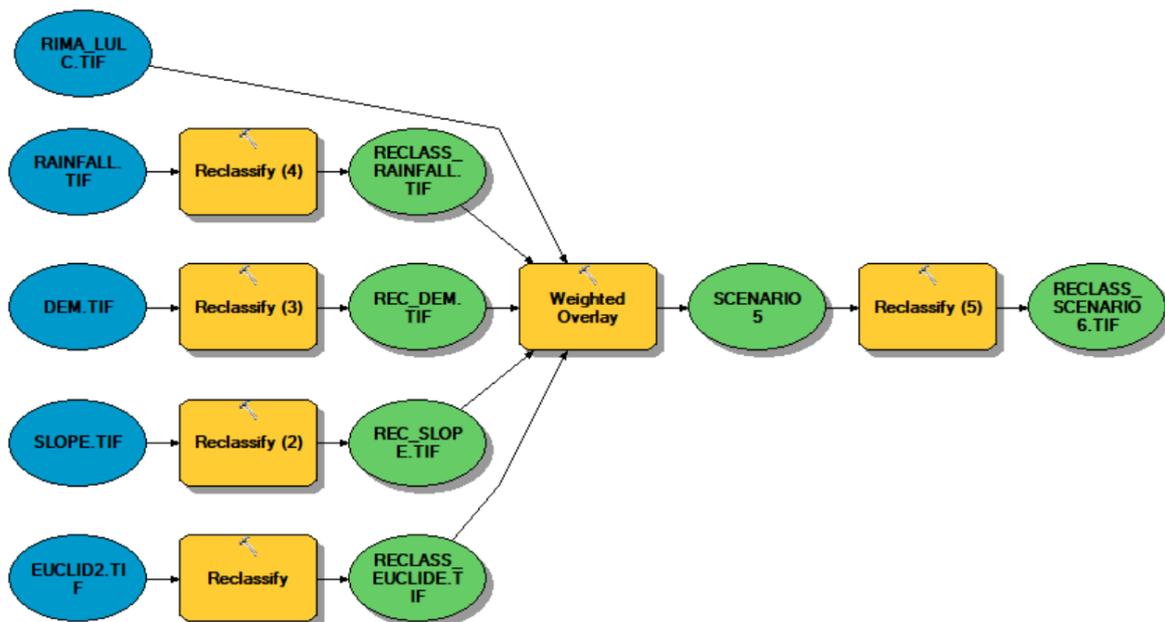


Figure 2.30: The flow chat of the methodology (Source: MSL, 2025)

Various factors that influence or contribute to flooding were incorporated into the model for determining vulnerable areas. For this study, slope, elevation, proximity to rivers, Land use/Land cover and rain fall datasets were used. Before performing the weighted overlay, standardization is carried out by reclassifying each layer. This gives the layers a common scale (i.e. 1 to 5, 1 to 9, etc.) that will be preserved in the final overlay. Finally, the weight of each layer is assigned, the layers are combined in a weighted overlay, and the results are analysed. See Fig. 1 for a graphical depiction of the model used to carry out the flood vulnerability model exercise.

2.9.1 Elevation

Elevation is crucial in flood modelling as it affects the flow, direction, and extent of floodwaters. Models use elevation data to predict water movement and identify vulnerable areas. The terrain's slope and gradient influence the speed and direction of water flow. Water naturally flows from higher to lower elevations due to gravity.

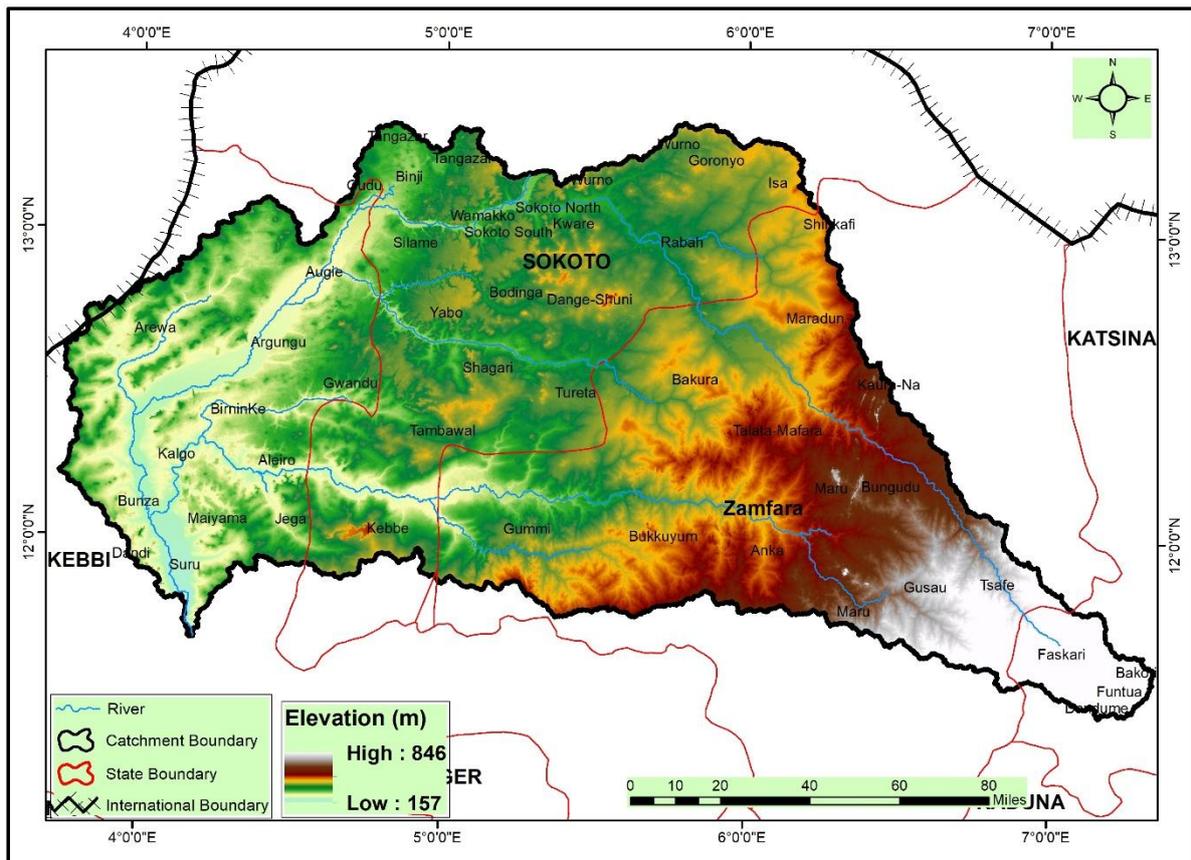


Figure 2.31 Digital Elevation Model of the Catchment (Source: MSL, 2025)

Steeper slopes can lead to faster-moving floodwaters, increasing the risk of flash floods, while flatter areas may experience slower-moving but more widespread flooding.

The light grey areas from the legend above indicate areas with higher elevations while the green to the light green shows lower elevation areas. The general elevation of the catchment ranges between 157m to 846m above sea level particularly in the south-eastern part of the catchment also serving as the source of most of the rivers in the catchment.

2.9.2 Rainfall

Rainfall is a critical factor in flood vulnerability modelling due to its direct and significant impact on the likelihood, severity, and extent of flooding events. As a key driver of surface runoff and river discharge, rainfall plays an integral role in determining flood risk, particularly in regions prone to heavy or intense precipitation.

- The amount and intensity of rainfall within a specific time frame are essential for predicting flash floods, urban floods, and riverine floods. Short, intense rainfall events can overwhelm drainage systems, causing rapid runoff and localized flooding.
- Long-duration, moderate rainfall can saturate the soil, increasing the likelihood of river and lake basin flooding.

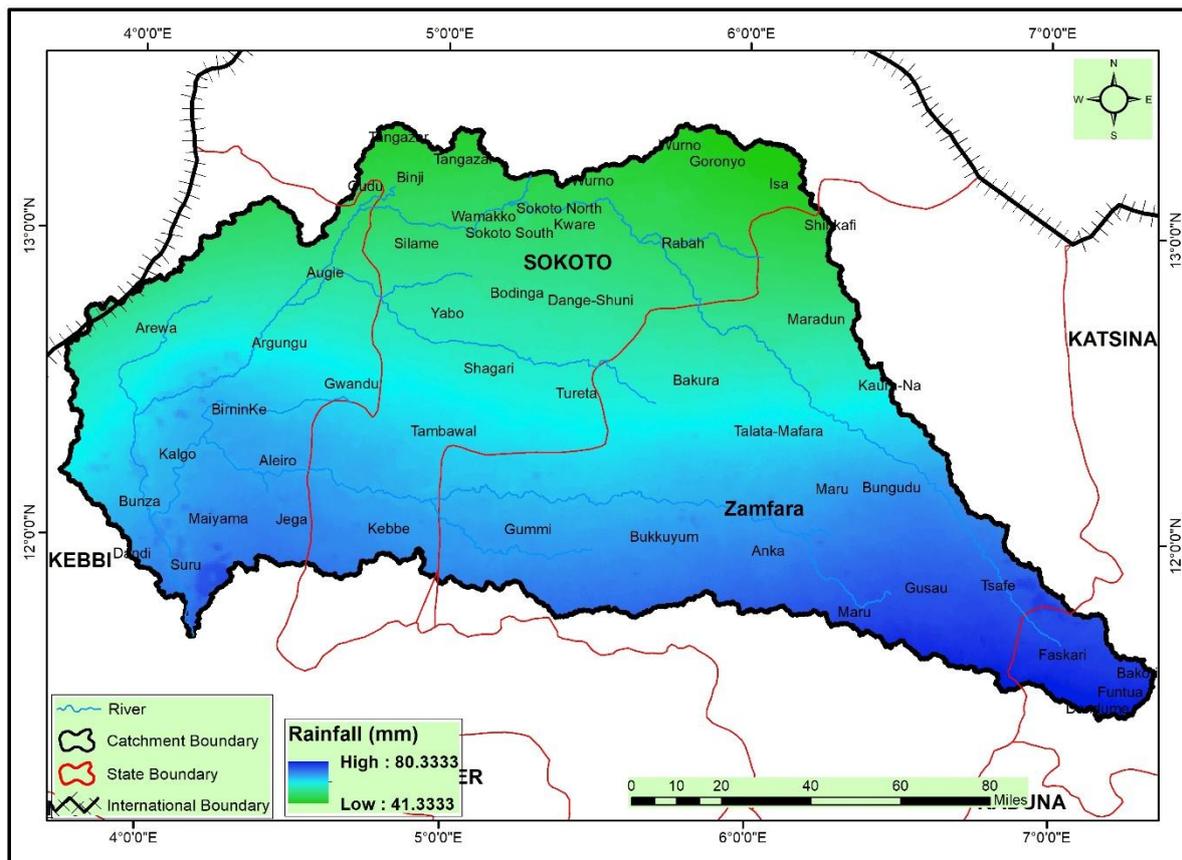


Figure 2.32 Rainfall Map of the Catchment (Source: MSL, 2025)

Rainfall varies significantly across geographic regions, and the impacts of rainfall on flood vulnerability can differ based on topography, land use, and local climate. In mountainous regions, for instance, rainfall can lead to rapid runoff down steep slopes, causing flash floods in valleys and foothills.

- The rainfall map of the catchment revealed a-some what moderate range of rainfall distribution, with the values showing gradual variation in spatial distribution from 80.33mm to as low as 41.33mm annual rainfall in the catchment area.
- With these minimum values of precipitation in the catchment area precipitation may not be the major driver of flooding in the catchment area, however it can cause havoc when there is high intensity of rainfall that can result to flash floods.

2.9.3 Slope

Slope influences surface runoff speed and volume. Steeper areas experience quicker rainfall flow, increasing the risk of flash flooding. In contrast, flatter regions allow for slower runoff, promoting better water infiltration and reducing immediate flooding. However, even in flatter

areas, accumulated water can eventually overwhelm drainage systems if the capacity to handle runoff is exceeded

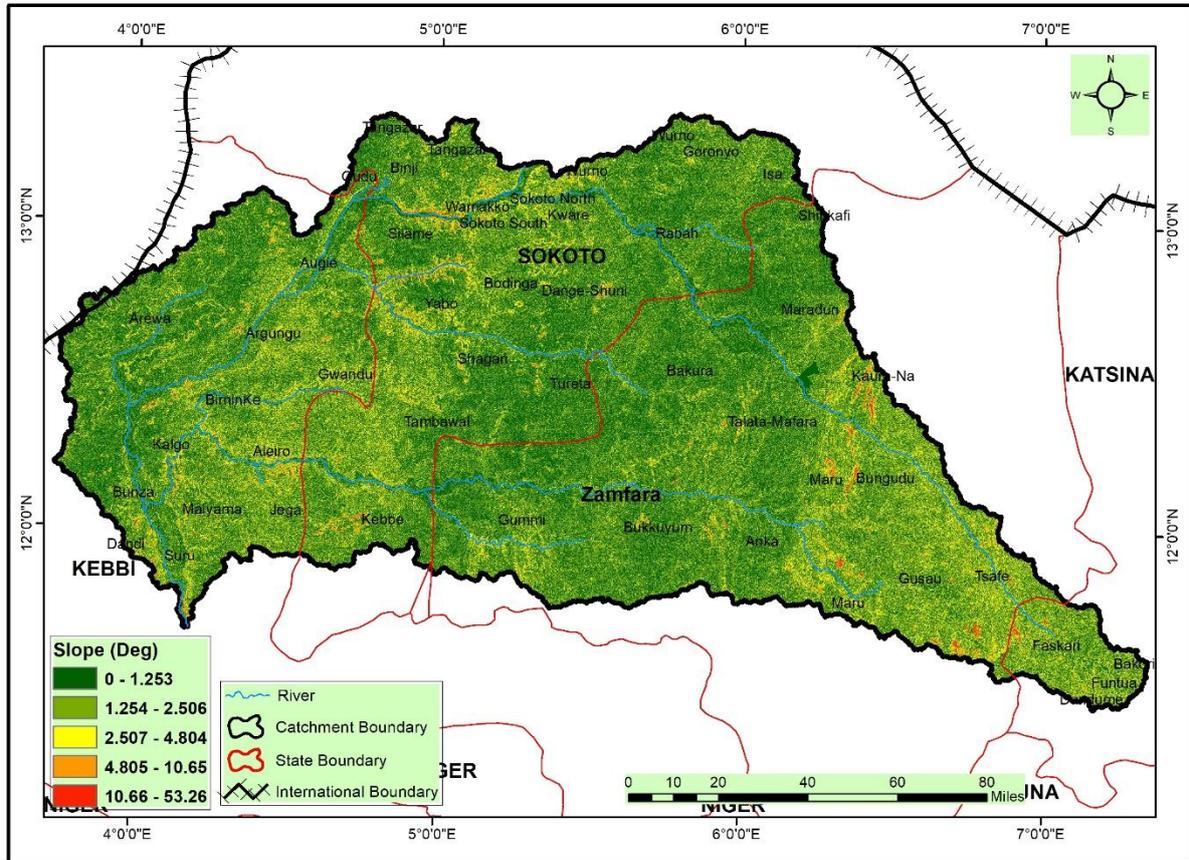


Figure 2.33 Slope Map of the Catchment (Source: MSL, 2025)

The map delineates various levels of inclination in the terrain, providing insights into the landscape’s characteristics.

- Areas with flat to very gentle slopes (0–1.3°) are predominantly flat, increasing the likelihood of water pooling and slower drainage, potentially leading to flooding during heavy rainfall.
- Regions with gentle slopes (1.3–2.6°) facilitate better water runoff than flatter areas but still pose a moderate risk of water accumulation.
- Areas with moderate slopes (2.6–4.8°) exhibit a moderate steepness, promoting more rapid surface runoff, reducing water retention, and heightening the risk of soil erosion.
- Steep slopes (4.8–10.7°) are susceptible to swift runoff and increased erosion, which could potentially cause sediment displacement and accelerate downstream water flow.

- Very steep slopes in this catchment (10.6-53.3⁰) represent the steepest gradients in the area where the velocity of runoff is at its maximum.
- The southern and some northern parts of the catchment show some high elevations, making it less prone to standing water but capable of causing rapid runoff that could impact the adjoining floodplains downstream.

2.9.4 Proximity to River

- Distance is a critical factor in flood modelling because it directly influences how floodwaters spread, the time it takes for flooding to impact specific areas, and the severity of the flood's effects. Distance determines how quickly floodwaters travel from the source (a river, dam breach, or coastal area) to downstream or inland locations.
- The distance from the flood source influences the spatial extent of inundation.

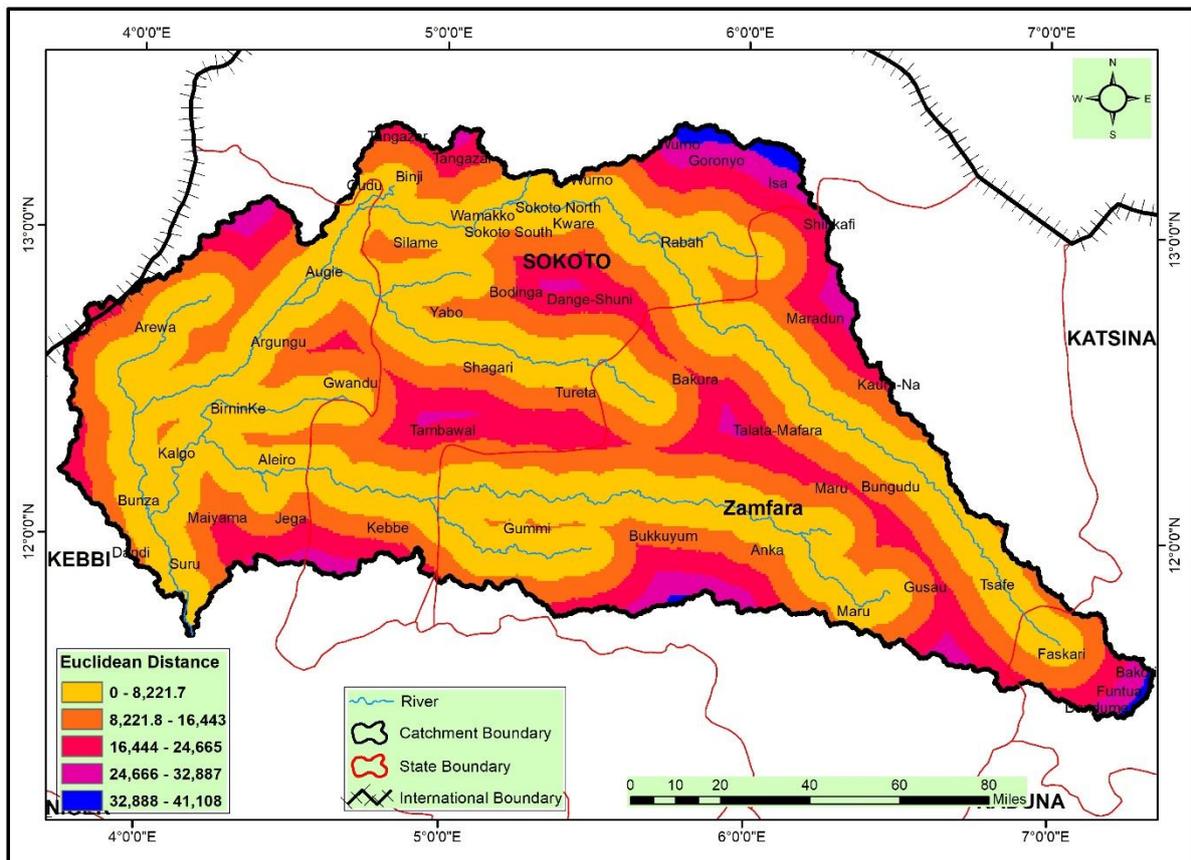


Figure 2.34 Proximity to River Map of the Catchment (Source: MSL, 2025)

Topography also tends to interact with distance to influence the behaviour.

- In hilly or mountainous regions, floodwaters may travel longer distances but at slower speeds due to elevation changes.

- In flat areas, floodwaters can spread quickly over large distances. Flood models incorporate distance and elevation data to simulate these dynamics accurately.
- Euclidean distance can identify areas within a certain radius of a river, lake, or coastline that are likely to be affected during a flood event. This information is crucial for zoning regulations and insurance purposes

2.9.5 Land Use and Land Cover

Land use types affect water movement; natural areas like forests absorb rainfall better, reducing surface runoff. In contrast, urban areas with impervious surfaces increase runoff, elevating flood risks. This urbanisation, especially in floodplains, can overwhelm drainage systems and cause flash flooding. Modelling the distribution of land use types helps to predict runoff patterns, which is crucial for assessing flood risk.

