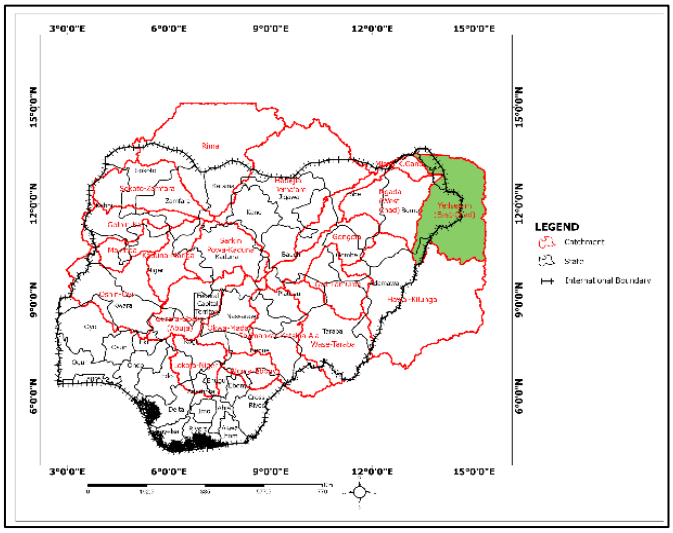
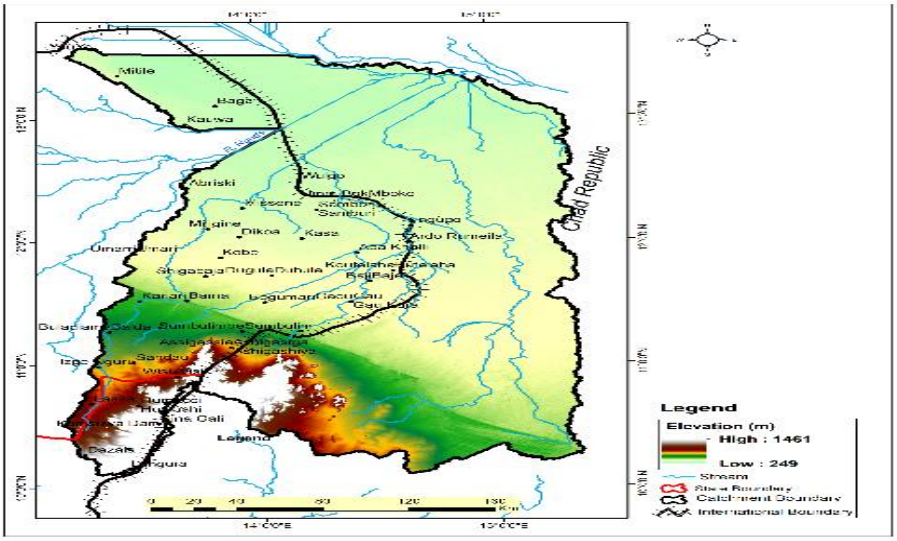
ACReSAL
Agro-Climatic Resilience in Semi-Arid Landscapes

THE WORLD BANK

YEDSERAM STRATEGIC CATCHMENT MANAGEMENT PLAN REPORT





MARCH 2025

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ABBREVIATIONS AND ACRONYMS

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

FGD	Focus Group Discussion
FMAFS	Federal Ministry of Agriculture and Food Security
FMEnv	Federal Ministry of Environment
FMWR	Federal Ministry of Water Resources
GBV	Gender-based violence
GCM	Global Climate Model
GEFC	Global Environmental Flow Calculator
GIS	Geographic Information System
GPS	Global Positioning System
GRDB	Global Runoff Data Base
GRDC	Global Runoff Data Centre
Ha	Hectares
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
masl	Metres above sea level
MCM	Million Cubic Metre
MDG	Millennium Development Goal
MSF	And Médecins Sans Frontières
MSL	Mecon Services Limited
M&E	Monitoring & Evaluation

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

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

EXECUTIVE SUMMARY

The Yedseram Catchment is a vital hydrological region within the Lake Chad Basin, spanning approximately 6.85 million hectares across northeastern Nigeria and parts of northern Cameroon. This catchment is a crucial resource base for agriculture, fisheries, livestock rearing, and biodiversity conservation, supporting millions of people who rely on its water and land resources for their livelihoods.

The catchment's geology varies, with sedimentary rocks, igneous formations, seasonal surface water, and pressured groundwater resources prone to salinization. Vegetation ranges from the Sudan savanna in the south to the desert in the north. However, the catchment faces numerous challenges, including climate variability, land degradation, deforestation, water scarcity, and conflicts over resource use. The NDVI study conducted as part of the SCMP provides valuable insights into the state of vegetation health in the catchment. The analysis highlights significant seasonal variations in vegetation density, degradation in specific areas due to deforestation and unsustainable agricultural practices, and the impact of climate variability on ecosystem stability. The study underscores the importance of integrating reforestation programs, sustainable land use planning, and ecosystem-based conservation strategies into catchment management efforts. Given the direct relationship between vegetation health and water resource sustainability, NDVI-based monitoring should be incorporated into long-term planning to guide interventions effectively.

Despite its ecological and socio-economic significance, the catchment faces numerous challenges relating to its various watershed services from both climatic and socio-economic drivers. These include the degradation of its land, biodiversity, and water resources and socio-political instability due to rapid population growth, high poverty rate, and weak governance. Another extant factor is climate change. The catchment's population is rapidly growing, with significant increases projected by 2050, placing pressure on water resources, land use, and infrastructure. Key activities like agriculture and aquaculture are vulnerable to climate change, and infrastructure such as dams and irrigation schemes requires improved maintenance and adaptation to meet future demands. Given these threats to the Catchment, a sustainable watershed management plan, considering a sound balance between conservation and development, is imperative.

This plan marshals various activities and initiatives to enhance climate resilience, promote socio-economic development, and protect natural resources in the Yedseram catchment for its socio-economic and environmental development. The purpose of this watershed plan is to help decision-makers and practitioners at local, basin, state, and national levels to understand the Yedseram Catchment's status, problems, issues, risks, and opportunities, as well as leverage investments for improving watershed management in short, medium and long-terms. The methodology for developing this plan would also be relevant to other watersheds in the ACReSAL Project's areas of northern Nigeria. The successful implementation of such a plan at the watershed level can also support integrated river basin management of larger river basins in the country.

Past and Ongoing Development Initiatives in the Catchment Area

To put the Plan in proper perspective, Table ES1 and Figure ES1 depict some past and ongoing development initiatives by different partners in the Yedseram Catchment.

Table ES 1: Past and Ongoing Initiatives in the Yedseram Catchment

LOCATION	PAST INITIATIVE	ONGOING INITIATIVE
Borno State	**Project: National Fadama Development Project (NFDP):** **Agency:** Federal Ministry of Agriculture & World Bank **Focus:** Enhancing agricultural productivity and rural livelihoods through irrigation and improved water management.	**Project: Agroclimatic Resilience in Semi-Arid Landscapes (ACReSAL)** **Agency:** World Bank & Nigerian Government **Focus:** Climate resilience, sustainable agriculture, and water conservation.
Adamawa State	**Project: Water, Sanitation, and Hygiene (WASH) Programs** **Agency:** Federal Ministry of Water Resources & UNICEF	**Project: Climate Resilience Projects** **Agency: UNDP and GIZ**

	Focus: Improved water supply and hygiene awareness in rural areas.	**Focus:** Sustainable land management and adaptive strategies to climate change.
Yedseram River Basin	**Project: Integrated River Basin Development Programs** **Agency: Chad Basin Development Authority** **Focus:** Managed surface and groundwater for irrigation and domestic use.	**Project: Renewable Energy and Livelihood Programs** **Agency: Federal Ministry of Environment & USAID** **Focus:** Promotes solar energy solutions and alternative livelihoods.
Various LGAs	**Project: Wetland Restoration and Biodiversity Projects** **Agency: Nigerian Conservation Foundation & Wetlands International** **Focus:** Conservation of critical wetlands and biodiversity.	**Project: Community-Based Resource Management Initiatives** **Agency: Local NGOs & State Governments** **Focus:** Encourages local participation in conservation and sustainable development.
Lake Chad Basin	**Project: Lake Chad Basin Commission (LCBC) Projects** **Agency: LCBC & African Development Bank** **Focus:** Regional water resource management to address declining water levels and resource conflicts, biodiversity conservation, and	**Project: Great Green Wall Initiative (GGWI)** **Agency: African Union & Nigerian Government** **Focus:** Large-scale afforestation and desertification control efforts to restore degraded landscapes, and promote sustainable land use in

	climate adaptation measures in the Lake Chad Basin	northern Nigeria, including the catchment area..

Despite the above initiatives, there is a general concern that most of the interventions within the catchment did not address most of the development challenges in an integrated manner. Many of the projects seemed to lack the needed integrated approach to tackle multiple issues that cascade around the same environmental and socio-economic development challenges. Thus, the catchment is still plagued by several biophysical and social problems, some of which are of significance as indicated below.

Main Biophysical and Socio-economic Challenges

Based on biophysical assessments and stakeholder engagement, the following are the key biophysical and socio-economic issues of the Yedseram Catchment:

1. **Water resources deterioration:** The Catchment is facing significant water resource deterioration due to climate change, deforestation, pollution, over-extraction, and poor management. Reduced rainfall and rising temperatures have decreased water availability, while deforestation and unsustainable land use contribute to erosion and sedimentation. Agricultural runoff and inadequate waste disposal have further degraded water quality, posing health risks and threatening biodiversity. Overuse of groundwater has led to declining water tables, exacerbating scarcity.
2. **Environmental Degradation:** Deforestation, soil erosion, and unsustainable land use practices are prevalent in the catchment area, threatening the ecosystem services that support agriculture, biodiversity, and human well-being. These practices lead to the degradation of land and water resources, reducing the catchment's ability to support its population. These conditions are exacerbated by the prolonged insurgency in the catchment area leading to indiscriminate clearing of forests as part of the military operations, as well as pressure on forest resources by internally displaced (IDPs) populations.
3. **Unsustainable agriculture and livestock practices**: The current practices have led to severe environmental degradation, including deforestation, soil erosion, water depletion, and biodiversity loss. Overgrazing, excessive use of chemical fertilizers, inefficient irrigation, and encroachment on wetlands have further exacerbated land and water resource

decline. These issues threaten food security, reduce agricultural productivity, and heighten conflicts between farmers and pastoralists.

4 **Climate Change Impacts:** Climate change exacerbates existing vulnerabilities in the Yedseram Catchment. Rising temperatures, erratic rainfall patterns, and increased frequency of floods and droughts intensify the catchment's challenges. These impacts disrupt the natural hydrological cycle, affecting water availability and agricultural productivity.

5 **Competing Water Demands:** The growing population and expanding agricultural activities in the catchment area intensify competition for limited water resources. This competition often leads to conflicts among different water users, including farmers, livestock herders, and industrial sectors, further straining the catchment's resources.

6 **Socio-economic disparities and unsustainable livelihood practices**: Widespread poverty, limited access to education, and unequal resource distribution have driven many communities to engage in unsustainable activities such as over-extraction of water, deforestation for fuelwood, and unregulated farming and grazing. These practices exacerbate land degradation, reduce agricultural productivity, and increase vulnerability to climate shocks.

7 **Weak Governance and Institutional Gaps:** Inadequate policy enforcement, fragmented stakeholder engagement, and insufficient funding hinder effective management of the Yedseram Catchment. These governance and institutional gaps prevent the implementation of sustainable resource management practices and the establishing of effective regulatory frameworks.

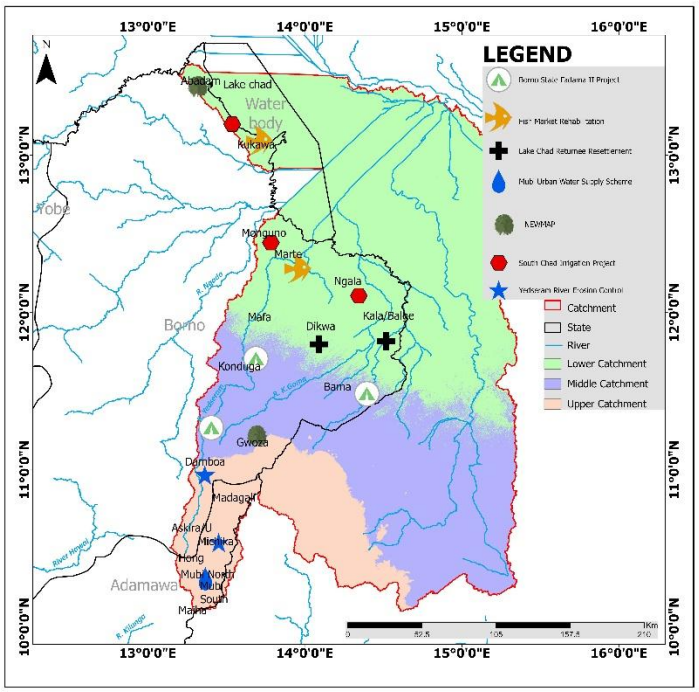


Figure E.S.1: Yedseram Catchment Showing Ongoing Interventions (Source: MSL, 2024)

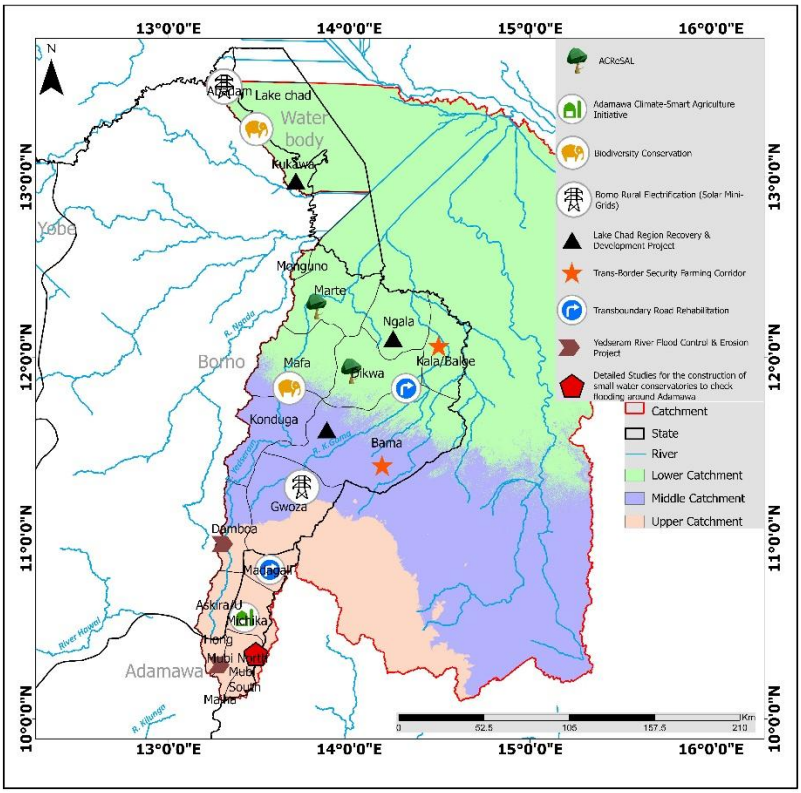


Figure E.S.2: Yedseram Catchment showing the ongoing interventions (Source: MSL, 2024)

Elements of the Catchment Management Plan

The elements of the catchment plan are captured through the lenses of the following strategic vision and objectives:

Strategic Vision

The strategic vision for the Yedseram Catchment Management Plan is to ensure the sustainable management and utilization of water and land resources to support economic development, environmental conservation, and community well-being. This vision aligns with broader national and regional sustainability goals, aiming to enhance resilience to climate change and secure water resources for future generations.

Strategic Objectives

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

i. **Integrated Water Resource Management (IWRM):** Promote coordinated water, land, and related resources management to maximize economic and social welfare without compromising ecosystem sustainability. Strategies include watershed planning, transboundary cooperation, and policy integration.

ii. **Climate Resilience and Disaster Risk Reduction:** Strengthen adaptive capacity and implement mitigation strategies to address flooding, droughts, and climate variability. This involves early warning systems, infrastructure adaptation, and resilient farming techniques.

iii. **Sustainable Land Use and Agriculture:** Encourage environmentally sustainable agricultural practices, afforestation, and soil conservation to combat desertification and land degradation. Key actions include promoting conservation agriculture, agroforestry, and sustainable irrigation systems.

iv. **Biodiversity and Ecosystem Conservation:** Protect and restore wetlands, forests, and other critical ecosystems to enhance biodiversity and ecological balance. Measures include habitat restoration, enforcement of conservation laws, and ecological monitoring.

v. **Improved Water Supply and Sanitation:** Enhance access to safe drinking water, sanitation, and hygiene to improve public health and reduce waterborne diseases. This objective includes improving water treatment facilities, expanding sanitation coverage, and community-led hygiene awareness campaigns.

vi. **Institutional Strengthening and Governance:** Build institutional capacity for effective catchment management, improve regulatory frameworks, and promote stakeholder

participation. This includes establishing catchment management committees and strengthening legal frameworks.

vii. **Community Engagement and Livelihood Development:** Foster inclusive decision-making processes and support alternative livelihoods to reduce pressure on natural resources. Efforts include training programs, microfinance support for sustainable enterprises, and local governance empowerment.

viii. **Data Collection, Monitoring, and Evaluation:** Establish a robust monitoring and evaluation framework to track progress, inform policy decisions, and ensure adaptive management approaches. This will involve remote sensing, hydrological data collection, and community-based participatory monitoring.

This strategic vision and objectives provide a framework for managing the Yedseram catchment's natural resources, promoting ecosystem services, and improving livelihoods while maintaining ecological integrity. They constitute the guiding directives for identifying the following strategic interventions or components of the Catchment Plan.

Catchment Policies

For harmonious relationships 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 the principle of binding nature of treaty once signed, ratified and enforced *(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 groundwater as well as application to all uses of the shared watercourse,
- Lake Chad Water Charter as the 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

To address the challenges facing the Yedseram Catchment, a comprehensive approach to sustainable water and land resource management is proposed. The key interventions include:

Component 1: Integrated Water Resource Management (IWRM) and Conservation

Strengthening coordination among government agencies, local communities, and private sector stakeholders is crucial for effective resource management. Developing catchment-based water allocation plans can help balance water demands and ensure equitable distribution of resources, and hence, the optimal utilization of water resources for sustainable development; equitable distribution and use of water resources to reduce conflict; mitigation and reduction of environmental degradation and disasters; development of water storage for post-wet season economic activity; and sustainable groundwater and surface water monitoring.

Component 2: Climate Resilience and Adaptation Measures

Implementing flood early warning systems can mitigate disaster risks and protect communities from the impacts of floods. Promoting drought-resistant crop varieties and water-efficient irrigation systems will enhance agricultural resilience. Expanding reforestation and afforestation programs will help restore degraded landscapes and improve ecosystem health. These are predicated on the vulnerability of the Yedseram catchment to the impacts of climate change, in particular, the temperature and precipitation variability along with climate extremes which are likely to impact the watershed characteristics and functions with socio-economic implications, particularly a possible increase in the frequency of climate-induced disasters and the imperative for climate-resilient infrastructure.

Component 3: Sustainable Land Use Planning and Conservation

Establishing protected areas is essential to safeguard wetlands, forests, and critical biodiversity hotspots. Encouraging practices such as agroforestry, conservation agriculture, and soil fertility management can enhance land productivity and sustainability. Predicated on the pressure exerted by human activities on land resources, enhancing the quality of the land resources through ecosystem restoration will be a significant initiative of this component.

Component 4: Infrastructure Development and Rehabilitation

Constructing and maintaining water storage facilities such as dams and reservoirs will improve water availability during dry periods. Improving rural and urban water supply infrastructure will ensure reliable access to clean water for communities.

Component 5: Strengthening Governance and Community Engagement

Enhancing policy enforcement through capacity building and regulatory frameworks is vital for sustainable catchment management. Encouraging participatory decision-making by involving traditional leaders, women, and youth groups will foster local ownership and commitment to

Table ES 2: Summary of Components and Activities of the Yedseram Catchment

Component	Key Activities	Key Indicators	Responsible Agencies/Partners
Integrated Water Resource Management	Watershed planning, transboundary cooperation, policy integration Construct small-scale water storage facilities and enhance rainwater harvesting techniques.	Number of watershed management plans, implemented policies Number of small-scale water reservoirs constructed, number of rainwater harvesting systems. established.	Federal Ministry of Water Resources, Chad Basin Development Authority and allied agencies. As above
Climate Resilience & Disaster Risk Reduction	Flood mitigation, drought preparedness, resilient farming techniques	Early warning systems were established, percentage reduction in flood/drought impacts	NIMET, State Ministries of Environment
Sustainable Land Use & Agriculture	Conservation agriculture, agroforestry, irrigation efficiency	Area of land under conservation agriculture, number of agroforestry projects	Federal Ministry of Agriculture, FAO
Biodiversity & Ecosystem Conservation	Wetland restoration, habitat protection, enforcement of conservation laws	Area of wetlands restored, biodiversity index	Nigerian Conservation Foundation, Wetlands International

Improved Water Supply & Sanitation	Water treatment, sanitation expansion, hygiene promotion	Number of households with improved water access, percentage reduction in waterborne diseases	State Water Boards, UNICEF
Institutional Strengthening & Governance	Capacity building, regulatory improvements, stakeholder engagement	Number of governance frameworks strengthened; stakeholder meetings held	National Water Resources Institute, Local Governments
Community Engagement & Livelihood Development	Training programs, microfinance support, alternative livelihoods	Number of beneficiaries trained, increase in household incomes	NGOs, World Bank, Local Development Agencies
Data Collection, Monitoring & Evaluation	Hydrological data collection, participatory monitoring, policy adaptation	Availability of real-time hydrological data, number of monitoring reports	NIHSA, Research Institutes, Universities

resource conservation. Establishing catchment management committees will ensure effective oversight and implementation of conservation efforts.

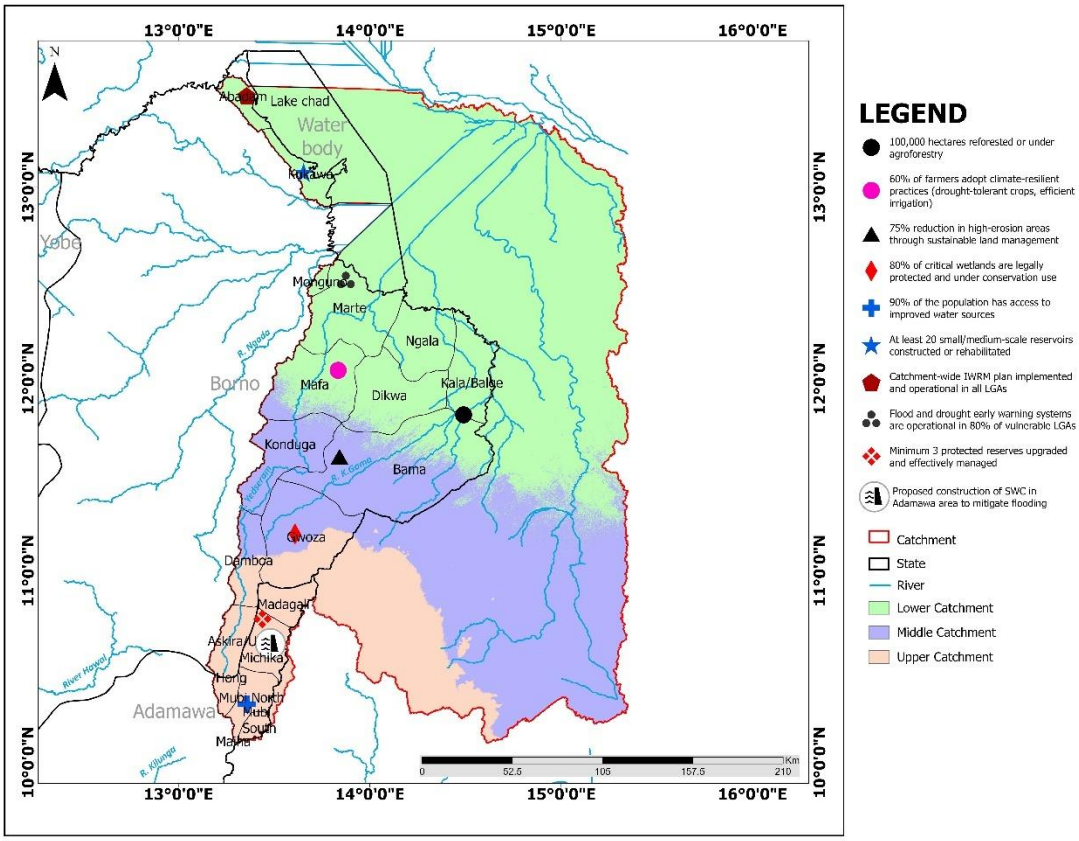


Figure E.S.3: Yedseram Catchment showing the Recommended interventions (Source: MSL, 2024)

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

Section	LGA/Towns	Specific Challenge	Proposed Intervention	Appropriate Tool(s) For Sustained Monitoring and Evaluation	Responsible Agencies	Expected Outcomes
Upper Catchment	**Damboa, Mubi South, Michika**	Soil erosion, slope degradation, and road damage on hilly terrain	- Terracing and erosion control (e.g., bunds, vetiver grass) - Construction of gabion walls and feeder road stabilization	DEMs (Digital Elevation Models), erosion risk maps, road surveys, GIS slope analysis, drone surveillance, erosion mapping.	FMAFS, FERMA, State Ministries of Works & Agriculture ACReSAL, NIWRMC. Ministry of tourism	- Reduced land degradation - Improved Road access and reduced landslides
	Askira, Mubi North	Water scarcity in upland areas & overgrazing drought	- Gravity-fed water supply systems - Rainwater harvesting - Rotational grazing and pasture rehabilitation Introduce climate-resilient crop	Satellite images and Ground trout measurement Hydrogeological surveys, livestock tracking tools, rainfall models	RUWASSA, FMEnv, Ministry of Livestock, FAO, NIHSA, ACReSAL , FMWR NIWRMC	- Enhanced water access - Sustainable grazing practices

	Madagali, Michika	Post-conflict displacement and damaged livelihoods	- Land and livelihood recovery support - Returnee assistance programs (housing, tools, seeds)	Conflict impact assessments, returnee tracking systems	NEDC, NEMA, UNHCR, FAO	- Reintegration of IDPs - Improved local food security
	Hong, Maha	Lack of services in remote highland communities	- Mobile clinics and schools - Solar microgrid electrification - Rural access road upgrades	Rural service accessibility maps, solar feasibility assessments	Ministry of Health, Ministry of Education, REA, GIZ	- Improved health & education - Reduced isolation and migration
	Mubi South, Mubi North	Deforestation & fuelwood pressure	- Reforestation with native species - Promotion of clean cookstoves & community woodlots	Consistent Soil testing (NDVI, and periodic land use land cover) drone monitoring, GIS maps	FMEnv, UNDP, State Forestry Depts ACReSAL , FMWR NIWRMC	- Forest restoration - Reduced reliance on natural forests
	Hong, Mubi South	Youth unemployment & limited non-farm income	Skills training in agro-processing and digital agribusiness -Technical/Vocational Training (TVET) - Small enterprise hubs and cooperatives	CBO, Focus group discussion, measurement of standard of living incubation software	SMEDAN, NDE, Adamawa State Skills Hub	- Increased youth employment - Rural economic diversification

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

Section	LGA/Town	Identified Challenges	Proposed Interventions	Appropriate Tools for Sustained Monitoring and Evaluation	Responsible Agencies	Expected Outcomes
Middle Catchment	**Konduga**	High number of IDPs with limited access to shelter, water, and food	- Integrated settlement upgrading for returnees - Emergency water & sanitation services - Support for dry-season farming	Humanitarian mapping tools, IDP tracking systems, WASH cluster tools	NEMA, NEDC, UNICEF, UNHCR, BOSEPA, FMHDS	- Improved living conditions - Resettled and supported returnees
	Bama	Damaged infrastructure (healthcare, schools, roads) from insurgency	- Reconstruction of public infrastructure - Rapid health facility deployment using mobile units	Post-conflict infrastructure audit, GIS-based facility planning	NEDC, WHO, Borno State Ministry of Health and Education, FMHDS, NEMA	- Restored access to basic services - Community confidence and stability

	Gwoza	Livelihood collapse due to displacement, poor access to markets	- Livelihood restoration programs (farming kits, livestock) - Market rehabilitation and rural access roads	Livelihood assessment tools, satellite market access maps	FAO, FMAFS, Mercy Corps, BOSEMA	- Increased income - Revived rural economies
	Bama, Gwoza	Frequent flash floods and water erosion in valleys during rainy season	- Construction of check dams and contour bunds - Community-led watershed management	DEMs (Digital Elevation Models), rainfall-runoff simulation tools	HJRBDA, FMEnv, Rural Water Agencies, RUWASSA	- Reduced flood damage - Enhanced water availability
	Konduga, Gwoza	Youth unemployment and risk of radicalization	- Vocational training and peacebuilding programs - Youth cooperative formation & micro-grants	Youth vulnerability mapping, skills match assessments	UNDP, SMEDAN, NDE, Peacebuilding NGOs	- Engaged youth workforce - Reduced security risk
	All Towns	Insecurity limiting access to humanitarian and development services	- Civil-military coordination for safe access - Security-informed	Conflict sensitivity tools, remote data collection (mobile surveys)	UN OCHA, ICRC, Nigerian Army Civil-Military Cooperation Unit	- Safer aid delivery - Improved field operations

			programming frameworks			

Table E.S.5: Lower Catchment of the Yedseram Strategic Catchment – Spatial Challenges and Intervention Matrix

Section	**Town**	**Identified Challenges**	**Proposed Interventions**	**Appropriate Tools, for Sustained Monitoring and Evaluation**	**Responsible Agencies**	**Expected Outcomes**
Lower Catchment	**Abadam**	Inaccessibility due to security and flooding, Gender based Violence	- Deployment of mobile aid units - Elevated access roads construction. Activities governance	Remote sensing (floodplain mapping), road condition surveys	NEMA, NEDC, Nigerian Army Engineers, IOM, ACReSAL	- Improved access for aid - Reduced isolation during floods. Improved security.
	Lake Chad Region	Shrinking water body, collapsing fisheries & ecosystem degradation. Gender base violence	- Sustainable fisheries program, Ground water exploitation - Wetland restoration	Satellite lake monitoring (NDVI, water level sensors)	LCBC, FMEnv, UNDP, FAO, ACReSAL, HJRBDA, CBDA, NIHSA, NIWRMC	- Improved ecosystem health - Revived local fisheries

			(reforestation, buffer zones). Awareness campaign			
	Kukawa, Ngala	IDP overpopulation and pressure on water and sanitation. Gender base violence	- Drilling of boreholes and solar water schemes - WASH services in camps and host communities. Capacity Building	WASH vulnerability maps, water quality testing kits	UNICEF, ICRC, RUWASSA, WHO, FMWR, NIWRMC	- Reduced disease outbreaks - Improved living conditions. Improved Awareness
	Monguno, Marte	Agricultural land underutilized due to insecurity and mine contamination	- Mine clearance operations - Provision of improved seed and tools for returnees	Land mine risk maps, GIS crop suitability maps	UNMAS, FAO, FMAFS, HALO Trust,	- Safe access to farmland - Increased agricultural production
	Ngala, Kala/Balge	Cross-border trade disruptions and poor market access	- Rehabilitate trade routes and customs facilities - Support local market revival through grants	Trade corridor mapping, market potential assessments	ECOWAS, NCS, BOSEMA, Mercy Corps	- Revived trade and economic activity - Job creation

	Dikwa	Repeated seasonal floods displacing communities	- Construction of drainage and embankments	Flood risk zoning, hydrological models	NEMA, HJRBDA, Borno State Urban Dev Agency	- Reduced displacement - Long-term flood resilience
	Marte, Abadam	Limited energy access for households and small businesses	- Community-scale solar mini-grids - Solar lanterns and irrigation pumps	Energy need mapping, solar irradiance assessment tools	REA, GIZ, Power Africa, BOSEPA	- Improved energy access - Boost in small-scale enterprises

Expected Outcomes

By implementing this strategic plan, the following outcomes are anticipated:

- **Improved Water Security:** Enhanced availability and quality of water resources to meet growing demand.
- **Increased Climate Resilience:** Reduced vulnerability to climate-induced risks such as floods and droughts.
- **Enhanced Agricultural Productivity:** Sustainable irrigation and soil management practices leading to higher crop yields.
- **Stronger Governance Frameworks:** More effective policy enforcement and institutional coordination.
- **Biodiversity and Ecosystem Protection:** Conservation of critical habitats and restoration of degraded areas.
- **Reduced Resource-Based Conflicts:** Equitable access to water and land resources, minimizing tensions among users.

CHAPTER 1 INTRODUCTION

1.1 Purpose of the Plan

The Yedseram catchment is a critical ecosystem that supports the livelihoods of millions of people in Northern Nigeria. However, the catchment faces numerous challenges, including:

i. Environmental degradation: Deforestation, soil erosion, and pollution threaten the catchment's ecosystem services and biodiversity.
ii. Water scarcity: The catchment's water resources are under pressure due to increasing demand, climate change, and inefficient use.
iii. Poverty and inequality: Many communities in the catchment live in poverty, with limited access to basic services, such as healthcare, education, and sanitation.
iv. Climate change: The catchment is vulnerable to climate change, with projected changes in temperature and precipitation patterns likely to exacerbate existing challenges.

1.1.1 Rationale for a Strategic Catchment Plan

In response to these challenges, a strategic catchment plan is necessary to:

a. Promote sustainable development: The plan will promote sustainable development in the catchment, balancing economic, social, and environmental objectives.
b. Improve water resources management: The plan will address water scarcity and improve water resources management, ensuring equitable access to water for all users.
c. Enhance ecosystem services: The plan will protect and restore ecosystem services, including forests, wetlands, and wildlife habitats, to maintain biodiversity and ecological integrity.
d. Support climate change adaptation and mitigation: The plan will support climate change adaptation and mitigation efforts, reducing the catchment's vulnerability to climate-related hazards.
e. Foster stakeholder engagement and collaboration: The plan will foster stakeholder engagement and collaboration, ensuring that all stakeholders, including local communities, civil society organizations, and government agencies, work together to achieve the plan's objectives.

