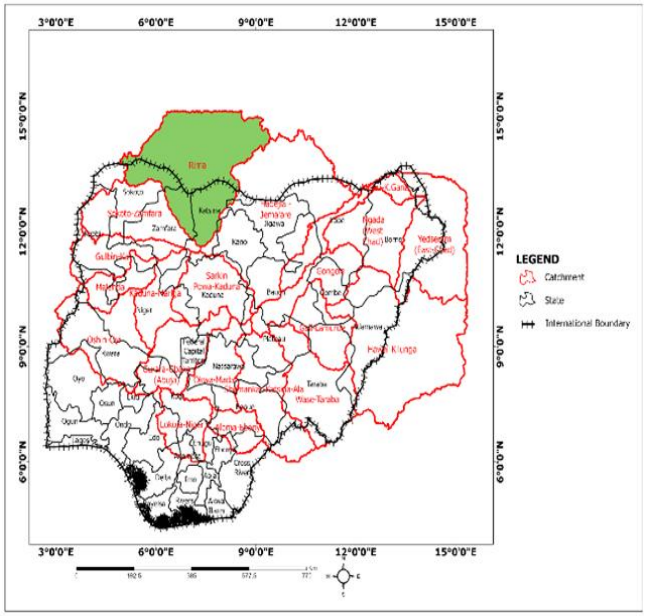
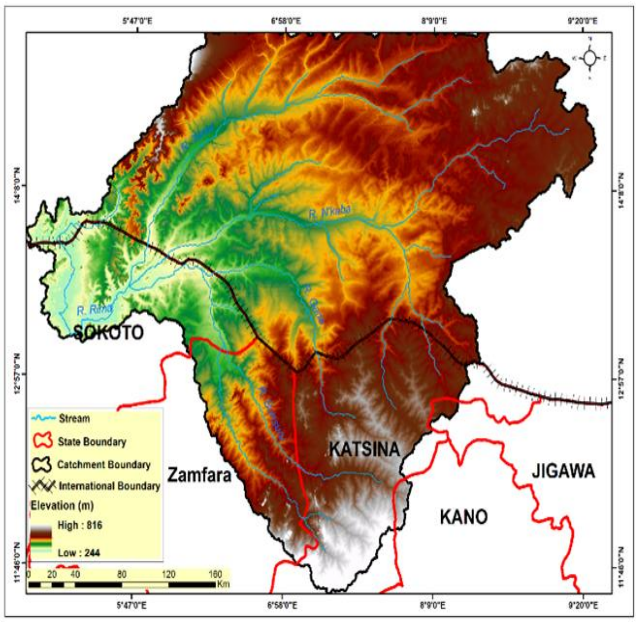
ACReSAL
Agro-Climatic Resilience in Semi-Arid Landscapes

THE WORLD BANK

RIMA STRATEGIC CATCHMENT MANAGEMENT

PLAN





MARCH, 2025

TABLE OF CONTENTS

Table of Contents---- i
ACRONYMS AND ABBREVIATIONS ---- vii
EXECUTIVE SUMMARY ---- xiii
Chapter 1 : INTRODUCTION ---- 1
1.1 Purpose of the Plan ---- 1
1.2 Rationale for a Strategic Catchment Plan ---- 1
1.3 Expected Outcomes ---- 2
1.4 Environmental Roles ---- 2
1.5 Socio-Economic Roles ---- 3
1.6 Governance and Institutional Roles ---- 4
1.7 Catchment Policies ---- 5
1.8 Integration Mechanisms ---- 6
Chapter 2 : CHARACTERISTICS OF THE CATCHMENTS ---- 8
2.1 Location ---- 8
2.1.1 Location and Boundary ---- 8
2.2 Precipitation, Temperature, Sunshine and Relative Humidity ---- 8
2.2.1 Precipitation ---- 8
2.2.2 Temperature ---- 9
2.2.3 Sunshine Duration ---- 10
2.2.4 Relative Humidity ---- 10
2.3 Topography, Drainage, Geology and Soils ---- 11
2.3.1 Drainage ---- 11
2.3.2 Topography ---- 12
2.3.3 Geology and Soil Types ---- 13
2.4 Land Use and Land Cover ---- 18
2.4.1 Natural Vegetation ---- 19
2.4.2 Agricultural Land Use ---- 19
2.4.3 Wetlands ---- 20
2.4.4 Grazing Land and Pastoralism ---- 20
2.4.5 Human Settlements ---- 21
2.4.6 Forest and Woodland Areas ---- 22
2.4.7 Biodiversity ---- 23
2.5 Hydrology and Water Resources ---- 25
2.5.1 Hydrology ---- 25
2.5.2 Hydrograph/Water Budget of The Catchment ---- 26

2.5.3 Hydrogeological Disposition of the Catchment ----------32
2.6 Water Demand for Rima Catchment----------33
2.6.1 Water Availability by Sub-Basin ----------33
2.6.2 Water Use and Demands ----------33
2.6.3 Livestock Indices and Water Demand ----------35
2.6.4 Aquaculture water demand ----------38
2.6.5 Irrigation water demand ----------40
2.6.6 Irrigation Water Demand Projection ----------43
2.6.7 Total Water Demand----------46
2.6.8 Infrastructure and Assets ----------47
2.7 Water Quality ----------49
2.7.1 Surface Water Quality ----------49
2.7.2 Groundwater Quality ----------50
2.7.3 Surface Water Resources----------53
2.7.4 Groundwater Resources ----------53
2.8 Climate Change Impact On Water and Land Resources----------59
2.8.1 Historical and Future Climatic Trends ----------59
2.8.2 Annual Rainfall and Temperature for Rima Catchment----------59
2.8.3 Projected Mean Annual Temperature for Rima Catchment ----------61
2.8.4 Analysis of Downscaled Output of GCMs ----------62
2.8.5 Evapotranspiration ----------65
2.8.6 Major Impacts of Climate Change----------66
2.8.7 National and International Climate Change Frameworks/Agreements ----------69
2.9 Flood and Drought Vulnerability----------71
2.9.1 Digital Elevation Model----------72
2.9.2 Rainfall----------73
2.9.3 Slope----------74
2.9.4 Proximity to River----------76
2.9.5 Land Use and Land Cover ----------77
2.9.6 Flood Vulnerability ----------79
2.9.7 Flood Risk ----------81
2.10 Socio-Economic Dynamics----------83
2.10.1 Population Distribution and Growth ----------83
2.10.2 Demographics and Poverty----------85
2.10.3 Gender Issues----------87
Chapter 3 : STAKEHOLDER ENGAGEMENT AND GOVERNANCE----------90
3.1 Methodology ----------90

3.2 Key Stakeholders Engaged----------90
3.3 Major Topics for Stakeholder Discussions ----------92
3.4 Key Points from the Stakeholder Engagement----------93
3.5 Coordination Mechanisms----------94
Chapter 4 : STRATEGIC VISION AND GOALS ----------96
Chapter 5 : STRATEGIC CHALLENGES AND PRIORITY INTERVENTIONS ----------99
5.1 Key Issues----------99
5.2 Strategic Interventions ---------- 100
5.3 Expected Outcomes ---------- 114
Chapter 6 : MONITORING, EVALUATION AND LEARNING ---------- 115
6.1 Monitoring and Evaluation---------- 115
6.2 Data Collection Methods ---------- 115
6.3 Feedback Mechanisms ---------- 116
6.4 Data Management and Analysis---------- 116
Chapter 7 : CONCLUSION AND MOVING FORWARD---------- 119
7.1 Summary of Strategic Issues and Priorities---------- 119
7.2 Recommendations for Aligning with Broader National and Regional Programs---------- 120
7.3 Catchment Policy for Interstate River Systems ---------- 122
7.4 High-Level Funding Strategies and Partnership Opportunities---------- 125
7.5 Moving Forward with the Catchment Plan ---------- 128
7.6 Conclusion ---------- 130
Annexes---------- 131
ANNEX 1: DETAILED POPULATION STATISTICS FOR THE CATCHMENT ---------- 131
ANNEX 2: THREATS, CHALLENGES, SOCIO-ECONOMICS AND POLICIES LINKED TO WATER INFRASTRUCTURE IN THE CATCHMENT AS INDICATED BY THE STAKEHOLDERS---------- 133
ANNEX 3---------- 135
STAKEHOLDER ENGUAGEMENT PHOTOGRAPHS ---------- 138
GLOSSARY ---------- 139
REFRENCES ---------- 144

List of Figures

Figure 2.1: Rima catchment showing the LGAs (Source: MSL, 2025) ---------- 8
Figure 2.2: Annual precipitation of Rima Catchment (2000 - 2021) (Source: CHIRPS, 2015) 9
Figure 2.3: Annual Average Temperature for Rima Catchment (2000 - 2023) (Source: MSL, 2025) ---------- 9
Figure 2.4: Annual Average Sunshine Duration in the Catchment (Source MSL, 2025) ------10
Figure 2.5: Annual Average Relative Humidity of the Catchment (Source: MSL, 2025) -----11
Figure 2.6: Drainage Map of Rima Catchment showing dams (Source: MSL, 2025)----------12
Figure 2.7: Digital Elevation Model (DEM) of the catchment (Source: MSL, 2025)----------13
Figure 2.8: Geological Map of Rima Catchment (Source: MSL, 2025)----------15
Figure 2.9 Soil Map of Rima Catchment (Source: MSL, 2025)----------17
Figure 2.10: Land Use and Land Cover of Rima Catchment 2017 and 2023 (Source: MSL, 2025) ----------18
Figure 2.11: Vegetation Map of Rima Catchment (Source: MSL, 2025)----------23
Figure 2.12: Hydrograph of Rima Strategic catchment----------26
Figure 2.13: 40 - Year Summary Hydrograph of Rima Strategic catchment ----------27
Figure 2.14: Hydrograph of Rima Strategic Catchment for Specific Year----------27
Figure 2.15: Water Budget for Rima Strategic Catchment ----------28
Figure 2.16: Monthly Actual Evapotranspiration Distribution for the Catchment----------28
Figure 2.17: Water Resources of the catchment----------31
Figure 2.18: Hydrogeological province Map of the Catchment (Source: MSL, 2025) --------32
Figure 2.19: Map showing Rima Catchment on Nigeria Map ----------34
Figure 2.20: Daily Municipal Water Demand for Rima Catchment ----------35
Figure 2.21: Water capacity for Rima Catchment ----------35
Figure 2.22: Groundwater Flow in Sokoto Basin----------55
Figure 2.23: Density of Distribution of Borehole Fields (2030) by LGA----------57
Figure 2.24: Balance of Groundwater Demand and Recharge in 2030----------58
Figure 2.25: Balance of Groundwater Demand and Recharge in 2030 by Effect of Climate Change ----------58
Figure 2.26: Annual rainfall trend for Rima Catchment (1981-2050). ----------60
Figure 2.27: Mean monthly temperature for Rima Catchment (1981-2022 and 2023-2050) -61
Figure 2.28: Trends in mean annual temperature for Rima Catchment (1981-2050)----------62
Figure 2.29:Average changes in precipitation derived from outputs of 7 GCMs (source: JICA,2014) ----------64
Figure 2.30: Average changes in temperature derived from outputs of 7 GCMs (source: JICA 2014),----------65
Figure 2.31: Annual evapotranspiration trend for Rima Catchment (1990-2050).----------66
Figure 2.32: The flow chat of the methodology----------71
Figure 2.33: Digital Elevation Model of the Catchment (Source: MSL, 2025) ----------72
Figure 2.34: Rainfall Map of the Catchment (Source: MSL, 2025) ----------74
Figure 2.35: Slope Map of the Catchment (Source: MSL, 2025) ----------75
Figure 2.36: Proximity to River Map of the Catchment (Source: MSL, 2025)----------77
Figure 2.37: LULC Map of the Catchment (Source: MSL, 2025) ----------78

Figure 2.38: Flood Vulnerability Map of the Catchment (Source: MSL, 2025) ----------79
Figure 2.39: Flood Vulnerability Analysis of the catchment----------81
Figure 2.40: Flood Risk Map of the Catchment (Source: MSL, 2025)----------82
Figure 2.41: Flood Risk LULC analysis of the Catchment (Source: MSL, 2025)----------83
Figure 2.42: Rima Catchment population projection from 2006 – 2050 (Source: NPC 2006)84
Figure 5.1: Strategic Catchment Management Plan---------- 103
Figure 5.2: Component 1 (Sustainable Conservation, Management, and Use of Water Resources)---------- 105
Figure 5.3: Component 2 (Preservation and Restoration of Critical Ecosystems and Services for Sustainable Land Use)---------- 106
Figure 5.4: Component 3 (Improved Diversification for Enhanced Livelihoods and Well-being)---------- 107
Figure 5.5: Component 4 (Climate Change, Disaster Risk Management, and Climate-Resilient Infrastructure) ---------- 109
Figure 5.6: Component 5 (Strengthening Institutional Mechanisms and Project Coordination Mechanisms) ---------- 110
Figure 5.7: Component 6 (Mainstreaming Gender Equality and Social Inclusion (GESI) Mechanism ---------- 111
Figure 5.8: Component 7 (Research and Extension) ---------- 112
Figure 5.9: Component 8 (Effective Coordinated Monitoring, Evaluation, and Reporting Mechanism and System) ---------- 113

List of Tables

Table 2.1: Summary of Discharge, Rainfall and Evapotranspiration Data for Rima Strategic29
Table 2.2: Table below shows the water resource potential for HA-1 ----------31
Table 2.3: water requirement per head of livestock ----------36
Table 2.4: Number of livestock heads/ fowls in 2009 / 2010 ----------37
Table 2.5: Estimated growth rate of livestock heads during the period 2010 ~ 2030 ----------37
Table 2.6: Corresponding livestock water requirement projected to 2050----------37
Table 2.7: Breakdown of water requirement into hydrological area (HA)----------37
Table 2.8: Fish Farm Pond ----------38
Table 2.9: Projected Water Demand for Inland Aquaculture----------39
Table 2.10: Surface Water Demand of Existing Irrigation Schemes in Rima Catchment------40
Table 2.11: Surface Water Demand of Existing Irrigation Schemes in Rima Catchment------41
Table 2.12: Underflow Water Demand of Existing Irrigation Schemes in Rima Catchment--42
Table 2.13: Groundwater Demand of Existing Irrigation Schemes in Rima Catchment-------43
Table 2.14: *Current Cropping Pattern (%)* ----------44
Table 2.15: HA-1 Existing Cropping Pattern----------44
Table 2.16: Proposed Cropping Pattern (%)----------44
Table 2.17: Water Balance Analysis for Rima Catchment----------46
Table 2.18: Catchment Infrastructure and Assets ----------47
Table 2.19: Water Quality Status of Some Rivers within Rima Catchment Area ----------49

Table 2.20: Health risks of heavy metals in ground water----------52
Table 2.21: Ground water recharge ----------53
Table 2.22: Groundwater Recharge by Aquifer ----------54
Table 2.23: Aquifer of Sokoto Basin ----------54
Table 2.25: Relation between Aquifer Type and Aquifer Model ----------55
Table 2.26: Groundwater Development Potential by Aquifer----------56
Table 2.27: Optimum Yield of Borehole Field ----------57
Table 2.28: Overview of change factors for the two target years----------64
Table 2.29: Key Impacts of Climate Change ----------67
Table 2.30: Flood Vulnerability Analysis of the catchment ----------80
Table 2.31: Flood Risk Analysis of the catchment ----------82
Table 2.32: Summary of the characteristics of Rima Catchment ----------84
Table 2.33: Catchment Demographics and Poverty ----------85
Table 4.1: Strategic Goals and Objectives for Sustainable Catchment Development ----------96
Table 6.1: Monitoring and Evaluation Plan for Rima Catchment ---------- 117

ACRONYMS AND ABBREVIATIONS

Symbols	Description
°C	Degree Celsius
°F	- Fahrenheit
Abbreviation/ Acronym	Description
ACReSAL	Agro Climatic Resilience in Semi- Arid Landscapes
ADP	Agriculture Development Program
AfDB	African Development Bank
AMSL	Above Mean Sea Level
ATA	Agricultural Transformation Agenda
AWDROP	Association of Water Well Drilling Rig Owners and Practitioners
AWF	African Water Facility
BCM	Billion Cubic Metre
BORDAN	Borehole Drilling Association of Nigeria
CBDA	Chad Basin Development Authority
CBOs	Community-Based Organizations
CCAFS	Climate Change, Agriculture and Food Security
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station.
CJTF	Civilian Joint Task Force
CMCs	Catchment Management Committees.
CMP	Catchment Management Plan
CN	Curve Number
COP	Conference of the Parties
CSOs	Civil Society Organizations

CSR	Corporate Social Responsibility
DEM	Digital Elevation Model
EA	Executing Agency
EC	Electrical Conductivity
ECOWAS	Economic Community of West African States
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
FMAFS	Federal Ministry of Agriculture and Food Security
FMARD	Federal Ministry of Agriculture and Rural Development
FMEnv	Federal Ministry of Environment
FMWR	Federal Ministry of Water Resources
FPMU	Federal Project Management Unit
FUDMA	Federal University Dutsinma
GBV	Gender-based violence
GCM	Global Climate Model
GEF	Global Environment Facility
GEFC	Global Environmental Flow Calculator
GESI	Gender Equality and Social Inclusion
GHG	Greenhouse Gas
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 Person's
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
KII	Key Informant Interview
LCBC	Lake Chad Basin Commission
LGP	Length of Growing Period
LUA	Land Use Act
LULC	Land Use Land Cover
M	Metres
M&E	Monitoring & Evaluation
masl	Metres above sea level
MCM	Million Cubic Metre
MDG	Millennium Development Goal
MSF	And Médecins Sans Frontières
MSL	Mecon Services Limited
NADEP	National Agricultural Development Programme
NARSDA	National Space Research and Development Agency

NBA	Niger Basin Authority
NCWR	National Council on Water Resources
NDVI	Normalized Different Vegetation Index
NEAZDP	North East Arid Zone Development Programme
NEMA	National Emergency Management Agency
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
NRCS	Natural Resources Conservation Service
NRW	Non-Revenue Water
NSE	Nash-Sutcliffe Efficiency
NW	North West
NWRMP	
NWRMP	National Water Resource Master Plan
OSGOF	Office of Surveyor General
PES	Payment for Ecosystem Services
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
SCMP	Strategic Catchment Management Plan
SCS	Soil Conservation Service
SEMA	State Emergency Management Agency
SESA	Strategic Environmental and Social Assessment
SGS	Streamflow Gauging Station
SHA	Sub Hydrologic Area
SMA	State Ministry of Agriculture
SME	Small Medium Enterprise
SMM	Soil Moisture Method *(Hydrology rainfall-runoff model within WEAP)*
SMWR	State Ministry of Water Resources
SON	Standard Organization of Nigeria
SRRBDA	Sokoto Rima River Basin Development Authority
SSEA	Strategic Social and Environmental Assessment
SUBEB	Small Medium Enterprise
SWA	State Water Agencies
TAP	Technical Advisory Panel

TDS	Total Dissolved Solids
TOR	Terms of Reference
TRIMING	Transforming Irrigation Management in Nigeria
TRIMING	
TRIMING	Transforming Irrigation Management in Nigeria
UBE	Universal Basic Education
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational Scientific & Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UTM	Universal Traverse Mercator
VAPP	Violence against Persons Prohibition
WASH	Water, Sanitation, and Hygiene
WBG	World Bank Group
WEAP	Water Evaluation and Planning
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
ZAGIS	Zamfara Geographic Information System
ZASEPA	Zamfara State Environmental Protection Agency
ZASEPA	Zamfara State Environmental Protection Agency

EXECUTIVE SUMMARY

The Rima Catchment in northwestern Nigeria covers 101,961 km^2 (10,196,100 hectares) across Katsina, Zamfara, and Sokoto states, and is vital for agriculture and ecosystems. It faces challenges like water availability variability, land degradation, and security issues. Projected population growth by 2050 will increase pressure on its resources.

The catchment has diverse topography, from upland areas in Zamfara and Katsina to lowland floodplains in Sokoto, with elevations ranging from 500 to 200 meters. The Sokoto-Rima River system, flowing into the Niger River, is the region's main waterway. It experiences wet and dry seasons, with peak river discharge from June to September, influenced by several dams and reservoirs.

Vegetation ranges from Sudan Savannah in the north to Woodland in the south, affected by climate, soil, and threats like land degradation and deforestation. Geology, including the Precambrian Basement Complex, influences agricultural productivity and water retention.

Land use is varied, with the northern regions primarily used for grazing and the southern parts for intensive agriculture. Wetlands, which provide critical ecological functions, are under pressure from water diversion and land conversion. Urbanization, particularly around Sokoto, has implications for land and water management.

Sustainable land and water management are essential to address desertification and water scarcity. The NDVI aids in monitoring changes influenced by climate factors. Interventions like rainwater harvesting are needed in areas like Kaura Namoda and Argungu. A multi-faceted approach is crucial for enhancing resilience in the Rima Catchment.

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

S/No	Locations	Past Initiatives	Ongoing Initiatives
1	Bagudo, Koko-Besse, Shanga, Suru, and Yauri LGAs, Kebbi State	**Project:** Large-Scale Rice Farming Mobilization (2016) **Agency:** Sokoto Rima River Basin Development Authority (SRRBDA) and Labana Farms **Focus**: Agricultural Development & Food Security	**Project**: Strategic Catchment Management Plan Development (2025) **Agency:** Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL) **Focus**: Sustainable Catchment Management, Environmental Resilience, Livelihood Support
2	Sokoto State	**Project:** Rima Valley Irrigation Project Phase I **Agency**: Federal Government of Nigeria	**Project:** Rima Valley Irrigation Project Phase II Completion **Agency:** Federal Executive Council (FEC) of Nigeria

		Focus: Irrigation Development, Agricultural Productivity, Food Security	**Focus:** Large-Scale Irrigation, Food Production, Employment Generation, Agricultural Development
3	Talata Mafara, Zamfara State	**Project:** Bakolori Irrigation Scheme and Dam Rehabilitation **Agency:** Sokoto Rima River Basin Development Authority (SRRBDA), TRIMING Project **Focus:** Dam Rehabilitation, Irrigation Infrastructure, Water Management, Agricultural Productivity	**Project:** Provision of Solar-Powered Irrigation Systems **Agency:** Sokoto Rima River Basin Development Authority (SRRBDA) **Focus:** Renewable Energy, Sustainable Irrigation, Climate-Smart Agriculture, Food Security
4	Goronyo, Sokoto State	**Project:** Goronyo Dam Construction (Completed in 1992) **Agency:** Sokoto Rima River Basin Development Authority (SRRBDA) **Focus:** Flood Control, Water Storage, Irrigation Development, Agricultural Expansion	**Project:** Goronyo Dam Rehabilitation **Agency:** Sokoto Rima River Basin Development Authority (SRRBDA) under the TRIMING project **Focus:** Dam Rehabilitation, Water Storage Enhancement, Irrigation Management, Water Security
5	Sokoto and Zamfara States	**Project:** Centre Pivot Irrigation Systems Installation (2019) **Agency:** Federal Ministry of Water Resources **Focus:** Irrigation Technology, Agricultural Efficiency, Food Production	**Project:** Songhai Model Integrated Farms Development **Agency:** Sokoto Rima River Basin Development Authority (SRRBDA) **Focus:** Integrated Farming, Sustainable Agriculture, Employment Creation
6	Katsina State	**Project:** Zobe Dam Construction (1970s **Agency:** Federal Government of Nigeria, Local Communities **Focus:** rrigation, Water Supply, Agricultural Productivity, Community Development	
7	Katsina State	**Project:** Fadama Projects (2008-2023) **Agency:** National Agricultural Development Programme (NADEP), Local Farmers, Government Agencies **Focus:** Agricultural Productivity, Irrigation, Food Security, Rural Development	**Project:** Katsina State Water Supply Improvement Project **Agency:** Katsina State Water Corporation **Focus:** Water Supply Infrastructure, Domestic Water Quality, Public Health
8	Zamfara State	**Project:** Sustainable Land Management Project **Agency:** World Bank **Focus:** Land Degradation Reduction, Sustainable Agriculture, Soil Health Improvement, Agricultural Productivity	**Project:** Zamfara State Irrigation Modernization Project **Agency:** Zamfara State Ministry of Agriculture **Focus:** Irrigation Modernization, Water Efficiency, Crop Yields
9	Zamfara State	**Project:** Women Empowerment Programs (2016-2023)	**Project:** Environmental Protection and Afforestation Program

		Agency: National Agricultural N-Power Program, Women's Groups, Government Agencies **Focus:** Women Empowerment, Agricultural Productivity, Economic Empowerment, Gender Equality	**Agency:** Zamfara State Environmental Protection Agency (ZASEPA) **Focus:** Reforestation, Environmental Conservation, Ecosystem Health
10	Sokoto State	**Project:** Goronyo Dam Construction (1980s) **Agency:** Sokoto State Government, Local Communities **Focus:** Irrigation, Flood Control, Water Supply, Agricultural Productivity	**Project**: Sokoto State Climate Resilience Project **Agency**: Sokoto State Ministry of Environment **Focus:** Climate Change Adaptation, Resilience Building, Environmental Sustainability
11	Sokoto State	**Project:** Primary Health Care Revitalization (2017-2023) **Agency:** Sokoto State Government, Local Healthcare Providers, Communities **Focus:** Healthcare Infrastructure, Public Health, Community Wellbeing	**Project:** Sustainable Agriculture and Agribusiness Development Project **Agency:** World Bank **Focus:** Sustainable Agriculture, Agribusiness Development, Livelihood Improvement, Agricultural Productivity

Many initiatives in the Rima Catchment have failed to address developmental challenges in an integrated way. Numerous projects lack a comprehensive approach to tackle interconnected environmental and socio-economic issues. Consequently, the catchment continues to face significant biophysical and social challenges.

Main Biophysical and Socio-economic Challenges

This region is vital for agriculture, water supply, and livelihoods, supporting diverse ecosystems such as wetlands and floodplains. However, it faces several biophysical and socio-economic challenges that threaten its sustainability.

Biophysical Challenges:

1. **Climate Variability:** The region experiences significant climate variability, including fluctuations in rainfall and temperature. These changes adversely affect agricultural productivity and water availability. For instance, studies have shown that while cattle and sheep populations decreased, goat populations increased, with temperature significantly influencing goat populations in certain areas.
2. **Land Degradation:** Land degradation occurs through erosion, overgrazing, and loss of fertile land, threatening soil health and agriculture. A GIS-based assessment revealed the

semi-arid ecosystem's vulnerability, underscoring the necessity for sustainable land management practices.

3. **Water Scarcity:** The catchment faces water scarcity due to low and variable rainfall, high evaporation rates, and increasing aridity. This scarcity is exacerbated by land degradation and unsustainable water extraction for irrigation, leading to a decline in both surface and groundwater levels. Projections indicate that the region will experience shortages of both surface and groundwater, especially with the impacts of climate change.

4. **Flooding:** Flooding poses a significant threat to the region, affecting farmlands and settlements. A geospatial study of the 2020 flooding along River Rima identified extensive farmland affected, highlighting the need for effective flood management strategies.

5. **Water Quality:** Pollution from agricultural runoff, urban wastewater discharge, and industrial activities affects surface and groundwater quality. Contaminated water sources pose health risks to communities and reduce the suitability of water for drinking, irrigation, and ecosystem health.
6. **Biodiversity Loss:** Wetland degradation, deforestation, and overexploitation of natural resources have led to a decline in biodiversity. Loss of species and habitats affects ecosystem services such as water purification, flood control, and soil stabilization.
7. **Invasive Species:** Invasive plants like Typha grass have proliferated in wetlands and water bodies, clogging water channels and reducing water flow. These invasive species negatively impact agriculture, fisheries, and water management, leading to reduced productivity and increased maintenance costs.

Socio-economic Challenges:

1. **Agricultural Sustainability:** Agriculture is the primary livelihood in the catchment, but it faces challenges such as declining soil fertility, water scarcity, and the impacts of climate variability. These challenges threaten food security and the livelihoods of farming communities.

2. **Irrigation Project Viability:** Irrigation projects in the region face viability issues due to underutilization, with cultivated areas ranging from 30% to 40% of the proposed irrigation land. Challenges include poor participation of younger farmers, inadequate extension services, and financial constraints. These issues hinder the sustainability of irrigation initiatives aimed at enhancing agricultural productivity.

3. **Flood-Related Displacement:** Flooding leads to the displacement of communities, loss of livelihoods, and destruction of infrastructure. The 2020 floods, for example, affected significant portions of farmland, disrupting local economies and exacerbating poverty levels.

4. **Poverty and Livelihoods:** Many communities in the catchment are resource-poor, relying heavily on natural resources for their livelihoods. Unsustainable exploitation of these resources, coupled with environmental degradation, perpetuates poverty and hampers socio-economic development.

5. **Youth Participation in Agriculture:** There is a notable lack of youth engagement in agricultural activities, leading to an aging farming population. This trend threatens the future of agriculture in the region and necessitates interventions to attract younger generations to farming.

6. **Water Quality Issues:** Water quality is compromised by factors such as high colloidal sediment load and occasional high iron levels above WHO standards. These issues affect both surface and groundwater, posing health risks and challenges for agricultural use.

7. **Inadequate Infrastructure:** The catchment lacks adequate infrastructure for water supply, sanitation, and transportation, particularly in rural areas. Poor infrastructure limits access to essential services, hampers economic development, and affects the quality of life for residents.
8. **Security Challenges:** Insecurity, including banditry and communal conflicts, has disrupted socio-economic activities and affected land use and migration patterns. Insecurity reduces agricultural productivity, disrupts trade, and leads to displacement of communities, further exacerbating poverty and food insecurity.
9. **Limited Access to Education and Healthcare:** Many areas within the catchment have limited access to quality education and healthcare services. Poor access to education and healthcare limits opportunities for economic advancement and affects overall well-being, perpetuating cycles of poverty.
10. **Gender and Social Inequality:** Gender disparities and social inequalities limit the participation of women and marginalized groups in economic activities and decision-making processes. These inequalities reduce the potential for inclusive economic growth and sustainable development, affecting the overall resilience of communities.

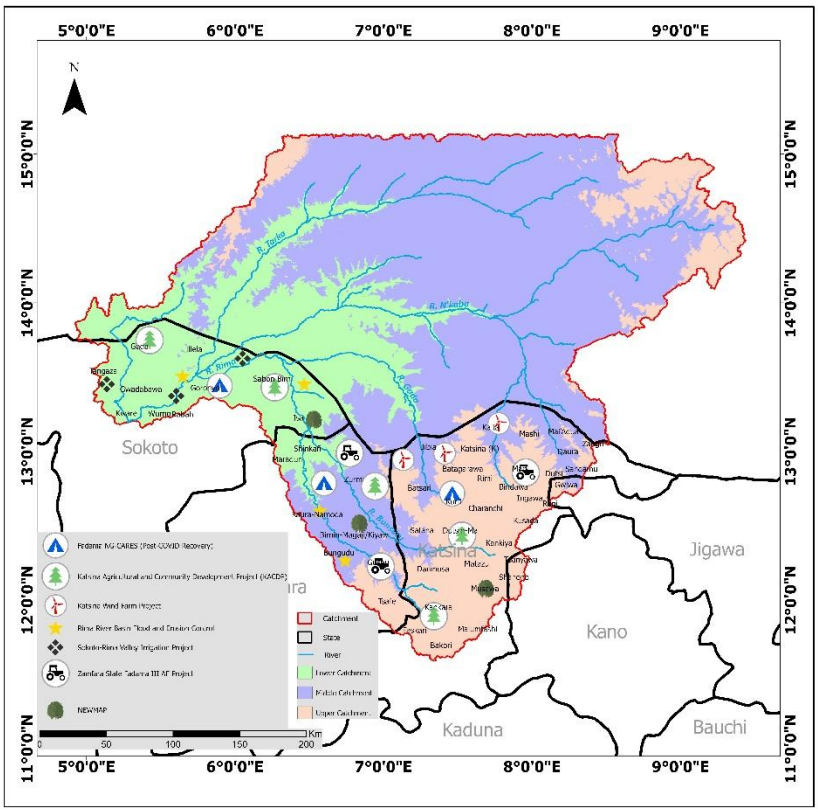


Fig E.S.1: Rima Catchment Showing the Past Interventions (Source: MSL, 2025)

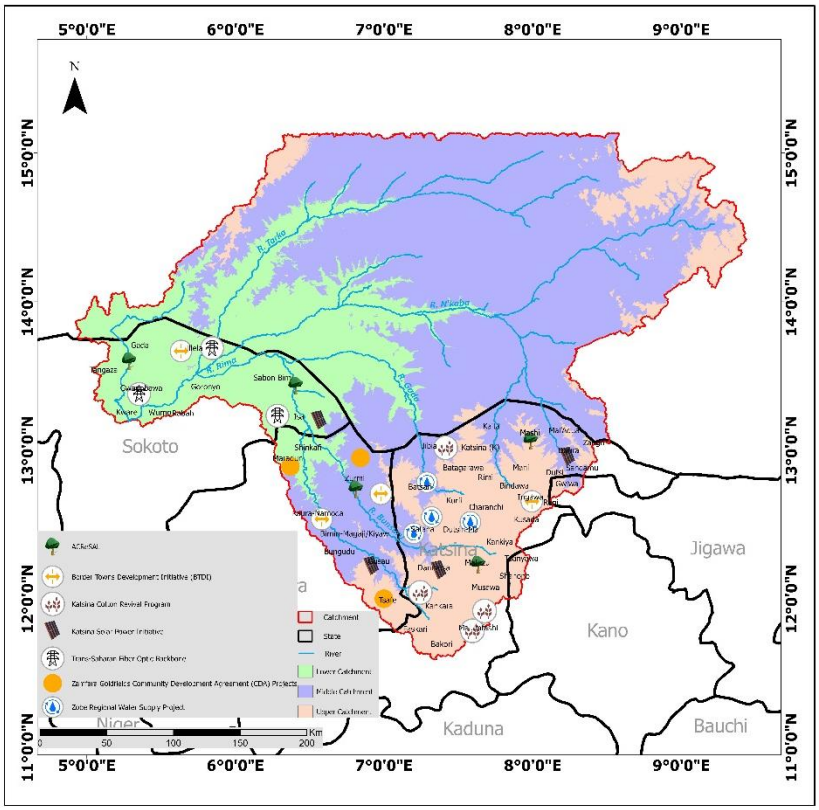


Fig E.S.2: Rima Catchment Showing the Ongoing Interventions (Source: MSL, 2025)

Elements of the Catchment Management Plan

The strategic vision of the Rima Catchment Management Plan is to achieve sustainable and equitable management of natural resources within the catchment while ensuring climate resilience, environmental protection, economic and social security for all.

This vision aims to balance the needs of the growing population with the preservation of the catchment's ecological integrity and water resources by engaging with the following objectives.

Objectives

Aligning with the vision of the Catchment Plan, the strategic objectives are to:

1. **Advocate for Sustainable Policies and Enforcement:** Develop and implement mechanisms for the regulation, monitoring, and evaluation of water resource usage. Review and strengthen laws to protect water bodies and ecosystems. Eradicate open defecation to enhance water quality.
2. **Improve Water Availability and Quality:** Implement desilting of river channels and reservoirs, rainwater harvesting, and efficient irrigation systems. Establish additional water quality and monitoring stations within the catchment.
3. **Enhance Biodiversity and Ecosystem Services:** Enhance existing ecosystems and establish new ones within the catchment. Restore wetlands for erosion and flood control. Implement waste-to-energy initiatives for sustainable waste management.
4. **Reduce Soil Erosion and Land Degradation:** Enforce sustainable land use policies and environmental laws. Restore 45% of degraded lands and optimize land use by at least 50% through sustainable irrigation and agriculture. Conduct collaborative research on land management and maintain a database on irrigation, geospatial, weather, soil, water quality, and land use changes.
5. **Implement Flood Control Measures and Drought Preparedness Strategies:** Develop and implement short- and long-term land management strategies for uniform restoration. Install integrated early warning systems for agriculture, pollution, water quality, and flood control.
6. **Mainstream Gender, Security, and Social Inclusion:** Promote gender-responsive capacity-building programs on alternative energy sources to reduce deforestation. Secure donor-funded projects from organizations like the World Bank, Global Environment

Facility (GEF), and African Development Bank for natural resource management. Develop green areas and recreation centers to promote eco-tourism.

7. **Secure Funding and Partnerships:** Improve access to finance and funding opportunities, including revolving loans and grants for grassroots associations. Ensure a secure and conducive environment to attract foreign direct investment and promote commodity exports.

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)

Plan Components

The Rima Catchment Management Plan aims to address the multifaceted challenges facing the catchment by implementing a comprehensive set of components. These components are designed to promote sustainable resource management, enhance livelihoods, and build resilience against climate change. Below is an outline of each component, incorporating information from available sources:

Component 1: Sustainable conservation, management and use of water resources: The goal is to promote sustainable water resource management in the catchment. Key actions include desilting channels, enhancing irrigation efficiency, and establishing water quality monitoring stations. We will also strengthen laws to protect water bodies and encourage community participation through capacity-building programs.

Component 2: Preservation and restoration of critical ecosystems and services for sustainable land use (to include sustainable agricultural and livestock practices): The goal is to preserve and restore critical ecosystems while promoting sustainable land use. This includes enhancing existing systems, implementing waste-to-energy initiatives, and restoring wetlands to prevent erosion and flooding. Policies and laws will ensure long-term ecological health, supported by collaborative research and a comprehensive database on key environmental aspects.

Component 3: Improved diversification for enhanced sustainable livelihoods and well-being: The objective is to enhance livelihoods by diversifying economic activities, boosting agricultural productivity through modern techniques, and promoting sustainable livestock practices. Access to financing for small-scale farmers will be improved, along with infrastructure development for artisans. Creating a secure environment will attract foreign investment and support local exports.

Component 4: Climate change, disaster risk management, and climate-resilient infrastructure: The goal is to enhance resilience to climate change by promoting women-led green initiatives and smart farming practices. Efforts will strengthen early warning systems and expand renewable energy use. Climate-resilient infrastructure and adaptation strategies in agriculture and water management will be developed for long-term sustainability.

Component 5: Strengthening institutional and project coordination mechanisms: Strengthening coordination mechanisms is vital for effective project implementation, requiring active engagement with all stakeholders. Integrated management committees will facilitate collaboration, while policies for sustainable resource management will be developed. Capacity-building programs will enhance stakeholders' project management skills, ensuring smooth implementation of activities.

Component 6: The project emphasizes gender equality and social inclusion (GESI) by conducting gender-sensitive capacity-building programs on alternative energy to combat deforestation. It aims to empower women and marginalized groups through skill development and economic opportunities. Community participation will be prioritized to ensure diverse voices are included in decision-making, fostering social inclusion and equitable opportunities.

Component 7: Mainstreaming gender equality and social inclusion (GESI) mechanism: The research and extension component aims to promote evidence-based decision-making through collaborative research on land management, water resources, and environmental conservation. Extension services will support farmers and communities in adopting sustainable agricultural practices. Platforms for sharing research findings will be developed, alongside capacity-building programs to equip stakeholders with essential skills.

Component 8: Research and extension: An effective monitoring and evaluation system is essential for tracking project progress through baseline assessments of key performance indicators. A comprehensive database will support ongoing assessments, with seasonal data collected to evaluate intervention effectiveness. Stakeholder engagement will be prioritized, and regular progress reports will ensure transparency and data-driven decision-making. Robust reporting mechanisms will facilitate clear communication of project outcomes.

Table ES2 shows the significant issues in the watershed and the proposed solutions, including the local, state, and national implementing partners.

Table ES2: Summary of Components and Activities

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

	Enhance public awareness and preparedness for flood events. Implement integrated water management practices that address seasonal variability, optimize groundwater recharge, and enhance surface water distribution to meet agricultural, domestic, and industrial demands. Define and operationalize a set of technical standards for water efficiency (conservation, reuse, recycling) for recreation and - other uses based on best practices Assessment of demand and supply of drinking water Construction and maintenance of pipelines and water tanks Construction of recharge structures to rejuvenate drying and dried springs.	Routine Reports Reports	NHISA, The three tiers of government encompassing the RBDA's, FMWR and allied agencies NHISA, NIMET, MOA, CBO's

	Roof rainwater harvesting and improved water use efficiency 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.		
Preservation and restoration of critical ecosystems and services for sustainable land use (to include sustainable agricultural and livestock practices)	Restoration of 30% to 40% of degraded land through afforestation Restore 25% and improve agricultural degraded land Restore and maintain wetlands to stabilize hydrological cycles and support biodiversity. Enforce the protective boundaries of national parks and valuable reserves such as Nguru Increase agricultural productivity by 40% through climate-smart agriculture, capacity building, and data gathering	Increase in agricultural productivity	Federal, state and local government MDA's on agriculture and food security,

	Improve soil fertility management, and apply soil and water conservation to reduce erosion Support smallholder farmers through training and access to improved technologies Encourage the use of micro-irrigation facilities	As above Increase in number of farmers. Increase in agricultural productivity	livestock, water resources and environment As above Bank of agriculture, NGOs and other international agencies. CBOs As above
Improved diversification for enhanced sustainable livelihoods and well-being	Ensure the proper conditions for the effective organization of fish farming in floodplains of rivers, natural and artificial reservoirs; Provide training programs for sustainable farming, fishing, and aquaculture practices. Facilitate access to credit and market opportunities for smallholder farmers and fisherfolk.	Improved quality of living. Improved funding	Federal, state and local government MDAs, CBOs

	Develop community-based tourism and eco-friendly economic activities. Improve access to sustainable natural resources, low-cost energy, better sanitation and hygiene practices Promote farming of high-value agricultural products such as high yielding climate resilience seeds such as maize, sorghum, SAMNUT-22, millet Providing comprehensive training on irrigation techniques, preparation of compost manure, water ponds for irrigation, Integrated Pest Management (IPM) and other technical skills to women, men, and marginalized communities to reduce the pollution of the main water resources. Promote of multi-year crops to improve the average income of the people living in the catchment.	Improved income/job creation. Availability of renewable energy and improved standard of living.	Donor agencies, banks and cooperatives CBOs and the three tiers of government As above

	Promote the use of water as an alternative to road transport system		
Climate change, disaster risk management, and climate-resilient infrastructure	Promote the use of local runoff of small rivers to mass-arrange water bodies and provide water measures to combat climate change-induced drought. Expand early warning systems and enhance the capacity for disaster response Construct resilient infrastructure to address flood risks and water distribution challenges. Support the adoption of drought-resistant crop varieties and efficient irrigation technologies. Promote afforestation programs to combat desertification and stabilize soils.	Reduction in climate change induced disaster Reduction in environmental degradation and climate change disaster Improved agricultural output and increased employment	Federal, State and local Government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs Federal, State and local Government MDAs, NGOs, donor agencies.