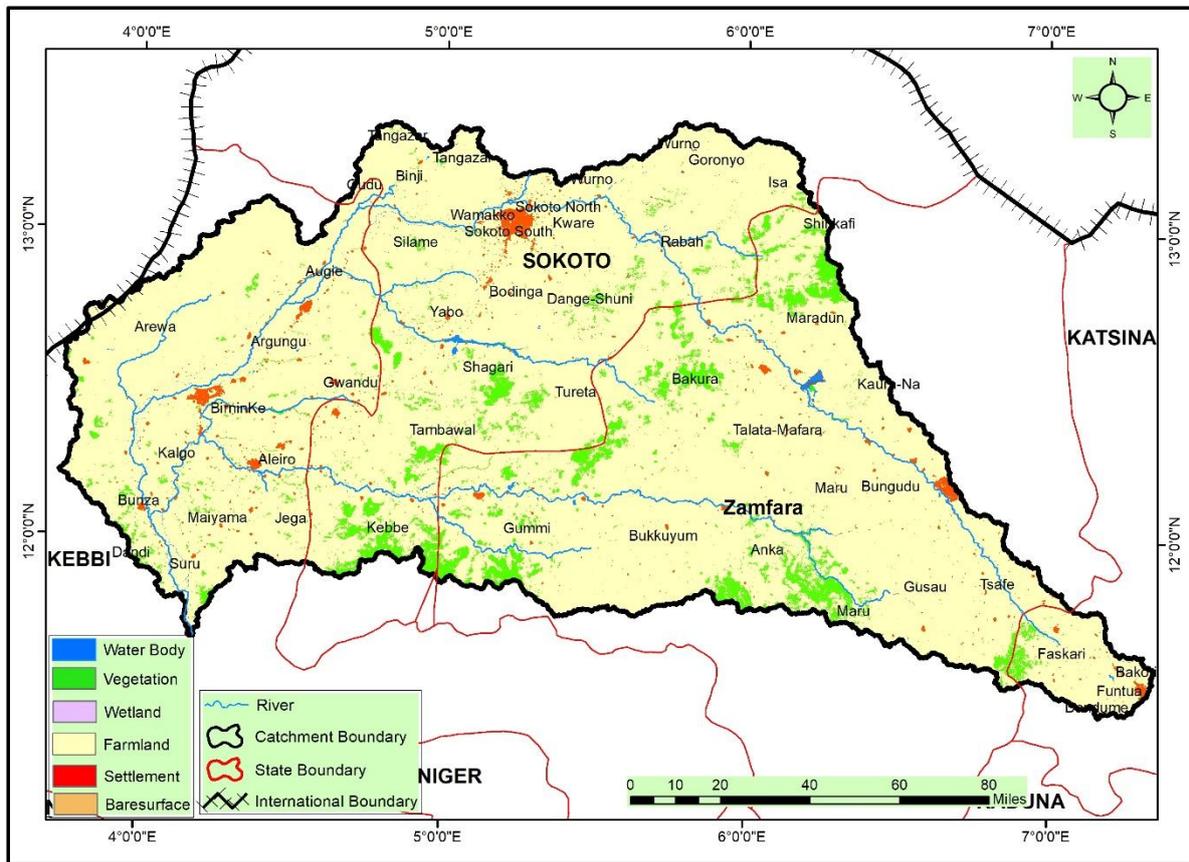


Figure 2.35 LULC Map of the Catchment (Source: MSL, 2025)

Human activities like urbanization and agriculture alter natural drainage systems, obstructing rivers and streams. This can change water flow and increase flood risk, especially where natural flood controls like wetlands and forests have been disrupted.

2.9.6 Flood Vulnerability

The study used a weighted overlay analysis to evaluate flood vulnerabilities in the catchment, creating a composite flood vulnerability map by overlaying datasets like DEM, proximity to rivers, precipitation, slope, and land use. The layers were categorized, weighted, and scored on a 1–9 scale before analysis. Proximity to rivers received the highest weight, followed by elevation, precipitation, slope, and Land use.

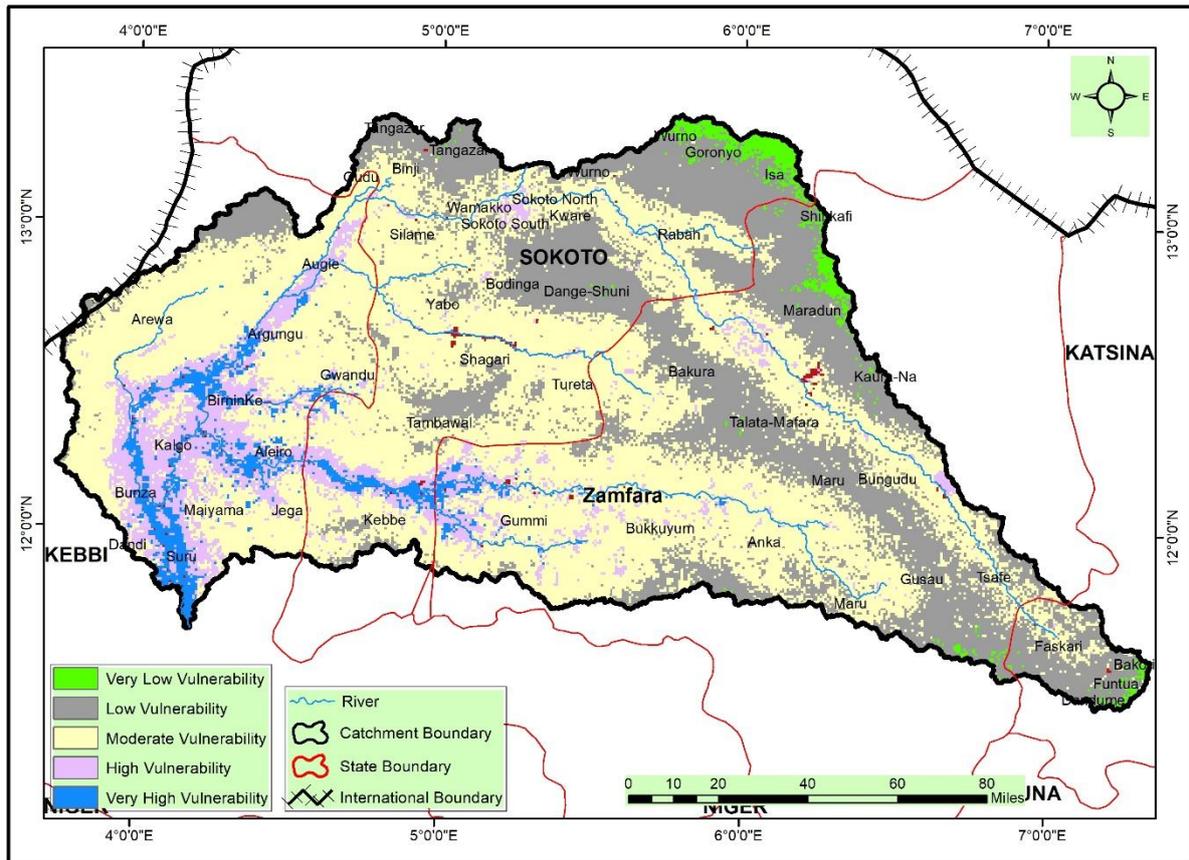


Figure 2.36 Flood Vulnerability Map of the Catchment (Source: MSL, 2025)

The vulnerability risk map delineates various potential flood zones within the catchment area, classified into five risk levels: Very low vulnerability, Low Vulnerability, Moderate Vulnerability, High Vulnerability, and Very high Vulnerability (Figure above). The total study area spans about 4,588,344.446 Ha.

Low flood risk areas are primarily found in high-elevation regions, with moderate flooding potential during heavy rainfall. Areas immediately following these heights also exhibit low vulnerability. In contrast, high and very high flood vulnerability zones are concentrated in

lower elevation areas. These areas face a greater risk of flooding due to their proximity to the highlands and are characterized by large floodplains.

Table 2.28: Flood Vulnerability Analysis of the Catchment

Vulnerabilities	Ha	%
Very Low Vulnerability	80307.3834	1.69
Low Vulnerability	1412108.879	29.79
Moderate Vulnerability	2685437.027	56.65
High Vulnerability	541439.2581	11.42
Very High Vulnerability	21310.6185	0.45
Total	4,740,603.166	100



Figure 2.37 Flood Risk LULC analysis of the Catchment (Source: MSL, 2025)

2.9.7 Flood Risk

The flood risk map is derived by extracting the optimal flood vulnerable zones and extracting from the land use to estimate land use at higher risk of flooding. This analysis depicts areas and land uses within the critical zone that are at high risk of flooding, as shown below.

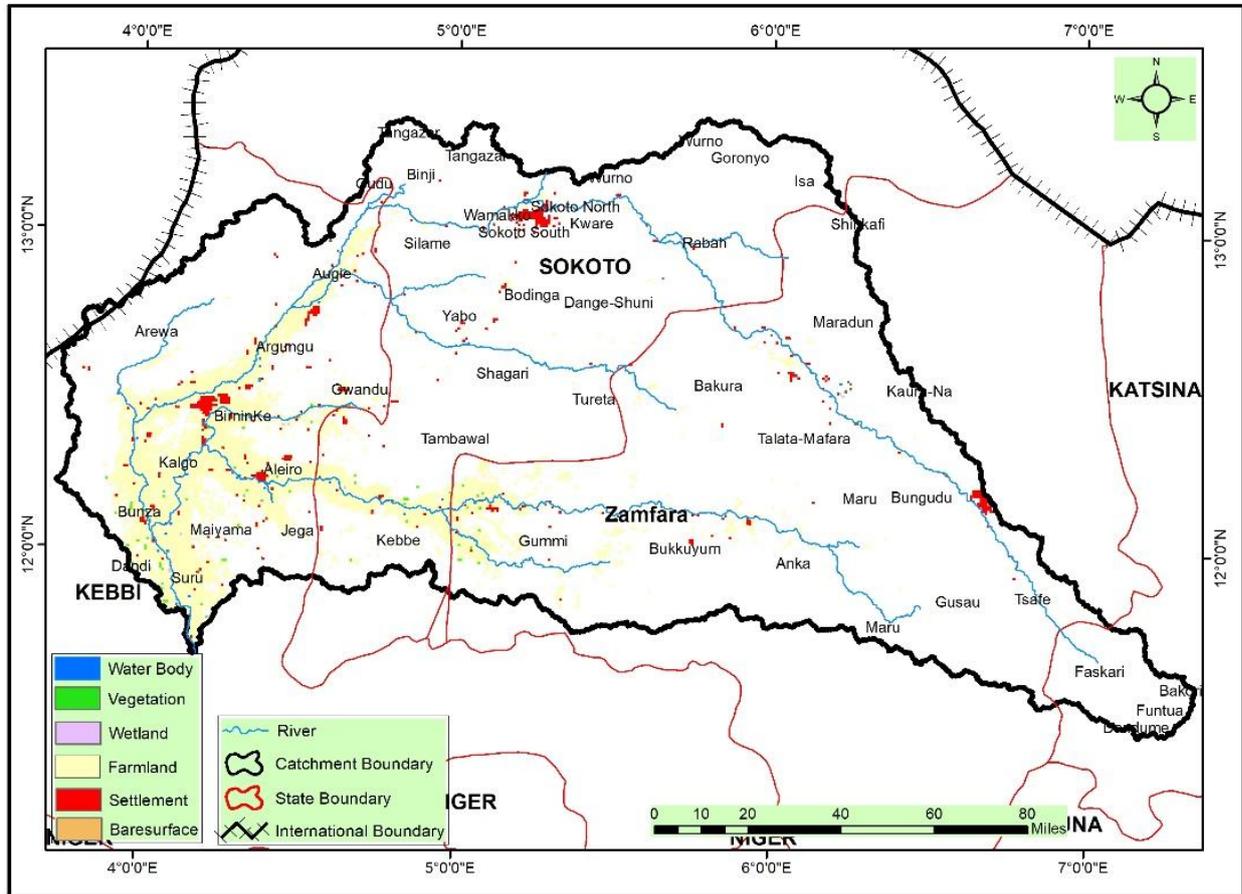


Figure 2.38 Flood Risk Map of the Catchment (Source: MSL, 2025)

The land use at risk in the Sokoto-Zamfara catchment is predominantly farmland at 64.2ha which is 90.64% of the total land use at risk within the vulnerable area. Flooding in the Sokoto-Zamfara catchment is majorly influenced by the relief and proximity to rivers within the catchment area.

Table 2.29 Flood Risk Analysis of the catchment

LULC	Ha	%
waterbody	0.33	0.465904
Vegetation	0.68	0.960045
Wetland	0.11	0.155301
Farmland	64.2	90.63956
Settlement	5.22	7.369759
Baresurface	0.29	0.409431
Total	70.83	100

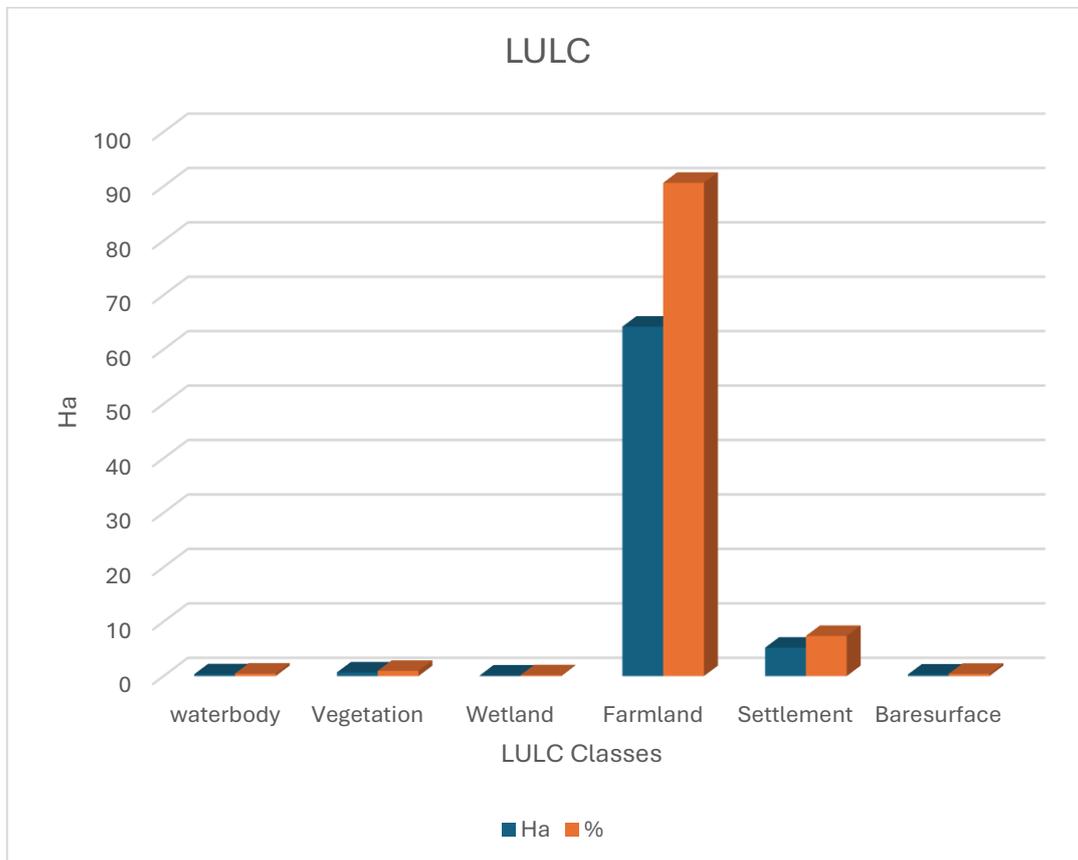


Figure 2.39 Flood Risk LULC analysis of the Catchment (Source: MSL, 2025)

2.10 Socio-Economic Dynamics

2.10.1 Population Distribution and Growth

The current population within the Sokoto-Zamfara Catchment is estimated at around 11.17 million people Figure 2.40. This number is projected to rise to 17.1 million by 2050. More detailed tables, breaking down the population by state and Local Government Area (LGA), are provided in Annex 1.

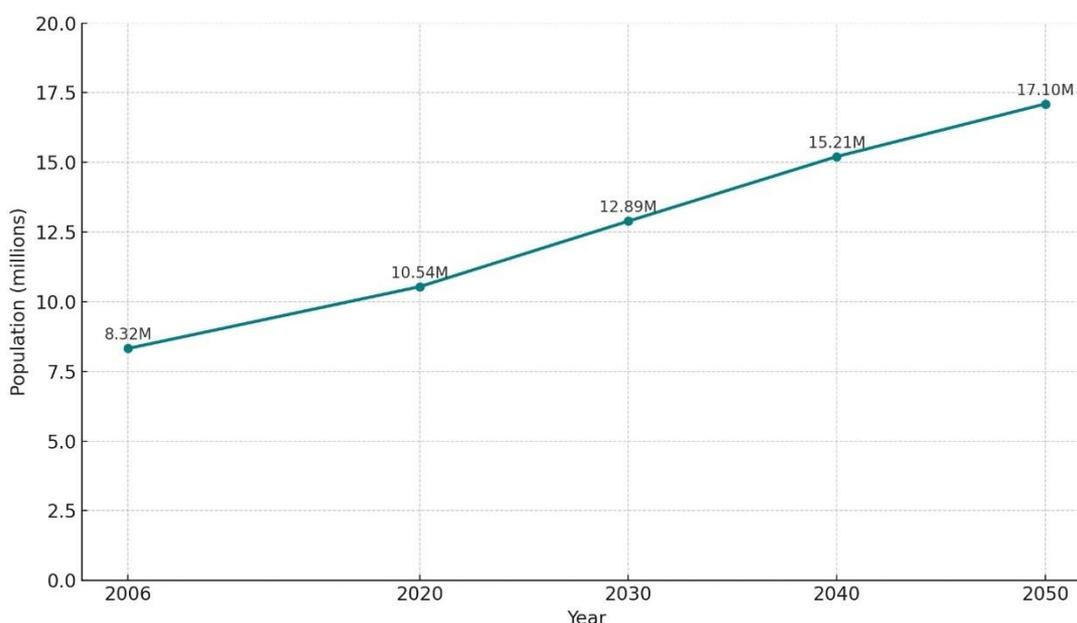


Figure 2.40: Population Projection for Sokoto-Zamfara Catchment (Source: MSL, 2025)

Table 2.30: Population Projection for Sokoto-Zamfara Catchment

State	Estimated Population (2023)	Growth Trend	Population Density	Urbanization	Key Observations
Sokoto	~5.2 million	Growing steadily (from ~3.9M in early 2000s)	~200 people/km ²	~40% urban, 60% rural	Youthful population (60% <25 years), high fertility (TFR ~5.7), rural-urban migration to Sokoto City
Zamfara	~4.7 million	Steady increase (projected ~6.5M by 2035)	~118 people/km ²	~30% urban, 70% rural	High fertility (TFR ~6.4), rapid growth in Gusau and Talata Mafara, urban services under pressure

Kebbi	~5.6 million	Growth from ~3.8M in 1990s, projected ~7.5M by 2035	~152 people/km ²	~30-35% urban, 65-70% rural	Strong agricultural economy attracts migrants; youth majority (58% <25), increasing urban pressures Only part of Katsina is within the catchment; Funtua, Dandume, Faskari among key LGAs included
Katsina (partial)	~7 million (statewide)	Projected ~10M by 2035 (statewide)	~289 people/km ² (state average)	~35-40% urban	



Table 2.31: Summary of the characteristics of Sokoto-Zamfara Catchment

NAME	STATES	POPULATION	GEOGRAPHY	GEOLOGY	HYDROGEOLOGY	VEGETATION	SOCIAL ECONOMICS
Sokoto-Zamfara Catchment	Sokoto, Zamfara, Katsina, Kebbi	Population of the catchment is over 10 million	<p>Location: Northwestern Nigeria, covering parts of Sokoto, Kebbi, Katsina and Zamfara states.</p> <p>Topography: Primarily flat plains with some low hills and ridges</p>	<p>Underlying rock formations: Primarily consist of sedimentary rocks like sandstones and shales, with some igneous intrusions in specific areas.</p> <p>Geologic vulnerability: Certain areas might be susceptible to erosion due to the type of underlying rock and soil composition</p>	<p>Drainage system: The Rima River is a major tributary of the Sokoto River,</p> <p>Groundwater resources: Underlying aquifers provide essential water for domestic use, irrigation, and livestock. However, these resources are under pressure due to increasing demand and potential salinization</p>	<p>Predominant vegetation: Sudanian savanna with woodlands and grasslands.</p> <p>Vegetation degradation: Overgrazing, deforestation, and desertification threaten the natural vegetation cover, impacting soil quality and water retention</p>	<p>Livelihoods: Agriculture (rain-fed and irrigated farming), livestock rearing, fishing (along the river), and some trade and commerce.</p> <p>Water dependence: Communities heavily rely on the Rima River and groundwater resources for their survival and economic activities.</p> <p>Challenges: Poverty, water scarcity (seasonal), environmental degradation, and limited infrastructure development in some rural areas</p>

2.10.2 Demographics and Poverty

Table 2.32: Catchment Demographics and Poverty

State	Demographics	Poverty Indicators
Sokoto	- Population: ~5.2 million (2023 estimate) - Age Distribution: Predominantly youthful; ~60% under 25 years - Urban/Rural Ratio: ~40% urban, 60% rural - Literacy Rate: Data not available	- Poverty Rate: 87.73% (highest in Nigeria as of 2019) - Income Levels: Data not available - Access to Basic Services: Limited; high rural poverty impacts access to education, healthcare, and clean water
Zamfara	- Population: ~4.7 million (2023 estimate) - Age Distribution: High youth population; exact figures not specified - Urban/Rural Ratio: ~30% urban, 70% rural - Literacy Rate: Data not available	- Poverty Rate: 78% (multidimensional poverty as of 2022) - Income Levels: Data not available - Access to Basic Services: Challenges in education (e.g., 422,213 out-of-school children in 2018), healthcare, and infrastructure
Kebbi	- Population: ~5.6 million (2023 estimate) - Age Distribution: Youth majority; exact figures not specified - Urban/Rural Ratio: ~30–35% urban, 65–70% rural - Literacy Rate: Data not available	- Poverty Rate: 38.9% (as of 2018) - Income Levels: Data not available - Access to Basic Services: Data not available
Katsina	- Population: ~9.5 million (2023 estimate) - Age Distribution: Significant youth population; exact figures not specified - Urban/Rural Ratio: ~35–40% urban, 60–65% rural - Literacy Rate: Data not available	- Poverty Rate: 72.7% (multidimensional poverty as of 2022) - Income Levels: Data not available - Access to Basic Services: High number of out-of-school children (1.4 million as of 2021), limited access to healthcare and clean water

2.10.2.1 Unsustainable Livelihoods

The Sokoto-Zamfara Catchment faces significant challenges related to unsustainable livelihoods. These challenges are driven by a combination of environmental, economic, and social factors that impact the region's ability to support its population sustainably. Below is a detailed review of the unsustainable livelihoods within the catchment, based on the provided document and additional credible sources.