1.1.2 Expected Outcomes

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

a) Enhanced Agricultural Productivity

b) Biodiversity and Ecosystem Conservation

c) Strengthened Institutional and Policy Frameworks

d) Socio-Economic Development and Poverty Reduction

e) Reduced Resource-Based Conflicts:

f) Sustainable Urban Development

1.1.3 Environmental Roles

1 Conservation of natural resources: The catchment area hosts diverse ecosystems including wetlands, forests and grasslands. These ecosystems serve as habitats for a wide range of flora and fauna.

2 Protection of ecosystem services: Wetlands within the Yedseram Catchment provide essential ecosystem services, such as groundwater recharge, flood control, and Carbon sequestration

3 Mitigation of climate change: Natural features of the catchment help regulate the climate, mitigate the impact of extreme weather events, and maintain the overall health of the region's water systems.

1.1.4 Socio-Economic Roles

1. Improved Livelihoods: The Yedseram Catchment is a fundamental driver of economic activity in the region. Local communities rely on rain-fed and irrigated farming for subsistence and commercial purposes. The availability of water from the catchment is critical for sustaining crops and livestock. Beyond agriculture, the catchment supports fishing, forestry, and small-scale manufacturing industries.

2. Enhanced Food Security: Agriculture ensures food security for rural households. Sustainable irrigation and soil management practices contribute to higher crop yields.

3. Increased Economic Benefits: Agriculture generates income for rural households. The efficient management of water and land resources can enhance economic stability. The catchment supports industries such as fishing, forestry, and small-scale manufacturing, which depend on sustainable

resources. Urban centers within the catchment are expanding, increasing demand for water supply, sanitation, and infrastructure, necessitating sustainable urban planning for balanced development.

1.1.5 Governance and Institutional Roles

1. Coordination and collaboration: Effective governance and institutional coordination are critical for the sustainable management of the Yedseram Catchment. The catchment plan will promote coordination and cooperation among government agencies, local communities, and civil society organizations

2. Policy and legislative framework: A well-structured governance framework helps regulate water and land use, prevent conflicts, and ensure stakeholder participation in decision-making (local communities to governmental agencies).

3. Monitoring and evaluation: The Yedseram Catchment Plan will establish a monitoring and evaluation framework to track progress, identify challenges, and make adjustments to the plan as needed. By so doing, the SCMP will help to mitigate and sustain the following:

- Disaster risk reduction
- Human health and well-being
- Cultural heritage conservation

1.1.6 Catchment Policies

For harmonious relationships 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 the principle of binding nature of treaty once signed, ratified and enforced *(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 groundwater as well as application to all uses of the shared watercourse,
- Lake Chad Water Charter as the 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)

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 North Eastern Development Commission (NEDC) oversees several initiatives, including Newmap projects, initiatives from the Lake Chad Commission, the Upper Benue River Basin Development

Authority, the Hadejia-Jamare River Basin Authority along with its Trust Fund, and the Rural Access and Mobility Project, FMWR-TRIMING project among others.

However, the strategic Catchment Management Plan is anticipated to integrate the essential components of the catchment as outlined in this report, facilitating a comprehensive development approach for the region. This integration is crucial considering the interconnectedness of these components, thereby ensuring that the interventions are strategically planned with regard to the spatial relationships of these factors. The plan's development in this integrated fashion is expected to foster cohesive growth across the entire region, as opposed to conducting interventions in isolation.

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 Dk Catchment management Plan are prominent initiatives in Kenya.

CHAPTER 2 : CHARACTERISTICS OF THE CATCHMENTS

2.1 Location

2.1.1 Location and Boundary

The Yedseram Catchment is a vital hydrological region within the Lake Chad Basin, spanning 6,852,750 hectares. It covers the larger parts of Borno State and extends to the northern parts of Adamawa State. The area lies between latitude 10°17’13’’N and 13°25’50’’N and longitude 12°57’58’’E and 15°30’15’’E (Figure 2.1). The Ngada River Catchment bounds the catchment to the west and Lake Chad to the north, making it an important resource for water supply, agriculture, and biodiversity conservation in the region.

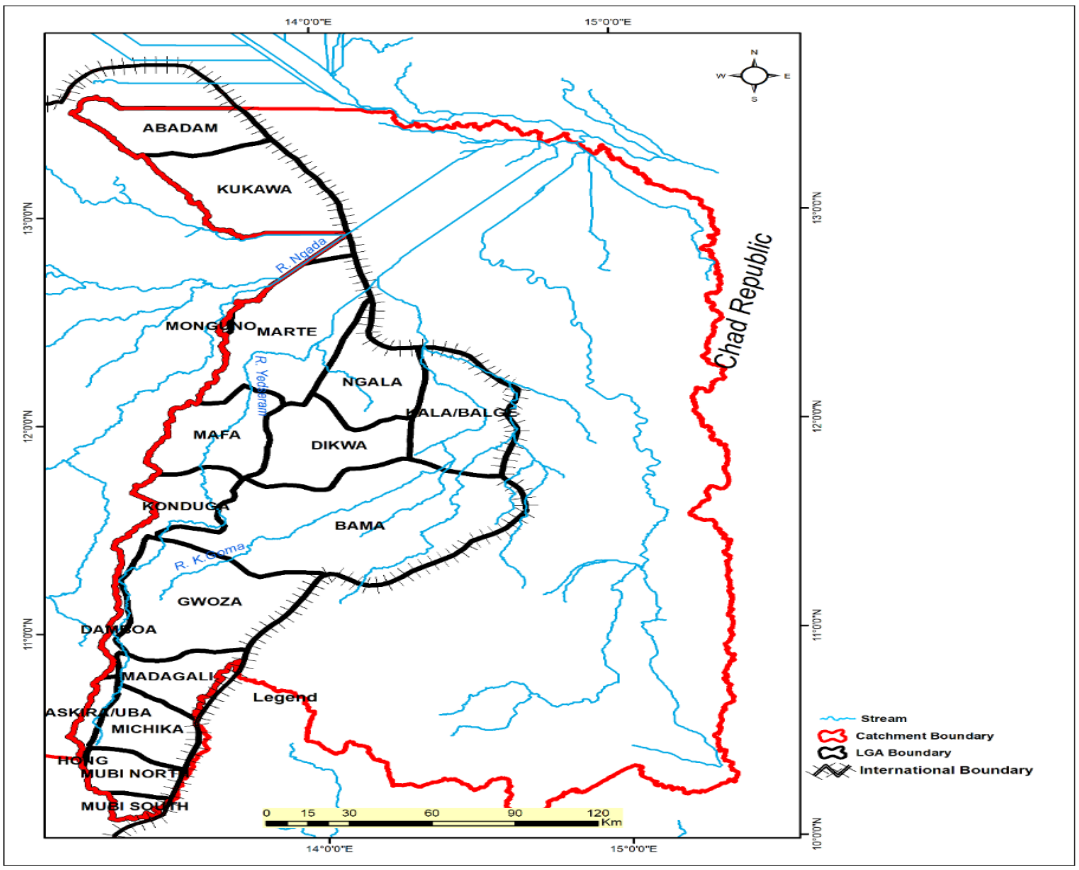


Figure 2.1: Yedseram Catchment showing the LGA's (Source: MSL, 2024)

The Strategic Yedseram Catchment Management Plan was developed based on a comprehensive scientific report, which integrates data collected, analyzed, and derived using modern techniques from multiple sources, including online databases, field surveys, focus group discussions, interviews, secondary literature, and stakeholder engagements.

2.2 Precipitation, Temperature, Sunshine, and Relative Humidity

The catchment area has a tropical climate with distinct wet and dry seasons. The interplay of rainfall, temperature, sunshine duration, and relative humidity shapes its hydrological and ecological patterns.

2.2.1 Precipitation

Rainfall patterns vary across the catchment, with precipitation ranging from 500 mm in the northern Sahel to over 800 mm in southern sub-humid zones. Rainfall is seasonal and influenced by the Inter-Tropical Convergence Zone (ITCZ). The wet season is from June to September, peaking in July and August, while the dry season lasts from October to May, significantly reducing water availability and impacting agriculture and water management.

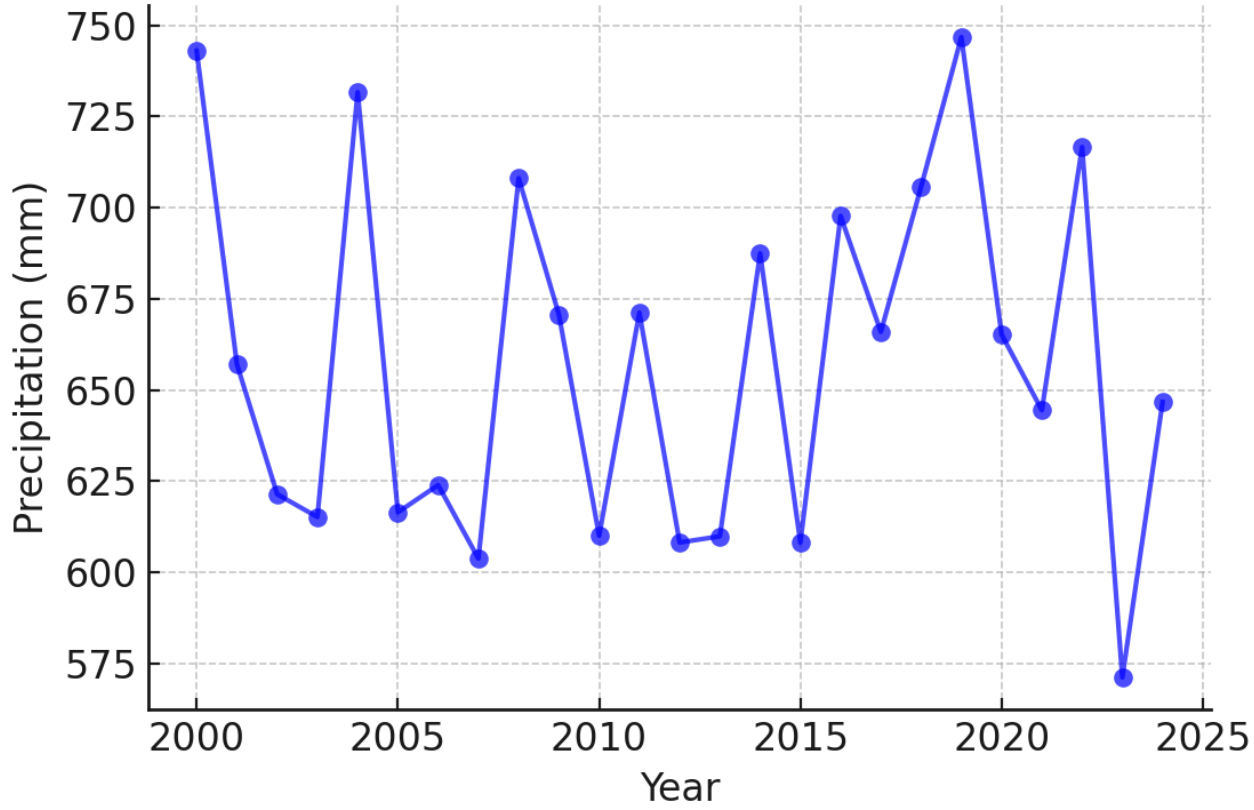


Figure 2.2: Annual Precipitation of the Catchment (2000 – 2024) (Source: Nimet, 2021)

2.2.2 Temperature

The catchment's temperature is high year-round, averaging 26°C to 30°C. The record highs occur from March to May, often surpassing 40°C in the north, leading to significant evaporation and water loss from rivers, lakes, and reservoirs. Cooler temperatures are present in November to February, dropping to around 15°C influenced by the harmattan winds, which bring dry and dusty conditions across the region.

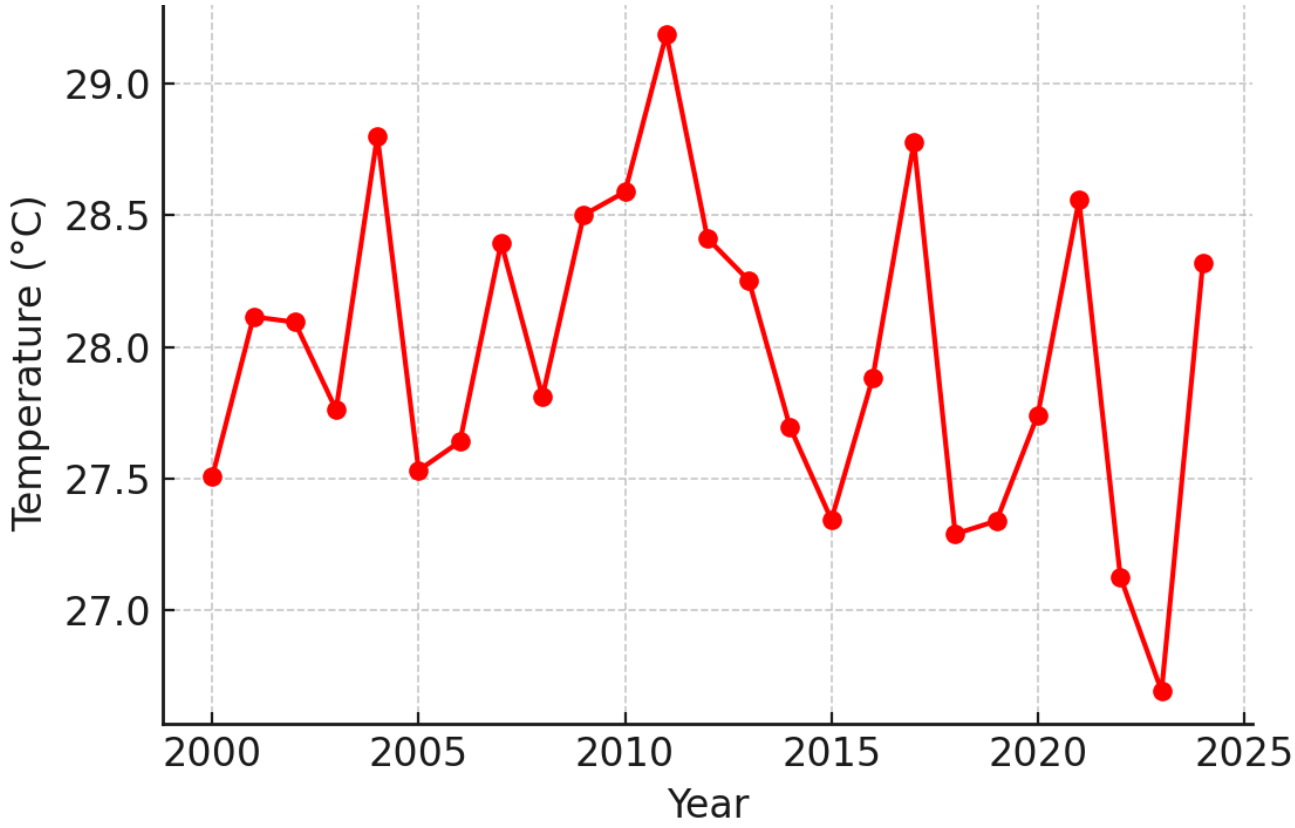


Figure 2.3: Annual Temperature of the Catchment (2000 – 2024) (Source: World Bank Climate Knowledge Portal, 2020)

2.2.3 Sunshine Duration

The region enjoys 8 to 10 hours of daily sunshine from November to April due to clear skies and minimal clouds. Conversely, May to October sees reduced sunshine, averaging 4 to 6 hours daily because of increased cloud cover and rain. Monthly averages show November to February with the highest sunshine at 7 to 8 hours, while July and August have the lowest at 4 to 5 hours due to peak rain.

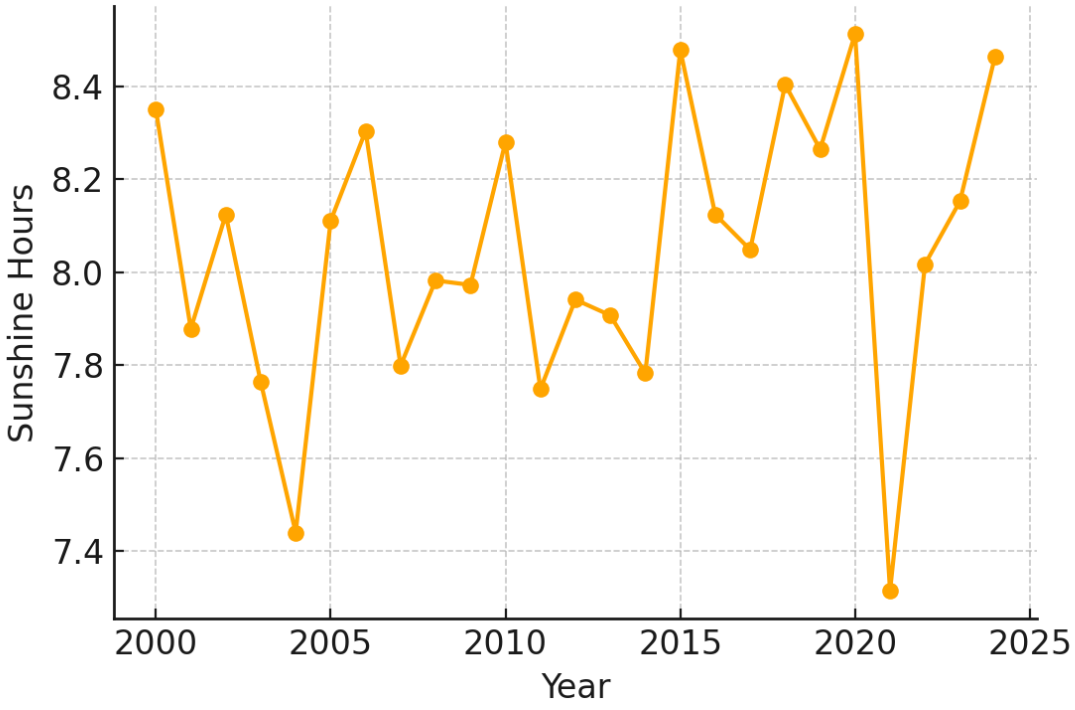


Figure 2.4: Annual Sunshine Duration (2000 – 2024) (Source: NASA Power Data, 2022)

2.2.4 Relative Humidity

The relative humidity in the Yedseram catchment varies seasonally. During the dry season (October to May), low humidity results from Harmattan winds, leading to arid conditions and high evapotranspiration. In contrast, the rainy season (June to September) sees moderate humidity, reaching up to 80% in the mornings and dropping to 50-60% in the afternoons. The dry season often sees humidity levels below 20%, especially during the Harmattan.

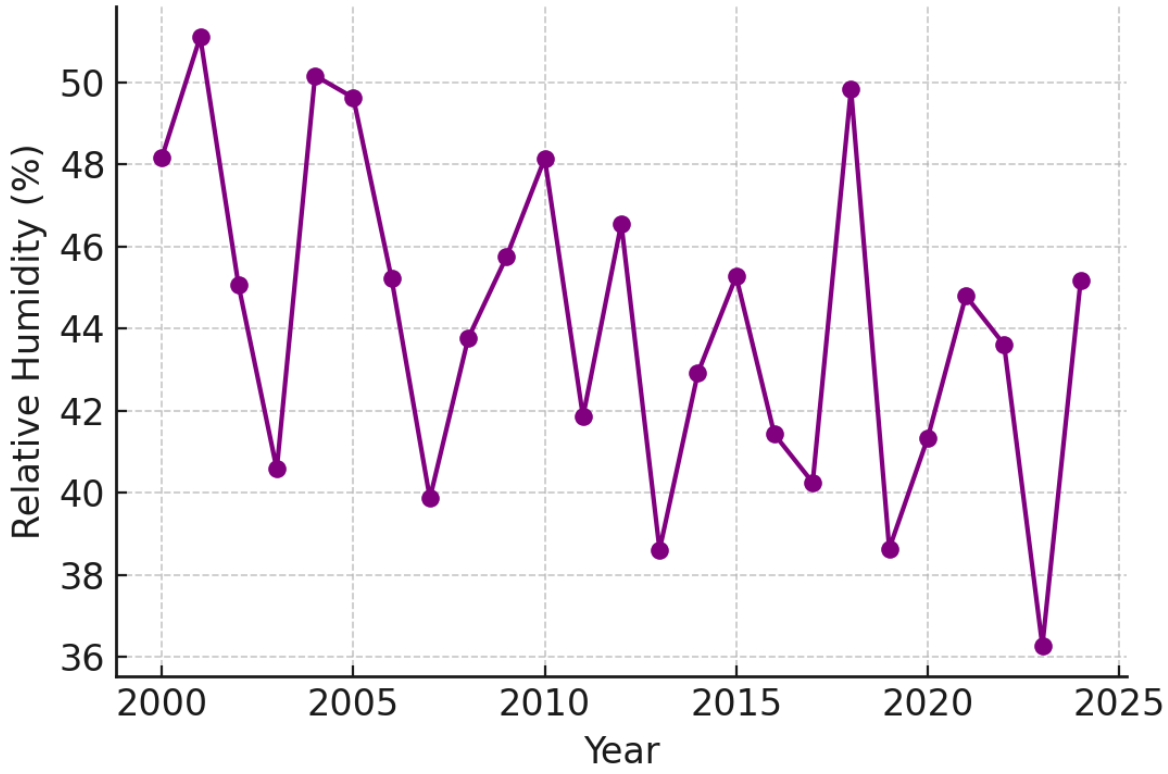


Figure 2.5: Annual Relative Humidity of the Catchment (2000 -2024) (Source: FAO AQUASTAT, 2019)

2.3 Topography, Drainage, Geology and Soils

- This section analyzes the topography and drainage of the Yedseram Catchment, focusing on their impact on water resources, flood management, and land use.
- This catchment is in the Chad Basin (Hydrological Area VIII), which drains into Lake Chad, a shallow freshwater lake in northeastern Borno.
- Lake Chad has reduced in size in recent decades due to climate change and human activities, raising concerns about water availability and environmental sustainability.
- The Yedseram Catchment exhibits diverse topographical features that significantly influence its hydrology, land use, and ecosystem functions.
- The catchment is characterized by a combination of lowland plains, rolling hills, and highland areas, contributing to the varied drainage patterns across the region.

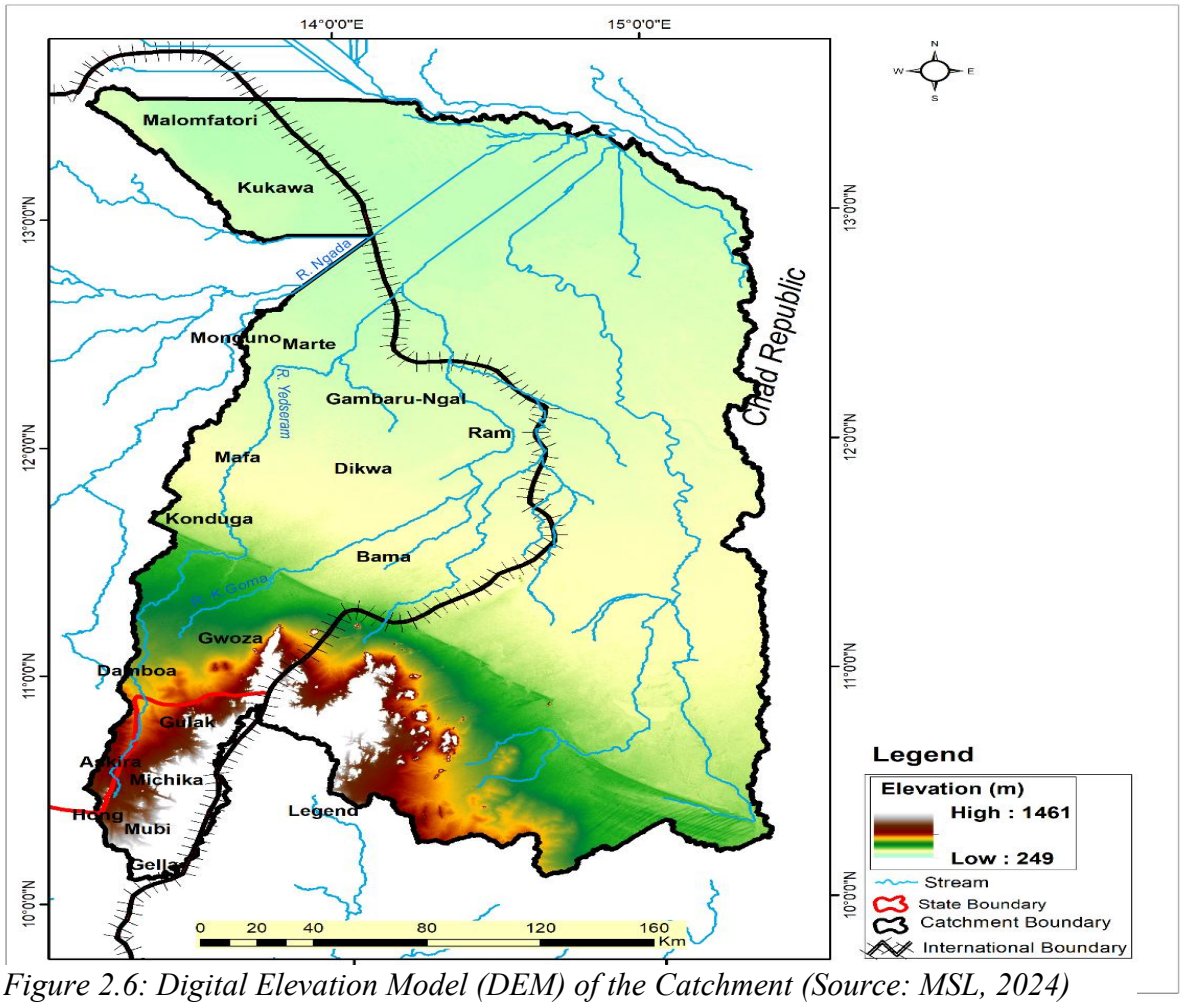


Figure 2.6: Digital Elevation Model (DEM) of the Catchment (Source: MSL, 2024)

2.3.1 Drainage

- The drainage system of the Yedseram catchment is shaped by its topography and climate, as it lies within the Chad Basin, an endorheic system that drains into Lake Chad.
- The catchment features a predominantly flat terrain interspersed with isolated hills and ridges, while the Mandara Mountains along the southeastern border with Cameroon serve as the source of several rivers, including the Yedseram River (Figure 2.7).
- The River Yedseram is seasonal, with peak flows occurring during the rainy season (June to September) and significantly reduced flows in the dry season (October to May).
- This seasonality impacts agriculture, fishing, and domestic water supply. Due to the flat topography, certain areas experience poor drainage, leading to the formation of inland depressions and wetlands, which become waterlogged in the rainy season and support swamp vegetation.
- Additionally, the sandy soils of the catchment contribute to erosion and gully formation, further influencing local drainage patterns

STATES OF INFLUENCE

1. Borno
2. Adamawa
3. Northern Cameroun

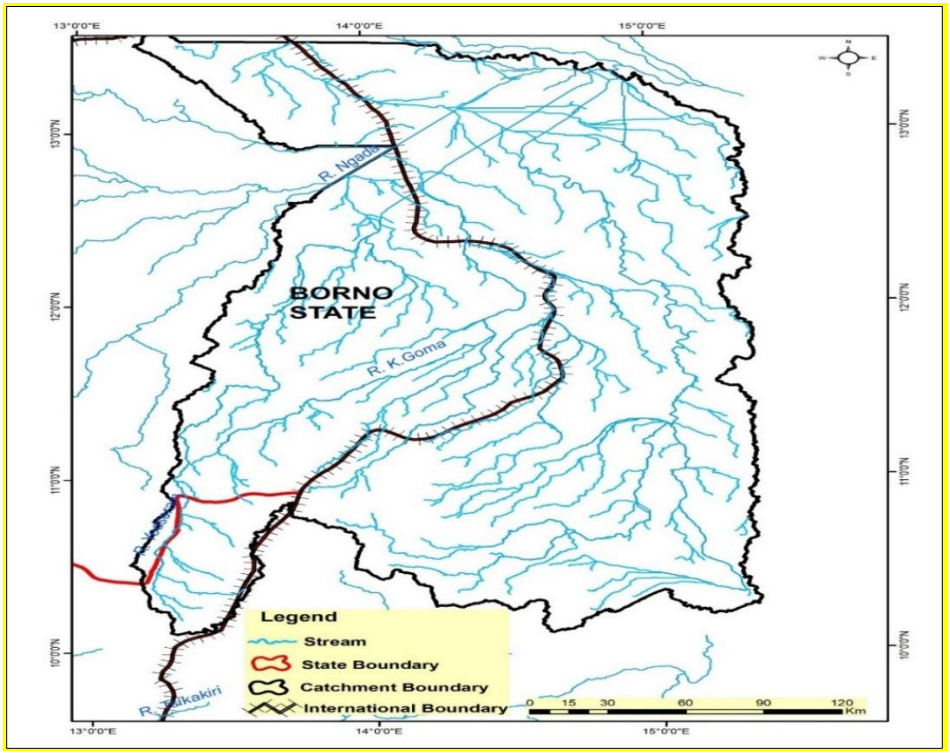


Figure 2.7: Drainage Map of Yedseram Catchment (Source: MSL, 2024)

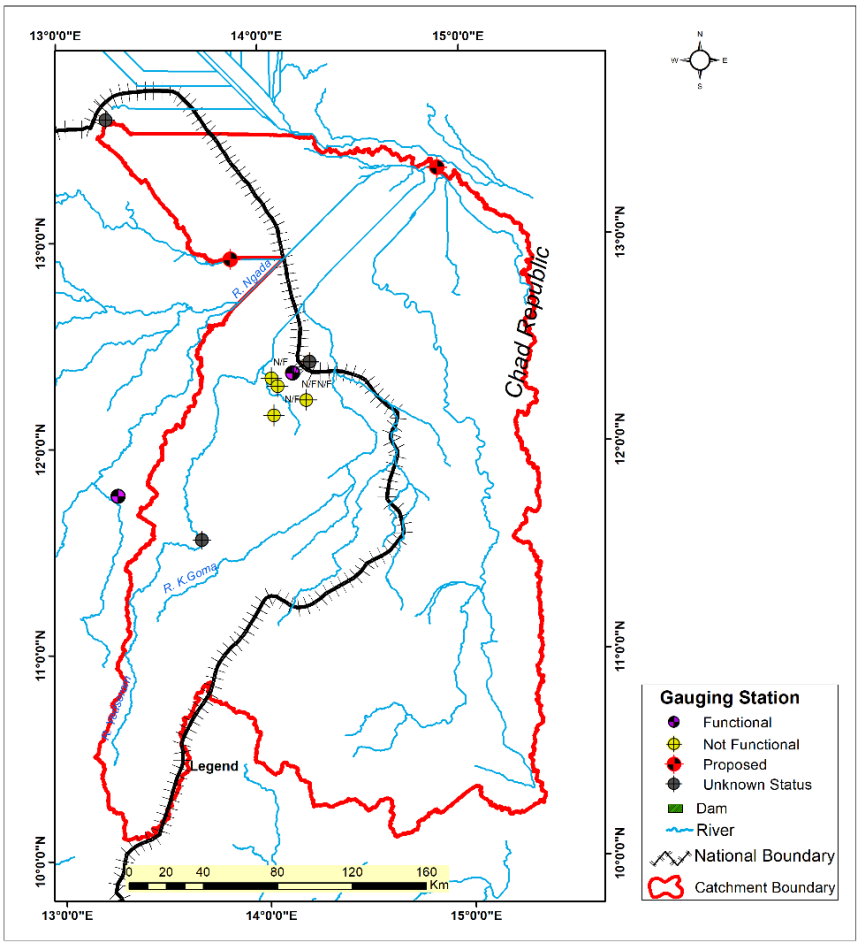


Figure 2.8: The Catchment Map Showing the Recorded Gauging Stations (Source MSL, 2025)

2.3.2 Geology and Soil Types

- The geological formations within the Yedseram Catchment are diverse, influencing groundwater storage, soil fertility, and overall land use patterns.
- The catchment is underlain by two primary geological structures: the **Precambrian Basement Complex** in the southern regions and the **Chad Basin Sedimentary Formation** in the northern parts.
- These formations play a crucial role in determining the catchment's hydrological characteristics, including groundwater availability and surface water flow dynamics.

2.3.2.1 Geology

The **Chad Basin Sedimentary Formation, Precambrian Basement Complex**, and **Tertiary to Recent Volcanics.**

1. Chad Basin Sedimentary Formation (Northern and Central Area)
2. Precambrian Basement Complex (Southeastern Area)
3. Tertiary to Recent Volcanics (Southern Area)

2.3.2.2 Soil Types

The Yedseram Catchment contains a variety of soil types (Figure 8), each with distinct properties affecting land productivity and water retention capabilities. The major soil groups in the catchment include:

1. **Arenosols (Sandy Soils):** Found mainly in northern catchment areas. They have loose, well-drained textures and low water retention. While limited in fertility, they are suitable for drought-resistant crops like millet and sorghum.
2. **Luvisols (Clay-Rich Soils):** Common in central and southern areas, this soil is highly fertile from clay and minerals. Ideal for intensive crops like maize, rice, and vegetables cultivation.
3. **Ferralsols (Leached Tropical Soils):** Found in highland areas near the Mandara Mountains, these soils are weathered and rich in iron and aluminum oxides. They have moderate fertility and need organic amendments for improved productivity.