	Implement community-based initiatives for floodplain management and watershed protection. Prepare risk sensitive Land-use Plan (RSLUP) and implementation for identified degraded areas Revitalise erosion-affected areas, including stream banks and gully stabilization in the upstream micro-catchment vulnerable areas Promote green roads through bioengineering in erosion-prone areas Creating a green infrastructure system to protect ecosystems, ecologic corridors and natural landscapes in the water bodies 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	Decrease in soil erosion, improved NDVI Reduction in environmental degradation. Designated livelihood areas and updated reports Increase in land resources available for livelihoods in updated reports. As above	

	Undertake hazard and risk assessment to minimize the risk. Conducting EIA/IEE of major development projects to minimize impact on ecosystem. Undertake effective and timely review and monitoring of infrastructure development projects	Updated reports Updated reports and increase in harmonious engagement with stakeholders Updated reports	
Strengthening institutional mechanisms and project coordination mechanisms:	Establish a regulatory framework for integrated water resource management at the catchment level. Strengthen coordination among federal, state, and local agencies. Ensure community representation in decision-making processes and management committees.	Reduced conflict and equitable distribution of water resources Reduced conflict among stakeholders and better institutional collaboration	Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs.

	Strengthening the watershed management committee to implement the watershed management plan. Implementing production-based incentives and monitoring mechanisms for agricultural land management. Developing mechanisms to ensure effective implementation and management of springshed and recharge areas, particularly on public and private land.	Increase in agricultural output Policy formulation and Implementation	
Mainstreaming gender equality and social inclusion (GESI) mechanism	Ensure equitable distribution of roles and responsibilities to women, men and marginalized communities during the planning, implementation and evaluation of any projects/plans/activities Provide training and exposure visits to both women and men in order to enhance their understanding on water conservation technologies and economic development.	Comprehensive participation of all stakeholders Better outputs of environmental conservation	Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs.

	Identify vulnerable areas and communities (with gender and social disaggregated data) to disaster and climate risk and develop focused projects to address identified challenges Promote women and marginalized communities to leadership positions through participatory approaches. Establishing counseling centers for handling domestic violence, grievances, and psychosocial services for supporting the well-being of women, men, and marginalized communities.	Updated Reports on key social issues within a community More women participation Improved psycho-social status of victims of abuse	
Research and extension	Undertake action research on pertinent issues such as: ✓ accounting of water resources and regulation of their flow ✓ Indigenous knowledge and practices, ✓ nature-based solutions, ✓ effectiveness of soil conservation measures, ✓ watershed services for IWM,	Increased awareness	Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs.

	✓ sediment yield, ✓ climate change impact on vegetation and land use, ✓ pests, ✓ micro-finance and others for an evidence-based watershed management plan and strategies.	Increased livelihood output	
Effective coordinated monitoring, evaluation, and reporting mechanism and system	Establish a coordinated and functional watershed management monitoring system (to be institutionalized in a reputable already existing institution in the Catchment) to include: ✓ 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	Quarterly reports, updated watershed plans	Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs, NASRDA, NCRS.

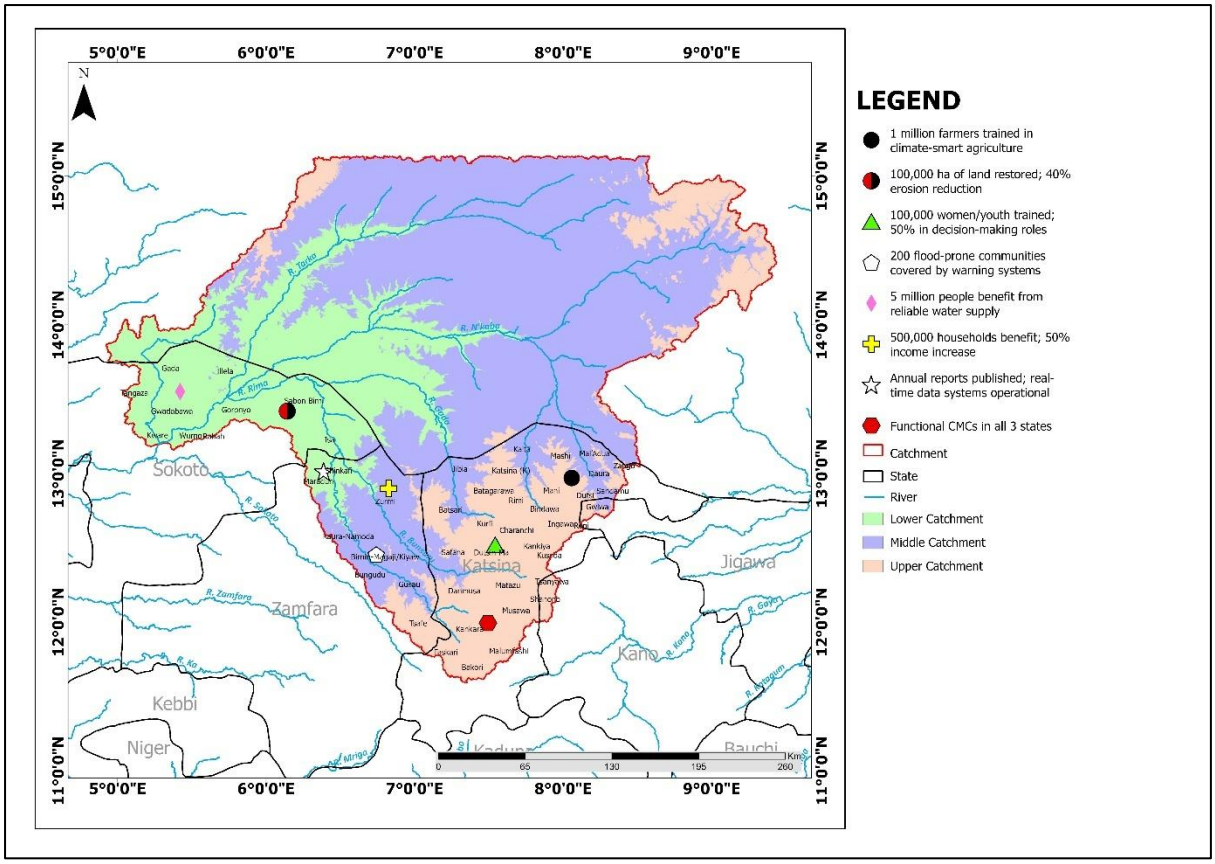


Fig E.S.3: Rima Catchment Showing the Recommended Interventions (Source: MSL, 2025)

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

Section	LGA/Town(s)	Challenge	Intervention	Appropriate Tool(s) For Sustained Monitoring and Evaluation	Responsible Agency	Expected Outcome
Lower Catchment	**Goronyo, Wurno, Rabah, Gwadabawa**	Seasonal flooding leading to farmland loss and displacement	Flood control dikes, reforestation along riverbanks	Flood risk maps, hydrological modelling	Sokoto RIMA, NIHSA, NEMA, NIWRMC, ACReSAL. FMWR	Reduced flooding, protected communities
	Sabon Birni, Isa, Shinkafi, Maradun	Banditry and insecurity affecting agricultural productivity	Community policing support, security-enhanced agro-schemes	Security mapping, rural resilience frameworks	State Security Council, Agric Extension Services, LGA	Enhanced security, restored farming activities
	Gada, Illela, Tangaza	Desertification and loss of arable land, Loss of Biodiversity	Large-scale tree planting, promotion of drought-resistant crops	Remote sensing (vegetation cover), land degradation maps, NDVI Mapping	Ministry of Environment, Forestry Dept, ACReSAL, FMAFS, Ministry of Tourism	Reduced land degradation, improved soil fertility
	Kware	Poor irrigation infrastructure and water management	Rehabilitation of irrigation canals, introduction of efficient water use	Irrigation system diagnostics, water balance models	Sokoto RIMA, Ministry of Water Resources, FMAFS, ACReSAL	Improved irrigation, enhanced crop yields

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

Section	LGA/Town(s)	Challenge	Intervention	Appropriate Tool(s) For Sustained Monitoring and Evaluation	Responsible Agency	Expected Outcome
Middle catchment	**Kaura-Namoda, Birni-Magaji/Kiyawa, Bungudu, Gusau**	Gully erosion damaging farmlands and infrastructure	Gully reclamation, check dam construction, contour bunding	Erosion risk mapping, drone survey, GIS terrain analysis	ACReSAL, State Min. of Environment. State ADP,	Stabilized soils, protected infrastructure, restored land
	Zarmi, Jabia, Kaita, Batsari	Deforestation and fuelwood pressure leading to habitat loss	Community forestry programs, woodlot establishment, clean cookstove promotion	Satellite monitoring of forest cover, community forest plans	Forestry Dept, Rural Dev Agencies. LGA, NGO, ACReSAL	Restored vegetation, reduced deforestation, improved energy security
	Daura, Sandamu, Mai'Adua	Water scarcity impacting	Drilling of Solar-powered boreholes,	Hydrogeological surveys, groundwater	Rural Water Supply Agency, Agric. Dev	Improved water availability, increased crop production

		dry season farming	small earth dams, rainwater harvesting	recharge mapping	Program, NIHSA, NIWEMC, FMWR	
	Giwa	Crop-pest outbreaks (e.g. quelea birds, locusts)	Integrated pest management (IPM), early warning systems	Remote sensing pest monitoring, mobile alert systems	Agric. Research Institutes, State Agric Dept, LGA	Reduced crop losses, better pest control

Table E.S.6: Upper Catchment of the Rima 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	**Tsafe, Faskari, Bakori, Malumfashi, Kankara, Danmusa, Musawa, Matazu**	Soil erosion on slopes, land degradation Loss of biodiversity	Gully stabilization, reforestation, terracing. Establish protected areas for biodiversity, alongside	GIS erosion mapping, slope stabilization design	ACReSAL, State Ministry of Environment, State ministry of Tourism	Reduced erosion, stabilized farmlands, improved soil health

			community-led reforestation projects.			
	Dutsinma, Safana, Kurfi, Kankiya, Kusada, Charanchi, Bindawa	Water scarcity for domestic and agricultural use	Small dam construction, solar boreholes, rainwater harvesting	Hydrogeological surveys, water balance modelling	Rural Water Supply Agency, ADP, NIHSA, NIWRMC, FMWR.	Enhanced water availability, improved livelihoods
	Zango, Dutsi, Nani, Mashi, Ingawa-Roni	Deforestation and loss of biodiversity	Community woodlots, agroforestry schemes, fuel-efficient cookstoves	Satellite forest cover monitoring, community action plans	Forestry Department, FMAFS, NGO, State ministry of Environment.	Restored tree cover, reduced wood fuel demand, biodiversity protection
	Katsina, Batagarawa, Rimi, Tsanyawa, Shanono	Urban expansion leading to flood risk and drainage problems Diversification of Livelihoods	Improved urban drainage, flood control channels Encourage alternative livelihood opportunities such as ecotourism, non-timber forest products, and small-scale agro-processing industries	LiDAR flood risk mapping, urban drainage modelling	Urban Planning Authority, SEMA, NEMA, FMEnv	Reduced flood vulnerability, safer settlements

	All the Towns	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 Outcome

The successful implementation of the interventions outlined in the Rima Strategic Catchment Management Plan is expected to yield the following outcomes:

- Improved Water Availability
- Enhanced Agricultural Resilience
- Ecosystem Restoration and Biodiversity Enhancement
- Strengthened Governance and Stakeholder Engagement
- Reduced Flood Vulnerability
- Socio-Economic Development

CHAPTER 1 : INTRODUCTION

1.1 Purpose of the Plan

The Rima catchment is a significant ecosystem in northwestern Nigeria that supports the livelihood of millions of people within the region. The purpose for the Plan is developed to provide a strategic framework for the sustainable management of water resources within the Rima Catchment. The catchment faces a multitude challenge that threaten its sustainability and well-being of the inhabitants. Some of these challenges include the following:

i. Water Scarcity and Over-Extraction: Increased demand for water due to population growth and agricultural expansion is straining available resources.
ii. Pollution and Water Quality Degradation: Agricultural runoff, urban wastewater discharge, and industrial effluents contaminate surface and groundwater sources, posing risks to human health and aquatic ecosystems.
iii. Deforestation and Land Degradation: Unsustainable land use practices, including deforestation and overgrazing, lead to soil erosion and reduced water retention capacity.
iv. Climate Change Impacts: Unpredictable rainfall patterns, extreme weather events, and prolonged droughts affect water availability and agricultural productivity.
v. Poor Catchment Governance and Institutional Gaps: Weak enforcement of water management policies, lack of coordination among stakeholders, and inadequate funding hinder effective conservation efforts.
vi. Conflicts Over Water Use: Competition between different water users (agriculture, industry, and domestic use) leads to disputes, particularly during periods of scarcity.
vii. Sedimentation and Siltation: Excessive soil erosion leads to sediment accumulation in rivers and reservoirs, reducing water storage capacity and flow efficiency.

1.2 Rationale for a Strategic Catchment Plan

The Rima Strategic Catchment Management Plan is developed based on the need to address critical environmental, hydrological, and socio-economic challenges affecting the catchment. The plan is designed to:

a. **Promote Sustainable Water Resource Management**: Ensuring the availability of water for various uses, including domestic consumption, agriculture, industry, and ecosystems, while preventing over-extraction and depletion.

b. **Enhance Climate Resilience**: The catchment faces increasing threats from climate change, including erratic rainfall, droughts, and flooding. The plan aims to implement strategies that mitigate these impacts and enhance water security.
c. **Prevent Environmental Degradation**: Addressing deforestation, soil erosion, land degradation, and water pollution to maintain the ecological balance of the catchment.
d. **Improve Agricultural Productivity**: Since agriculture is a major activity in the catchment, the plan promotes sustainable farming practices, improved irrigation systems, and better watershed management.
e. **Ensure Equitable Access to Water Resources**: Reducing conflicts over water use by establishing policies that balance the needs of different water users, including farmers, pastoralists, and urban populations.
f. **Support Economic Growth and Livelihoods**: Providing a framework for sustainable economic activities, such as fishing, irrigation farming, and eco-tourism, while protecting natural resources.
g. **Strengthen Governance and Stakeholder Collaboration**: Improving coordination among government agencies, local communities, NGOs, and private sector actors to ensure effective water and land management policies.

1.3 Expected Outcomes

The Rima strategic catchment plan is expected to achieve the following outcomes:

a) Improved Water Availability and Quality
b) Enhanced Ecosystem Services
c) Sustainable Socio-Economic Development
d) Climate Change Adaptation and Mitigation
e) Effective Governance and Stakeholder Engagement
f) Enhanced Monitoring and Evaluation
g) Improved Health and Social Well-being

1.4 Environmental Roles

The environmental component of the Rima SCMP is designed to improve ecological health, water resources, and biodiversity of the catchment the following integrated approaches:

1. **Water Resources Management**: The Rima SCMP promotes efficient water use, reduces pollution, and develops strategies to enhance water availability for sustainable management.

2. **Ecosystem Protection and Restoration**: Protect and restore ecosystems, enhance biodiversity, and promote sustainable land management to strengthen agricultural resilience.
3. **Climate Change Adaptation and Mitigation**: Implement adaptive water management, promote carbon sequestration, and encourage climate-resilient farming practices.
4. **Wetland and Floodplain Management**: Protect and restore wetlands, implement sustainable floodplain management, and support integrated river basin management to reduce flood risks.
5. **Pollution Control and Environmental Health**: Implement pollution control, monitor its impact, and promote sustainable practices to protect ecosystems and environmental health.
6. **Sustainable Land Use Planning**: Develop and enforce land use regulations, promote ecosystem-based planning, and engage local communities in land management.
7. **Environmental Education and Awareness**: The SCMP promotes environmental awareness, conservation, and sustainable resource use through public education, training, and collaboration with communities, government, and stakeholders.

1.5 Socio-Economic Roles

The Rima SCMP is designed to address not only environmental challenges but also socio-economic issues to ensure comprehensive and sustainable development. Below are the key socio-economic roles of the plan:

1. **Sustainable Livelihoods and Food Security**: The SCMP promotes sustainable farming, provides credit to small farmers, and supports eco-friendly livestock practices to enhance livelihoods and food security.
2. **Economic Diversification**: Promote non-agricultural activities and value-added agro-processing to boost economic value and create jobs.
3. **Poverty Reduction and Social Inclusion**: promotes the implementation of targeted programs to reduce poverty, promotes gender equality and develop programs to address youth unemployment.
4. **Improved Infrastructure and Services**: The SCMP enhances access to clean water, sanitation, transportation, and sustainable energy to improve public health and infrastructure.
5. **Stakeholder Engagement and Community Participation**: Encourage stakeholder participation in planning and implementation, while offering training and capacity-building for local communities.

6. **Market Access and Trade**: improves market access for agricultural products and other goods and supports cross-border trade with neighbouring countries to enhance economic opportunities.
7. **Health and Social Well-being**: Enhance access to healthcare services, particularly in rural areas and ensures the implementation of social protection programs to support vulnerable groups.

1.6 Governance and Institutional Roles

The governance and institutional roles of the Rima SCMP promotes accountability, conflict resolution, capacity building, and adaptive management, providing the foundation for long-term ecological and socio-economic sustainability through the following:

1. **Multi-Stakeholder Engagement and Collaboration**: The SCMP fosters inclusive decision-making, encourages participatory governance in resource management, and promotes partnerships with businesses and stakeholders.
2. **Institutional Coordination and Management**: Encourages the creation of catchment management authorities, fosters collaboration among government ministries and agencies, and ensures local development plans align with catchment management objectives.
3. **Policy Development and Implementation**: Supports the development of policies, regulations, and legal frameworks for land use, water management, conservation, and environmental protection within the catchment area.
4. **Monitoring, Evaluation, and Accountability**: The SCMP encourages strong monitoring and evaluation systems, ensures transparency through regular progress reports, and promotes efficient fund usage and proper governance.
5. **Conflict Resolution and Consensus Building**: The SCMP creates conflict resolution mechanisms and encourages consensus-building among local communities, government, and other stakeholders.
6. **Capacity Building and Knowledge Sharing**: The SCMP fosters collaboration with research institutions and universities to gather data on ecosystems, water resources, and socio-economic conditions, while promoting awareness of sustainable catchment management.
7. **Financial Management and Resource Mobilization**: The SCMP supports the development of institutions for sustainable financing and ensures efficient resource allocation to priority areas of the plan.

8. **Legitimacy and Stakeholder Trust**: The SCMP provides feedback opportunities to build trust in governance and promotes cultural sensitivity and inclusivity for vulnerable groups within the catchment.
9. **Adaptive Governance**: The SCMP uses an adaptive governance model that offers flexibility for adjustments and integrates lessons learned and innovative approaches to catchment management.

1.7 Catchment Policies

For harmonious relationship and engagement of stakeholders regarding equitable utilization of inter-state resources including water, 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

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

National Laws and Policies

- Constitution of Federal Republic of Nigeria (1999)

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

The Strategic Catchment Management Plan (SCMP) can align with Nigeria's National Water Resources Policy (2016) for sustainable water management and environmental protection. It also integrates with the National Environmental Policy (1999) to promote conservation and restoration. Additionally, the SCMP supports the National Agricultural Policy (2016) by fostering sustainable agricultural practices and enhancing food security.

The SCMP can integrate with the Niger Basin Authority's Water Charter and ECOWAS Water Resources Policy to promote sustainable water management in the region. It can also align with Nigeria's Agricultural Transformation Agenda to enhance food security and support sustainable practices, as well as the National Forest Policy for forest conservation.

1.8 Integration Mechanisms

- Establish a coordination committee: Set up a committee comprising representatives from relevant government agencies, regional organizations, and stakeholders to ensure coordination and integration.
- Conduct policy gap analysis: Identify gaps and inconsistencies between the Strategic Catchment Management Plan and existing policies and develop strategies to address them.
- Develop a monitoring and evaluation framework: Establish a framework to track progress, identify challenges, and adjust ensure the plan's alignment with national and regional policies.
- Engage stakeholders: Involve stakeholders, including government agencies, regional organizations, and local communities, in the planning and implementation process to ensure ownership and buy-in.

- The catchment area spans parts of Sokoto, Zamfara, and Katsina States, bounded by adjacent catchments. It experiences distinct wet and dry seasons, with annual rainfall varying from 300-600 mm in the northern regions to 800-1,000 mm in the south.
- Temperatures are consistently high, ranging from 30°C to 40°C, particularly peaking from March to May. The area sees significant diurnal variations, especially in the north.
- Relative humidity is higher during the wet season, exceeding 60%, which supports agriculture. The impact of seasonal patterns significantly influences water availability and agricultural activities in the region.
- The catchment area is well-acquainted with various development and intervention initiatives, including the Multisectoral Crisis Recovery Projects (MCRP) aimed at rehabilitating and enhancing critical infrastructure such as roads, bridges, hospitals, and water resources. The Niger basin Authority and the Sokoto-Rima Basin Authority as well, and the Rural Access and Mobility Project, FMWR-TRIMING project among others.

The Strategic Catchment Management Plan aims to integrate key components of the catchment, which spans Sokoto, Zamfara, and Katsina States. It experiences distinct wet (300-1,000 mm rainfall) and dry seasons, with high temperatures (30°C to 40°C) and significant diurnal variations. The plan seeks to ensure strategic, cohesive growth by addressing the interconnectedness of these factors and avoiding isolated interventions.

Several noteworthy examples of successful strategic catchment management plans include South Africa's National Water Act, the Mpanga Catchment Conservation Project, and the River Rwizi Catchment Management Plan, all located in Uganda. Additionally, the Tana Catchment Area Management Plan, the Ngarelan Springs Catchment Area Management Plan, and the Dik Dik Catchment Management Plan are prominent initiatives in Kenya.

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 Katsina State. The area lies between latitude 11°37'11''N and 15°08'48''N, and longitude 4°53'08''E and 09°26'40''E (Figure 2.1). It is bounded by the Sokoto Zamfara catchment to the Southwest, Sarkin Pawa catchment to the south and Hadejia-Jama'are catchment to the southeast.

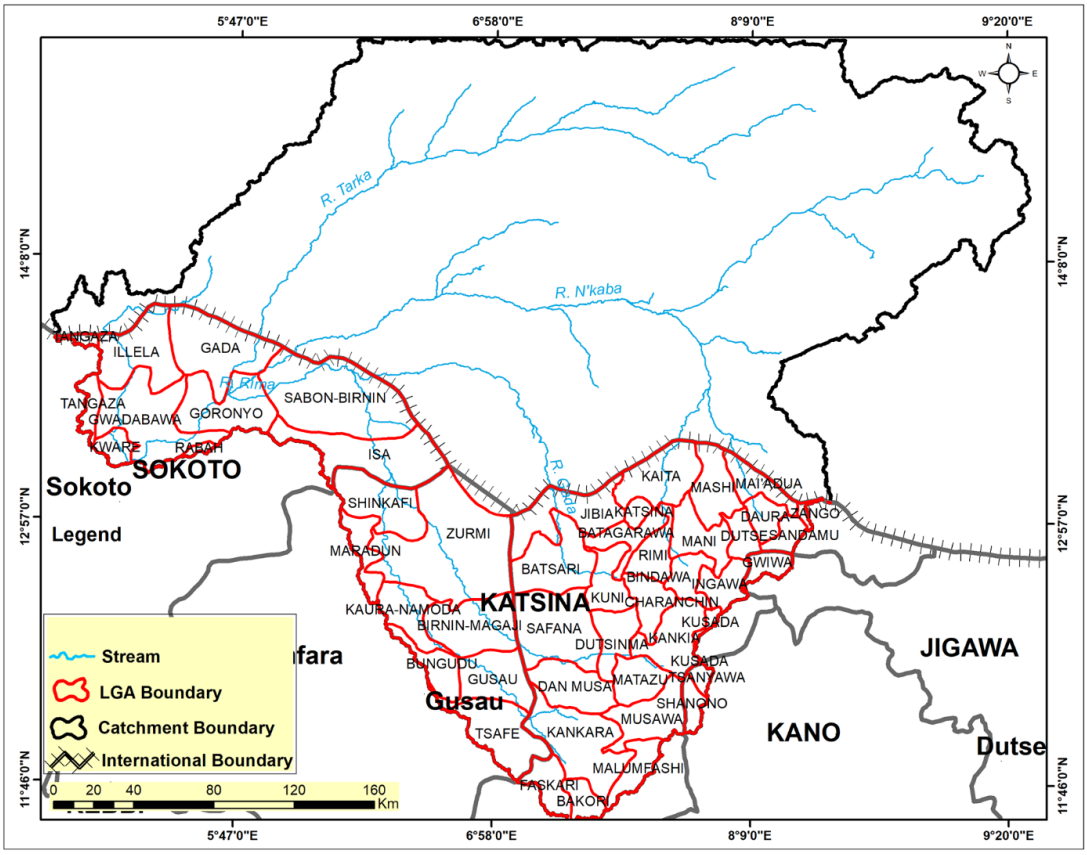


Figure 2.1: Rima catchment showing the LGAs (Source: MSL, 2025)

2.2 Precipitation, Temperature, Sunshine and Relative Humidity

2.2.1 Precipitation

The Rima Catchment has a seasonal precipitation pattern with a wet season and a dry season. Annual rainfall ranges from 300 to 600 mm in the northern semi-arid regions and 800 to 1,000 mm in the southern areas, supporting more reliable agriculture. The dry season lasts from October to April, characterized by the Harmattan winds, leading to increased reliance on groundwater as water sources diminish.

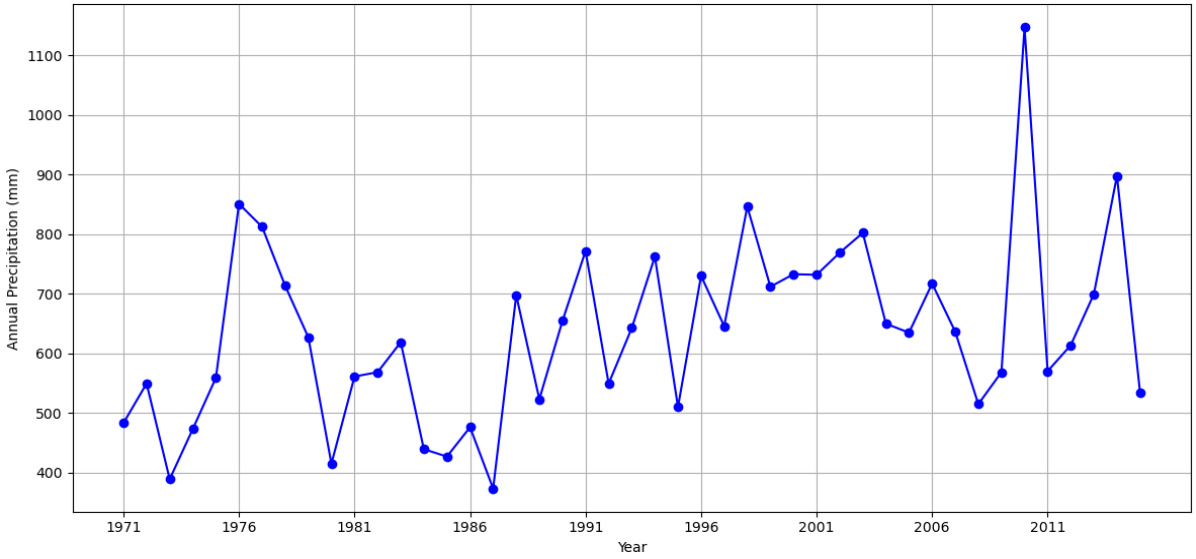


Figure 2.2: Annual precipitation of Rima Catchment (2000 - 2021) (Source: CHIRPS, 2015)

2.2.2 Temperature

The Rima Catchment has a hot semi-arid climate (Köppen BSh) with temperatures ranging from 27°C to 30°C. The hottest months are March to May, exceeding 40°C, while cooler Harmattan conditions occur from December to February, with nighttime temperatures dropping below 20°C in the north.

Over the past two decades, temperature trends show gradual warming in the catchment, affecting evapotranspiration, water balance, and agricultural productivity. Extreme heat occurs during the pre-rainy season, with some moderation during the rainy season..

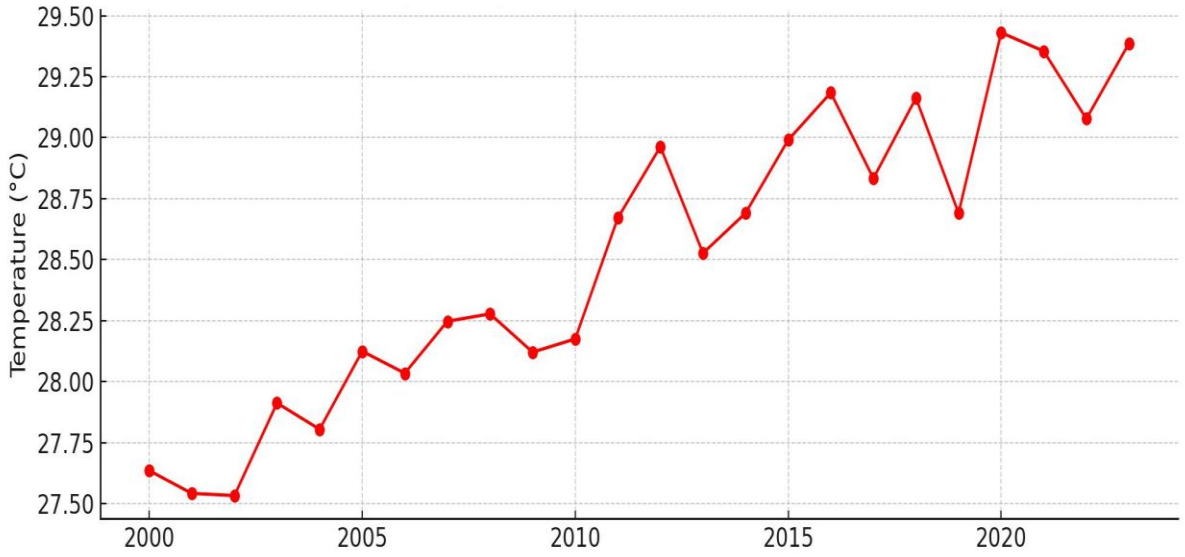


Figure 2.3: Annual Average Temperature for Rima Catchment (2000 - 2023) (Source: MSL, 2025)

2.2.3 Sunshine Duration

The Rima Catchment area experiences high sunshine duration year-round, averaging 2,800 to 3,200 hours annually, peaking during the dry season. This consistent solar exposure significantly impacts evapotranspiration, agricultural productivity, and water availability. Long-term data shows stability in sunshine duration, aiding irrigation and renewable energy planning.

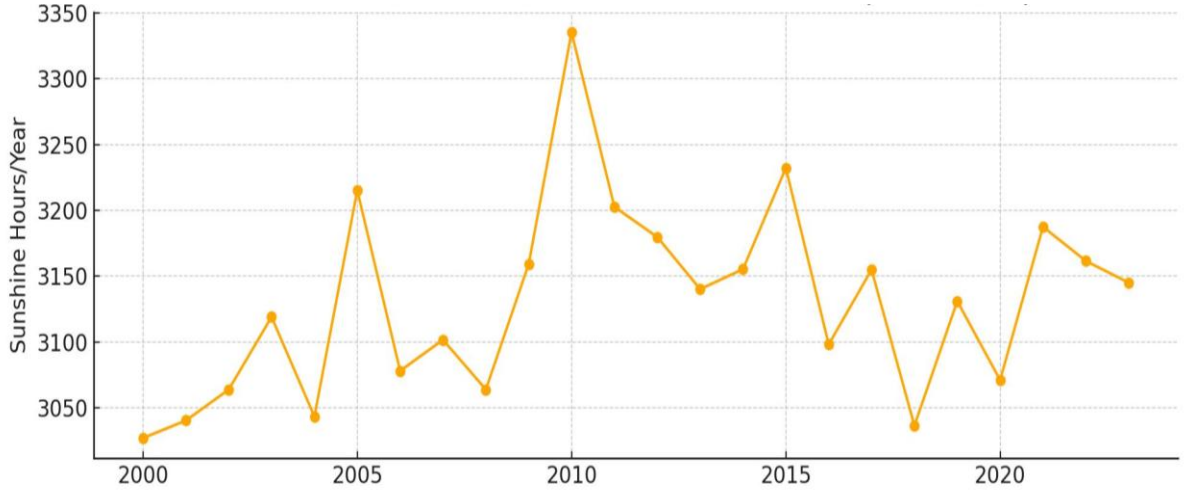


Figure 2.4: Annual Average Sunshine Duration in the Catchment (Source MSL, 2025)

2.2.4 Relative Humidity

Relative humidity in the Rima Catchment varies seasonally, with low values (20%–40%) during the dry Harmattan season and peaks (70%–90%) in the rainy season due to moisture-laden winds. Long-term trends indicate a slight decline in average humidity, potentially linked to rising temperatures and land use changes, affecting water loss and ecosystem resilience.

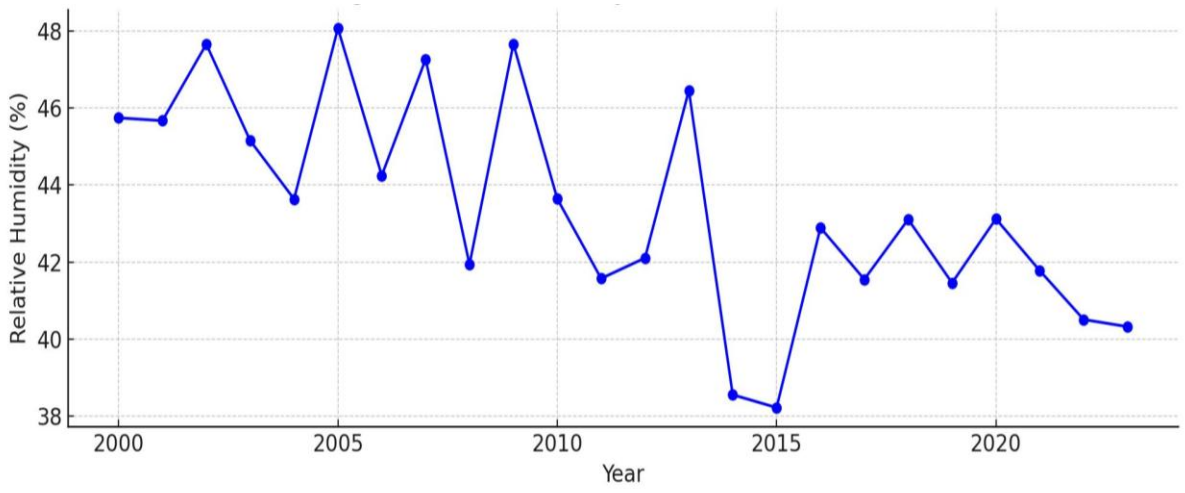


Figure 2.5: Annual Average Relative Humidity of the Catchment (Source: MSL, 2025)

2.3 Topography, Drainage, Geology and Soils

2.3.1 Drainage

The catchment is primarily defined by the Sokoto-Rima River System, consisting of the Rima and Sokoto Rivers (refer to Figure 2.6), 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 north-westerly 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 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.

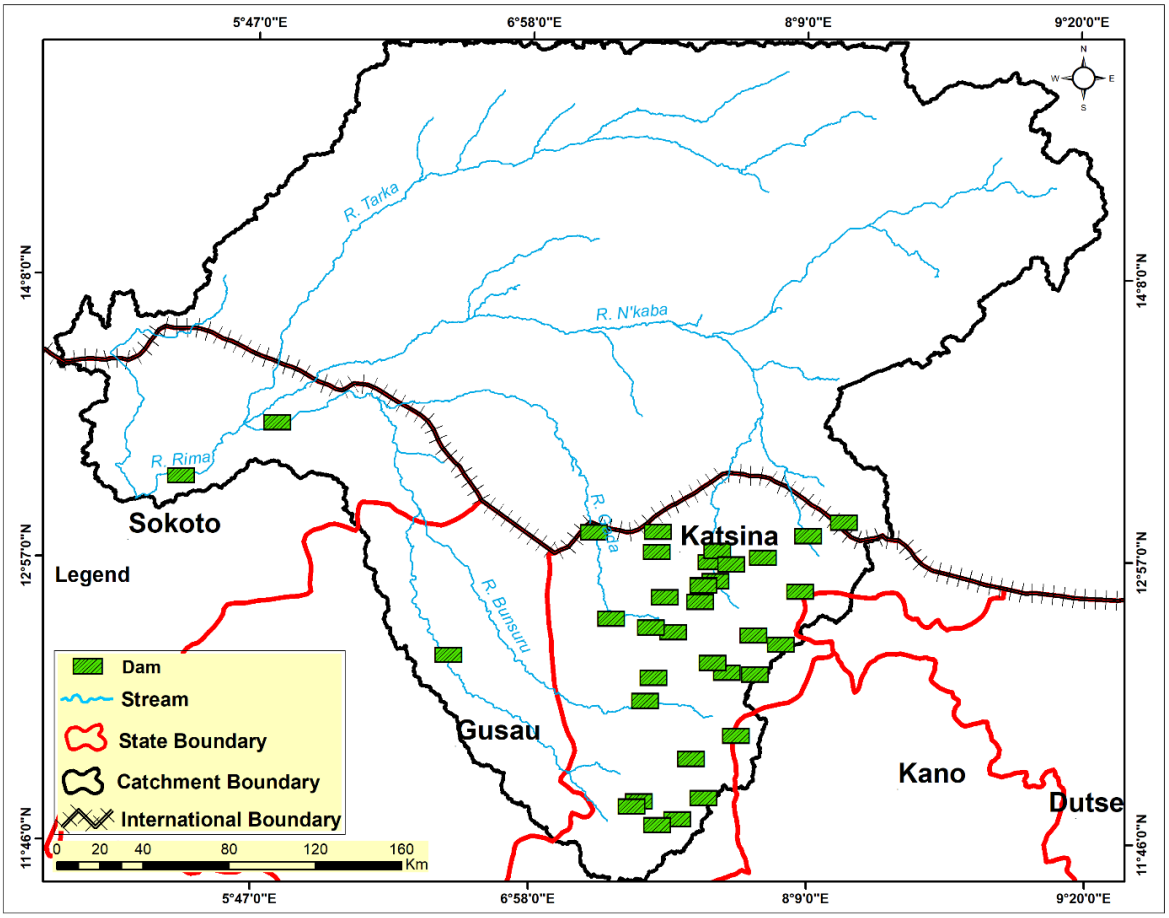


Figure 2.6: Drainage Map of Rima Catchment showing dams (Source: MSL, 2025)

2.3.2 Topography

- The Rima Catchment spans across Katsina, Zamfara, and Sokoto states, covering a variety of topographical and hydrological features (see Figure 2.7Figure 2.7).
- It plays a crucial role in the hydrological and ecological dynamics of northern Nigeria, influencing agricultural activities, flood patterns, and ecosystem sustainability.
- The catchment generally exhibits low to moderate relief, with elevations ranging from approximately 500 meters in the upper parts of the basin (such as in Katsina and Zamfara states) to around 250 meters in the lower parts near Sokoto.
- The region is characterized primarily by flat plains with scattered hills and inselbergs (isolated rocky outcrops).
- The southern portions of the catchment in Katsina and Zamfara feature more elevated terrains, with occasional hills and ridges that influence localized water flow patterns. Moving northward, the terrain becomes increasingly flat, forming expansive floodplains, especially within Sokoto, which are prone to seasonal flooding.

- The Sokoto-Rima River system is the major drainage feature of the catchment, with numerous tributaries and seasonal streams contributing to its flow, especially during the rainy season. However, water availability fluctuates significantly between wet and dry seasons, making sustainable water management a critical challenge in the catchment.

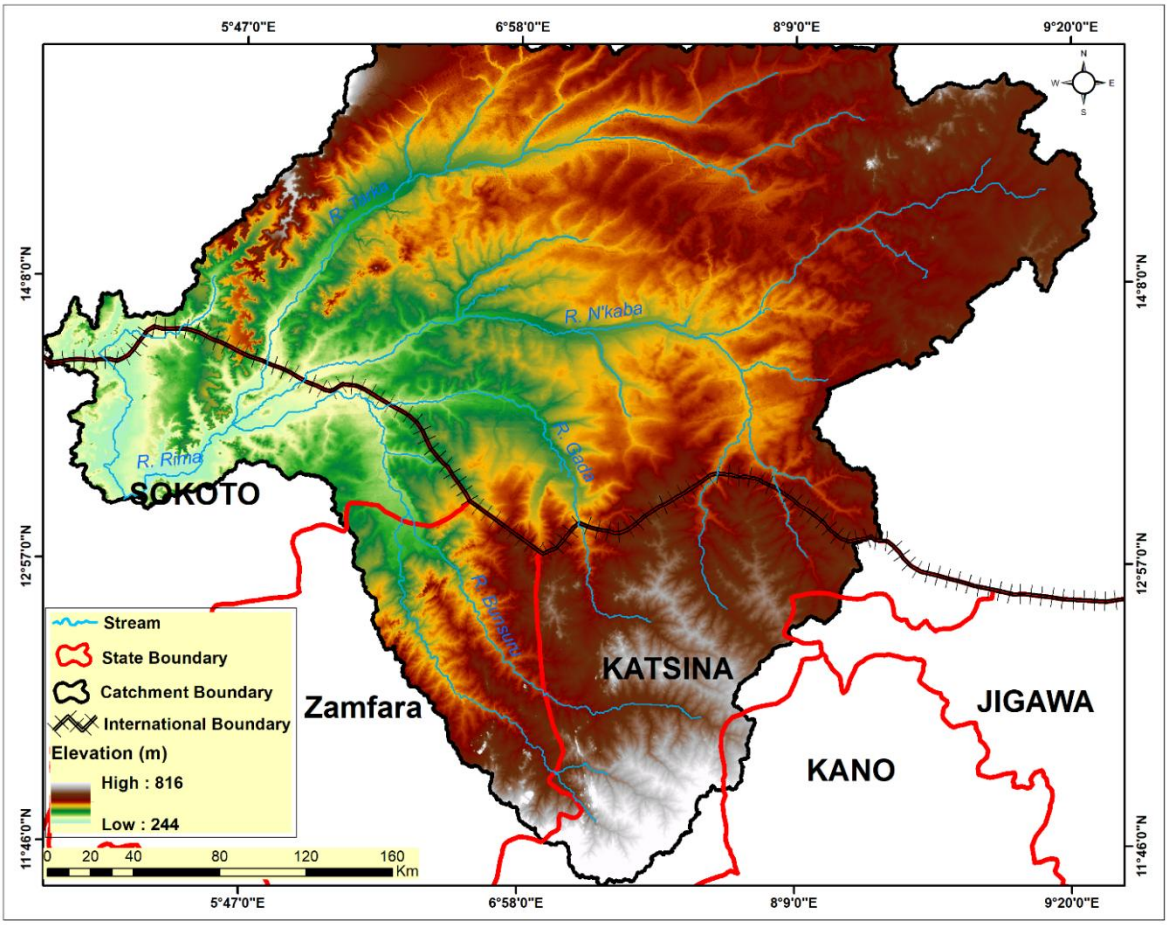


Figure 2.7: Digital Elevation Model (DEM) of the catchment (Source: MSL, 2025)

STATES OF INFLUENCE

1. KATSINA STATE
2. ZAMFARA STATE
3. SOKOTO STATE

2.3.3 Geology and Soil Types

- The Rima Catchment, spanning Katsina, Zamfara, and Sokoto 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 Rima Catchment as shown in Figure 2.8 can be categorized into two major provinces: the Precambrian Basement Complex and the Sokoto Basin sediments.