1. Agricultural Practices

- Agriculture is the primary livelihood for the majority of the population in the Sokoto-Zamfara Catchment. However, several unsustainable practices threaten the long-term viability of this sector:
- Soil Degradation: Intensive farming and overuse of land without proper soil conservation measures lead to soil erosion and loss of fertility. This is exacerbated by the region's semi-arid climate and frequent droughts.

- **Overgrazing:** The catchment is home to a significant number of livestock, leading to overgrazing in many areas. This degrades the vegetation cover and contributes to soil erosion and desertification.
- **Deforestation:** The demand for firewood and charcoal, along with agricultural expansion, has led to widespread deforestation. This not only reduces the availability of forest resources but also contributes to climate change and loss of biodiversity.
- **Inadequate Irrigation:** Many farmers rely on rain-fed agriculture, which is highly vulnerable to climate variability. The lack of efficient irrigation systems limits agricultural productivity, especially during the dry season.

2. Water Management

- Water scarcity and poor water management practices pose significant challenges to sustainable livelihoods in the catchment:
- **Declining Water Resources:** The region faces declining surface water levels and groundwater depletion due to over-extraction for irrigation and domestic use. This is exacerbated by the construction of dams that alter natural river flows.
- **Water Pollution:** Agricultural runoff, industrial effluents, and urban wastewater contribute to water pollution, affecting the quality of surface and groundwater resources.
- **Inefficient Irrigation:** Many irrigation systems are outdated and inefficient, leading to significant water losses. This reduces the overall water availability for agriculture and other uses.

3. Economic Constraints

- The catchment's economy is predominantly agrarian, with limited opportunities for alternative livelihoods:
- **Limited Diversification:** The lack of industrial and commercial activities limits economic diversification, making the population highly dependent on agriculture.
- **High Unemployment:** The region faces high levels of unemployment, particularly among the youth. Limited access to education and training further exacerbates this issue.
- **Poverty:** High poverty rates, particularly in rural areas, limit access to resources and opportunities, perpetuating the cycle of poverty.

4. Environmental Degradation

- Environmental degradation poses a significant threat to sustainable livelihoods in the catchment:

- Desertification: The region is highly vulnerable to desertification due to overgrazing, deforestation, and climate change. This reduces the availability of arable land and exacerbates water scarcity.
 - Soil Erosion: Wind and water erosion are significant problems, particularly in areas with sparse vegetation cover. This leads to loss of topsoil and reduced agricultural productivity.
 - Climate Change: The catchment is highly vulnerable to climate change, with increasing temperatures, erratic rainfall patterns, and more frequent extreme weather events. These changes disrupt agricultural cycles and water availability.
5. Social and Cultural Factors
- Social and cultural factors also contribute to unsustainable livelihoods in the catchment:
 - Gender Inequality: Limited access to education and economic opportunities for women restricts their ability to contribute to household income and sustainable development.
 - Rural-Urban Migration: The trend of rural-urban migration places additional pressure on urban infrastructure and services, leading to overcrowding and inadequate housing.
 - Insecurity: Issues such as banditry and kidnapping disrupt economic activities and deter investment, exacerbating poverty and limiting opportunities for sustainable livelihoods.

2.10.3 Gender Issues

2.10.3.1 Challenges

1. Access to Resources

- Land Ownership: Women in the Sokoto-Zamfara Catchment often have limited access to land ownership, which is predominantly controlled by men. This restricts their ability to engage in agricultural activities and limits their economic opportunities.
- Financial Resources: Access to credit and financial services is limited for women, hindering their ability to invest in agricultural inputs, technology, and other productive assets.
- Education and Training: Women and girls have lower literacy rates and limited access to education and vocational training compared to men. This gap restricts their participation in economic activities and decision-making processes.

2. Social Norms

- Cultural Practices: Traditional and cultural norms in the region often limit women's participation in public life and decision-making processes. These norms can restrict women's mobility and their ability to engage in economic activities outside the home.

- Gender Roles: Gender roles are rigidly defined, with women primarily responsible for household chores and childcare. This limits their time and ability to participate in income-generating activities and community development initiatives.

3. Participation in Decision-Making

- Representation: Women are underrepresented in local governance structures and decision-making bodies. This lack of representation means that their needs and perspectives are often overlooked in the development and implementation of policies and programs.
- Community Involvement: Women's participation in community-level decision-making processes is limited, reducing their influence on issues that directly affect them, such as water management and land use.

2.10.3.2 Opportunities

1. Roles in Sustainable Land/Water Management

- Agricultural Practices: Women play a crucial role in sustainable agricultural practices, including crop management, soil conservation, and water use efficiency. Empowering women through training and access to resources can enhance these practices.
- Water Management: Women are often the primary users of water for domestic purposes and small-scale agriculture. Involving them in water management initiatives can improve water use efficiency and sustainability.

2. Income Diversification

- Non-Farm Activities: Women can contribute to income diversification through participation in non-farm activities such as small-scale trading, handicrafts, and agro-processing. Supporting these activities can provide additional income and reduce dependence on agriculture.
- Entrepreneurship: Encouraging women's entrepreneurship through access to credit, training, and market linkages can create new economic opportunities and enhance their economic independence.

3. Empowerment Initiatives

- Education and Training: Providing education and vocational training programs tailored to women's needs can enhance their skills and employability, improving their economic status and social standing.
- Microfinance Programs: Implementing microfinance programs specifically targeting women can provide them with the financial resources needed to start or expand small businesses.

2.10.3.3 Recommendations

1. Policy Actions

- **Land Reform:** Implement policies that ensure women's rights to land ownership and access to agricultural resources. This can include legal reforms and awareness campaigns to promote gender equality in land ownership.
- **Financial Inclusion:** Develop financial products and services that are accessible to women, including microfinance, credit facilities, and savings programs.

2. Gender-Responsive Programming

- **Capacity Building:** Design and implement capacity-building programs that address the specific needs of women, including training in sustainable agricultural practices, water management, and entrepreneurship.
- **Community Engagement:** Promote community-level initiatives that encourage women's participation in decision-making processes and local governance structures.

3. Institutional Reforms

- **Representation:** Ensure that women are adequately represented in local governance bodies and decision-making processes. This can be achieved through quotas or other affirmative action measures.
- **Supportive Policies:** Develop and enforce policies that support gender equality and women's empowerment, including laws against gender-based violence and discrimination.

Addressing gender-related issues in the Sokoto-Zamfara Catchment requires a comprehensive approach that includes policy actions, gender-responsive programming, and institutional reforms. By ensuring women's access to resources, promoting their participation in decision-making, and supporting their economic empowerment, the region can achieve more sustainable and equitable development outcomes. These measures are essential for integrating gender considerations into development planning and policy frameworks, ultimately leading to improved socio-economic conditions for all residents of the catchment.

CHAPTER 3 : STAKEHOLDER ENGAGEMENT AND GOVERNANCE

3.1 Methodology

Considering that the strategic catchment management plan study was conducted on a macro level, stakeholder mapping for participants was done mainly on an institutional level. The institutions sent in representatives as a central location. Information was gathered through interviews, focus group discussions and outright enquiries.

3.2 Key Stakeholders Engaged

For the purpose of this study, the stakeholder engagement concepts that have been employed are as follows:

- Natural Resources (Land, water, vegetation, wildlife, minerals etc.)
- Threats and Challenges
- Socio-economics
- Policies
- Past and Present Interventions

To develop the strategic catchment management plan at a macro level, the study entailed the engagement of institutional stakeholders.

Sokoto State:

- i. Sokoto-Rima River Basin Development Authority
- ii. Farmers association/ pastoralists of the State
- iii. Rural Water Supply and Sanitation Agency (RUWASA)
- iv. State Ministry of Environment,
- v. State Ministry of Agriculture and Food Security
- vi. State Ministry of Water Resources
- vii. State Ministry of Lands, Housing and Survey
- viii. State Ministry of Women Affairs,
- ix. State Ministry of Solid Mineral Resources
- x. State Miners Association
- xi. Sokoto Leather Goods Producers Association.
- xii. Center for Environment and Gender Studies (Usman Dan Fodio University)
- xiii. Dr. Murtala Dangulla, PhD Environmental Quality and Conservation

xiv. Prof. Murtala Abubakar Gada, PhD Hydrology and Water Resources Mgt

xv. Dr. Nura Bello, PhD Environmental Hydrology

Zamfara State:

- i. Nigeria Integrated Water Resources Management Commission **Gusau**
- ii. Farmers association/ pastoralists of the State
- iii. Rural Water Supply and Sanitation Agency (RUWASA)
- iv. State Ministry of Water Resources
- v. State Ministry of Lands, Housing and Survey
- vi. State Ministry of Women Affairs,
- vii. State Ministry of Solid Mineral Resources
- viii. State Miners Association
- ix. Borehole Drilling Association of Nigeria (BORDAN)
- x. Association of Water Well Drilling Rig Owners and Practitioners. (AWDROP)
- xi. Zamfara State Emergency Management Agency (ZEMA)
- xii. Directorate of Rural Water Supply
- xiii. Zamfara State Water Users Association
- xiv. Zamfara State Water Cooperation
- xv. Zamfara State Rural Water Sanitation and Hygiene
- xvi. Zamfara State Ministry Environment and Natural Resources
- xvii. Zamfara State Ministry of Agriculture
- xviii. National Environmental Standard Regulation and Enforcement Agency (NESREA) zonal office
- xix. Zamfara State Culture and Tourism
- xx. Zamfara Geographic Information System (ZAGIS)
- xxi. Department of Geography Federal University, Gusau
- xxii. Department of Biological Science Federal University, Gusau

Katsina State:

- i. Farmers Association/ Pastoralists of the State
- ii. Rural Water Supply and Sanitation Agency (RUWASA)
- iii. State Ministry of Environment,
- iv. State Ministry of Agriculture and Food Security
- v. State Ministry of Water Resources

- vi. State Ministry of Lands, Housing and Survey
- vii. State Ministry of Women Affairs,
- viii. State Ministry of Solid Mineral Resources
- ix. State Miners Association
- x. Sudano Sahelian Centre for Sustainable Agriculture, Federal University Dutsinma (FUDMA)

Kebbi State:

- i. Farmers Association/ Pastoralists of the State
- ii. Rural Water Supply and Sanitation Agency (RUWASA)
- iii. State Ministry of Environment,
- iv. State Ministry of Agriculture and Food Security
- v. State Ministry of Water Resources
- vi. State Ministry of Lands, Housing and Survey
- vii. State Ministry of Women Affairs,
- viii. State Ministry of Solid Mineral Resources
- ix. State Miners Association
- x. Abdullahi Fidio University of Science Technology Aliero, Kebbi State
- xi. The National Fresh Water Fisheries Research Institute - Yauri LGA
- xii. Livestock Research And Development Centre At Kebbi State Polytechnic Dakingari LGA
- xiii. Agricultural Machinery Development Institute (AMEDI) - Ambursa Birnin Kebbi
- xiv. Professor Gona Ayuba (08137206544; ayubagona@gmail.com) EXPERT

The above stakeholders were considered as the institutions that could influence and impact development of the strategic catchment management plan.

3.3 Major Topics for Stakeholder Discussions

The stakeholders identified were key institutions and actors with the potential to influence and shape the development of the **Sokoto-Zamfara Catchment Strategic Management Plan**. Engagements were conducted through group consultations held across the four catchment states—Sokoto, Zamfara, Kebbi, and Katsina—bringing together representatives from government agencies, civil society, traditional authorities, and community groups. During these sessions, the Federal Project Management Unit (FPMU) team presented the outcomes of the catchment analysis, highlighting both biophysical conditions and socio-economic dynamics. Building on this shared understanding, the discussions aimed to foster consensus around a long-term vision, define strategic goals for sustainable catchment development, and identify priority actions to address the most pressing challenges and harness emerging opportunities.

The discussions covered issues and potential best practices around:

- Water Resources Management
- Climate Change and Environmental Sustainability
- Agricultural Practices and Food Security
- Community Involvement and Capacity Building
- Policy and Governance

More specific topics included:

- Availability and Accessibility of water resources
- Quality and Pollution of water resources
- Equitable Distribution of water resources
- Ecosystem Degradation
- Sustainable Farming
- Capacity Building
- Gender Inclusion
- Policy Coordination
- Enforcement of Regulations

3.4 Key Points from the Stakeholder Engagement

Based on the stakeholder engagement information from Annex 2 on strategic issues and opportunities. The stakeholder consultations in the Sokoto-Zamfara Catchment identified critical concerns related to water resources, agriculture, environmental sustainability, and socio-economic issues, the following detailed points were developed around the key topics of interest identified in the previous section above:

1. Water Resources and Management

- **Water Scarcity:** Stakeholders highlighted the increasing scarcity of water resources, particularly in the context of growing demand from agriculture, domestic use, and industry. The construction of dams and changes in river flow patterns were identified as contributing factors.
- **Groundwater Depletion:** Over-extraction of groundwater for irrigation and domestic use was noted as a significant concern, leading to declining water tables and increased difficulty in accessing clean water.
- **Water Quality:** Pollution from agricultural runoff, industrial effluents, and urban wastewater was identified as a major threat to water quality, affecting both surface and groundwater resources.

2. Agriculture and Livelihoods

- **Soil Degradation:** Intensive farming practices and overgrazing were cited as leading to soil erosion and loss of fertility, impacting agricultural productivity.
- **Climate Change:** Stakeholders expressed concerns about the impacts of climate change, including erratic rainfall patterns, prolonged dry spells, and increased temperatures, which exacerbate water scarcity and reduce agricultural yields.
- **Resource Conflicts:** Competition for limited land and water resources between farmers, herders, and urban dwellers was identified as a source of conflict, affecting social stability and livelihoods.

3. Environmental Sustainability

- **Deforestation:** The expansion of agricultural land and demand for firewood and charcoal were noted as significant drivers of deforestation, contributing to environmental degradation and loss of biodiversity.
- **Wetland Degradation:** Stakeholders highlighted the degradation of wetlands due to reduced water availability, invasive plant species, and overfishing, which threatens local ecosystems and livelihoods.

- Socio-Economic Issues
- Poverty and Unemployment: High levels of poverty and unemployment, particularly among the youth, were identified as major challenges, limiting access to resources and opportunities.

3.5 Coordination Mechanisms

1. Federal Stakeholders

- Federal Ministry of Water Resources (FMWR):** It oversees the implementation of national water policies, coordinates inter-state water issues, and provides technical support to state and local governments. The FMWR plays a crucial role in funding major water infrastructure projects, such as dams and irrigation schemes, and in promoting integrated water resource management (IWRM) practices.
- Federal Ministry of Environment (FMEnv):** Tasked with developing and implementing policies related to environmental protection and sustainable development. It enforces environmental regulations, monitors environmental impact assessments (EIAs), and promotes sustainable land use practices. The FMEnv supports reforestation efforts, soil conservation initiatives, and the protection of natural habitats within the catchment.
- Nigerian Hydrological Services Agency (NIHSA):** Responsible for monitoring and managing the nation's water resources, including data collection and analysis. It provides hydrological data and information to support water resource planning and management. NIHSA supports the development of hydrological models, flood forecasting, and water balance assessments for the catchment.

2. State Stakeholders

- State Ministries of Water Resources:** These ministries are responsible for implementing federal water policies at the state level and managing local water resources. They oversee the construction and maintenance of water infrastructure, regulate water use, and manage state-level water boards. State Ministries of Water Resources in Sokoto, Zamfara, and Kebbi states are involved in the day-to-day management of water resources, including the operation of dams and irrigation systems.
- State Ministries of Environment:** These ministries enforce state-level environmental regulations and promote sustainable development. They coordinate local environmental initiatives, monitor compliance with environmental standards, and support reforestation and soil conservation efforts. State Ministries of Environment work closely with local communities to implement sustainable land use practices and protect natural habitats.

iii. **State Ministries of Agriculture:** These ministries are responsible for promoting agricultural development and ensuring food security. They provide extension services, support agricultural research, and promote sustainable farming practices. State Ministries of Agriculture support farmers through training programs, provision of agricultural inputs, and the development of irrigation schemes.

3. Local Level

- i. **Local Government Authorities (LGAs):** LGAs are responsible for implementing state and federal policies at the local level and managing local resources. They oversee community-level water supply projects, sanitation services, and local environmental management. LGAs play a crucial role in community engagement, ensuring that local water and environmental initiatives are contextually relevant and sustainable.
- ii. **River Basin Development Authorities (RBDAs):** They are responsible for the integrated management of water resources within their respective river basins. They also implement water resource management plans, regulate water use, and coordinate water-related projects. The Sokoto-Rima River Basin Development Authority (RBDAs) manages water resources within the catchment, ensuring sustainable use and equitable distribution.
- iii. **Civil Society Organizations (CSOs):** CSOs advocate for community rights, promote sustainable practices, and support local development initiatives. They engage in environmental education, community mobilization, and the implementation of sustainable development projects. They play a crucial role in raising awareness about sustainable practices and supporting community-led initiatives in water and environmental management.
- iv. **Traditional Institutions:** Traditional leaders and institutions play a significant role in community governance and resource management. They mediate conflicts, enforce local customs and traditions, and support community development initiatives. Traditional institutions can facilitate community engagement and ensure that local practices align with sustainable development goals.

Federal, state, and local stakeholders participate in inter-agency committees to coordinate water resource management efforts.

CHAPTER 4 : STRATEGIC VISION AND GOALS

Based on the biophysical and socio-economic assessment, as well as extensive stakeholder consultations, a consensus strategic vision for the Sokoto-Zamfara Catchment was established as follows:

To build a climate-resilient, inclusive, and sustainable catchment that restores degraded landscapes, secures water and ecosystem services, and improves livelihoods across the catchment—through integrated resource management and strong local and regional partnerships.