4. **Gleysols (Waterlogged Soils):** Found in floodplains and wetlands, these areas retain high moisture and are ideal for rice cultivation and conservation. However, they are prone to waterlogging and require effective drainage management for optimal use.
5. **Regosols (Eroded Soils):** These areas, especially deforested or overgrazed ones, are prone to erosion and desertification due to low organic matter. Soil stability requires conservation techniques like afforestation and controlled grazing.

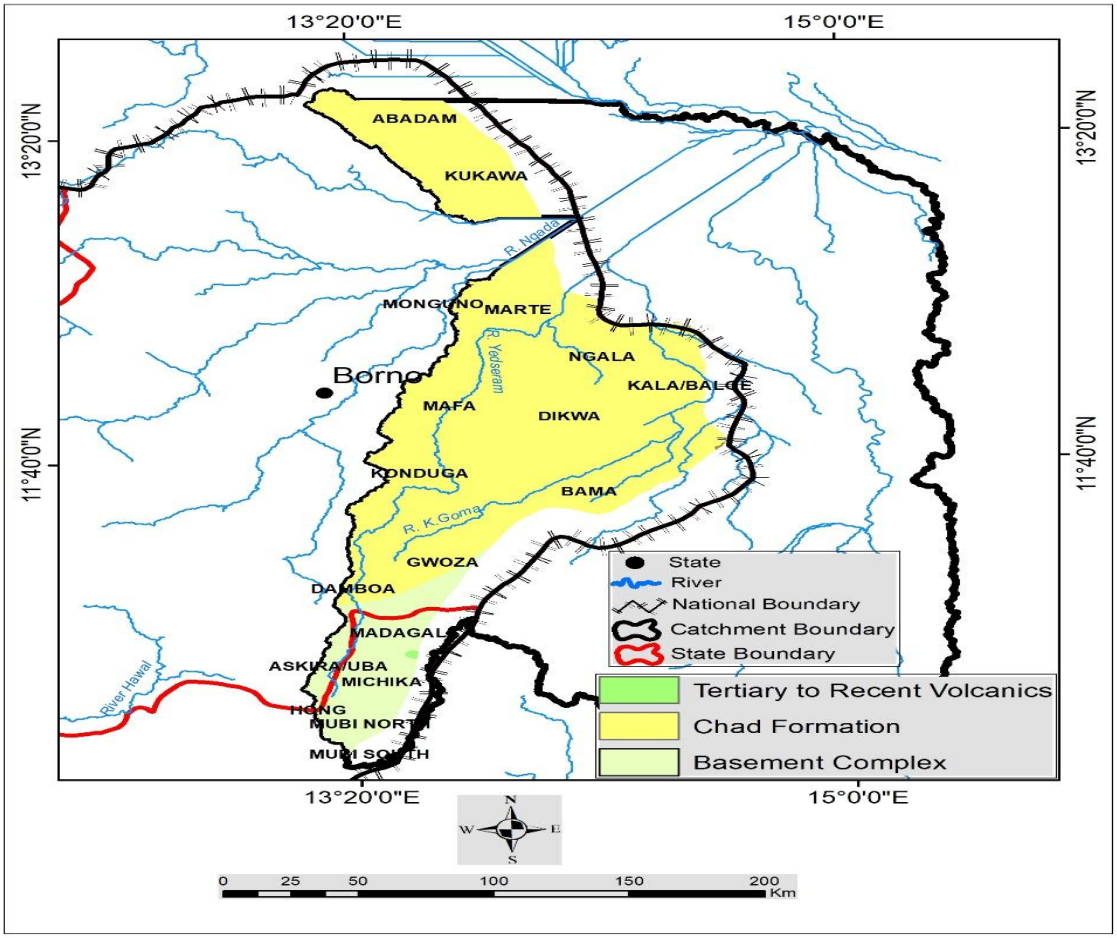


Figure 2.9: Geological Map of The Yedseram Catchment (Source: MSL, 2024)

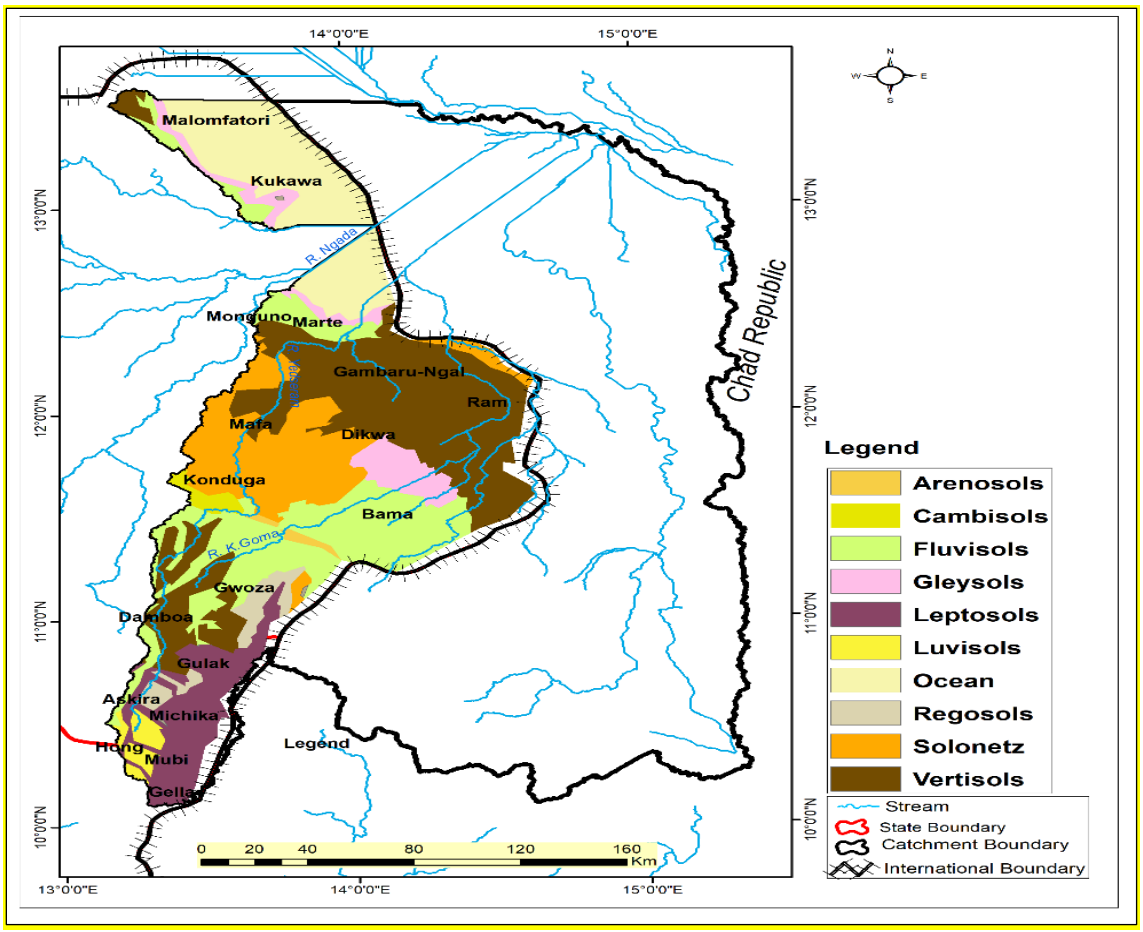


Figure 2.10: Soil map of the Yedseram Catchment (Source: MSL, 2024)

2.4 Land Use and Land Cover

- The Yedseram Catchment exhibits diverse land use and land cover types shaped by natural and human activities (Figure 2.10).
- Various factors, including climate, geology, hydrology, and socio-economic activities, influence the catchment's land use and land cover (LULC).
- The catchment supports agriculture, settlements, forests, wetlands, and rangelands, all of which contribute to the socio-economic and environmental functions of the region. However, rapid population growth, urban expansion, and climate variability have significantly altered land use patterns, leading to deforestation, soil degradation, and increased pressure on water resources.

2.4.1 Natural Vegetation

The natural vegetation in the Yedseram catchment varies by regions within the catchment, shaped by climate and soil types:

- **Central Yedseram Catchment (Transitional Zone – Shrubland and Grassland):** Vegetation changes from woodland to scrubland, featuring drought-resistant trees like desert dates and shea trees. Dominant grass species include Andropogon gayanus and Hyparrhenia spp. This area experiences desertification due to overgrazing and deforestation.
- **Northern Yedseram Catchment (Sahel and Semi-Arid Zone):** The landscape has sparse vegetation, with drought-resistant shrubs and grasses like gum arabic trees and wild date palms. Severe threats from desertification, overgrazing, and climate change endanger this vegetation. Harsh conditions dominate livestock rearing use**.**
- **Wetland and Riparian Vegetation (Lake Chad Basin and Riverbanks):** This zone supports aquatic plants like reeds, papyrus, and other hydrophytic species. These wetlands provide habitats for fish, birds, and wildlife, playing a key role in flood regulation and sustaining fisheries.

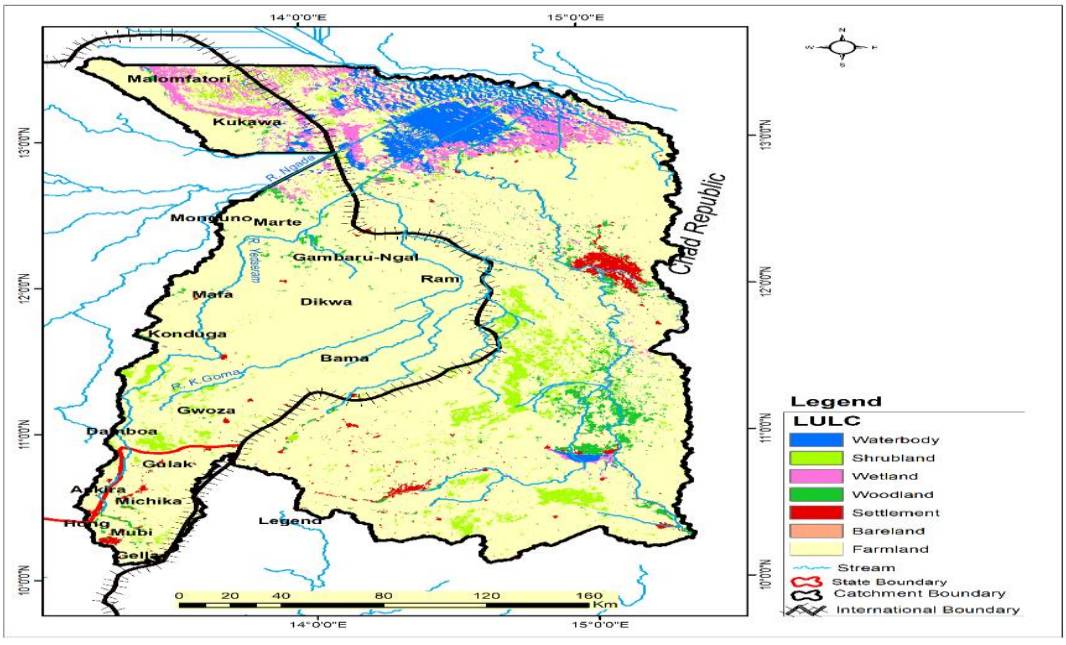


Figure 2.11: Land Use/Land Cover Map of the Catchment (Source: MSL, 2024)

Agricultural Land use:

- **Intensive Rain-Fed Agriculture:** In southern areas, major crops are maize, millet, sorghum, groundnuts, beans, cassava, and rice. Challenges like soil erosion, bush burning, and land clearing diminish soil fertility.

- **Mixed Farming with Pastoralism:** In the central area, major crops include sorghum, millet, cowpea, sesame, and groundnut. Key issues are desertification, erratic rainfall, and land degradation from overuse.
- **Pastoralism and Drought-Resistant Crops**: This predominates in the north, where millet, cowpea, sesame, and drought-resistant sorghum are grown. Challenges include severe desertification, unreliable rainfall, and frequent droughts.
- **Wetland and Floodplain Agriculture:** Lake Chad Basin and Riverbanks focus on irrigation and recession agriculture, cultivating rice, vegetables (tomatoes, onions, peppers), wheat, and sugarcane. Challenges include water scarcity from declining Lake Chad levels, pollution, and high irrigation costs.
- **Livestock Grazing and Pastoralism:** This is common in all zones, especially the north and central areas. Challenges include conflict between farmers and herders, overgrazing, and water shortages.

2.4.2 Wetlands

The Yedseram catchment includes wetlands along the Yedseram River, seasonal swamps, and Lake Chad, which collect rainwater in low-lying areas and support vegetation and agriculture through groundwater**.**

- **Ecological Significance**: The Yedseram wetlands are vital for biodiversity, supporting aquatic life and migratory birds. They manage water flow, reduce flood risks, and recharge groundwater, while enhancing climate resilience and preventing land degradation.
- **Agricultural Use**: Wetlands support fadama farming of rice, vegetables, and wheat using residual moisture post-floods. Their nutrient-rich soils reduce fertilizer needs. Yet, rising water extraction and climate change threaten sustainable agriculture.

2.4.3 Grazing Land and Pastoralism

Livestock grazing is a key land use in the Yedseram catchment, especially in the northern and central regions where pastoralism is central to livelihoods.

- **Pastoralism in the Central and Northern Areas:** In the semi-arid northern and central regions, open grasslands and shrublands support livestock, providing seasonal pastures for cattle, sheep, goats, and camels. Pastoralists migrate in search of water and grazing.
- **Conflict with Agriculture:** Land expansion has caused overgrazing, desertification, and conflict between herders and farmers.

2.4.4 Human Settlements

Human settlements in the Yedseram catchment are concentrated around river systems and fertile agricultural zones, with high population density in areas like Mubi and Bama.

- **Urban Areas:** Urban areas in the Yedseram catchment, including Gwoza, Bama, Dikwa, Mubi, and Monguno, face infrastructure strain from rapid population growth and insecurity, resulting in water shortages, housing deficits, and environmental degradation.
- **Rural Areas**: Rural settlements in the catchment consist mostly of farming and pastoral communities practicing subsistence agriculture. They often face limited access to electricity, healthcare, and education. Challenges like land degradation and conflicts threaten their sustainability.

2.4.5 Forest and Woodland Areas

The Yedseram catchment's forests are mainly in the south, especially around the Mandara Mountains and riverbanks, featuring Sudanian savanna woodlands with species like acacia, baobab, and shea. In contrast, the central and northern areas exhibit sparser vegetation dominated by drought-resistant shrubs and trees. These adaptations reflect the region's semi-arid climate.

- **Deforestation**: Deforestation in the Yedseram catchment is fuelled by agricultural expansion, fuelwood harvesting, and urbanization, leading to tree cover loss and biodiversity. This has caused increased soil erosion and desertification. Climate change and insecurity exacerbate the issue as displaced populations depend on forest resources for survival.
- **Reforestation Efforts**: Reforestation efforts in the area involve community tree-planting, agroforestry, and government initiatives promoting drought-resistant species. However, challenges like limited funding and weak policy enforcement hinder progress. Overcoming these obstacles is essential for effective land restoration.

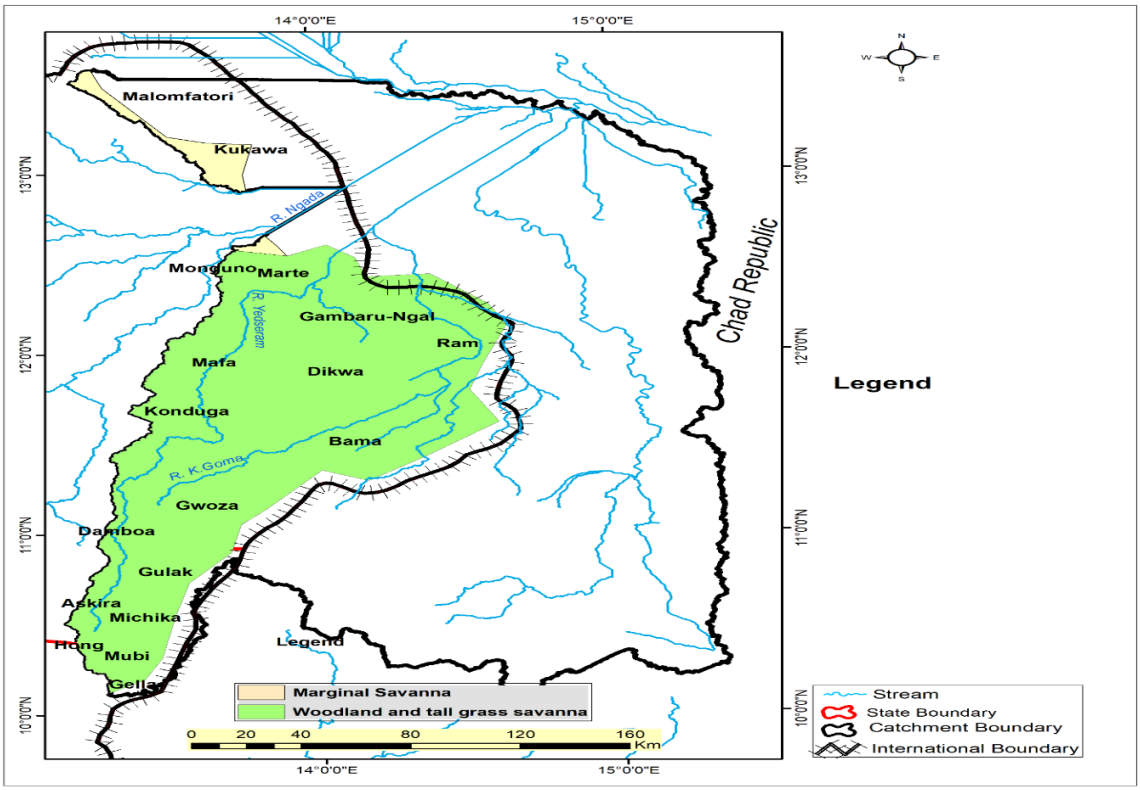


Figure 2.12: Vegetation cover of the Catchment (Source: MSL, 2024)

2.4.6 Biodiversity

Category	Details
Flora (Plant Diversity)	**Savanna Vegetation**: Dominated by Sahel and Sudan savanna types; features include Acacia spp., Vitellaria paradoxa (Shea butter tree), Azadirachta indica (Neem), and Baobab trees. **Wetland Vegetation**: Papyrus, reeds, water lilies around Lake Chad Basin and seasonal wetlands. **Riparian Forests**: Found along floodplains and rivers like the Yedseram; includes tamarind and acacia species.
Fauna (Animal Diversity)	**Mammals**: Historically included elephants, lions, and antelopes—now largely restricted to isolated or protected areas due to poaching and habitat degradation. **Birds**: Rich birdlife, especially in wetlands—African jacana, herons, storks, migratory waterfowl. **Fish and Aquatic Life**: Nile perch, catfish, tilapia dominate the Lake Chad and its tributaries. Amphibians and Reptiles: Frogs, toads, turtles found in seasonal wetlands.
Key Ecosystems	- Lake Chad Basin (transboundary wetland complex with seasonal floodplains and aquatic habitats) - Yedseram River System (seasonal flow, vital for irrigation and wildlife corridors)
Ecosystem Services	- Provisioning: Fisheries, wild foods, fuelwood, medicinal plants. - Regulating: Climate regulation, water purification, flood buffering, erosion control. - Supporting: Nutrient cycling, habitat for biodiversity. - Cultural: Sacred groves, water bodies with cultural/religious significance.
Tourism Potential	- Lake Chad Basin: Ecotourism, birdwatching, fishing communities (potential under safe conditions).
Protected Areas & Conservation Initiatives	- Community-based reforestation, agroforestry and wetland restoration supported by NGOs, ACReSAL, and international partners.
Challenges & Threats	- Armed conflict and insecurity (especially in Borno) - Climate change (desertification, rainfall variability, shrinking Lake Chad) - Deforestation and overgrazing - Overfishing and pollution in aquatic systems - Weak enforcement of conservation policies
Water-Dependent Ecosystems	- Lake Chad: Seasonal wetlands, vital for birds, fish, agriculture. - Yedseram River: Seasonal river supporting dry-season farming and livestock. - Floodplains: Used for flood-recession agriculture and seasonal fish breeding.

Cultural & Spiritual Significance	Many rivers, wetlands, and forests are considered sacred or used for traditional rituals; strong linkage between natural features and local identity.
Notable Species	- Flora: Neem (Azadirachta indica), Shea tree (Vitellaria paradoxa), Papyrus (Cyperus papyrus) - Fauna: African elephant (Loxodonta africana), Nile perch (Lates niloticus), African jacana (Actophilornis africanus), Lion (Panthera leo)—historically.
International Collaboration Needs	- Coordinated wetland and water resource management with Chad, Cameroon, and Niger (for Lake Chad) - Support from UNEP, LCBC, ACReSAL, FAO, and IUCN for restoration and monitoring programs.

2.5 Hydrology and Water Resources

2.5.1 Hydrology

The hydrology of the Yedseram Catchment is shaped by seasonal rivers, surface water bodies, and groundwater aquifers that support agriculture, domestic needs, and industry.

- **River systems:**
    - **Yedseram River:** The Yedseram River originates in the Mandara Mountains near the Nigeria-Cameroon border and flows northeast into Lake Chad. It is crucial for agriculture, fishing, and water supply, with high flows during the rainy season (June–September) and lower levels in the dry season (October–May).
    - **Bararam River:** The Bararam River is a tributary of the Yedseram River, experiencing intermittent flow with flash flooding after heavy rains. It supports local irrigation and livestock but faces challenges from sand deposition and erosion. Dry conditions dominate much of the year.
    - **Forunduma River:** The Forunduma River is a seasonal river fed by rainfall runoff from surrounding hills. It supports wetland ecosystems and local agriculture, providing water for small-scale irrigation and domestic use. During the dry season, the riverbed often dries up, prompting residents to find alternative water sources.
    - **El-Beid River:** The El-Beid River is a part of the Nigeria-Cameroon border that flows into Lake Chad. It features some perennial sections supported by

groundwater, aiding in fishing and wetland ecosystems. However, water abstraction and climate change pose significant threats to its sustainability..

  - **Nasawa River:** The Nasawa River is a seasonal river that supports irrigation and livestock in the Yedseram catchment. However, deforestation and land degradation have diminished its flow. It also suffers from drying up during droughts and increased sedimentation.

- **Flooding and Wetlands:** Seasonal flooding in the Yedseram catchment occurs from June to September, replenishing wetlands that support biodiversity and flood-recession agriculture. These wetlands along riverbanks and near Lake Chad provide vital habitats while reducing flood intensity.
- **Groundwater:** Groundwater is crucial in the catchment, primarily located in Chad Basin's sedimentary aquifers and southern highlands' fractured basement rocks. It is tapped via shallow and deep boreholes, yielding more in alluvial deposits near river valleys and floodplains.

2.5.2 Hydrograph/Water Budget of the Catchment

2.5.2.1 The Yedseram Strategic Catchment

- The hydrograph and water budget analysis of the Yedseram Strategic Catchment, presented in Figures 2.13, 2.14, 2.15, 2.16 and 2.17, demonstrate distinct seasonal variability.
- The catchment experiences six months of minimal to no rainfall (November–April) followed by six months of flow activity (May–October) annually.
- The hydrograph's rising limb begins in May, peaking in August. As shown in figure 2.13, the year 2020 recorded the highest flow, followed by 1991, while 1984 had the lowest discharge among the years examined.

The water budget graph reveals an eight-month period of water deficit and a four-month surplus (June–September), culminating in a low annual water budget of 82.52 mm. Given this prolonged deficit and limited surplus, implementing an alternative water supply system is critical for the catchment's sustainability.

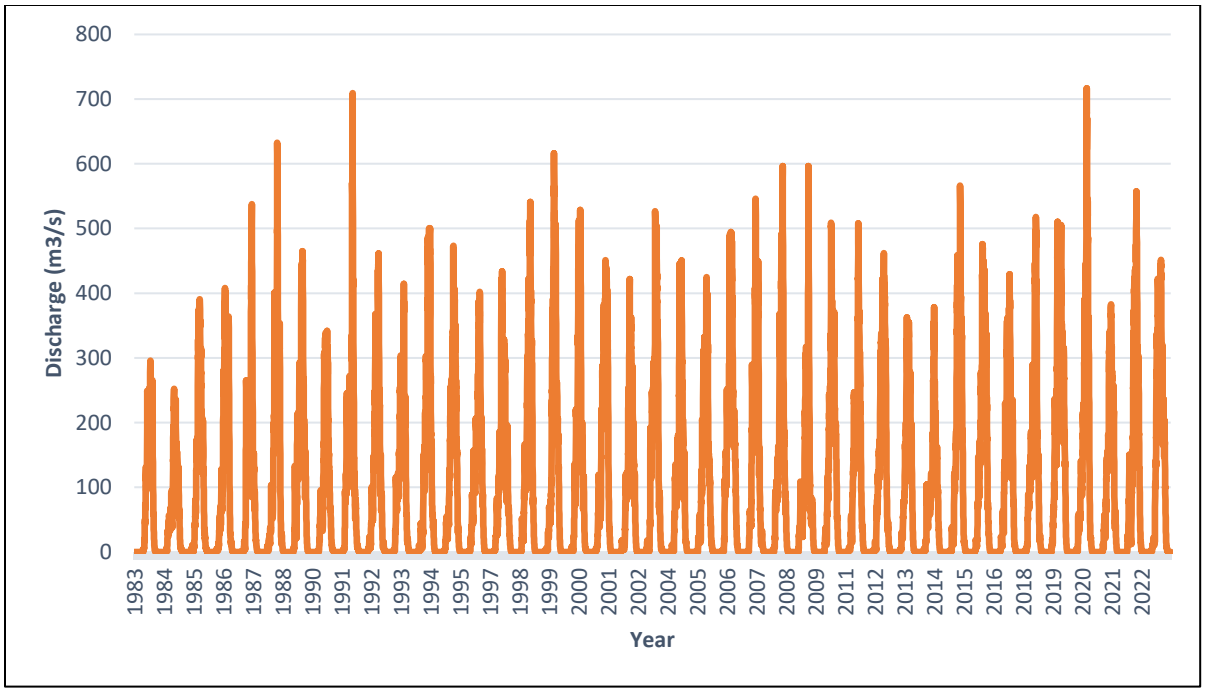


Figure 2.13: Hydrograph of Yedseram Strategic Catchment Based on HEC-HMS modelling for Strategic catchment.

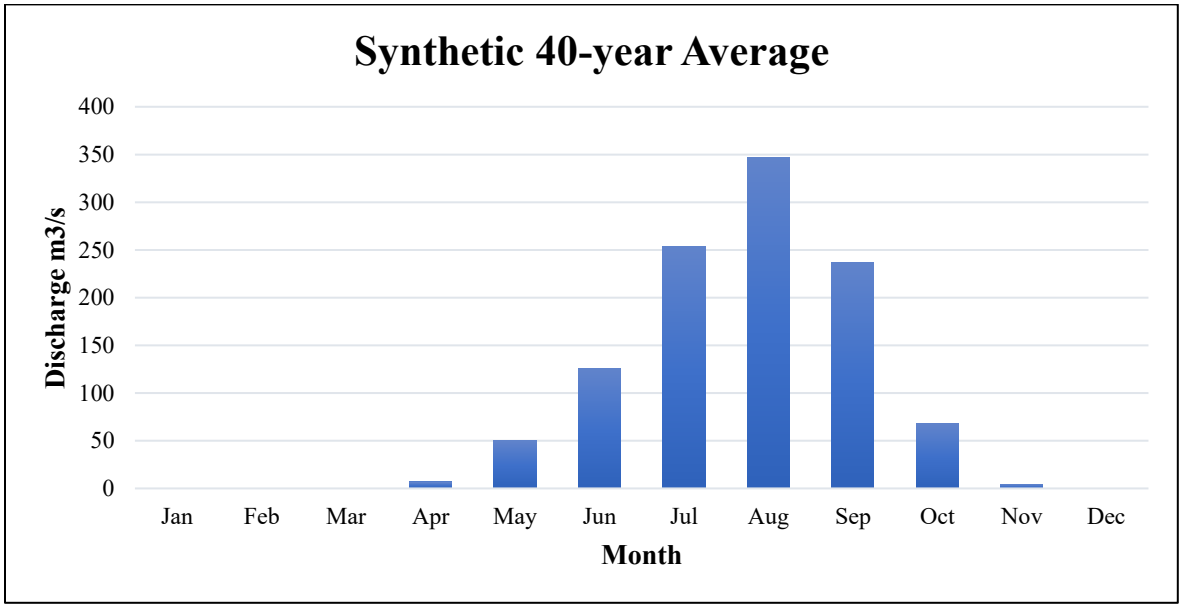


Figure 2.14: 40 - Year Summary Hydrograph of Yedseram Strategic Catchment

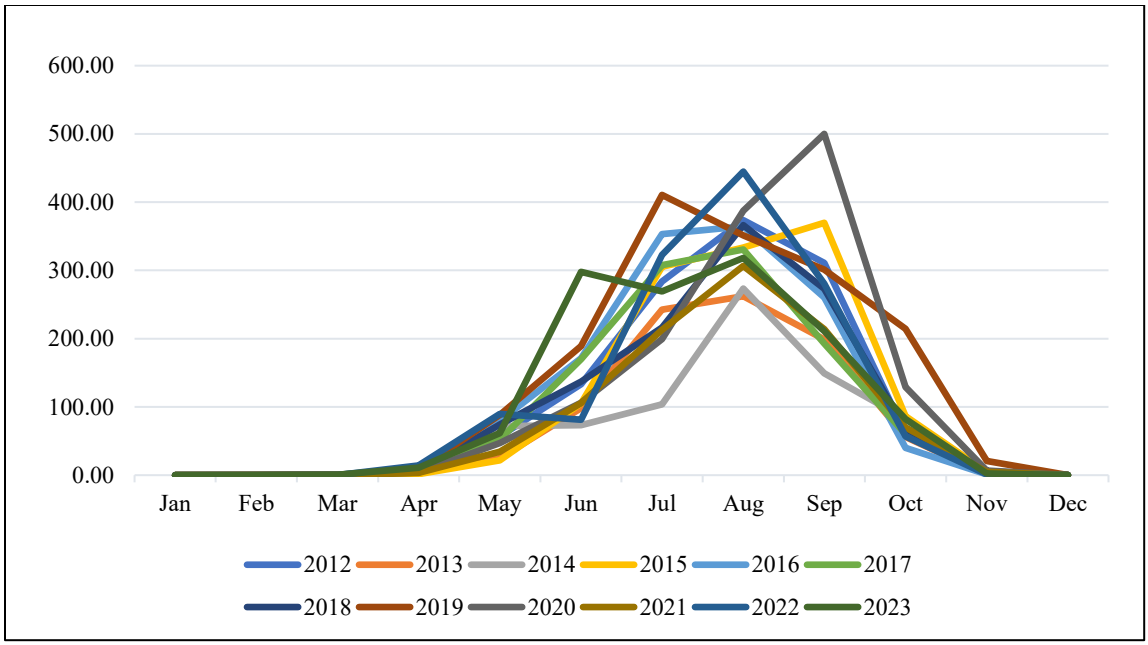


Figure 2.15: Hydrograph of Yedseram Strategic Catchment for Specific Years

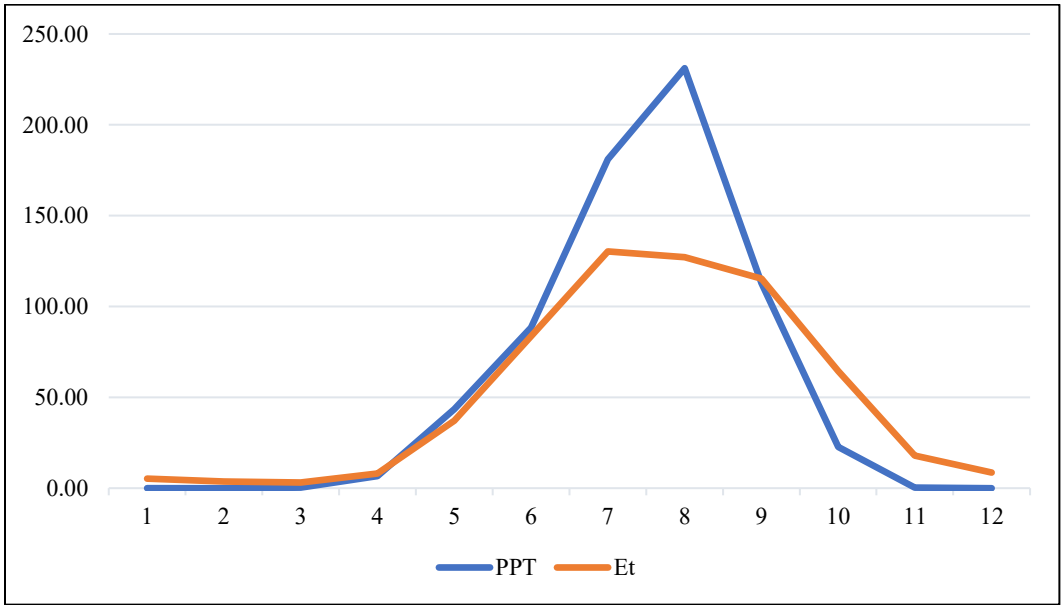


Figure 2.16: Water Budget for Yedseram Strategic Catchment

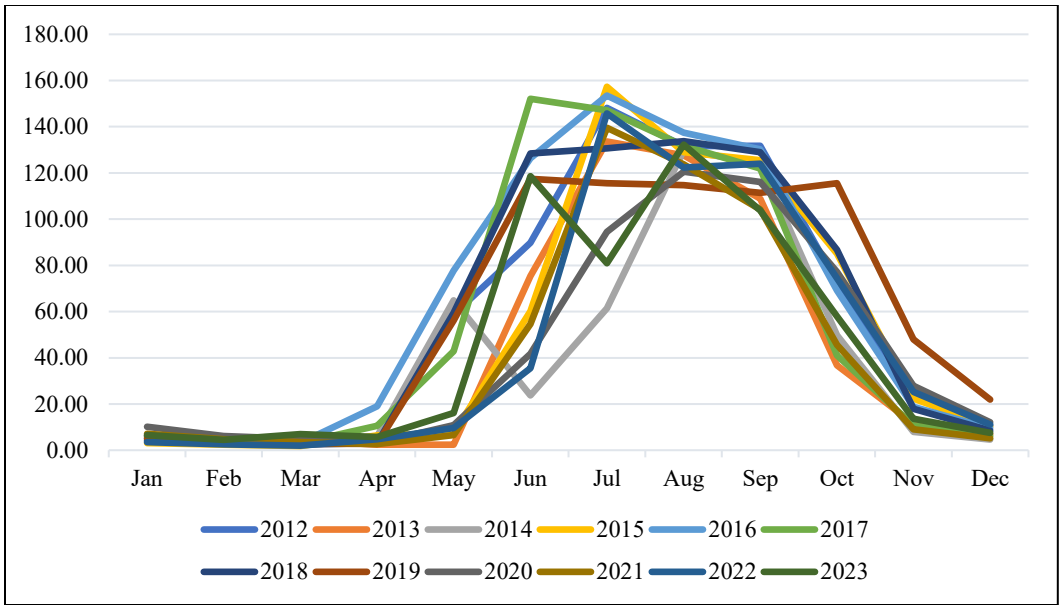


Figure 2.17: Monthly Actual Evapotranspiration Distribution for the Yedseram Catchment

Source: TerraClimate

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

MONTH	PPT	ET	Synthetic Peak Runoff (m^3/s)
Jan	0.00	5.20	0.00
Feb	0.01	3.65	0.01
Mar	0.35	3.13	0.30
Apr	6.64	8.07	6.77
May	43.45	37.20	50.58
Jun	88.41	83.63	125.64
Jul	181.07	130.30	253.40
Aug	231.16	127.05	347.36
Sep	112.85	115.38	236.34
Oct	22.67	64.39	67.92
Nov	0.37	17.92	4.41
Dec	0.01	8.56	0.04

2.5.2.2 Prospects

- Multi-Scale Reservoir Infrastructure: Build reservoirs or small-scale dams to capture peak flows during the high-discharge months (May–October), especially leveraging the August peak. Given the low annual surplus, storage systems must prioritize efficiency to retain maximum water for dry periods (November–April).
- Distributed Water Harvesting: Promote decentralized rainwater harvesting (e.g., rooftop systems, farm ponds, and check dams) to capture sporadic rainfall during the wet season and reduce reliance on centralized supplies.
- Floodwater Diversion: Redirect excess flows during high-discharge years (e.g., 2020) to recharge groundwater or fill storage infrastructure, mitigating flood risks while addressing deficits.
- Agricultural Water Savings: Shift to drought-resistant crops and adopt precision irrigation (e.g., drip/sprinkler systems) to reduce water use during dry months. Incentivize farmers to align cropping calendars with surplus periods.
- Inter-Basin Transfers: Explore transferring water from neighbouring catchments with higher reliability, particularly during extreme dry years (e.g., 1984).