1. The southern catchment area, covering parts of Katsina and Zamfara States, is characterized by Precambrian Basement Complex rocks like granites and gneisses. The rugged terrain results in shallow, less fertile soils and limited groundwater recharge due to low rock permeability..
2. The northern part of the catchment in Sokoto State is part of the Sokoto Basin, a significant sedimentary area in northwestern Nigeria. It features Tertiary and Quaternary sediments, such as sandstones and claystones. These deposits formed over time through fluvial processes, resulting in a gently undulating landscape. The sedimentary nature of the Sokoto Basin, particularly its porous and permeable sandstones, contributes significantly to groundwater storage and recharge in this region.

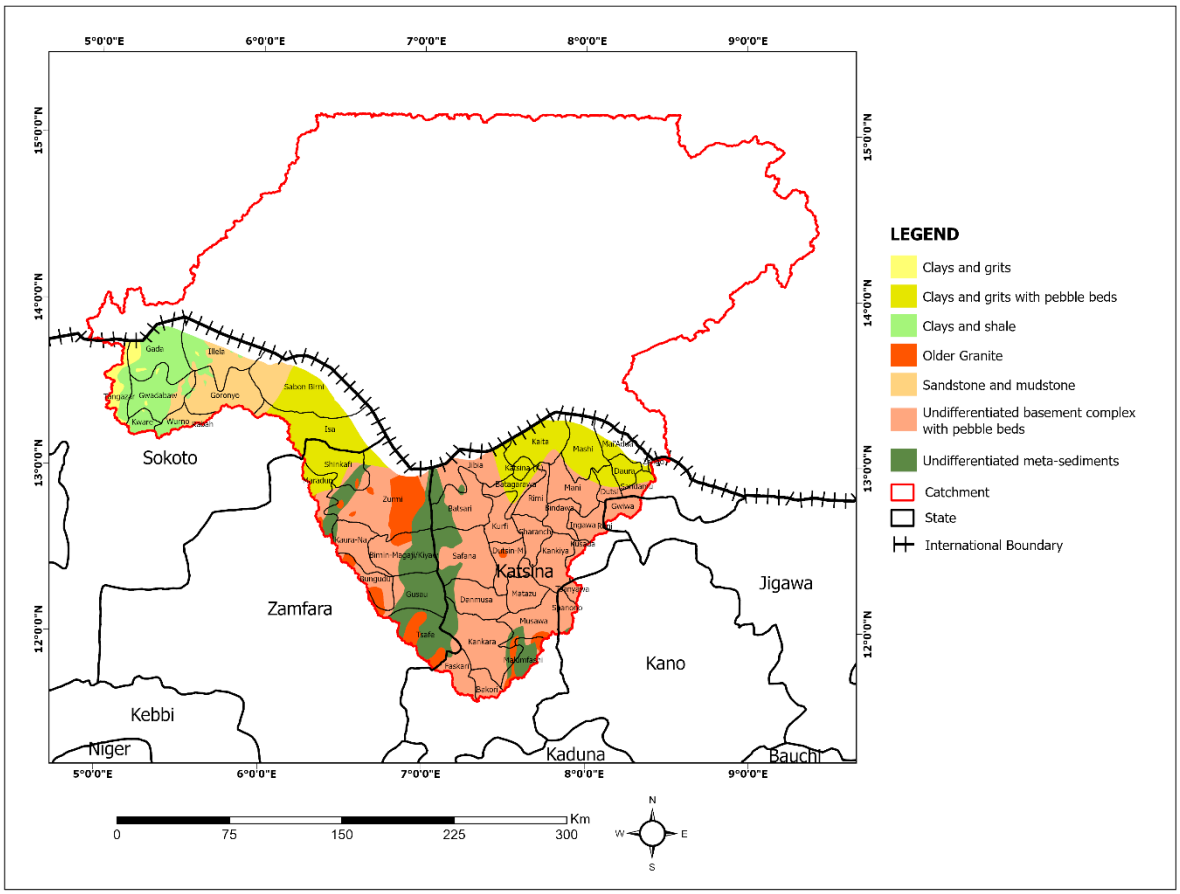


Figure 2.8: Geological Map of Rima Catchment (Source: MSL, 2025)

2.3.3.2 Soil Types

In the Rima Catchment, soils are classified using the FAO framework, highlighting factors like formation processes and parent materials. Key soil types include Arenosols, Vertisols, Gleysols, Fluvisols, and Leptosols, each with unique properties affecting water retention and agricultural potential. This classification aids in understanding soil distribution and its implications for land use and environmental management.).

Soil types in the catchment include:

1. Arenosols

Arenosols are sandy, arid-region soils found mainly in northern Sokoto State, characterized by low water retention and organic matter. They support drought-resistant crops like millet and sorghum but need fertilizers and irrigation for better productivity.

2. Vertisols

Location: Found in floodplains and depressions across the catchment. it contains Clay-rich soils that shrink and swell with moisture changes. They are highly fertile but prone to waterlogging. It is 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. It a hydromorphic soil with poor drainage and prolonged water saturation. It is Suitable for paddy rice cultivation but require drainage improvements.

4. Fluvisols

Location: Common along riverbanks and floodplains. They are young soils formed from recent river deposits with high fertility. Agriculturally it is used for flood-recession agriculture, supporting crops like rice, maize, and vegetables.

5. Leptosols

Location: Found in the rugged, elevated areas of Katsina and Zamfara States. It's Shallow, stony soils on hard rock substrates with limited agricultural potential. 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.

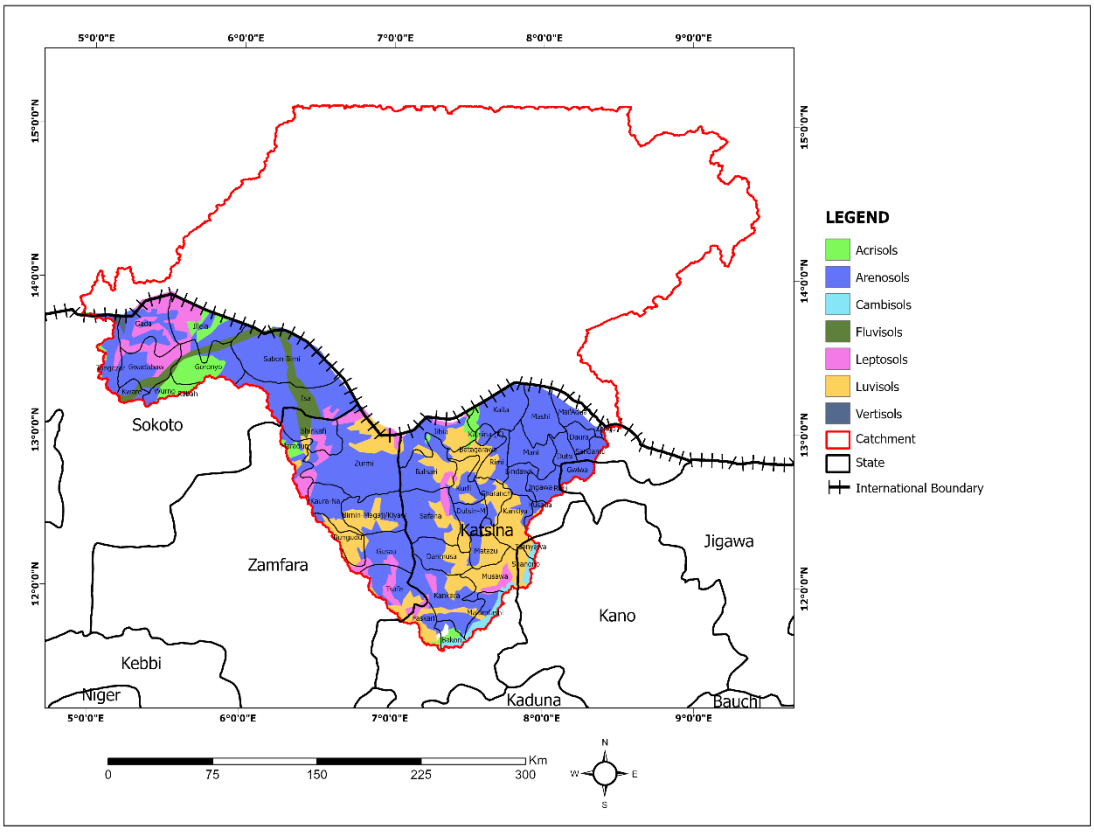


Figure 2.9 Soil Map of Rima Catchment (Source: MSL, 2025)

Varied geology and soil types across the catchment influence land use patterns. Fertile alluvial soils support agriculture, while sandy soils pose challenges due to low fertility. Effective land and water management, especially irrigation, is vital to optimize agricultural potential and combat soil degradation in the north.

The groundwater potential in the sedimentary areas of the Chad Basin provides opportunities for irrigation and water supply, but over-exploitation of this resource could lead to long-term sustainability concerns, especially in the face of climate change.

2.4 Land Use and Land Cover

The Rima catchment features a diverse landscape influenced by climate, geology, and human activities. Key land uses include agriculture, livestock grazing, wetlands, and settlements. Human-induced changes like deforestation and cultivated land expansion have significantly impacted the environment and water resources.

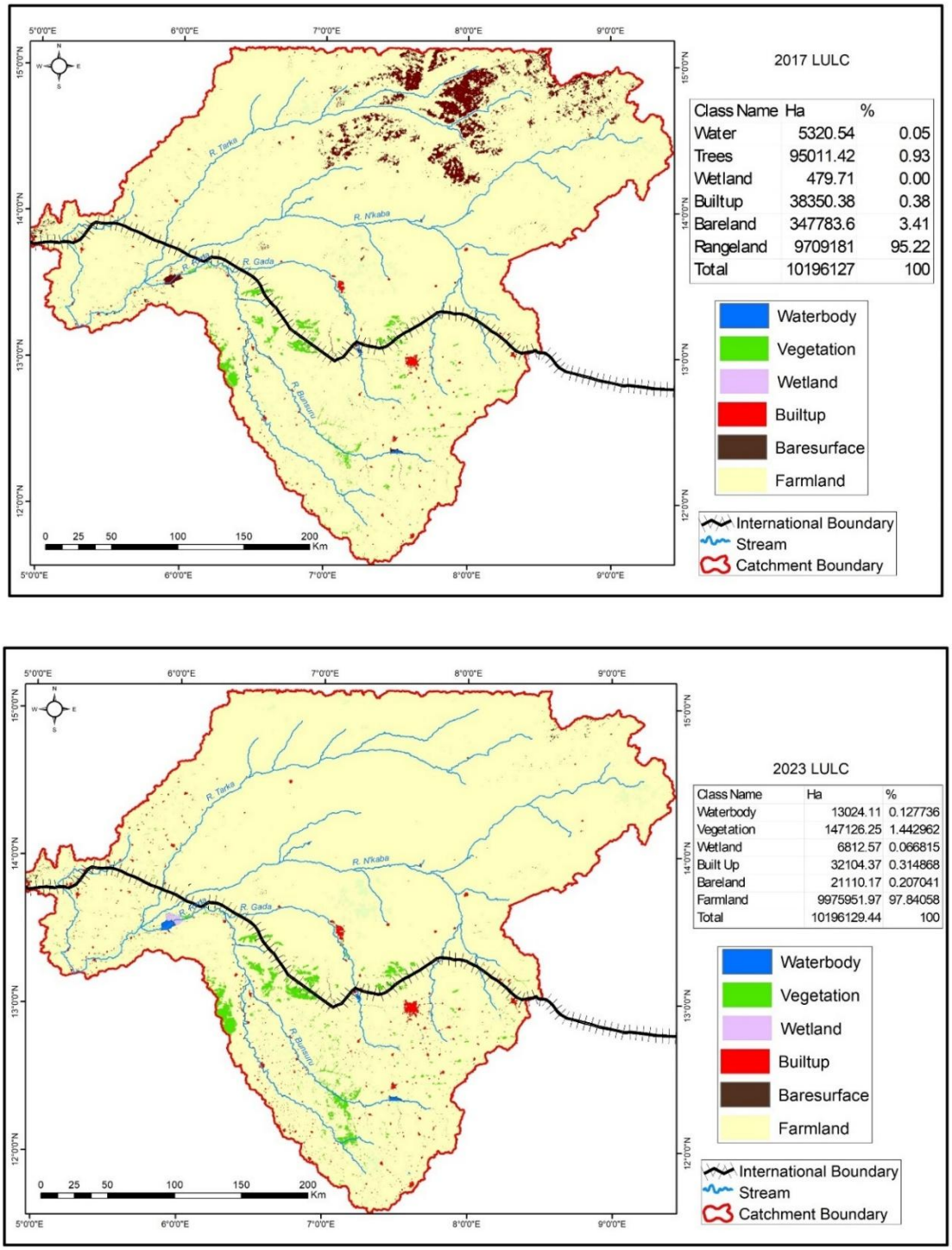


Figure 2.10: Land Use and Land Cover of Rima Catchment 2017 and 2023 (Source: MSL, 2025)

2.4.1 Natural Vegetation

The natural vegetation cover (Figure 2.11) of the Rima catchment varies from north to south, influenced largely by climatic gradients and soil types.

- **Northern Area (Sokoto State)**

The northern catchment area, especially in Sokoto State, features Sudan savannah with scattered Acacia trees and grasslands. Its semi-arid climate limits dense vegetation, making it suitable for pastoral grazing. However, desertification, overgrazing, and fuelwood collection are leading to vegetation degradation.

- **Central Area (Katsina State)**

The central part of the catchment, covering Katsina State, exhibits a transitional zone between the Sudan savannah and Guinea savannah. This area supports a mix of grasslands and scattered trees such as baobab, shea butter, and tamarind. The slightly higher rainfall compared to the north allows for a richer vegetation cover, though land clearing for agriculture is a major factor reducing natural vegetation.

- **Southern Area (Zamfara State)**

The southern parts of the catchment, particularly in Zamfara State, fall within the Guinea savannah zone, which supports a denser and more diverse range of plant species. Trees such as neem, locust bean, and shea butter dominate the landscape, along with a mixture of tall grasses. The relatively higher rainfall and better soil quality favour agriculture, leading to increasing deforestation and land conversion for farming.

2.4.2 Agricultural Land Use

Agriculture is the dominant land use in the Rima catchment. Over the past several decades, the expansion of agricultural activities has significantly transformed the landscape, particularly in the fertile regions along river floodplains.

• Rainfed Agriculture (Katsina and Zamfara States)

In Katsina and Zamfara States, most agriculture is rainfed, particularly on Alfisols suitable for millet, sorghum, maize, groundnuts, and cowpeas. This reliance on seasonal rainfall makes farming vulnerable to climatic variability and periodic droughts, especially in the drier northern regions.

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

The floodplains of the Rima River in Sokoto and Zamfara States support irrigated farming of high-value crops like rice and vegetables. While irrigation boosts agricultural productivity, it also strains water resources during the dry season, causing conflicts between farmers and pastoralists.

• **Fallow and Shifting Cultivation (Northern Katsina and Parts of Zamfara State)**

In some areas with poorer soils, particularly in northern Katsina and parts of Zamfara State, fallow and shifting cultivation practices are still observed. Farmers allow land to rest and regenerate before cultivation, but increasing population pressure has led to shorter fallow periods, resulting in soil degradation and declining yields.

2.4.3 Wetlands

The wetlands of the Rima catchment are significant land cover features, particularly in Sokoto and Zamfara States. These wetlands are fed by the Rima River and its tributaries, playing a crucial role in supporting biodiversity and local livelihoods.

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

  The wetlands provide a habitat for various bird species, aquatic plants, and fish populations, making them essential breeding and feeding grounds. They also act as natural flood regulators, storing excess water during the rainy season and gradually releasing it during the dry season. This hydrological function helps maintain water availability for surrounding communities and ecosystems.
- **Agricultural Use (Sokoto and Zamfara States)**

  Wetland agriculture, particularly rice farming, is a common practice in the floodplains of the Rima River. The seasonal flooding replenishes soil nutrients and ensures moisture availability for crops even in drier months. However, increasing pressure from unsustainable farming practices, overgrazing, and upstream water diversion for irrigation poses a threat to the long-term viability of these wetlands.

2.4.4 Grazing Land and Pastoralism

Livestock Grazing

Livestock grazing is a major land use in the catchment, especially in the northern and central parts where pastoralism is an important livelihood activity. Nomadic and semi-nomadic herders move across the region in search of pasture for their cattle, sheep, and goats. Grazing lands include the natural grasslands of the savannah and areas of marginal land not suitable for crop cultivation.

● Pastoralism in Northern Areas The drier northern regions of Yobe and Jigawa States are home to large numbers of pastoralists. However, overgrazing has led to land degradation and the loss of vegetation cover in some areas. This has been exacerbated by climatic factors such as reduced rainfall and increased frequency of droughts.

● Conflict with Agricultural Land The expansion of croplands into traditional grazing areas has led to increasing competition for land and resources between farmers and herders. Conflicts over land use are becoming more common as both groups struggle to access fertile land and water, particularly in times of scarcity.

2.4.5 Human Settlements

Human settlements in the Rima Catchment are concentrated around river systems and fertile agricultural zones. The population density is higher in the southern parts of the catchment, particularly in Sokoto State, which has major urban and rural settlements.

● Urban Areas Major urban centers such as Sokoto and Gusau serve as hubs for economic activities, including trade, manufacturing, and services. The expansion of these urban areas is putting pressure on surrounding agricultural and grazing lands. In recent years, urban sprawl has led to the conversion of peri-urban agricultural land into residential and commercial developments.

● Rural Settlements Most rural settlements in the catchment are small villages or hamlets that are closely tied to agricultural production. Access to basic infrastructure such as roads, schools, and healthcare facilities is limited in many rural areas, impacting the socio-economic development of these regions.

2.4.6 Forest and Woodland Areas

2.4.6.1 Forest and Woodland Areas

Small patches of forests and woodlands are found in the southern parts of the Rima catchment, particularly in Zamfara and parts of Katsina State. These areas are mostly located in protected reserves or exist as remnants of the original savannah woodlands.

2.4.6.2 Deforestation (Katsina and Zamfara States)

Deforestation has been widespread across the catchment due to agricultural expansion, 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 vulnerable to desertification.

2.4.6.3 Reforestation Efforts (Sokoto, Katsina, and Zamfara States)

In response to deforestation, several reforestation and afforestation projects have been introduced, particularly in areas at risk of desertification, such as northern Katsina and Sokoto States. These efforts focus on restoring degraded lands, improving soil fertility, and enhancing water retention in the landscape, often through tree-planting initiatives and sustainable land management practices.

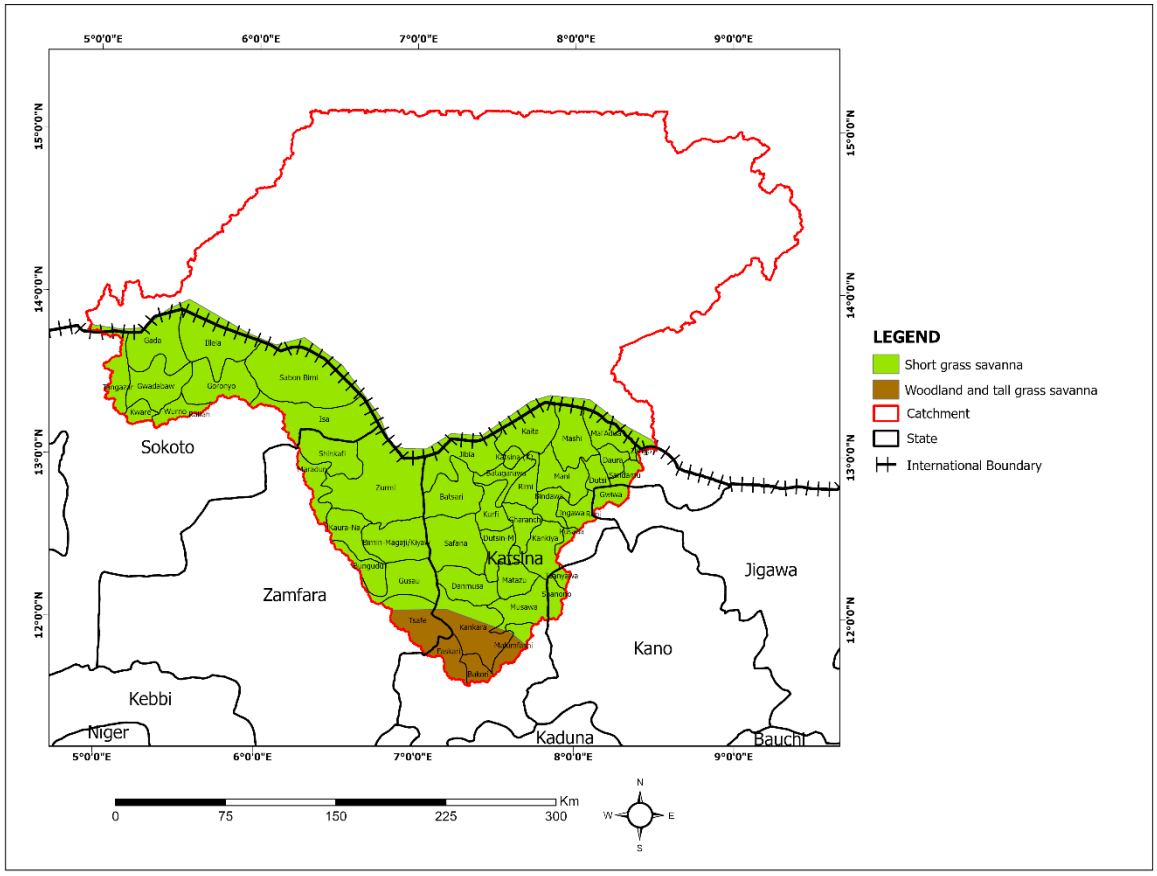


Figure 2.11: Vegetation Map of Rima Catchment (Source: MSL, 2025)

2.4.7 Biodiversity

Category	Description
Ecosystem Types	- Sudan and Sahel Savanna (dominant)- Riverine ecosystems (Rima River and tributaries) - Seasonal floodplains and wetlands (e.g., Dutsin Ma, Rima valley) - Fadama lands
Flora (Plant Diversity)	- **Savanna Vegetation**: *Acacia nilotica*, *Acacia senegal*, *Baobab (Adansonia digitata)*, *Shea (Vitellaria paradoxa)*, *Neem (Azadirachta indica)* - **Grasses**: *Andropogon gayanus*, *Hyparrhenia rufa* - **Wetlands/Riparian Plants**: *Typha domingensis*, *Wild Rice (Oryza longistaminata)*, *Water Lily (Nymphaea lotus)*
Fauna (Wildlife)	- **Mammals**: Roan antelope (*Hippotragus equinus*), Red-fronted gazelle (*Eudorcas rufifrons*), Warthog (*Phacochoerus africanus*), Hyenas (*Crocuta crocuta*, *Hyaena hyaena*)

	- **Birds**: • Migratory: Black-crowned crane, Spur-winged plover, White-faced whistling duck • Riparian/Savanna: Pied kingfisher, Grey heron, Marabou stork
Fish Resources	- **Key species**: *Oreochromis niloticus* (Tilapia), *Clarias gariepinus* (Catfish), *Heterotis niloticus*- Support artisanal fisheries and local protein supply
Reptiles & Amphibians	- **Reptiles**: Nile Crocodile (*Crocodylus niloticus*), Freshwater turtles - **Amphibians**: African bullfrog (*Pyxicephalus adspersus*), other frogs inhabiting wetlands and rice fields
Agro-Biodiversity	- **Crops**: • Cereals: Millet, sorghum, maize, rice • Legumes: Cowpea, groundnut • Vegetables: Tomato, onion, pepper- **Livestock**: • Cattle (White Fulani breed) • Sheep, goats, camels
Wetlands & Aquatic Ecosystems	- Seasonal floodplains provide: • Fish spawning habitats • Bird migration stopovers • Seasonal livestock grazing • Water filtration and erosion control • Agricultural buffer zones
Ecological Functions	- Biodiversity supports: • Soil fertility and structure (via plant roots and litter) • Water filtration • Pollination and pest control • Groundwater recharge • Carbon sequestration
Community Use of Biodiversity	- Fuelwood collection (Acacia, Shea)- Traditional medicine (e.g., neem, baobab leaves)- Fishing and hunting- Grazing- Local crop and seed preservation practices
Key Biodiversity Areas	- Rima River corridor- Kwiambana Forest Reserve (Zamfara)- Dutsin Ma Wetlands (Katsina)- Seasonal floodplains along Rima and Gagere rivers
Conservation Challenges	- Overgrazing and drought pressure- Land conversion and deforestation- Illegal fishing and wildlife hunting- Drying wetlands from climate variability and irrigation abstraction
Legal/Institutional Protection	- Forest Reserves and community-managed lands under state laws (limited enforcement)- Environmental regulations under NESREA and State Ministries of Environment

2.5 Hydrology and Water Resources

2.5.1 Hydrology

The hydrology of the Rima Catchment is shaped by its major river systems, seasonal flood dynamics, groundwater resources, and the interaction between surface and subsurface water flows. The catchment is primarily influenced by the Rima River and its tributaries, which sustain agriculture, livestock, and local economies. However, water availability is highly seasonal, with distinct wet and dry periods affecting both river flows and groundwater recharge.

a) River Systems

Rima River: The Rima River serves as the backbone of the catchment, originating in the highlands of Katsina State and flowing northwest through Zamfara and Sokoto before merging with the Sokoto River. This river is seasonal, experiencing high flows from June to September during the rainy season, while drastically reducing in volume during the dry months. Its flow is significantly influenced by rainfall variability and upstream water management infrastructure, such as the Goronyo Dam, which regulates water availability for irrigation and domestic use.

Tributary Network: The catchment is fed by several key tributaries, including the Bunsuru, Gagere, and Ka Rivers, which contribute to local water supplies and enhance agricultural productivity in the floodplains. Many of these tributaries are ephemeral, flowing only during the rainy season and drying up in the dry months, making them important yet unpredictable water sources for communities relying on surface water.

b) Flooding and Wetlands

Seasonal Floodplains: Unlike the permanent wetlands of the Hadejia-Nguru region, the Rima Catchment is characterized by vast seasonal floodplains, particularly in the Sokoto-Rima basin. These floodplains play a crucial role in water storage and soil moisture retention, supporting floodplain agriculture and grazing lands. The periodic inundation of these plains replenishes soil nutrients, making them ideal for farming activities once the waters recede.

Wetland Ecosystems: While not as extensive as those in other parts of northern Nigeria, the wetland areas around the Goronyo Reservoir and surrounding lowlands provide critical habitats for aquatic life and migratory birds. These wetlands also serve as natural buffers against excessive flooding, reducing the impact of high river flows during the peak rainy season.

c) Groundwater Resources

Groundwater is essential for communities in the Rima Catchment, especially in Sokoto and Zamfara States, where surface water varies year-round.

- Major aquifers in the Sokoto Basin offer good water storage, while deep boreholes access confined aquifers for stable supplies.
- Katsina State has basement complex aquifers, but water extraction is more difficult. The region's hydrology balances seasonal water availability, human demands, and floodplain processes.
- Sustainable water management strategies are vital for adapting to climate variability and increasing consumption.

2.5.2 Hydrograph/Water Budget of The Catchment

The hydrographs and water budgets of the Rima strategic catchment are examined in detail. The catchment exhibits uniform hydrologic characteristics, with river flow peaking in August and September during the wet season. Significant discharge occurs from May to October, especially in the five months leading up to peak flow, leading up to peak flow, followed by a four-month dry season.

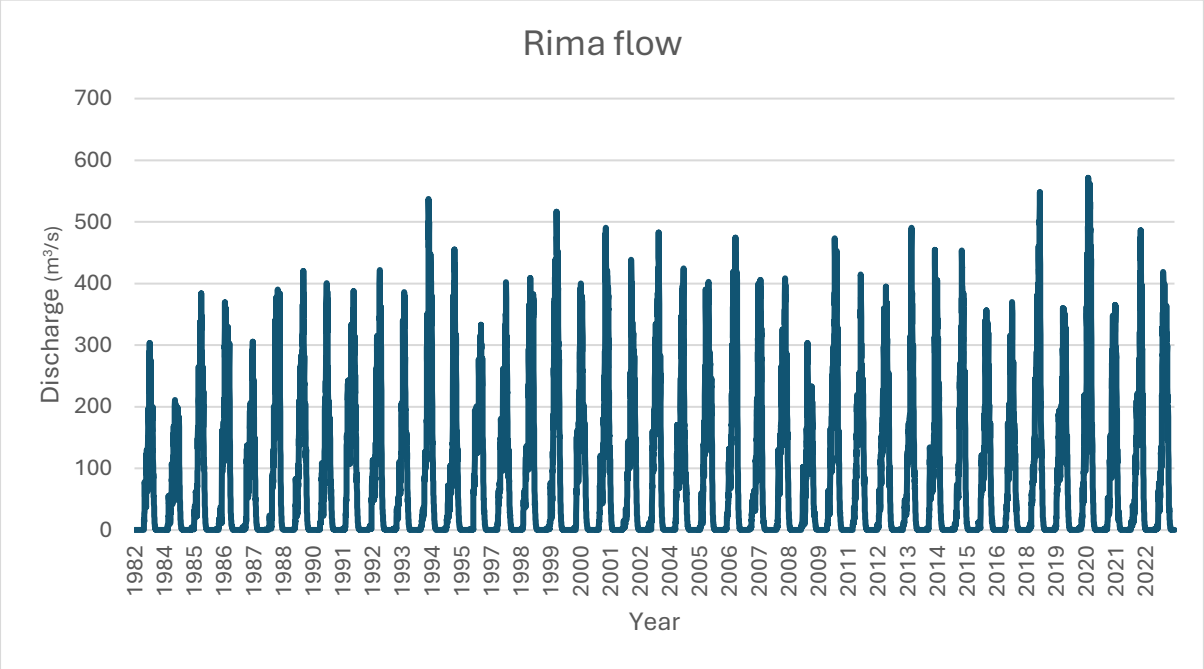


Figure 2.12: Hydrograph of Rima Strategic catchment

Based on HEC-HMS modelling for Strategic catchment.

Evapotranspiration exceeds precipitation most of the year, resulting in a low average water budget of 84.69mm. Notably, water surplus occurs for only four months, indicating prolonged water shortages and emphasizing the need for alternative water supply solutions to mitigate these challenges.

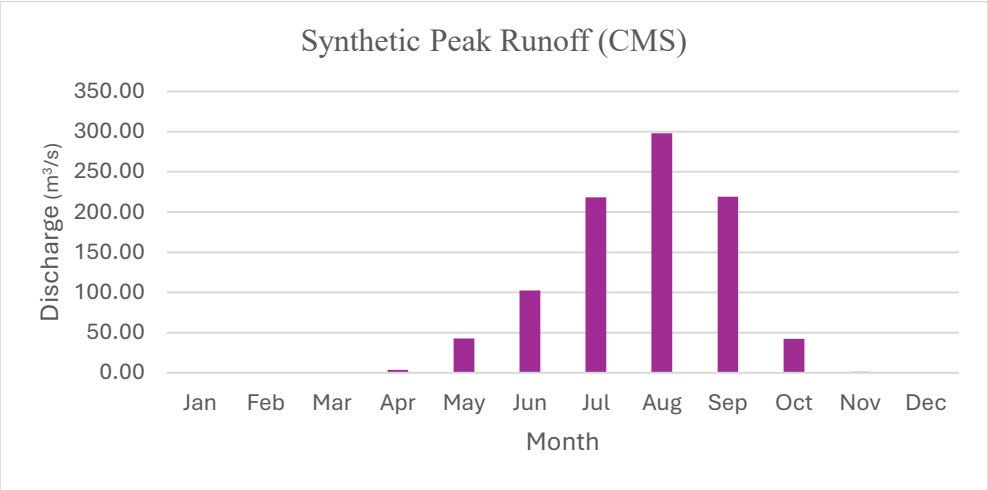


Figure 2.13: 40 - Year Summary Hydrograph of Rima Strategic catchment

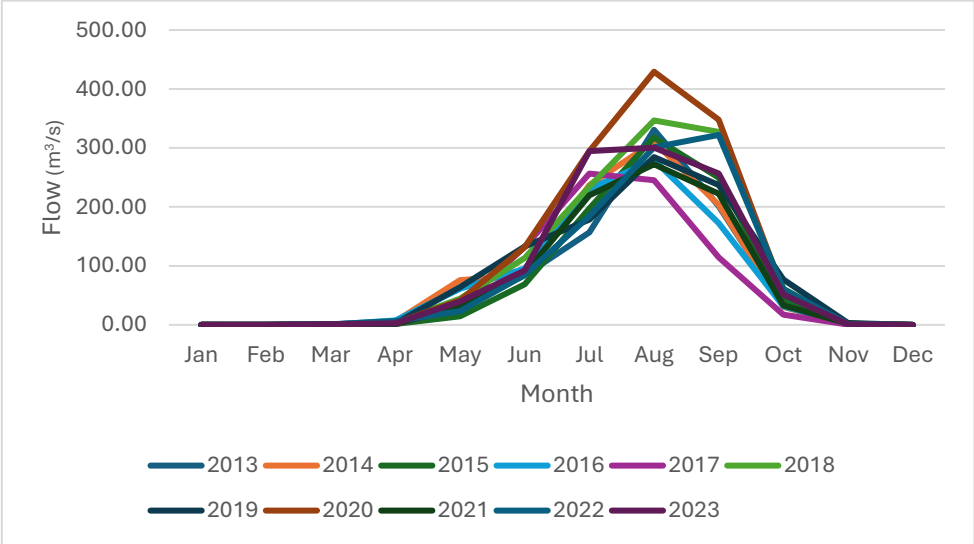


Figure 2.14: Hydrograph of Rima Strategic Catchment for Specific Year

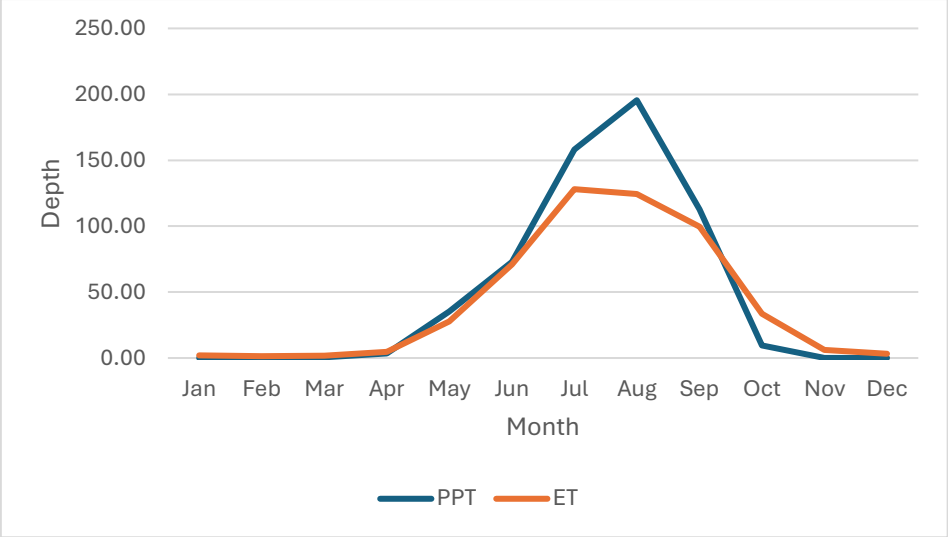


Figure 2.15: Water Budget for Rima Strategic Catchment

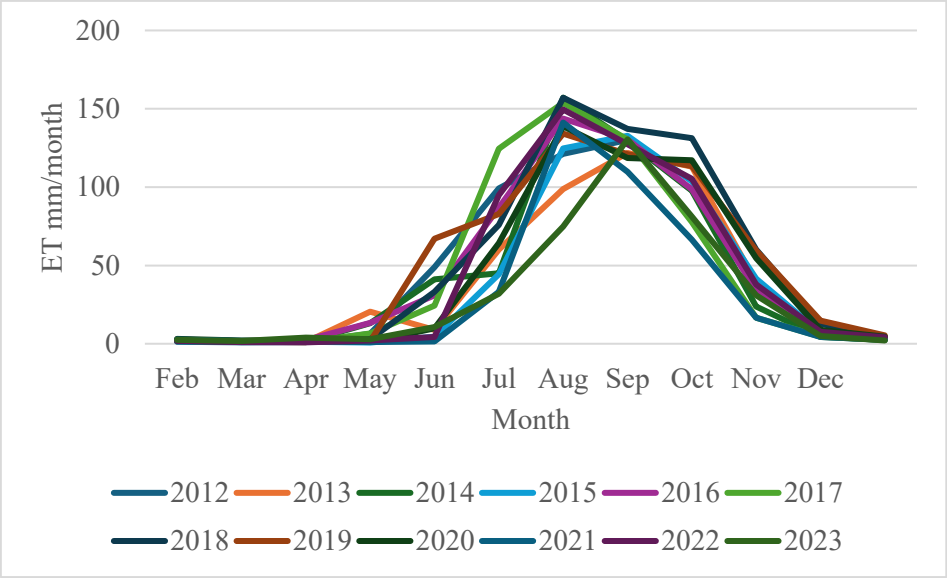


Figure 2.16: Monthly Actual Evapotranspiration Distribution for the Catchment

Prospects

- Significant potential for agricultural development is plausible in the catchment, with opportunities for irrigation and dry-season farming. Groundwater exploration and management. Groundwater flow plays a crucial role in maintaining base flow in the Rima River during the dry season.
- Effective management of water resources is essential to ensure sustainable development and mitigate the impacts of climate variability. Watershed restoration and protection involve revitalizing and preserving the natural functions of the watershed to maintain its

ecological integrity, water quality, and biodiversity can help alleviate water scarcity issues in the region.

Table 2.1: Summary of Discharge, Rainfall and Evapotranspiration Data for Rima Strategic

YEAR	PPT	ET	Synthetic Peak Runoff (m^3/s)
Jan	0.00	1.99	0.00
Feb	0.01	1.40	0.01
Mar	0.46	1.73	0.48
Apr	3.37	4.72	3.63
May	35.38	27.64	42.59
Jun	72.98	71.03	102.27
Jul	158.21	128.06	218.21
Aug	195.52	124.43	297.95
Sep	112.71	99.65	219.18
Oct	9.58	33.64	42.29
Nov	0.06	6.20	1.25
Dec	0.00	3.10	0.02

2.5.2.1 Stream Flow and Seasonal Variability

Stream flow in the Rima Catchment exhibits strong seasonal variations, closely linked to rainfall distribution across the region. The hydrological regime is characterized by pronounced wet and dry season fluctuations, impacting river discharge, groundwater recharge, and floodplain dynamics.

a) Wet Season Flow

The wet season (June to September) marks the peak of river discharge across the catchment, driven by monsoonal rainfall and surface runoff contributions. Rainfall is more intense in the upstream portions of the catchment (Katsina and Zamfara States), where runoff from hilly

terrain feeds into the Rima River and its tributaries. Peak flows are observed between July and September, sustaining floodplain agriculture and replenishing groundwater reserves.

Rima River: The Rima River experiences a sharp increase in flow during the wet season, with discharge rates varying between 40 and 180 cubic meters per second (m^3/s), depending on rainfall intensity. Flooding is common along the river's middle and lower courses, particularly in Sokoto State, where the expansive floodplains temporarily store excess water.

Tributary Contributions: The Bunsuru, Gagere, and Ka Rivers act as important seasonal feeders to the Rima system, contributing significantly to local hydrological processes. These tributaries provide short-lived but intense water inflows, supporting wet-season agriculture and sustaining local ecosystems.

b) Dry Season Flow

From October to April, river discharge drops significantly due to reduced rainfall, relying on groundwater and reservoirs. Flow rates can fall below 10 m^3/s in smaller tributaries, raising water scarcity concerns for irrigation and livestock.

The Goronyo Dam regulates dry-season flows by storing and releasing water, but increased upstream irrigation reduces downstream availability for river-fed agriculture. Seasonal floodplains in Sokoto and Zamfara States provide crucial moisture for dry-season farming, but their extent is diminishing due to changing hydrological patterns.

2.5.2.2 Discharge Measurements

Monitoring river discharge is vital for effective water resource management, especially in areas with significant seasonal variability. Measurements by the Nigeria Hydrological Services Agency (NIHSA) provide critical insights for irrigation, reservoir management, and flood control.

2.5.2.3 Surface Water Resource Potential

The country's average precipitation is about 1,150mm, with Hydrological Area 1 receiving 767mm/year. Only 24% of this precipitation becomes runoff, with 10.7 BCM/year generated internally.

- The total water resources potential is estimated at 37.4 BCM/year, including 26.7 BCM/year from neighboring countries.
- Approximately 71.4% of surface water resources depend on these external sources.

Groundwater recharge data is primarily available at the Hydrological Area scale.

- Hydrological Area 1 covers Rima Catchment, Sokoto- Zamfara Catchment, Golbin-Ka Catchment and Malenda Catchment Areas. As such the current surface and groundwater potential at HA level can be considered as a grand total of the above-mentioned catchments.

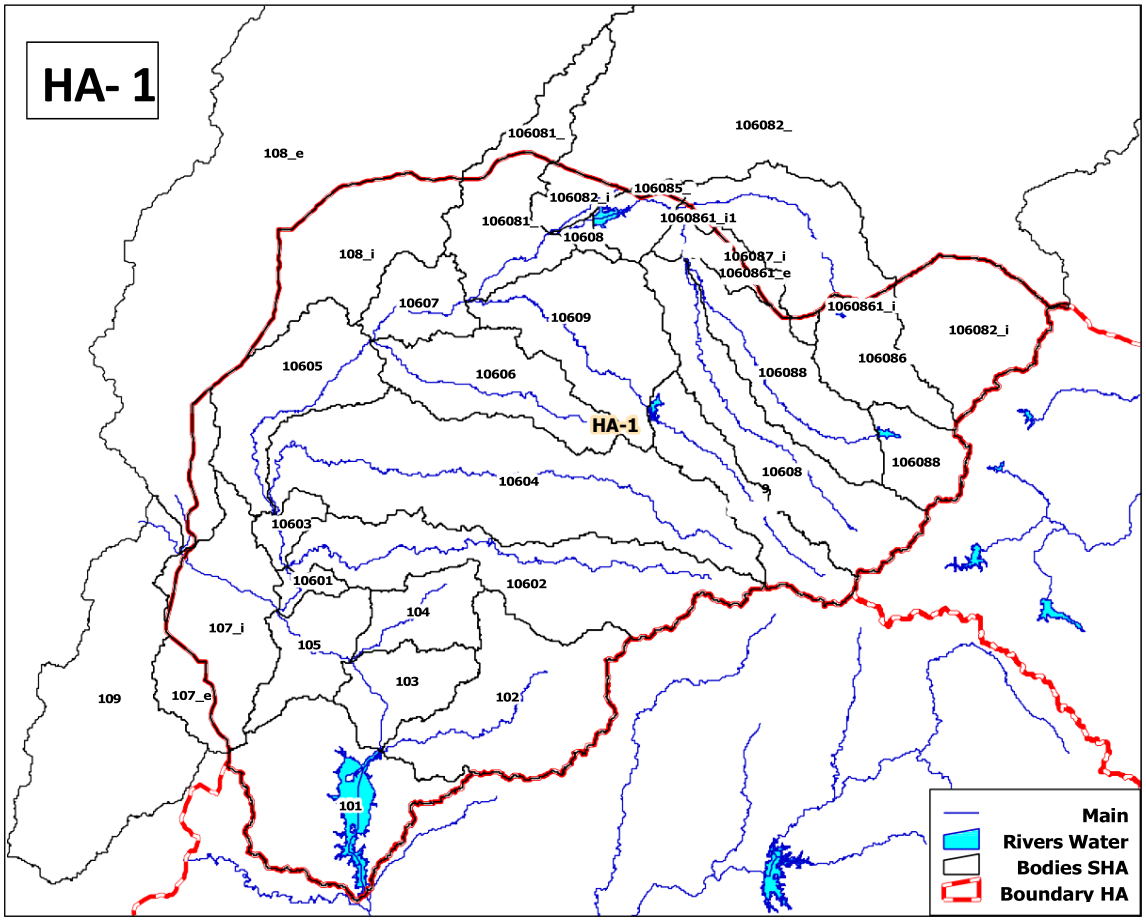


Figure 2.17: Water Resources of the catchment

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

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 2.18.