The consensus for long-term and short-term strategic goals and expected outcomes are shown in Table 4.1 below:

Table 4.1: Strategic Goals and Objectives for Sustainable Catchment Development

Long-Term Strategic Goals (by 2030)	KPIs for Long-Term Goals	Short-Term Strategic Goals (by 2025)	KPIs for Short-Term Goals	Targets (Expected Outcomes)
Comprehensive and sustainable management of natural and human resources within the catchment	<ul style="list-style-type: none"> Percentage decrease in land degradation. Percentage increase in sustainable farming adoption by 2030 	Promote sustainable land use and water management practices	Percentage of farmers adopting improved practices (annual surveys)	100% adoption of improved farming practices in target communities; Reduced land degradation
Support economic development and poverty reduction through integrated resource use	<ul style="list-style-type: none"> Percentage reduction in poverty rates. Increase in agricultural GDP by 2030 	Expand access to low-interest loans for agro-entrepreneurs and cooperatives	<ul style="list-style-type: none"> Number of loans disbursed. Percentage increase in household access to finance (annual reports) 	At least 40% of farming households access micro-finance and inputs by 2025
Promote equitable use of transboundary rivers and surface/groundwater	<ul style="list-style-type: none"> Percentage reduction in water conflicts. 	Establish and operationalize Water	<ul style="list-style-type: none"> Number of functional WUAs. 	Functional WUAs in $\geq 80\%$ of LGAs; Improved



	<ul style="list-style-type: none"> • Increase in cross-border water-sharing agreements by 2030 	User Associations (WUAs) across all LGAs	<ul style="list-style-type: none"> • Percentage of LGAs with active WUAs (quarterly monitoring) 	upstream-downstream cooperation
Scale community-based biodiversity conservation and wetland restoration efforts	<ul style="list-style-type: none"> • Percentage increase in biodiversity index. • Hectares of wetlands restored by 2030 	Launch wetland rehabilitation and forest replanting in degraded zones	<ul style="list-style-type: none"> • Hectares rehabilitated annually. • Survival rate of replanted vegetation (bi-annual audits) 	At least 30% of degraded ecosystems rehabilitated by 2025
Mainstream gender equality and social inclusion in all catchment programs	<ul style="list-style-type: none"> • Percentage of women/youth in leadership roles by 2030. • Gender parity in resource access 	Implement women- and youth-focused extension and livelihood schemes	<ul style="list-style-type: none"> • Percentage of female/youth beneficiaries. • Number of women in water committees (annual tracking) 	50% of extension beneficiaries are women or youth; increased female participation in water governance
Enhance climate resilience through early warning systems and adaptation measures	<ul style="list-style-type: none"> • Percentage reduction in climate-related losses by 2030. • Number of adaptation policies implemented. 	Install additional hydromet stations and strengthen disaster response protocols	<ul style="list-style-type: none"> • Number of functional hydromet stations. • Response time to disasters (quarterly evaluations) 	100% LGA coverage with early warning alerts; improved flood/drought preparedness
Achieve water security through improved storage, desilting, and infrastructure upgrades	<ul style="list-style-type: none"> • Percentage increase in water storage capacity by 2030. • Reduction in water scarcity incidents. 	Desilt Bakolori, Goronyo, and Gusau dams; construct small earth dams in priority areas	<ul style="list-style-type: none"> • Volume of silt removed. • Number of small dams completed (project completion reports) 	3 major reservoirs desilted; 10+ small earth dams operational by 2025
Foster integrated data sharing and policy coordination across states and institutions	<ul style="list-style-type: none"> • Number of inter-state agreements signed. • Percentage improvement in policy compliance by 2030 	Establish state-level catchment planning units and harmonize water laws	<ul style="list-style-type: none"> • Number of operational planning units. • Adoption rate of unified platform (annual reviews) 	Unified regulatory framework and reporting platform by 2025



<p>Promote digital transformation and innovation for sustainable catchment management</p>	<ul style="list-style-type: none"> • Number of digital platforms adopted and in use by 2030 • Rate of technology uptake among key stakeholders. 	<p>Deploy-GIS-based monitoring, digital reporting tools and promote innovation hubs across the catchment.</p>	<ul style="list-style-type: none"> • Number of LGAs using digital platforms for monitoring/resource planning. • Number of tech-driven pilot initiatives implemented 	<p>All LGAs using digital monitoring tools by 2025; Increased efficiency and transparency in planning and reporting.</p>
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CHAPTER 5 : STRATEGIC CHALLENGES AND PRIORITY INTERVENTIONS

5.1 Key Issues

Based on biophysical assessments and stakeholder engagement, the strategic challenges facing the Sokoto-Zamfara Catchment are multifaceted, encompassing environmental, socio-economic, institutional, and technical dimensions as outline below:

1. Environmental Challenges

- **Water Scarcity:** Declining surface water levels and groundwater depletion due to over-extraction for irrigation and domestic use. The Goronyo and Bakolori Dams have altered natural river flows, reducing water availability for downstream users.
- **Land Degradation:** Intensive farming, overgrazing, and deforestation have led to soil erosion and loss of fertility, impacting agricultural productivity and contributing to desertification. Large areas of farmland in Sokoto and Zamfara states are affected by soil erosion, reducing crop yields.
- **Climate Change:** Erratic rainfall patterns, prolonged dry spells, and rising temperatures exacerbate water scarcity and reduce agricultural productivity. Climate change has led to more frequent droughts and flash floods, affecting both water availability and agricultural output.

2. Socio-Economic Challenges

- **High Poverty Rates:** The catchment has high levels of poverty, particularly in rural areas, limiting access to resources and opportunities. Many rural communities lack access to basic services such as clean water, electricity, and healthcare.
- **Unemployment:** High unemployment rates, especially among the youth, limit economic opportunities and contribute to social instability. The lack of diverse employment opportunities forces many young people to migrate to urban areas in search of better prospects.
- **Insecurity:** Issues such as banditry and kidnapping disrupt economic activities and deter investment, exacerbating poverty and limiting development. Insecurity in parts of Zamfara and Sokoto states has led to the displacement of communities and reduced agricultural productivity.

3. Institutional Challenges

- **Fragmented Governance:** Multiple agencies oversee water and land use, leading to coordination challenges and inefficiencies. Lack of coordination between federal, state, and local governments hampers effective resource management.
- **Weak Enforcement:** Poor enforcement of environmental and water management regulations allows unsustainable practices to continue. Illegal mining activities in Zamfara state contribute to land degradation and water pollution.
- **Capacity Gaps:** Limited technical and financial capacity at the local level hinders the implementation of sustainable practices. Local government authorities often lack the resources to implement and maintain water infrastructure.

4. Technical Challenges

- **Outdated Infrastructure:** Many irrigation systems and water management facilities are old and inefficient, leading to significant water loss. Irrigation systems in the catchment often suffer from poor maintenance and inefficiencies.
- **Limited Data and Monitoring:** Insufficient data on water resources and environmental conditions hampers effective planning and management. The lack of robust water quality monitoring networks limits the ability to enforce pollution control measures.
- **Climate Resilience:** The catchment lacks adaptive capacity to respond to climate change impacts, such as improved early warning systems and resilient infrastructure. The absence of climate-resilient agricultural practices leaves farmers vulnerable to climate variability.

5.2 Strategic Interventions

Addressing these challenges requires a comprehensive and integrated approach that includes a range of priority interventions. The following are the recommended strategic interventions designed to achieve the stated goals of the Sokoto-Zamfara Catchment Management Plan. Interventions are also tailored to specific ecological zones and institutions based on vulnerability assessments in Chapter 2.

1. Water Resource Management

Priority Zones: Bakolori floodplain, eastern Sokoto (Goronyo sub-basin)

Lead Institutions: RUWASA, RBDA, LGAs

- Desilt and rehabilitate major dams (Goronyo, Gusau, Bakolori)
- Construct small earth dams in flood-prone zones
- Develop groundwater abstraction policy and regulate borehole drilling using GIS mapping
- Promote sustainable water use via Water User Associations (WUAs)
- Treat and recycle wastewater; introduce real-time pollution and sand mining monitoring
- Pilot digital water management platforms for monitoring abstraction and usage

2. Land Use and Degradation Control

Priority Zones: Northern Zamfara, Illela-Gada (Sokoto)

Lead Institutions: State Ministries of Environment and Agriculture, LGAs

- Restore 30–70% of degraded land through afforestation and sand dune stabilization
- Promote agroforestry, sustainable soil practices, and land use zoning
- Provide extension services on soil types and high-yield crops
- Upgrade grazing reserves with water points, fodder supply, and veterinary support
- Deploy remote sensing for monitoring land degradation and restoration

3. Climate Change and Environmental Resilience

Priority Zones: Western Sokoto, Riverine Zones

Lead Institutions: Nigerian Meteorological Agency, State Ministries, Community Groups

- Establish hydromet stations for early warning and data sharing (see Chapter 2.7)
- Mainstream climate-smart agriculture (e.g., drip irrigation, drought-tolerant crops)
- Create low-cost land restoration models (cover crops, home gardens)
- Restore riparian buffer zones and degraded wetlands
- Integrate climate risk mapping into planning processes

4. Biodiversity Conservation

Priority Zones: Bakolori wetlands, Zamfara River basin

Lead Institutions: NESREA, Community Groups, State Environment Ministries

- Enforce policies on overfishing and habitat destruction.
- Reclaim wetlands and monitor aquatic ecosystems with drone mapping.
- Launch community-led conservation and reforestation initiatives.

5. Livelihoods and Poverty Reduction

Priority Zones: Rural Zamfara and Sokoto (e.g, Gummi, Rabah, Isa LGAs)

Lead Institutions: SMEDAN, Women/Youth Groups, NGOs

- Provide vocational training in agro-processing, crafts, and solar energy
- Expand microfinance access, especially for women and youth
- Support agribusiness hubs and market linkages for rural producers
- Introduce performance-based landscape restoration incentives for private investors

6. Governance and Institutional Strengthening

Catchment-Wide; Spatial roles differ by function and mandate

Lead Institutions: RBDA (inter-state), RUWASA (rural water), LGAs (local land enforcement)

- Harmonize land and water policies across catchment states
- Strengthen catchment and sub-basin coordination institutions
- Build capacity in local government authorities and community councils
- Promote transparency through digital dashboards and public reporting

7. Gender and Social Inclusion

All Zones (based on inclusive participation mapping in Chapter 3)

Lead Institutions: Gender Focal Units, NGOs, Traditional Councils

- Create safe spaces and participatory platforms for women and youth
- Integrate gender-based violence (GBV) response in project design
- Use culturally sensitive awareness methods to increase community buy-in
- Pilot gender-responsive budgeting and monitoring

8. Research, Extension and Innovation

Lead Institutions: Universities, Research Institutes, Extension Agencies

- Promote Innovation labs for water and land solutions
- Deploy mobile apps for climate advisory and extension services
- Conduct adaptive research to desert crops and climate resilience
- Establish knowledge-sharing platforms across sub-basins

9. Monitoring and Evaluation (M&E)

Lead Institutions: RBDA, State Ministries, ACRoSAL Units

- Develop coordinated monitoring system with community inputs
- Use satellite imagery and mobile tools for real-time updates
- Align indicators with national M&E frameworks for catchment health
- Implement annual joint progress reviews with stakeholders

These strategic interventions (in components) are as outlined in figures 5.1 to 5.9

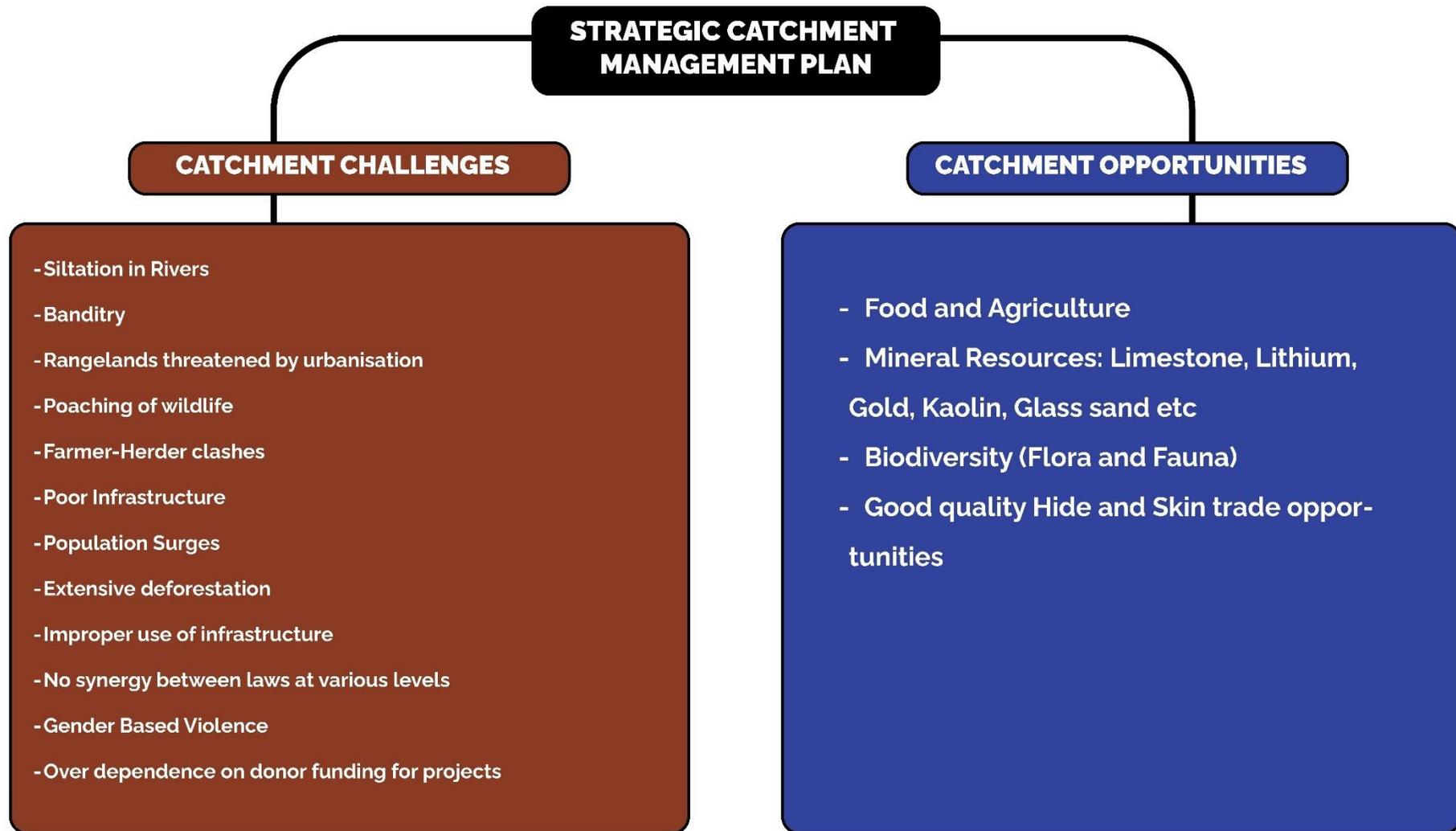


Figure 5.1: Strategic Catchment Management Plan

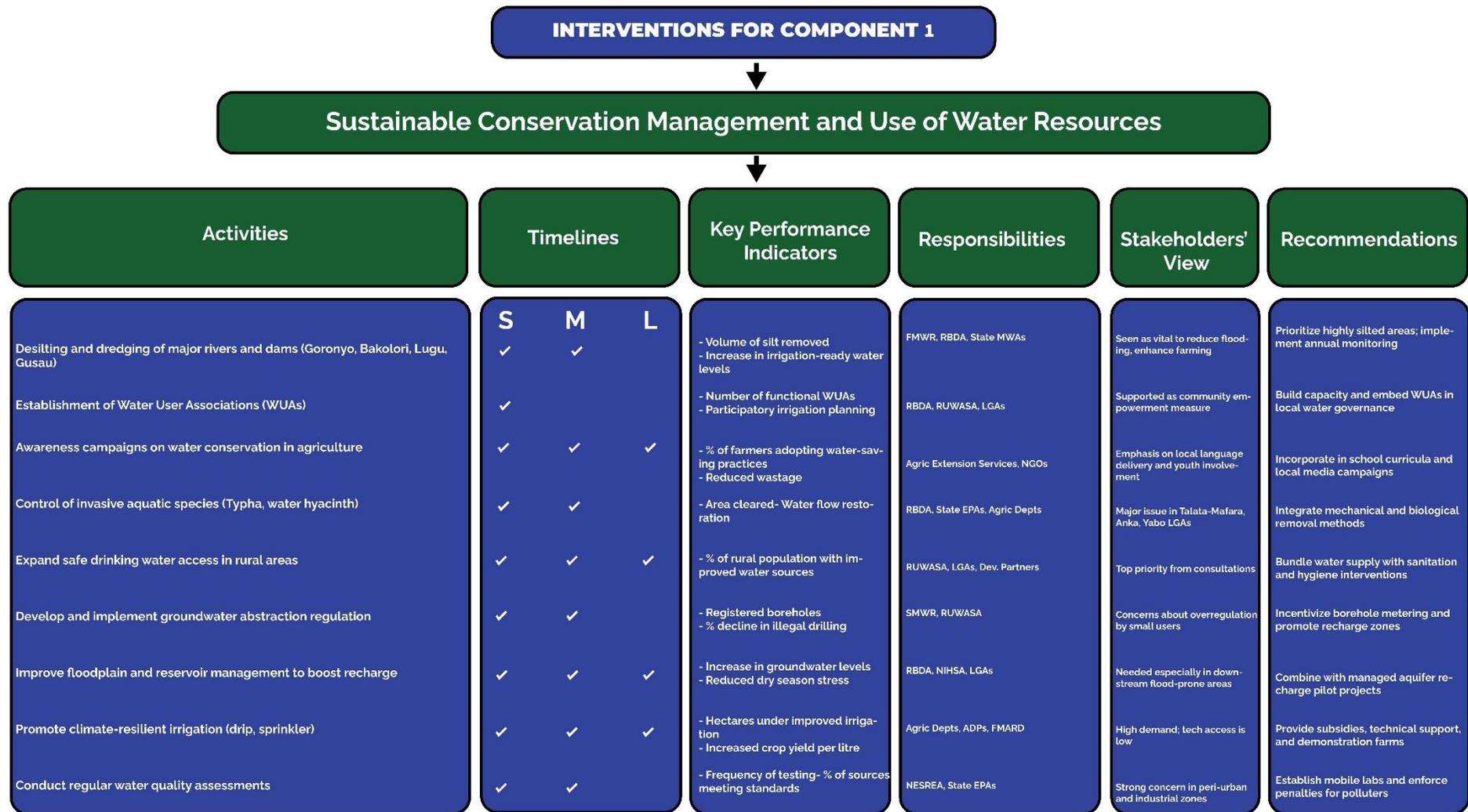


Figure 5.2: Component 1 (Sustainable Conservation Management and Use of Water Resources)