2.5.2.3 Water Resources Assessment Concept in the Catchment

- The water resources assessment in the Yedseram catchment involves evaluating surface water, groundwater, and climatic influences on water availability and sustainability.
- Streamflow analysis and discharge measurements help determine seasonal water variability, while groundwater recharge studies assess aquifer sustainability.
- The assessment also includes water demand projections for domestic, agricultural, and industrial uses, ensuring that future water management strategies align with climate change impacts and population growth.

2.5.2.4 Stream Flow and Seasonal Variability

- Stream flow in the Yedseram catchment is highly seasonal, with rivers experiencing peak discharge during the rainy season (June–September) and significantly reduced flow or complete drying up in the dry season (October–May).
- This variability is influenced by rainfall patterns, evapotranspiration rates, and groundwater recharge, leading to water surpluses in wet months and deficits in dry months.

a) Wet Season Flow

During the wet season (June–September), rivers in the Yedseram catchment experience peak flows, especially in August, due to heavy rainfall. The Yedseram River significantly increases in discharge, supporting agriculture and groundwater recharge, while other rivers like Bararam and El-Beid contribute to seasonal flooding in low-lying areas.

b) Dry Season Flow

During the dry season (October–May), flow in the Yedseram catchment declines, leading to reduced discharge and the drying up of many rivers. Isolated pools remain in rivers like the Yedseram, Bararam, and Forunduma. This scarcity increases reliance on groundwater and reservoirs, highlighting the need for effective water conservation and management.

2.5.2.5 Discharge Measurement

Discharge, the volume of water flowing through a river channel over a specific period, is a fundamental metric for assessing water quantity in the Yedseram catchment. Various agencies, including the Nigeria Hydrological Services Agency (NIHSA) and local water resource authorities, regularly monitor river discharge to track water availability and manage water resources effectively.

2.5.2.6 Surface Water Resource Potential

- According to Jica's study, Only 24% of the precipitation becomes runoff, and the rest is lost as evapotranspiration and/or other forms of abstractions.
- Total surface water resource potential is estimated at 7.2 BCM/year.
- The total water resources potential was evaluated by adding the lost component

without becoming surface runoff among recharge.

- The total potential for the internal generation of water resources is estimated at 10.3 CM/year.
- The total annual groundwater recharge is estimated at 4.3 BCM/year as a renewable source based on the estimated groundwater recharge. The table below shows the water resource potential for HA-8

2.5.3 Hydrological Disposition of the Catchment

As shown and explained in Figure 2.18, the catchment's hydrogeological disposition, hydrogeological units, and aquiferous layers comprise part of its water resources.

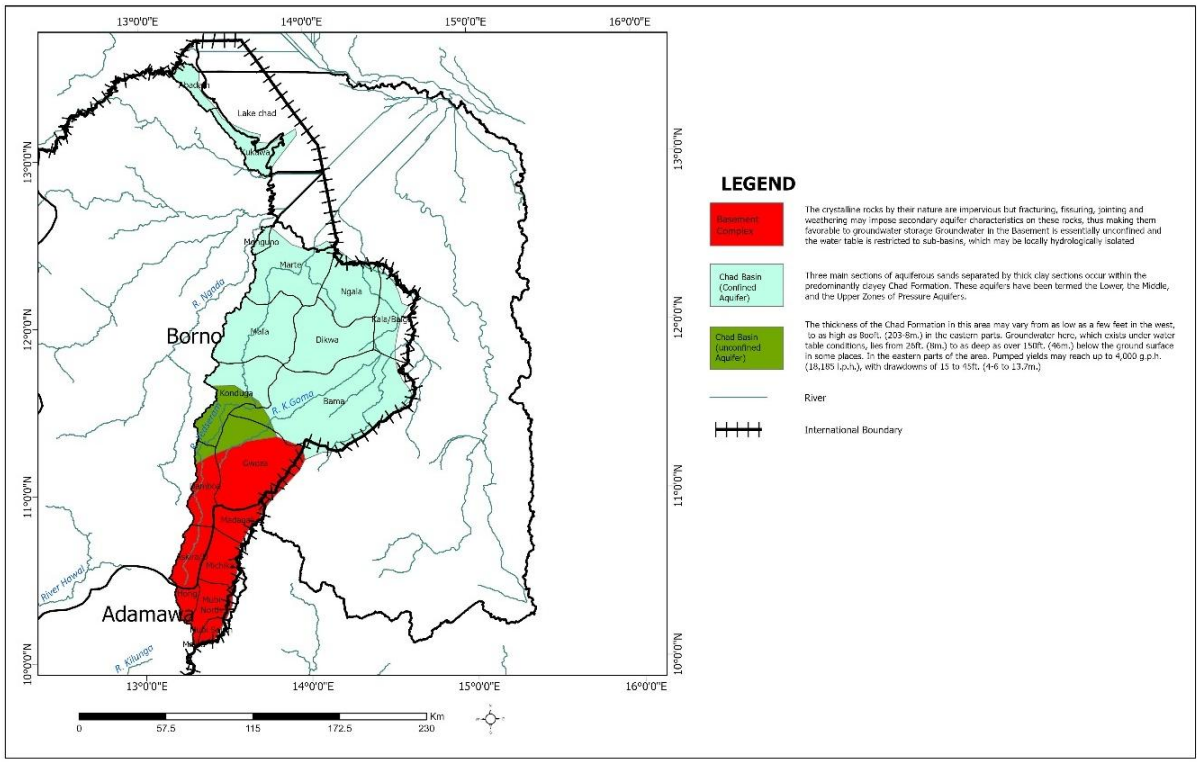


Figure 2.18: Hydrogeological provinces of the catchment (Source: MSL, 2024)

2.5.3.1 Groundwater Recharge

- Groundwater recharge in the Yedseram catchment largely depends on seasonal rainfall, with most infiltration occurring during the rainy season (June–September).
- Water enters aquifers through rainfall and river seepage. Fractured rocks in upland areas like the Mandara Mountains aid recharge, while sandy soils in the Chad Basin enhance infiltration. However, factors like high evapotranspiration and clay-rich soils hinder this process, worsened by deforestation and overgrazing..
- Despite its importance, groundwater recharge faces challenges such as over-extraction, climate change, and desertification, which threaten long-term water availability.
- Declining water tables, particularly in populated areas, highlight the need for better management strategies.
- Artificial recharge systems, afforestation, rainwater harvesting, and sustainable water-use policies can enhance recharge and manage groundwater extraction. Integrated water management is essential as climate variability and growing demand affect water resources. These approaches will ensure long-term sustainability in the Yedseram catchment.

2.6 Water Demand for Yedseram Catchment

2.6.1 Water Availability by Sub-Basin

Table 2.2: Water Resource Potential for HA-8

		HA-8
Water Resources Potential		
Total Water Resources Potential [1)]		
Including inflow from outside Nigeria	(BCM/year)	10.3
Only internal generation in Nigeria	(BCM/year)	10.3
Surface Water Resources Potential		
Including inflow from outside Nigeria	(BCM/year)	7.2
Only internal generation in Nigeria	(BCM/year)	7.2
Groundwater Resources Potential		
Groundwater Recharge	(BCM/year)	4.3
Runoff Condition（Only internal generation in Nigeria）		
Precipitation (P)	(mm/year)	609
Total Run off (RO)	(mm/year)	40
Groundwater Recharge (GRE)	(mm/ year)	24
Loss of Recharge (LOS)	(mm/year)	17
Runoff Rate (RO/P)	(%)	6.6
Recharge Rate (GRE/P)	(%)	3.9
Loss Rate (LOS/P)	(%)	2.9
Total Water Res. Rate ((RO+LOS)/P)	(%)	9.5

Source: JICA Project Team

2.6.2 Water Use and Demand

- Water use in the Yedseram catchment is driven by domestic, agricultural, livestock, and industrial needs, with agriculture being the largest consumer.
- Irrigation is crucial for crop farming in wetlands during the dry season, while livestock watering is significant for pastoralist communities depending on seasonal water sources.
- Domestic water demand is increasing due to population growth and urbanization, particularly in towns like Gwoza, Bama, and Dikwa, where access to safe drinking water remains a challenge.
- Boreholes and wells primarily provide groundwater for domestic use due to unreliable seasonal surface water. Climate change, over-extraction, and poor management are

straining resources. Sustainable water use strategies are essential to balance demand and supply.

The water demand is divided into the following categories:

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

2.6.2.1 Municipal water use

- Municipal water demand in the basin primarily relies on groundwater due to pollution of surface rivers and poor treatment facilities. A 2015 survey in Borno state revealed that water from motorized boreholes accounts for 54.7% in urban areas, with unprotected traditional wells leading in rural areas at 24.9%.
- Future water demand projections are crucial for balancing water demand with available resources and ensuring adequate supply and infrastructure development. This project focuses on improving water supply coverage and includes a sensitivity analysis with various projection scenarios for comparison.
- This municipal water demand is basically estimated by considering current/future population projection and the basic quantity requirement for domestic, commercial and industrial usage.
- Future population projection in water demand estimation is important as it enables water infrastructure planning and determination the potential adequacy of water source for development and effective utilization (optimal allocation) within a catchment.
- Daily average demand is computed by multiplying the number of intended population to be served by per capita consumption (lit/cap/day).

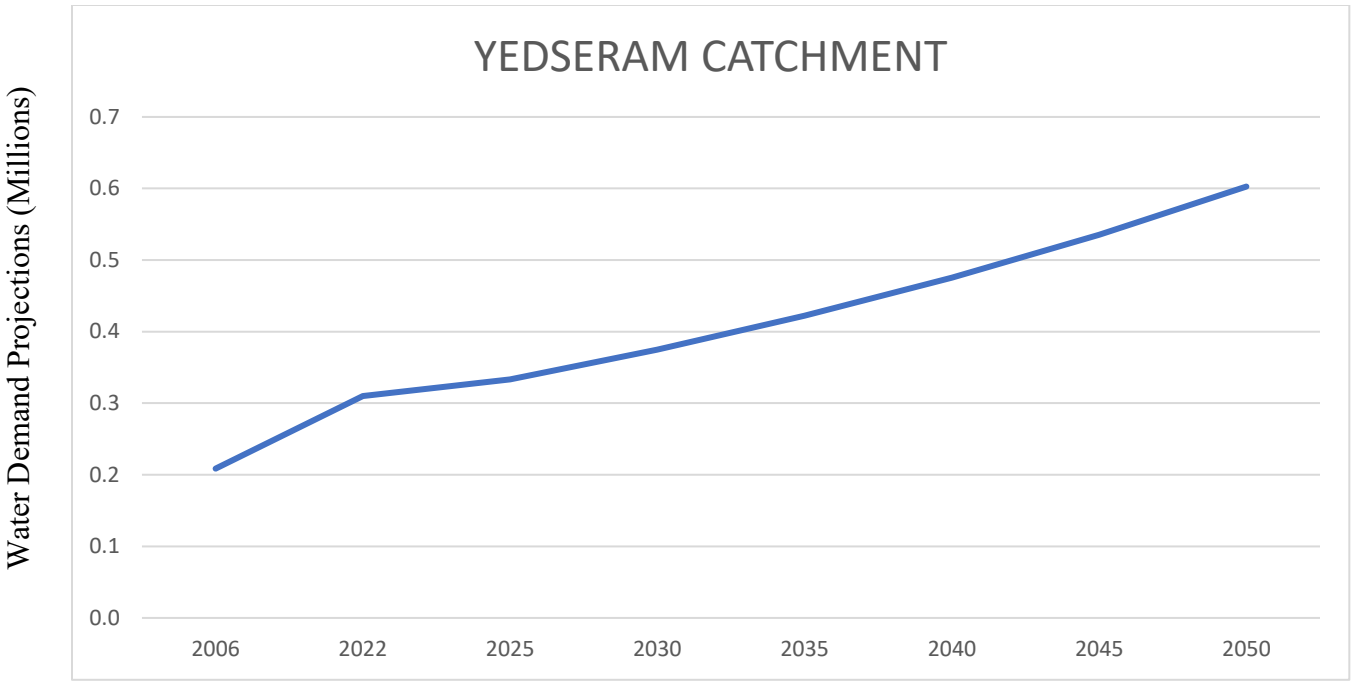


Figure 2.19: Water demand Projections Yedseram Catchment

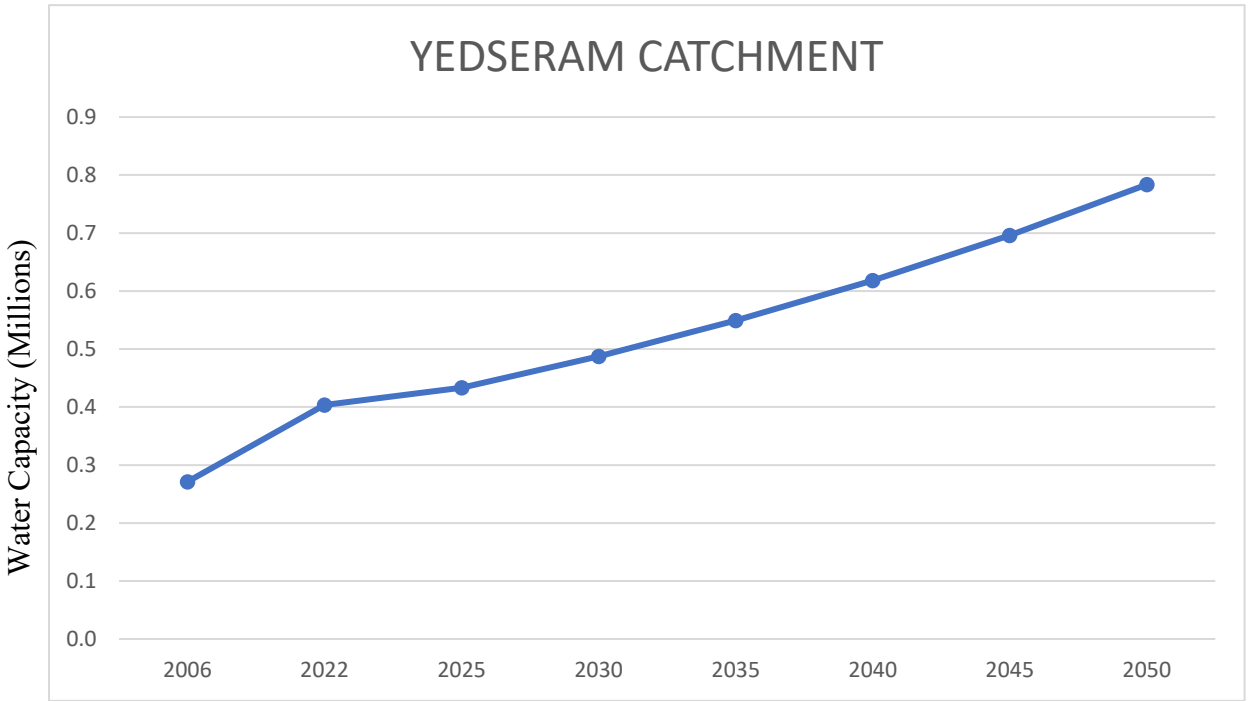


Figure 2.20: Water Capacity Projection Yedseram Catchment

2.6.3 Livestock Indices and Water Demand

Livestock production is a key economic activity in the Yedseram catchment, with cattle, sheep, goats, and camels being the dominant livestock species. The water demand for livestock varies depending on species, climate conditions, and the availability of natural water sources.

Water Consumption: The estimated water intake per kilogram of body weight for different is as follows:

- Cattle (400–500 kg): 30–60 liters per day, with higher intake in hot weather.
- Goats and Sheep (30–50 kg): 5–10 liters per day, depending on breed and environment.
- Camels (500–600 kg): 30–80 liters per drinking session, but they can go days without water.
- Donkeys (200–300 kg): 20–35 liters per day, mainly used for transport in rural areas.

Movement and Water Needs: Pastoralists in the catchment practice seasonal migration from the semi-arid north to wetter southern regions during the dry season in search of water and pasture. Livestock may cover tens to hundreds of kilometers, increasing their daily water intake. Estimated additional water needs for moving livestock in the Yedseram catchment are:

- Cattle: 50–80 liters per day (compared to 30–60 liters for stationary cattle).
- Sheep and Goats: 8–15 liters per day (compared to 5–10 liters when stationary).
- Camels: 100–150 liters per drinking session, but they can store water for longer periods.
- Donkeys: 30–50 liters per day, depending on distance traveled and load carried.

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

The annual water supply for inland fish farming is calculated at 0.03 MCM per hectare, sourced primarily from shallow wells (75-85%) and supplemented by surface runoff or stagnant water. Water quality must meet specific requirements—free from detergents and chemicals, neutral pH, and dissolved oxygen above 4 ppm, with groundwater preferred for its higher oxygen content.

- **Fish Farming Projections**: Aquaculture is growing in the Yedseram catchment, mainly in wetlands and ponds, reliant on water resources and species selection. Its expansion is promising in areas with sufficient water and favorable conditions.

- **Water Demand**: Water demand for aquaculture depends on fish species, pond size, stocking density, and evaporation rates. On average, 1 kg of fish requires 3,000–5,000 liters of water over its production cycle, with variations based on intensive or extensive farming methods.

2.6.5 Irrigation Water Demand

Irrigation is vital for dry-season farming in the Yedseram catchment, especially where rain-fed agriculture fails. Demand for water varies by crop type, soil, climate, and efficiency, averaging 5,000–12,000 cubic meters per hectare each season, especially for water-intensive crops like rice and vegetables.

The dry season (October–May) heavily strains groundwater and surface water due to reliance on boreholes and reservoirs. Inefficient irrigation methods and high evaporation rates worsen water scarcity. Sustainable strategies like drip irrigation and rainwater harvesting are recommended to optimize water use.

2.6.6 Irrigation Water Demand Projection

Future irrigation water demand in the Yedseram catchment will significantly increase due to population growth, agricultural expansion, and climate change. Rising demand is expected as more farmers adopt dry-season farming for food security, particularly for water-intensive crops. Annual irrigation needs may exceed 12,000 cubic meters per hectare in certain areas.

2.6.7 Existing and Potential Irrigation Areas

Existing Irrigation Areas: Irrigation in the Yedseram catchment occurs along riverbanks and wetlands, supporting fadama farming through shallow wells and reservoirs for crops like rice and vegetables. However, inefficient techniques and declining groundwater levels restrict expansion.

Potential Irrigation Areas: Expanding irrigation in lowland floodplains and alluvial valleys and developing small dams and modern irrigation technologies can boost agricultural productivity. Enhanced access to climate-resilient water sources will further support sustainable water management. This approach effectively increases agricultural output.

2.6.8 Total Water Demand/ Balance Of The Yedseram Catchment

Table 2.3: Water Balance of the Catchment

WATER BALANCE ANALYSIS FOR YESDERAM CATCHMENT			
WATER DEMAND (CUBIC METER)		**2025**	**2050**
MUNICIPAL		121,590,691	219,988,126
LIVESTOCK		47,651,545	66,156,321
AQUACULTURE		1,284,286	1,483,100
IRRIGATION		277,700,000	365,400,000
TOTAL		**448,226,521**	**653,027,548**
AVAILABLE WATER RESOURCES (CUBIC METER)		**679,505,900**	**679,505,900**
WATER BALANCE (CUBIC METER)		**231,279,379**	**26,478,352**

SOURCE : JICA 2014 MP AND SMEC 2019 AS ANALYSED

2.6.9 Infrastructure and Assets

Table 2.4 : Catchment Infrastructure and Assets

Infrastructure	Location	Importance	Risk Factor
Dams and Reservoirs	No recorded dams within the catchment		
Irrigation Schemes	Bama, Biu, Mongonu, chibok	Enhances agriculture, supports food production, and trade.	Unsustainable farming practices, lack of funding, insecurity, and land degradation.
Hydropower Stations	None recorded		
Rural Electrification	All the local governments within the catchment	Supports local economies and industrialization.	Infrastructure failure, security threats.
Grain Storage Facilities	Bama, Mongonu, ngala,Dikwa	Reduces post-harvest losses and supports food security.	Risk of vandalization and inadequate storage conditions.
Research Institutes	Maidugri,	Enhances innovation and agricultural productivity.	Lack of research funding and data reliability issues.
Local Markets and Abattoirs	Major towns in the catchment (e.g. Banki, Mubi, Kirawa, Bama, G/Ngala)	Supports livestock trade and food processing industries.	Seasonal produce availability, insecurity, and pollution.
Tourism (Parks & Reserves)	Waza Game Reserves	Promotes biodiversity conservation and cultural heritage.	Overgrazing, poaching, and weak policy implementation.

2.7 Water Quality

2.7.1 Surface Water Quality

Surface water quality in the Yedseram catchment is seasonally variable, influenced by rainfall, runoff, and human activities. Key sources of pollution in the catchment area include:

- **Livestock Waste**
- **Deforestation and Soil Erosion**
- **Domestic Wastewater and Sewage**
- **Industrial and Artisanal Activities**
- **Climate Variability and Reduced Flow**

A preliminary study indicated that river water quality is usually good in the wet season, with acceptable levels of biochemical oxygen demand (BOD) and dissolved oxygen (DO). Conversely, in the dry season, water quality deteriorates due to lower flow, which hampers self-purification efficiency.

Heavy metals like iron, arsenic, and cadmium in certain rivers require ongoing monitoring to identify their sources and improve water quality management. The study's limited sampling (one in wet season, one in dry) hinders the establishment of long-term trends. Continued monitoring is strongly advised.

2.7.2 Groundwater Quality

Groundwater quality has a significant influence on the potential for availability. Groundwater quality was analyzed in the context of its availability by considering the following chemical characteristics.

- Total Dissolved Solids (STD) and Salinity
- Microbial contamination
- Heavy metals concentration

Analyses of heavy metal contamination in the Yedseram River catchment are limited. Table 2.5 shows the preliminary water quality status of some rivers in the catchment areas.

Table 2.5 Preliminary Conclusion of Water Quality Status of Some Rivers in the Catchment

N	State	River Name	Code	Wet Season	Dry Season	NFA
1	Adamawa	River Benue at intake to Yola WTP	SW/003	Moderate	Poor	Fe, As, Cd
		River Gongola at Kiri Dam	SW/001	Moderate	Moderate	Cd, Pb
2	Borno	River Ngada at Alau Dam intake to Maiduguri WTP	SW/001	Good	Good	
		River Banki at Banki town	SW/001	Good	Good	Ni, Zn

JICA 2014 MP

2.7.3 Surface Water Resources

Description of the catchment

- The Yedseram catchment in northeastern Nigeria spans parts of Borno and Adamawa States, extending to the Lake Chad Basin. Dominated by seasonal rivers, the Yedseram River originates from the Mandara Mountains.
- Its semi-arid to sub-humid climate features distinct wet and dry seasons, affecting water availability and land use.
- The landscape consists of lowland floodplains, sandy and clayey soils, and patches of savanna woodlands, supporting agriculture, livestock grazing, and fishing.
- The hydrology of the catchment is influenced by rainfall patterns, groundwater reserves, and seasonal surface water flows, with wetlands and fadama lands playing a crucial role in sustaining livelihoods.
- However, the catchment faces water scarcity, desertification, and land degradation, necessitating integrated water resource management strategies for long-term sustainability.
- The Yedseram catchment is a seasonal river system dominated by the Yedseram River from the Mandara Mountains along the Nigeria-Cameroon border. It flows northeast into the Lake Chad Basin, characterized by ephemeral rivers with high flow during the rainy season and low or no flow in the dry season.

- Key rivers such as the Bararam, Forunduma, El-Beid, and Nasawa support wetlands and local agriculture while creating floodplains that sustain livelihoods. However, climate variability and increased water demand threaten these river flows. Thus, sustainable water management is vital for the catchment.

Table 2.5: Runoff Yield for Yedseram, an SHA in HA-8

HA	SHA	SHA divided by National Boundary	SN	Area(km2)	Average Monthly Runoff Yield (Height) (mm/month)												Average Annual Runoff Yield (mm/ year)	Average Annual Precipitation (mm/ year)	Average Runoff Rate(%)
					1	2	3	4	5	6	7	8	9	10	11	12			
8		802_e	163	13,857.30	0	0	0	0	0	0.4	4.4	7.8	4.2	0.4	0.1	0	17	666	2.6
	802	802_i	164	2,422.80	0	0	0	0	0	0	2.9	4.6	1	0	0	0	8	517	1.6
	80401	80401	165	4,647.60	0	0	0	0	0	0	2.8	5.1	1.3	0	0	0	9	517	1.8
		80402_e	166	626.1	0	0	0	0	0.2	1.2	5.6	11.2	8.5	1	0.2	0	28	782	3.6
	80402	80402_i	167	7,171.80	0	0	0	0	0	0.5	4.4	7.3	3.7	0.3	0.1	0	16	664	2.4
		80403_e	168	253.1	0	0	0	0	0.9	3	7.2	24.9	27.3	4.6	0.9	0.2	69	951	7.3
	80403	80403_i	169	6,656.50	0	0	0	0	0.2	1.2	5.2	13.9	12.1	1.8	0.3	0.1	35	747	4.7

2.7.4 Ground Water Potential

Table 2.6: Amount of Groundwater by Newly Drilled Boreholes and Borehole Rehabilitation.

state		Amount of groundwater to be developed by 2030		Amount of groundwater by rehabilitated boreholes		Amount of groundwater by newly drilled boreholes		
		Urban/semi-urban/town	Rural	Urban/semi-urban/town	Rural	Urban/semi-urban/town	Rural	
						Motorized pump	Motorized pump	Hand pump
		M3/day	M3/day	M3/day	M3/day	M3/day	M3/day	M3/day
1	Adamawa	176,499	64,336	3,435	2,007	173,064	37,397	24,931
2	Borno	290,589	82,243	37,792	4,037	252,797	46,924	31,283
	TOTAL	467,088	146,579	41,227	6,044	425,861	84,321	56,214

Source: JICA Project Team 2014

2.7.4.1 Groundwater Recharge

- Climate change appears to reduce groundwater recharge, with varying decreases in different areas. Areas with lower groundwater recharge are more significantly affected than those with higher recharge, despite similar amounts of decrease. Thus, the impact is not uniform across regions.
- Groundwater levels will remain stable near rivers but significantly decrease in inland areas far from them. These regions will be more affected by reduced groundwater recharge. Climate change countermeasures will consider these conditions.

2.7.4.2 Balance of Demand and Supply by Groundwater

The balance between groundwater recharge and demands is shown in Table 2.7 below.

- The groundwater demand/recharge ratio in the Yedseram catchment is 10%, varying between 4% to 48% across the covered states. This variation results from differences in groundwater recharge levels from state to state.
- Groundwater demand/recharge ratios are higher in areas with sedimentary rocks, where recharge is lower than in other regions. Aquifers extend across state

boundaries, allowing groundwater extraction from boreholes to meet demand from surrounding areas.

Table 2.7: Groundwater Recharge and Groundwater Demand (2030)

No	State	Ground water Recharge (MCM/year)	Ground water demand (2030) (MCM/year)					
			Water Supply	Private irrigation	Live stock	Aquaculture	Total	Ground water Demand/ recharge
1	Adamawa	3,707	96	26	17	4	142	4%
2	Borno	570	197	47	26	2	272	48%
	Total	**4,277**	**293**	**73**	**43**	**6**	**414**	**10%**

Source: National Water Resources Master Plan (JICA)

Balance of groundwater recharge and demand is shown in Table 2.7 below in case of the Climate Change. Ratio of groundwater demand/recharge is 15% in yedseram catchment. Effect of the Climate Change will make difference lager in water balance among states.

Table 2.8: Groundwater Recharge and Demand by effect of climate (2030)

NO.	State	Groundwater Recharge (MCM/year)	Groundwater demand (2030) (MCM/year)					
			Water Supply	Private irrigation	Live stock	Aquaculture	Total	Ground water Demand/ recharge
1	Adamawa	2,567	96	29	17	4	145	6%
2	Borno	295	197	53	26	2	278	94%
	Total	2,862	293	82	43	6	423	15%

Source: National Water Resources Master Plan (JICA)

2.8 Climate Change Impact on Water and Land Resources

2.8.1 Historical and Future Climate Trends

The Yedseram Catchment has faced significant climate changes, affecting water availability and agriculture. Understanding these trends is vital for effective adaptation and mitigation strategies.

a) **Rainfall Patterns:**
   - The region has witnessed **increasing variability in rainfall patterns**, with alternating periods of excessive rainfall and prolonged droughts.
   - Rainfall distribution has become more erratic, with the onset of the rainy season shifting unpredictably, affecting agricultural planning.
   - Intense rainfall events have increased, leading to flash floods and soil erosion, while dry spells have prolonged, exacerbating water shortages.
   - The projected annual rainfall trend for Yesderam from 1981 to 2050 indicates annual decrease in rainfall of approximately 3.41 mm, see (Figure and below). This downward trend implies a long-term decline in rainfall, which could have significant implications for water availability, agriculture, and ecosystems in the area.

b) **Temperature:**
   - Table … presents the mean monthly temperatures for Yedseram from 1981-2022 and projections for 2023-2050, showing an overall warming trend. There are significant temperature increases in the hottest months, while cooler months show smaller changes. Average annual temperatures in the Yedseram Catchment have risen by about 1.2°C to 1.5°C over the past 50 years.
   - The mean annual temperature is expected to increase from 28.18°C to 29.04°C, with notable rises in the warmest months: April will go from 32.97°C to 34.55°C, and May from 32.92°C to 34.33°C. This trend suggests an even hotter dry season, impacting water resources and crop viability.
   - The cooler months like January and December exhibit slight warming, with January increasing from 23.45°C to 24.06°C, possibly reducing winter distinctiveness. August and September show minimal changes due to rainfall's cooling effects.

Overall, maximum and minimum monthly temperatures rise, indicating an upward shift in temperature ranges and potential increased heat..

- The frequency of extreme heat events has risen, particularly during the dry season, leading to higher evapotranspiration rates and reduced soil moisture.
- The duration of hot periods has increased, affecting crop yields and livestock health.
- October and November show significant increases, with October rising from 28.52°C to 29.11°C and November from 26.44°C to 27.51°C. This extended warming into late-year months could affect the length and intensity of the dry season, impacting water demand and agricultural cycles.
- A steady warming trend, with substantial increases in peak temperatures and slight to moderate rises in cooler months, is the temperature trend's hallmark. These shifts could have significant implications for agriculture, water resource management, and public health, aligning with broader regional patterns of climate change.

c) Evapotranspiration

Evapotranspiration (ET) is a critical component of the hydrological cycle in the Catchment,. It represents the combined process of water loss from the surface through **evaporation** and **plant transpiration**. Given the semi-arid to sub-humid climatic conditions of the region, ET plays a significant role in water availability, agricultural productivity, and ecosystem stability.