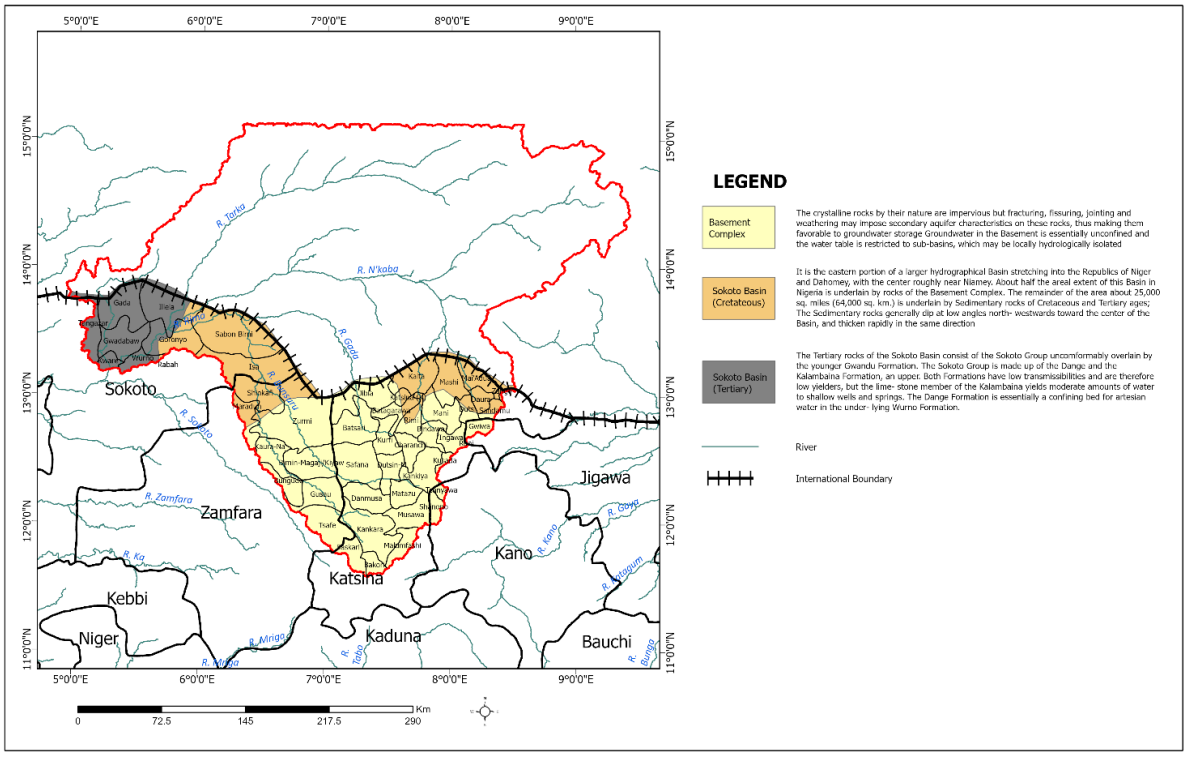


Figure 2.18: Hydrogeological province Map of the Catchment (Source: MSL, 2025)

2.5.3.1 Groundwater Recharge

Groundwater recharge within the Rima Catchment has been experiencing a gradual decline, primarily due to the impacts of climate change, unsustainable water abstraction, and land-use changes.

- The degree of this decline varies across the catchment, with some areas more severely affected than others. Given the region's reliance on groundwater for both domestic and agricultural use, understanding the spatial variations in recharge rates is crucial for sustainable water management.
- Recharge rates are naturally higher in areas where precipitation is more abundant and where surface water bodies contribute to infiltration. However, in semi-arid regions of the catchment, such as eastern Sokoto, Zamfara, and parts of Katsina State, groundwater recharge is relatively low, making these areas more vulnerable to declining water tables.

2.6 Water Demand for Rima Catchment

The Rima Catchment is divided into several sub-basins, each with distinct hydrological characteristics and water availability patterns.

2.6.1 Water Availability by Sub-Basin

Kaura Namoda Sub-Basin	600 to 800 mm/year
Sokoto-Rima Sub-Basin	800 to 1,000 mm/year
Gwadabawa Sub-Basin	400 to 600 mm/year
Argungu Sub-Basin	800 to 1,000 mm/year

2.6.2 Water Use and Demands

Current and future water demand for Rima Catchment were estimated utilizing the methodology adopted in the NWRMP (JICA Team, 2014). The demand-related data obtained were based on the State level. The States considered are Sokoto, Zamfara, Katsina and part of Jigawa and Kano (Figure 2.19).

Figure 2.19: Map showing Rima Catchment on Nigeria Map

The water demand (refer to Figure 2.20 and Figure 2.21) is divided into the following categories:

- Municipal water demand
- Irrigation water demand.
- Livestock water demand.
- Aquaculture water demand.

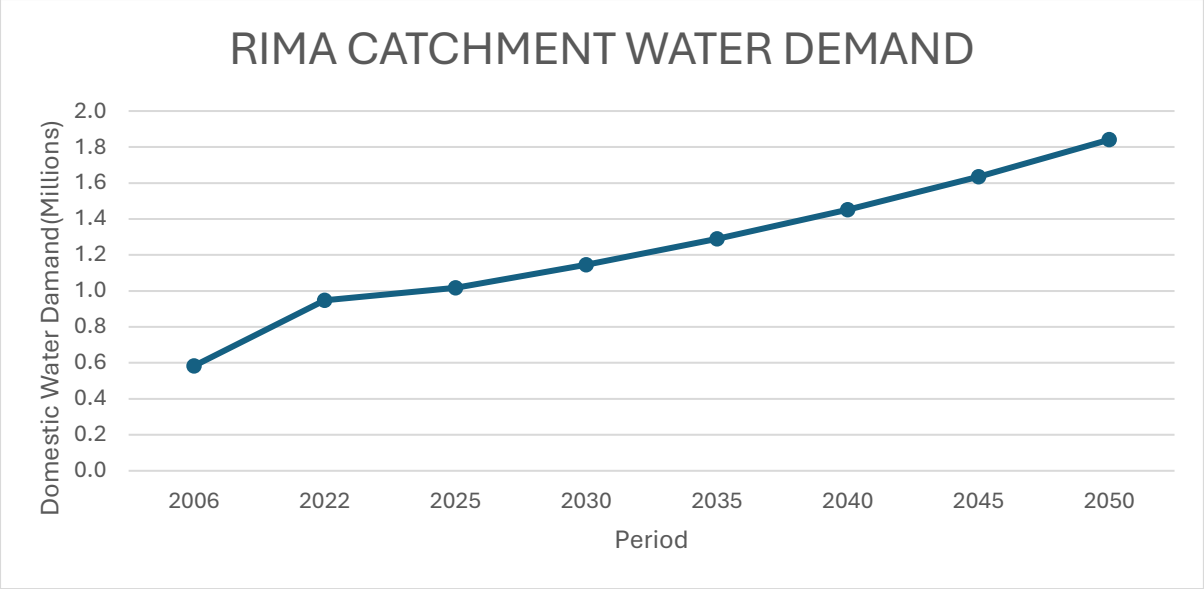


Figure 2.20: Daily Municipal Water Demand for Rima Catchment

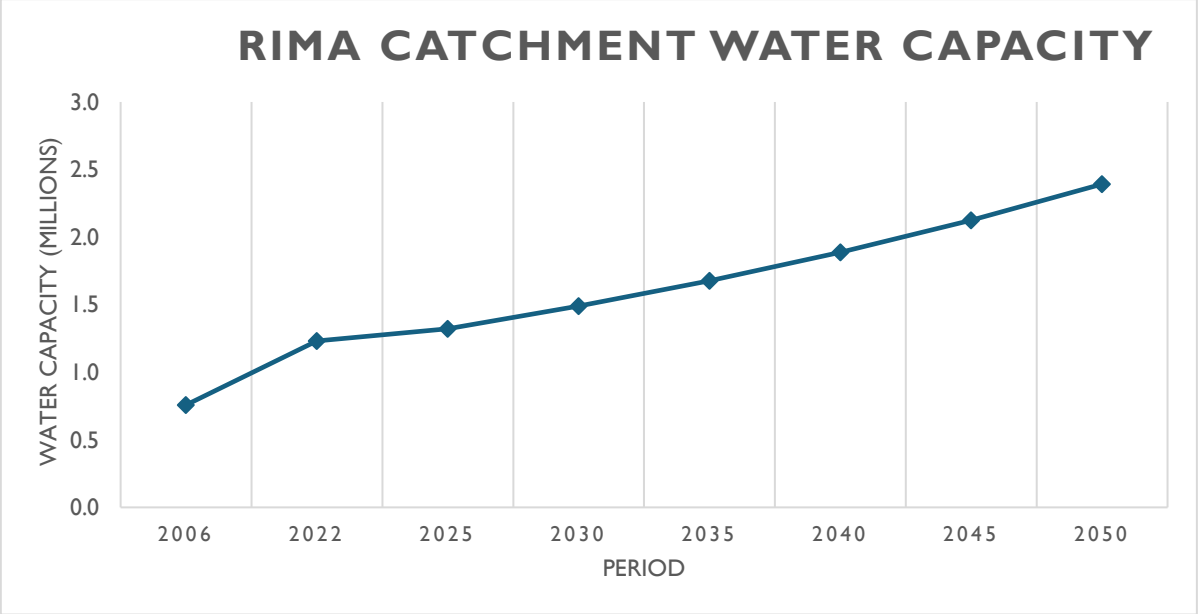


Figure 2.21: Water capacity for Rima Catchment

2.6.3 Livestock Indices and Water Demand

Projected water demand for inland aquaculture in Nigeria shows an increase from 4.56 million cubic meters in 2010 to 8.19 million cubic meters by 2050 across various states. Katsina's demand grows from 2.41 to 4.33 million cubic meters, while Sokoto and Zamfara also see increases. In the Rima Catchment area, small-scale irrigation systems, primarily Fadama schemes, use surface and groundwater. Irrigation water demand data focuses on rice and vegetables, reflecting conservative and optimistic estimates.

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	**7.9**
Goat	30	6.6	4.3	2.3	**0.8**
Sheep	40	8.8	6.8	2.0	**0.7**
Pig	90	20	16.7	3.3	**1.2**
Donkey	110	24	15.6	8.4	**3.1**
Camel	350	80	55.4	24.6	**9.0**
Horse	300	70	47.8	22.2	**8.1**
Fowl	**2**	**0.4**	**0.292**	**0.108**	**0.039**

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
Katsina	1,676,024	4,488,812	4,336,486	0	5,204,109	6,108	0	0
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	**4,002,293**	**11,953,564**	**10,710,322**	**188,475**	**19,592,609**	**107,689**	**82,640**	**100,459**

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 to 2050

WATER DEMAND (M3) FOR EACH LIVESTOCK IN THE RIMA CATCHMENT PROJECTED TO 2050									
	2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Cattle	4002293	4140440	4283355	4431203	4584155	4742386	4906079	5075421	5250609
Goats	11953564	13204818	14587050	16113968	17800718	19664030	21722388	23996206	26508039
Sheep	10710322	12416199	14393777	16686333	19344033	22425036	25996763	30137373	34937475
Pigs	188475	210140	234295	261226	291254	324733	362060	403678	450080
Poultry	19592609	21435942	23452701	25659203	28073300	30714522	33604238	36765828	40224870
Donkeys	107689	119481	132565	147081	163187	181057	200883	222881	247287
Camels	82640	91689	101730	112869	125229	138942	154157	171037	189767
Horses	100459	111460	123665	137207	152231	168901	187396	207917	230685
TOTAL	**46,738,051**	**51,730,169**	**57,309,137**	**63,549,090**	**70,534,106**	**78,359,606**	**87,133,963**	**96,980,341**	**108,038,812**

Source: JICA 2014 MP

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

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

2.6.4 Aquaculture water demand

Basic Data for 2030 projection: Area of farm ponds by Fishery Statistics of Nigeria, Inventory of Private and Government Fish Harm and Hatcheries (Dec. 2004) published in 2007 (Table 2.8).

Table 2.8: Fish Farm Pond

State	Number of Fish Farm	Water Area of Farm Pond (ha)	Brackish Water Area of Farm Pond (ha)
KATSINA	7	29	0
KEBBI	56	57.7	0
SOKOTO	9	14.2	0
ZAMFARA	9	37.5	0
TOTAL	81	138	0

Source: JICA 2014 MP

Annual water supply per hectare is estimated at 0.03 MCM, with 75-85% sourced from shallow wells and the remainder from surface runoff. Water quality must be free of detergents and chemicals, with a neutral pH and dissolved oxygen above 4 ppm for replacement. Groundwater is preferred due to its higher oxygen content, especially in colder temperatures.

The envisaged inland fish farming in Nigeria aims to supply 1.73 kg/year/person by 2030, assuming a population of 257 million and a growth rate of 0.75%. The target yield is 10 t/ha, surpassing rice yields, but requires higher initial investments. With 1.4 million ha suitable for fish culture, projections suggest less than 500 thousand tons/year due to investment and marketing challenges.

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
70%	KATSINA	2.41	3.40	3.64	3.75	3.87	3.98	4.10	4.21	4.33
35%	SOKOTO	0.59	0.83	0.89	0.92	0.95	0.97	1.00	1.03	1.06
35%	ZAMFARA	1.56	2.20	2.35	2.42	2.50	2.57	2.65	2.72	2.80
Total Aquaculture Water Demand		**4.56**	**6.42**	**6.89**	**7.09**	**7.31**	**7.53**	**7.75**	**7.97**	**8.19**

2.6.5 Irrigation water demand

Several small-scale irrigation systems, both formal and informal, exist in Rima Catchment. Local communities develop Fadama schemes mostly using surface water, either by gravity diversion or small diesel pumps. The irrigation water demand data comes from the Nigeria National Water Resources Master Plan (NNWRMP 2013). The table outlines water demands for rice, the most conservative estimate, and vegetables, the most optimistic 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.

Table 2.11 to

Table 2.13 shows Surface Water Demand, Underflow Water Demand and Groundwater Demand.

Table 2.10: Surface Water Demand of Existing Irrigation Schemes in Rima Catchment

HA	Area (km2) (only inside Nigeria)	Catchment	SHA	SHA divided by National Boundary	SHA Area (km2)	Public Irrigation Irrigated Area (ha)	Wet Season Diversion Water Req. (m3/ha)	Dry Season Diversion Water Req. (m3/ha)	Wet Season Water Demand (MCM)	Dry Season Water Demand (MCM)	Surface Water Total (A) (MCM)
			106081	106081_e	2,220.30						
				106081_i	4,132.30	1400	5,737	3,864	8	5.4	13.4
				106082_e	80,006.80						
			106082	106082_i1	1,322.20	0	5,737	3,864	13.4	4.9	12.3
				106082_i2	6,043.40	1280					
			106083	106083	412.5	1308	5,737	3,864	7.5	5.1	12.6
		Rima	106085	106085_e	290.3						
1	124,684.60			106085_i	1,499.60	0	5,737	3,864	0	0	0
				1060861_e	6,067.90						
			1060861	1060861_i1	164.7	0	5,737	3,864	17.2	11.6	28.8
				1060861_i2	548	3000					
			1060863	1060863	3,509.30	50	5,737	3,864	0.3	0.2	0.5
			106087	106087_e	632.3						
				106087_i	1,216.50	0	5,737	3,864	0	0	0
			1060881	1060881	5,750.60	160	5,737	3,864	0.9	0.6	1.5
			1060883	1060883	2,513.80	0	5,737	3,864	0	0	0
			106089	106089	8,354.10	0	5,737	3,864	0	0	0
	Total					7,198			17	11	69.1

Source: JICA Team

Note: e = outside Nigeria, i = inside Nigeria

Table 2.11: Surface Water Demand of Existing Irrigation Schemes in Rima Catchment

Catchment			SHA divided by National Boundary	Inside (I) or Outside (O) Nigeria	Public Irrigation Irrigated	Wet Seazon Diversion Water Req.	Dry Seazon Diversion Water Req.	Wet Seazon Water Demand	Dry Seazon Water Demand	Surface Water Total (A)
HA		SHA			Area (ha)	(m3/ha)	(m3/ha)	(MCM)	(MCM)	(MCM)
			106081_e	O						
			106081_i	I	1400					
		106081		Wurno	700	5,737	3,864	4	2.7	6.7
				Kware	300	5,737	3,864	1.7	1.2	2.9
				Kalmalo	400	5,737	3,864	2.3	1.5	3.8
			106082_e	O						

			106082_i1	I	0					
			106082_i2	I	1280					
		106082		Sabke	540	5,737	3,864	3.1	2.1	5.2
				Ajiwa	500	5,737	3,864	2.9	1.9	4.8
	Rima			Mashigi	0	5,737	3,864	0	0	0
1				Mangwal	0	5,737	3,864	0	0	0
				Deberam	240	5,737	3,864	1.4	0.9	2.3
		106083	106083	I	1308					
				Goronyo	120	5,737	3,864	0.7	0.5	1.2
				Middle Rima	1188	5,737	3,864	6.8	4.6	11.4
				Valley						
		106085	106085_e	O						
			106085_i	I	0					
			1060861_e	O						
		1060861	1060861_i1	I	0					0
			1060861_i2	I	3000					
				Jibiya	3000	5,737	3,864	17.2	11.6	28.8
		1060863	1060863	I	50					
				Raddewa	50	5,737	3,864	0.3	0.2	0.5
		106087	106087_e	O						
			106087_i	I	0			0	0	0
		1060881	1060881	I	160					
				Zobe	60	5,737	3,864	0.3	0.2	0.5
				Makere	100	5,737	3,864	0.6	0.4	1
		1060883	1060883	I	0			0	0	0
		106089	106089	I	0					
				Gagere	0	5,737	3,864	0	0	0
		Total			7,198			184.6	124.6	69.1

Source: JICA Team

Note: e = outside Nigeria, i = inside Nigeria

Table 2.12: Underflow Water Demand of Existing Irrigation Schemes in Rima Catchment

		SHA			Private Small Irrigation Area(2) (ha)		Dry Seazon Diversion Water Req. (m3/ha)		
	Catchment		divided by National Boundary	Fadama Irrigation Area (ha)		Area Sub-total (ha)		Underflow Total (B) (MCM)	Total (A)+(B) (MCM)
HA		SHA							
		106081	106081_e						
			106081_i	1,291	892	2,183	3,757	8.2	21.6
			106082_e						
		106082	106082_i1	983	679	1,662	3,757	6.2	6.2

	Rima		106082_i2	187	129	316	3,757	1.2	1.2
		106083	106083	177	122	299	3,757	1.1	13.7
		106085	106085_e						
1			106085_i	409	283	692	3,757	2.6	2.6
			1060861_e						
		1060861	1060861_i1	50	34	84	3,757	0.3	0.3
			1060861_i2	0	0	0	3,757	0	0
		1060863	1060863	0	0	0	3,757	0	0.5
		106087	106087_e						
			106087_i	148	102	250	3,757	0.9	0.9
		1060881	1060881	360	249	609	3,757	2.3	3.8
		1060883	1060883	324	224	548	3,757	2.1	2.1
		106089	106089	424	293	717	3,757	2.7	2.7
		Total		4,353	3,007	7,360		27.6	96.7

Source: JICA Team

Note: e = outside Nigeria, i = inside Nigeria

Table 2.13: Groundwater Demand of Existing Irrigation Schemes in Rima Catchment

					Wet Seazon Diversion Water Req. (m3/ha)	Dry Seazon Diversion Water Req. (m3/ha)			
	Catchment		SHA divided by National Boundary	Private Small Irrigation Area(1) (ha)			Wet Seazon Water Demand (MCM)	Dry Seazon Water Demand (MCM)	Ground Water Total (MCM)
HA		SHA							
		106081	106081_e						
			106081_i	309	3,772	3,757	1.2	1.2	2.4
1			106082_e						
		106082	106082_i1	0	3,772	3,757	0	0	0
			106082_i2	1,240	3,772	3,757	4.7	4.7	9.4
		106083	106083	0	3,772	3,757	0	0	0
	Rima	106085	106085_e						
			106085_i	0	3,772	3,757	0	0	0
			1060861_e						
		1060861	1060861_i1	0	3,772	3,757	0	0	0
			1060861_i2	58	3,772	3,757	0.2	0.2	0.4
		1060863	1060863	515	3,772	3,757	1.9	1.9	3.8
		106087	106087_e						
			106087_i	0	3,772	3,757	0	0	0
		1060881	1060881	541	3,772	3,757	2	2	4
		1060883	1060883	478	3,772	3,757	1.8	1.8	3.6
		106089	106089	1,290	3,772	3,757	4.9	4.8	9.7
		Total		4,431			16.7	16.6	33.3

Source: JICA Team

Note: e = outside Nigeria, i = inside Nigeria

2.6.6 Irrigation Water Demand Projection

Rima Catchment located within HA-1 in northern Nigeria belongs to semi-arid zone with scanty annual rainfall, however, rice cultivation during rainy season is widely practiced with so far learnt ample experiences/ performances. In dry season, wheat and other cereal crops as well as vegetables are mainly cultivated because of huge water requirement for rice cultivation and high cost of diesel to fuel the water generators.

Current Cropping Pattern

The following Table 2.14 and Table 2.15 shows the current cropping rate set based on RBDA's materials and cropping acreages of large-scale irrigation schemes.

Table 2.14: *Current Cropping Pattern (%)*

HA	Irrigation scheme (%)				Small-scale private irrigation (%)			
	Wet Season		Dry Season		Wet Season		Dry Season	
	Paddy	Upland	Paddy	Upland	Paddy	Upland	Paddy	Upland
I	40	25	5	60	20	50	0	70

Table 2.15: HA-1 Existing Cropping Pattern

Scheme	Crop	Wet season Area (ha)	Dry season Area (ha)	Crop intensity		Developed Area (ha)
				Wet (%)	Dry (%)	
Shagari	Rice	50	0	25	0	200
	Others	110	80	55	40	
Middle Rima Valley	Rice	80	0	7	0	1,188
	Others	1,000	950	84	80	
Bakalori	Rice	7,200	0	90	0	8,000
	Others	800	4,000	10	50	
Jibiya	Rice	0		0	0	3,000
	Others	2,700	1,500	90	50	
Zauro Polder	Rice	85	0	85	0	100
	Others	15	15	15	15	
Niger Valley	Rice	0	700	0	10	7,000
	Others	1,400	6,300	20	90	
Total	Rice	7,335	700	38	4	19,488
	Others	**5,025**	**11,895**	**26**	**61**	

Source: Inventory survey, Data collected from SRRBDA, Interview at Project site

Table 2.16: Proposed Cropping Pattern (%)

HA	Irrigation scheme (%)				Small-scale private irrigation (%)			
	Wet Season		Dry Season		Wet Season		Dry Season	
	Paddy	Upland	Paddy	Upland	Paddy	Paddy	Upland	Paddy
I	40	60	0	50	10	75	0	75

Source: JICA Team

a) Crop coefficient (Kc)

Crop coefficient (Kc) on growth stage is selected based on FAO technical text. Wind condition is clam or weak.

Rice

HA	Season	Initial stage(1) First month 15 days	Initial stage(2) econd month 30 days	Middle stage 30 days	Tardive stage 30 days
Common	Wet	1.1	1.1	1.05	**0.95**
Common	**Dry**	**1.1**	**1.1**	**1.25**	**1.0**

Maize

HA	Season	Sowing time	ETo (mm/ day)	Irrigation interval	Initial stage (1) 30days	Initial stage (2) 30days	Middle stage 30days	Tardive stage 30days
HA-1	Wet	May	5.8	7	0.44	0.75	1.05	**0.55**
	Dry	**Nov.**	**3.2**	**7**	**0.58**	**0.87**	**1.15**	**0.60**

Wheat

HA	Season	Sowing time	ETo (mm /day)	Irrigation interval	Initial stage (1) 30days	Initial stage (2) 30days	Middle stage 30days	Tardive stage 30days
HA-1	**Dry**	**Dec.**	**2.7**	**7**	**0.6**	**0.88**	**1.15**	**0.2**

2.6.7 Total Water Demand

Table 2.17 show Water Balance Analysis for Rima Catchment

Table 2.17: Water Balance Analysis for Rima Catchment

WATER BALANCE ANALYSIS FOR RIMA CATCHMENT			
WATER DEMAND (CUBIC METER)		2025	2050
MUNICIPAL		333,929,779	604,162,918
LIVESTOCK		63,549,090	108,038,812
AQUACULTURE		7,090,904	8,188,617
IRRIGATION		130,000,000	307,800,000
TOTAL		534,569,773	1,028,190,346
AVAILABLE WATER RESOURCES (CUBIC METER)		992,164,400	992,164,400
WATER BALANCE (CUBIC METER)		457,594,627	(36,025,946)

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

2.6.8 Infrastructure and Assets

Table 2.18 shows Catchment Infrastructure and Assets of Rima Catchment Area.

Table 2.18: Catchment Infrastructure and Assets

S/No.	Infrastructure	Location	Importance	Risk Factor
1	Water Management Infrastructure	Rima River Basin	Regulates water flow, supports agriculture and domestic use	Siltation, water loss, climate change impacts
2	Goronyo Dam	Sokoto State	Provides irrigation water, supports domestic water supply	Siltation, reduced downstream flow, climate variability
3	Bakolori Dam	Zamfara State	Supports irrigation and domestic water supply	Inefficiencies in irrigation canals, water loss
4	Jibia Dam	Katsina State	Provides irrigation and drinking water	Evaporation losses, sediment accumulation
5	Kwalkwalawa Dam	Katsina State	Stores water for irrigation and drinking	Climate variability, water loss
6	Lugu Dam	Katsina State	Supports irrigation and drinking water supply	Climate variability, water loss
7	Shagari Dam	Katsina State	Stores water for irrigation and drinking	Climate variability, water loss
8	Energy Infrastructure	Various locations within the catchment	Supports power generation and distribution	Climate variability, infrastructure degradation
9	Agricultural Infrastructure	Rima River floodplains	Supports floodplain farming (Fadama agriculture)	Climate variability, water scarcity
10	Traditional Water Storage	Various locations within the catchment	Supports small-scale irrigation, livestock watering	Climate variability, water loss
11	Earth Dams and Ponds (Rijiya Systems)	Katsina and Zamfara States	Stores rainwater for irrigation, livestock, and domestic use	Climate variability, water loss

12	Fadama (Floodplain) Farming	Rima River Basin, Goronyo Floodplain, Sokoto Wetlands	Utilizes seasonal floodwaters for agriculture	Climate variability, water scarcity
13	Water Harvesting Techniques	Arid areas	Improves soil moisture retention	Climate variability, water loss
14	Cultural and Tourism Infrastructure	Various locations within the catchment	Supports tourism and cultural activities	Climate variability, infrastructure degradation
15	Sultan of Sokoto's Palace	Sokoto State	Historical and cultural significance	Climate variability, infrastructure degradation
16	Shehu Uthman Dan Fodio Tomb	Sokoto State	Historical and cultural significance	Climate variability, infrastructure degradation
17	Sokoto Central Mosque	Sokoto State	Religious and cultural significance	Climate variability, infrastructure degradation
18	Argungu Fishing Festival	Kebbi State	Cultural and economic significance	Climate variability, infrastructure degradation
19	Katsina Emirate Palace	Katsina State	Historical and cultural significance	Climate variability, infrastructure degradation
20	Gobarau Minaret	Katsina State	Historical and cultural significance	Climate variability, infrastructure degradation
21	Kurmi Market	Sokoto State	Economic and cultural significance	Climate variability, infrastructure degradation
22	Zamfara's Ancient City Walls and Ruins	Zamfara State	Historical and cultural significance	Climate variability, infrastructure degradation
23	Goronyo Dam (Recreational)	Sokoto State	Recreational and tourism significance	Climate variability, infrastructure degradation
24	Dutsi Rock Paintings	Katsina State	Archaeological and cultural significance	Climate variability, infrastructure degradation

2.7 Water Quality

This study analyzed the hydrochemistry of surface water along the River-Rima floodplain. Five sampling sites were selected, and 30 water samples were collected over two periods. The results showed that BOD, TDS, Mg2+, and Fe3+ exceeded WHO and SON guidelines for drinking water. Coliform analysis revealed the presence of Enterobacter aerogene, Escherichia coli, and Citrobacter freundii, indicating unsafe water quality. Principal component analysis identified pollutant wash-off and rock weathering as influencing factors. Human activities, particularly agriculture and municipal sewage, contributed to elevated Cl-, NO3-, and PO42- levels. sewage.

Table 2.19: Water Quality Status of Some Rivers within Rima Catchment Area

N	State	River Name	Code	Wet Season	Dry Season	NFA
1	Zamfara	River Sokoto at Gusau WTP	SW/002	Good	Poor	Ni
2		River Gagre at intake Kaura Namoda WTP	SW/003	Good	Poor	Ni, Zn
3	Sokoto	River Rima at Sokoto WTP	SW/001	Good	Poor	-
		River Sokoto at Sokoto WTP	SW/002	Good	Poor	Fe, Ni
4	Katsina	River Sokoto at Ajiwa Dam	SW/001	Good	Poor	Ni

Note: The number of sampling of water quality is only two times (one in wet season and another in dry season). This table shows only preliminary evaluation based on the results of these limited samples.

Criteria:

Good quality : BOD = < 3 and 6=<DO (based on Nigeria Standard Values for surface water- recreation & fisheries) Moderate : 3<BOD = <6 and 4=<DO < 6 (based on Nigeria Standard Values for surface water- irrigation & reuse) Poor: BOD > 6 or DO < 4 (proposed by JICA Project Team)

NFA: need further assessment because of the presence of higher values in the samples than the standard (abdulqadir musa et al) collected 30 samples at selected points to test the quality of water in river rima. His findings revealed that

2.7.1 Surface Water Quality

The Rima Catchment faces increasing risks of surface water pollution due to rapid urbanization, industrial activities, and agricultural expansion (refer to Table 2.20). While it is less industrialized compared to the Hadejia Catchment, several factors contribute to water quality deterioration in the region. Some of the major sources of pollution in the Rima Catchment include:

Agricultural Runoff: Large-scale irrigated agriculture, particularly in areas around the Goronyo Dam and Bakolori Irrigation Scheme, results in the leaching of fertilizers and pesticides into the Rima River system. The heavy use of nitrogen-based fertilizers and herbicides contributes to nutrient loading, leading to eutrophication and potential contamination of drinking water sources.

Urban Wastewater Discharge: Towns such as Sokoto, Gusau, and Katsina discharge untreated or poorly treated sewage into rivers. Many urban centers lack adequate wastewater treatment infrastructure, allowing domestic waste and pathogens to enter watercourses.

Industrial Effluents: While industrialization in the Rima Catchment is not as advanced as in Kano, there are tanneries, textile processing plants, and abattoirs in urban centers like Sokoto and Gusau. Effluents from these industries introduce heavy metals such as chromium, cadmium, and lead into the water.

Mining Activities: Artisanal mining in Zamfara State, especially gold mining, has led to contamination of water sources with lead, mercury, and arsenic, posing a significant health hazard to communities relying on these water sources.

Sediment Load and Erosion:

- Due to deforestation and unsustainable land-use practices, increased sedimentation is a major concern in rivers such as the Gagere, Ka, and Maradi tributaries of the Rima River.
- High sediment loads degrade water quality and reduce the capacity of reservoirs such as the Goronyo Dam.
- Studies conducted on the Rima River have shown elevated levels of total dissolved solids (TDS), coliform bacteria, and heavy metals, especially downstream of urban and industrial areas. Further investigations are needed to assess long-term pollution trends and their impact on aquatic ecosystems and human health.

2.7.2 Groundwater Quality

Groundwater in the Rima Catchment is an essential source of water for domestic use, irrigation, and livestock production. However, water quality varies significantly depending on location, aquifer depth, and proximity to pollution sources. The following parameters are critical in assessing groundwater quality in the catchment:

2.7.2.1 Groundwater Electrical Conductivity (EC)

Electrical conductivity (EC) is a key indicator of total dissolved salts (TDS) in groundwater. In the Rima Catchment:

- The Sokoto Basin aquifer system, which includes the Dukamaje, Taloka, and Gundumi formations, generally exhibits moderate EC levels (200–600 µS/cm), indicating relatively fresh water.
- Areas near urban centers such as Sokoto, Gusau, and Katsina show higher EC values, exceeding 1,000 µS/cm, due to industrial effluents, agricultural runoff, and domestic waste infiltration.
- The highest EC values are observed in shallow aquifers near the Goronyo Dam, where irrigation return flows contribute to increased salinity.

2.7.2.2 Fluoride Distribution

- Fluoride concentration in groundwater is a concern in certain parts of the Rima Catchment. WHO and Nigerian drinking water standards recommend a maximum permissible fluoride concentration of 1.5 mg/L.
- High fluoride levels (above 2.0 mg/L) have been recorded in some deeper aquifers, particularly in northwestern Sokoto State, leading to cases of dental and skeletal fluorosis.
- The shallow unconfined aquifers generally have fluoride concentrations below the permissible limit, making them suitable for drinking.
- Mitigation strategies such as defluoridation treatments and alternative water sources need to be considered in high-risk areas.

2.7.2.3 Nitrate Distribution

- Nitrate contamination is primarily linked to fertilizer application, septic tanks, and pit latrines, particularly in urban areas.
- Highest nitrate levels (above 100 mg/L) have been recorded in groundwater samples from Sokoto and Gusau, exceeding the WHO limit of 50 mg/L.
- The correlation between high nitrate concentration and urban centers suggests contamination from poor sanitation infrastructure and excessive fertilizer use in peri-urban agricultural lands.
- Shallow groundwater sources near irrigation schemes in Bakolori and Goronyo also show elevated nitrate levels.

- To prevent further contamination, proper waste disposal, improved sanitation, and controlled fertilizer use must be enforced.

2.7.2.4 Heavy Metal and other Metals

Heavy metal contamination in the Rima Catchment is largely due to industrial effluents, mining activities, and natural leaching from rock formations.

Lead and Mercury: Gold mining activities in Zamfara State have resulted in elevated lead (Pb) and mercury (Hg) levels, causing severe health crises, particularly among children.

Chromium and Cadmium: Tanneries in Sokoto and Gusau discharge chromium-rich effluents, which infiltrate groundwater and pose long-term health risks.

Arsenic: Arsenic contamination is localized but present in areas with extensive pesticide use, particularly in agricultural zones along the Rima and Gagere Rivers.

To mitigate these risks, industrial wastewater treatment, mine waste management, and stricter environmental regulations should be enforced across the catchment.

Maximum allowable limits and health implications of continuous ingestion of high quantities of heavy metals are presented in the table below:

Table 2.20: 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	Renaldys function, 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

Groundwater quality assessments in the Rima Catchment have focused primarily on urban centers with high groundwater exploitation due to population density, industrial activities, and agricultural practices. Laboratory analysis indicates heavy metal contamination in several areas, with the highest levels recorded in major urban centers and regions influenced by industrial discharge and mining activities.

2.7.3 Surface Water Resources

Description of the basin

The Rima River Basin is situated in the semi-arid Northern Nigeria. The Rima River Basin has a strongly seasonal rainfall regime. Around 80% of the rainfall occurs in just three or four months, between June and September, supporting rain-fed agriculture and extensive pastures for livestock grazing, with little or no flows occurring during the driest months. Farmers and pastoralists concentrate in the vast floodplains and wetlands that have formed where the waters of the Rima River flows. The groundwater system is recharged mainly from seasonal flooding due to riverbank overtopping and to a lesser extent from concentration of rainfall in depressions. (Source: FMWR-TRIMING PROJECT REPORT 2016)

2.7.4 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 (Table 2.21 and Table 2.22) can flow passing through the boundary in large scale.

Table 2.21: Ground water recharge

Item	Hydrological area
	HA-1
Area(km2)	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 2.22: 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**
Maestrichitian	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

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 Bain as shown in

Table 2.23 and Figure 2.22.

Table 2.23: 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

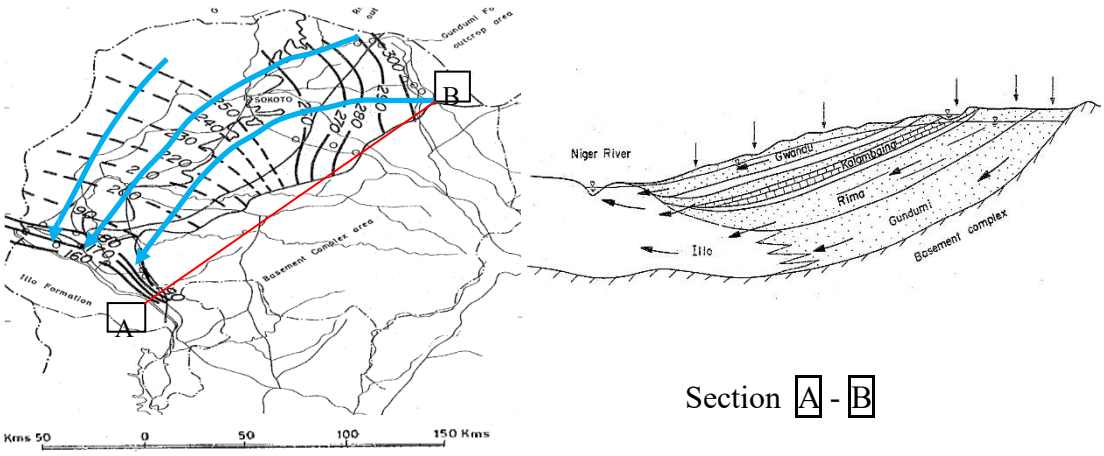


Figure 2.22: Groundwater Flow in Sokoto Basin

Error! Reference source not found. to

Table *2.26* shows Aquifer Model, Relation between Aquifer Type and Aquifer Model, Groundwater Development Potential by Aquifer and Optimum Yield of Borehole Field of the Rima Catchment.