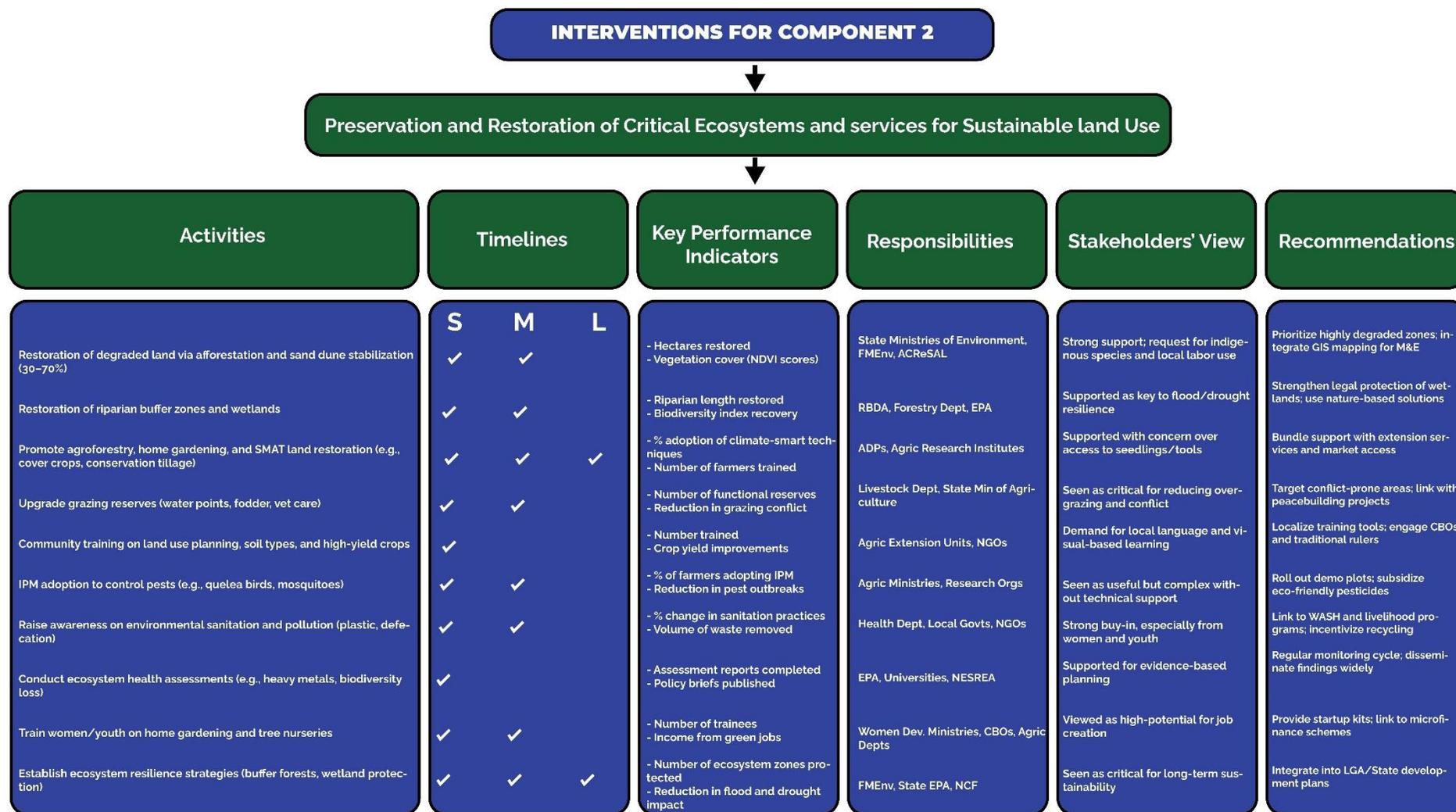


Figure 5.3: Component 2 (Preservation and Restoration of Critical Ecosystems and Services for Sustainable Land Use)

INTERVENTIONS FOR COMPONENT 3

Improved Diversification for Enhanced Sustainable Livelihoods and Well-Being

Activities	Timelines	Key Performance Indicators	Responsibilities	Stakeholders' View	Recommendations
Establish Climate-Smart Agricultural Enterprises (e.g., dry-season farming, drip irrigation)	S ✓ M ✓ L	- Number of enterprises established - Increase in agricultural yield	State Ministries of Agriculture, ADPs, NGOs	High interest; need for training and resources	Provide capacity building and access to inputs
Develop Agro-Processing and Value Addition Centers (e.g., rice milling, shea butter processing)	✓ M ✓ L ✓	- Number of centers operational - Increase in processed goods	Local Governments, Cooperatives, Private Sector	Positive reception; concerns about market access	Facilitate market linkages and infrastructure development
Promote Non-Farm Livelihoods (e.g., tailoring, carpentry, ICT services)	✓ M ✓ L ✓	- Number of individuals trained - Increase in non-farm income	Vocational Training Centers, NGOs, Community Leaders	Enthusiastic; require startup capital	Provide microfinance and mentorship programs
Implement Community-Based Savings and Loan Schemes	✓ M ✓ L	- Number of schemes established - Increase in savings and loans disbursed	Microfinance Institutions, CBOs, NGOs	Supportive; need for financial literacy	Conduct financial education workshops
Enhance Access to Renewable Energy Solutions (e.g., solar-powered irrigation, lighting)	✓ M ✓ L ✓	- Number of systems installed - Reduction in energy costs	Energy Agencies, Private Sector, NGOs	Interested; affordability is a concern	Offer subsidies and flexible payment plans
Strengthen Women's and Youth Empowerment Programs (e.g., leadership training, entrepreneurship)	✓ M ✓ L	- Number of participants - Increase in leadership roles held	Gender Affairs Ministries, Youth Organizations, NGOs	Highly supportive; desire for inclusive programs	Ensure programs are culturally sensitive and accessible
Establish Market Information Systems (e.g., price alerts, demand forecasts)	✓ M ✓ L	- Systems operational - Increase in market efficiency	Agricultural Extension Services, ICT Firms, NGOs	Positive feedback; need for training	Provide user-friendly platforms and support
Facilitate Access to Land and Resources for Vulnerable Groups	✓ M ✓ L	- Number of land allocations - Increase in resource utilization	Land Management Agencies, Traditional Authorities	Supportive; require transparent processes	Develop clear guidelines and dispute resolution mechanisms
Promote Sustainable Tourism and Cultural Heritage Projects	✓ M ✓ L ✓	- Number of projects initiated - Increase in tourism revenue	Tourism Boards, Cultural Associations, NGOs	Interested; need for infrastructure	Invest in facilities and marketing strategies
Implement Health and Nutrition Programs (e.g., maternal health, school feeding)	✓ M ✓ L	- Improvement in health indicators - Reduction in malnutrition rates	Health Ministries, NGOs, Community Health Workers	Strong support; need for consistent services	Ensure regular monitoring and community involvement

Figure 5.4: Component 3 (Improved Diversification for Enhanced Sustainable Livelihoods and Well-Being)



INTERVENTIONS FOR COMPONENT 4

Climate Change, Disaster Risk Management, and Climate Resilient Infrastructure

Activities	Timelines	Key Performance Indicators	Responsibilities	Stakeholders' View	Recommendations
Establish Early Warning Systems (EWS) for Floods and Droughts	S ✓	- Number of functional EWS - Reduction in disaster response time	State Emergency Management Agencies (SEMAs), NiMet, NEMA	Communities express need for timely alerts	Integrate local knowledge into EWS design; conduct regular drills
Rehabilitate and Upgrade Critical Infrastructure (e.g., Dams, Irrigation Systems)	S ✓ M ✓	- Number of infrastructures rehabilitated - Increase in water storage capacity	Federal Ministry of Water Resources (FMWR), River Basin Development Authorities (RBDAs)	Concern over aging infrastructure	Prioritize high-risk areas; ensure maintenance plans are in place
Implement Climate-Resilient Agricultural Practices	S ✓ M ✓	- Adoption rate of resilient practices - Increase in crop yields	State Ministries of Agriculture, NGOs	Farmers interested but need training	Provide extension services and access to climate-resilient seeds
Develop Community-Based Disaster Risk Management Plans	S ✓	- Number of communities with DRRM plans - Community participation rate	Local Governments, Community-Based Organizations (CBOs)	Desire for inclusive planning processes	Ensure plans are culturally appropriate and regularly updated
Construct and Maintain Flood Control Structures (e.g., Embankments, Drainage Systems)	S ✓ M ✓ L ✓	- Kilometers of structures built - Reduction in flood-affected areas	State Ministries of Environment, Public Works Departments	Supportive; emphasize need for quality construction	Use climate projections in design; involve local labor
Promote Renewable Energy Solutions for Climate Mitigation	S ✓ M ✓	- Number of renewable energy installations - Reduction in greenhouse gas emissions	State Energy Agencies, Private Sector	Interest in alternative energy sources	Provide incentives for adoption; ensure affordability
Enhance Capacity Building and Public Awareness on Climate Risks	S ✓ M ✓ L ✓	- Number of training sessions conducted - Increase in public awareness levels	NGOs, Educational Institutions, Media	Communities eager for information	Develop targeted campaigns; utilize local languages
Integrate Climate Risk Assessments into Development Planning	S ✓ M ✓	- Number of plans incorporating climate risk - Adoption rate of risk-informed policies	Planning Commissions, Development Partners	Recognition of importance; need for technical support	Provide training for planners; establish guidelines

Figure 5.5: Component 4 (Climate Change, Disaster Risk Management, and Climate Resilient Infrastructure)

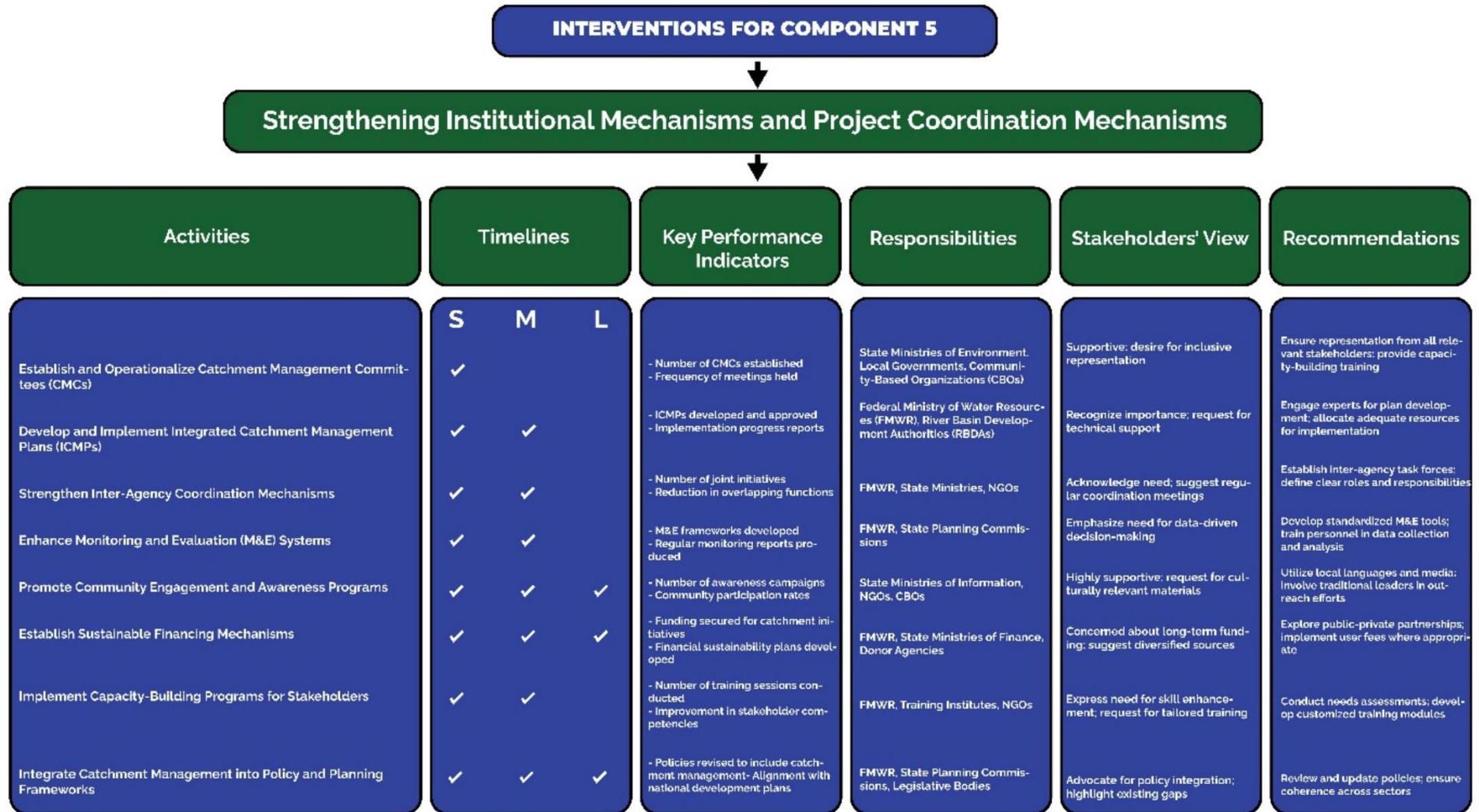


Figure 5.6: Component 5 (Strengthening Institutional Mechanisms and Project Coordination Mechanisms)

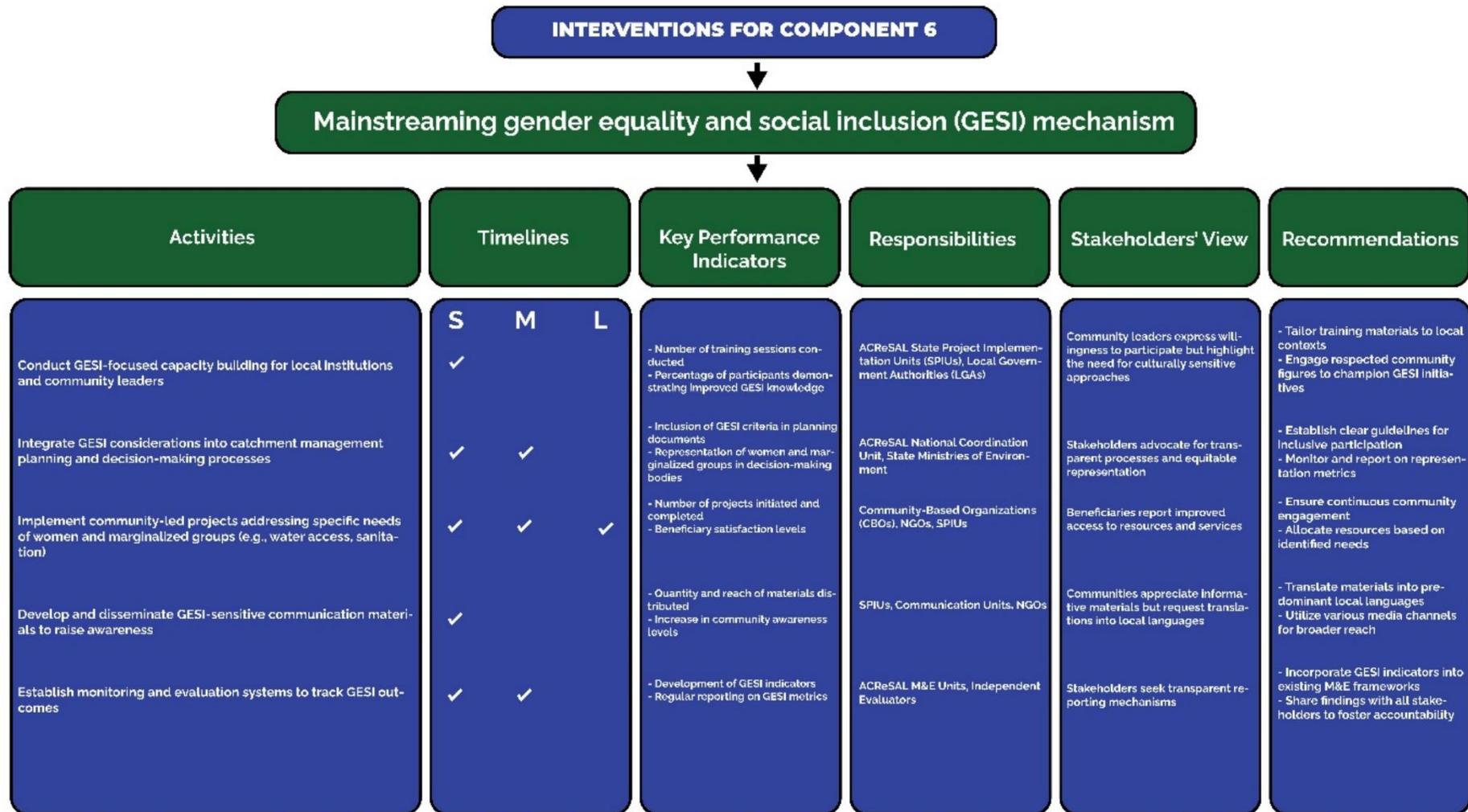


Figure 5.7: Component 6 (Mainstreaming Gender Equality and Social Inclusion (GESI) Mechanism)

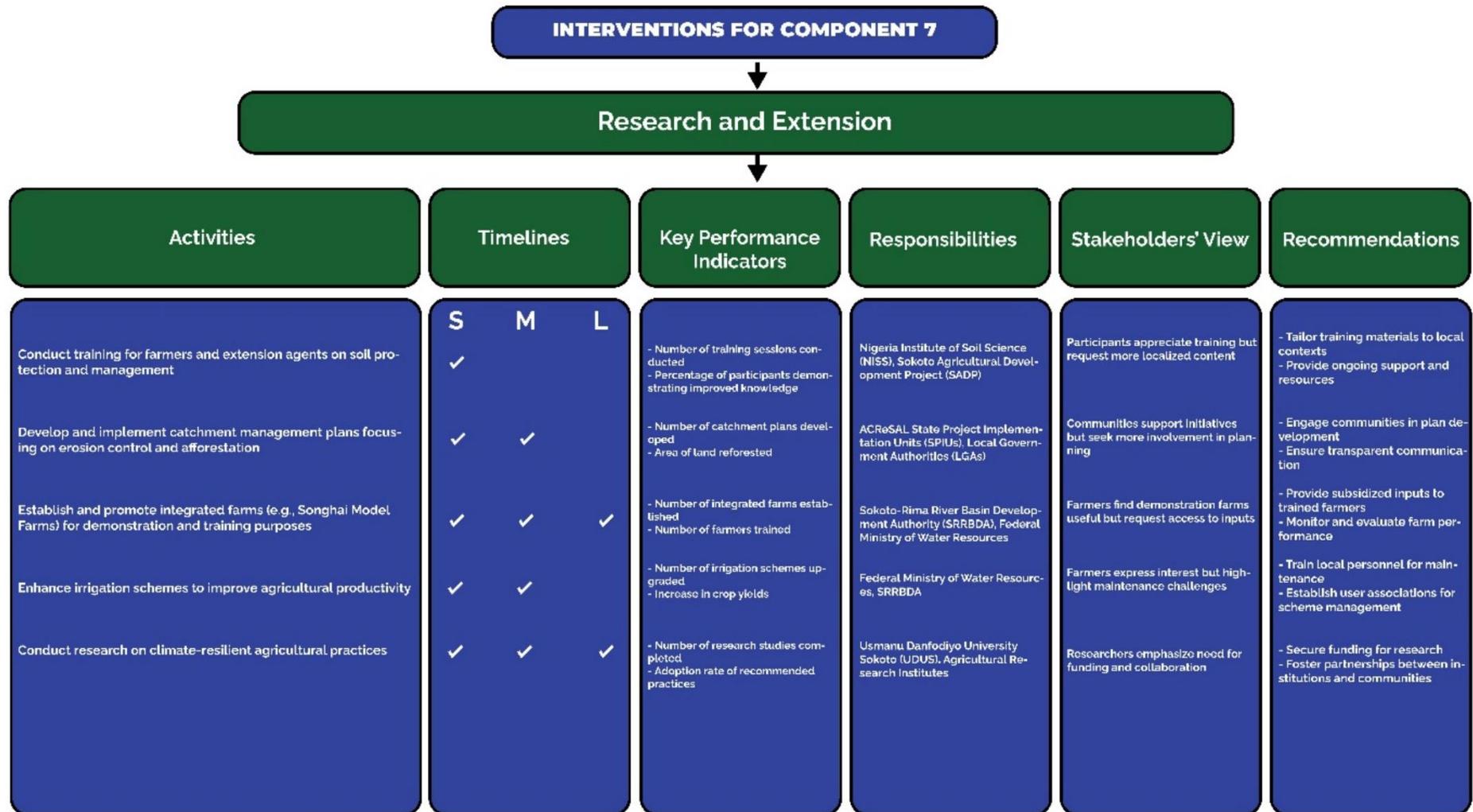


Figure 5.8: Component 7 (Research and Extension)