The catchment experiences a **high potential evapotranspiration (PET)** due to prolonged sunshine hours, high temperatures, and moderate relative humidity. Based on regional climate data and studies:

- **Annual Potential Evapotranspiration (PET):** Estimated at **1,600–2,200 mm/year**
- **Actual Evapotranspiration (AET):** Ranges between **600–1,200 mm/year**, depending on land cover, soil moisture, and seasonal rainfall distribution.

2.8.2 Projected Annual Rainfall for Yesderam

Figure 2.22 shows the projected annual rainfall trend for Yesderam from 1981 to 2050.

- The trend indicates a downward slope over time. The equation y = -3.4051x + 641.49 suggests an annual decrease in rainfall of approximately 3.41 mm. This downward trend implies a long-term decline in rainfall, which could have significant implications for water availability, agriculture, and ecosystems in the area.
- The projected mean annual temperature for Yedseram is expected to rise from 28.18°C (1981-2022) to 29.04°C (2023-2050), highlighting significant increases in the hottest months, particularly from April and May.
- Cooler months show moderate warming, indicating reduced seasonal variability.
- These temperature shifts may impact agriculture, water resources, and public health.
- Fluctuations in annual rainfall during the projected period appear to decrease**.** This suggests that the projections assume a more stable but gradually declining rainfall trend.
- A persistent decline in rainfall could impact agriculture, water resources, and biodiversity in Yesderam.
- Lower rainfall levels may stress crops, reduce water availability, and lead to increased competition for water resources, especially in agriculture-dependent communities.

In summary, Figure 2.22 projects a decline in annual rainfall for Yedseram, with less variability in the later years. This declining trend could present challenges for water resource management and agricultural productivity, underscoring the importance of planning for potential water scarcity in the coming decades.

Annual Rainfall and Temperature for Yedzaram Catchment

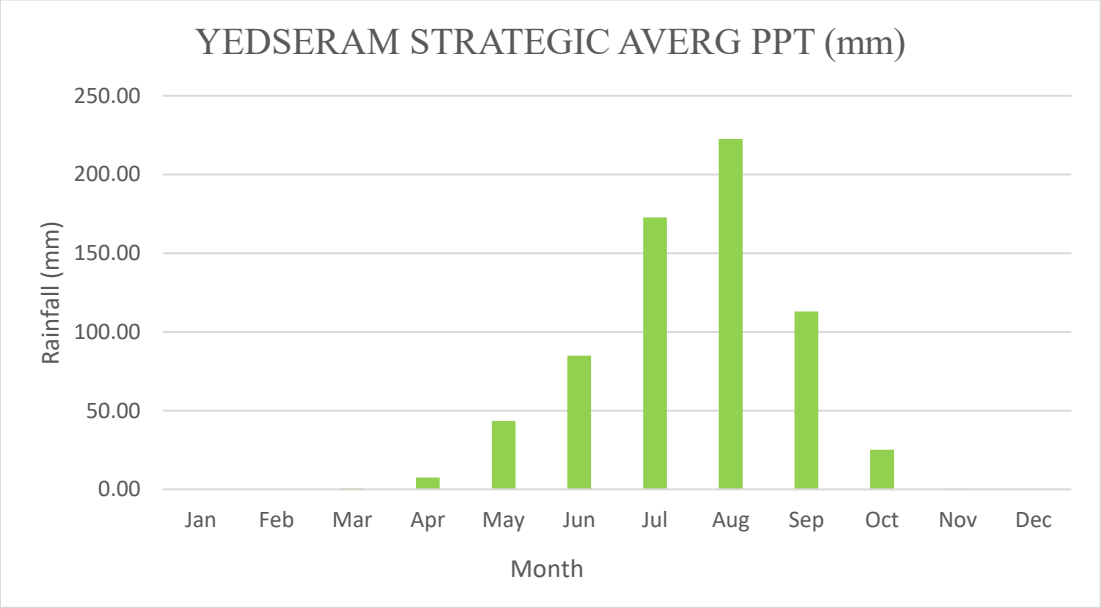


Figure 2.21: Rainfall histogram for Yedseram Strategic Catchmet

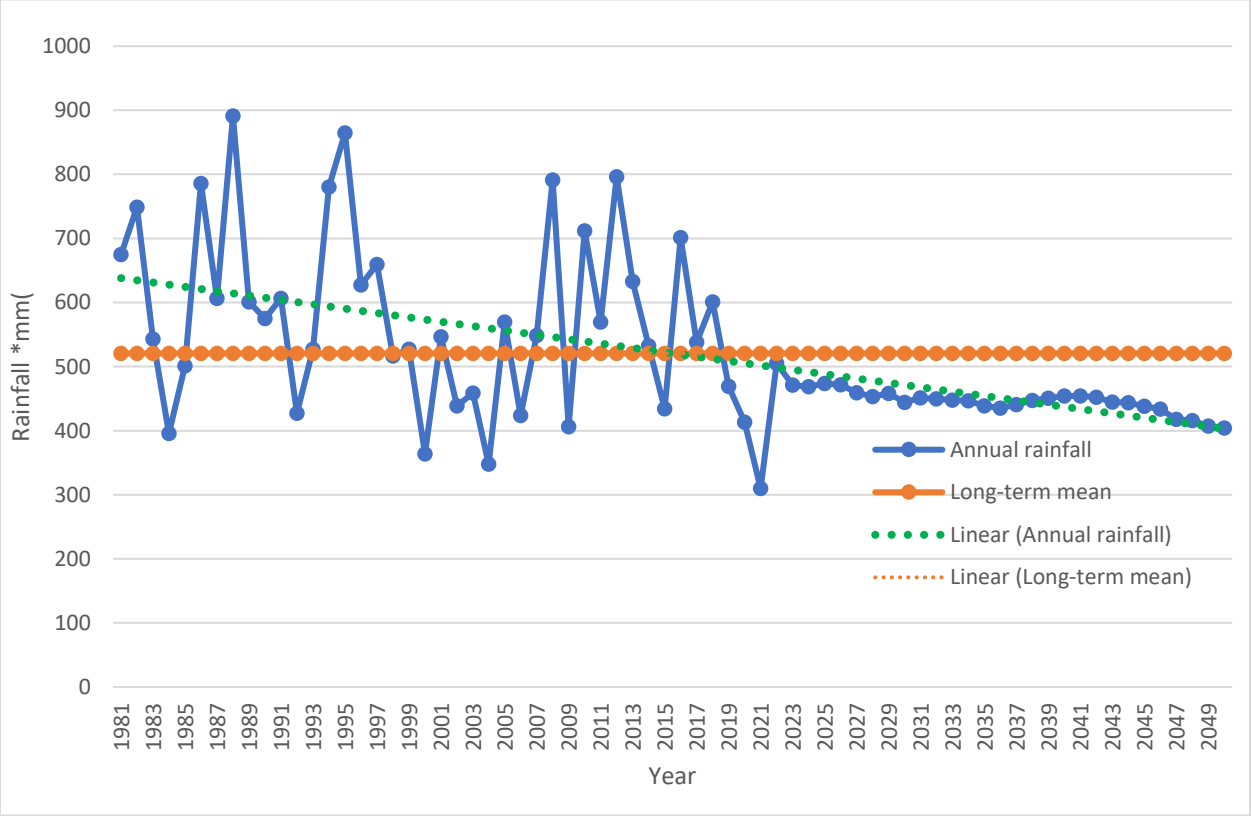


Figure 2.22: Projected Annual Trend (1981-2050) for Yesderam .

Table 2.9: Mean monthly temperature for Yedseram for 1981-2022 and 2023-2050

Month	Mean monthly Temperature 1981-2022	Mean monthly Temperature 2023-2050
January	23.45	24.06
February	26.33	27.94
March	30.31	31.80
April	32.97	34.55
May	32.92	34.33
June	31.05	31.77
July	28.29	29.08
August	26.67	26.68
September	27.35	27.42
October	28.52	29.11
November	26.44	27.51
December	23.90	24.27
Mean	28.18	29.04
Maximum	32.97	34.55
Minimum	23.90	24.06

Table 2.9 compares the mean monthly temperatures for Yedseram between the historical period (1981-2022) and the projected period (2023-2050).

- The data indicate an overall warming trend, with notable increases during the hottest months and smaller changes in cooler months.
- The mean annual temperature is projected to rise from 28.18°C to 29.04°C, suggesting a consistent upward shift in temperatures across most months. March to May, traditionally the warmest months, show considerable increases, with April rising from 32.97°C to 34.55°C and May from 32.92°C to 34.33°C.
- This trend indicates that the peak of the dry season will likely become even hotter, potentially straining water resources and affecting crop viability.
- The cooler months, such as January and December, show moderate warming, with January increasing from 23.45°C to 24.06°C.
- This subtle warming in the cooler months may reduce seasonal temperature variability, making winters less distinct. August, at the height of the rainy season, remains nearly unchanged, with only a slight rise from 26.67°C to 26.68°C.

- Similarly, September shows minimal change, suggesting that the cooling effects of rainfall may temper warming during these months.
- The maximum monthly temperature rises from 32.97°C to 34.55°C, while the minimum monthly temperature also increases from 23.90°C to 24.06°C. These changes indicate that the range of temperatures will shift upward, potentially leading to increased heat stress.
- October and November show significant increases, with October rising from 28.52°C to 29.11°C and November from 26.44°C to 27.51°C.
- This extended warming into late-year months could affect the length and intensity of the dry season, impacting water demand and agricultural cycles.

In summary, the projected data for Yedseram indicates a steady warming trend with substantial increases in peak temperatures and slight to moderate rises in cooler months. These shifts could have significant implications for agriculture, water resource management, and public health, aligning with broader regional patterns of climate change.

The pattern is represented in Figure 2.23

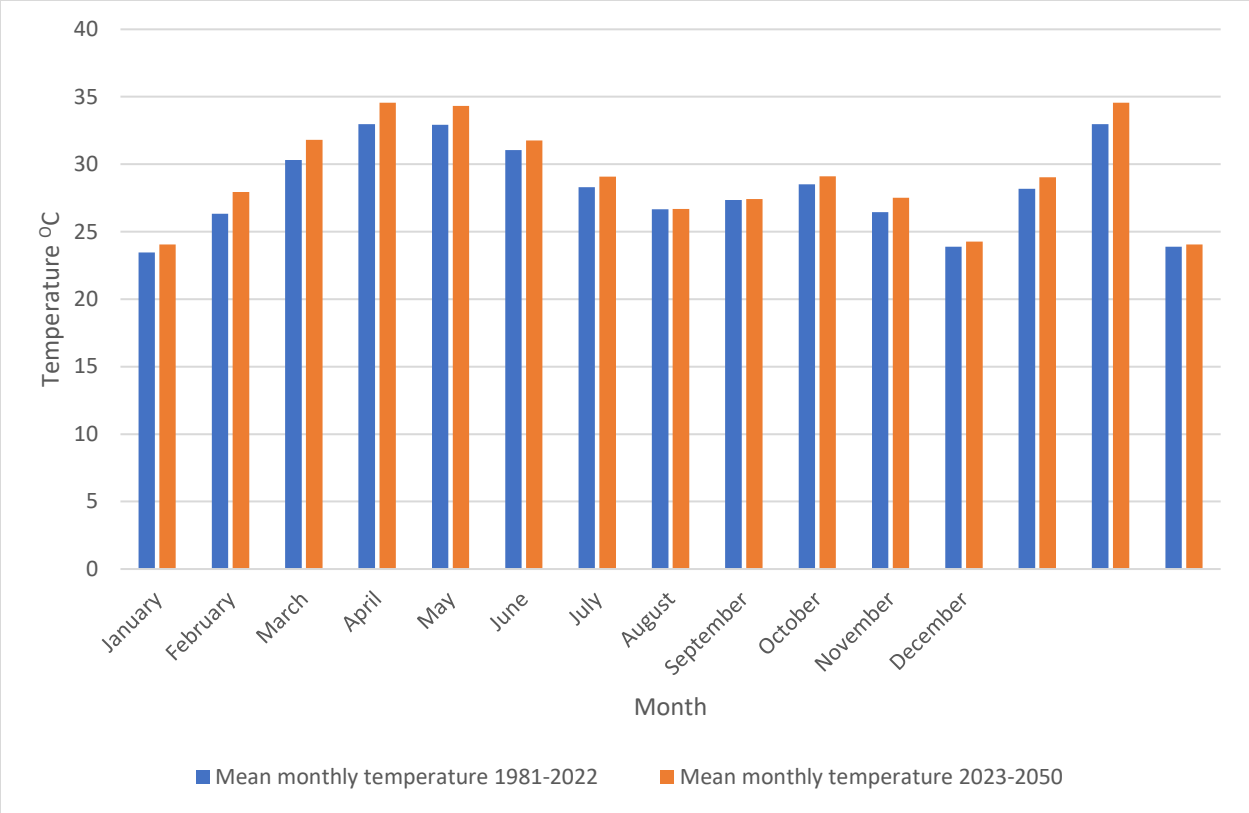


Figure 2.23: Mean monthly temperatures from 1981 to 2022 and 2023 to 2050 for Yedseram

2.8.3 Projected Mean Annual Temperature for Yesderam Catchment

Figure 2.24 presents the projected mean annual temperature trend for Yesderam from 1981 to 2050. The graph displays both historical (1981–2022) and projected future (2023–2050) temperature data.

- Within the historical period (1981-2022), the figure shows considerable fluctuation in annual temperatures, with noticeable peaks and dips, indicating variability in temperature from year to year. The trendline shows a positive slope, suggesting a gradual increase in temperature over the years, with an annual increase of approximately 0.0251°C.
- The R^2 value of 0.6325 implies that the upward trend can explain about 63.25% of the temperature variation. The future temperature projections (2023–2050) show a relatively flat line, showing no additional increase over this period, suggesting that temperatures are expected to stabilize at around 28.5°C.
- The overall trend shows a warming pattern from 1981 to 2022, this is consistent with observed global climate warming trends.

- The flat projection for 2023–2050 might reflect expectations of temperature stabilisation, possibly due to regional climate conditions or assumed interventions in climate models.

In summary, Yesderam has experienced a warming trend from 1981 to 2022, with projections suggesting temperatures may level off through 2050.

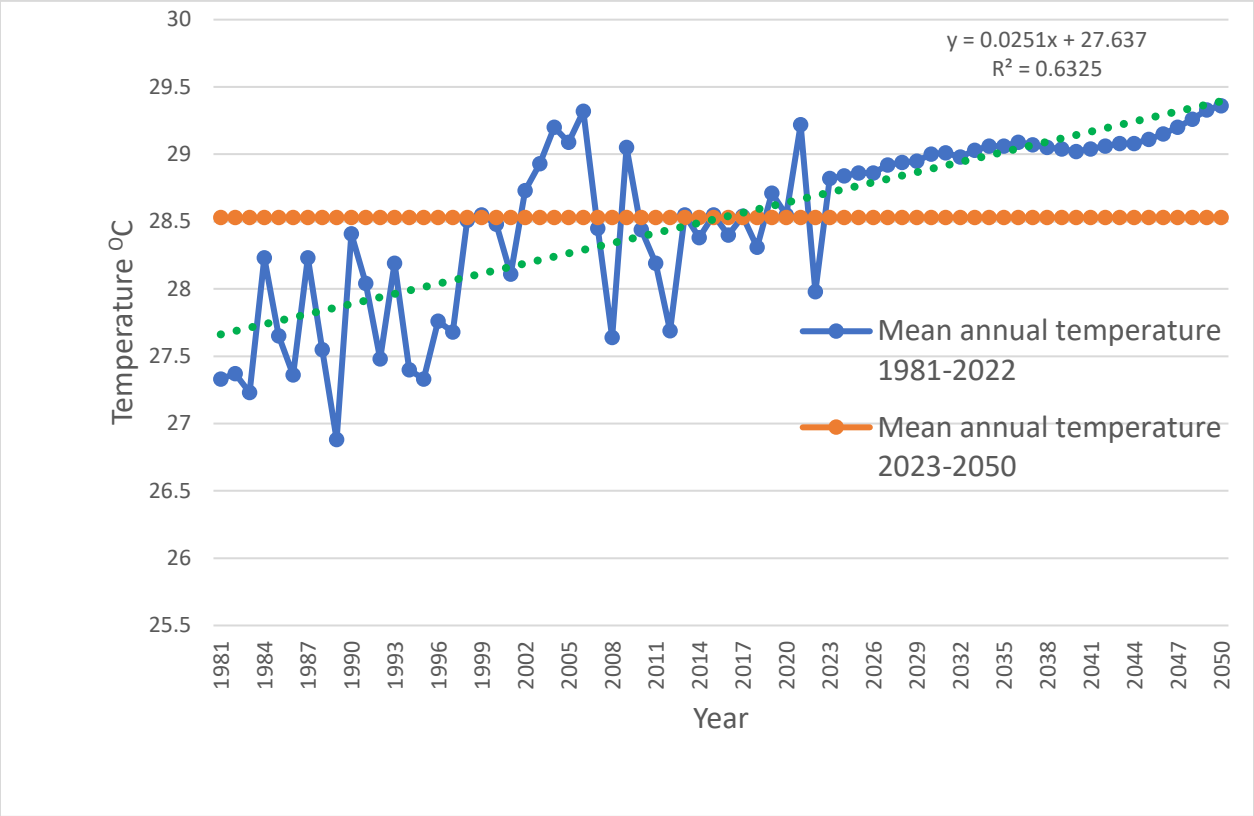


Figure 2.24: Projected Mean Annual Temperature Trend (1981-2050) for Yesderam.

2.8.4 Analysis of Down scaled Output of GCMs

In other to explore the possible change in climate conditions in future, the statistically downscaled output of GCMs, which is provided by CCAFS[2], are analyzed. The statistical downscaling as well as bias correction was conducted utilizing the spatial distribution of parameters provided by Worldclim[3] dataset. The available dataset by CCAFS includes the average monthly precipitation and air temperature with 30 year running averages from 2020s to 2080s. As for the emission scenarios, the followings are available.

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

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

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

2.8.4.1 Scenarios for Change in Precipitation and Air Temperature

In order to assess the effect of climate change on runoff, the scenarios for change in precipitation and air temperature are set as follows.

- The scenarios refer the analysis of the statistically downscaled output of GCMs shown in Section (2).
- The target year of the master plan is 2030. Considering the project life time is usually 50 years for civil works, the proposed project in the master plan should be functional for 50 years after completion of the project under possible change of climate conditions. Thus, the 2030 plus 50 years should be the longest time frame to be considered. As the average condition from around 2015 to 2080

(=2030+50), the results for 2050s from the output of the GSMs are referred.

- For the emission scenario, A1B scenario is adopted as the most-likely scenario.
- Considering a lot of uncertainty on the precipitation, the following two cases are taken as the scenarios.

Table 2.10: Scenarios for Change in Precipitation and Air Temperature

Case	Item	Season	HA-8	HA-8e
1	P(%)	ANN	0	**0**
	T(°C)	ANN	+2.5	**+2.5**
2	P(%)	DJF	+12.3	**+33.3**
		MAM	-0.5	**+0.6**
		JJA	+7.9	**+12.5**
		SON	+7.6	**+11.8**
	T(°C)	**ANN**	**+2.5**	**+2.5**

Source: JICA Project Team

Remarks:

1) P=Precipitation, T=Air Temperature
2) HA-8e: Catchment area outside Nigeria whose runoff comes into HA-8
3) DJF=December, January, February, MAM=March, April, May, JJA=June, July, August, SON=September, October, November, ANN=Annual

Table 2.11 below summarizes the response of internal annual runoff volume, which is generated in the territory of Nigeria, to the change in precipitation and air temperature, on the basis of the simulated results.

The followings are noted;

Table 2.11: Response of Internal Runoff Volume to Change in Precipitation and Air Temperature

Case	Item	Entire Country	HA-8
1	Ave. ARV (%)	-18	**-22**
	80%Dep.ARV (%)	-19	**-21**
	90%Dep.ARV (%)	-20	**-21**
2	Ave. ARV(%)	-12	**0**
	80%Dep.ARV (%)	-14	**-1**
	90%Dep.ARV (%)	**-13**	**-2**

Source: JICA Project Team

Remarks: Ave. ARV=Average Annual Runoff Volume, 80% Dep. ARV=80% Dependable Annual Runoff Volume, 90% Dep. ARV=90% Dependable Annual Runoff Volume

Table 2.12: Summary of Climate Impact, Online Visibility, Climate Policy and Action Plan, and Climate Appropriation in States covering Yedseram Catchment

S/No	STATES	CLIMATE IMPACT (Ranging from Most Prevalent challenges)	ONLINE CLIMATE VISIBILITY POLICY	CLIMATE ACTION PLAN	CLIMATE PROVISION BUDGET	CHANGE IN STATE
1.	**ADAMAWA**	Flooding, Loss of crop yield, Farmers/herders clashes, Drought	Medium	None	No	NO
2.	**BORNO**	Drought, Loss of crop yield, Desertification, Farmers/herders clashes	Medium	None	No	NO

Source: Department of Climate Change, Fed. Ministry of Environment. 2023

2.8.5 Evapotranspiration

High evapotranspiration rates in the catchment due to hot and dry conditions, particularly in the north, can exceed rainfall at 2,000 to 2,500 mm annually, worsening water deficits. This results in limited surface water availability and greater dependence on groundwater during dry months.

- Evapotranspiration, a critical component of the hydrological cycle, represents the combined water loss through evaporation and plant transpiration. Its dynamics significantly influence water availability, agriculture, and ecosystem health, making its study essential for effective resource management.
- The analysis covers historical data (1990-2023) and projected data (2024-2050), providing insights into interannual variability, long-term trends, and future scenarios.
- The historical period reveals fluctuations influenced by climatic factors, while the projections indicate a consistent upward trend attributed to climate change and associated global warming effects.
- The observed and projected increases in evapotranspiration pose challenges for water resources management, agriculture, and energy production, particularly in regions dependent on dams and reservoirs for irrigation and hydropower.
- This report underscores the implications of rising evapotranspiration for water resource sustainability, food security, and climate adaptation strategies. The findings emphasize the urgency of adopting innovative approaches, such as advanced irrigation systems, climate-resilient agricultural practices, and enhanced reservoir management, to mitigate the impacts of increasing evapotranspiration across the catchments.
- The evapotranspiration data were sourced from Amy McNally NASA/GSFC/HSL (2018), FLDAS Noah Land Surface Model L4 Global Monthly 0.1 x 0.1 degree (MERRA-2 and CHIRPS), Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), Accessed: [16/11/1024], doi:10.5067/5NHC22T9375G.
- The evapotranspiration trends for the catchments were forecast (projected) from 2024 to 2050 based on the monthly and annual data from 1990 to 2023, deploying the growth rate schema in Excel. It is of the following specifications:

- Growth Rate = (ending value - beginning value/beginning value) x 100.
- This above rate is then used to extrapolate for each projected period by multiplying it with the ending value.
- The formula thus explores the data generation process by linking each value to the previous period, which aids a graphical depiction of trends over time.
- It needs to be noted that growth may take different forms, including simple growth and exponential growth. Given the nature of the data when explored from the point of view of period to period, the simple growth projection has been used.

Figure 2.25 presents the trend in annual evapotranspiration from 1990 to 2050. The historical data (1990-2023) shows significant interannual variability in evapotranspiration, with peaks and troughs reflecting climatic fluctuations. The average evapotranspiration appears relatively stable, with occasional spikes above 150 mm.

- The long-term trend suggests a gradual increase in evapotranspiration over time.

For the projected period (2024-2050), evapotranspiration shows a more consistent upward trend, surpassing historical variability. By 2050, values are projected to exceed 200 mm annually, indicating a substantial rise compared to historical averages.

- The linear trend line demonstrates a steep slope, reflecting an acceleration in evapotranspiration rates.
- The high R^2 value (0.9231) indicates a strong correlation between time and evapotranspiration, suggesting that the increasing trend is statistically significant and likely driven by climate change factors.
- Higher evapotranspiration values will increase crop water demands, soil moisture depletion, and a shift in crop suitability.
- Higher evapotranspiration rates mean crops require more water for optimal growth, stressing existing irrigation systems.
- Faster evaporation rates will quickly deplete soil moisture, potentially leading to crop failures during droughts. Traditional crops may no longer be viable under these conditions, necessitating the adoption of drought-resistant or water-efficient varieties.

Increased evapotranspiration will result in greater water loss from open water bodies, including dams and reservoirs, reducing storage capacity. The decreased water levels would hinder hydropower generation, impacting energy supply.

- The situation would further exacerbate competition for limited water resources between agriculture, industry, and domestic use.
- The upward trend in evapotranspiration underscores the urgent need for sustainable water management practices in the Yedseram Catchment. This includes adopting advanced irrigation techniques, enhancing reservoir efficiency, and promoting climate-resilient agricultural practices.
- Without proactive measures, rising evapotranspiration could significantly impact food and water security in the region.

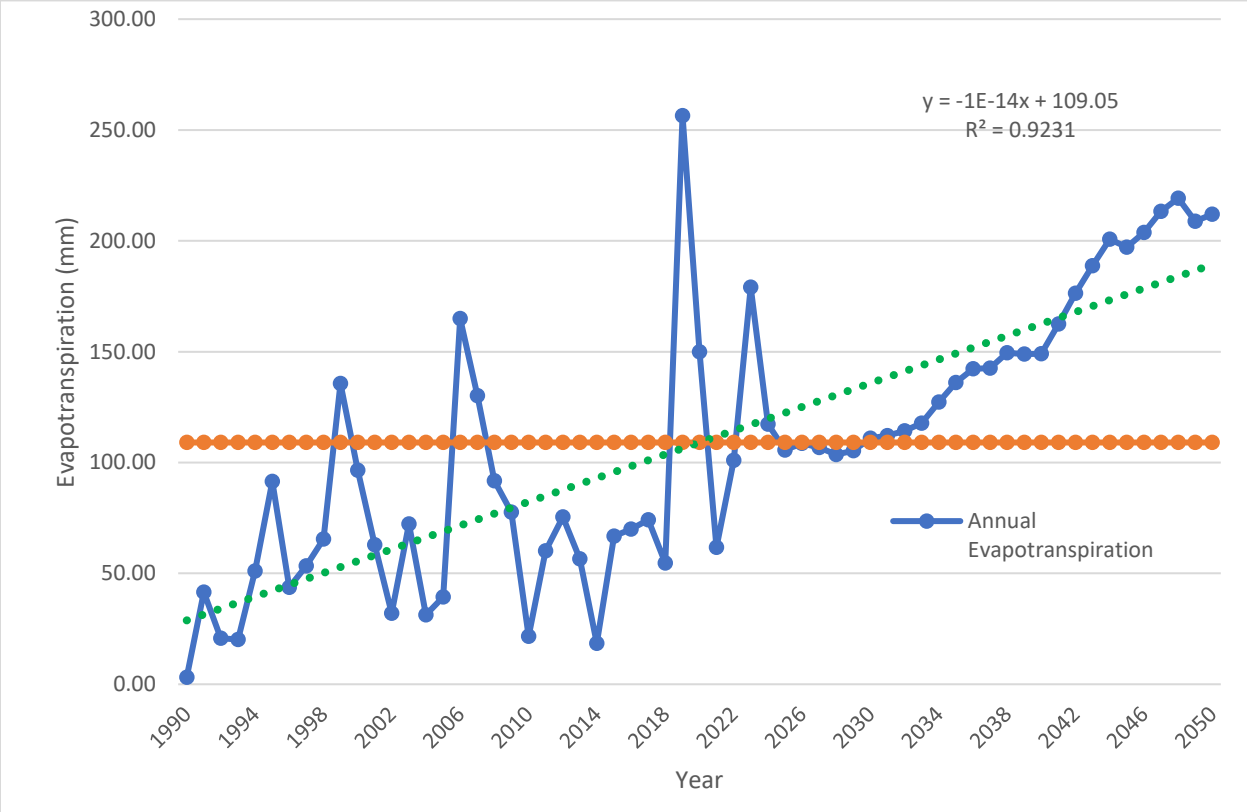


Figure 2.25: Trend in Evapotranspiration for Yedseram Catchment.

2.8.6 Major Impacts of Climate Change

Climate change has devastating effects on several sectors of the environment, some of which include socio-economic, health, and infrastructure. Table 2.12 gives some of the details of these impacts mentioned

Table 2.13. Key Impacts of Climate Change

Impacts	Details
Economic	Damage to infrastructure Loss of property and assets Disruption of businesses and services Increased costs for emergency response and recovery
Social	Loss of life and injury Displacement and migration Psychological trauma and stress Social disruption and community cohesion
Environmental	Water pollution Soil erosion and sedimentation Loss of biodiversity Increased risk of waterborne diseases
Health	Waterborne diseases Vector-borne diseases Mental health impacts Injuries and trauma
Infrastructure and Service	Power Outage Transportation disruption Water and sanitation disruption Communication disruption

2.8.7 National and International Climate Change Frameworks/Agreements

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

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

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

2.8.7.1 Climate Change Scenarios

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

According to the 4th IPCC report (2007), it is expected that the increase of air temperature in West Africa area in 2100 would be about 3-5 degree Celsius in the case of A1B scenario, which is about 1.5 times higher than the average in the world. As for the precipitation, the predictions of precipitation by different GCM models vary very much. Itis 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 on Climate Change is essential for assessing and tackling climate change impacts according to the Paris Agreement and UNFCCC. It analyzes greenhouse gas emissions and vulnerability while proposing adaptation and mitigation strategies tailored to Nigeria's socio-economic and environmental conditions.

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

i. Greenhouse Gas (GHG) Inventory and Emissions Trends
ii. Vulnerability and Impacts of Climate Change
iii. Adaptation Measures and Challenges
iv. Mitigation Strategies and Potential
v. Barriers to Climate Action
vi. International Cooperation and Support Needs

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

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

2.8.7.4 Nigeria's Third National Communication on Climate Change

The Third National Communication on Climate Change was held to update Nigeria's assessment of GHG emissions, climate vulnerabilities, and adaptation strategies. It reflects the country's ongoing commitment to climate action and sustainable development. The report presents a comprehensive review of climate policies and future directions for a low-carbon economy.

Nigeria's emissions mainly come from Agriculture, Forestry, and Other Land Use (60.1%), with energy contributing 33.9%. Without action, emissions could increase by over 58% by 2035 amid serious climate vulnerabilities.

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 joining the UNFCCC in 1994, Nigeria ratified the Kyoto Protocol in 2004 and the Paris Agreement in 2007. The Paris Agreement, adopted on December 12, 2015, aims to limit global temperature rise to below 2°C, with efforts to cap it at 1.5°C. It took effect on November 4, 2016.

2.9 Flood and Drought Vulnerability

The rainfall pattern within the catchment revealed a wide range of rainfall distribution across the city, with the values showing a sharp variation in spatial distribution from 689mm around the Adamawa Mountains to 216mm in almost 85% of the catchment area.

This suggests that precipitation may be one of the major drivers of flooding in the catchment area. Intense, localized rainstorms have the potential to result in flash flooding, particularly in areas where the urban drainage system is overwhelmed, however, the catchment area is predominantly a rural area and annual average precipitation data may not capture these variations, but they are important in assessing the flood risk in the catchment.

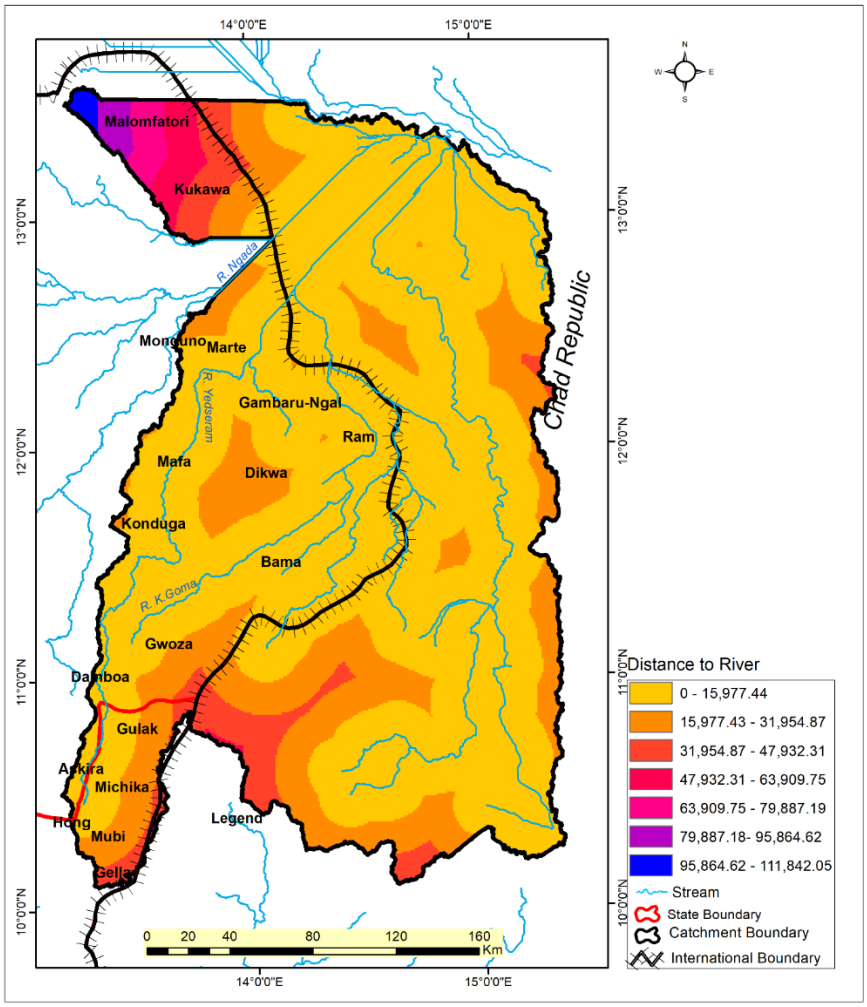


Figure 2.26: Distance to River Map (Source: MSL, 2024)

Proximity to streams is crucial in flood vulnerability analysis, as closer distances indicate a higher likelihood of flooding. In this study, areas within 0-15 km of the river are considered closest, while areas 95-111 km away are far from the river.