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

Model	Symbol		Aquifer type	Thicknesof 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 2.24: 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 (san/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 2.25: Groundwater Development Potential by Aquifer

Age	Formation	Lithology	Aquifer Characteristics	Ground-water recharge (mm/year)	Aquifer Model
HA-1 ： Niger North					
Eocene	Gwandu Formation	Sand and clay.	Aquifer with large outcropping area ofmaximum thickness of 300m. Basal sandstone form good aquifer.	24	MM
Paleocene	Kalambaina Formation (Sokotogroup)	Limestone, calcareous shale.	Sandstone form perched aquifers, which provide groundwater to shallow wells.	1	ML
	Dange Formation （Sokotogroup）	Shale and limestoneat bottom.	Aquitard confining underlying aquifer.	1	WL
	Wurno Formation (Rima Group)	Fine sandstone and Dukamaje clay stoneat the top.	Confined aquifer of medium to coarse sand with recharge area of 330 km^2.	18	MM
Maestri-chitian	Dukamaje Formation (RimaGroup)	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 is180m.	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 2.26: 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

Source: JICA Project Team. What is WH, WM, WL, MH, MM and ML

Figure 2.23 to Figure 2.25 Density of Distribution of Borehole Fields, Balance of Groundwater Demand and Recharge and Balance of Groundwater Demand and Recharge in 2030 by Effect of Climate Change

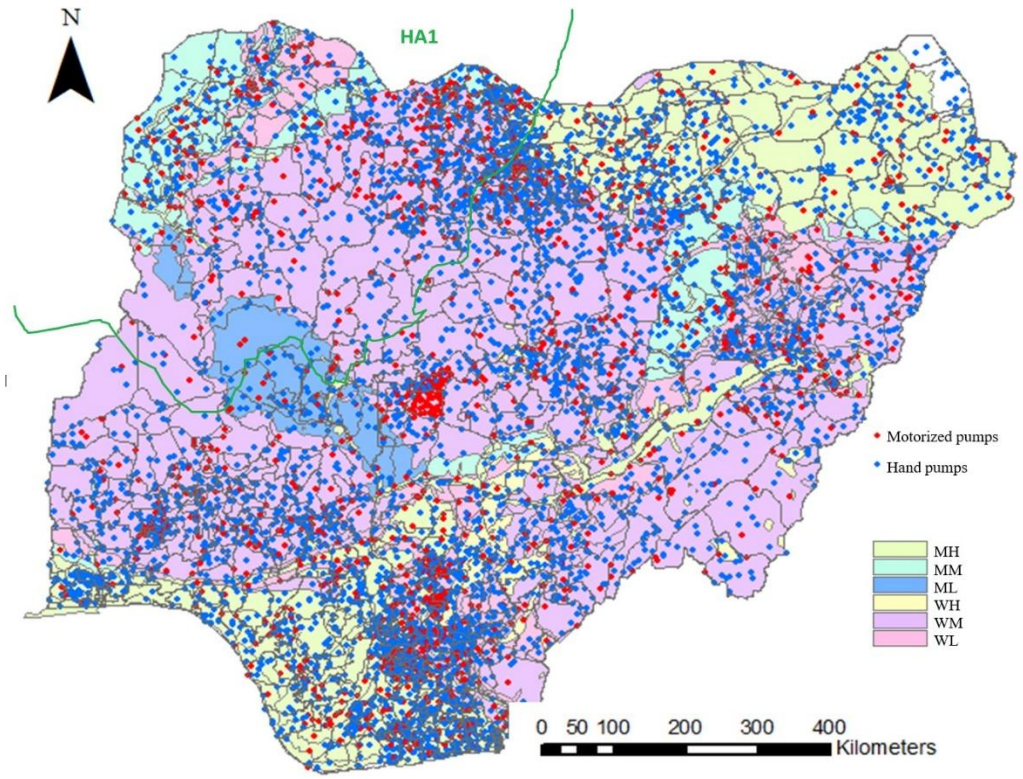


Figure 2.23: Density of Distribution of Borehole Fields (2030) by LGA

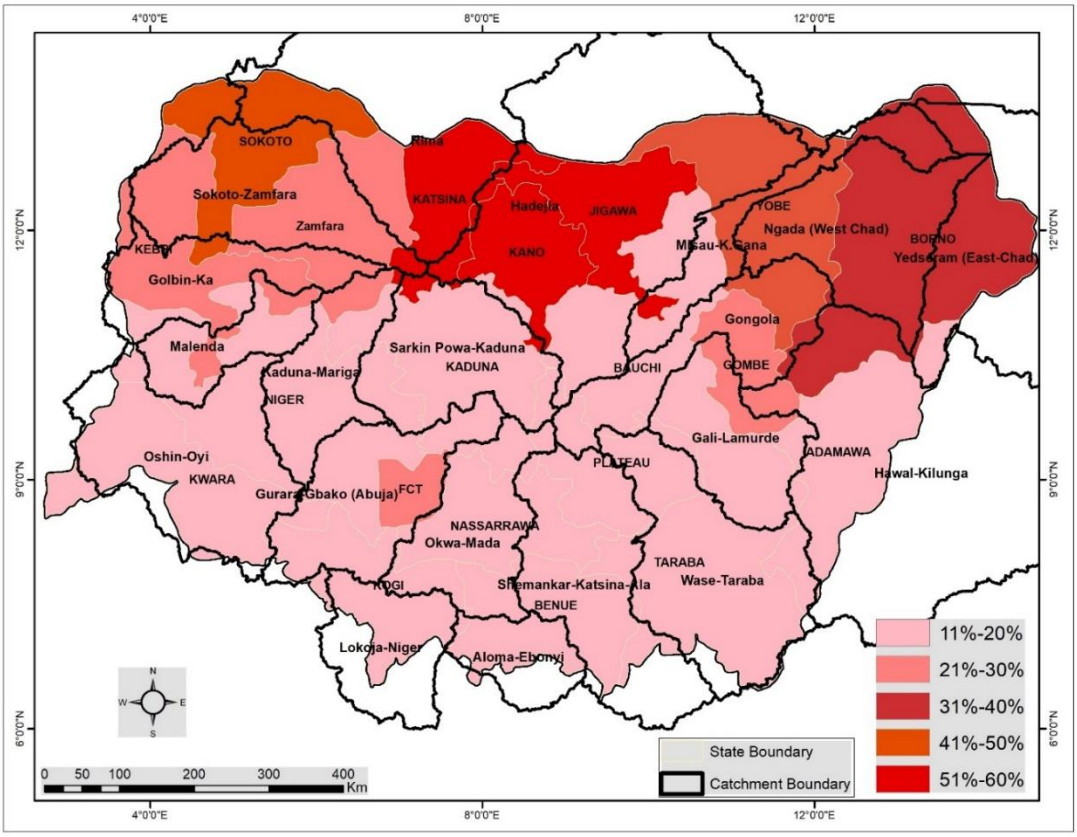


Figure 2.24: Balance of Groundwater Demand and Recharge in 2030

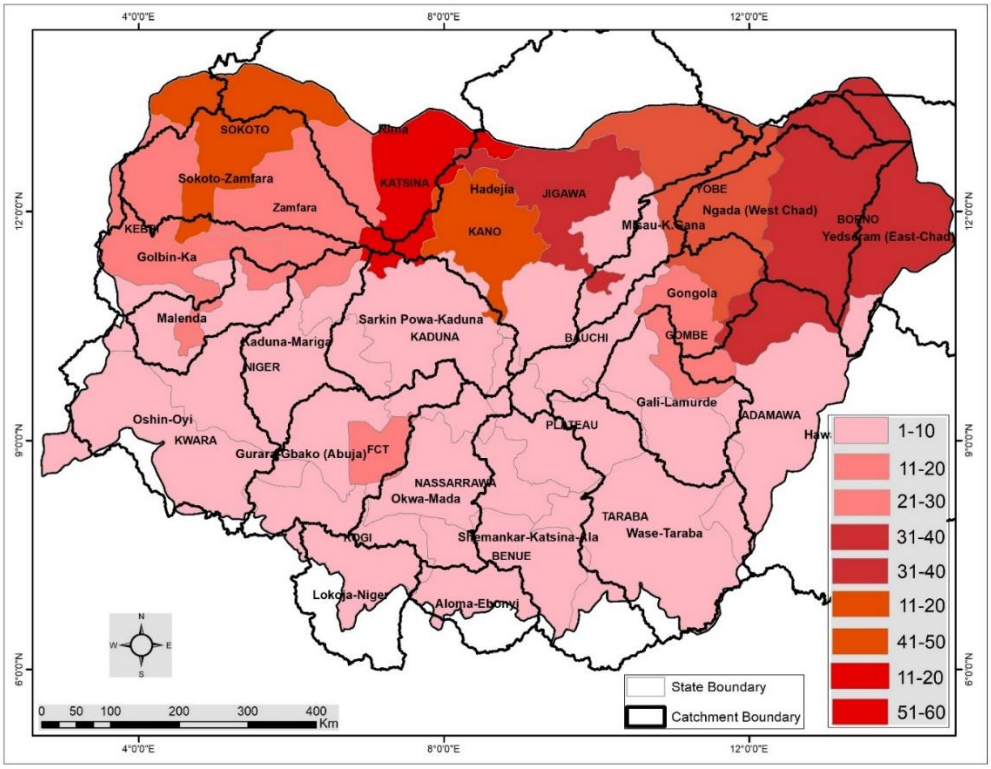


Figure 2.25: Balance of Groundwater Demand and Recharge in 2030 by Effect of Climate Change

2.8 Climate Change Impact On Water and Land Resources

Climate change is significantly altering the water and land resources of the Rima Catchment, threatening water security, agricultural productivity, and overall ecosystem stability. The impacts are driven by changes in temperature, precipitation patterns, and extreme weather events. Below is an overview of climate change impact on water and land resources in the Rima catchment.

2.8.1 Historical and Future Climatic Trends

The Rima catchment is vital for agriculture and water supply, but climate change poses serious risks like water scarcity and reduced agricultural productivity. Rising temperatures and changing rainfall patterns will worsen these issues. Sustainable management and climate-resilient practices are essential for long-term viability.

2.8.2 Annual Rainfall and Temperature for Rima Catchment

2.8.2.1 Rainfall Trends

Figure 2.26 is the annual rainfall trend for the Rima Catchment (1981-2050). From the figure, the slope of 1.8599 indicates a declining trend in annual rainfall over time (1981-2050). On average, rainfall increases by 1.86 mm per year during the rainy season.

An R^2 of 0.3522 suggests that approximately 35.22% of the variability in rainfall is explained by the trend, meaning that while rainfall is generally increasing, significant variability exists, and other factors may influence rainfall patterns. Comparison of Historical and Projected Periods

- The increasing trend in rainfall could have implications for agriculture, water resources, and flood risks in the region. Increased rainfall may improve water availability for agriculture, hydropower, and ecosystems.
- Higher rainfall could enhance soil moisture and support crop production, provided that variability does not lead to extreme flooding.

If the increasing trend continues, it could lead to a higher risk of seasonal flooding, which may threaten infrastructure, settlements, and farmlands.

- Variability in rainfall, including droughts and extreme wet periods, may still pose challenges for water resource management.

While increasing rainfall could benefit agriculture and water availability, managing extreme events such as droughts and floods will be critical for sustainable development in the region.

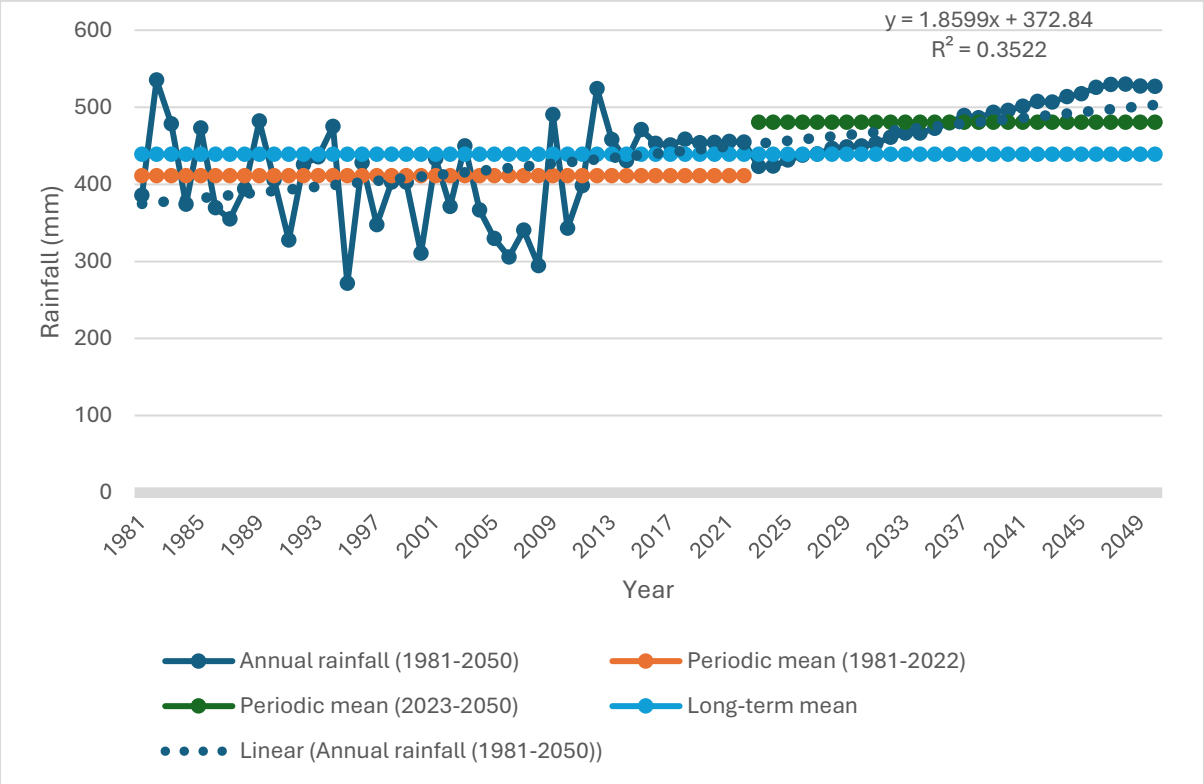


Figure 2.26: Annual rainfall trend for Rima Catchment (1981-2050).

2.8.2.2 Temperature Trends

- The mean monthly temperatures during the historical period ranged from 20.58°C (January) to 33.28°C (May), indicating a significant seasonal variation (Figure 2.27). The coolest month is January, while the hottest month is May.
- In January (20.58°C) and February (23.55°C), temperatures are mild, followed by a sharp increase in March (28.05°C), reaching a peak in May (33.28°C).
- Temperatures remain high but begin to decline slightly, with June (32.26°C) and July (29.55°C) being hot and August (27.58°C) showing a noticeable drop.
- September (28.22°C) and October (28.04°C) remain warm and stable, dropping in November (24.79°C) as Harmattan sets in.

The projected period follows the same pattern with a slight increase in both minimum and maximum temperatures compared to the historical period.

- The mean temperature is projected to increase by 0.40°C (from 27.44°C to 27.84°C), indicating a gradual warming trend.

- The overall warming trend aligns with global climate change predictions, with the most significant increases occurring in spring and summer.
- The slight cooling in August and September highlights the importance of catchment climatic factors, which can sometimes offset broader warming trends.
- The projected increases in spring and summer temperatures may require adaptation strategies, such as improved heat mitigation, water management, and agricultural planning.

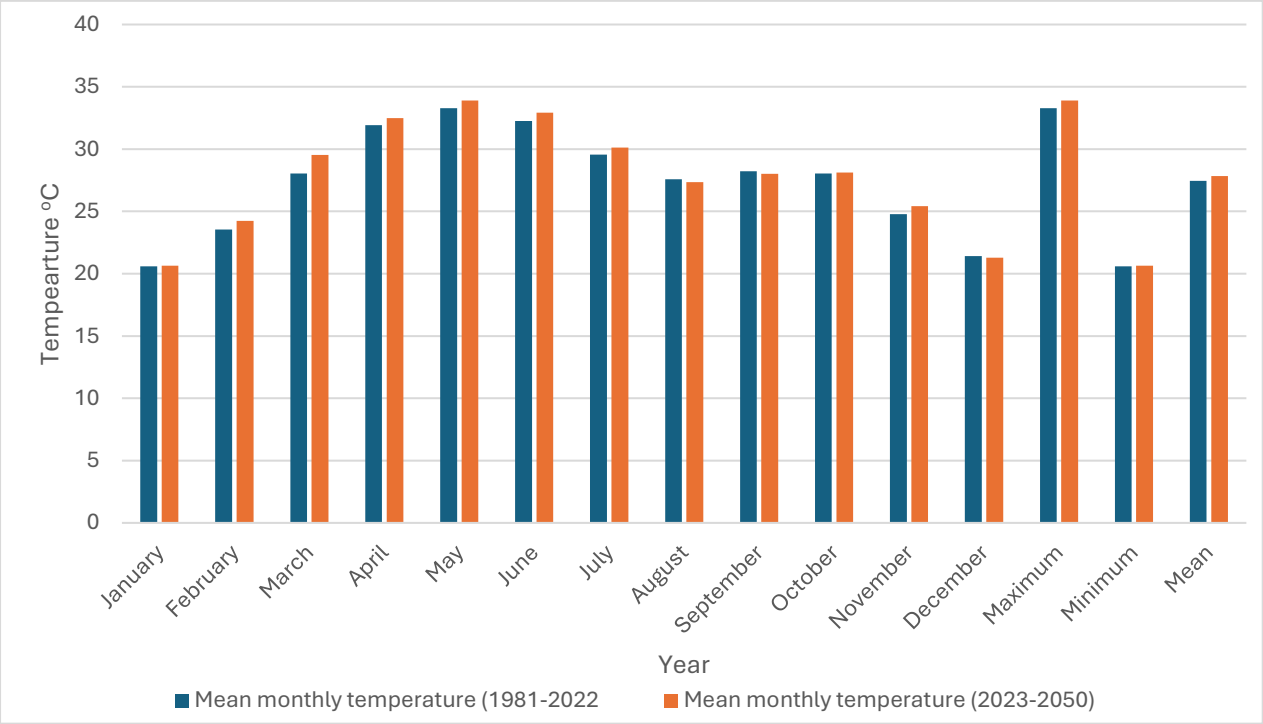


Figure 2.27: Mean monthly temperature for Rima Catchment (1981-2022 and 2023-2050)

2.8.3 Projected Mean Annual Temperature for Rima Catchment

Error! Reference source not found. presents a time series analysis of temperature trends from 1981 to 2022, with projections extending to 2050.

Figure 2.28 shows that the annual mean temperature for the Rima Catchment from 1981 to 2050 is gradually increasing with a slope of 0.0118, which indicates that temperatures are rising at an average rate of 0.0118°C per year, or approximately 1.18°C per century.

An R^2 of 0.3357 suggests that about 33.57% of the variability in annual mean temperature can be explained by the linear trend, while the remaining variability is due to other factors.

In general, the linear trend line indicates a consistent increase in temperature over the 70 years, with the projected period (2023-2050) being warmer than the historical period (1981-2022).

- The increasing temperature trend could have significant implications for agriculture, water resources, and ecosystems in the Rima Catchment.
- Higher temperatures may lead to increased evapotranspiration, water stress, and changes in crop productivity.
- The negative impact of increasing temperature on the ecosystem could further aggravate the farmer-herder crisis being experienced in the basin.
- The projected warming trend highlights the need for adaptation strategies (e.g., improved water management, heat mitigation) and mitigation efforts (e.g., reducing greenhouse gas emissions) to address the impacts of climate change.

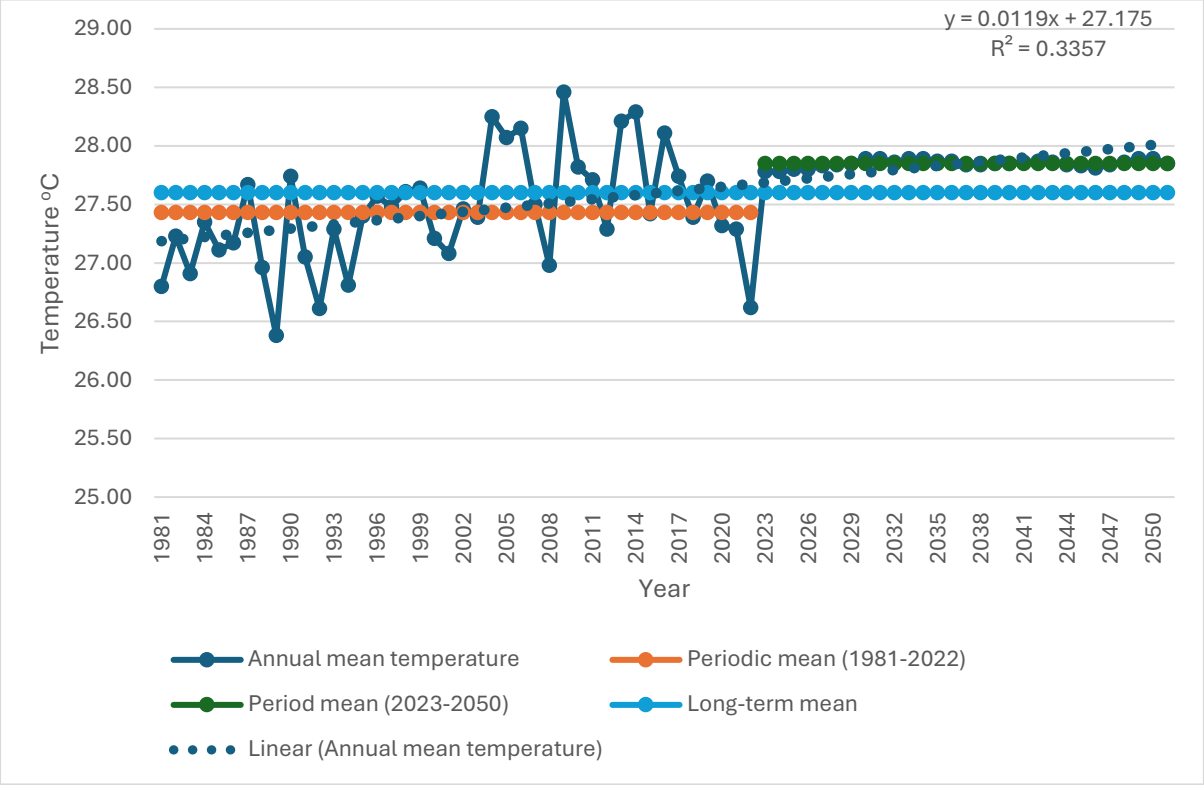


Figure 2.28: Trends in mean annual temperature for Rima Catchment (1981-2050)

2.8.4 Analysis of Downscaled Output of GCMs

To explore future climate changes, the statistically downscaled output from GCMs by CCAFS is analyzed, using Worldclim3 for bias correction. The CCAFS dataset includes average monthly precipitation and air temperature with 30-year running averages from the 2020s to the 2080s. Various emission scenarios are available for this analysis.

- 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.

To explore future climate conditions, the statistically downscaled output from seven Global Climate Models (GCMs) was analyzed using the A1B emission scenario, which assumes high economic growth with balanced energy sources.

- Changes in precipitation and temperature averaged over the 7 GCM for three time horizons are presented in Figures 43 and 44.

The study follows the NWRMP's method for determining a 30-year running average, targeting the years 2035 and 2065. Given a typical 50-year project lifespan, results for the 2050s (2040-

2069 averages) from the GCMs are applicable for 2035, while results for the 2080s (2070-2099 averages) apply for 2065.

The study assumes seasonal precipitation changes are based on average GCM outputs, and the annual change in mean air temperature reflects GCM results. The change factors are summarized in Fig 2.29, Fig 2.30 and Table 2.27 below.

Table 2.27: 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

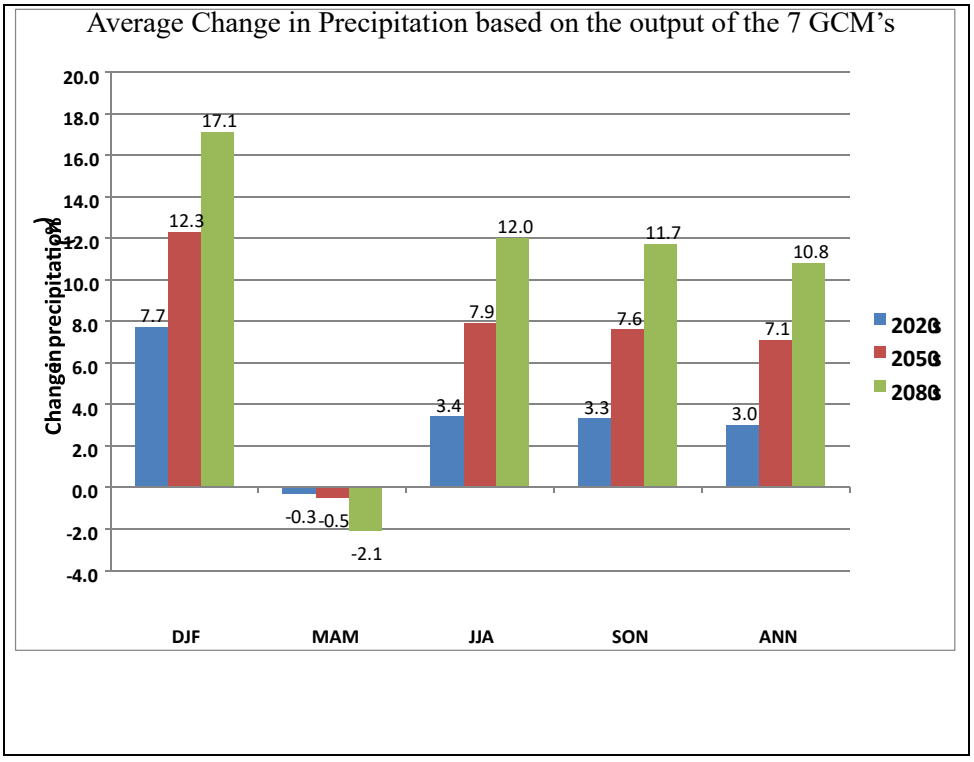


Figure 2.29:Average changes in precipitation derived from outputs of 7 GCMs (source: JICA,2014)

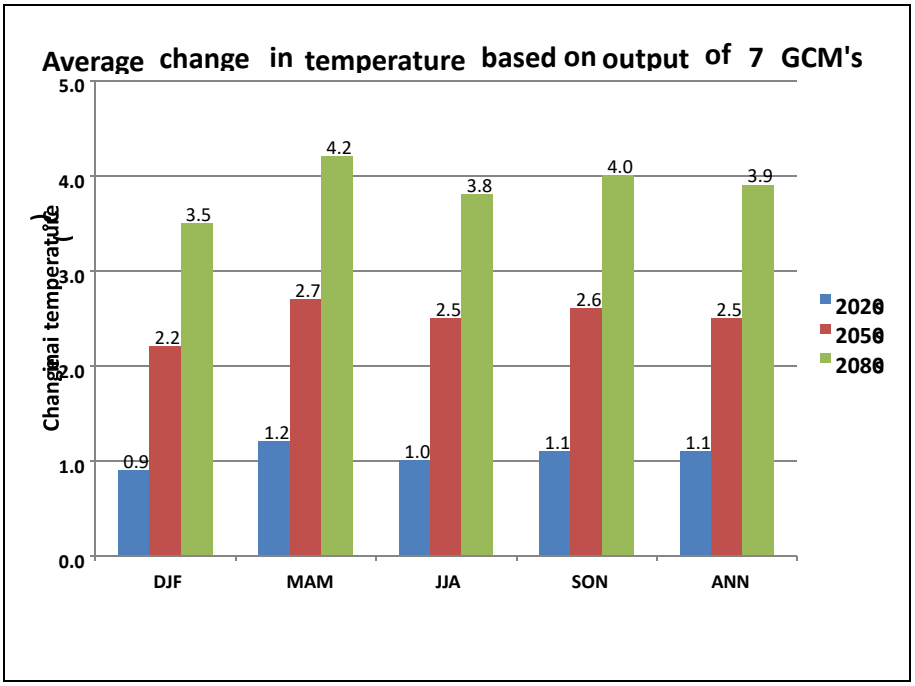


Figure 2.30: Average changes in temperature derived from outputs of 7 GCMs (source: JICA 2014),

2.8.5 Evapotranspiration

Evapotranspiration rates are high throughout the Rima Catchment due to the hot and dry conditions, particularly during the dry season.

- In the northern areas, annual evapotranspiration can reach 2,000 to 2,500 mm, often exceeding annual rainfall, leading to water deficits (see Figure 2.31).
- This high rate of water loss limits surface water availability, making irrigation difficult and increasing reliance on groundwater resources for agriculture, domestic use, and livestock rearing.
- The combination of high temperatures, seasonal water shortages, and variable rainfall contributes to the catchment's vulnerability to desertification, drought, and agricultural instability.

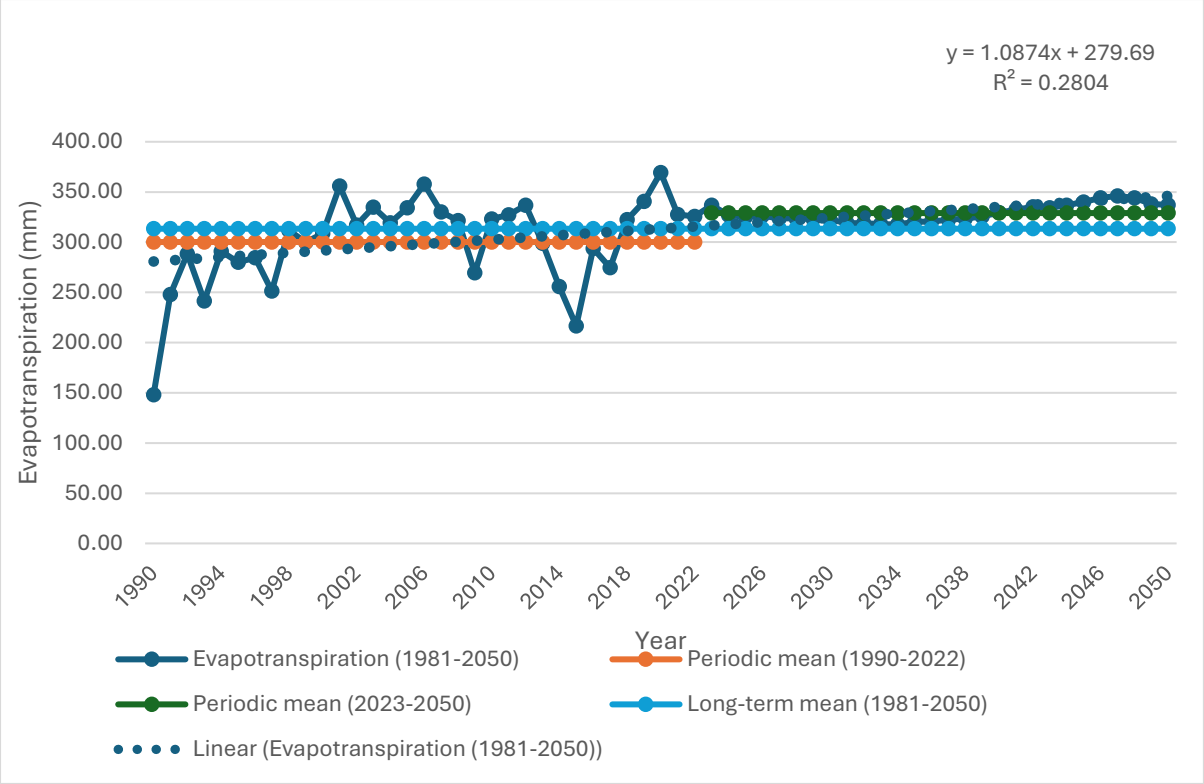


Figure 2.31: Annual evapotranspiration trend for Rima Catchment (1990-2050).

2.8.6 Major Impacts of Climate Change

Climate change is significantly impacting multiple sectors in the Rima Catchment shown in Table 2.28. Addressing the impacts of climate change challenges requires climate adaptation strategies, including water resource management, resilient infrastructure, improved healthcare systems, and sustainable agricultural practices.

Table 2.28: Key Impacts of Climate Change

S/No.	Sector	Impact	Details
1	**Social**	Increased vulnerability of communities	Higher poverty rates due to crop failures and loss of livelihoods.
		Food insecurity	Reduced agricultural productivity leading to food shortages.
		Displacement and migration	Flooding and droughts force people to leave their homes.
		Health risks	Increased prevalence of waterborne diseases due to poor water quality.
2	**Environmental**	Desertification and land degradation	Soil erosion, reduced soil fertility, and expansion of desert areas.
		Loss of biodiversity	Decline in wildlife populations and degradation of habitats.
		Wetland degradation	Shrinkage of wetlands due to reduced flooding and increased evaporation.
		Water scarcity	Reduced river flow and groundwater recharge.
3	**Health**	Waterborne diseases	Increased incidence of diseases like cholera and typhoid.
		Heat-related illnesses	Higher temperatures leading to heatstroke and dehydration.
		Malnutrition	Reduced food availability and quality affecting overall nutrition.
		Increased vector-borne diseases	Spread of diseases like malaria due to changing climate conditions.
4	**Infrastructure**	Damage to water infrastructure	Flooding and erosion affecting dams, reservoirs, and irrigation systems.
		Urban flooding	Increased frequency and intensity of floods in urban areas.
		Reduced effectiveness of drainage systems	Inability to handle increased runoff and flooding events.
		Increased maintenance costs	Need for more frequent repairs and upgrades to infrastructure.

5	**Services**	Water supply disruptions	Reduced availability of water for domestic and agricultural use.
		Increased demand for irrigation	Higher water requirements for crops due to changing rainfall patterns.
		Reduced hydropower generation	Lower river flows affecting hydroelectric power production.
		Increased costs for water treatment	Need for more advanced treatment to address water quality issues.

2.8.7 National and International Climate Change Frameworks/Agreements

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 challenges in line with the Paris Agreement and UNFCCC. It analyzes greenhouse gas emissions, climate vulnerability, and outlines adaptive and mitigation strategies tailored to Nigeria's socio-economic and environmental contexts.

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

To build on previous insights and provide an updated assessment of Nigeria's greenhouse gas (GHG) emissions, climate vulnerabilities, and adaptation strategies, the Third National Communication on climate change was released. This report reflects Nigeria's commitment to climate action and sustainable development, reviewing its climate policies and future directions. The Agriculture, Forestry, and Other Land Use (AFOLU) sector is the largest contributor to emissions at 60.1%, followed by the energy sector at 33.9%. Without intervention, emissions are projected to rise by over 58% by 2035. Nigeria faces significant climate vulnerabilities, including risks of drought, desertification, 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 shown in Figure 2.32 Weighted vulnerability analysis allows us to answer questions that are impacted by many factors and assign varying weights to each factor. The result gives more information than binary analysis, as it ranks locations based on their vulnerability rather than giving only a vulnerable/not vulnerable result.

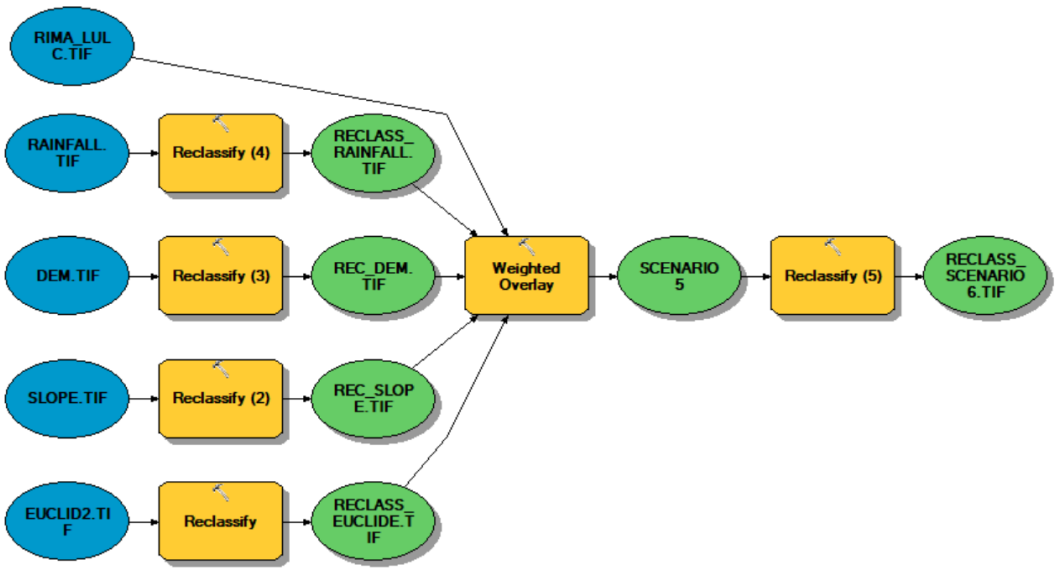


Figure 2.32: The flow chat of the methodology

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. 2.32 for a graphical depiction of the model used to carry out the flood vulnerability model exercise.

2.9.1 Digital Elevation Model

Elevation is one of the most critical factors in flood modelling, as it directly influences the flow, direction, and extent of floodwaters. Flood models rely on elevation data to simulate how water moves across a landscape, where it accumulates, and which areas are most vulnerable to inundation. Elevation (Figure 2.31) determines the slope and gradient of the terrain, which dictate the direction and speed of water flow.

- Water naturally flows from higher to lower elevations due to gravity.

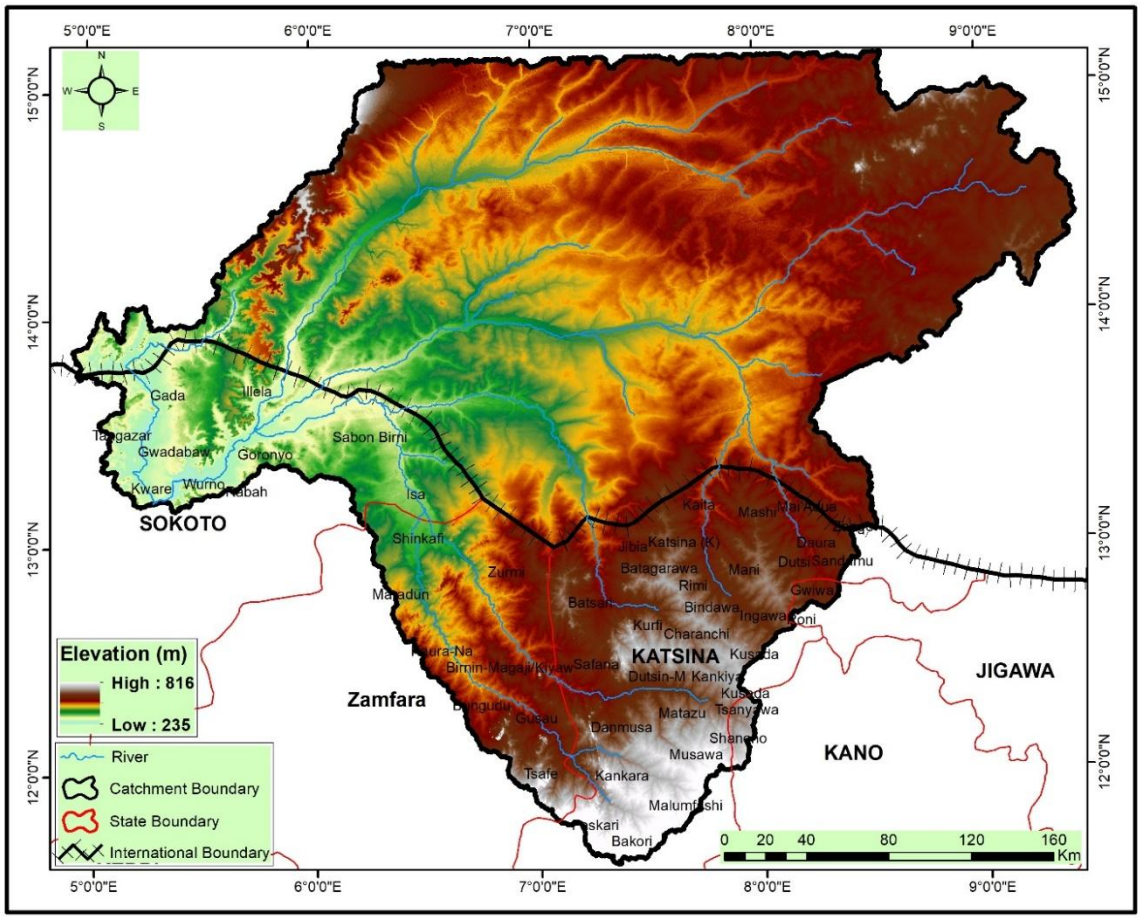


Figure 2.33: Digital Elevation Model of the Catchment (Source: MSL, 2025)

- 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.

From the legend above.

- The light grey areas indicate areas with higher elevations while the green to the light green shows lower elevation areas.
- The general elevation of the catchment ranges between 235m to 816m 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 significantly affects flood vulnerability, influencing the likelihood and severity of flooding events. It drives surface runoff and river discharge, especially in areas with heavy precipitation. (refer to Figure 2.34).

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.

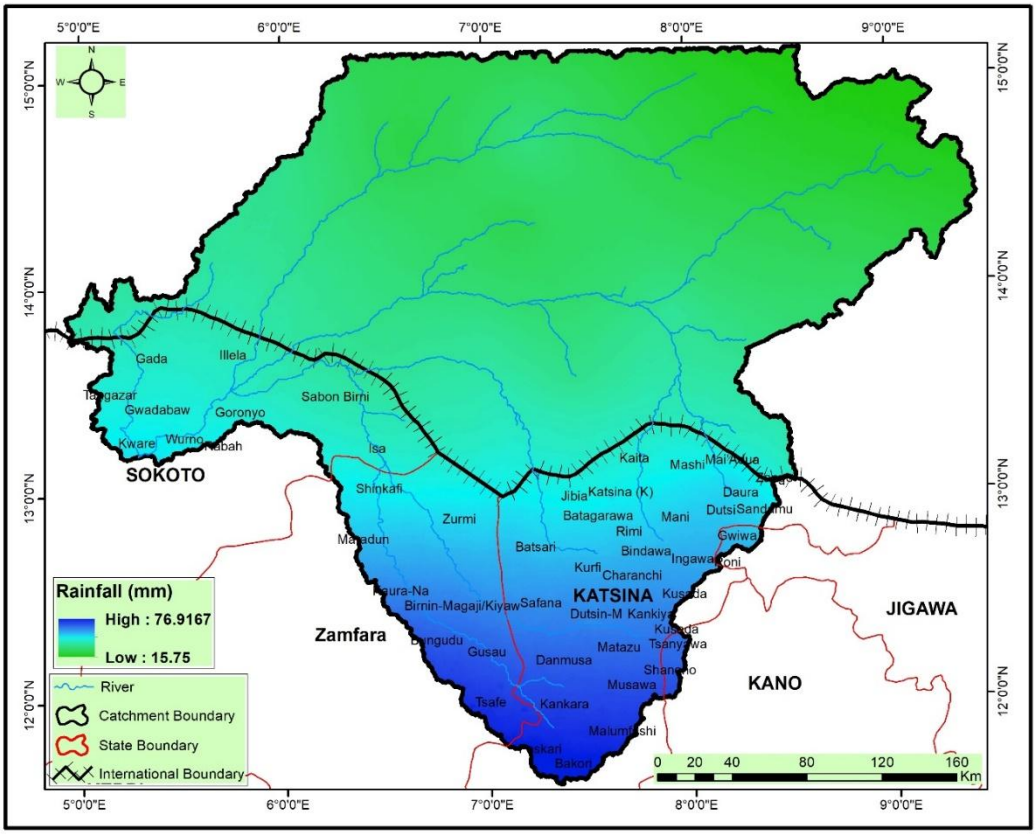


Figure 2.34: Rainfall Map of the Catchment (Source: MSL, 2025)

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 wide range of rainfall distribution, with the values showing a sharp variation in spatial distribution from 76.92mm to as low as 15.75mm 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 affects the speed and volume of surface runoff. Like elevation, in areas with steep slopes, rainfall tends to flow faster due to gravity, resulting in higher velocity runoff (Figure 2.35).

- This rapid movement of water can lead to flash flooding, particularly in mountainous or hilly regions, where water moves quickly downstream, overwhelming drainage systems and causing damage to infrastructure.
- On the other hand, flatter areas tend to experience slower runoff, which may allow for better water infiltration and less immediate flooding. However, even in flatter areas, accumulated water can eventually overwhelm drainage systems if the capacity to handle runoff is exceeded

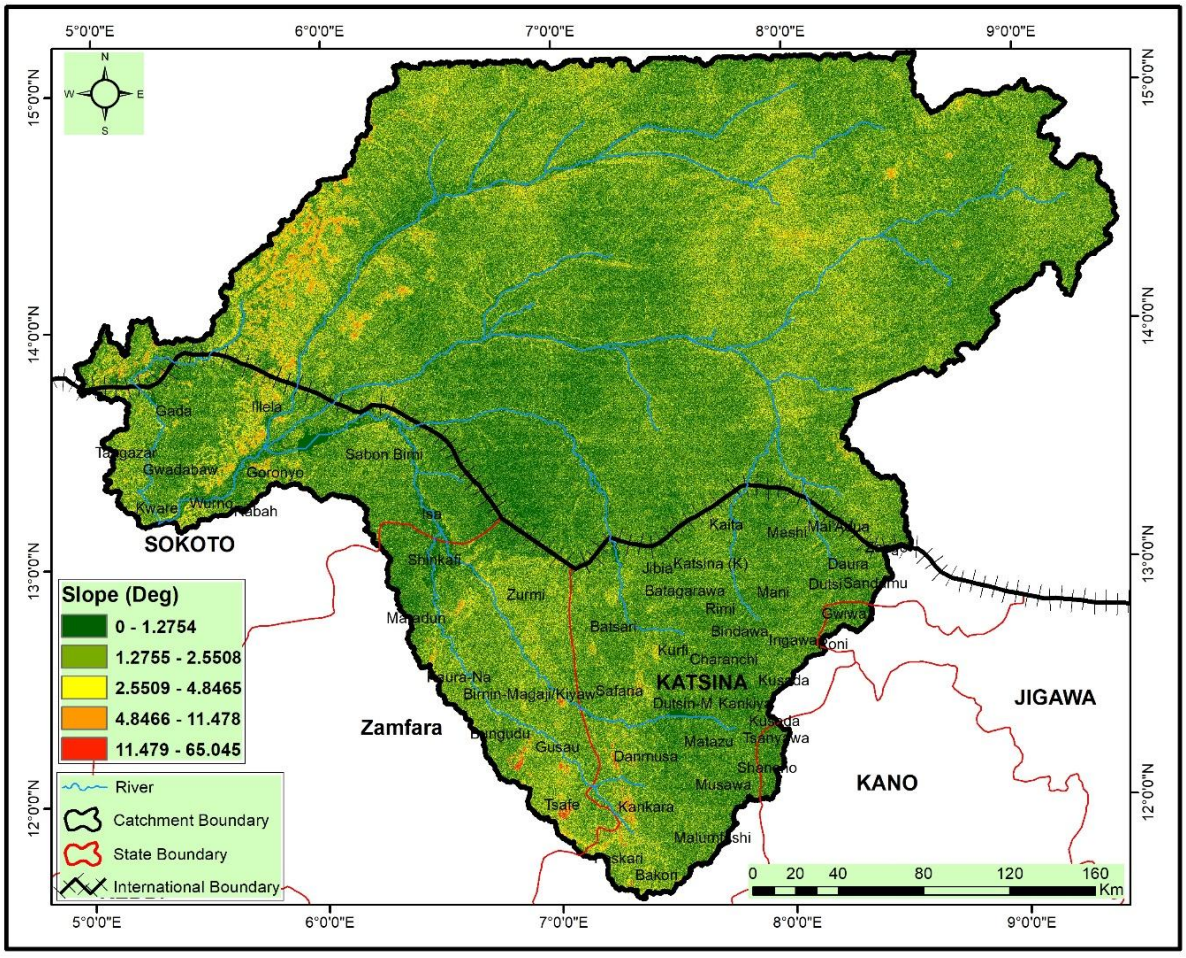


Figure 2.35: Slope Map of the Catchment (Source: MSL, 2025)

- The map delineates various levels of inclination in the terrain, providing insights into the landscape's characteristics.
- Areas with flat to very gentle slopes ($0–1^0$) are predominantly flat, increasing the likelihood of water pooling and slower drainage, potentially leading to flooding during heavy rainfall. Regions with gentle slopes ($1.3–2.6^0$) facilitate better water runoff compared with flatter areas but still pose a moderate risk of water accumulation.