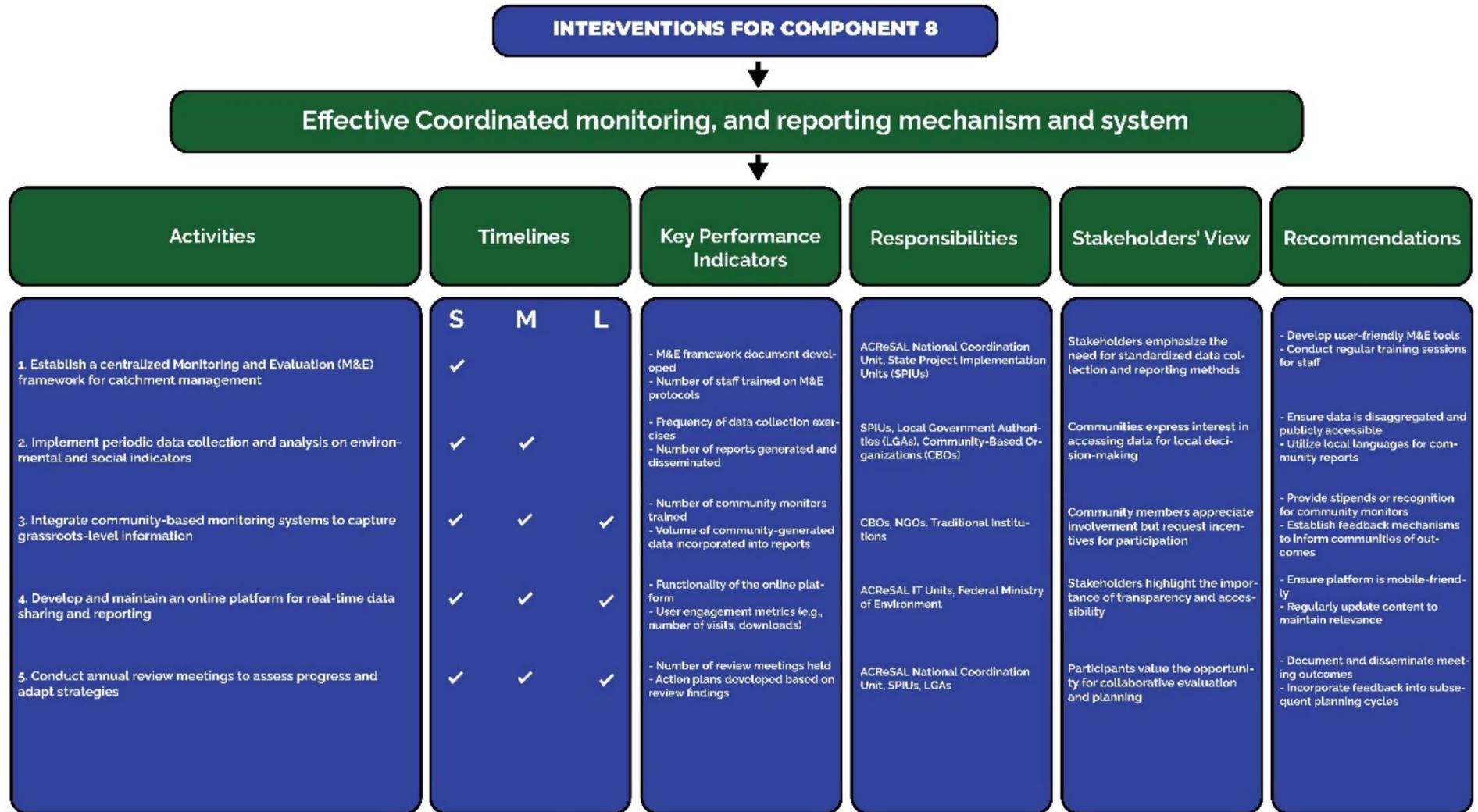


Figure 5.9: Component 8 (Effective Coordinated Monitoring, and Reporting Mechanism and System)

5.3 Expected Outcomes

The successful implementation of the interventions in the Sokoto-Zamfara SCMP will result in:

1. Water Resource Management:

- Increased water storage and availability
- Reduced seasonal shortages and improved water quality

2. Land Use and Restoration:

- Rehabilitated landscapes and reduced erosion
- Increased agricultural productivity

3. Climate and Environmental Resilience:

- Improved early warning and response to climate shocks
- Enhanced ecosystem services and risk mitigation

4. Biodiversity Conservation:

- Revived aquatic habitats and protected wetlands
- Strengthened community stewardship

5. Livelihoods and Poverty Reduction:

- Job creation and reduced rural poverty
- Increased youth and women participation in value chains

6. Governance and Institutions:

- Improved coordination across agencies and tiers
- Transparent, data-driven decision-making processes

7. Gender and Social Inclusion:

- Empowered women and youth through inclusive programming
- Reduced exclusion and increased community voice

8. Research and Innovation:

- Scalable solutions and increased adoption of modern practices
- Strengthened research-extension linkage for continuous learning

9. Monitoring and Evaluation:

- Data-informed planning and adaptive management
- Joint stakeholder tracking of project impact and sustainability

CHAPTER 6 : MONITORING, EVALUATION AND LEARNING

The Sokoto-Zamfara Catchment represents a vital hydrological and socio-economic zone in Northern Nigeria, currently facing acute environmental challenges such as climate variability, land degradation, deforestation, and increasing water stress. These pressures threaten livelihoods, ecosystems, and long-term resilience in the region.

To ensure that the Strategic Catchment Management Plan (SCMP) achieves its intended objectives, continuous monitoring and evaluation is essential. This process not only tracks implementation progress but also provides a mechanism for learning, adaptation, and course correction.

Establishing a comprehensive monitoring, evaluation, and learning (MEL) framework will enable the systematic review of achievements, challenges, and emerging insights. Such a framework is essential for evidence-based decision-making and adaptive management of land and water resources within the catchment.

If effectively implemented, the structured MEL system outlined below will provide a strong foundation for tracking performance, engaging stakeholders, and ensuring the long-term sustainability of water and environmental resources in the Sokoto-Zamfara Catchment.

6.1 Data Collection Methods

- i. **Water Quality Monitoring:** Regular sampling of water quality parameters such as pH, turbidity, and nutrient levels at designated monitoring sites.
- ii. **Field Observations:** Regular field visits to monitor changes in vegetation cover, erosion, and other environmental indicators.
- iii. **Remote Sensing:** Use of satellite or aerial imagery to monitor changes in land use, vegetation cover, and water quality.
- iv. **Stakeholder Surveys:** Regular surveys of stakeholders, including landholders, community groups, and government agencies, to gather information on their perceptions, attitudes, and experiences related to catchment management.
- v. **Community-Based Monitoring:** Engagement of local communities in monitoring and reporting on environmental indicators, such as water quality and vegetation cover.
- vi. **Automated Sensors:** Installation of automated sensors to monitor water quality, flow, and other environmental parameters in real-time.

6.2 Monitoring, Evaluation, and Learning (MEL) Indicators

The MEL indicators for the Strategic Catchment Management Plan (SCMP) can be mapped to the plan's vision and goals as indicated in Table 6.1.

Table 6.1: MEL indicators to the plan's vision and goals

Item	Statement	Indicators
Vision	Climate-Resilient, Inclusive, and Sustainable Catchment	<ul style="list-style-type: none"> Percentage of catchment area with restored landscapes and improved ecosystem health. Number of people benefiting from improved water and ecosystem services. Level of community engagement and participation in catchment management
Goal 1	Restore Degraded Landscapes	<ul style="list-style-type: none"> Hectares of degraded land restored through reforestation and sustainable land management practices. Change in vegetation cover and soil health over time. Number of community members adopting sustainable land management practices.
Goal 2	Secure Water and Ecosystem Services	<ul style="list-style-type: none"> Water quality parameters (e.g., pH, turbidity, nutrient levels) in key water bodies. Flow regime and water availability in key rivers and streams. Biodiversity metrics (e.g., species abundance, diversity) in key ecosystems.
Goal 3	Improve Livelihoods	<ul style="list-style-type: none"> Change in household income and poverty levels among catchment communities. Number of people with improved access to water and sanitation services. Level of community satisfaction with catchment management initiatives.
Goal 4	Integrated Resource Management and Partnerships	<ul style="list-style-type: none"> Level of coordination and collaboration among stakeholders. Number of partnerships established with local and regional organizations. Effectiveness of catchment management institutions and governance structures

6.3 Core Indicators and Institutional Responsibilities

To ensure effective monitoring and evaluation of the Strategic Catchment Management Plan (SCMP), a streamlined set of core indicators can be identified. These indicators should be relevant, measurable, and actionable.

6.3.1 Core Indicators

1. **Land Restoration:** Hectares of degraded land restored through reforestation and sustainable land management practices.
2. **Water Quality:** Water quality parameters (e.g., pH, turbidity, nutrient levels) in key water bodies.

3. **Livelihoods:** Change in household income and poverty levels among catchment communities.
4. **Community Engagement:** Level of community engagement and participation in catchment management.
5. **Partnerships:** Number of partnerships established with local and regional organizations.

6.3.2 Institutional Responsibilities

The following institutions can be responsible for tracking and reporting on these core indicators:

1. **Catchment Management Agencies:** Overall coordination and reporting on SCMP implementation, including tracking progress toward core indicators.
2. **Federal and State Ministry of Environment:** Monitoring and reporting on water quality and land restoration indicators.
3. **Federal and State Ministry of Agriculture:** Tracking and reporting on livelihoods indicators, including household income and poverty levels.
4. **Federal and State Ministry of Water Resources:** Tracking and reporting on water quality and availability
5. **Local Government Authorities:** Reporting on community engagement and participation in catchment management.
6. **Partnership Coordination Unit:** Tracking and reporting on partnerships established with local and regional organizations.

6.4 Feedback Mechanisms

- i. **Regular Progress Reports:** Preparation and dissemination of regular progress reports to stakeholders, highlighting achievements, challenges, and future directions.
- ii. **Stakeholder Meetings:** Regular meetings with stakeholders to provide updates, gather feedback, and discuss emerging issues.
- iii. **Community Engagement Forums:** Hosting of community engagement forums to provide information, gather feedback, and build support for catchment management initiatives.
- iv. **Social media:** Utilization of social media platforms to share information, gather feedback, and engage with stakeholders.

- v. **Online Feedback Mechanisms:** Establishment of online feedback mechanisms, such as surveys or comment boxes, to gather feedback from stakeholders.
- vi. **Independent Review Panels:** Establishment of independent review panels to provide objective feedback and assessment of catchment management initiatives.

6.5 Data Management and Analysis

- i. **Data Storage:** Establishment of a secure and accessible data storage system to store and manage data.
- ii. **Data Analysis:** Regular analysis of data to identify trends, patterns, and insights that inform catchment management decisions.
- iii. **Data Visualization:** Use of data visualization tools to present complex data in a clear and concise manner.
- iv. **Reporting and Dissemination:** Preparation and dissemination of reports and other communication materials to stakeholders, highlighting key findings and insights.

6.6 Data-Driven Decision Making

Data can inform real-time decision-making in catchment management by providing insights into current conditions, trends, and patterns. In this catchment, data can be used to support real-time decision-making by doing a real-time data analysis and having a data-driven decision support system.

For real-time data, analysis on water quality parameters such as pH, turbidity, and nutrient levels can inform decisions on water treatment and management. Also, weather data can help predict and prepare for extreme weather events, such as floods or droughts. Additionally, data on water quality and pollution sources can inform decisions on pollution mitigation and control.

Based on data-driven decision support systems, data-driven predictive models can forecast water quality, quantity, and flow, enabling proactive decision-making. Real-time data can trigger early warning systems for extreme weather events, water quality issues, or other catchment-related hazards. Furthermore, data-driven decision support tools can provide insights and recommendations for catchment management decisions, such as water allocation, pollution control, and infrastructure management.



The benefits of real-time data-driven decision making that the catchment can derive include but not limited to faster response times to emerging issues, reducing the risk of adverse impacts on the catchment, more informed, effective, and sustainable catchment management decisions. Another benefit is in promoting transparency and accountability in catchment management.



Table 6.2: Monitoring and Evaluation Plan for Sokoto-Zamfara Catchment

S/No.	Monitoring Tools and Techniques	Target/Output	Monitoring	Evaluation	Responsibility
1	Geospatial Monitoring (GIS, Remote Sensing, NDVI)	- Land area under sustainable landscape management practices (e.g., 830,000 ha by 2028) - Increase in Normalized Difference Vegetation Index (NDVI) in targeted areas (e.g., 5% by 2028)	- Quarterly satellite imagery analysis - NDVI trend assessments	- Annual spatial analysis reports - Mid-term and end-term evaluations	- ACRoSAL National and State Project Management Units (PMUs) - Federal Ministry of Environment - Remote sensing specialists
2	Field Surveys and Participatory Rural Appraisals (PRAs)	- Area under community-led landscape restoration (e.g., 350,000 ha by 2028) - Number of direct project beneficiaries (e.g., 3.4 million by 2028)	- Bi-annual field assessments - Community feedback sessions	- Annual impact assessments - Beneficiary satisfaction surveys	- State PMUs - Local Government Authorities - Community-Based Organizations (CBOs)
3	Management Effectiveness Tracking Tool (METT)	- Protected areas under improved management (e.g., 300,000 ha by 2028)	- Annual METT assessments - Stakeholder workshops	- Comparative analysis over project duration - Adaptive management recommendations	- Federal Ministry of Environment - Conservation NGOs - Protected area managers
4	Water Resource Monitoring (Hydrological Assessments, Water Quality Testing)	- Area provided with new/improved irrigation or drainage services (e.g., 10,000 ha by 2028) - Area under improved rainwater harvesting (e.g., 100,000 ha by 2028)	- Monthly water flow measurements - Quarterly water quality tests	- Bi-annual water resource reports - Evaluation of irrigation efficiency	- Federal Ministry of Water Resources - State Water Agencies - Agricultural Extension Services
5	Community Feedback Mechanisms (Surveys, Focus Groups, Grievance Redress Mechanisms)	- Increase in community satisfaction and engagement levels - Number of grievances resolved	- Continuous feedback collection - Quarterly analysis of grievances and suggestions	- Annual social impact evaluations - Integration of feedback into project design	- State PMUs - Community Liaison Officers - Independent M&E Consultants

CHAPTER 7 : CONCLUSION AND MOVING FORWARD

7.1 Summary of Strategic Issues and Priorities

The Sokoto-Zamfara Catchment, covering parts of Sokoto, Zamfara, and Kebbi States, is vital for agriculture and livelihoods in Northwest Nigeria. It faces significant challenges such as land degradation, erratic rainfall, and water scarcity. Climate change has further increased its vulnerability.

Table 7.1 Shows a summary of strategic pillars for action.

Long-Term Strategic Goals (by 2030)	Short-Term Strategic Goals (by 2025)
Comprehensive and sustainable management of natural and human resources within the catchment	Promote sustainable land use and water management practices
Support economic development and poverty reduction through integrated resource use	Expand access to low-interest loans for agro-entrepreneurs and cooperatives
Promote equitable use of transboundary rivers and surface/groundwater	Establish and operationalize Water User Associations (WUAs) across all LGAs
Scale community-based biodiversity conservation and wetland restoration efforts	Launch wetland rehabilitation and forest replanting in degraded zones
Mainstream gender equality and social inclusion in all catchment programs	Implement women- and youth-focused extension and livelihood schemes
Enhance climate resilience through early warning systems and adaptation measures	Install additional hydromet stations and strengthen disaster response protocols
Achieve water security through improved storage, desilting, and infrastructure upgrades	Desilt Bakolori, Goronyo, and Gusau dams; construct small earth dams in priority areas
Foster integrated data sharing and policy coordination across states and institutions	Establish state-level catchment planning units and harmonize water laws
Promote digital transformation and innovation for sustainable catchment management	Deploy-GIS-based monitoring, digital reporting tools and promote innovation hubs across the catchment.

The plan emphasizes strong financial support through increased public budget allocations for the environment, agriculture, and water. A Sokoto-Zamfara Catchment Development Fund will aid coordination and mobilization. Collaboration with international partners like the World Bank and private sector involvement via PPPs is encouraged, alongside community contributions for sustainability.

Finally, robust governance, inclusive planning, and multi-stakeholder coordination are crucial for the catchment's success. The Sokoto-Zamfara Catchment Management Plan promotes an Integrated Water Resources Management framework that encourages collaboration among ministries, local institutions, and community groups. This approach aims to build resilience, support sustainable livelihoods, and protect ecosystems, fostering long-term environmental health and socio-economic prosperity.

7.2 Recommendations for Aligning with Broader National and Regional Programs

The Sokoto-Zamfara Catchment Management Plan (SZCMP) is a strategic initiative aimed at sustainable water and land resource management in Northwestern Nigeria. To ensure its effectiveness and sustainability, it's crucial to align the plan with broader national and regional development frameworks. Key recommendations include the following:

1. National Water Resources Master Plan (NWRMP) 2013

- Both plans advocate for IWRM and sustainable water use.
- Emphasis on infrastructure development, such as dams and irrigation systems, aligns with SZCMP's objectives.
- Incorporate specific guidelines from NWRMP on transboundary water issues.
- Establish joint monitoring mechanisms with neighbouring catchments.

2. National Adaptation Plan (NAP) Framework

- Both emphasize climate-resilient agriculture and sustainable land management.
- Focus on community-based adaptation measures.
- SZCMP could further detail its strategies for addressing climate-induced migration and health impacts.
- Integrate health and migration considerations into SZCMP's adaptation strategies.
- Collaborate with NAP implementation bodies for technical support and funding opportunities.

3. Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL) Project

- Shared goals of combating land degradation and promoting sustainable agriculture.
- Both prioritize community engagement and capacity building.
- SZCMP needs to align its monitoring and evaluation frameworks with ACReSAL's for consistency.

- Adopt ACRoSAL's monitoring tools and indicators for SZCMP.
- Seek integration into ACRoSAL's funding and technical assistance programs.

4. ECOWAS Water Resources Coordination

- Shared emphasis on IWRM and sustainable water use.
- Potential for regional collaboration on transboundary water issues.
- SZCMP currently lacks mechanisms for regional data sharing and joint planning.
- Establish partnerships with WRCC for knowledge exchange and capacity building.
- Participate in ECOWAS-led initiatives for transboundary water management.

7.3 Catchment Policy for Interstate River Systems

The Sokoto-Zamfara Catchment, forming a critical part of the Sokoto-Rima River Basin, is not only an inter-state watercourse traversing multiple states in northwestern Nigeria, but also a sub-basin of the transboundary Niger River Basin. This positioning underscores its strategic importance and the broader implications of water use and land management activities within the catchment.

Given its link to a shared international watercourse, any interventions, extractions, or developments in the Sokoto-Zamfara Catchment may impact water availability, quality, and ecosystem health downstream, including in neighbouring countries. Consequently, the catchment falls under the purview of several international legal frameworks and regional agreements that govern transboundary water cooperation.

Nigeria, as a riparian state of the Niger River, is a member of the Niger Basin Authority (NBA) along with eight other countries: Niger, Cameroon, Burkina Faso, Republic of Benin, Mali, Guinea, Chad, and Côte d'Ivoire. Nigeria is also a signatory to the 2008 Niger Basin Water Charter, which sets out principles for equitable and reasonable use, cooperation, data sharing, and conflict prevention among member states.

In addition to the Niger Basin framework, Nigeria is party to several other key international water treaties that reinforce transboundary obligations, including:

- The 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses,

- The 1992 UNECE Water Convention, and
- Relevant provisions of the Vienna Convention on the Law of Treaties (Article 26), which mandates compliance with treaty obligations in good faith.

At the national level, the Sokoto-Zamfara Catchment Management Plan must be implemented in alignment with the National Water Resources Act and associated policies on water resources, environmental protection, land use, and climate change. These national instruments are designed to work in synergy with broader regional commitments, including the ECOWAS Water Resources Policy, which promotes Integrated Water Resources Management (IWRM), basin-level planning, and sustainable transboundary cooperation.

Additionally, non-binding international “soft law” instruments adopted under United Nations frameworks—such as the SDGs, the Sendai Framework for Disaster Risk Reduction, and the Paris Agreement—also shape Nigeria’s approach to water governance and climate resilience.

In summary, the transboundary nature of the Sokoto-Zamfara Catchment amplifies the importance of ensuring that all water-related interventions are harmonized not only with national strategies but also with regional and global legal obligations. This alignment is crucial for sustaining cooperation, peace, and shared development benefits across the Niger River Basin and beyond.

7.3.1 Five Principles of International Water Law Enunciated in the Water Treaties

The Sokoto-Zamfara Catchment, forming a significant part of the Sokoto-Rima River Basin, is hydrologically connected to the larger transboundary Niger River Basin, which spans multiple West African countries. As such, all water resource use and management actions within the catchment are subject not only to Nigeria’s national legal frameworks but also to international water law and transboundary water governance principles.

The following Five Core Principles of International Water Law, embedded in numerous binding and non-binding instruments, are particularly relevant to the management of the Sokoto-Zamfara Catchment:

1. **Equitable and Reasonable Utilization:** Article 5 of the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses

Nigeria, as a riparian state of the Niger River Basin, must ensure that water withdrawals and land use in the Sokoto-Zamfara Catchment are balanced and justifiable, considering population needs, ecological conditions, and socio-economic development across all riparian countries.

2. **Obligation Not to Cause Significant Harm:** Helsinki Rules (1966), Article 7 of the 1997 UN Watercourses Convention

Water management activities—such as dam operations, irrigation expansion, or pollution discharges—within the catchment must not adversely impact downstream users or neighbouring riparian states like Niger and Benin.

3. **Prior Notification and Consultation:** Indus Waters Treaty, reflected in multiple transboundary water agreements

Any planned infrastructural or hydrological intervention (e.g., construction of reservoirs or abstraction schemes) that may affect the shared Niger River system must be communicated to other basin states through mechanisms like the Niger Basin Authority (NBA).