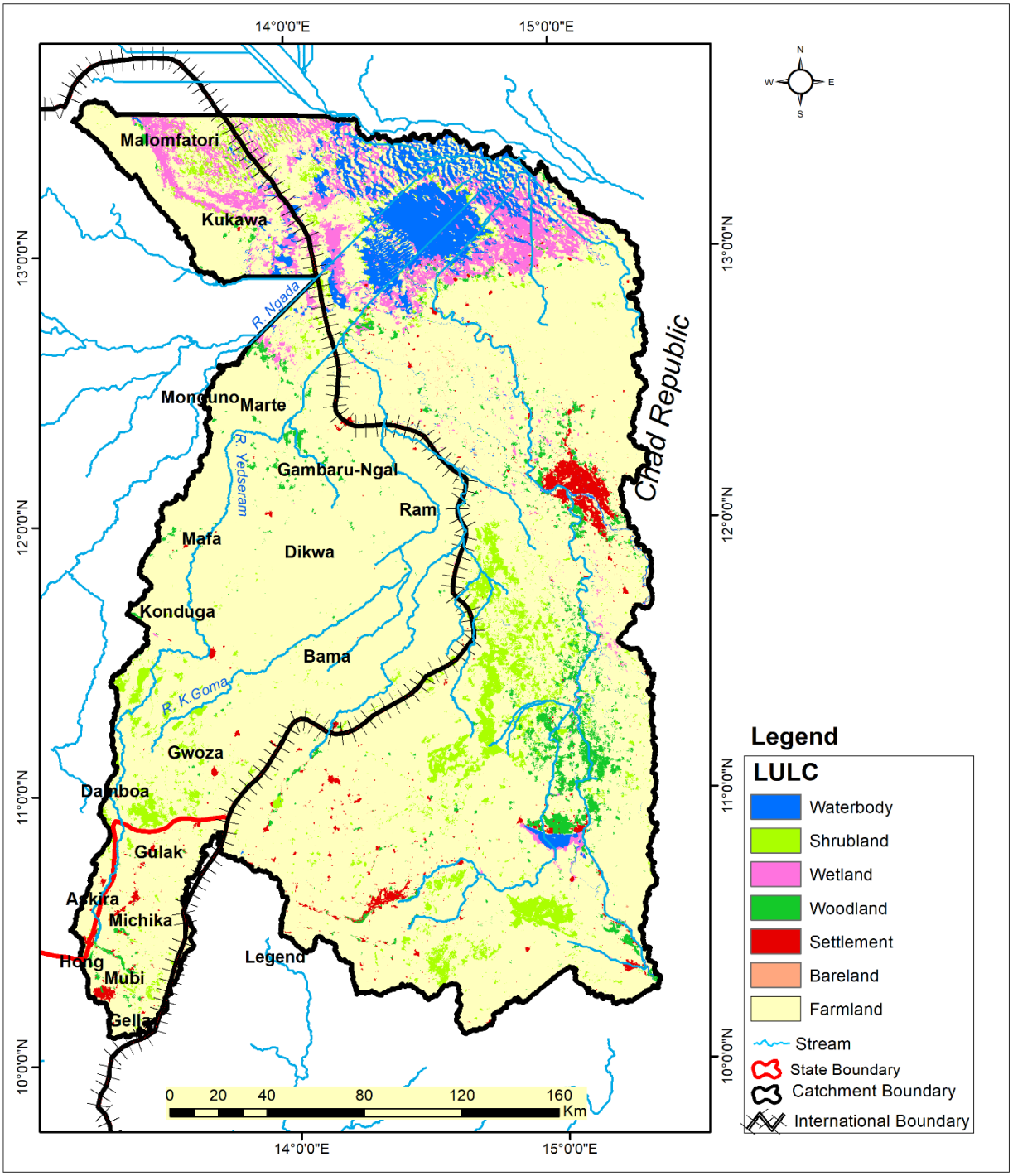


Figure 2.27: LULC Map of the Catchment (Source: MSL, 2024)

- Water body 5 extremely vulnerable. Directly involves water, prone to overflow and flooding during heavy rainfall.

- Riparian/wetland 5 extremely vulnerable. Naturally waterlogged areas with high susceptibility to flooding.

- Settlement/buildup 4 High vulnerability. Impermeable surfaces increase runoff, leading to higher flood risk.

- Cropland is assigned 3 which indicates moderate vulnerability. This class can retain some water, but large-scale runoff can still occur.

- Bare surface, 3 also indicates Moderate vulnerability. Limited vegetation means higher runoff and erosion potential.

- Shrubland 2 Low vulnerability. Some vegetation reduces runoff, but not as effective as forests.

- Vegetation/forest 1 Least vulnerable. Dense vegetation and root systems improve water absorption and reduce runoff.

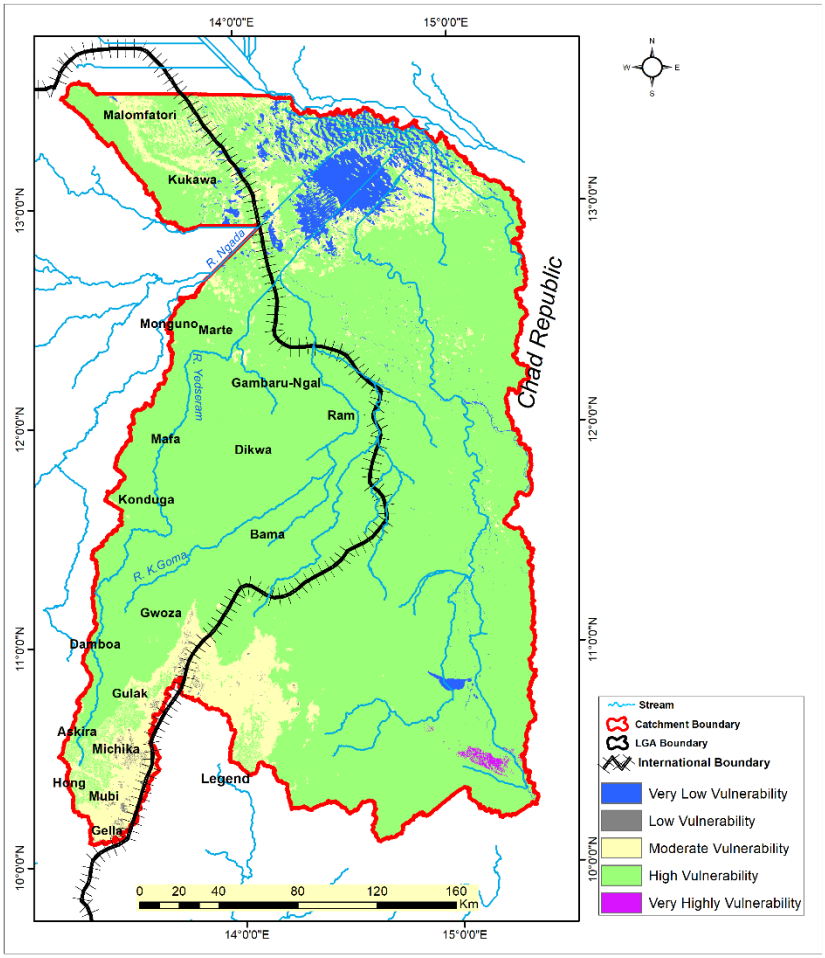


Figure 2.28: Flood Vulnerability Map of the Catchment (Source: MSL, 2024)

2.9.1 Flood Vulnerability

The study used 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,
- The flood risk map delineates various potential flood zones within the catchment area, classified into five risk levels: Highly not vulnerable, Not Vulnerable, moderate, Vulnerable, and highly Vulnerable (Figure above). The total study area spans 4,35km2.
- Areas with low flood risk areas are primarily located in high-elevation regions, which, due to their favorable topography, and the restricted areas around the Lake Chad area which also receive low rainfall, are less likely to experience flooding.
- Moderate flood vulnerability zones are also mostly found around the high mountains of Adamawa are with diverse topographical features.
- 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.
- 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 its adjoining proximity with the highlands.

Despite the result of the analysis, the region generally experiences less flooding because of the sedimentary nature of the geology which encourages infiltration and less runoff.

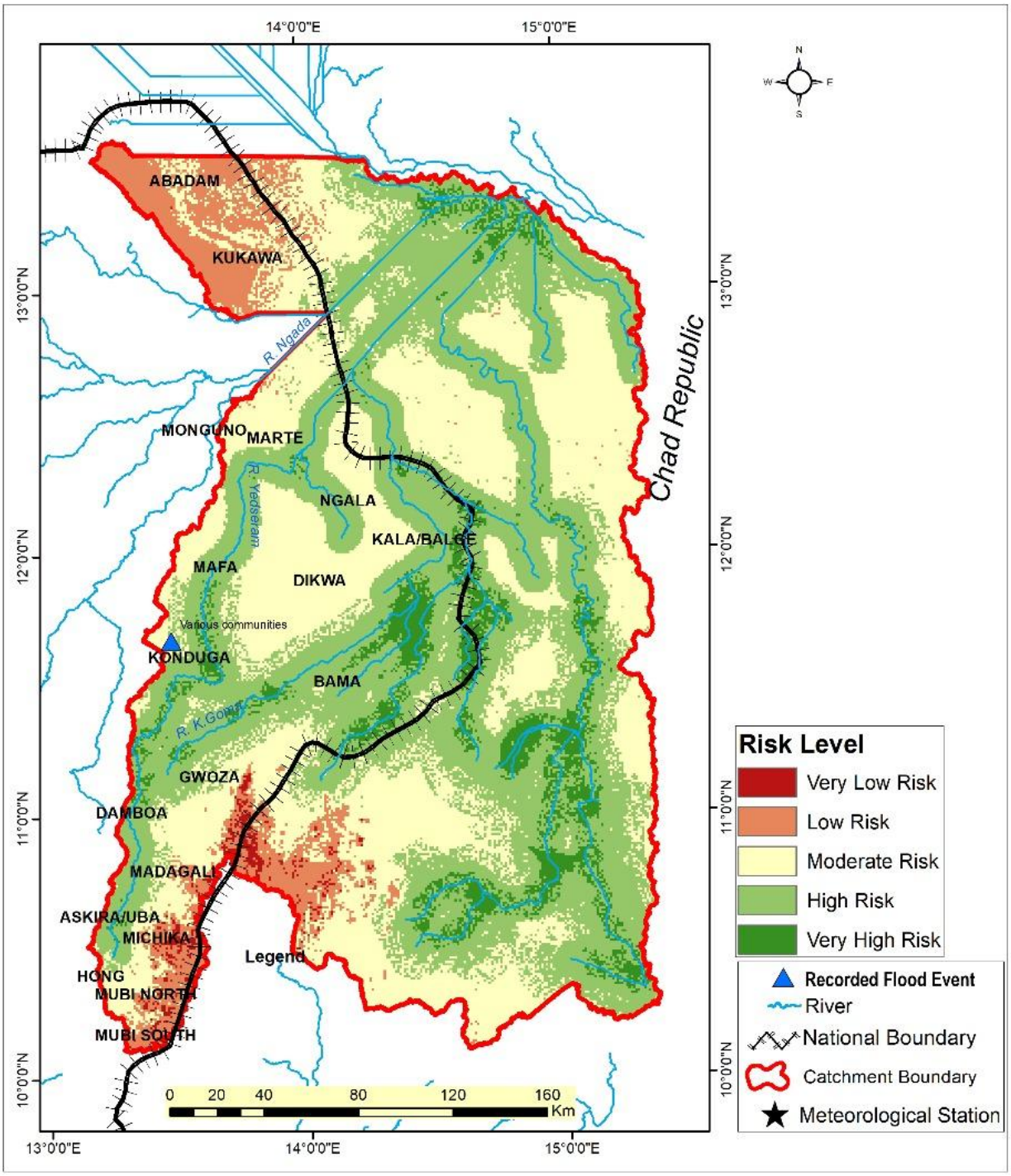


Figure 2.29: Flood Risk Level Map. (Source. MSL 2024)

Table 2.14: Flood risk analysis class name of the catchment.

Class Name	Ha	%
Farmland	926,599.4	75.43334
Wetland	90,855.6	7.396445
Waterbody	153,609.3	12.50515
Vegetation	34,654.65	2.821193
Builtup	21,506.32	1.750804
Baresurface	1143.276	0.093073

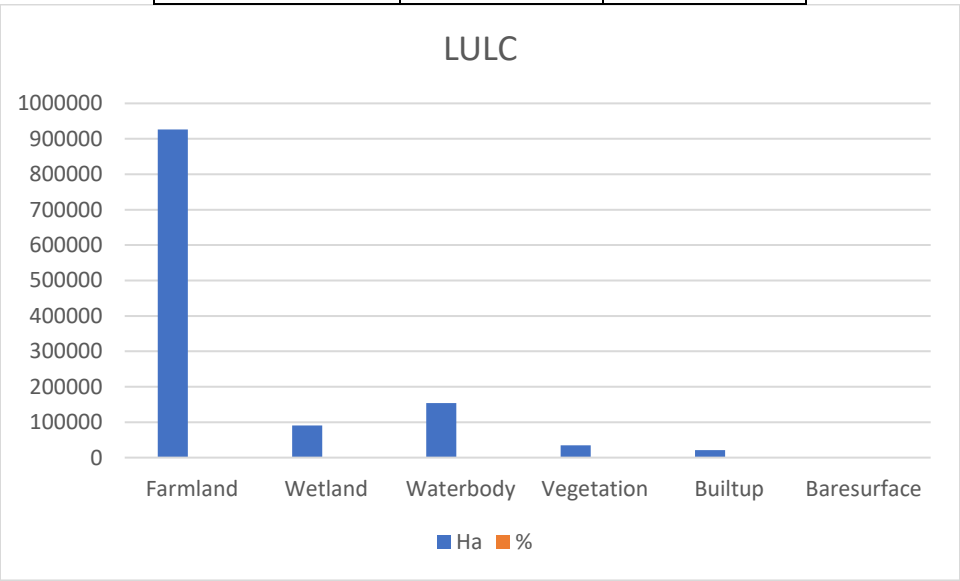


Figure 2.30: Class name bar chart (Source MSL 2024)

The flood risk analysis shows the Land use/Land cover of about 1,228,369Ha is at high risk of flood and of this figure, farmland makes up about 75% of the land use/land cover at risk at 926,599.4Ha, while the least is bare surface at 0.0931%

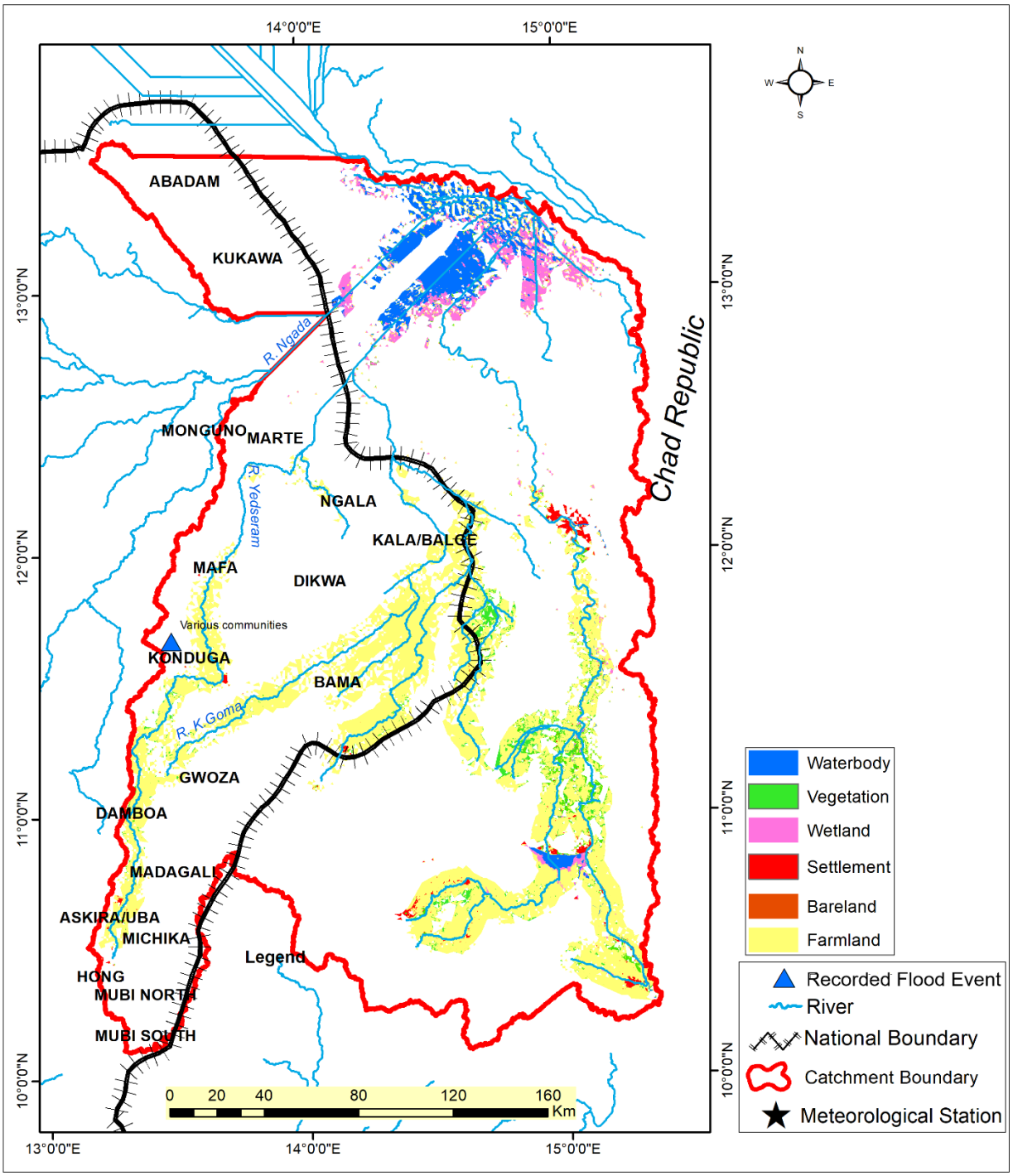


Figure 2.31: Flood Event Map (Source. MSL 2024)

The September to October 2022 flooding in this catchment affected approximately 55,000 people, damaging housing and agricultural lands. Ongoing insecurity compounded the situation, making humanitarian access challenging.

2.10 Socio-Economic Dynamics

2.10.1 Population Distribution Growth

Population Projection

Population was projected using the 2006 census data for a duration up to 2050 by utilizing the projection growth rate in the table 2.14 below

Table 2.15: Population projection ratio

2010-2015	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040	2040 2045	2045 2050
2.78%	2.71%	2.65%	2.60%	2.54%	2.35%		

Source (UN, 2012)

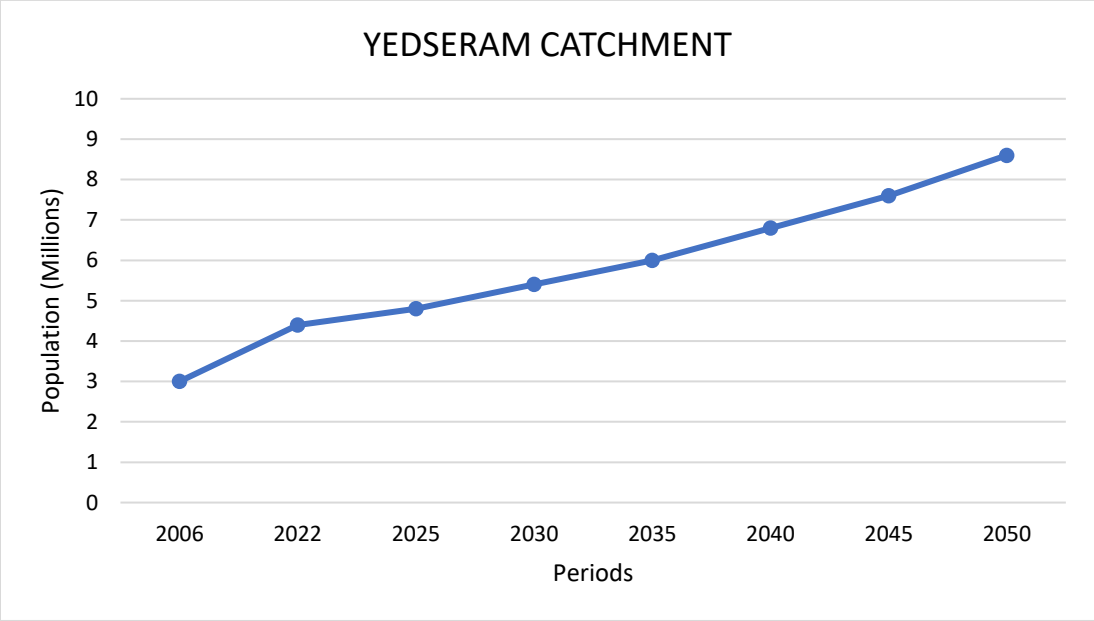


Figure 2.32: Population Projection Yedseram Catchment

Table 2.16:Summary of Yedseram Catchment

NAME	STATES	POPULATION	GEOGRAPHY	GEOLOGY	HYDROGEOLOGY	VEGETATION	THREATS AND CHALLENGES
Yedseram	Borno Adamawa	About 3.8 million reside within this catchment (NPC projection for 2022)	Varies depending on specific sub-catchments within the eastern section. Can include plains, plateaus, and highlands	The geology of the Lake Chad Basin is complex, with sedimentary rocks, igneous intrusions, and volcanic formations in some areas	Surface water availability relies on seasonal rainfall and river flows. Groundwater resources are present but face pressure and potential salinization	Varies from Sudanian savanna in the south to desert in the north. Desertification is a major threat	Similar challenges to the Gali-Lamurde catchment, but on a larger scale. Water scarcity, poverty, environmental degradation, and competition for resources strain livelihoods like agriculture and livestock rearing. Biodiversity issues and insecurity.

2.10.2 Demographics and Poverty

Table 2.17: Catchment Demographics and Poverty

STATE	DEMOGRAPHICS AND POVERTY
BORNO	Borno State, located in northeastern Nigeria, has a diverse demographic profile. Here are some key statistics: - Population: As of 2016, the estimated population of Borno State is approximately 5.86 million people, making it the eleventh most populous state in Nigeria. The local governments of Abadam, Askira/Uba, Bama, Damboa, Dikwa, Gwoza, Kala/Balge, Konduga, Kukawa, Mafa, Marte, Monguno, and Ngala in Borno State exhibit extremely high levels of poverty, with estimates indicating that more than 75% of households live below the poverty line. Several factors contribute to this extreme poverty: 1. Protracted Conflict and Displacement: Borno State is the epicenter of the Boko Haram insurgency. Continuous attacks and violent confrontations have led to the displacement of millions of people within and beyond the state's borders. The resulting humanitarian crisis has caused massive destruction of infrastructure, agriculture, and economic activities. Local governments such as Bama, Ngala, Kala/Balge, and Monguno have witnessed some of the most severe impacts, pushing them into Phase 4 (Emergency) on the food insecurity scale. 2. Disrupted Livelihoods and Economic Activities: Borno's economy was primarily based on agriculture, livestock rearing, and trade. However, with large portions of the population displaced and infrastructure destroyed, these traditional economic activities have been severely disrupted. In LGAs like Mafa, Kukawa, and Gwoza, where the rural economy heavily depended on farming, insurgency and insecurity have severely curtailed agricultural productivity. Even essential markets have been disrupted due to insecurity and poor accessibility.

3. Widespread Malnutrition and Health Crises: With most of the population dependent on humanitarian assistance, malnutrition and lack of healthcare have become critical issues. The Cadre Harmonisé reports that many of these LGAs have entered Phase 4, signifying large food consumption gaps, critically high malnutrition rates, and even increased mortality risks. This directly correlates with the extreme levels of poverty, where households struggle to access even the most basic needs.
4. Environmental Degradation and Climate Stress: The Yedseram catchment is also exposed to climate-induced challenges such as flooding, which is exacerbated by poor land use and degraded watersheds. LGAs such as Abadam and Marte have been particularly affected by both insurgency and environmental challenges, reducing agricultural yields and increasing food insecurity.

- Age Distribution: The population is relatively young, with about 50% of residents under the age of 15 [3].

- Ethnic Groups: The dominant ethnic group in Borno State is the Kanuri people, but there are also other ethnic groups present, including the Shuwa Arabs and the Babur/Bura people [4].

- Language: The main languages spoken in Borno State are Kanuri, Hausa, and Shuwa Arabic [4].

- Religion: Islam is the predominant religion in Borno State, with a significant majority of the population identifying as Muslim [4].

- Urban-Rural Distribution: The state has a mix of urban and rural areas, with the capital city Maiduguri being the largest urban center [3].

	- Education: Education is a key sector in Borno State, with several institutions of higher learning, including the University of Maiduguri [5]. - Economy: The economy of Borno State is largely agrarian, with crops like sorghum, millet, and peanuts being major staples [4]. Borno State has a poverty index of 64%, ranking it among the poorest states in Nigeria [1]. The state's poverty level is attributed to various factors, including: - Low Economic Growth Performance: Borno State's economy has been witnessing low growth due to factors like insurgency, low industrialization, and agricultural production [2]. - Insurgency, Crime, and Violence: The activities of insurgent groups have resulted in the death of over 10,000 people and displaced over a million individuals, crippling economic activities and creating food insecurity [2]. - Debt Burden: The state has a debt profile of N30.9 billion, which encroaches on government expenditure for social and physical infrastructure [2]. - Human Capital Development: Borno State has a poor human development index, with a literacy rate of about 14.5% and high infant and under-five mortality rates [2]. To alleviate poverty in Borno State, the government and non-governmental organizations have implemented various programs, including creating enabling environments, setting up local programs and schemes, and establishing a Ministry of Poverty Alleviation [2]. However, these measures have not been successful in reducing poverty levels in the state.

Adamawa	Adamawa State in Nigeria has a diverse demographic profile. As of 2021, the projected population is approximately 4,902,100 people, with a nearly equal split between males and females [1] [2] [3]. The state has over 100 indigenous ethnic groups, making it one of the most heterogeneous states in Nigeria [4]. Some of the prominent ethnic groups include: - Fulani: The dominant ethnic group in the state - Mumuye: Known for their expertise in farming and herding - Higi: Skilled in farming, herding, and fishing - Kapsiki: Engaged in farming, herding, and trading - Chamba: Known for their agricultural skills and traditional crafts In terms of occupation, the majority of the population is engaged in farming, herding, and fishing [5] [6]. The state is also home to various cottage industries, including leatherwork, calabash decoration, mat weaving, pottery making, metalwork, canoe carving, and cloth dyeing [6]. Adamawa State has a total area of 39,742.12 square kilometers, making it one of the largest states in Nigeria [5] [3]. The state capital is Yola, which is also home to a federal university and various industries, including a sugar-processing plant and a timber industry [6]. Adamawa State has a poverty index of 59.9%, ranking it 25th among the 37 states in Nigeria, including the Federal Capital Territory (FCT) [1]. This

means that almost 60% of the population in Adamawa State lives below the poverty line.

The local governments of Hong, Madagali, Maiha, Michika, Mubi North, and Mubi South in Adamawa State exhibit high to very high levels of poverty, with estimates suggesting that between 50% to 60% of households live below the poverty line. The poverty situation in these areas is largely a result of:

1. Conflict and Insurgency: The Boko Haram insurgency has significantly impacted these local governments. Frequent attacks and insecurity have led to substantial displacement, destruction of infrastructure, loss of livelihoods, and limited access to essential services such as education, healthcare, and clean water. Displacement has also interrupted traditional farming and trading activities, which are primary economic drivers in these areas.
2. Limited Economic Opportunities: Before the insurgency, the region was characterized by modest agricultural and commercial activities, mainly in food crops and animal rearing. The crisis has rendered many areas unsafe for farming and trading activities, pushing many households deeper into poverty. Lack of employment opportunities further compounds poverty.
3. Food Insecurity: According to Cadre Harmonisé assessments, local governments in Adamawa have been classified in Phase 3 (Crisis), indicating high food insecurity, which often overlaps with poverty. With disrupted livelihoods, many households are unable to afford basic food items, resulting in compromised dietary quality and increased malnutrition rates.

Breaking it down further, a study analyzing poverty levels among households in Girei Local Government Area of Adamawa State found that

	60% of respondents were poor, with a poverty gap of 27% and a poverty severity of 10% [2]. Another study in Michika Local Government Area revealed that 64% of households were poor, with a poverty gap of 33% [3]. These statistics indicate that poverty is a significant challenge in Adamawa State, with a substantial proportion of the population struggling to meet their basic needs.

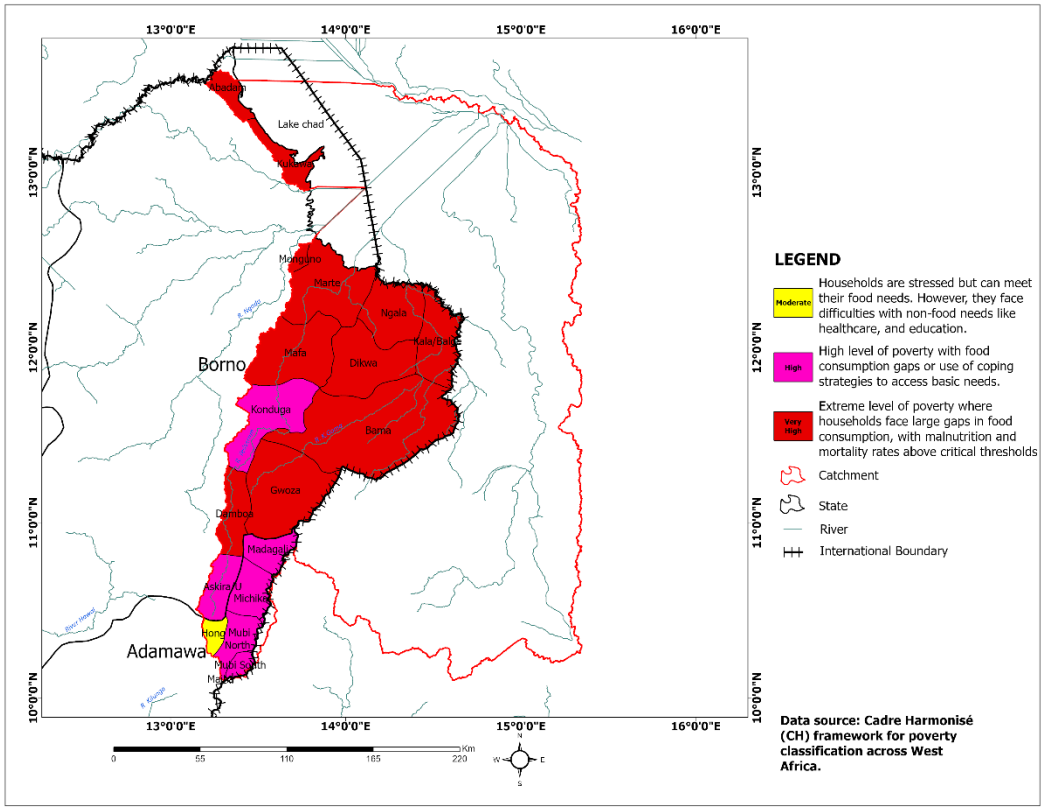


Figure 2.33:Poverty Levels Map of the Catchment (Source: MSL, 2024)

2.10.2.1 Unsustainable Livelihoods

Many communities in the Yedseram catchment rely on natural resources for their livelihoods, including farming, fishing, and livestock rearing. However, high poverty levels and limited access to alternative livelihoods have led to unsustainable resource use.

- **Overexploitation of Resources**: Due to poverty, local communities often resort to overharvesting resources, such as overfishing, deforestation for firewood, and overgrazing, leading to long-term environmental degradation.
- **Lack of Alternative Livelihoods**: In many rural areas, there are limited opportunities for alternative income sources. This forces people to rely on agriculture and natural resources, making it difficult to implement sustainable practices.

2.10.3 Gender Issues

Challenges

Gender inequality in the catchment is driven by cultural, social, and economic factors that disadvantage women and vulnerable groups. Limited access to education, skills, and financial services restricts their economic opportunities and participation in leadership and decision-making.

Socio-economic challenges like poverty, conflict, and weak governance exacerbate issues related to climate change. Women face increased vulnerability to its impacts, including natural disasters and migration, which elevate their risk of gender-based violence (GBV) and hinder their ability to adapt. Although policies such as the Gender Policy and Violence Against Persons Prohibition (VAPP) Law are in place, their implementation is hindered by language barriers, lack of community engagement, and insufficient enforcement.

Opportunities

Despite challenges, the catchment presents opportunities for advancing gender equality. The presence of government, civil society, and development actors—spurred by insurgency-related interventions—has increased funding and programs targeting gender and social inclusion. These efforts provide a foundation for integrating gender considerations into resource management and development initiatives.

Recommendations

- **Social and Behavioral Change Communication**: Promote rights-based social norms through sensitization campaigns, emphasizing equitable resource management and gender inclusion. Utilize local knowledge and innovative approaches to address cultural beliefs and foster gender equity.

- **Economic Empowerment**: Enable women to access credit, land ownership, and entrepreneurial opportunities. Encourage government initiatives that support women-led businesses, enforce equal pay, and create policies for career advancement.

- **Policy Implementation**: Translate existing policies into local languages and engage communities to ensure effective implementation. Develop costed workplans and budgets for translating policy into action.

- **Addressing GBV**: Make GBV prevention and response integral to all programs. Establish confidential reporting systems, grievance redress mechanisms, and referral directories to support survivors. Promote cultural shifts that redefine masculinity and challenge GBV norms.

- **Multi-Sectoral Collaboration**: Integrate gender and social inclusion across sectors such as education, agriculture, water resources, and economic development to strengthen the impact and sustainability of programs like ACReSAL.

By addressing these challenges and leveraging opportunities, sustainable resource management and socio-economic development can be achieved with equitable gender representation and participation.