- Areas with moderate slopes (2.6–4.8^0) exhibit a moderate steepness, promoting more rapid surface runoff, reducing water retention, and heightening the risk of soil erosion.
- Steep slopes (4.8–11.5^0) are susceptible to swift runoff and increased erosion, potentially causing the displacement of sediment and accelerated downstream water flow.
- Very steep slopes in this catchment (11.5-65^0) 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 shows some high elevations, making it less prone to standing water but capable of causing rapid runoff that could impact the adjoining flood plains 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.

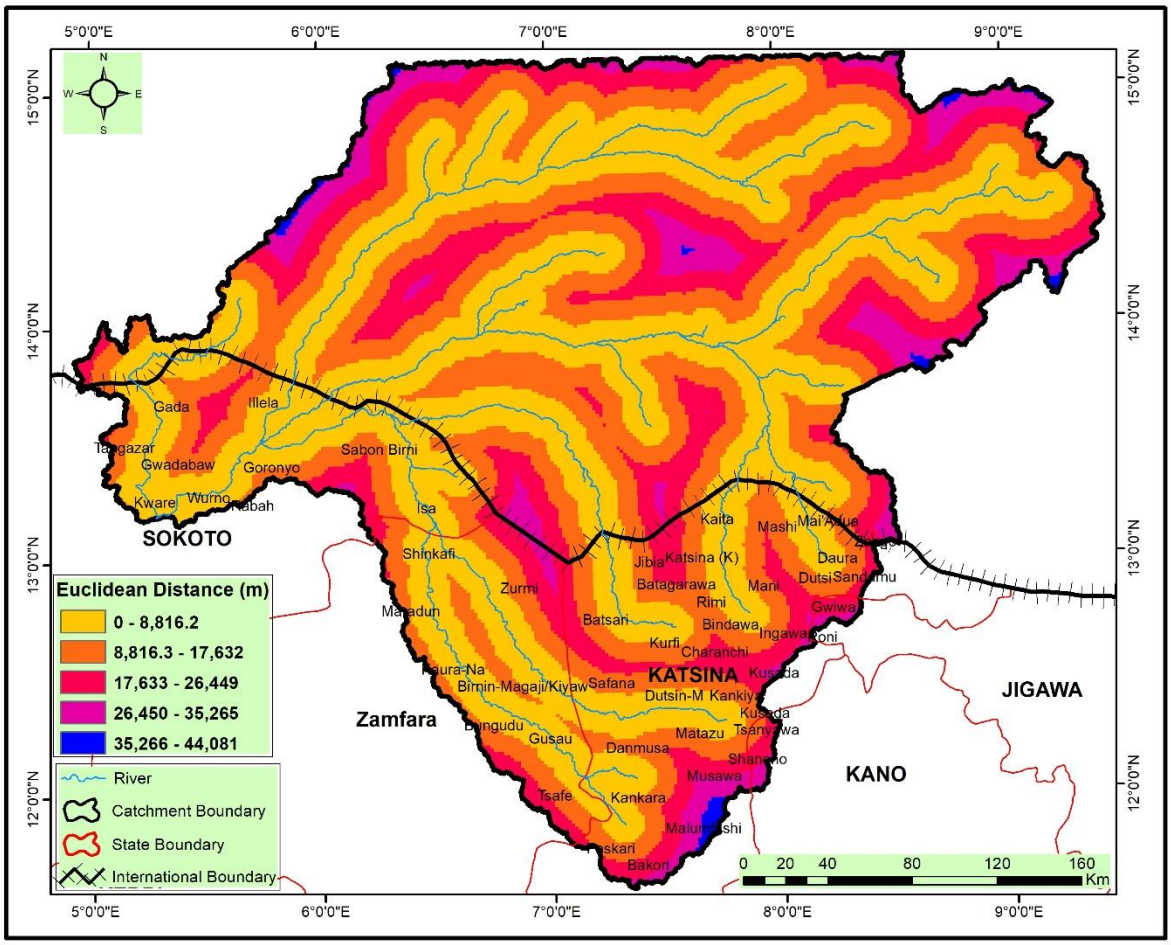


Figure 2.36: Proximity to River Map of the Catchment (Source: MSL, 2025)

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 ash shown in Figure 2.36.
- 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 influence how water moves across the landscape.

- Natural, undeveloped areas such as forests, wetlands, and grasslands have a higher capacity to absorb rainfall, reducing the volume of surface runoff.
- In contrast, urbanized areas (Figure 2.37) with impervious surfaces like roads, buildings, and parking lots prevent water from being absorbed, leading to higher runoff.
- Urbanization, particularly in floodplains and other vulnerable areas, exacerbates flood risk by increasing the rate and volume of runoff, which can overwhelm drainage systems and lead to flash flooding.
- Modelling the distribution of land use types helps to predict runoff patterns, which is crucial for assessing flood risk.

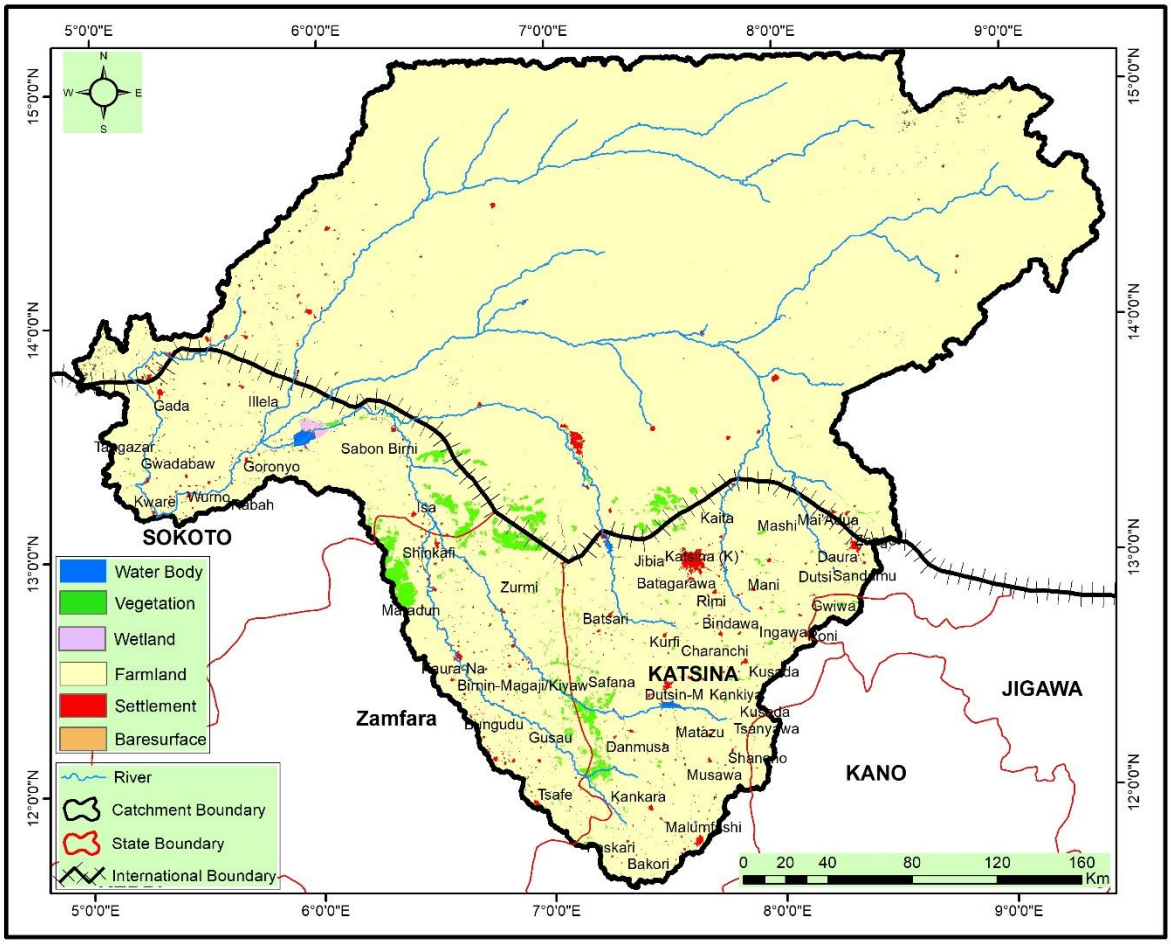


Figure 2.37: LULC Map of the Catchment (Source: MSL, 2025)

Human activities, such as urbanization and agriculture, often involve altering natural drainage systems to facilitate land development.

- The construction of roads, buildings, and infrastructure can obstruct or divert natural watercourses, leading to changes in the flow paths and velocities of rivers and streams.

- In some cases, floodplains may be filled in or levees may be constructed thereby changing the natural flood behaviour of the area.
- These alterations to the landscape can significantly increase flood risk, especially in areas where natural flood control mechanisms (e.g., wetlands, forests, or floodplains) have been disrupted.

2.9.6 Flood Vulnerability

The study deployed a weighted overlay analysis to assess the potential flood vulnerabilities across the catchment. The composite flood vulnerability map resulted from overlaying datasets, including the DEM, Proximity to rivers, precipitation, slope, and Land use Land cover. Prior to the overlay analysis, the layers underwent categorization, weighting, and scoring on a 1– 9 scale. Proximity to rivers received the highest weight, followed by elevation, precipitation, slope and Land use.

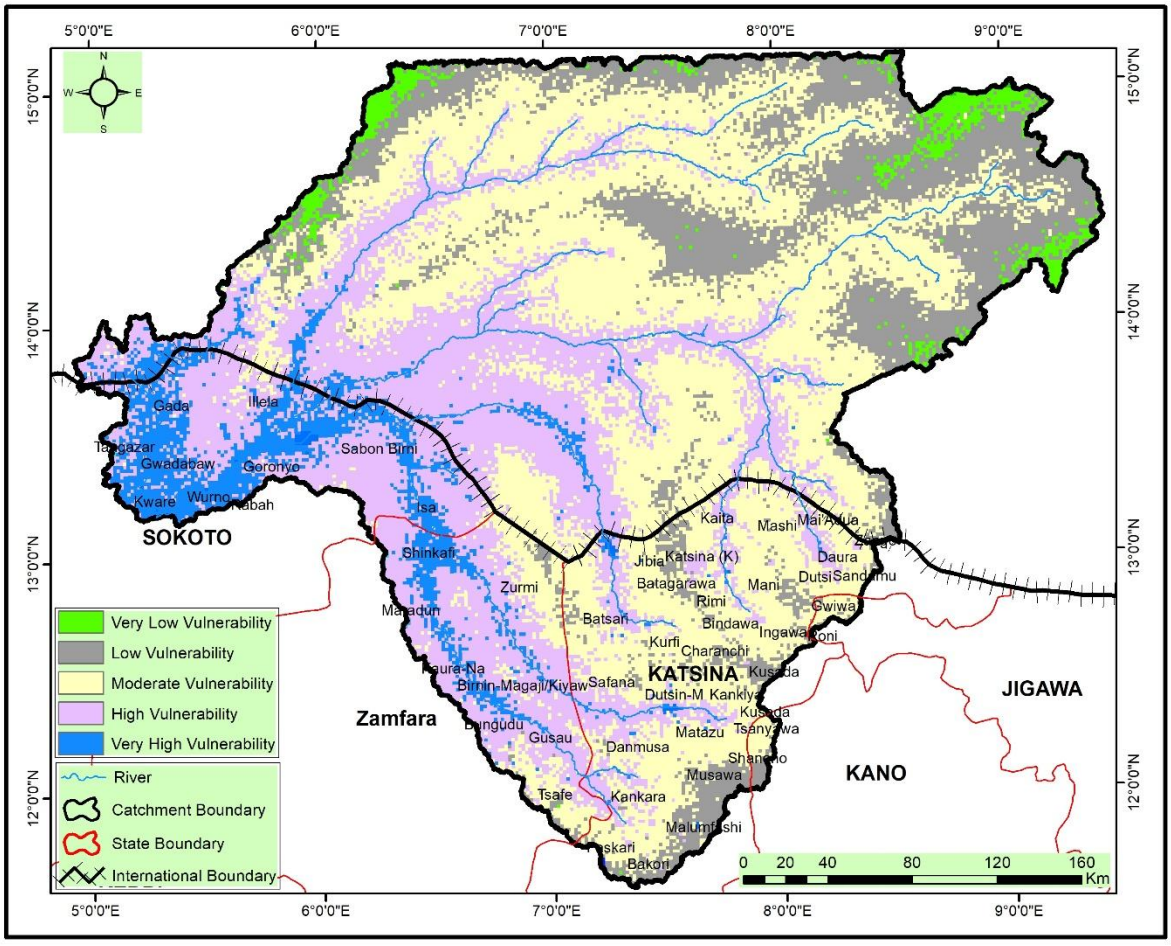


Figure 2.38: Flood Vulnerability Map of the Catchment (Source: MSL, 2025)

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 10,196,128.63 Ha.
- Areas with low flood risk areas are primarily located in high-elevation regions.
- Low flood vulnerability zones are also mostly found immediately after the highest areas. While these areas are not as susceptible to severe flooding as the high-risk areas, they still hold the potential for moderate flooding, particularly during heavy rainfall events (refer to Figure 2.38, Figure 2.39, and Table 2.29).
- High and very high flood vulnerability zones are predominantly concentrated in areas with lower elevation. These areas face a greater risk of flooding due to their proximity to the highlands and are characterized by large flood plains.

Table 2.29: Flood Vulnerability Analysis of the catchment

Vulnerabilities	Ha	%
Very Low Vulnerability	244849.498	2.421497
Low Vulnerability	1838290.12	18.18021
Moderate Vulnerability	4362005.33	43.13909
High Vulnerability	2985526.43	29.52607
Very High Vulnerability	667259.657	6.599023
Total	10111491.1	99.86589

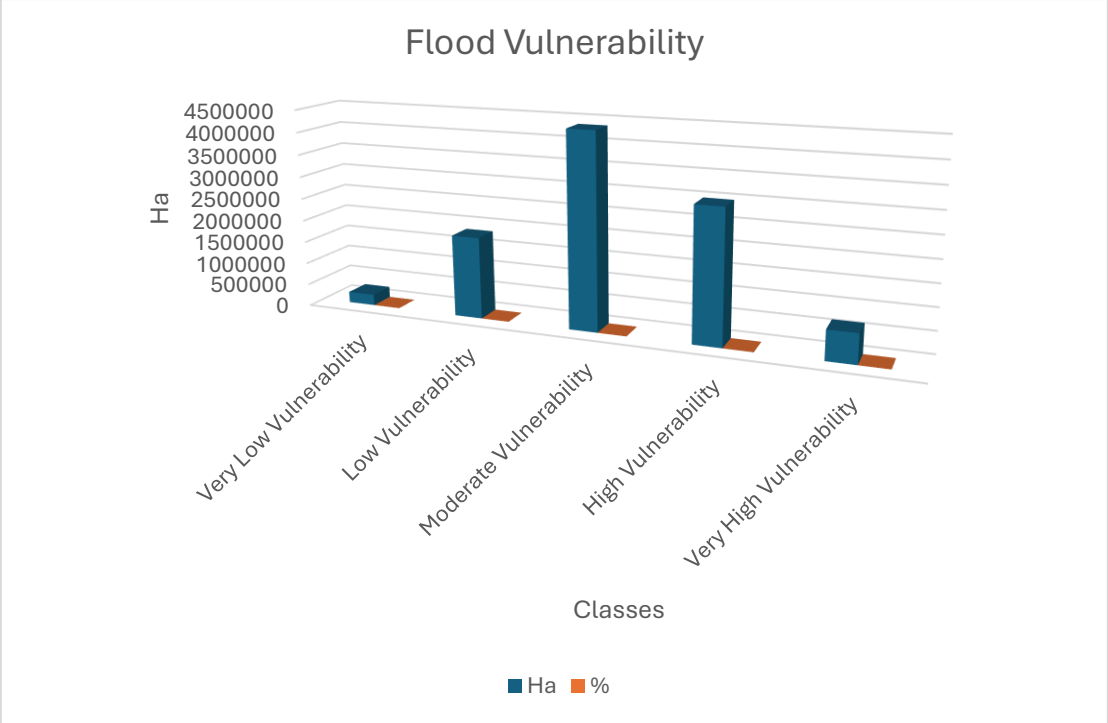


Figure 2.39: Flood Vulnerability Analysis of the catchment

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 landuse at higher risk to flooding. This analysis depicts areas and land uses within the critical zone are at high risk to flooding as shown Figure 2.40below.

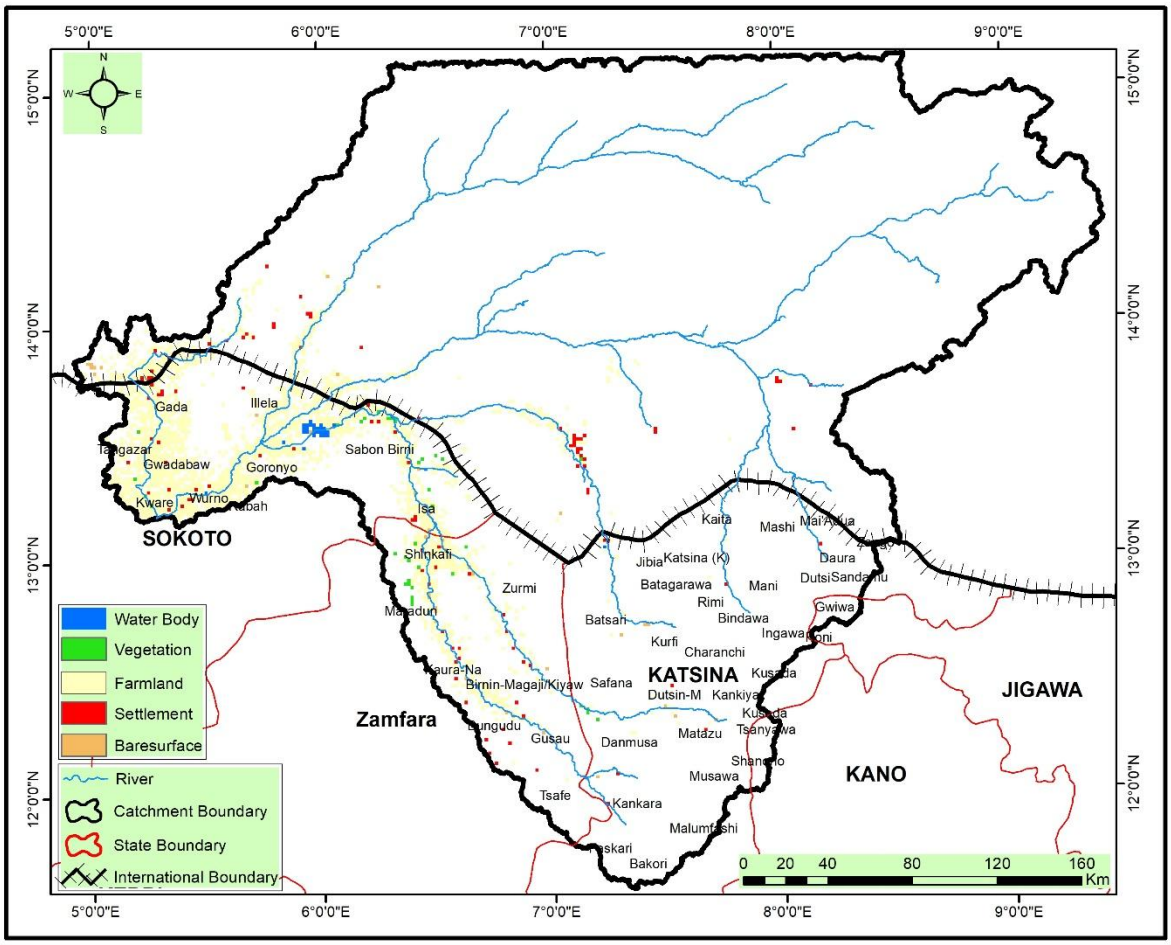


Figure 2.40: Flood Risk Map of the Catchment (Source: MSL, 2025)

The land use at risk in the Rima catchment is predominantly farmland at 24ha which is 91% of the total land use at risk withing the vulnerable area. Flooding in the Rima catchment is majorly influenced by the relief and proximity to rivers withing the catchment area (see Table 2.30and Figure 2.41).

Table 2.30: Flood Risk Analysis of the catchment

Class Name	**Ha**	**%**
Waterbody	0.05	0.191865
Forest	0.38	1.458173
Wetland	0.24	0.920952
Farmland	23.8	91.32771
Settlement	1.16	4.451266
Bareland	0.43	1.650038
Total	26.06	100

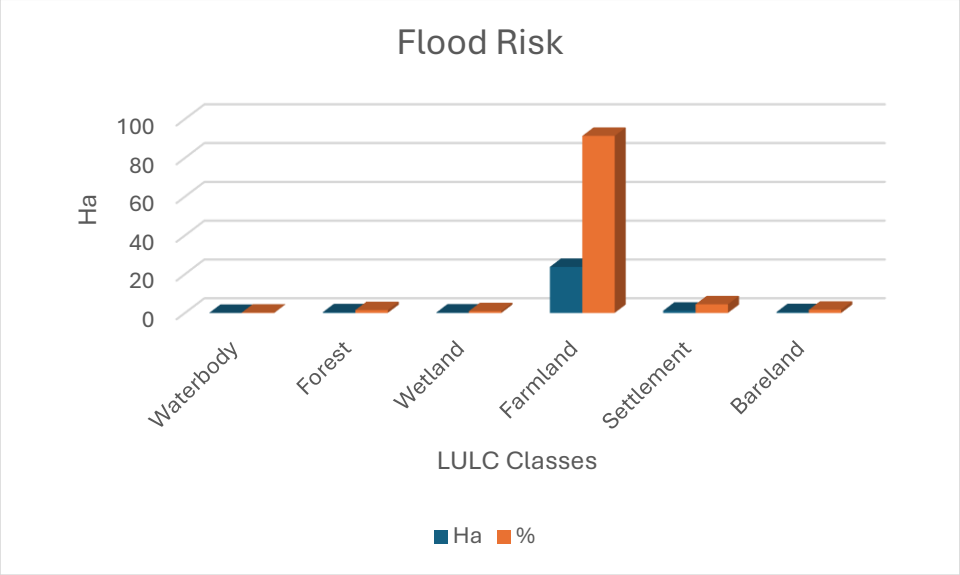


Figure 2.41: Flood Risk LULC analysis of the Catchment (Source: MSL, 2025)

2.10 Socio-Economic Dynamics

2.10.1 Population Distribution and Growth

The current population of the Rima catchment is approximately 15 million people (Figure 2.42 and Table 2.31).

- The population is primarily concentrated in urban centers and along major rivers, particularly the Rima River and its tributaries.
- Key cities within the catchment include Sokoto, Gusau, and Katsina, which serve as major hubs for economic activities and governance.

It is expected to grow to 20 million by the year 2050. This growth is driven by high fertility rates, particularly in rural areas, and improvements in healthcare infrastructure. More detailed tables with population by state and Local Government Area (LGA) is shown in Annex 1.

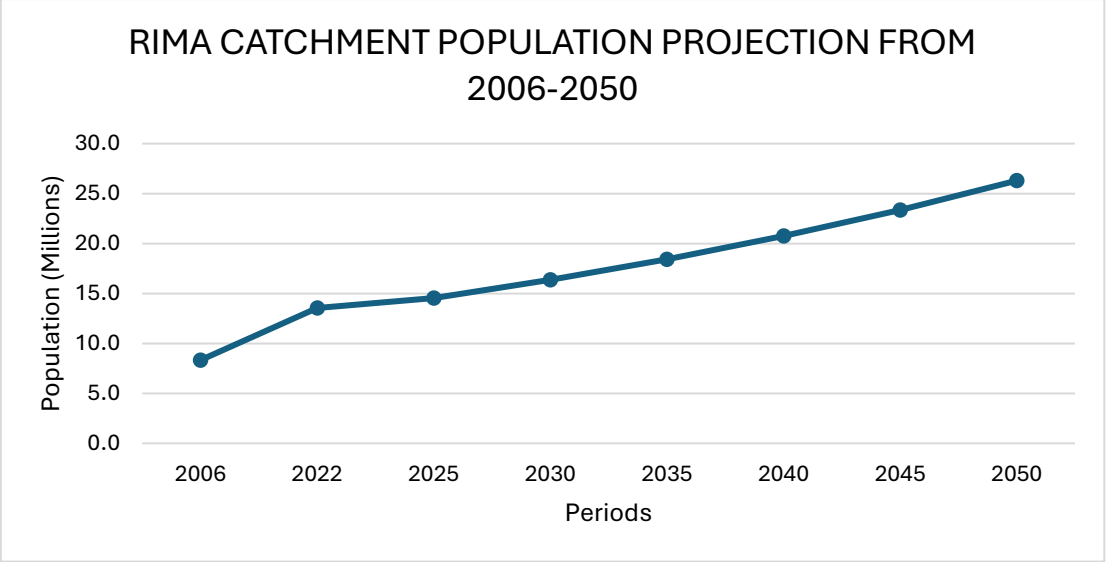


Figure 2.42: Rima Catchment population projection from 2006 – 2050 (Source: NPC 2006)

Table 2.31: Summary of the characteristics of Rima Catchment

Name	States	Population	Geography	Geology	Hydrology – Hydrogeology	Vegetation	Socio-economic
Rima Catchment	Sokoto, Kebbi, Zamfara	Growing population, concentrated in urban areas like Sokoto and Birnin Kebbi	Semi-arid to sub-humid climate; characterized by river valleys, plains, and upland areas	Composed of sedimentary formations, including sandstone and shale; significant groundwater potential	Seasonal river flow: Rima River and its tributaries play a crucial role in water availability; groundwater is an essential source for irrigation and domestic use	Predominantly Sudan and Sahel Savannah vegetation; affected by deforestation and desertification	Agriculture-based economy with livestock farming, irrigation farming, and fishing; urban centers serve as trade and administrative hubs

2.10.2 Demographics and Poverty

Table 2.32 shows the Rima Catchment Demographics and Poverty

Table 2.32: Catchment Demographics and Poverty

Name	States	Demographics and Poverty
Rima Catchment	Katsina	• Population: Approximately 7 million (2023) • Population Density: 289 people per square kilometres • Age Distribution: 60% under 25 years, 40% under 15 years • Gender Ratio: 1.02 males per female • Urbanization: 35-40% urban, 60-65% rural • Fertility Rate: 5.7 children per woman • Migration: Significant rural-urban migration • Population Projections: Expected to reach 10 million by 2035 • Poverty: High poverty rates, significant youth unemployment, challenges in education and healthcare access
	Zamfara	• Population: Approximately 4.7 million (2023) • Population Density: 118 people per square kilometres • Age Distribution: 65% under 25 years, median age around 18 years • Gender Ratio: 1.03 males per female • Urbanization: 30% urban, 70% rural • Fertility Rate: 6.4 children per woman • Migration: Rural-urban migration within the state, out-migration to other states and countries • Population Projections: Expected to reach 6.5 million by 2035 Poverty: High poverty rates, significant youth unemployment, challenges in education and healthcare access

	Sokoto	• Population: Approximately 5.2 million (2023) • Population Density: 200 people per square kilometres • Age Distribution: 60% under 25 years, median age around 17 years • Gender Ratio: 1.04 males per female • Urbanization: 40% urban, 60% rural • Fertility Rate: 6.2 children per woman • Migration: Significant rural-urban migration within the state, out-migration to other states and countries • Population Projections: Expected to reach 7 million by 2035 • Poverty: High poverty rates, significant youth unemployment, challenges in education and healthcare access

2.10.2.1 Unsustainable Livelihoods

The unsustainable livelihoods in the Rima Catchment stem from interconnected environmental, socio-economic, and governance challenges. Tackling these issues demands a multi-faceted approach, including sustainable land and water management, improved infrastructure, diversified economic opportunities, and effective governance. Here are some examples of these unsustainable livelihoods in the Rima Catchment:

i. **Deforestation and Land Degradation:** Large-scale Forest clearing for agriculture and fuelwood collection has led to significant biodiversity loss, soil erosion, and desertification. Overgrazing and unsustainable agricultural practices further degrade soil quality, reducing productivity and increasing vulnerability to droughts and floods.

ii. **Water Resources Depletion:** Unsustainable water use practices, including over-extraction for irrigation and domestic use, have led to declining water levels in rivers and aquifers. Additionally, pollution from agricultural runoff, industrial effluents, and urban waste has degraded water quality. This often affects both human health and aquatic ecosystems.

iii. **Poverty and Limited Economic Opportunities:** Many communities in the Rima Catchment live in poverty, with limited access to basic services such as healthcare, education, and clean water. High fertility rates and rapid population growth further strain resources.

iv. **Agricultural Vulnerability:** Erratic rainfall patterns, soil degradation, and lack of irrigation infrastructure have reduced agricultural productivity. This leads to food shortages and increased reliance on food aid.

v. **Unsustainable Fishing Practices:** In areas with significant fishing activities, overfishing and the use of destructive fishing methods have depleted fish stocks.

vi. **Poor Water Management:** Weak enforcement of water management policies and lack of coordination among different agencies lead to inefficient use of water resources.

vii. **Lack of Waste Management**: Inadequate waste management systems in urban areas contribute to pollution of water bodies.

viii. **Banditry and Farmer-Herder Conflicts:** Insecurity due to banditry and conflicts between farmers and herders disrupts agricultural activities and trade. This further exacerbates poverty and food insecurity.

2.10.3 Gender Issues

2.10.3.1 Challenges

i. **Limited Access to Resources and Decision-Making**: Women often have limited access to land, water, and other productive resources, which restricts their ability to engage in income-generating activities. Women are underrepresented in decision-making processes related to water resource management and agricultural practices.

ii. **Increased Workload and Time Poverty**: Women bear the primary responsibility for collecting water for domestic use, which is time-consuming and labor-intensive, especially in areas with limited water infrastructure. This increased workload limits their ability to participate in other economic activities or education.

iii. **Gender-Based Violence (GBV):** Insecurity and conflict in the region, including banditry and communal conflicts, disproportionately affect women and girls, making them more vulnerable to GBV.

iv. **Limited Economic Opportunities**: Women have fewer opportunities for economic empowerment due to cultural norms and lack of access to education and training.

v. **Health and Sanitation**: Women and girls face significant health risks due to inadequate sanitation facilities and poor access to clean water.

2.10.3.2 Opportunities

i. **Empowerment through Participation**: Involving women in water users' associations and other community-based organizations can enhance their participation in decision-making processes.

ii. **Income-Generation Projects**: Promoting women's self-help groups and income-generation projects can provide economic opportunities and reduce poverty.

iii. **Education and Training**: Providing gender-sensitive education and training programs can equip women with the skills needed to participate more fully in economic activities.

iv. **Policy and Legal Frameworks**: Strengthening legal frameworks to protect women's rights to land and water resources can improve their economic status.

v. **Social and Behavioural Change Communication**: Implementing programs that promote social and behavioural change can help address cultural norms that limit women's participation in economic and social activities.

2.10.3.3 Recommendations

1. **Social and Behavioural Change Communication**
   - **Awareness Campaigns**: Launch awareness campaigns to challenge traditional gender roles and promote gender equality.
   - **Community Engagement**: Engage community leaders and influencers to advocate for women's participation in water resource management and other economic activities.
2. **Economic Empowerment**
   - **Access to Credit and Financial Services**: Provide women with access to credit and financial services to support their economic activities.
   - **Skill Development Programs**: Implement skill development programs tailored to women's needs to enhance their economic opportunities.
3. **Policy Implementation**
   - **Gender-Sensitive Policies**: Develop and enforce policies that ensure women's rights to land and water resources.
   - **Inclusive Governance**: Promote inclusive governance structures that ensure women's participation in decision-making processes.
4. **Addressing GBV**
   - **Support Services**: Establish support services for survivors of GBV, including legal aid, counselling, and safe shelters.

- **Community-Based Interventions**: Implement community-based interventions to prevent GBV and promote a culture of respect and safety.

5. **Multi-Sectoral Collaboration**

- **Inter-Agency Coordination**: Foster collaboration between government agencies, NGOs, and community-based organizations to address gender issues holistically.
- **Integrated Programs**: Develop integrated programs that address multiple aspects of gender inequality, including education, health, and economic empowerment.

CHAPTER 3 : STAKEHOLDER ENGAGEMENT AND GOVERNANCE

3.1 Methodology

The methodology adopted for stakeholder Engagement in the Rima Catchment is comprehensive and participatory. It ensures that diverse voices are heard and integrated into the catchment management plans. This is aimed at developing an SCMP that addresses the unique challenges and opportunities within the catchment.

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)

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 aforementioned stakeholders were identified as key institutions with the capacity to influence and shape the development of the Strategic Catchment Management Plan. Stakeholder engagement was conducted through structured group sessions held in each State, aimed at deliberating on the critical challenges impacting catchment development and exploring viable solutions.

During these sessions, the Federal Project Management Unit (FPMU) team-initiated discussions by presenting the findings of the catchment analysis, highlighting both biophysical and socio-economic dimensions. The dialogues then progressed towards building consensus on a long-term vision, establishing strategic objectives for catchment development, and identifying priority actions for implementation.

The discussions covered issues and potential best practices around:

- Identification of Challenges and Opportunities
- Water Resources Management
- Climate Change Adaptation and Resilience
- Policy and Legal Frameworks
- Monitoring and Evaluation
- Multi-Sectoral Collaboration

3.4 Key Points from the Stakeholder Engagement

1. **Importance of Stakeholder Engagement**
   - Crucial for Sustainable Management: Stakeholder engagement is essential for developing effective and sustainable catchment management plans. It ensures that diverse perspectives and needs are considered, leading to more inclusive and resilient strategies.
   - Building Trust and Ownership: Engaging stakeholders helps build trust and shared understanding, which are vital for the successful implementation of the management plans.
2. **Identification and Analysis of Stakeholders**
   - Comprehensive Identification: Stakeholders are identified and categorized based on their role, interest, and power. This includes government agencies, local communities, private sector, NGOs, and academic institutions.
   - Inclusive Approach: The engagement process is designed to be inclusive, ensuring that marginalized groups, such as women, youth, and people with disabilities, are represented.
3. **Engagement Objectives**
   - Inform and Shape Planning: Stakeholder engagement aims to inform and shape place-based planning by incorporating local knowledge and expertise.
   - Secure Commitment and Shared Ambition: The process seeks to secure commitment and build a shared ambition for joint engagement to maximize environmental and social outcomes.
4. **Engagement Methods**
   - Workshops and Consultations: Knowledge and planning workshops, as well as consultations, are conducted to gather input from stakeholders. These sessions help identify local problems and barriers to change.
   - Capacity Building: Training and capacity-building programs are implemented to enhance stakeholders' ability to participate effectively in catchment management.
5. **Policy and Legal Frameworks**
   - Policy Development: Stakeholder engagement is crucial for developing and enforcing policies that support sustainable catchment management and protect stakeholders' rights.
   - Legal Support: Ensuring legal frameworks address gender-based violence and other forms of discrimination that hinder women's participation.
6. **Monitoring and Evaluation**
   - Continuous Engagement: Stakeholder engagement is an ongoing process, with regular consultations and feedback sessions to monitor progress and adapt strategies as needed.
   - Evaluation of Success: Success is measured by the representativeness, proportionality, and clarity of reasons for engagement.

7. **Multi-Sectoral Collaboration**
   - Inter-Agency Coordination: Collaboration between different government agencies, NGOs, and community-based organizations is fostered to address the complex issues within the catchment.
   - Integrated Programs: Integrated programs are developed to address multiple aspects of catchment management, including education, health, and economic empowerment.

3.5 Coordination Mechanisms

The roles of federal, state, and local stakeholders in catchment plan Management and implementation are:

Federal Stakeholders

1. Federal Ministry of Environment: Provides overall guidance and coordination for catchment management in Nigeria. Supports the implementation of environmental aspects of the catchment plan, including conservation and sustainable use of natural resources (through the ACReSAL project)
2. Federal Ministry of Water Resources and Sanitation: Provides support in implementation and guidance.
3. Federal Ministry of Agriculture and Food Security
4. National Space Research and Development Agency (NARSDA): Provided Satellite data
5. National Centre for Remote Sensing (NCRS): Provided geospatial support
6. Nigerian Meteorological Agency (NIMET): Provides climate and weather data to support catchment planning and management.
7. National Emergency Management Agency (NEMA): Supports disaster risk reduction and management efforts in the catchment.

State Stakeholders

8. State Ministry of Water Resources: Implements state-level policies and programs for catchment management.
9. State Ministry of Environment: Supports the implementation of environmental aspects of the catchment plan at the state level.
10. State Ministry of Agriculture: Supports sustainable agriculture practices and water management in the catchment.
11. State Emergency Management Agency (SEMA): Supports disaster risk reduction and management efforts in the catchment.

Local Government Stakeholders

12. Local Government Councils: Implement catchment management plans at the local level, including waste management and environmental conservation.

Community Oriented Stakeholders

13. Community-Based Organizations (CBOs): Support community-led initiatives for catchment management, including water conservation and sustainable land use practices.
14. Traditional Rulers: Provide leadership and support for catchment management efforts at the local level.
15. Farmers and Water Users Associations: Support sustainable water management practices and conservation of natural resources in the catchment.
16. Civil Society Organizations (CSOs): Support advocacy and awareness-raising efforts for catchment management and conservation.

Private Sector Stakeholders

17. Private Sector: Supports the implementation of catchment management plans through corporate social responsibility initiatives and investments in sustainable water management practices.

Research Institutions

18. Research Institutions: Provide technical support and research expertise for catchment management and conservation efforts.

International Stakeholders

19. International Development Partners: Support catchment management efforts through funding, technical assistance, and capacity-building programs.

CHAPTER 4 : STRATEGIC VISION AND GOALS

Based on the biophysical and socio-economic assessment, and comprehensive stakeholder engagement, the consensus for a strategic vision for the Rima catchment is:

> To achieve sustainable and equitable management of natural resources within the Rima Basin while ensuring climate resilience, environmental protection, economic and social security for all.

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 (2030)	Long-Term KPIs (2030)	Short-term Strategic Goals (2025)	Short-Term KPIs (2025)	Targets (Expected Outcomes)
• **Sustainable Water Management:** Ensure the sustainable management and efficient use of water resources to meet current and future demands for agriculture, domestic use, and ecosystems	• Percentage reduction in water stress index. • Annual freshwater availability per capita (m^3/year) • Percentage of water sources under sustainable management	• **Water Resource Management**: Develop and implement integrated water management plans within the next five years.	• Number of integrated water plans adopted. • Percentage of communities with improved water access. • Annual water use efficiency improvement rate.	• **Sustainable Water Management:** Achieve sustainable withdrawals and supply of freshwater to address water scarcity.

• **Enhanced Livelihoods:** Improve socio-economic conditions through sustainable agricultural practices, enhanced infrastructure, and diversified economic opportunities • **Climate Resilience:** Build resilience to climate change impacts, including droughts, floods, and variability in rainfall patterns, to safeguard water resources and livelihoods. • **Environmental Conservation:** Protect and restore natural ecosystems, including	• Percentage decrease in poverty rate. • GDP contribution from sustainable agriculture. • Employment rate in green sectors. • Percentage reduction in crop losses from extreme weather. • Number of households with disaster-resilient infrastructure. • Percentage increase in forest cover. • Biodiversity index score.	• **Agricultural Development:** Support climate-smart agriculture and sustainable farming practices within the next three years. • **Environmental Conservation**: Restore degraded lands and protect natural ecosystems within the next five years. • **Infrastructure Development:** Improve transportation, electricity, and water supply	• Number of farmers adopting climate-smart practices. • Kilometer of roads/electricity lines upgraded. • Number of reforestation projects completed. • Percentage reduction in illegal logging. • Number of protected areas established. • Number of early warning systems implemented.	• **Enhanced Livelihoods:** Reduce poverty rates and improve access to social services • **Climate Resilience:** Reduce the impacts of climate change on water resources and livelihoods.

forests, wetlands, and biodiversity, to maintain ecological balance and support sustainable development	• Hectares of wetlands restored.	infrastructure within the next five years • **Community Empowerment:** Provide skills training and vocational education to enhance employability within the next three years	• Percentage of farms using drought-resistant crops. • Number of individuals completing vocational training.	• **Environmental Conservation:** Protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes

CHAPTER 5 : STRATEGIC CHALLENGES AND PRIORITY INTERVENTIONS

5.1 Key Issues

Based on the biophysical assessments and stakeholder engagement outlined in the Rima Catchment Management Plan, the following key challenges have been identified:

1. Environmental Challenges

Water Scarcity and Quality: The catchment faces significant water scarcity, particularly during the dry season, exacerbated by high evaporation rates and limited rainfall. Water quality is also compromised due to pollution from agricultural runoff, industrial waste, and inadequate sanitation facilities.

Ecosystem Degradation: Deforestation, soil erosion, and loss of biodiversity are prevalent due to unsustainable land use practices and climate change. The catchment's wetlands and forests, which play crucial roles in water regulation and biodiversity conservation, are under threat.

Climate Change: The region is experiencing more frequent and severe droughts and floods, altering the hydrological cycle and increasing the unpredictability of water availability.

2. Socio-Economic Challenges

Poverty and Livelihoods: High levels of poverty, particularly in rural areas, limit access to essential services and economic opportunities. Many communities rely heavily on subsistence agriculture, which is vulnerable to environmental shocks.

Infrastructure Deficits: There is a significant lack of infrastructure for water supply, sanitation, and irrigation, particularly in remote areas. This is compounded by inadequate transportation networks, which hinder market access for agricultural products.

Health and Social Issues: Limited access to clean water and sanitation facilities leads to high incidences of waterborne diseases. Social issues such as gender inequality and lack of education further exacerbate vulnerabilities.

3. **Governance Challenges**

Institutional Coordination: There is a lack of coordination among different government agencies and stakeholders involved in water and land management. This results in fragmented efforts and inefficient use of resources.

Policy and Regulatory Framework: Existing policies and regulations are often outdated or not effectively enforced. There is a need for more comprehensive and adaptive frameworks to address emerging challenges such as climate change.

Community Engagement: Limited involvement of local communities in decision-making processes related to water and land use. This often leads to a lack of ownership and sustainability of development projects.

5.2 Strategic Interventions

The following strategic interventions are proposed to effectively address the Rima catchment challenges. These interventions focus on actionable, sustainable steps that address environmental, socio-economic, and governance issues and aim to achieve the goals outlined in the plan while ensuring long-term resilience through community-based, integrative approaches.