4. **Cooperation and Information Exchange:** Article 9 of the 1997 UN Watercourses Convention; 1992 UNECE Water Convention

Nigeria is expected to collaborate with other NBA member states through regular data sharing, joint monitoring, and institutional coordination related to the Sokoto-Zamfara sub-basin.

5. **Peaceful Settlement of Disputes:** Reflected in the Berlin Rules (2004) and the UN Watercourses Convention

Any conflicts arising from water use or perceived harm must be addressed through diplomatic channels, mediation, or legal recourse such as arbitration or adjudication via the International Court of Justice (ICJ).

7.3.2 Relevant International Policies ("Soft Laws") Affecting Sokoto-Zamfara Catchment Governance

Although not legally binding, several international policy instruments provide guidance for integrated and sustainable management of shared water resources in the catchment:

- 1971 Stockholm Declaration: Principle 21 on the *no harm rule* guides Nigeria's obligation not to degrade shared water environments.

- 1992 Dublin Principles: Promote Integrated Water Resources Management (IWRM), a cornerstone of the Sokoto-Zamfara Catchment Plan.
- 1992 Rio Declaration and Agenda 21: Introduce key principles such as:
 - *Precautionary Principle* (Principle 15)
 - *Polluter Pays Principle* (Principle 16)
 - *Environmental Impact Assessment* (Principle 17)
 - *Transboundary Notification* (Principles 18 & 19)
- 2008 ECOWAS Water Resources Policy: Though not a treaty, it supports regional coordination, encourages river basin institutions, and endorses principles such as:
 - Equitable water sharing
 - Subsidiarity
 - Gender equity
 - Sustainable financing
 - User-pays and polluter-pays models
 - Partnership and cooperation
- Draft Articles on the Law of Transboundary Aquifers: Provide a framework for managing shared groundwater resources, which are also critical in the Sokoto-Zamfara area.

7.3.3 National Legal and Policy Frameworks Governing Sokoto-Zamfara Catchment

The management of the Sokoto-Zamfara Catchment is further governed by Nigeria's national legal instruments and sectoral policies:

1. National Water Resources Policy (2016)
 - Emphasizes IWRM, catchment-based planning, stakeholder participation, and pollution control.
 - Aligns with the objectives of the Sokoto-Zamfara Catchment Management Plan.
2. Water Resources Act (2004)

- Provides the legal basis for regulating water abstraction, pollution, and inter-sectoral use.
 - Supports licensing systems, groundwater protection, and floodplain zoning.
3. Environmental and Catchment-Level Policies While the Sokoto-Zamfara Catchment spans multiple states (e.g., Sokoto, Zamfara, Kebbi), state-level laws also complement federal frameworks:
- Sokoto State: Implements water quality and sanitation bylaws to limit waste discharge into rivers.
 - Zamfara State: Enforces environmental and agricultural land-use controls in catchment zones.
 - Kebbi State: Integrates water resource sustainability in rural development and irrigation programs.

7.4 High-Level Funding Strategies and Partnership Opportunities

1. **Domestic Funding Mechanisms**
 - i. **Federal and State Budget Allocations:** The Sokoto-Zamfara Catchment Management Plan can leverage allocations from Nigeria’s National Development Plan (NDP) 2021–2025, which emphasizes infrastructure development, environmental sustainability, and climate resilience. Federal and state governments can earmark funds specifically for water resource management, afforestation, and climate adaptation projects within the catchment area.
 - ii. **Catchment Development Funds:** Establishing dedicated catchment development funds can pool resources from federal, state, and local governments. These funds can be utilized for projects such as dam rehabilitation, small-scale irrigation systems, and community-based watershed management initiatives.
 - iii. **Sectoral Allocations:** Budgetary provisions from sectors like agriculture, environment, and water resources can be aligned to support integrated projects within the catchment. For instance, funds allocated for agricultural development can be directed towards climate-smart agriculture practices that also contribute to water conservation.
2. **International and Multilateral Funding Sources**
 - i. **World Bank:** The Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL) project, supported by a \$700 million credit from the World Bank, aims to enhance

sustainable landscape management in northern Nigeria. The Sokoto-Zamfara Catchment can benefit from this initiative by aligning its projects with ACREsAL's objectives, such as afforestation, climate-resilient agriculture, and watershed management.

- ii. **African Development Bank (AfDB):** AfDB has approved loans for water and sanitation projects in Nigeria, including a \$124.2 million loan for Akure and a \$205 million loan for Port-Harcourt. These projects focus on improving access to safe drinking water and sanitation, which are critical components of catchment management.
- iii. **Green Climate Fund (GCF) and Global Environment Facility (GEF):** These funds provide financial resources for projects that address climate change and environmental degradation. The Sokoto-Zamfara Catchment Management Plan can seek funding for initiatives like reforestation, renewable energy integration, and sustainable land management.
- iv. **ECOWAS Regional Funds:** ECOWAS supports regional integration and development projects. Funding can be sought for transboundary water management initiatives, especially considering the Sokoto-Rima River Basin's significance in the region.

3. Public-Private Partnerships (PPPs) and Private Sector Investment

- i. **Infrastructure Development:** Engaging private sector partners in the development and maintenance of water infrastructure, such as dams and irrigation systems, can enhance efficiency and sustainability.
- ii. **Agro-Ecological Resilience Projects:** Private investments can be attracted to support climate-smart agriculture, agroforestry, and sustainable land use practices that contribute to both economic development and environmental conservation.
- iii. **Renewable Energy Initiatives:** The catchment area has potential for renewable energy projects, such as solar-powered irrigation and mini-hydropower plants. PPPs can facilitate the financing and implementation of these projects, contributing to energy access and sustainability.

4. Strategic Institutional and Donor Partnerships

- i. **Technical Assistance and Capacity Building:** Partnerships with institutions like the World Bank, AfDB, and international NGOs can provide technical expertise, training, and capacity-building programs for local stakeholders involved in catchment management.
- ii. **Co-Financing Opportunities:** Collaborative funding arrangements with development partners can enhance resource mobilization for large-scale projects. For instance, co-financing agreements can be established for integrated water resource management programs that align with both national and donor priorities.

5. Alignment with National and Regional Development Frameworks

- i. **Nigeria’s National Development Plan (NDP) 2021–2025:** The NDP emphasizes sustainable development, infrastructure expansion, and environmental protection. Aligning the catchment management plan with the NDP can facilitate access to national funding and policy support.
- ii. **ACReSAL Program:** By integrating the catchment management initiatives with the ACReSAL program, the plan can benefit from existing frameworks and funding mechanisms aimed at enhancing climate resilience in semi-arid regions.
- iii. **ECOWAS Environmental Policies:** Adhering to ECOWAS policies on water resource management and environmental sustainability can open avenues for regional cooperation and funding. This alignment can also enhance the transboundary management of the Sokoto-Rima River Basin.

6. Inclusive, Climate-Resilient, and Scalable Financing Strategies

- i. **Community Participation:** Ensuring active involvement of local communities in project planning and implementation enhances ownership and sustainability. Community-based financing mechanisms, such as cooperatives and microfinance schemes, can support small-scale initiatives.
- ii. **Climate Resilience:** Investments should prioritize projects that enhance the catchment's resilience to climate change impacts, such as drought-resistant agriculture, flood control measures, and ecosystem restoration.
- iii. **Scalability:** Pilot projects with successful outcomes can be scaled up across the catchment area. Documenting best practices and lessons learned facilitates replication and attracts further investment.

7.5 Moving Forward with the Catchment Plan

The Sokoto-Zamfara Catchment Management Plan (SCMP) is a dynamic and evolving tool designed to guide long-term sustainable management of the catchment’s land, water, and natural resources. It marks the transition from planning to implementation, setting the stage for integrated, inclusive, and climate-resilient development. To remain effective and relevant, the SZCMP must be reviewed and updated regularly, reflecting new scientific insights, policy developments, environmental changes, and socio-economic dynamics within the catchment.

Both the Federal Project Management Unit (FPMU) and national technical consultants, alongside state-level stakeholders, should maintain continuous access to the plan and its supporting knowledge base. To ensure transparency, accessibility, and collaborative

management, the SCMP should eventually be transformed into a digital e-Plan platform—allowing real-time updates, data sharing, and stakeholder interaction.

Key Priorities for Keeping the SCMP Active and Impactful

- **Environmental Awareness and Stewardship:** Promote environmental awareness through education and community engagement to support local stewardship of biodiversity and natural resources.
- **Policy Strengthening and Enforcement:** Strengthen and enforce environmental policies through collaboration with government, ensuring alignment with IWRM and adequate resourcing.
- **Inter-Agency Coordination:** Enhance inter-agency coordination by equipping and funding key regulatory bodies to jointly enforce environmental protection laws.
- **Open Data and Monitoring:** Implement an open, catchment-wide monitoring system to share environmental data and support evidence-based decision-making.
- **Ecosystem and Resource Integration:** Adopt holistic, long-term environmental policies that integrate water, soil, vegetation, and biodiversity management across the entire catchment system.
- **Scale-Appropriate Partnerships:** Promote multi-stakeholder collaboration and decentralized implementation by engaging civil society, research bodies, private investors, and communities from micro-catchments to the full Sokoto-Rima Basin.
- **Diversified Funding Approaches:** Adopt a blended finance approach combining public funds, donor support, private investment, and community contributions to ensure resilient and inclusive implementation.
- **.Simplified and Enabling Regulation:** Simplify environmental regulations to enhance compliance and enable timely action while maintaining essential safeguards.
- **.Improved Compliance and Deterrents:** Strengthen enforcement of environmental violations through clear penalties and restoration mandates, backed by sufficient funding for agencies and local authorities.
- **.Sustainable Agricultural Practices:** Promote sustainable farming by adopting alternatives to conventional pesticides, including IPM, organic practices, precision agriculture, and locally tailored innovations like biochar and cover cropping.

- **.Capacity Building and Awareness on Land Use Impacts:** Educate stakeholders on the hydrological and ecological impacts of land use changes and integrate this knowledge into development and land-use planning.
- **Support for Nature-Based Solutions (NbS):** Promote ecosystem-based solutions like reforestation and wetland restoration for flood control, erosion prevention, and groundwater recharge.
- **Catchment-Wide Perspective:** Integrate systems thinking into policy and practice to address upstream-downstream linkages across hydrology, ecology, and community well-being.
- **Green Infrastructure and Urban Integration:** Promote sustainable urban drainage systems (SUDS), permeable surfaces, and green corridors in urban centers like Sokoto and Gusau to enhance stormwater management and biodiversity.
- **Riparian and Floodplain Protection:** Identify and protect key riparian corridors and floodplain areas, implementing development controls to preserve ecological and hydraulic functions.
- **Groundwater and Baseflow Enhancement:** Protect recharge zones and promote infiltration practices to sustain aquifers and stream baseflows, particularly during dry seasons.
- **Protection of Aquatic Habitat:** Maintain stream connectivity, water quality, and fish passage infrastructure, particularly in areas affected by dams or road crossings.
- **Sediment and Erosion Control:** Implement on-site (primary) and off-site (secondary) erosion and sediment control measures during development, including terracing, check dams, and silt traps.
- **Stormwater Quality Management:** Apply targeted source control techniques for pollutants (e.g., oil, heavy metals) and implement catchment-wide pollutant reduction strategies.
- **Ongoing Communication and Stakeholder Engagement:** Sustain momentum by regularly communicating progress, challenges, and achievements to stakeholders. Use inclusive forums, town halls, and digital platforms.

- **Adaptive Management and Flexibility:** Ensure the plan is adaptable to new research, community feedback, and changing conditions, with continuous learning embedded in governance.

7.6 Roadmap for 2025-2027

The Strategic Catchment Management Plan provides a comprehensive framework for managing the catchment area, addressing the complex relationships between water, land, and stakeholders. To ensure successful implementation, a roadmap for 2025-2027 has been developed, outlining key institutional, technical, and policy steps.

Institutional Steps

- **Establish a Catchment Fund:** Create a dedicated fund to support catchment management initiatives, ensuring sustainable financing for projects and activities.
- **Stakeholder Platforms:** Establish stakeholder platforms to facilitate collaboration, coordination, and engagement among stakeholders, including local communities, government agencies, and private sector organizations.

Technical Activities

- **E-Plan Development:** Develop an electronic plan (e-Plan) to track progress, monitor implementation, and facilitate adaptive management.
- **Capacity-Building:** Provide training and capacity-building programs for stakeholders, including local communities, government officials, and private sector organizations.

Policy Reforms

- **Harmonize State Water Laws:** Harmonize state water laws and regulations to ensure consistency and coherence in catchment management.
- **Review and Update Policies:** Review and update policies and regulations to reflect the changing needs and challenges of catchment management.

7.7 Investment Areas and Financing Instruments

Table 7.2: Investment Areas and Financing Instruments

S/No	Key Investment Area	Possible Financing Instruments or Partners
1	Dam Desilting	Government grants, World Bank loans, African Development Bank (AfDB) funding
2	Afforestation/Reforestation	Green Climate Fund (GCF), Global Environment Facility (GEF), private sector partnerships (e.g., corporate social responsibility initiatives)
3	Early Warning Systems	International donors (e.g., USAID, DFID), government funding, private sector partnerships (e.g., tech companies)
4	Water Conservation	Water utility companies, government subsidies, international organizations (e.g., UNICEF, WHO)
5	Livelihood Support	International organizations (e.g., FAO, IFAD), government programs, private sector partnerships (e.g., agribusiness companies)
6	You can add others	

7.8 Risks and Adaptive Mechanisms for SCMP Implementation

The Strategic Catchment Management Plan (SCMP) may face various risks that could impact its implementation, including:

Environmental risks: climate change, natural disasters, and ecosystem degradation.

Social risks: community resistance, stakeholder conflicts, and social inequality.

Financial risks: funding shortfalls, budget constraints, and economic downturns.

Institutional risks: inadequate governance, lack of coordination, and capacity constraints.

To mitigate these risks, adaptive mechanisms can be employed, including:

Contingency planning: developing contingency plans to address potential risks and uncertainties.

Phased rollouts: implementing the plan in phases to test assumptions, build momentum, and adapt to changing circumstances.

Mid-term reviews: conducting regular reviews to assess progress, identify challenges, and make adjustments to the plan.

7.9 Conclusion

The Sokoto-Zamfara Strategic Catchment Management Plan aims to transform the catchment through strategic interventions in environmental sustainability, socio-economic development, institutional strengthening, and technical advancements. Key goals include reducing water wastage by 30%, increasing forest cover by 20%, and enhancing agricultural productivity by 25% by 2030. The plan also focuses on reducing poverty, improving access to clean water and sanitation, and strengthening governance through inter-agency coordination and community participation. Technical advancements will modernize irrigation infrastructure and establish robust monitoring systems. Community engagement will empower local communities, especially women and youth, through conservation initiatives and vocational training. Grounded in evidence from biophysical assessments and stakeholder consultations, the plan addresses water scarcity, land degradation, and climate change impacts. Successful implementation will require coordinated efforts from federal, state, and local stakeholders, leading to sustainable development and enhanced resilience for future generations.

ANNEXES

ANNEX 1: DETAILED POPULATION STATISTICS FOR THE CATCHMENT

Table A-1 I: Population Projection for Sokoto-Zamfara Catchment

State	LGA	2006	2022	2025	2030	2035	2040	2045	2050
Kebbi	Aleiro	67078	110,519	118668	133609	150430	169369	190693	214701
Kebbi	Arewa- Dandi	189728	312,598	335650	377908	425486	479055	539368	607275
Kebbi	Argungu	200248	329,931	354261	398862	449079	505618	569275	640947
Kebbi	Augie	116368	191,729	205868	231786	260968	293824	330817	372467
Kebbi	Birnin Kebbi	268620	442,581	475218	535048	602411	678254	763646	859789
Kebbi	Bunza	123547	203,557	218568	246086	277068	311951	351226	395445
Kebbi	Gwandu	151077	248,916	267272	300921	338807	381463	429489	483562
Kebbi	Jega	197757	325,827	349854	393900	443492	499328	562193	632974
Kebbi	Kalgo	84928	139,928	150247	169163	190461	214440	241438	271834
Kebbi	Maiyama	173759	286,287	307399	346100	389674	438734	493971	556162
Kebbi	Suru	148474	244,628	262667	295737	332970	374891	422089	475230
Sokoto	Binji	104,274	168,111	180507	203233	228820	257629	290064	326583
Sokoto	Bodinga	174,302	281,010	301732	339720	382491	430646	484865	545909
Sokoto	Dange Shuni	193,443	311,869	334867	377026	424494	477938	538110	605858
Sokoto	Kebbe	123,154	198,549	213190	240031	270251	304275	342584	385715
Sokoto	Kware	134,084	216,170	232111	261334	294236	331280	372988	419947
Sokoto	Rabah	149,152	240,463	258195	290702	327301	368508	414904	467140
Sokoto	Shagari	156,907	252,966	271620	305817	344319	387669	436476	491428
Sokoto	Silame	104,601	168,638	181074	203871	229538	258437	290974	327607
Sokoto	Sokoto North	233,012	375,662	403364	454148	511325	575701	648181	729787
Sokoto	Sokoto South	197,686	318,710	342212	385296	433805	488421	549913	619147
Sokoto	Tambuwal	225,917	364,224	391082	440319	495756	558171	628445	707566
Sokoto	Tureta	68,414	110,297	118431	133341	150129	169030	190311	214271
Sokoto	Wamakko	179,246	288,981	310291	349356	393340	442861	498618	561394
Sokoto	Yabo	115,302	185,890	199598	224727	253020	284876	320741	361123
Zamfara	Anka	143,637	237,761	255294	287436	323624	364368	410242	461892
Zamfara	Bakura	187,141	309,773	332617	374493	421642	474726	534494	601787
Zamfara	Bukkuyum	216,348	358,120	384528	432940	487447	548817	617913	695708
Zamfara	Bungudu	258,644	428,132	459703	517580	582743	656110	738714	831718
Zamfara	Gummi	206,721	342,184	367417	413675	465757	524396	590417	664750

Zamfara	Gusau	383,712	635,156	681994	767857	864530	973374	1095922	1233898
Zamfara	Maradun	207,563	343,578	368914	415360	467654	526531	592822	667458
Zamfara	Maru	293,141	485,235	521017	586613	660467	743620	837241	942650
Zamfara	Talata Mafara	215,650	356,964	383287	431543	485874	547046	615919	693463
Zamfara	Tsafe	266,929	441,846	474429	534159	601410	677127	762377	858360
Katsina	Dandume	145,323	234,654	251958	283679	319394	359606	404881	455855
Katsina	Faskari	194,400	313,899	337046	379481	427257	481049	541613	609802
Katsina	Funtua	225,156	363,561	390371	439518	494853	557155	627301	706278
TOTAL		6,825,443	11,168,903	11,992,519	13,502,376	15,202,324	17,116,295	19,271,235	21,697,481



ANNEX 2: THREATS, CHALLENGES, SOCIO-ECONOMICS AND POLICIES LINKED TO WATER INFRASTRUCTURE IN THE CATCHMENT AS INDICATED BY THE STAKEHOLDERS

Table A-1 2: Threats, Challenges, Socio-Economics and Policies Linked to Water Infrastructure in the Catchment from Stakeholders

Natural Resources					Threats and Challenges	Socioeconomics	Policies	Past & Present Interventions
Water reservoirs	Minerals	Flora	Fauna	Agriculture				
Bakolori Dam in Talata Mafara/Maradun LGA, Zamfara	Limestone in Maiyama, Wamako LGAs	Gum Arabic	Diverse species of Mammals, Reptiles, Amphibians, Fish and Birds.	Gum Arabic in Maiyama LGA	Inhabitants lack support in key areas such as proper water availability and conservation	There is substantial Agriculture and Agribusiness, which is the major source of livelihood for most households.	Water law which is currently with the house of assembly for implementation across the catchment.	The ACRoSAL project has been running from 2022 and is scheduled to end in 2028.
	Gold Resources in Suru, Faskari, Bakori LGAs	Bambara Nuts		Rice in Augie, Suru and Argungu LGAs	Banditry in areas and communities across Bukkuyum, Anka, Talata-Mafara, Bakura LGAs	Livestock rearing is also a major economic activity that spans through the entire catchment. Inhabitants rear Cattle, Sheep, Goats, Poultry, as well as animal products such as milk	VAP Law is implemented across the catchment, which emphasizes zero tolerance to violence against people.	N-Power program was in phase between 2016 and 2023, benefitting all LGAs



						processing and hide/skin tanning.		
Goronyo Dam in Goronyo LGA, Sokoto	Lithium in Gusau and Maradun LGAs	Shea Butter		Cassava in Tambuwal, Arewa, Goronyo LGAs	Areas upstream of the Bakolori river are experiencing siltation in rivers which have affected fishing activities seriously.	Up to 30,000 Farmers have received farming inputs as grants to promote livelihoods by the farmers' association	Child Protection Law, 2010 is implemented which grants children rights to education	The NEWMAP project was in phase between 2013 and 2020. Only Sokoto and Katsina are states within the catchment that participated in NEWMAP.
	Kaolin in Funtua, Faskari LGAs	Lemon grass		Bambara Nuts in Arewa LGA	Problems surrounding availability of good seeds for farmers to plant	There are farmers associations across the catchment that partners with farmers to improve their wellbeing and production capabilities.	State gender equality and women empowerment Law, which gives women and girls rights to access education and other basic rights. This cross cuts women in agriculture as well.	
Gusau Dam in Gusau LGA, Zamfara		Locust Bean		African Locust Bean in Zuru LGA	Flooding in LGAs including Goronyo, Rabah,	A very good percent of agricultural interventions across the catchment is aimed	National Action plan on gender and climate change, which is implemented across	Fadama Projects have been running from 2008



					Wurno, Wammako.	at the women population, which helps the livelihood of the female population	the states of the Country.	till date within the catchment.
				Potatoes in Maiyama LGA	Deforestation due to increase in charcoal making	Women farmers across Sokoto state are regularly given aids to encourage them to farm and support themselves	Integrated Solid Waste Management Policy that addresses pollution across the catchment	Fadama III project is one of the projects that covered a very large area compared to others, covering 20 LGA in Sokoto and 21 LGAs in Kebbi, training farmers on very good agricultural practices
Lugu Dam in Wurno LGA, Sokoto				Onion in Haliru LGA	Rapid population increase	500 women and girls have been empowered with skill acquisition across Sokoto state to aid livelihoods	National Forest Policy	
					Gender based violence is a problem across the catchment		Policy guidelines for the production of charcoal, involving	There are various afforestation and



							states for implementation.	reforestation programs which are ongoing within the catchment
					Typha grass constitutes a problem in and around Yabo, Bakura, Anka, Talata-Mafara LGAs, as well as the vast land that spreads from the spillway of Shagari dam		Mineral Resources and Environmental Management Committee has a policy that ensures synergy between federal Government and Miners. Miners are trained on safe ways to go about their mining activities.	International Fund for Agricultural Development (IFAD) was implemented in 14 LGAs in Kebbi State
					Over dependence on donor funding which has caused various projects to collapse		Kebbi State Water Users Association Law (2024)	The NG-Cares Project is currently being rounded up and all LGAs within the catchment are participating.