CHAPTER 3 : STAKEHOLDER ENGAGEMENT AND GOVERNANCE

3.1 Methodology

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

3.2 Key Stakeholders Engaged

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

- Natural Resources
- Threats and Challenges
- Socio-economics
- Policies

Water Resources

Natural Resources (Forestry, Mineral Resources, etc)

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

i. Chad Basin Development Authority, Maiduguri-Borno
ii. Northern Borno Development Initiative Initiatives-Borno
iii. Kanem Borno Human Development Association (Kabhuda).-Borno
iv. Center for Arid Zones Studies, Uni Maid-Borno
v. Farmers association/ pastoralists of the State
vi. Rural Water Supply and Sanitation Agency (RUWASA)
vii. State Ministries of Environment,
viii. State Ministry of Agriculture and food security
ix. State Ministry of Water Resources,
x. State Ministry of Min of Lands,
xi. State Ministry of Women Affairs,
xii. State Ministry of Solid Mineral Development
xiii. State Miners Association

3.3 Major Topics for Stakeholder Discussions

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

Stakeholders were engaged in group settings in each State , in this case ,mainly Bornu State to discuss key issues affecting development of catchment and opportunities for addressing these issues. The FPMU team first presented the results of the catchment analysis, focusing on the biophysical and socio-economic aspects. The meetings then tried to develop a consensus around a long-term vision, strategic goals for catchment development, and finally, priority actions.

The discussions covered issues and potential best practices around:

- Water management
- Land-Use
- Environmental protection/biodiversity conservation
- Community benefits
- Economic development
- Climate change resilience
- Monitoring and evaluation alignment of policies governing the catchment
- Insecurity Issues

More specific topics included:

- Water supply
- Agriculture
- Industrial use
- Making rivers more navigable
- Implementing the water charter of the Basin
- Creating and maintaining a decision support system/databank for the catchment
- Need for a Dam within the catchment
- River training
- Flow proportioning structures
- Restoration and expansion of the hydromet monitoring network

3.4 Key Points from the Stakeholder Engagement

Based on the stakeholder engagement information from Annex 1 on strategic issues and opportunities, the following detailed points were developed around the key topics of interest identified in the previous section above:

1. **Water Management and Access**:
    - Stakeholders emphasized the importance of sustainable water resource management, particularly addressing overuse and pollution from upstream activities.
    - A significant focus was on implementing and enforcing operational guidelines for dams and reservoirs, alongside river training to manage sedimentation and flow distribution effectively.
    - Enhancing climate resilience through rainwater harvesting and expanding hydromet monitoring networks were considered critical.
2. **Land Use and Degradation**:
    - Concerns were raised about unsustainable farming practices, leading to soil degradation and reduced productivity.
    - Encroachment into forest reserves for agriculture was identified as a pressing issue, impacting biodiversity and contributing to deforestation.
3. **Environmental Protection**:
    - Restoration of degraded wetlands and afforestation initiatives were highlighted to improve ecosystem services and carbon sequestration.
    - Stakeholders emphasized the need for protecting riparian corridors and ensuring the sustainable use of natural resources.
4. **Community and Livelihoods**:
    - There was widespread acknowledgment of the socio-economic challenges linked to water resource access, including poverty and food insecurity.
    - Livelihood support through initiatives like providing farming equipment, credit facilities, and skills training was noted as a vital intervention.
    - Issues of insecurity in certain regions hinder the effective implementation of initiatives.
5. **Institutional Gaps and Policy Alignment**:
    - Weak coordination among agencies and gaps in policy implementation were recurring themes.
    - Suggestions included harmonizing existing policies on land tenure, mining, and water resources, alongside developing costed action plans and budgets.

6. **Strengthening Coordination Mechanisms:**
    - Create a multi-stakeholder platform to improve collaborative decision-making.
    - Encourage capacity building for local institutions to enhance governance structures.
7. **Promoting Sustainable Practices:**
    - Roll out community-driven sustainable agricultural practices and integrated land management approaches.
    - Incentivize the use of organic farming methods to reduce chemical runoff into water systems.
8. **Enhancing Data and Monitoring Systems:**
    - Regularly collect and share water quality and hydrological data to inform planning and mitigate risks.
    - Utilize modern tools like GIS and remote sensing for better resource management.
9. **Engaging Communities:**
    - Strengthen community engagement through awareness campaigns about sustainable practices.
    - Include gender-sensitive approaches to empower marginalized groups, particularly women, in resource management activities.

In consideration of a clear understanding of the outcome of the valuable inputs from the stakeholders, as indicated above and listed in the components of the plan interventions were suggested:

Most in concurrence with the stakeholder output,

- While others were slightly modified in line with existing data on related factors, as deduced from the study, the idea is to develop the most practicable intervention projects.
- By addressing these identified challenges and leveraging the opportunities highlighted, the catchment management plan can achieve sustainable development outcomes that balance ecological health with socio-economic goals.

It is pertinent to note that there were very few areas of none concurrence,while participants preferred that the management of the catchment should be under the purview of the North East Development Commission (NEDC)

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 the catchment plan's environmental aspects 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): This agency 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 Yedseram catchment is:

> "To attain a comprehensive, sustainable, efficient, and equitable use of all the resources within the catchment".

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 of the Catchment

LONG-TERM STRATEGIC GOALS (2030)	KEY PERFORMANCE INDICATORS (KPIs)	SHORT TERM STRATEGIC GOALS (2025)	KEY PERFORMANCE INDICATORS (KPIs)	TARGETS (EXPECTED OUTCOMES)
1. **Ensure Sustainable Water Resource Management:** o Promote integrated water resource management (IWRM) to	• Percentage increase in year-round water availability for domestic, agricultural and industrial use. • Number of water sources protected and rehabilitated (e.g., springs, boreholes, rivers. • Reduction in drought-related water shortages.	**1. Conduct a Comprehensive Assessment of the Catchment's Natural Resources, Ecosystem Services, and Livelihoods**	• Completion of the comprehensive assessment report within the defined timeframe. • Number of natural resources, ecosystem services, and livelihood indicators assessed. • Percentage of stakeholders consulted	Improved Water quality and quantity

balance water demand across domestic, agricultural, industrial, and environmental needs. o Enhance the protection and conservation of surface and groundwater resources to prevent depletion and degradation.	• Percentage of water users adopting efficient water use practices (e.g rainwater harvesting, drip irrigation).		during the assessment process. • Number of maps and datasets produced. • Identification of key challenges and opportunities documented in the assessment report.	
2. **Promote Sustainable Land**	• Improvement in biodiversity indicators (e.g., number of species observed)	**2. Establish a Multi-Stakeholder Platform for Coordinated Management of the Catchment**	• Increase in number of stakeholders represented in the	Increase in forest cover and biodiversity

Use and Ecosystem Protection: ○ Implement land-use planning strategies that prevent environmental degradation and promote watershed conservation. ○ Encourage reforestation and afforestation initiatives to enhance ecosystem stability and	• Area of critical ecosystems (forests, wetlands, wildlife habitats) protected and restored. • Increase in eco-system services (e.g., water regulation, soil fertility, carbon sequestration). • Reduction in deforestation and land degradation rates • Number of community-led conservation initiatives		multi-stakeholder platform. • Frequency of platform meetings (e.g., quarterly or biannually). • Increase in the percentage of platform members actively participating in meetings and activities. • Development of a terms of reference (TOR) or governance framework for the platform.	

water retention.				
3. **Promote Sustainable Agriculture and Livestock Practices**: Promote sustainable agriculture and livestock practices, including conservation agriculture, agroforestry, and integrated water management, to reduce environmental degradation and improve livelihoods.	• Percentage increase in farmers adopting sustainable agricultural practices. • Reduction in soil erosion and land degradation rates • Increase in agricultural productivity • Number of integrated water management systems implemented • Percentage reduction in the use of harmful agrochemicals	**3. Develop and Implement a Water Resources Management Plan**	• Completion and approval of the water resources management plan within the defined timeframe • Number of water resource management interventions implemented • Increase in the percentage of water users adopting efficient water use practices. • Reduction in water-related conflicts • Improvement in water quality indicators	
4. **Enhance Climate Resilience**: Implement climate-resilient practices, including climate-smart agriculture, disaster risk reduction, and ecosystem-based adaptation, to enhance	• Percentage of households and farms adopting climate-smart agricultural practices.	**4. Launch a Sustainable Agriculture and Livestock Program**	• Increase in number of farmers trained in sustainable agriculture and livestock practices • Area of land (in hectares) under	Reduced greenhouse gas emissions

the catchment's resilience to climate change.	• Reduction in crop failure rates due to climate variability. • Number of disaster risk reduction measures implemented (e.g., early warning systems, flood barriers) • Increase in the use of ecosystem-based adaptation practices (e.g., reforestation, wetland restoration). • Percentage of communities with access to climate-resilient infrastructure (e.g., flood-resistant housing, drought-resistant water systems).		sustainable agricultural practices. • Increase in crop yield pr livestock productivity. • Reduction in soil erosion and land degradation rates	
5. **Improved Livelihoods and Well-Being of the various stakeholders in the catchment**: Enhance the livelihoods of local communities, including women and youth, through	• Percentage increase in household income among local communities. • Improvement in access to education	**5. Establish a Climate Change Mitigation and Adaptation Program**	• Number of climate change mitigation and adaptation measures implemented • Increase in percentage of households	Enhanced livelihoods and human well-being

improved access to education, healthcare, and economic opportunities.	and healthcare services. • Percentage increase in women and youth engaged in income-generating activities. • Reduction in poverty rates within the catchment		adopting climate-resilient practices • Reduction in vulnerability to climate-related disasters • Number of community awareness campaigns conducted on climate change mitigation and adaption • Improvement in climate resilience indicators (e.g., reduced crop failure rates, increased water availability during droughts)	
6. **Strengthen inclusive governance / Institutional capacity and Stakeholder Partnerships**: Strengthen governance and stakeholder engagement, including the involvement of local communities, civil society organizations, and private sector entities, to ensure inclusive decision-making	• Increase in number of stakeholder engagement platforms established and functional • Increase in local communities actively participating in decision-making processes. • Percentage increase in environmental	• **Infrastructure Development and Management:** a. Upgrade and expand water supply infrastructure to meet the		Improved governance and stakeholder engagement

and coordinated management of the catchment.	regulations and policies enforced effectively. • Reduction in land-use conflicts	growing needs of urban and rural populations. b. Improve irrigation efficiency through modern techniques such as drip and sprinkler irrigation systems. c. Enhance stormwater management infrastructure to prevent urban flooding and erosion.		

		• **Disaster Preparedness and Climate Adaptation:** a. Strengthen early warning systems for floods and droughts through enhanced meteorological data collection. b. Implement community-based adaptation programs to enhance resilience to climate-		

		induced water stress.		
3. **Enhance Water Supply and Sanitation Services:** o Expand access to clean and reliable water for domestic, agricultural, and industrial use. o Improve wastewater management and sanitation infrastructure to prevent	• **Water Resource Sustainability:** a. Establish mechanisms for monitoring and regulating water abstraction to prevent over-extraction of groundwater. b. Develop policies to ensure equitable distribution of water resources across different sectors. •			

contamination of water bodies.				
4. **Support Socio-Economic Development through Water Security:** o Promote efficient and sustainable agricultural practices to enhance food security and livelihoods. o Encourage industrial and economic	6. **Community Engagement and Awareness:** o Increase public awareness campaigns on sustainable water management practices. o Encourage community-led water conservation initiatives	o Encourage sustainable agricultural expansion through the provision of water-efficient technologies and training programs. o Foster industrial compliance with water efficiency and pollution		

activities that comply with sustainable water usage standards. **5.**	and participation in decision-making processes. ○ Support gender-inclusive and youth-focused programs that promote equitable access to water resources. 7.	control standards. ○ Promote ecotourism and conservation-based enterprises that contribute to local economies while preserving water resources.		

CHAPTER 5 : STRATEGIC CHALLENGES AND PRIORITY INTERVENTIONS

5.1 Key Issues

1. Climate Change

Climate change is likely to impact stream flow and discharge patterns in the catchment, leading to increased variability and potential reductions in water availability. Changes in rainfall patterns and temperature can affect both the quantity and timing of stream flow.

2. Human Activities

- **Agricultural Practices:** Irrigation and land use changes can alter natural flow regimes and affect discharge rates.
- **Water Withdrawal:** Increased demand for water for agriculture, industry, and domestic use can reduce stream flow and discharge.

3. Data Gaps

Limited monitoring infrastructure and insufficient data collection can hinder effective water resource management. Expanding and maintaining hydrological monitoring networks are essential for accurate assessments.

4. Water levels and storage

- The catchment faces unique challenges concerning water levels and storage due to its semi-arid climate, variable rainfall patterns, and ongoing environmental changes.
- The catchment's water resources are crucial for domestic use, agriculture, and livestock, making the understanding of water levels and storage capacity essential for sustainable development and management.

5. Seasonal Variability:

- The water levels in the catchment are highly seasonal, with significant fluctuations between the rainy and dry seasons.
- During the rainy season (typically from June to September), surface water bodies such as rivers, lakes, and reservoirs experience a rise in water levels due to increased rainfall and runoff. Conversely, in the dry season (October to May), water levels drop significantly, leading to a scarcity of surface water resources (Aliyu et al., 2019).

6. **Groundwater Levels:**
   - Groundwater is a critical source of water in the catchment, particularly in rural areas where surface water may be scarce.
   - Studies indicate that groundwater levels vary across the state, with some areas experiencing a decline due to over-extraction and reduced recharge rates.
   - In the Lake Chad Basin, for instance, groundwater levels have been reported to decrease due to excessive withdrawal for agricultural and domestic purposes (Musa et al., 2020).

7. **Flood and Drought Patterns**
   - The catchment experiences significant environmental challenges, notably floods and droughts.
   - These extreme weather events have profound impacts on the state's socio-economic development, agriculture, water resources and overall livelihoods of the inhabitants.
   - Understanding the patterns, causes, and effects of floods and droughts in the catchment is crucial for developing effective mitigation and adapt.

8. **Climate Variability and Extreme Weather Events**
   - **Threats:** The Yedseram catchment is subject to erratic rainfall patterns, extended dry seasons, and increasingly frequent extreme weather events, such as droughts and floods. These climate variations impact crop cycles, soil health, and water availability, making it challenging for farmers to maintain consistent yields.
   - **Challenges:** Farmers face difficulty in planning and adapting to unpredictable weather patterns, leading to crop losses and income instability. Additionally, extended droughts reduce groundwater recharge and soil moisture, further straining agricultural productivity.

9. **Water Scarcity and Competing Demands**
   - The availability of water resources is limited, especially during dry seasons, when agricultural demand is highest. The Yedseram River and other seasonal streams in the region often experience reduced flow, impacting both crop irrigation and livestock needs.
   - Competition for water between agriculture, livestock, and household use creates strain on available resources. Farmers often face difficulties in accessing sufficient water for irrigation, especially in regions where boreholes yield low quantities. This results in

reduced crop yields and increased reliance on rain-fed agriculture, which is less reliable.

10. Soil Degradation and Nutrient Depletion

- **Threats:** Soil health in the catchment is compromised due to continuous cultivation, limited fallow periods, and minimal soil management practices. This leads to soil erosion, compaction, and nutrient depletion, particularly in areas prone to wind and water erosion.
- **Challenges:** Degraded soils are less productive, requiring increased input costs for fertilizers, which are often unaffordable for smallholder farmers. Furthermore, traditional farming practices are less suited to mitigate soil erosion, leading to a long-term decline in agricultural productivity.

11. **Inadequate Infrastructure and Access to Markets**

- **Threats:** Farmers in the catchment area face limited access to storage, transportation, and market infrastructure. Poor road networks make it difficult to transport produce to market centers, especially during the rainy season, when roads can become impassable.
- **Challenges:** Limited infrastructure leads to post-harvest losses due to spoilage and reduces market access for farmers, limiting their income potential. The lack of affordable, efficient storage facilities also forces farmers to sell their produce immediately after harvest when prices are low, impacting their profitability.

12. Pests and Crop Diseases

- **Threats:** Pests and diseases present a persistent threat to crop production in the Yedseram catchment, especially with increasing temperatures and changing rainfall patterns that create favorable conditions for pest outbreaks.
- **Challenges:** Farmers often lack access to effective pest management resources and practices, which results in substantial crop losses. The reliance on traditional pest control methods limits productivity, while inadequate extension services prevent farmers from adopting modern, resilient agricultural practices.

13. Conflict and Insecurity

- **Threats:** Conflict and insecurity, particularly in Borno State, have disrupted agricultural activities and led to displacement of farmers and rural communities. The presence of insecurity limits access to farmland and restricts the movement of agricultural goods.
- **Challenges:** Insecure conditions have led to decreased agricultural productivity and have created challenges in resource allocation, as farmers are often unable to tend to or harvest their crops. Additionally, the threat of conflict discourages investments in agriculture and restricts access to agricultural inputs.

14. Limited Access to Agricultural Inputs and Extension Services

- **Threats:** Access to quality seeds, fertilizers, and agricultural tools is limited due to high costs and distribution challenges. This reduces farmers' ability to improve productivity and adopt new technologies.
- **Challenges:** The limited availability of extension services in the catchment reduces farmers' exposure to best practices and modern farming techniques. As a result, agricultural practices remain low-yield, with minimal adoption of innovations that could enhance resilience to changing conditions.

15. Environmental Degradation and Land Use Pressure

- **Threats:** Agricultural expansion and overgrazing by livestock have led to deforestation, land degradation, and habitat loss, which negatively impact soil fertility and water quality. Encroachment into forested and marginal lands reduces ecosystem services essential for sustainable agriculture.
- **Challenges:** Balancing agricultural land use with conservation is difficult, especially in areas where land is under pressure from competing uses. The degradation of surrounding ecosystems also exacerbates soil erosion, reduces pollination services, and threatens water sources critical for irrigation.

5.2 Strategic Interventions

To achieve the outlined goals, the Yedseram Catchment Management Plan recommends the following strategic interventions:

1. **Climate resilience and water resource management**

- **Promoting Climate-Resilient Agriculture:** Encourage the adoption of drought-tolerant crop varieties, rainwater harvesting, and efficient irrigation systems to reduce dependence on variable rainfall.
- **Improving Infrastructure:** Investment in rural infrastructure, particularly roads, storage facilities, and market access points, is vital to reduce post-harvest losses and enhance market opportunities for farmers.
- **Enhancing Soil and Water Management:** Introducing sustainable land management practices, such as conservation agriculture, agroforestry, and erosion control measures, can improve soil health and water retention.
- **Strengthening Extension Services and Input Supply:** Expansion of agricultural extension services to provide farmers with access to information on modern practices and affordable inputs can enhance productivity and resilience.
- **Conflict Mitigation and Support for Displaced Farmers:** Establishing security measures and support systems for displaced farmers can help stabilize agricultural activities and encourage return to farming in safe zones.

- **Implement Drought-Resilient Farming Practices:** Introduce climate-resilient crop varieties that are drought-tolerant and can withstand erratic weather patterns. Crops such as millet, sorghum, and drought-resistant legumes are well-suited for the semi-arid conditions of the Yedseram catchment.
- **Adopt Water-Efficient Irrigation Systems:** Promote the use of drip and sprinkler irrigation systems that can optimize water use and reduce dependence on seasonal rainfall. These systems are more efficient than traditional flood irrigation and help to conserve water in areas where it is scarce.
- **Establish Rainwater Harvesting Infrastructure:** Install rainwater harvesting systems at community and farm levels to capture and store rainfall during the wet season. This stored water can be used for irrigation during dry periods, improving water availability year-round.

2. Soil Health Improvement and Sustainable Land Management

- **Encourage Conservation Agriculture:** Practices such as minimum tillage, crop rotation, and cover cropping can reduce soil erosion, increase organic matter, and improve soil fertility. These practices also contribute to water retention and help combat soil degradation.
- **Promote Agroforestry:** Integrating trees and shrubs into farmlands can reduce soil erosion, enhance soil fertility through nitrogen fixation, and provide shade, which is beneficial for crops and livestock. Agroforestry also contributes to biodiversity conservation and can improve local microclimates.
- **Implement Soil Replenishment Programs:** Provide subsidies or support for organic and inorganic fertilizers to restore soil nutrients. The introduction of soil testing services will allow farmers to identify specific nutrient needs and apply fertilizers more effectively.

3. Improved Infrastructure and Market Access

- **Upgrade Rural Road Networks:** Improving transportation infrastructure, particularly rural roads, will enhance farmers' access to markets and reduce post-harvest losses by facilitating quicker and more reliable transport of produce.
- **Develop Storage Facilities and Cold Chains:** Establish communal storage facilities, such as silos and cold storage units, in strategic locations to help farmers preserve produce and reduce post-harvest losses. These facilities should be equipped to handle perishable items, ensuring farmers can store goods until market prices are favorable.
- **Facilitate Market Linkages:** Create market linkages that connect farmers to local and regional buyers, such as cooperatives or agribusiness firms, to improve profitability. This can include establishing digital platforms that allow farmers to directly connect with buyers, reducing dependence on intermediaries.

- **Expand Access to Extension Services:** Increase the availability and reach of agricultural extension services to disseminate information on sustainable farming practices, pest control, and crop management. Extension agents should be trained to promote best practices and modern technologies suited for local conditions.

- **Conduct Farmer Training Programs:** Organize regular training programs to improve farmers' knowledge of new technologies, climate-smart agriculture, pest management, and soil conservation techniques. These programs can be delivered through workshops, demonstration plots, and mobile extension services.
- **Introduce Mobile-Based Advisory Services:** Leveraging mobile technology, SMS, and online platforms can provide farmers with timely information on weather forecasts, pest alerts, and market prices. This approach can also help extension services reach remote and underserved areas.

4. Enhanced Water and Conflict Management

- **Establish Community Water-User Associations (WUAs):** Forming WUAs can help farmers equitably manage and allocate water resources, reducing competition and conflicts. These associations can develop rules for water use, address disputes, and facilitate cooperation in times of water scarcity.
- **Develop Water Conservation Policies:** Implement water conservation policies at the regional level to regulate groundwater extraction and promote sustainable usage. This may include setting up regulations for borehole drilling, establishing groundwater recharge zones, and enforcing penalties for over-extraction.
- **Encourage Conflict Resolution Mechanisms:** Establish local conflict resolution bodies to address issues of land use and water allocation between farmers and pastoralists. This may involve community-led forums, dialogues, and agreements that set clear guidelines for resource-sharing and mitigate land use disputes.

5. Pest and Disease Control Measures

- **Provide Affordable Pest Control Solutions:** Facilitate access to low-cost and environmentally friendly pest control options, such as integrated pest management (IPM), which combines biological, cultural, and chemical control methods to reduce pest pressure on crops.
- **Promote Biological Pest Control:** Introduce natural pest control methods, such as the use of predatory insects, bio-pesticides, and crop diversity, which can reduce the need for chemical pesticides while maintaining a balanced ecosystem.

- **Establish Early Warning Systems:** Develop pest and disease early warning systems through the extension network, alerting farmers to potential outbreaks and advising them on preventive measures.

6. Policy and Institutional Support

- **Implement Supportive Agricultural Policies:** Formulate policies that provide incentives for sustainable farming practices, such as subsidies for drought-resistant seeds, low-interest loans for irrigation infrastructure, and tax breaks for agroforestry.
- **Strengthen Land Tenure Security:** Clear land tenure policies are necessary to prevent land-use conflicts and promote long-term investment in sustainable agriculture. Recognizing and securing land rights will encourage farmers to invest in soil and water conservation practices.
- **Create Agricultural Insurance Programs:** Establish crop insurance schemes to help farmers recover from losses due to climate shocks, pests, or diseases. This could be done in collaboration with private insurers, ensuring farmers are protected against unpredictable events.

7. Livelihood Diversification and Capacity Building

- **Encourage Alternative Income Sources:** Support income-generating activities that complement agriculture, such as beekeeping, handicrafts, or small-scale agro-processing, to reduce dependence on farming and increase resilience to crop failures.
- **Promote Skills Training Programs:** Introduce skills training for young people and women to diversify income streams, which could include training in agro-processing, animal husbandry, and agribusiness management.
- **Form Farmer Cooperatives and Groups:** Cooperatives can help farmers access inputs, share knowledge, and secure better prices for their produce. Cooperatives also provide a platform for collective bargaining, training, and knowledge-sharing on sustainable practices.

These strategic Interventions (In components) are as outlined in figure 5.1 to 5.8

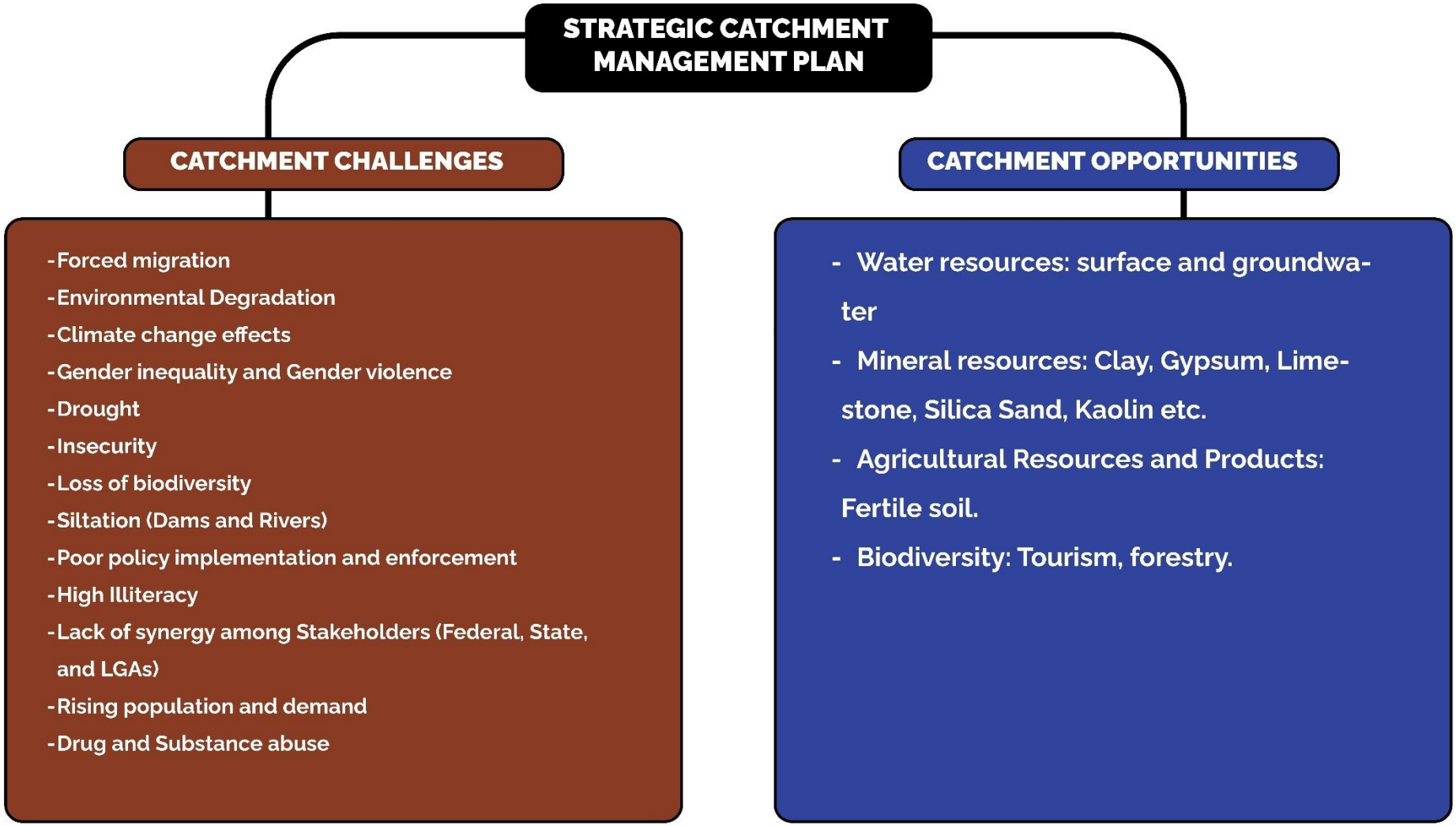


Figure 5.1: Strategic Catchment Management Plan

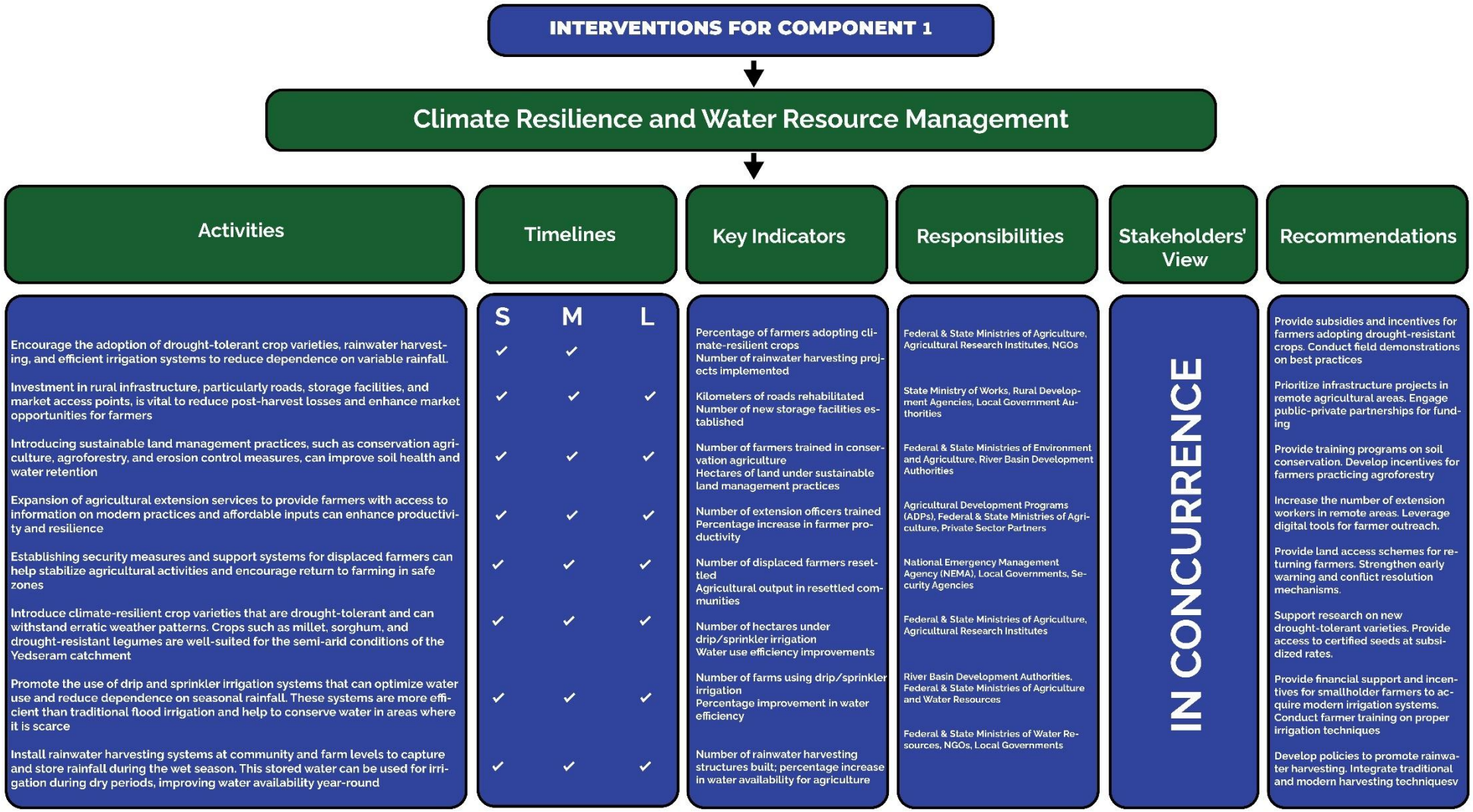


Figure 5.2: Component 1 (Climate Resilience and Water Resource Management)