1. **Environmental Interventions:**
   a. **Water Resource Management and Conservation:** Implement sustainable water management practices, including rainwater harvesting systems, efficient irrigation techniques, and water-efficient agricultural practices. Ensures better water quality and availability, reducing water scarcity and improving agricultural productivity.
   b. **Soil Erosion Control and Land Restoration:** Introduce agroforestry systems, terracing, and contour farming to prevent soil erosion. Promote the use of organic fertilizers and reduced tillage practices. Prevents land degradation, restores soil fertility, and enhances agricultural productivity.
   c. **Biodiversity Conservation and Habitat Restoration:** Establish protected areas for biodiversity, alongside community-led reforestation projects. Promote native species planting and discourage invasive species. Protects biodiversity and strengthens ecosystem services such as water purification, soil fertility, and climate regulation.
2. **Socio-Economic Interventions:**

a. **Diversification of Livelihoods:** Encourage alternative livelihood opportunities such as ecotourism, non-timber forest products, and small-scale agro-processing industries. Provide training and support for these sectors. Reduces over-reliance on agriculture, especially in vulnerable communities, and diversifies income sources.

b. **Infrastructure Development and Access to Services:** Improve rural infrastructure, such as roads, electricity, and water treatment facilities. Focus on ensuring equitable access to services like healthcare and education. Enhances the socio-economic development of local communities, improving their ability to adapt to environmental and economic challenges.

c. **Improving Access to Markets and Financial Services:** Facilitate better access to local and regional markets for farmers and entrepreneurs. Set up microfinance and credit schemes to support smallholder farmers in adopting sustainable agricultural practices. Strengthens local economies by improving access to markets, enhancing income opportunities, and enabling investments in sustainable practices.

3. **Governance-related Interventions:**

a. **Strengthening Institutional Capacity:** Build the capacity of local government agencies through training, resource mobilization, and knowledge exchange programs focused on catchment management. Improves governance, ensuring that catchment management is effectively coordinated, monitored, and implemented.

b. **Promoting Stakeholder Coordination and Participation:** Establish multi-stakeholder platforms for regular dialogue and decision-making, involving government bodies, NGOs, private sector actors, and local communities. Ensures that all relevant stakeholders are involved in the management of the catchment, preventing conflicts and aligning goals.

c. **Enforcing Environmental Regulations:** Strengthen enforcement mechanisms for environmental laws, particularly regarding illegal logging, over-extraction of water, and pollution. Establish clear penalties and incentivize compliance. Enhances environmental protection and ensures sustainable resource management.

d. **Building Public Awareness and Education:** Launch community outreach and education programs focused on sustainable resource management, climate change adaptation, and the importance of protecting the catchment's natural resources. Enhances public understanding of environmental challenges and encourages community participation in conservation efforts.

These Rima catchment strategic interventions (in components) are as outlined in **Error! Reference source not found.** and **Error! Reference source not found.** to 5.8 below.

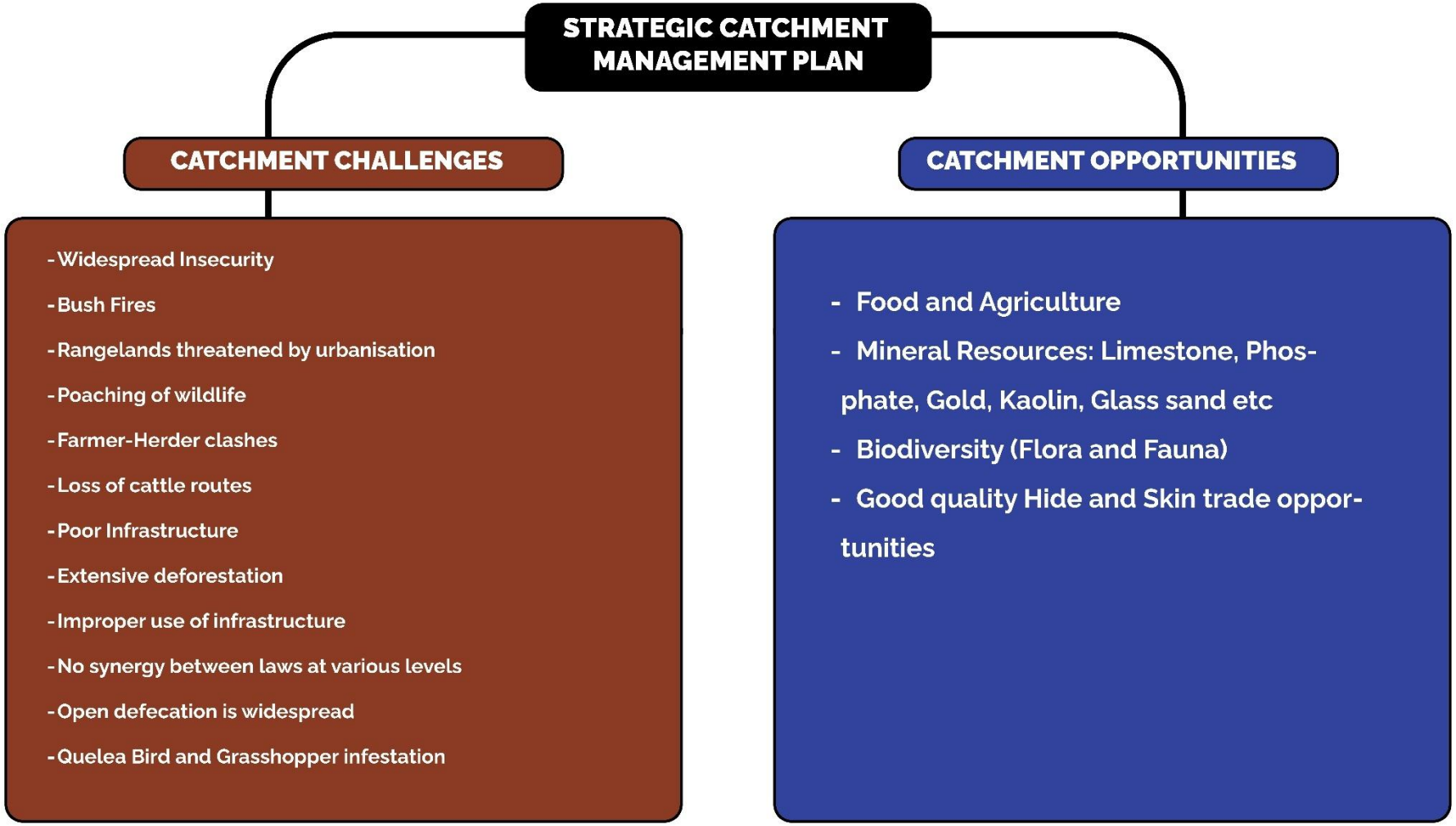
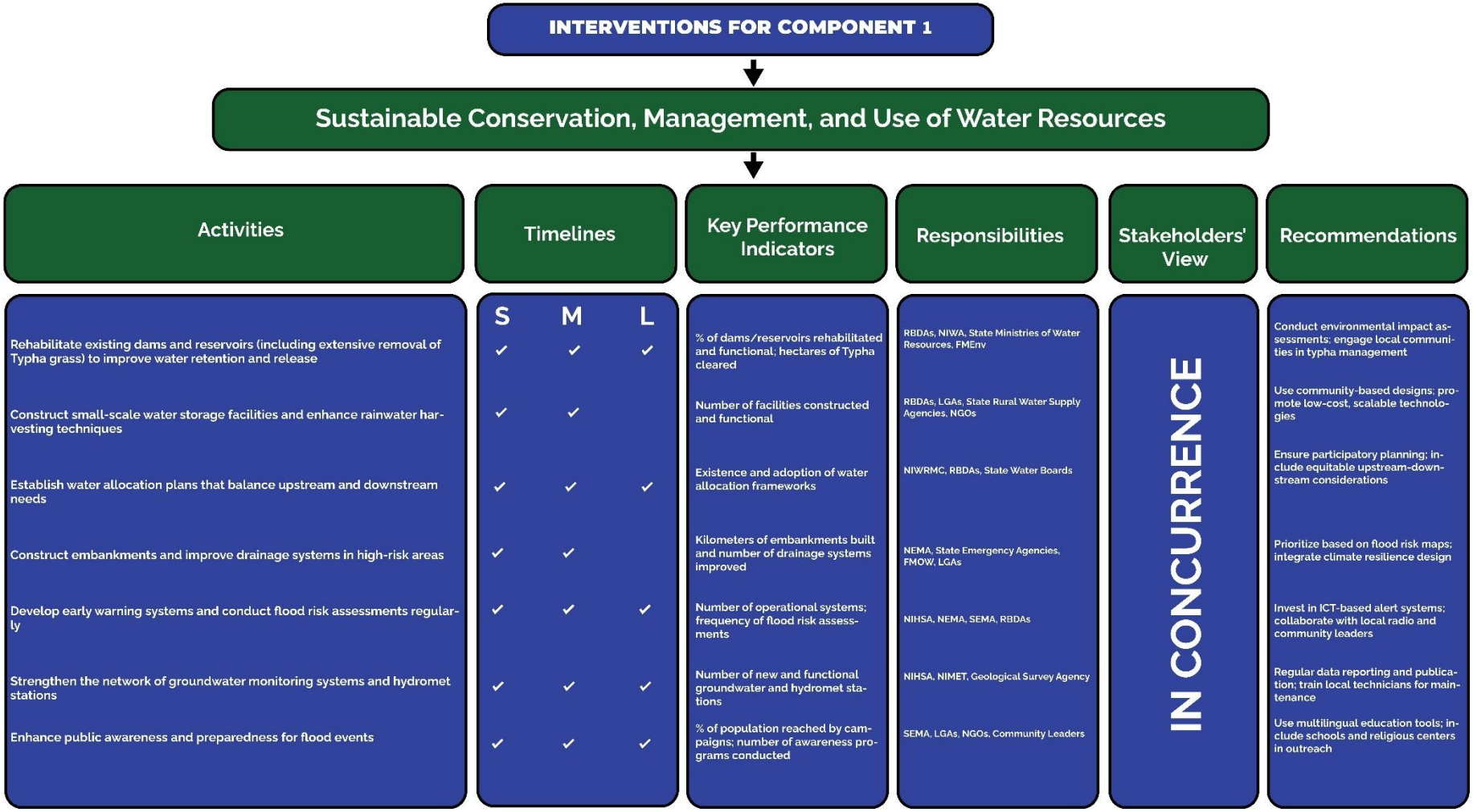


Figure 5.1: Strategic Catchment Management Plan


INTERVENTIONS FOR COMPONENT 1
Sustainable Conservation, Management, and Use of Water Resources
Activities
Timelines
S
M
L
Key Performance Indicators
Responsibilities
Stakeholders' View
Recommendations
Rehabilitate existing dams and reservoirs (including extensive removal of Typha grass) to improve water retention and release
% of dams/reservoirs rehabilitated and functional; hectares of Typha cleared
RBDAs, NIWA, State Ministries of Water Resources, FMEnv
Conduct environmental impact assessments; engage local communities in typha management
Construct small-scale water storage facilities and enhance rainwater harvesting techniques
Number of facilities constructed and functional
RBDAs, LGAs, State Rural Water Supply Agencies, NGOs
Use community-based designs; promote low-cost, scalable technologies
Establish water allocation plans that balance upstream and downstream needs
Existence and adoption of water allocation frameworks
NIWRMC, RBDAs, State Water Boards
Ensure participatory planning; include equitable upstream-downstream considerations
Construct embankments and improve drainage systems in high-risk areas
Kilometers of embankments built and number of drainage systems improved
NEMA, State Emergency Agencies, FMOW, LGAs
Prioritize based on flood risk maps; integrate climate resilience design
Develop early warning systems and conduct flood risk assessments regularly
Number of operational systems; frequency of flood risk assessments
NIHSA, NEMA, SEMA, RBDAs
Invest in ICT-based alert systems; collaborate with local radio and community leaders
Strengthen the network of groundwater monitoring systems and hydromet stations
Number of new and functional groundwater and hydromet stations
NIHSA, NIMET, Geological Survey Agency
Regular data reporting and publication; train local technicians for maintenance
Enhance public awareness and preparedness for flood events
% of population reached by campaigns; number of awareness programs conducted
SEMA, LGAs, NGOs, Community Leaders
Use multilingual education tools; include schools and religious centers in outreach
IN CONCURRENCE

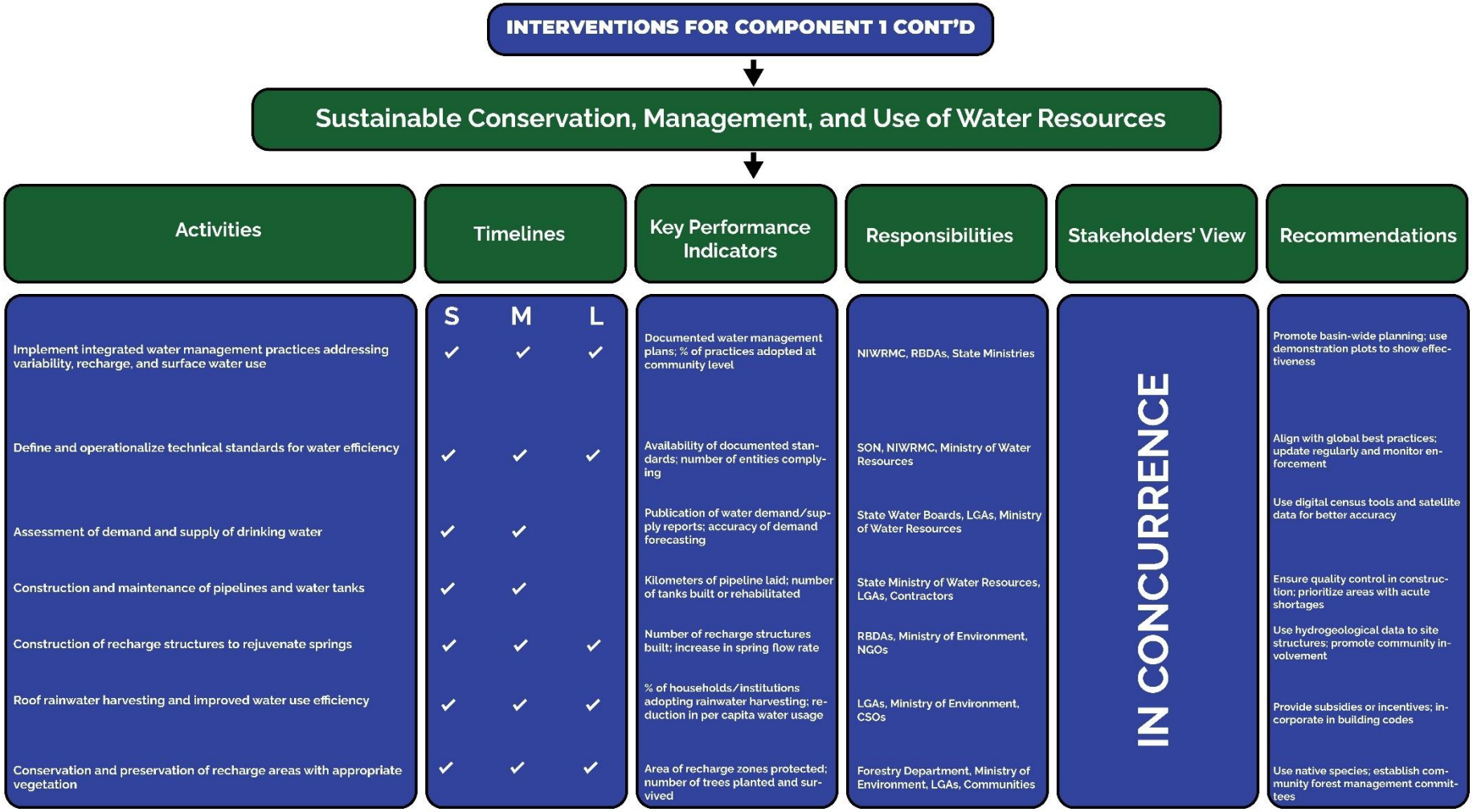


Figure 5.2: Component 1 (Sustainable Conservation, Management, and Use of Water Resources)

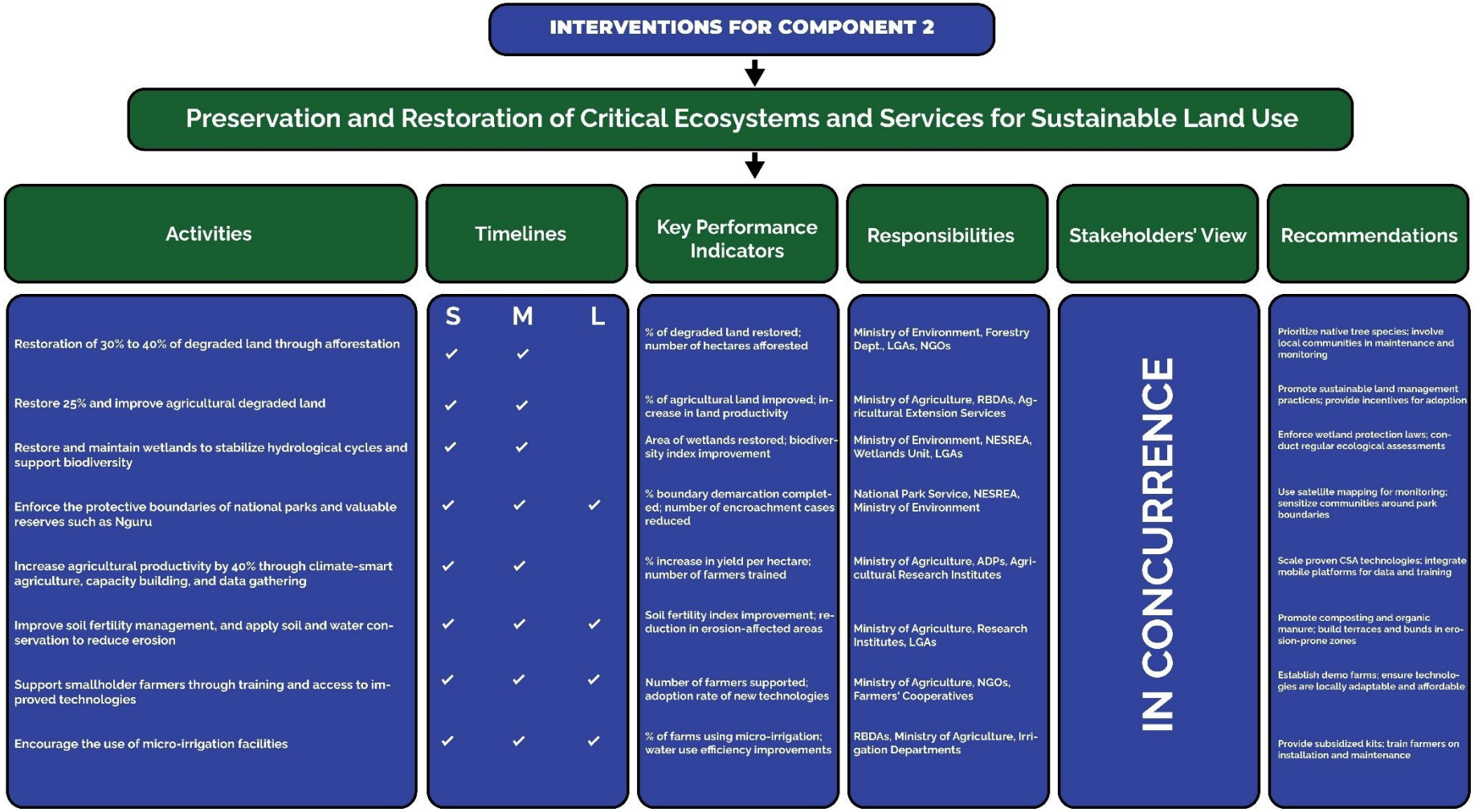


Figure 5.3: Component 2 (Preservation and Restoration of Critical Ecosystems and Services for Sustainable Land Use)

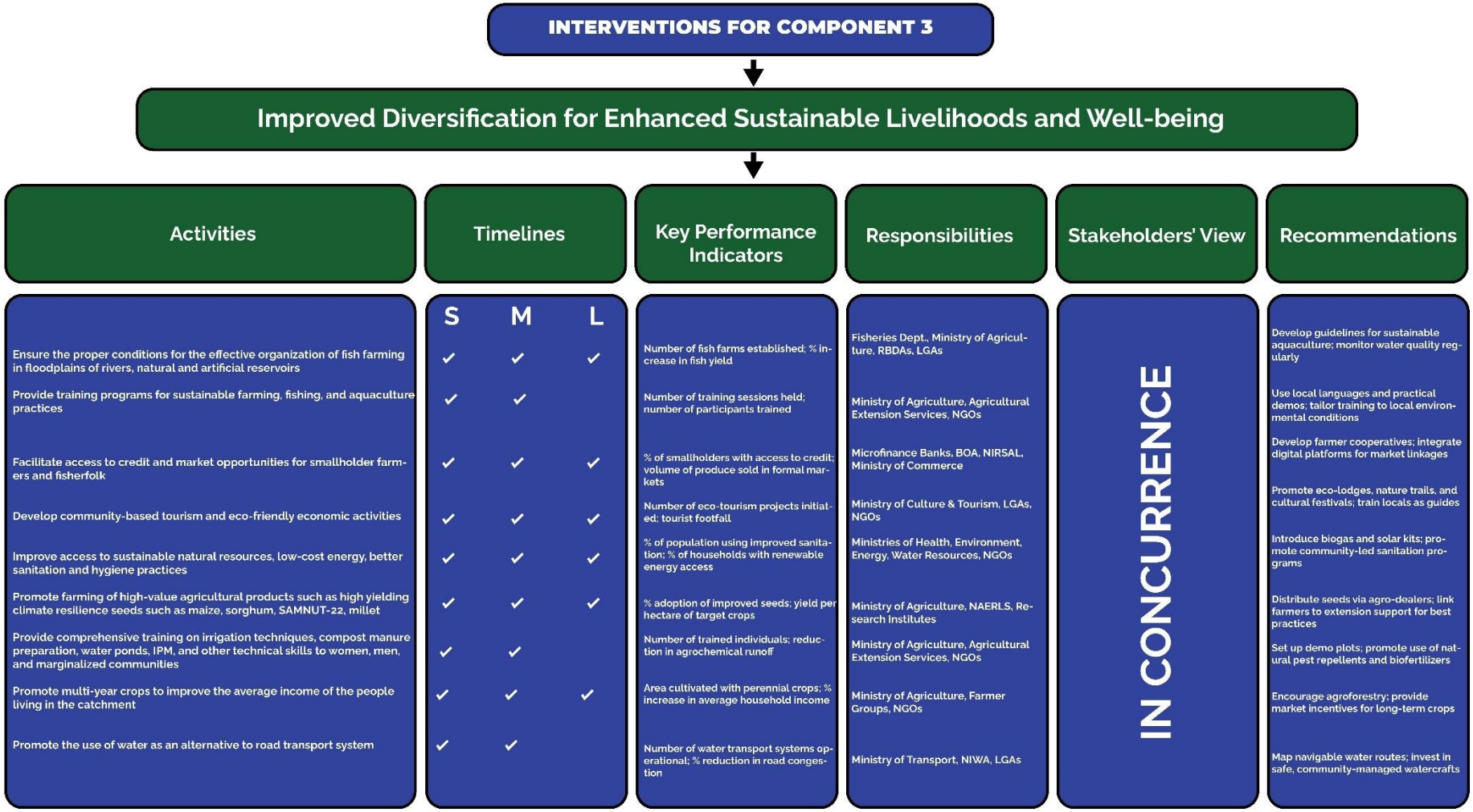


Figure 5.4: Component 3 (Improved Diversification for Enhanced Livelihoods and Well-being)

INTERVENTIONS FOR COMPONENT 4

Climate Change, Disaster Risk Management, and Climate-Resilient Infrastructure

Activities	Timelines			Key Performance Indicators	Responsibilities	Stakeholders' View	Recommendations
	S	M	L				
Promote the use of local runoff of small rivers to mass-arrange water bodies and provide water measures to combat climate change-induced drought	✓	✓		Number of water bodies enhanced; increase in water availability during drought	RBDAs, Ministry of Water Resources, LGAs	IN CONCURRENCE	Map small river systems; design localized water retention structures
Expand early warning systems and enhance the capacity for disaster response	✓	✓	✓	% coverage of functional early warning systems; number of trained responders	NEMA, SEMA, NIMET, LGAs		Integrate SMS alerts, radio broadcasts; simulate mock drills at the community level
Construct resilient infrastructure to address flood risks and water distribution challenges	✓	✓		Number of resilient structures built/upgraded; reduction in flood-related damage	Ministry of Works, RBDAs, NIWRMC		Use climate-resilient engineering designs; prioritize flood-prone areas
Support the adoption of drought-resistant crop varieties and efficient irrigation technologies	✓	✓	✓	% of farmers adopting new varieties/tech; increase in dry-season yield	Ministry of Agriculture, ADPs, Research Institutes		Distribute improved seeds with farmer training; subsidize drip and sprinkler systems
Promote afforestation programs to combat desertification and stabilize soils	✓	✓	✓	Number of trees planted and surviving; % of soil stabilized	Forestry Dept., Ministry of Environment, NGOs		Focus on windbreaks and native species; ensure post-planting maintenance
Implement community-based initiatives for floodplain management and watershed protection	✓	✓	✓	Number of community plans implemented; % of watershed area protected	LGAs, Community Leaders, Ministry of Environment		Encourage participatory planning; provide small grants for community actions
Prepare risk-sensitive land use plan (RSLUP) and implement for identified degraded areas	✓	✓	✓	Number of RSLUPs developed; % of land under regulated use	Urban Planning Authorities, Ministry of Lands & Survey		Integrate climate risk data in planning; enforce land-use zoning regulations

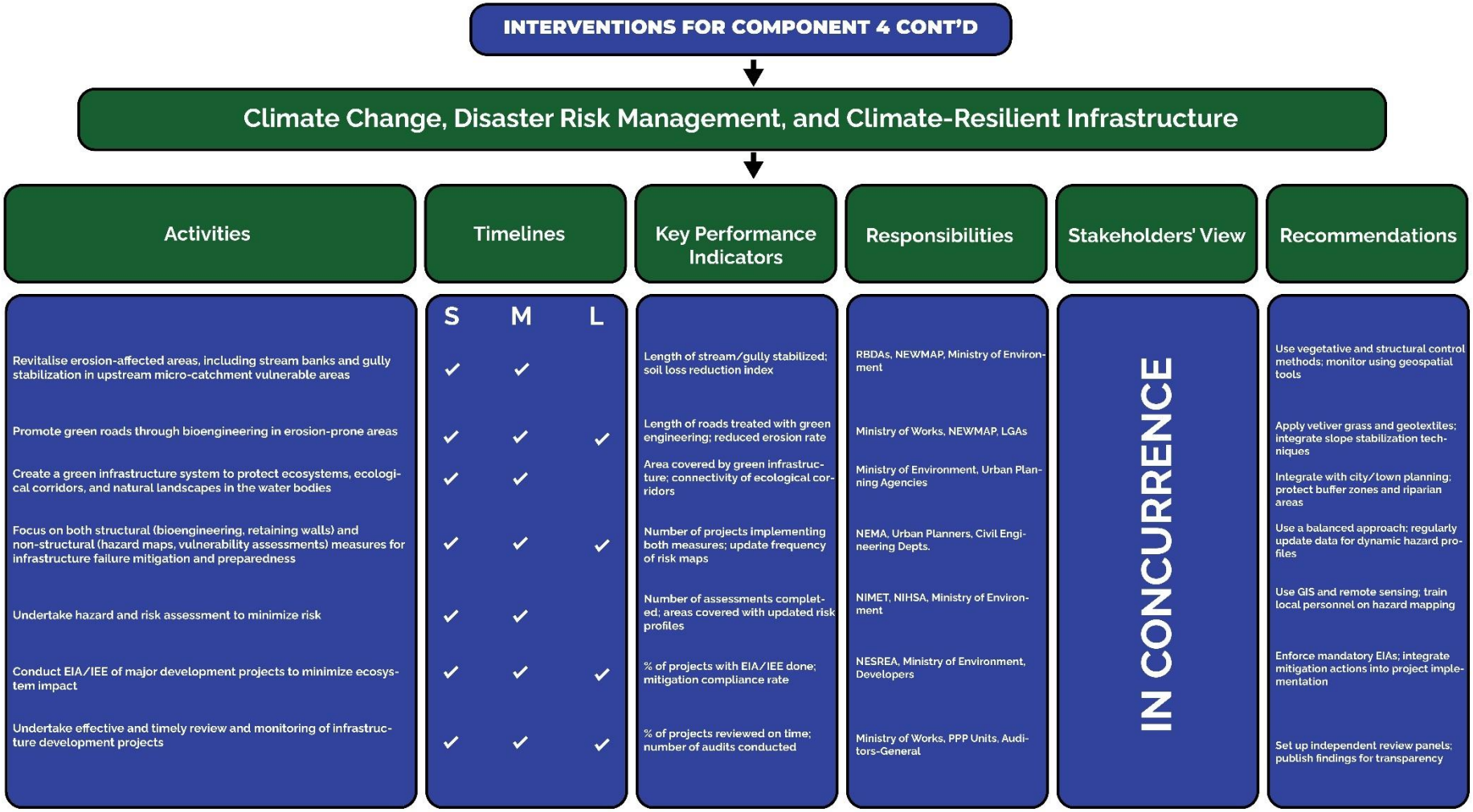


Figure 5.5: Component 4 (Climate Change, Disaster Risk Management, and Climate-Resilient Infrastructure)

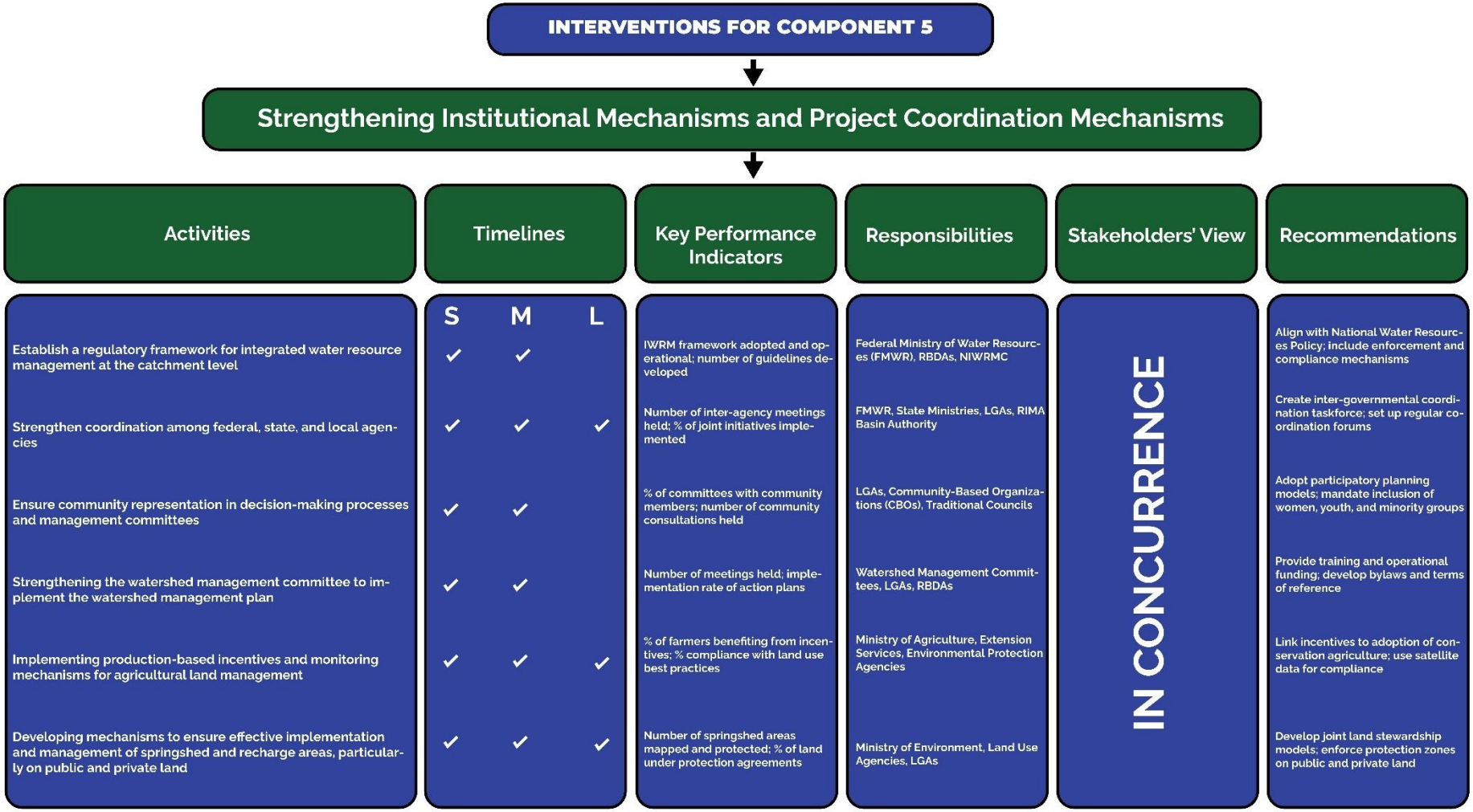


Figure 5.6: Component 5 (Strengthening Institutional Mechanisms and Project Coordination Mechanisms)

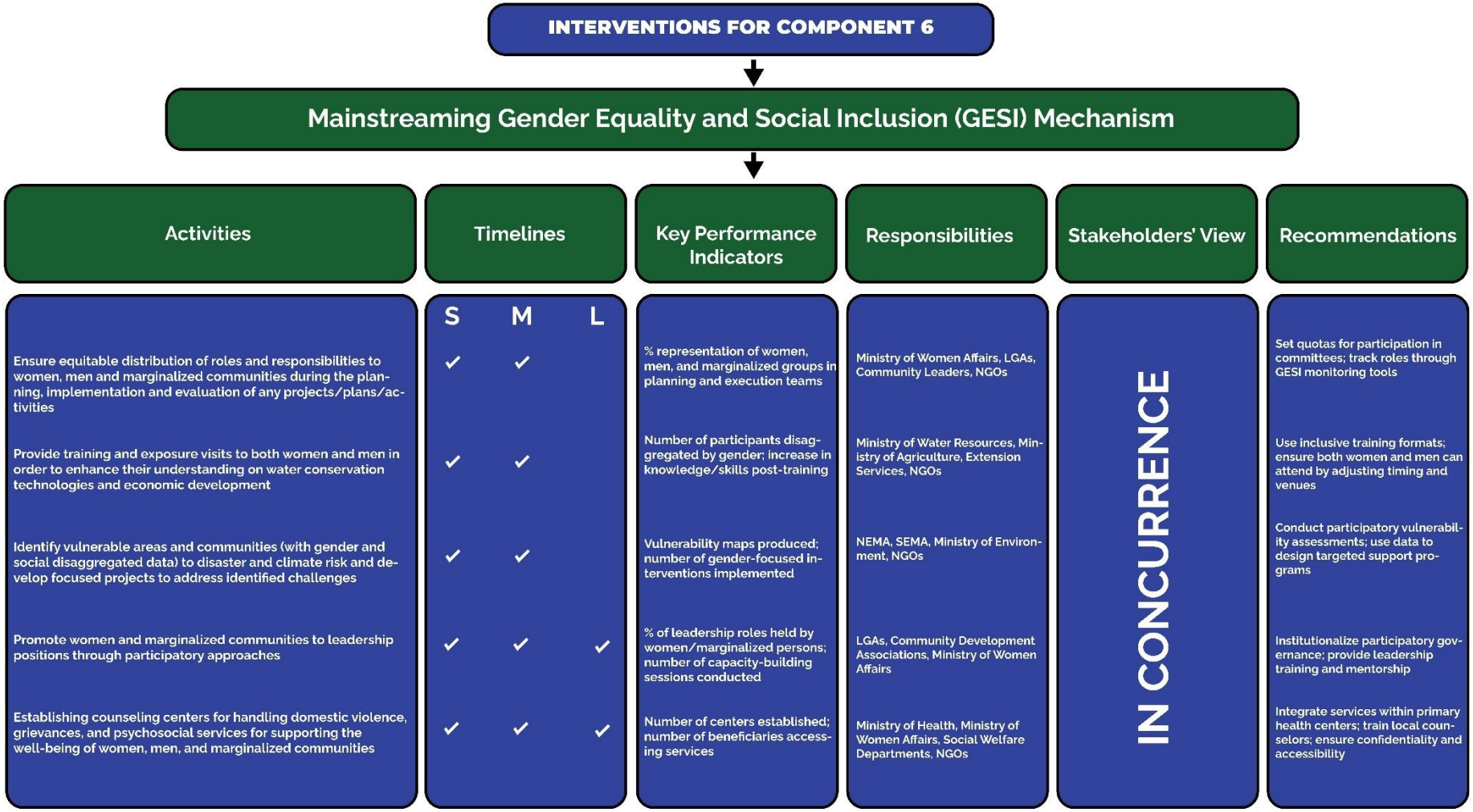


Figure 5.7: Component 6 (Mainstreaming Gender Equality and Social Inclusion (GESI) Mechanism

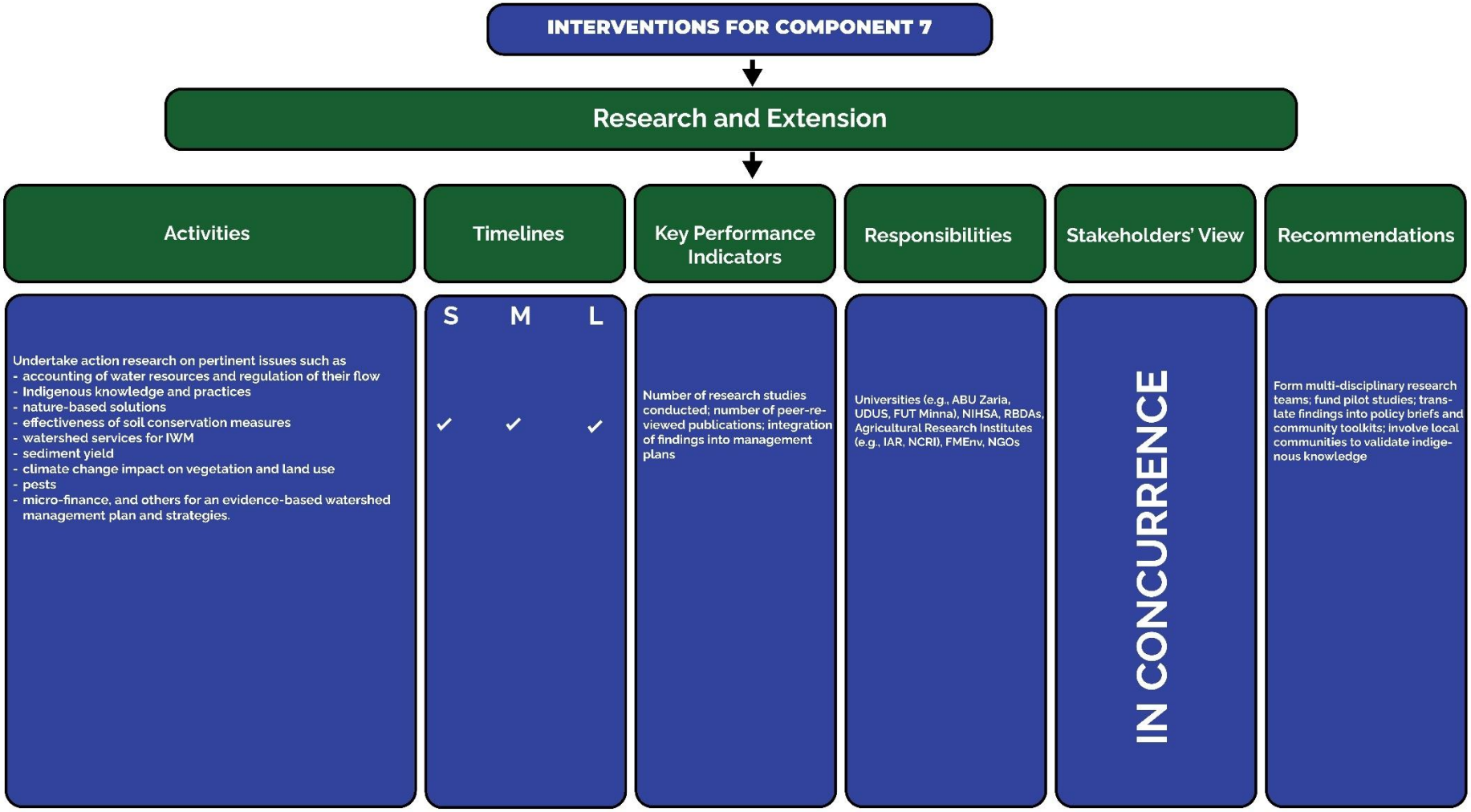


Figure 5.8: Component 7 (Research and Extension)

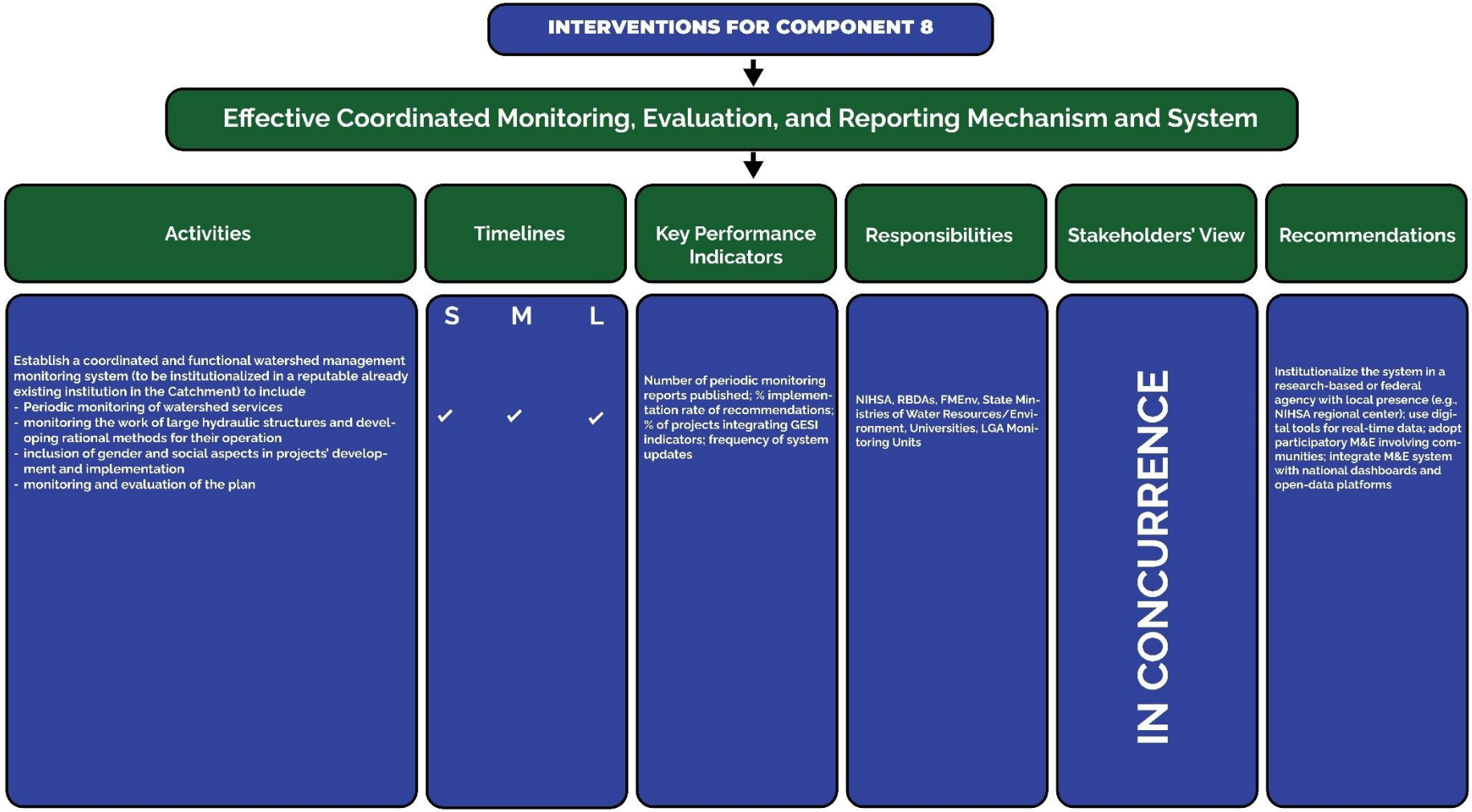


Figure 5.9: Component 8 (Effective Coordinated Monitoring, Evaluation, and Reporting Mechanism and System)

5.3 Expected Outcomes

The successful implementation of these interventions outlined in the Rima Catchment will contribute to a resilient, inclusive, and sustainably managed Rima Catchment. the expected outcomes are outlined as follows:

- Improved Water Availability and Accessibility
- Enhanced Water Quality
- Strengthened Ecosystem Health and Watershed Resilience
- Increased Agricultural Productivity and Water Efficiency
- Empowered and Engaged Communities
- Strengthened Institutional Capacity and Governance
- Sustainable and Equitable Water Resource Management
- Economic Benefits and Livelihood Improvement

CHAPTER 6 : MONITORING, EVALUATION AND LEARNING

6.1 Monitoring and Evaluation

It is imperative to conduct ongoing monitoring and evaluation of strategic catchment plans to ensure their effectiveness and to implement necessary adjustments as required. A comprehensive monitoring and evaluation framework should be established to capture insights, challenges, and milestones, thereby facilitating systematic progress reviews. These reviews will encompass, but are not limited to, the following elements:

- Activities undertaken and milestones achieved

- Results from water quality monitoring

- Challenges faced and lessons learned

- Financial data

- Amendments to the governance structure, if applicable

- Significant modifications to the Implementation Plan

As this document serves as a dynamic, operational guide, it is anticipated that actions will be modified to reflect evolving priorities. Any amendments shall be documented in the appendix of the original management plan. For the monitoring process, appropriate indicators will be identified to assess catchment management activities and their impacts, encompassing both biophysical and social dimensions. When relevant, these indicators will integrate multimedia elements, such as images, videos, and documents, and will capture both qualitative and quantitative data. The Monitoring and Evaluation Plan is shown in Table 6.1.