					Environmental degradation due to excessive mining, and lack of proper policies.		Kebbi State Water and Sanitation Policy (2025)	NIHSA Drilled 3 Boreholes in collaboration with NEWMAP. One in Geology department in Usman Danfodio University, and 2 in Kebbi – Malumfashi and Dutsin Ma.
							Policy on Desertification and Drought (2005)	
							The National Agricultural Technology and Innovation Policy (NATIP) is a policy in Nigeria that aims to improve the country's agriculture sector. The policy was launched in 2022 and will run until 2027.	

ANNEX 3

Shared Strategic Vision and Goals

GOALS

To develop comprehensive and sustainable management of the existing resources in the catchment.

OBJECTIVES

1. To promote sustainable land use management practices.
2. To support economic development and poverty reduction.
3. To provide sustainable and equitable use of rivers and transboundary water sources of the catchment
4. To mainstream gender equality and social inclusion in all policies, programs, and projects.
5. To enhance community sensitization and awareness and reporting on gender-based violence (GBV)
6. To strengthen the child protection system and support services
7. To strengthen the early warning system to enhance disaster management and community resilience
8. To provide efficient and environmentally friendly energy sources.
9. To promote adaptation and implementation of new technologies and tools for sustainable ecosystem management.
10. To promote extension services with a view to sharing awareness on land and water management.
11. To promote effective information management and sharing among different stakeholders.
12. To protect at least 30% of the catchment from open defecation within the lifespan of the project.
13. To strengthen the enforcement of extant resource laws and regulations in the catchments.
14. To create an environment free of plastic contamination at least 80% within the duration of the program.
15. To preserve biodiversity in the catchment area.
16. To scale and facilitate the financial accessibility of communities by financial institutions, through the provision of low-interest loans to relevant stakeholders.

2. STAKEHOLDERS ENGAGEMENT

1. Ensure a participatory approach to engage all stakeholders.
2. Establish community-based management structures.
3. Create educational outreach programs from the grassroots in the catchments.
4. Encourage stakeholder collaboration to engage different users such as farmers and herders
5. Establish conflict resolution mechanisms in the catchment.
6. Support gender inclusivity.
7. Create safe spaces in discussion and decision-making for women, children, and people with disability.
8. Use of culturally sensitive approaches to ensure women's participation is respected and valued.

3. WATER MANAGEMENT

1. Improve water storage capacities of rivers and dams through dredging and desilting which can also reduce flood risk and boost irrigation farming in the catchment.
2. Establish water user associations in the catchment.
3. Promote awareness of water management on farmlands to avoid wastage.
4. Control of invasive aquatic weeds in rivers and lakes within the catchment.
5. Provide sustainable development of catchment water by providing access to safe and sufficient drinking water for all citizens.
6. Treat and recycle wastewater where possible.
7. Develop a policy that will regulate the over-abstraction of groundwater to enhance water availability in the catchment.
8. Promote equitable and accessible utilization of surface and groundwater resources.
9. Ensure river embankment protection and monitoring of sand mining activities along the rivers.
10. Strengthen local /Indigenous knowledge for sustainable utilization of natural resources

11. Regulation of rampant drilling of boreholes and establishment of synergy between stakeholders.
12. Reclaiming the wetland where necessary in the catchment
13. Develop regulatory framework for development and sustainable management of water resources in the catchment
14. Establishment of more hydrometeorological stations for effective collaboration with relevant institutions for data sharing.
15. Adopt and promote sustainable water management practices protection of the catchment
16. Ensure regular desilting of the available dams and reservoir within the catchment
17. Provision of river gauges to save the risk of runoff in the rivers
18. Construction of small earth dams across the catchment. This will go a long way in reducing the flash flood and increasing animal food and fish production.
19. Control the concentration of pollutants in the catchment.
20. Aquifer restoration as a policy should be made as a result of mining that disturbs the formation of water and makes the boreholes dry as well as dug wells.
21. Strengthen policies against overfishing, pollution, and habitat destruction.
22. Establish water transportation safety plans for the catchment.

4. LAND USE MANAGEMENT

1. Develop a plan for sustainable land use and management practices.
2. Train communities on land use practices using a participatory approach on land use planning process and vulnerability assessment methods.
3. Restoration of 30% to 70% of the degraded land through afforestation and sand dune stabilization within the catchment.
4. Creating an enabling environment to enhance women's participation in agriculture.
5. Enlighten communities on different soil types and high-yielding/promising crop varieties.
6. Fostering collaboration and partnership among farmers, government agencies cooperate bodies, and investors.

7. Upgrade and rehabilitate grazing reserves by providing drinking water, fodder for the animals and health clinic in the catchment.

ENVIRONMENTAL PROTECTION

1. Ensuring improved energy efficiency and forest regeneration through afforestation.
2. Restoration of riparian buffer zones within the catchment area.
3. Create awareness in the catchment area on the dangers of living in an unclean environment where open defecation is prevalent and also construct improve latrines in the catchment.
4. Training of women and youth on home gardening for environmental restoration.
5. Develop cost-effective and simple techniques for land restoration. Such as agroforestry, afforestation, cover crop production, and other agroclimatic SMAT practices
6. Conduct a study on the presence of heavy metals and their locations within the catchment.
7. Use of integrated pest management (mosquitos and quelea birds) through the adaptation of IPM 25% of farmers should be trained so that at the end of the program about 30% of farmers should have adopted the use of IPM
8. Ecosystem resilience mainstreaming healthy and diverse ecosystems such as forests wetlands and aquatic habitats which can provide natural buffers against climatic-related impacts.
9. Create awareness in the catchment on how plastic pollution litters the environment, and clogs drains, causing flooding, property damage, and health risks.
10. Establish climate-smart agricultural techniques profiles for the catchment.

COMMUNITY BENEFITS

1. Creation of jobs for the youth and people with special needs e through proactive engagement.
2. Restoration of biodiversity.
3. Ensuring food security and productivity.
5. Disaster risk reduction.
6. Peace restoration.
7. Flood and health risk reduction

8. Encourage sustainable livelihood
9. Sustainable access to low-cost energy alternatives.
10. Environmental Conservation
11. Diseases control.
12. Gender mainstreaming
13. Minimize environmental littering and safeguard public health.
14. Reduce vulnerability to food insecurity.

ECONOMIC DEVELOPMENT

1. Increase income and reduce poverty
2. Promote the development of MSEs for agricultural value addition and minerals resources development within the catchment
3. Collect demographic data on population characteristics for proper planning and community engagement
4. Empower the vulnerable groups and traditional institutions for poverty reduction
5. Improve tourism potential in the catchment
6. Introduce to new technologies and innovations in the production of the catchment

CLIMATE CHANGE

1. Establish additional automated and ground-based weather stations in each state within the catchment for more climatic data
2. To encourage community-based climatic change adaptation techniques and strategies.
3. Provide regular and timely information on seasonal climate predictions and early warning on flooding.
4. Encourage the use of climate-SMART agricultural practices.
5. Encourage organic fertilizer production in the catchment.
6. Encourage the use of higher yielding and mature crops varieties.

MONITORING AND EVALUATION

1. Encourage collaboration between CBOs/ NGOs and state Government to ensure grassroots get the necessary information.

2. Make use of GIS agencies as the source of vital information monitoring and evaluation on aligning policies.
3. Frequent visitation and monitoring of activities in the catchment.
4. Develop and adopt objectively verifiable indicators (OVIs) indicating sources of data frequencies of collection and agencies responsible.
5. Set up a monitoring and evaluation committee in the area.
6. Engaging local, civil society organizations in the area, community-based organizations, women groups, youth groups, etc.
7. Develop policies geared towards protecting the vegetal resources



Faruk Garba Illo
Chairman



Dr. Ibrahim Saadu
Secretary

STAKEHOLDER ENGAGEMENT PHOTOGRAPHS



GLOSSARY

Glossary of Key Terms

Term	Definition
Adaptive Management	A flexible approach to resource management that allows for adjustments based on monitoring results, stakeholder feedback, and changing environmental or socio-economic conditions.
Afforestation	The process of planting trees in areas where there were no forests previously, often to restore ecosystems, sequester carbon, or prevent soil erosion.
Agroforestry	A land-use system that integrates trees and shrubs with crops and/or livestock to enhance productivity, biodiversity, and sustainability.
Aquifer	An underground layer of water-bearing rock or sediment from which groundwater can be extracted for use.
Baseflow	The portion of streamflow that comes from groundwater seepage into streams, maintaining flow during dry periods.
Best Management Practices (BMPs)	Techniques or measures used to reduce pollution and manage water resources sustainably, such as buffer strips or sediment traps.
Biochemical Oxygen Demand (BOD)	A measure of the amount of oxygen consumed by microorganisms decomposing organic matter in water, indicating pollution levels.
Biodiversity	The variety of plant and animal life in a particular habitat or ecosystem, essential for maintaining ecological balance and resilience.
Buffer Zone	A designated area of vegetation or land that acts as a barrier to reduce pollution, control erosion, and protect water bodies from contaminants.
Capacity Building	The process of strengthening the skills, knowledge, and abilities of individuals, organizations, or communities to achieve their goals effectively.
Carbon Sequestration	The process of capturing and storing atmospheric carbon dioxide, often through reforestation, afforestation, or soil management, to mitigate climate change.
Carrying Capacity	The maximum population size of a species that an environment can sustain indefinitely, given the available resources.
Catchment Delineation	The process of defining the boundaries of a watershed using topographic and hydrological data.
Catchment Management Plan (CMP)	A strategic document outlining actions to manage land, water, and other natural resources within a specific catchment area, balancing environmental, social, and economic needs for sustainable development.

Channelization	The artificial straightening or modification of a river or stream, often to control flooding but sometimes leading to ecological harm.
Climate Adaptation	Actions taken to adjust to the impacts of climate change, such as building flood defenses, developing drought-resistant crops, or improving water management systems.
Climate Mitigation	Efforts to reduce or prevent greenhouse gas emissions, such as using renewable energy, improving energy efficiency, or reforestation.
Climate Resilience	The ability of a system, community, or ecosystem to anticipate, prepare for, and adapt to climate-related risks and recover from their impacts.
Community-Based Organizations (CBOs)	Local groups or associations that work to address community needs and challenges, often playing a key role in implementing development projects.
Desertification	The process by which fertile land becomes desert, typically due to drought, deforestation, or inappropriate agriculture.
Discharge	The volume of water flowing through a river or stream per unit of time (e.g., cubic meters per second).
Ecological Footprint	A measure of human demand on Earth's ecosystems, comparing the resources consumed to the planet's capacity to regenerate them.
Ecosystem Services	The benefits that humans derive from ecosystems, such as clean water, air, food, and climate regulation.
Environmental Degradation	The deterioration of the environment through depletion of resources, destruction of ecosystems, and pollution, often caused by human activities.
Environmental Impact Assessment (EIA)	A process used to evaluate the potential environmental effects of a proposed project or development before it is carried out.
Erosion	The process by which soil and rock are removed from the Earth's surface by natural forces such as wind, water, or human activities, often leading to land degradation.
Eutrophication	The excessive growth of algae and other plants in water bodies due to nutrient pollution, often leading to oxygen depletion and harm to aquatic life.
Evapotranspiration (ET)	The combined process of water evaporation from soil and transpiration from plants, a key component of the water cycle.
Floodplain	A flat area of land adjacent to a river or stream that is prone to flooding, often rich in biodiversity and fertile soil.
Geographic Information System (GIS)	A computer-based tool for mapping and analyzing spatial data, widely used in catchment management.
Greenhouse Gas (GHG)	Gases that trap heat in the atmosphere, contributing to global warming and climate change. Examples include carbon dioxide (CO ₂), methane (CH ₄), and nitrous oxide (N ₂ O).

Groundwater Recharge	The process by which water from precipitation or surface water percolates into the ground, replenishing aquifers and maintaining water availability.
Gully Erosion	Severe erosion where water cuts deep channels into the soil, often due to poor land management.
Hydraulic Conductivity	A measure of how easily water can move through soil or rock, important for groundwater studies.
Hydrological Cycle	The continuous movement of water on, above, and below the Earth's surface, including processes such as evaporation, condensation, precipitation, and runoff.
Hydrological Modeling	The use of mathematical models to simulate and predict the movement and distribution of water within a catchment or watershed.
Infiltration	The process by which water soaks into the soil from the surface.
Instream Flow	The water flow required to maintain aquatic ecosystems and downstream water needs.
Integrated Catchment Management (ICM)	A holistic approach to managing land, water, and other natural resources within a catchment, considering social, economic, and environmental factors.
Integrated Water Resources Management (IWRM)	A holistic approach to managing water resources that considers social, economic, and environmental factors, promoting sustainable and equitable use.
Land Degradation	The decline in land quality caused by human activities, such as deforestation, overgrazing, and poor agricultural practices, leading to reduced productivity and ecosystem health.
Land Tenure	The system of rights and institutions that govern access to and use of land, including ownership, leasing, and communal arrangements.
Land Use/Land Cover (LULC)	Categories describing how land is utilized (e.g., forest, agriculture, urban) and its surface characteristics.
Livelihood Diversification	The process by which households or communities expand their income sources to reduce dependence on a single activity, enhancing resilience to economic and environmental shocks.
Livelihood Resilience	The ability of households or communities to withstand and recover from economic, environmental, or social shocks, often through diversified income sources and adaptive strategies.
Microcredit	Small loans provided to low-income individuals or groups to support income-generating activities, often used to promote entrepreneurship and poverty alleviation.
Multidimensional Poverty Index (MPI)	A measure of poverty that considers multiple deprivations in health, education, and living standards, providing a

	comprehensive understanding of poverty beyond income levels.
Non-Governmental Organizations (NGOs)	Non-profit organizations that operate independently of government, often focused on social, environmental, or developmental issues.
Normalized Difference Vegetation Index (NDVI)	A remote sensing indicator used to assess vegetation health and density by measuring the difference between near-infrared (NIR) and red light reflectance. Higher values indicate healthier vegetation.
Participatory Approach	A methodology that involves stakeholders in decision-making processes, ensuring their perspectives and needs are considered.
Peak Flow	The highest discharge rate in a stream or river during a rainfall or snowmelt event.
Permeability	The ability of soil or rock to allow water to pass through it.
Public-Private Partnership (PPP)	A collaborative arrangement between government agencies and private sector entities to deliver public services or infrastructure projects.
Rainwater Harvesting	The collection and storage of rainwater for later use, such as irrigation, drinking water, or groundwater recharge.
Reforestation	The process of replanting trees in areas where forests have been depleted or degraded, aiming to restore ecosystem functions and biodiversity.
Resilience	The capacity of a system, community, or ecosystem to absorb disturbances, adapt to change, and continue to function effectively.
Riparian Zone	The interface between land and a river or stream, often rich in biodiversity and critical for water quality and ecosystem health.
Rotational Grazing	A livestock management practice where animals are moved between different grazing areas to allow vegetation recovery and prevent overgrazing.
Runoff	Water that flows over the land surface rather than infiltrating into the soil, often carrying pollutants.
Sediment Load	The amount of sediment carried by a river or stream, affecting water quality and aquatic habitats
Sedimentation	The deposition of soil, sand, and other particles carried by water, which can reduce water quality, clog waterways, and harm aquatic ecosystems.
Socio-Economic Indicators	Metrics used to measure the social and economic conditions of a population, such as income levels, education, health, and employment rates.
Soil Conservation	Practices aimed at preventing soil erosion and degradation, such as contour plowing, terracing, and cover cropping.
Soil Fertility	The ability of soil to sustain plant growth by providing essential nutrients, water, and a suitable physical structure.

Stakeholder Engagement	The process of involving individuals, groups, or organizations affected by or interested in a project or decision, ensuring their input and participation in planning and implementation.
Stakeholder Forum	A platform for dialogue and collaboration among stakeholders, often used to share knowledge, discuss challenges, and develop solutions.
Stakeholder Mapping	The process of identifying and analyzing stakeholders to understand their interests, influence, and potential impact on a project.
Streamflow	The flow of water in a natural channel, influenced by precipitation, groundwater, and land use.
Subsidence	The sinking of land due to groundwater over-extraction or soil compaction.
Sustainable Agriculture	Farming practices that meet current food needs without compromising the ability of future generations to meet theirs, often emphasizing soil health, water conservation, and biodiversity.
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs, balancing economic, social, and environmental goals.
Traditional Knowledge	Knowledge, practices, and beliefs developed by indigenous and local communities over generations, often used to manage natural resources sustainably.
Total Dissolved Solids (TDS)	A measure of the combined content of inorganic and organic substances dissolved in water, affecting quality.
Transboundary Water Management	Cooperative management of shared water resources (e.g., rivers, aquifers) between countries or regions.
Water Allocation	The regulated distribution of water resources among competing users (e.g., agriculture, industry, households).
Water Balance	An accounting of all water inputs (precipitation) and outputs (evapotranspiration, runoff) in a catchment.
Water Footprint	The total volume of freshwater used to produce goods and services consumed by an individual, community, or organization.
Water Quality	The chemical, physical, and biological characteristics of water, determining its suitability for specific uses such as drinking, irrigation, or ecosystem health.
Water Scarcity	A condition where the demand for water exceeds the available supply, often exacerbated by population growth, climate change, and poor water management.
Water Table	The upper surface of the zone of saturation in the ground, where the soil or rocks are permanently saturated with water.
Water Use Efficiency (WUE)	The ratio of beneficial water use (e.g., crop yield) to total water applied, indicating sustainable practices.



Watershed	An area of land that drains all precipitation and surface water into a common outlet, such as a river, lake, or ocean. Synonymous with "catchment."
Wetland	An area of land that is saturated with water, either permanently or seasonally, supporting unique ecosystems and providing services such as flood control and water filtration.
Wetland Restoration	The process of returning a degraded wetland to its natural state to improve water quality and biodiversity.
Zoning	The process of dividing land into areas with specific land-use regulations, such as residential, agricultural, or conservation zones.