6.2 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.

6.3 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.

6.4 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.

Table 6.1: Monitoring and Evaluation Plan for Rima Catchment

S/No.	Monitoring Tools and Techniques	Target/Output	Monitoring	Evaluation	Responsibility
1	Water Quality Monitoring	Improved water quality	Regular water quality testing using standardized protocols	Periodic analysis of water quality data to assess trends and compliance with standards	Water Resources Management Authority, Local Governments
2	Hydrological Monitoring	Sustainable water quantity	Installation and maintenance of hydrological monitoring stations	Analysis of hydrological data to assess water availability and flow patterns	Water Resources Management Authority, Local Governments
3	Ecosystem Health Indicators	Restored ecosystems	Use of ecological indicators (e.g., biodiversity indices, soil health metrics)	Assessment of ecosystem health through periodic surveys and audits	Environmental Agencies, NGOs
4	Climate Data Collection	Enhanced climate resilience	Collection of climate data using weather stations and remote sensing	Analysis of climate data to inform adaptation strategies and assess climate impacts	Climate Change Department, Local Governments
5	Agricultural Productivity Metrics	Increased agricultural productivity	Monitoring crop yields, irrigation efficiency, and adoption of sustainable practices	Evaluation of agricultural productivity through yield assessments and farmer surveys	Agricultural Extension Services, Local Governments
6	Livelihood and Socio-Economic Indicators	Reduced poverty rates, improved livelihoods	Collection of socio-economic data through household surveys and community assessments	Evaluation of livelihood improvements through periodic socio-economic assessments	Local Governments, NGOs
7	Infrastructure Performance Indicators	Improved infrastructure resilience	Monitoring infrastructure performance using performance indicators	Evaluation of infrastructure resilience through periodic assessments and audits	Infrastructure Development Agencies, Local Governments

8	Community Participation Metrics	Increased community participation	Monitoring community participation through attendance records and feedback mechanisms	Evaluation of community participation through periodic surveys and focus group discussions	Local Governments, NGOs
9	Gender and Social Inclusion Indicators	Enhanced gender equality and social inclusion	Monitoring gender and social inclusion through disaggregated data collection	Evaluation of gender and social inclusion through periodic assessments and stakeholder feedback	Gender and Social Inclusion Unit, Local Governments
10	Research and Extension Outputs	Enhanced knowledge base, improved practices	Monitoring research outputs and extension activities through project reports and field visits	Evaluation of research impact and extension effectiveness through periodic reviews and stakeholder consultations	Research Institutions, Local Governments
11	Monitoring and Reporting Systems	Improved decision-making, enhanced transparency	Implementation of monitoring and reporting systems using digital platforms	Evaluation of monitoring and reporting systems through periodic audits and user feedback	Data Management Agencies, Local Governments

CHAPTER 7 : CONCLUSION AND MOVING FORWARD

7.1 Summary of Strategic Issues and Priorities

The Rima Catchment, covering parts of Katsina, Zamfara, and Sokoto States, is characterized by diverse ecosystems and significant socio-economic potential. The Rima Catchment Management Plan provides a strategic roadmap for fostering resilience, sustainability, and prosperity in the region. It addresses multifaceted challenges with a balanced approach to socio-economic development and ecological conservation. A comprehensive summary of the strategic issues and priorities of the Rima catchment is outlined below:

1. **Water Resource Management**
   - Rehabilitation of Water Infrastructure: Focus on rehabilitating dams and reservoirs.
   - Small-Scale Water Storage: Development of small-scale water storage systems.
   - Enhanced Drainage and Flood Risk Management: Improved drainage systems, flood risk assessments, and public awareness campaigns.
   - Groundwater Monitoring and Rainwater Harvesting: Strengthening groundwater monitoring networks and advancing rainwater harvesting.
2. **Ecosystem Restoration**
   - Afforestation and Wetland Restoration: Goals to afforest up to 40% of degraded lands and restore wetlands.
   - Protection of Natural Parks and Reserves: Ensuring the preservation of key habitats and natural resources.
3. **Sustainable Agriculture**
   - Climate-Smart Practices: Increasing agricultural productivity through climate-smart approaches.
   - Soil Fertility and Training: Improving soil fertility and supporting smallholder farmers with training and technology.
   - Micro-Irrigation and Erosion Control: Promoting micro-irrigation and erosion control initiatives.
4. **Climate Resilience**
   - Community-Based Initiatives: Empowering local communities through sustainable practices and access to credit.
   - Afforestation Programs: Promoting afforestation and drought-resistant crop varieties.

- Eco-Friendly Economic Activities: Supporting eco-friendly economic activities to enhance livelihoods.

5. **Financial and Institutional Frameworks**
   - Increased Public-Sector Funding: Advocating for dedicated budgets for water, agriculture, and environmental projects.
   - Catchment Development Funds: Establishing funds to pool resources across agencies and stakeholders.
   - International Donor Support: Aligning with global funding mechanisms like the Green Climate Fund.
   - Public-Private Partnerships: Engaging the private sector in developing key infrastructure and renewable energy projects.
   - Community Contributions: Supporting localized interventions through cooperatives, savings schemes, and microfinance.
6. **Governance and Stakeholder Collaboration**
   - Integrated Water Resource Management: Establishing frameworks to improve inter-agency coordination.
   - Inclusive Decision-Making: Ensuring community representation in decision-making processes.

7.2 Recommendations for Aligning with Broader National and Regional Programs

To ensure the Rima Catchment Management Plan is effectively aligned with broader national and regional programmes, particularly the Catchment Policy for Interstate River Systems, the key recommendations include:

1. **Harmonize with National Water Policy**
   - Alignment with National Objectives: Ensure that the objectives of the Rima Catchment Management Plan are in line with the broader goals of the National Water Policy, focusing on sustainable water management, equitable water allocation, and environmental protection.
   - Integration with National Frameworks: Integrate the plan with existing national frameworks and policies, such as the National Water Resources Master Plan and the National Climate Change Policy.
2. **Strengthen Inter-State Coordination**

- Establish Inter-State Committees: Form inter-state committees involving representatives from Katsina, Zamfara, and Sokoto States to facilitate coordinated decision-making and resource sharing.
- Develop Joint Action Plans: Develop joint action plans for water resource management, ecosystem restoration, and climate resilience that are mutually beneficial and aligned with national priorities.

3. Enhance Data Sharing and Monitoring

- Centralized Data Platform: Establish a centralized data platform for sharing hydrological, climatological, and socio-economic data among states and federal agencies.
- Standardized Monitoring Protocols: Develop and implement standardized monitoring protocols to ensure consistent data collection and reporting across the catchment.

4. Promote Regional Collaboration

- Engage Regional Bodies: Engage with regional bodies such as the Lake Chad Basin Commission (LCBC) and the Niger Basin Authority (NBA) to align the Rima Catchment Management Plan with broader regional initiatives.
- Participate in Regional Forums: Actively participate in regional forums and workshops to share experiences, best practices, and lessons learned.

5. Align with Climate Change Initiatives

- Integrate Climate Adaptation Strategies: Ensure that climate adaptation strategies in the Rima SCMP are aligned with national and regional climate change initiatives, such as the National Adaptation Strategy and the Regional Climate Change Action Plan.
- Access Climate Funding: Leverage national and regional climate funding mechanisms, such as the Green Climate Fund, to support climate-resilient projects in the catchment.

6. Strengthen Legal and Regulatory Frameworks

- Review and Harmonize Laws: Review and harmonize state and federal laws related to water management, environmental protection, and land use to ensure consistency and effective implementation.
- Enforce Regulatory Standards: Strengthen enforcement mechanisms to ensure compliance with regulatory standards for water quality, pollution control, and sustainable land use.

7. Enhance Community Participation

- Community-Based Management: Promote community-based management of water resources and natural ecosystems, ensuring that local communities are actively involved in decision-making processes.

- Capacity Building: Provide training and capacity-building programs for local communities to enhance their ability to manage water resources sustainably.

8. **Promote Sustainable Agricultural Practices**
   - Climate-Smart Agriculture: Promote climate-smart agricultural practices that are aligned with national and regional food security initiatives.
   - Support Smallholder Farmers: Provide support to smallholder farmers through access to credit, technology, and training to enhance agricultural productivity and resilience.
9. **Develop Integrated Water Resources Management (IWRM) Plans**
   - State-Level IWRM Plans: Develop and implement state-level IWRM plans that are aligned with the national IWRM framework.
   - Catchment-Wide Coordination: Ensure coordination between state-level plans and the overall catchment management strategy to achieve integrated water management.
10. **Engage the Private Sector**
    - Public-Private Partnerships: Encourage public-private partnerships to develop key infrastructure and renewable energy projects, leveraging private sector expertise and resources.
    - Incentivize Sustainable Practices: Provide incentives for private sector involvement in sustainable water management and ecosystem restoration projects.

7.3 Catchment Policy for Interstate River Systems

Several river basins in Nigeria are not only inter-state watercourses but also sub-basins of transboundary or shared watercourses. Examples are the Hadeija Jama'are, sub-basin of Lake Chad, Sokoto Rima River Basin, sub-basin of Niger River Basin and Benue River Basin, sub-basin of Niger River Basin.

The implication is that uses and activities in the catchments affect the transboundary watercourse and so are subject of international water treaties that apply to the particular transboundary watercourse. Nigeria is member of the Niger Basin Authority with other eight other riparian states, Niger, Cameroun, Burkina Faso, Republic of Benin, Mali and Guinea, Chad and Cote d'Ivoire. Nigeria is also member of the Lake Chad Basin Commission with five other riparian states, Chad, Central Africa Republic, Cameroun, Niger, and Libya. Nigeria is party to the 2008 Niger Basin Water Charter, 2012 Lake Chad Basin Water Charter, 1997 UN Watercourses Convention and 1992 UNECE Water Convention. Accordingly, obligation to comply with provisions of the treaties under international law within Article 26 of Vienna Convention on the Law of treaties applies to Nigeria as a country that ratified the treaties.

Apart from the principles of international water law, other relevant instruments are the National Water Resources Act, policies on water resources, environment and climate change. Other policies are international soft laws adopted under auspices of United Nations and ECOWAS Water Resources Policy.

Five Principles Of International Water Law Enunciated In The Water Treaties

i. Scope of application of the treaty: Does it address surface water, ground water or both? Is it applicable to non-navigational uses only or for all purposes?
ii. Substantive Principles:
iii. Principle of equitable and reasonable utilization
iv. Obligation not to cause significant harm (no harm rule)
v. Protection of the Ecosystems
vi. Procedural Principles
vii. Principle of cooperation
viii. Notification of any planned project
ix. Exchange of data and information
x. Institutional Framework (river basin organization)
xi. Dispute Resolution Provisions

The Niger Basin Water Charter, Lake Chad Water Charter and UN water treaties reflect the five principles generously. Relevant treaties for transboundary watercourse management in Nigeria are:

- 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 Shared Water Resources

They are soft laws not treaties, but they provide direction. However, they lack legal significance and not binding.

i. 1971 Stockholm Declaration on Human Environment that states the principle of 'no harm rule' (Principle 21)

ii. 1992 Dublin principles on water and sustainable Development, which heralded integrated water resources management.

iii. 1992 Rio Declaration on Environment and Development and Agenda 21 that expounded on the Stockholm Declaration and also codifies other principles of sustainable environment, applicable to management of transboundary watercourse, which were absent in the Stockholm Declaration. They are Principle 15 (Precautionary Principle), Principle 16 (Polluter Pays Principle), Principle 17 (Environmental Impact Assessment) and Principles 18 and 19 (Principle of prior and timely notification of transboundary harm.)

iv. 2008 ECOWAS Water Resources Policy is not a regional water treaty but policy statements to guide ECOWAS member states in managing their water resources. According to the Policy, a river basin organization is paramount for cooperation and equitable sharing of water resources that affects transboundary watercourses. Article 2.3 of the ECOWAS Water Policy reflects guiding principles of equitable sharing or water resources and other principles of shared watercourse protection such as precaution, prevention and polluter-pays principles as well as principles exchange of information, subsidiarity and cooperation. Other enunciated principles are user pays, notification or information, effective governance in water resources management, gender equality, solidarity, progressiveness, partnership, and hydrographic basins or aquifers systems management.

v. Draft Articles on the Law of Transboundary Aquifer currently guides riparian states in negotiating groundwater treaties.

National Water Law and Policies On Water Resources

a) National Water Resources Act vests the use and control of all surface and ground water affecting more than one state on the Federal Government. Schedule to the Act lists the affected water resources to include River Niger, Sokoto/Rima River from the border, Hadeija Jama'are Basin, all the tributaries of River Niger crossing the border of Benin Republic and the Sokoto sedimentary (Western) hydro-geological area.

b) National Water Resources Policy recommends co-ordinating committee for interstate river basins. It also states that international water resources shall be managed in a manner that optimizes the benefits for all parties in a spirit of mutual co-operation … Accordingly

"transboundary or shared water resources shall be protected, developed, conserved, used and managed in accordance with the existing national or international riparian Laws/conventions/Guidelines and shared equitably, while maintaining the ecosystem.

c) National Policy on Environment reflects guiding principles of sustainable environment and water resources such as polluter pays, user pays, precautionary principle, subsidiarity principle, pollution prevention principle, principle of inter-generational equity, principle of intra-generational equity, principle of participation, international cooperation, good environmental governance, and integrated ecosystem approach. It recommends domestication of transboundary water treaties and establishing river basin institutions for managing shared watercourse

d) National Climate Change Policy for Nigeria

7.4 High-Level Funding Strategies and Partnership Opportunities

To effectively implement the Rima Catchment Management Plan, a comprehensive approach to funding and partnership development is essential. The following outlines high-level funding strategies and partnership opportunities tailored to the Rima Catchment:

1. Funding Strategies

a. Government Funding

- Federal and State Budget Allocations: Advocate for dedicated budget allocations from federal and state governments for water resource management, environmental conservation, and socio-economic development projects within the Rima Catchment.
- Catchment Development Funds: Establish a dedicated catchment development fund that pools resources from various government agencies and stakeholders to support priority projects.

b. International Donor Support

- Multilateral and Bilateral Donors: Engage with international donors such as the World Bank, African Development Bank, and European Union to secure funding for large-scale infrastructure and capacity-building projects.
- Global Funding Mechanisms: Align projects with global funding mechanisms like the Green Climate Fund, Adaptation Fund, and Global Environment Facility to access climate finance and support climate-resilient initiatives.

c. Private Sector Investment

- Public-Private Partnerships (PPPs): Develop PPPs to leverage private sector expertise and resources for key infrastructure projects, such as water treatment plants, renewable energy projects, and sustainable agricultural initiatives.
- Corporate Social Responsibility (CSR): Encourage private companies operating within the catchment to contribute to CSR programs focused on water management, environmental conservation, and community development.

d. Community Contributions

- Cooperatives and Savings Schemes: Support the formation of community cooperatives and savings schemes to mobilize local resources and support small-scale projects and localized interventions.
- Microfinance Opportunities: Promote microfinance institutions to provide small loans and financial services to local communities, particularly smallholder farmers and micro-entrepreneurs, to support sustainable livelihoods.

e. Innovative Financing Mechanisms

- Green Bonds: Issue green bonds to finance environmentally friendly projects, such as renewable energy and ecosystem restoration.
- Payment for Ecosystem Services (PES): Develop PES schemes to incentivize sustainable land and water management practices, ensuring that beneficiaries of ecosystem services contribute to their conservation.

2. Partnership Opportunities

a. Government Agencies

- Inter-State Collaboration: Strengthen collaboration among Katsina, Zamfara, and Sokoto States through inter-state committees and joint action plans to ensure coordinated management of shared water resources.
- Federal-State Partnerships: Foster partnerships between federal agencies and state governments to align national policies with local implementation needs and leverage federal resources for catchment management.

b. International Organizations

- Technical Assistance: Engage with international organizations such as the United Nations Development Programme (UNDP), Food and Agriculture Organization (FAO), and World Meteorological Organization (WMO) for technical assistance and capacity-building support.

- Knowledge Sharing: Participate in regional and global platforms to share experiences, best practices, and lessons learned with other catchment management initiatives.

c. Non-Governmental Organizations (NGOs)

- Community Engagement: Partner with NGOs to enhance community participation in catchment management, particularly in areas such as environmental conservation, sustainable agriculture, and gender equality.
- Project Implementation: Collaborate with NGOs to implement community-based projects, ensuring grassroots-level engagement and local ownership of interventions.

d. Academic and Research Institutions

- Research and Development: Collaborate with universities and research institutions to conduct research on sustainable water management, climate resilience, and socio-economic development within the catchment.
- Capacity Building: Partner with academic institutions to develop training programs and capacity-building initiatives for local stakeholders, including government officials, community leaders, and farmers.

e. Private Sector

- Infrastructure Development: Partner with private companies to develop and operate water infrastructure projects, ensuring sustainable and efficient water management.
- Sustainable Practices: Encourage private sector involvement in promoting sustainable agricultural practices, such as climate-smart agriculture and agroforestry, through technology transfer and investment in innovation.

f. Community-Based Organizations (CBOs)

- Local Governance: Strengthen partnerships with CBOs to enhance local governance and ensure community representation in decision-making processes related to catchment management.
- Localized Interventions: Support CBOs in implementing localized interventions, such as small-scale water storage systems, reforestation projects, and sustainable livelihood initiatives.

7.5 Moving Forward with the Catchment Plan

The Rima Catchment Management Plan (CMP) is a dynamic document that necessitates regular review and updates to reflect ongoing management processes. It marks the transition from the planning phase to the implementation phase of catchment management. The Federal Project Management Unit (FPMU) and national consultants should have access to the plan and its knowledge base to facilitate updates and transition it into an online ePlan.

To ensure the CMP remains a living document, the following tasks are essential:

1. **Environmental Education:**
   - Educate stakeholders on the importance of the natural environment and the collective actions required to restore and protect it.
2. **Regulatory Framework:**
   - Collaborate closely with the government to enhance and, where necessary, strengthen the regulatory framework to achieve greater environmental protection.
   - Ensure government agencies are adequately funded to enforce regulations when the natural environment is compromised.
   - Focus on groups with the most significant impact on the water environment to maximize benefits.
3. **Data Monitoring and Sharing:**
   - Monitor and share data to improve evidence and make it more widely available.
   - Integrated Policies:
   - Recognize the interrelation between biodiversity, environmental health, and water and soil quality.
   - Develop policies that are catchment-wide and long-term, ensuring they are well-coordinated.
4. **Partnership Development:**
   - Work in partnership with a wide range of organizations at appropriate scales, such as catchment or coastal scales.
   - Adopt an integrated and partnership approach to attract funding from diverse sources, including private funding, and ensure benefits are spread across sectors and landscapes.
5. **Simplified Legislation:**
   - Ensure that resources and environmental legislation are simpler and enabling.
   - Regulatory Enforcement:

- Advocate for tighter regulation and increased penalties, supported by funding for the Environment Agency to enforce these regulations.

6. **Sustainable Agriculture:**
   - Reduce the use of pesticides by adopting organic practices, integrated pest management systems, genetic crop manipulation, and targeted agrochemical applications.
7. **Awareness and Education:**
   - Increase efforts to educate and raise awareness about the impacts of physical modifications on the environment, their management, and societal benefits.
8. **Nature-Based Solutions:**
   - Provide strong support for nature-based solutions in flood risk and coastal erosion management.
9. **Landscape Management:**
   - Acknowledge the importance of broader landscape management and the value of viewing catchments as entire systems.
10. **Drainage and Green Infrastructure:**
    - Recognize the multiple benefits of well-designed drainage and green infrastructure for people and the environment, including better integration across urban areas.
11. **Riparian Corridors and Floodplain Management:**
    - Identify and designate appropriate riparian corridors to protect primary drainage paths and provide riparian cover.
    - Identify floodplain areas and establish rules to prevent inappropriate development.
    - Enhance groundwater and interflow to maintain stream base flows.
    - Protect important habitat qualities of streams, including provisions for fish passage.
    - Plan for primary (on-site control) and secondary (off-site backup) management of erosion and sediment runoff during development phases.
    - Implement targeted source control of contaminants and general catchment-wide removal of contaminants in stormwater.
12. **Stakeholder Engagement:**
    - Sustain public support and stakeholder engagement through transparent communication about progress.
    - Be prepared to revise strategies in response to new scientific findings or changes in socio-economic conditions affecting the catchment area.

7.6 Conclusion

The Rima Catchment is a critical resource for the socio-economic and environmental well-being of the region. Through strategic prioritization, alignment with broader programs, and robust funding mechanisms, the Rima SCMP sets a clear roadmap for sustainable development. Implementing these strategic recommendations, the Rima SCMP will enhance resource management, empower communities, and build resilience against environmental and socio-economic challenges. This approach ensures the catchment's long-term vitality and prosperity, contributing to the broader goals of sustainable development and environmental conservation.

ANNEXES

ANNEX 1: DETAILED POPULATION STATISTICS FOR THE CATCHMENT

Table A-1- 1: Population Projection for Rima Catchment

State	LGA	2006	2022	2025	2030	2035	2040	2045	2050
Sokoto	Gada	249,051	401,520	431129	485408	546521	615328	692798	780021
Sokoto	Goronyo	182,118	293,611	315262	354954	399642	449957	506607	570389
Sokoto	Gwadabawa	231,569	373,336	400866	451335	508158	572135	644167	725268
Sokoto	Illela	150,133	242,045	259893	292614	329454	370932	417633	470212
Sokoto	Isa	150,268	242,262	260127	292877	329750	371266	418008	470635
Sokoto	Sabon Birni	207,470	334,483	359149	404366	455275	512594	577130	649790
Sokoto	Tangaza	114,770	185,032	198677	223690	251853	283561	319262	359457
Sokoto	Wurno	162,403	261,826	281134	316529	356379	401248	451765	508642
Zamfara	Birnin Magaji	184,083	304,711	327181	368374	414752	466969	525760	591954
Zamfara	Bungudu	258,644	428,132	459703	517580	582743	656110	738714	831718
Zamfara	Gusau	383,712	635,156	681994	767857	864530	973374	1095922	1233898
Zamfara	Kaura Namoda	285,363	472,360	507192	571048	642943	723889	815027	917638
Zamfara	Maradun	207,563	343,578	368914	415360	467654	526531	592822	667458
Zamfara	Shinkafi	135,964	225,060	241657	272081	306336	344904	388327	437218
Zamfara	Tsafe	266,929	441,846	474429	534159	601410	677127	762377	858360
Zamfara	Zurmi	293,977	486,618	522503	588286	662351	745741	839629	945338
Katsina	Bakori	149,516	241,424	259228	291864	328610	369982	416563	469008
Katsina	Batagarawa	189,059	305,275	327786	369055	415519	467832	526732	593048
Katsina	Batsari	207,874	335,656	360407	405783	456871	514391	579152	652068
Katsina	Bindawa	151,002	243,824	261804	294765	331876	373659	420703	473669
Katsina	Charanchi	136,989	221,197	237509	267411	301078	338983	381661	429713
Katsina	Dan Musa	113,190	182,769	196246	220954	248772	280092	315356	355059
Katsina	Daura	224,884	363,122	389899	438987	494256	556482	626543	705425
Katsina	Dutsi	120,902	195,221	209617	236008	265721	299176	336842	379250
Katsina	Dutsin-Ma	169,829	274,224	294446	331516	373254	420247	473156	532726
Katsina	Faskari	194,400	313,899	337046	379481	427257	481049	541613	609802
Katsina	Ingawa	169,148	273,124	293265	330187	371758	418562	471259	530590
Katsina	Jibia	167,435	270,358	290295	326843	367993	414323	466486	525217
Katsina	Kaita	182,405	294,531	316250	356066	400894	451367	508194	572175
Katsina	Kankara	243,259	392,792	421757	474856	534641	601952	677738	763065

Katsina	Kankia	151,395	244,458	262485	295532	332740	374632	421798	474902
Katsina	Katsina	318,132	513,690	551570	621013	699198	787227	886339	997929
Katsina	Kurfi	116,700	188,436	202332	227805	256486	288778	325135	366069
Katsina	Kusada	98,348	158,803	170514	191981	216152	243365	274005	308502
Katsina	Mai'adua	201,800	325,848	349876	393926	443521	499360	562230	633014
Katsina	Malumfashi	182,891	295,315	317092	357014	401962	452569	509548	573700
Katsina	Mani	176,301	284,674	305667	344150	387479	436262	491188	553028
Katsina	Mashi	171,070	276,228	296597	333939	375982	423318	476614	536619
Katsina	Matazu	113,814	183,776	197328	222172	250143	281636	317094	357016
Katsina	Musawa	170,006	274,510	294753	331862	373643	420685	473649	533282
Katsina	Rimi	154,092	248,813	267161	300797	338667	381305	429312	483362
Katsina	Safana	185,207	299,055	321108	361535	407053	458300	516000	580965
Katsina	Sandamu	136,944	221,124	237430	267323	300979	338872	381536	429571
Jigawa	Gwiwa	128,730	203,705	218726	246264	277268	312177	351480	395731
Kano	Shanono	139,128	236,077	253486	285400	321332	361788	407337	458620
TOTAL		8,328,467	13,533,507	14,531,492	16,361,006	18,420,855	20,740,039	23,351,208	26,291,123

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 (Water Reservoirs, Minerals, Flora, Fauna, and Agriculture)	Threats and Challenges	Socio-economics	Policies
Water Reservoirs	**Water Management and Hydrological Alterations**	**Katsina State**	**National Water Resources Policy**
- Dams and reservoirs such as Zobe Dam, Bakolori Dam, Goronyo Dam, and Gusau Dam provide water for irrigation and domestic use.	- Construction of large dams and irrigation schemes has altered natural river flow, reducing seasonal flooding and affecting wetlands and floodplain agriculture.	- Agriculture is the backbone of the economy, with crops like millet, sorghum, maize, and groundnuts.	- Provides overarching framework for water resource management in Nigeria.
Minerals	**Climate Change and Variability**	**Zamfara State**	**Land Use Act (2004)**
- Presence of limestone, gypsum, kaolin, phosphate, and gold in various LGAs.	- Increased droughts, reduced river flow, and unpredictable rainfall patterns affect agriculture and water availability.	- Agriculture and livestock rearing are major economic activities.	- Regulates land acquisition, use, and development.
Flora	**Deforestation and Land Degradation**	**Sokoto State**	**National Environmental Standards and Regulations Enforcement Agency (NESREA) Act**
- Diverse plant species including baobab, shea butter, and lemon grass.	- Agricultural expansion, overgrazing, and fuelwood harvesting lead to deforestation and soil degradation.	- Agriculture supports crops like onions, garlic, pepper, and rice.	- Empowers NESREA to enforce environmental laws and standards.
Fauna	**Wetland Degradation**		**Climate Change Act (2021)**
- Diverse species of mammals, reptiles, amphibians, fish, and birds.	- Reduction in seasonal flooding and invasive species like Typha grass affect wetland ecosystems.		- Establishes a National Council on Climate Change.

Agriculture

- Major crops include onions, garlic, pepper, watermelon, cabbage, carrots, cowpea, and sugarcane.

Soil Erosion and Desertification

- Wind erosion, desert encroachment, and soil salinization reduce soil fertility.

Population Pressure and Urbanization

- Rapid urbanization in cities like Sokoto and Gusau puts strain on water, land, and environmental resources.

Agricultural Challenges

- Water scarcity, resource conflicts, and policy gaps affect farming and pastoral activities.

Poverty and Unsustainable Livelihoods

- Many rural communities face chronic poverty and rely on unsustainable practices.

Weak Institutional Framework and Governance Challenges

- Fragmented water management and lack of policy implementation hinder sustainable resource use.

Katsina State Environmental Protection Agency (KASEPA) Law (1995)

- Regulates waste management, pollution control, and environmental education.

Zamfara State Environmental Protection Agency (ZASEPA) Law (1999)

- Oversees environmental quality and pollution control.

Sokoto State Environmental Protection Law (1997)

- Regulates industrial emissions and waste disposal.

Sokoto State Water Resources and Sanitation Law (2010)

- Ensures sustainable management of water resources.

Relevant State Policies on Water Resources, Environment, and Agriculture

- Various state-specific policies to address water, land, and environmental management.

ANNEX 3

Shared Strategic Vision and Goals

Goal

To achieve sustainable and equitable management of natural resources within the Rima Basin while ensuring climate resilience, environmental protection, economic and social security for all.

Objectives

1. Advocate for sustainable policies and ensure strict enforcement of environmental and other relevant laws.
2. Improve water availability and quality for all users.
3. Enhance biodiversity and ecosystem services to support economic activities.
4. Reduce soil erosion and land degradation.
5. Implement flood control measures and drought preparedness strategies.
6. Mainstream gender, security, and social inclusion in all activities.
7. Secure funding through government budgets, international aid, and public-private partnerships (PPP).

Stakeholder Engagement

1. Identify and actively engage all relevant stakeholders across the catchment.
2. Establish integrated management committees for key interventions (water, land restoration, ecosystems, etc.).
3. Promote community participation in decision-making through a bottom-up approach.

Water Resource Management

1. Develop and implement mechanisms for the regulation, monitoring, and evaluation of water resource usage.
2. Review and strengthen laws to protect water bodies and ecosystems.
3. Eradicate open defecation to enhance water quality.
4. Implement desilting of river channels and reservoirs, rainwater harvesting, and efficient irrigation systems.

5. Additional water quality and monitoring stations within the catchment

Land Use Management

1. Enforce sustainable land use policies and environmental laws.
2. Restore 45% of degraded lands and optimize land use by at least 50% through sustainable irrigation and agriculture.
3. Conduct collaborative research on land management and maintain a database on irrigation, geospatial, weather, soil, water quality, and land use changes.
4. Develop and implement short- and long-term land management strategies for uniform restoration.

Environmental Protection

1. Enhance existing ecosystems and establish new ones within the catchment.
2. Implement waste-to-energy initiatives for sustainable waste management.
3. Integrate local knowledge and content into environmental management practices.
4. Restore wetlands for erosion and flood control.
5. Install integrated early warning systems for agriculture, pollution, water quality, and flood control.
6. Develop solar farms for clean energy generation.

Community Benefits

1. Promote the sustainable utilization of Non-Timber Forest Products for economic development.
2. Conduct gender-responsive capacity-building programs on alternative energy sources to reduce deforestation.
3. Secure donor-funded projects from organizations like the World Bank, Global Environment Facility (GEF), and African Development Bank for natural resource management.
4. Develop green areas and recreation centers to promote eco-tourism.
5. Improve access to potable water and enhance community capacity.
6. Expand access to renewable energy solutions for communities.

Economic Development

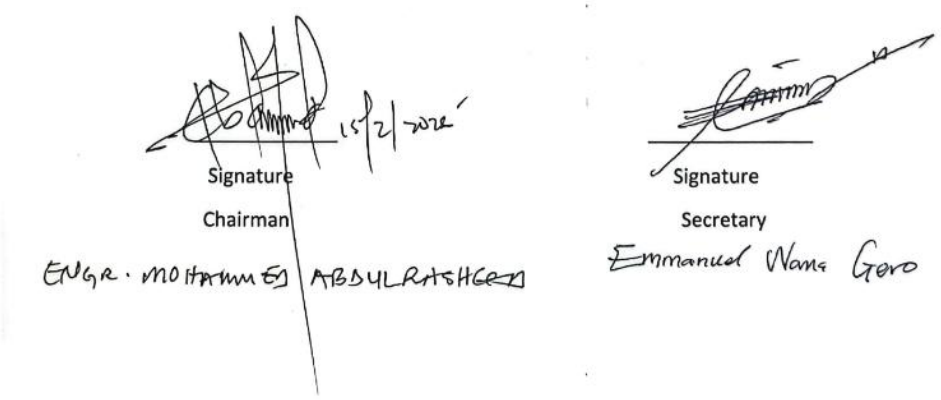
1. Improve access to finance and funding opportunities, including revolving loans and grants for grassroots associations.
2. Enhance agricultural productivity through modern techniques and precision farming.
3. Empower youth, women, and traditional institutions to drive agro-based economic initiatives.
4. Support infrastructural development for small-scale artisans and craftspeople.
5. Ensure a secure and conducive environment to attract foreign direct investment and promote commodity exports.

Climate Change Adaptation & Mitigation

1. Promote women-led green community initiatives for climate resilience and smart farming and agro-allied business.
2. Strengthen early warning systems for extreme weather preparedness.
3. Expand the use of renewable energy solutions in agricultural and other catchment activities (e.g. Briquettes, Biogas, Biofuel, etc).
4. Encourage the sustainable use of indigenous farming practices to protect the environment.

Monitoring & Evaluation / Policy Alignment

1. Conduct baseline assessments across key performance indicators, including social and livelihood factors, land degradation, and agricultural productivity.
2. Develop a database and monitoring tools for ongoing assessment.
3. Collect seasonal data to evaluate the effectiveness of interventions.
4. Engage all stakeholders in planning and regularly share progress reports to support data-driven decision-making.



STAKEHOLDER ENGUAGEMENT 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 (CO2), methane (CH4), and nitrous oxide (N2O).
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.

REFRENCES

Adebayo, A. A. (2014). "Climate Change and Hydrological Dynamics in the Jos Plateau, Nigeria." Journal of Geography and Environmental Management, 18(2), 112-126.

Adebayo, A. A., & Usman, B. A. (2016). "Environmental Degradation and Conservation in Plateau State, Nigeria." Journal of Nigerian Environmental Studies, 9(2), 45-61.

Adebayo, A. A., & Usman, B. A. (2017). "Infrastructure Development and Environmental Sustainability in Plateau State, Nigeria." Journal of Nigerian Environmental Studies, 9(2), 45-61.

Adeniyi, I. F., & Olabanji, I. O. (2015). "Assessment of Surface and Groundwater Quality in the Vicinity of Tin Mining Sites in Jos, Plateau State, Nigeria." Environmental Monitoring and Assessment, 187(6), 1-18.

Adeoye, N. O. (2013). "Topography and Drainage Systems of Plateau State, Nigeria". Nigerian Journal of Environmental Sciences, 7(4), 45-60.

Adeoye, N. O., & Abubakar, A. B. (2015). "Water Quality Assessment of Some Selected Rivers in Plateau State, Nigeria." Nigerian Journal of Hydrology, 8(2), 34 – 47

Adeoye, O. D., Bamidele, S. F., & Omole, F. K. (2019). "Water Supply and Sanitation Infrastructure in Plateau State, Nigeria: Current Status and Challenges." Nigerian Journal of Water Resources, 12(3), 78-89.

Adeyemi, S. O., & Oseni, O. G. (2017). "Youth Demographics and Social Mobility in Plateau State, Nigeria." African Journal of Development Studies, 10(2), 45-61.

Agwu, N. M., & Uzochukwu, A. (2015). "Agricultural Productivity and Rural Development in Plateau State, Nigeria." Nigerian Journal of Agriculture and Social Sciences, 8(4), 34-42.

Ayo, C. K., & Ojo, J. O. (2019). "Telecommunications Infrastructure and Digital Divide in Plateau State, Nigeria." Journal of Nigerian Information Technology, 10(1), 39-50.

Ayuba, H. K., & Shehu, R. A. (2016). "Mining and Environmental Degradation in Plateau State: An Overview." Nigerian Journal of Environmental Management, 20(1), 102-115.

Bawa, A. A., & Ogbonna, A. S. (2015). "Cultural Diversity and Conflict in Plateau State, Nigeria: Implications for National Integration." Journal of Ethnic Studies, 12(1), 89-103.

Bello, M. S., & Mundi, B. (2016). "Urbanization and Economic Development in Plateau State: Challenges and Opportunities." Nigerian Journal of Urban and Regional Planning, 15(2), 23-39.

Buba, S. A., & Nwokocha, C. M. (2015). "Biodiversity Conservation and Ecosystem Management in Plateau State, Nigeria." African Journal of Ecology, 18(3), 29-41.

Egwudah, N. E., & David, L. B. (2020). "Seasonal Climate Variations and Agricultural Productivity in Plateau State, Nigeria." Journal of Climatology and Agricultural Sciences, 11(2), 67-81.

Eze, C. A., & Ijeoma, O. I. (2018). "Climate Change and Its Impact on Water Resources in Plateau State, Nigeria." Nigerian Journal of Climate Studies, 7(3), 89-98.

Eze, P. C., & Abubakar, M. M. (2015). "Hydrological Characteristics of the Jos Plateau, Nigeria". International Journal of Water Resources and Environmental Engineering, 6(2), 34-42.

Ezekiel, M. A. (2017). "Mining and Land Degradation: The Jos Plateau Experience". Journal of Environmental Management, 15(2), 117-130.

Ezekiel, M. A. (2017). "Water Quality Issues in Plateau State, Nigeria: An Overview of Physical, Chemical, and Biological Parameters." Journal of Environmental Management, 25(3), 213-227.

Ibrahim, S. O., & Ahmed, M. G. (2018). "Road Infrastructure and Economic Development in Plateau State, Nigeria." Nigerian Journal of Transportation Studies, 14(4), 112-130.

Iloeje, N. P. (2017). "Hydrology of the Jos Plateau: Streamflow and Water Balance." Nigerian Geographical Journal, 14(3), 23-38.

Mallo, S. (2019). "The Impact of Elevation on Climatic Conditions in Plateau State, Nigeria." Nigerian Geographical Journal, 15(4), 23-35.

National Population Commission (2018). "Population Census Report: Plateau State." National Population Commission of Nigeria, Abuja.

Obot, E. A., Abdulrahman, B. I., & Ayoade, O. J. (2016). "Water Resources and Aquatic Biodiversity in Plateau State, Nigeria." Nigerian Journal of Hydrology, 14(1), 67-81.

Odeh, L. E. (2017). "Environmental Challenges and Sustainable Development in Plateau State, Nigeria." Journal of Nigerian Environmental Studies, 12(4), 112-130.

Odeh, L. E. (2018). "Development Planning and Economic Diversification in Plateau State, Nigeria." Journal of Nigerian Economic Studies, 14(3), 57-74.

Ogunleye, J. O., & Ayoade, J. O. (2016). "Flood and Drought Patterns in the Jos Plateau, Nigeria: An Overview." Journal of Climate and Water Resources, 9(1), 67-81.

Oguntoyinbo, J. S. (1983). "The Soils of the Jos Plateau and Their Agricultural Potentials". Journal of Soil Science, 34(2), 23-36.

Ojo, A. I., & Ayodele, R. A. (2020). "Wastewater Management and Environmental Health in Plateau State, Nigeria." Journal of Nigerian Environmental Management, 15(1), 33-50.

Ojo, O. A., Oloruntoba, E. O., & Olaleye, B. S. (2015). "Groundwater Resources in Plateau State, Nigeria: Challenges and Management." Nigerian Journal of Hydrogeology, 7(2), 41-54.

Okeke, I. C., & Onwuemesi, F. E. (2016). "Geomorphology and Environmental Hazards on the Jos Plateau". Nigerian Geographical Journal, 12(1), 50-65.

Olanrewaju, M. A., Adebola, O. O., & Bala, K. I. (2017). "Flood and Drought Management in Plateau State: Challenges and Prospects." Journal of Nigerian Water Resources, 9(4), 112-130.

Olofin, E. A. (1985). "Land Use Patterns on the Jos Plateau: A Historical Perspective". Nigerian Geographical Journal, 28(1), 45-56.

Oloruntoba, E. O. (2019). "Heavy Metal Contamination of Surface and Groundwater in Plateau State, Nigeria." Journal of Water and Health, 17(4), 545-558.

Oyeniyi, B. A., & Hassan, M. (2018). "Geographical Analysis of Jos Plateau, Nigeria: Climate, Vegetation, and Landforms". Journal of Geography and Regional Planning, 11(9), 179-188.

Udo, R. K. (1994). "Agricultural Land Use in Nigeria: Case Studies from the Jos Plateau". Nigerian Journal of Agricultural Economics, 9(3), 61-74.

Usman, B. A., & Alhaji, M. M. (2019). "Railway Transport and Economic Development in Plateau State, Nigeria." Nigerian Journal of Railway Studies, 8(2), 58-72.

Usman, B. A., Adebayo, A. A., & Nwosu, C. J. (2017). "Ecosystem Services and Environmental Sustainability in Plateau State, Nigeria." Nigerian Journal of Environmental Science, 14(2), 78-95.