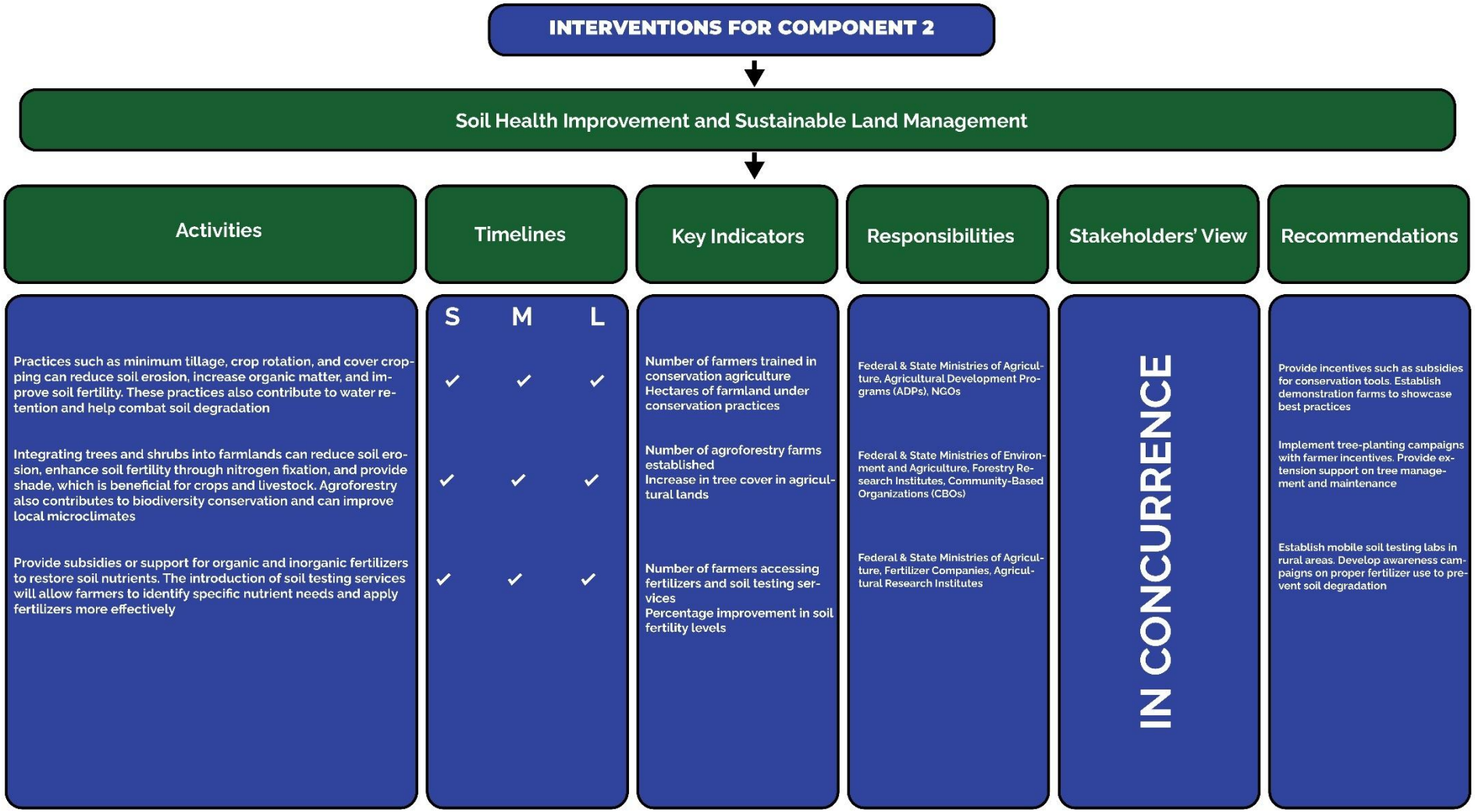


Figure 5.3: Component 2 (Soil Health Improvement and Sustainable Land Management)

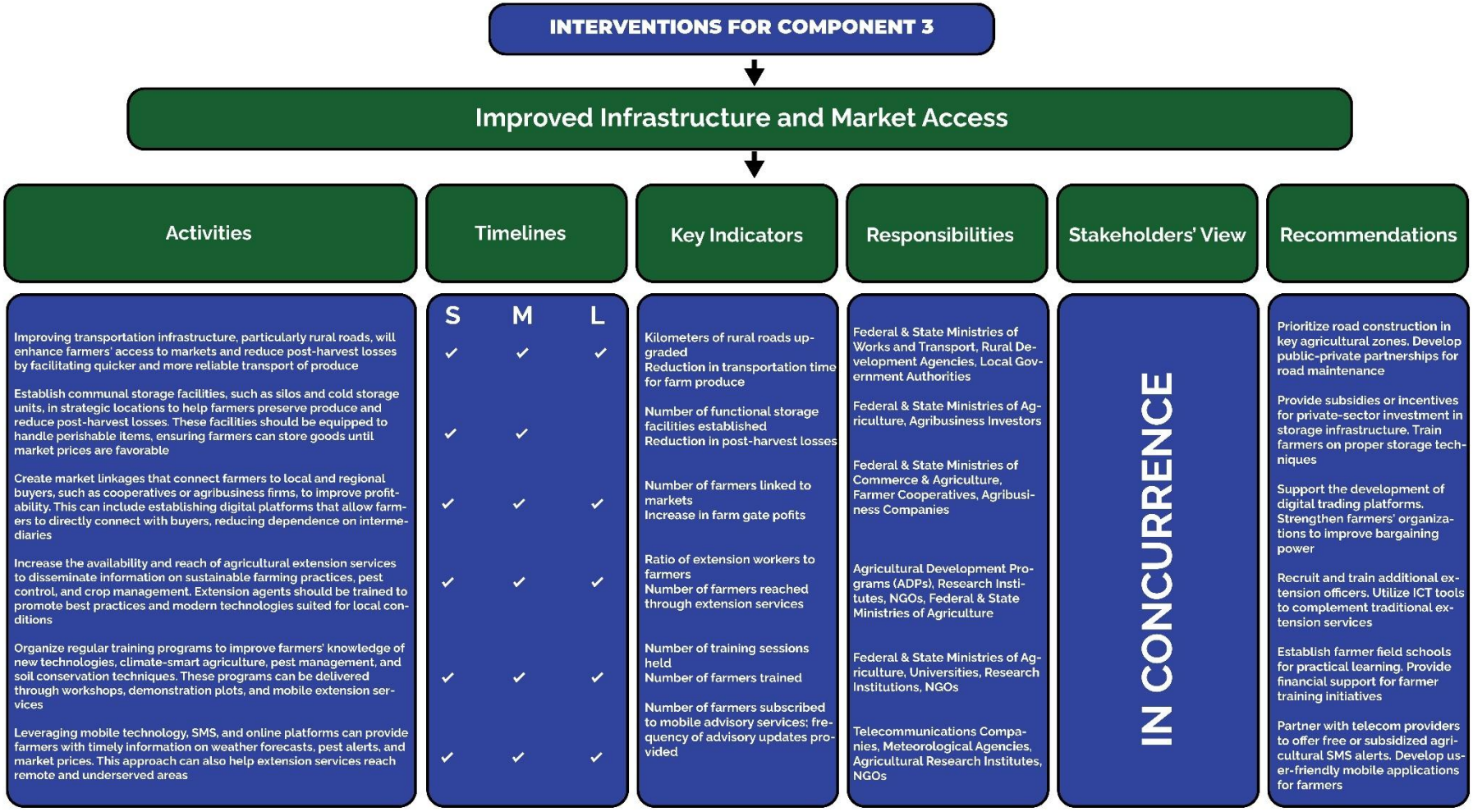


Figure 5.4: Component 3 (Improved Infrastructure and Market Access)

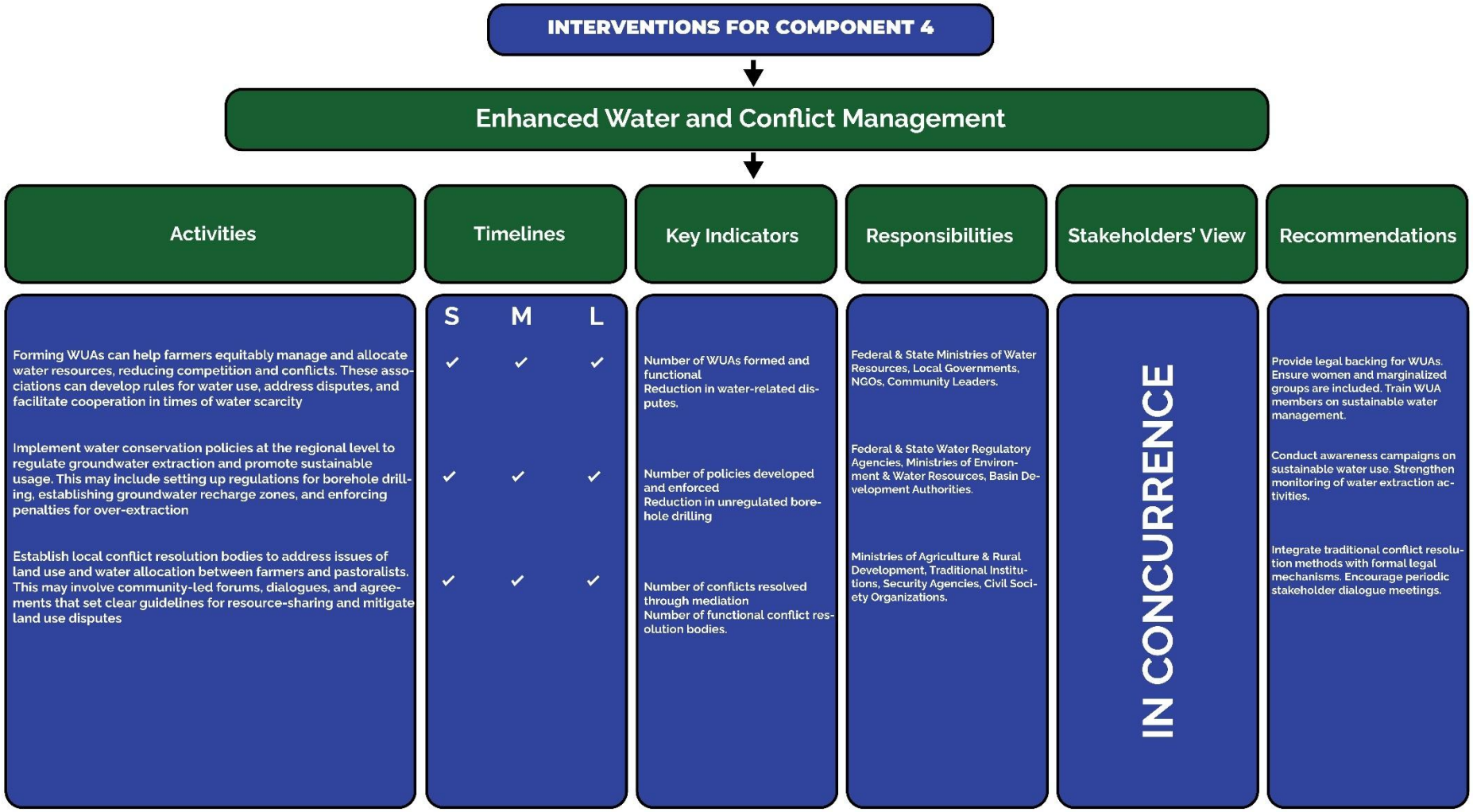


Figure 5.5: Component 4 (Enhanced Water and Conflict Management)

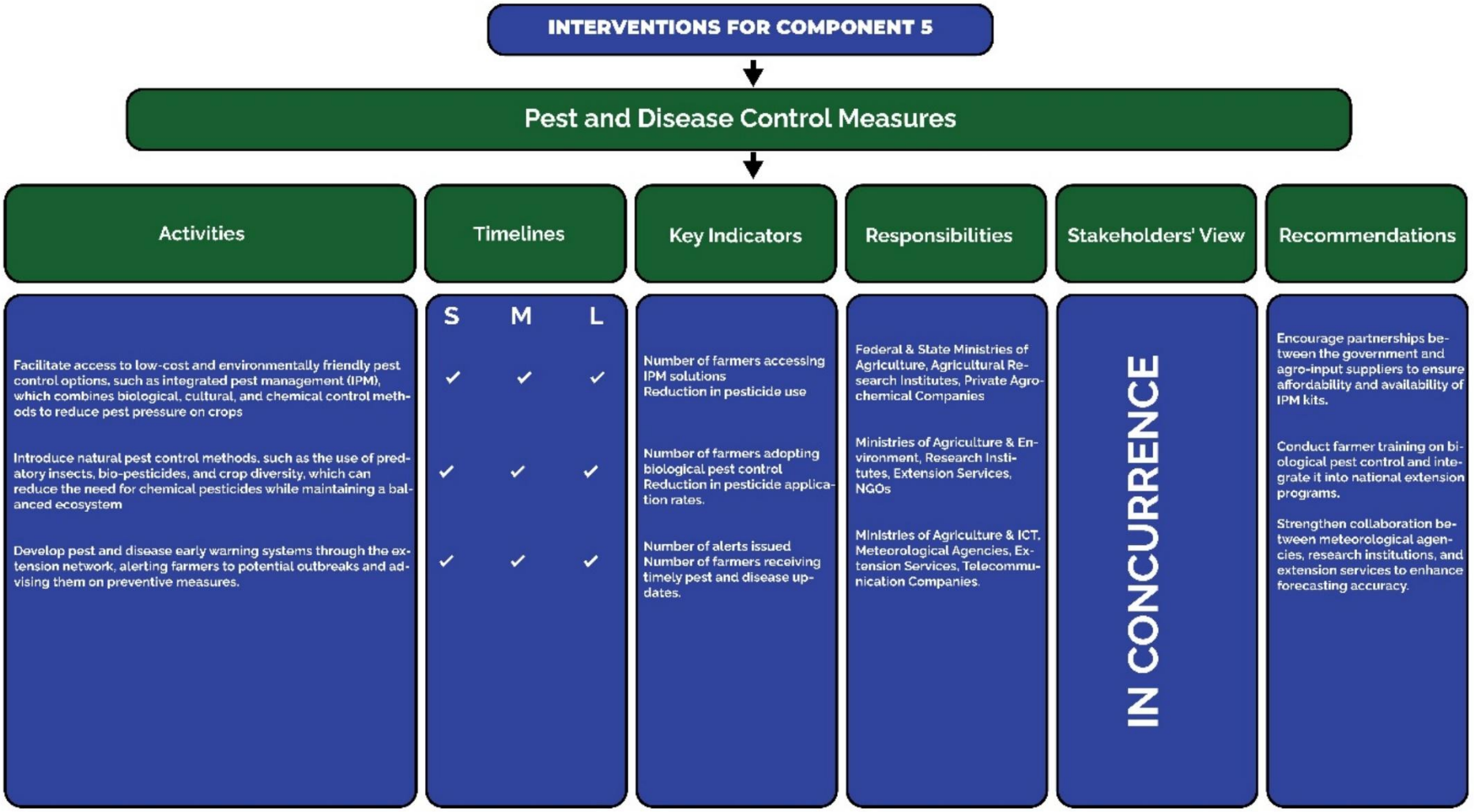


Figure 5.6: Component 5 (Pest and Disease Control Measures)

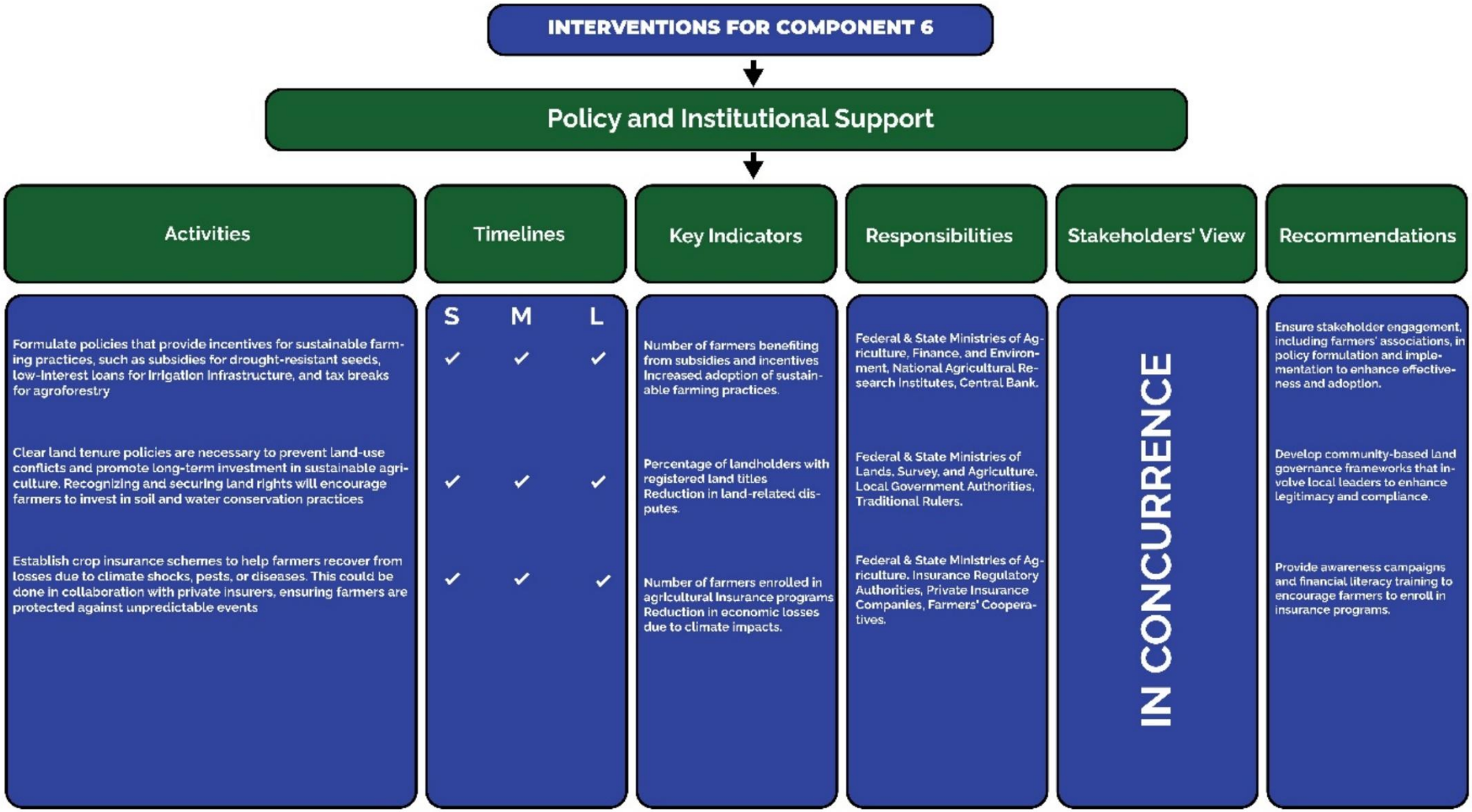


Figure 5.7: Component 6 (Policy and Institutional Support)

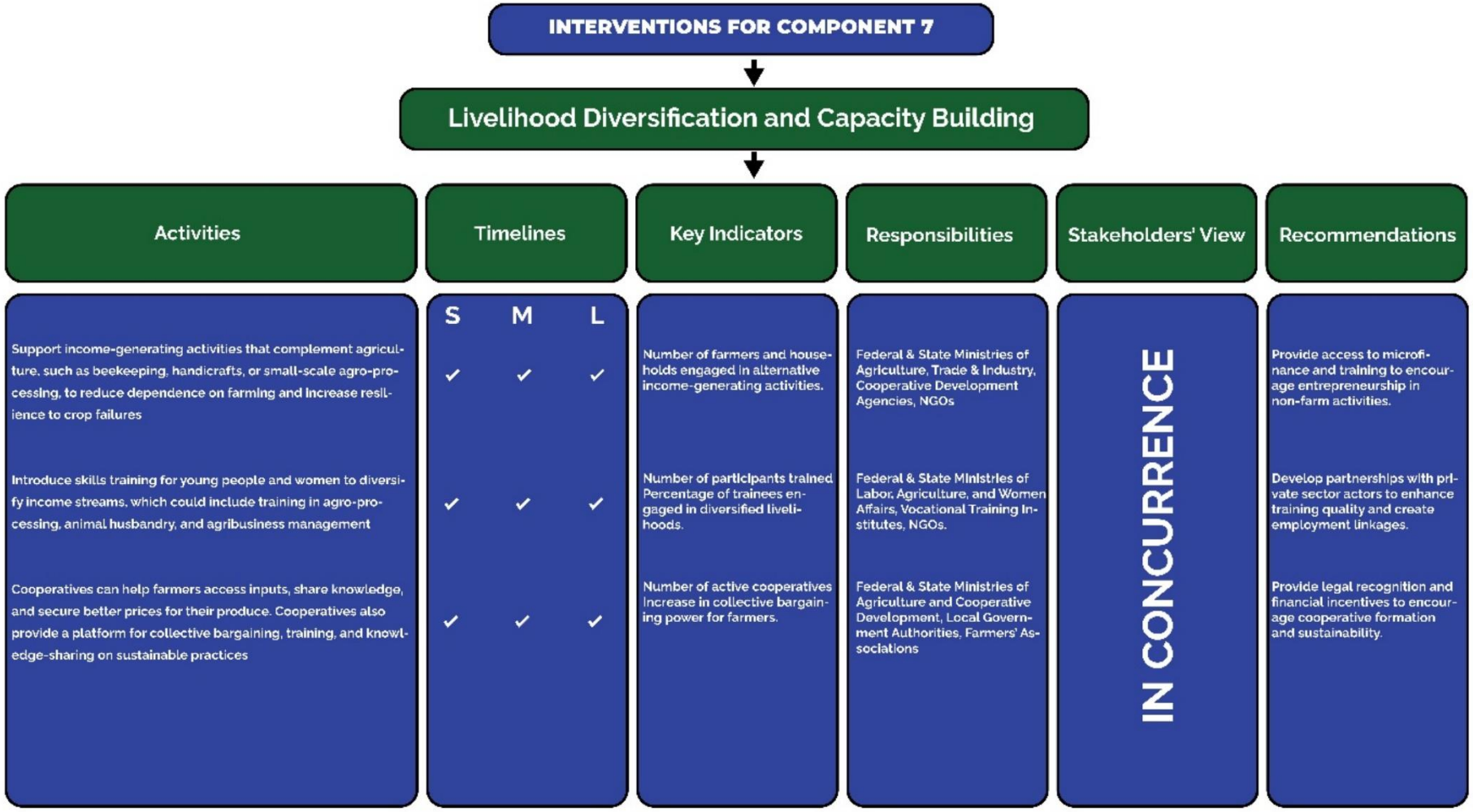


Figure 5.8: Component 7 (Livelihood Diversification and Capacity Building)

5.3 Expected Outcomes

The successful implementation of these interventions will result in:

- Improved water availability and reduced seasonal scarcity.
- Enhanced resilience of agricultural systems to climate variability.
- Enhanced resilience to climate change.
- Restoration of critical ecosystems and enhanced biodiversity.
- Strengthened governance and institutional structures and stakeholder engagement.
- Reduced flood vulnerability and minimized socio-economic disruptions from extreme weather events.
- Reduced conflicts in the region.
- Improved infrastructures and assets within the catchment.
- Improved socio-economic activity, livelihood, trade and commerce.

CHAPTER 6 : MONITORING, EVALUATION AND LEARNING

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 capture insights, challenges, and milestones, 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

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.

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.

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 Yedseram Catchment

S/NO	Monitoring Tools and Techniques	Target/Output	Monitoring	Evaluation	Responsibility
1	Geographical Information Systems Tools: software, ArcGIS, QGIS, Mapbox etc	Analyze and visualize spatial data use, water quality, and hydrological data.	Establish Key Performance Indicators to track progress. Analyse data and come out with outputs. Update visuals and maps on progress or otherwise.	Mid-Term and End Term: Conduct comprehensive evaluations at the midterm and end of implementations	WB/SPMU
2.	Remote Sensing/Drone technology. Tools: Multispectral and thermal imageries. Unmanned ariel vehicles and complimenting softwares.	Using remote sensing technology, such as satellite imagery to monitor land use and environmental changes	Water Quality Monitoring: Regularly collect and analyze water samples to assess changes. Analysis of past and present images, e.g., NDVI, the perimeter of water bodies, and degraded lands.	Stakeholder Feedback and Participation: Engaging Stakeholders within the local communities.	Consultant, NASRDA, NCRS SPMU, FoNGO, community.
3	Statistical Analysis	To analyze new data and monitor trends, patterns and correlations.	Hydrological Monitoring: monitor precipitation, stream flow and ground water levels to understand hydrological trends.	Cost -Benefit analysis: an assessment of the economic and social costs.	SPMU/Consultant
4	Participatory Rural Appraisal (PRA)	Engage local communities in the evaluation of the process, E.g., FGD, surveys and	Land use and land cover monitoring are used to track changes.	Environmental impact assessment.	Consultant, NASRDA, NCRS

		stakeholder workshops			
5	Ground truthing of intervention sites periodically	Entire catchment	Socio-Economic Monitoring through data collection to assess the impact of the plan on local communities	Institutional and governance assessment.	Consultant, SPMU, Ministry of Environment, FoNGO, community.
6	Video Documentary	Entire catchment		A movie documentary on the socio-economic and biophysical impact of environmental issues. It will also capture the progress of the implementation of BMPs	Consultant, SPMU, Ministry of Environment, FoNGO, community.

6.1 Specific Indicators for Success and Potential Reporting Framework

A typical measurable success story that can be used to monitor and evaluate a strategic catchment management plan will be indicated in the following:

Environmental Indicators

i. Water Quality Index: Measures the overall health of the waterway based on parameters such as pH, turbidity, and nutrient levels.
ii. Sediment Load Reduction: Tracks the reduction in sediment loads entering the waterway.
iii. Vegetation Cover: Monitors the increase in vegetation cover along the waterway and its tributaries.
iv. Biodiversity Index: Measures the health and diversity of aquatic and terrestrial ecosystems.

Social Indicators

i. Community Engagement: Tracks the number of community events, meetings, and activities related to catchment management.
ii. Stakeholder Satisfaction: Measures the satisfaction of stakeholders, including landholders, community groups, and government agencies, with the catchment management plan.
iii. Education and Awareness: Monitors the increase in knowledge and awareness of catchment management issues among the community.

Economic Indicators

i. Cost-Benefit Analysis: Evaluates the economic benefits of catchment management activities, such as reduced sedimentation and improved water quality.
ii. Job Creation: Tracks the number of jobs created in industries related to catchment management, such as conservation and restoration.
iii. Agricultural Productivity: Monitors the impact of catchment management activities on agricultural productivity and profitability.

6.2 Annual Report Template

It is important that monitoring and evaluation is reported either quarterly or annually based on a framework. The reporting framework provides a structure for presenting progress against objectives, highlighting key achievements and challenges, and identifying areas for future improvement. This plan will report monitoring and evaluation in the following manner:

1 Executive Summary

- Brief overview of progress against objectives
- Key achievements and challenges

2 Environmental Performance

- Water Quality Index
- Sediment Load Reduction
- Vegetation Cover
- Biodiversity Index

3 Social Performance

- Community Engagement
- Stakeholder Satisfaction
- Education and Awareness

4 Economic Performance

- Cost-Benefit Analysis
- Job Creation
- Agricultural Productivity

5 Case Studies and Success Stories

- Examples of successful catchment management projects
- Lessons learned and best practices

6 Challenges and Future Directions

- Identification of challenges and areas for improvement
- Outline of future directions and strategies for addressing challenges

7 Conclusion

- Recap of progress and achievements
- Commitment to ongoing improvement and accountability.

CHAPTER 7 : CONCLUSION AND MOVING FORWARD

7.1 Summary of Strategic Issues and Priorities

The Yedseram catchment encompassing mostly Borno State and a part of Adamawa State, is replete with diverse ecosystems and significant socio-economic potential.

The Yedseram Catchment Management Plan presents a thorough strategy for tackling the diverse issues confronting the region. It emphasizes sustainable resource management, improving livelihoods, and bolstering resilience to climate change, thereby promoting a balanced framework for socio-economic development alongside ecological conservation.

To enhance water resource management and reduce flood risks, the plan focuses on rehabilitating and desilting river systems, along with the construction of small water conservatories. These initiatives, combined with improved drainage systems, thorough flood risk assessments, and public awareness campaigns, seek to protect communities from water-related dangers while ensuring fair water distribution throughout the catchment area. Additionally, bolstering groundwater monitoring networks and promoting rainwater harvesting will further strengthen the region's ability to manage its water resources sustainably.

Restoring vital ecosystems is another key aspect of the plan, aiming to afforest up to 40% of degraded areas and revive wetlands. These initiatives will stabilize water cycles, enhance biodiversity, and strengthen the ecological health of the catchment. Safeguarding national parks and reserves helps maintain crucial habitats and natural resources for future generations.

Sustainable agricultural and livestock practices form the core of the strategy to boost food security and economic resilience. The plan seeks to transform the agricultural landscape by enhancing productivity using climate-smart methods, improving soil fertility, and providing training and technology to smallholder farmers. Additionally, initiatives like adopting micro-irrigation and implementing erosion control emphasize the dedication to sustainability.

Strengthening climate resilience is a crucial goal. Initiatives rooted in the community, afforestation efforts, and advocating for drought-resistant crops are essential in combating desertification and vulnerability from climate change. At the same time, improving livelihoods through sustainable methods, availability of credit, and environmentally friendly economic practices will empower local communities, especially smallholder farmers and fishers.

To meet these ambitious goals, strong financial and institutional frameworks are essential. The plan emphasizes the need for increased public sector funding, urging state and federal governments to set aside specific budgets for water, agriculture, and environmental initiatives. Establishing catchment development funds will consolidate resources among agencies and stakeholders. Support from international donors, including development partners like the World Bank and the African Development Bank, is crucial, with efforts focused on aligning projects with global funding sources like the Green Climate Fund. The private sector is also vital to developing essential infrastructure and renewable energy projects through public-private partnerships. At the same time, community involvement through cooperatives, savings initiatives, and microfinance opportunities can enhance local interventions.

Ultimately, effective governance and collaboration among stakeholders are crucial for the success of these initiatives

. By developing integrated water resource management frameworks, enhancing coordination between agencies, and guaranteeing community representation in decision-making, we can fortify the institutional groundwork necessary for long-term success.

In conclusion, the strategic initiatives and funding approaches offer a clear path for promoting resilience, sustainability, and prosperity in the Yedseram catchment, allowing its natural and human systems to flourish amidst future challenges.

7.2 Recommendations for Aligning with Broader National and Regional Programs

The catchment management plan should integrate with national and regional frameworks to maximize impact and ensure sustainability. Key recommendations include:

1. **Alignment with National Policies**:
    - Incorporate strategies into Nigeria's National Water Resources Policy and Agricultural Transformation Agenda.
    - Coordinate with the Great Green Wall Initiative to address desertification and land degradation.
2. **Regional Collaboration**:
    - Leverage partnerships with neighboring states to manage shared resources, such as water systems and wetlands, more effectively.
    - Align with regional development programs, such as ECOWAS agricultural and environmental initiatives, to foster cross-border cooperation.
3. **Community-Driven Development**:
    - Strengthen partnerships with local governments, traditional institutions, and civil society organizations to enhance grassroots participation.
    - Integrate gender-responsive approaches to empower women and youth in natural resource management.

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:
    a. Principle of equitable and reasonable utilization
    b. Obligation not to cause significant harm (no harm rule)
    c. Protection of the Ecosystems
iii. Procedural Principles
    a. Principle of cooperation
    b. Notification of any planned project
    c. Exchange of data and information
iv. Institutional Framework (river basin organization)
v. 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 coordinating 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

Achieving the goals outlined in this plan requires sustainable financing and strategic partnerships. Key strategies include:

1. **Public Sector Funding**:
    - Advocate for increased budgetary allocation from state and federal governments for water, agriculture, and environmental projects.
    - Establish dedicated catchment development funds to pool resources from government agencies and stakeholders.
2. **International Donor Support**:
    - Engage development partners, such as the World Bank, African Development Bank, and UNDP, to secure grants and technical assistance.
    - Align projects with global funding mechanisms, such as the Green Climate Fund, for climate resilience initiatives.
3. **Private Sector Investment**:
    - Promote public-private partnerships (PPPs) to develop critical infrastructure, such as irrigation systems and agro-processing facilities.
    - Encourage investment in renewable energy projects, such as solar irrigation pumps and mini-hydropower plants.
4. **Community Contributions**:
    - Mobilize community-based financing through cooperatives and savings schemes to fund localized interventions.
    - Explore microfinance opportunities to support smallholder farmers and rural entrepreneurs.

7.5 Moving Forward with the Catchment Plan

The CMP is a living document that needs to be reviewed and updated regularly as part of an ongoing management process. It signifies the conclusion of the planning phase and the start of the actual catchment management implementation process. The FPMU and the national consultants should also have access to the plan and knowledge base so they can update it and turn it into an online ePlan.

The following tasks are necessary to maintain the catchment management plan as a living document: Table 7.1 indicates next steps and key actions points moving forward.

Table 7.1: Next steps and key actions points

Next Steps	**Key Action Points**	**Responsibilities**	**Timeline**
Review and Update Plan	Review progress against objectives	Catchment Management Committee	Quarterly
	Update plan to reflect changes in policy, legislation, or catchment condition	Catchment Management Committee	Annually
Monitor and Evaluate Progress	Establish monitoring and evaluation framework	Catchment Management Committee	Ongoing
	Collect and analyze data on key indicators	Catchment Management Committee	Quarterly
	Report on progress against objectives	Catchment Management Committee	Annually
Engage Stakeholders	Identify and engage key stakeholders	Stakeholder Engagement Team	Ongoing
	Develop stakeholder engagement strategy	Stakeholder Engagement Team	Quarterly
	Report on stakeholder engagement activities	Stakeholder Engagement Team	Annually
Build Capacity and Skills	Identify capacity and skills gaps	Capacity Building Team	Ongoing
	Develop capacity building plan	Capacity Building Team	Quarterly
	Report on capacity building activities	Capacity Building Team	Annually
Secure Funding and Resources	Identify funding and resource needs	Funding and Resources Team	Ongoing
	Develop funding and resource mobilization plan	Funding and Resources Team	Quarterly
	Report on funding and resource mobilization activities	Funding and Resources Team	Annually

A committee comprising representatives from key stakeholders, including government agencies, local communities, and NGOs.

Other actions could include

- Educating people on the importance of the natural environment and what we can all do to restore and protect it.
- Work closely with the government to continue to improve and where required strengthen the regulatory framework to achieve greater protection for the environment.
- More joined-up thinking and enforcement from the different government agencies. The agencies should be funded to undertake their enforcement roles when the natural environment is damaged. Those groups with the biggest impact on the water environment should be focused on to gain the greatest benefits.
- Monitoring and sharing data with others to improve this evidence and make it more widely available.
- Acknowledging that biodiversity, environmental health, and water and soil quality are all closely interrelated. Policies need to link up well and be catchment-wide and long-term.
- Working in partnership with a wide range of organizations set at the appropriate scale for example catchment or coastal scales.
- Committed to an integrated and partnership approach that will attract funding from a wider range of sources including private funding and ensure that the benefits can be spread more widely, across sectors and the landscape.
- Ensuring that resources and environmental legislation should be simpler and enabling.
- Working towards tighter regulation and increased punishments, supported with funding for the Environment Agency to deliver this.
- Moving away from or reducing the use of pesticides by adopting organic, an integrated pest management system, genetic crop manipulation, and the use of highly targeted application of agrochemicals.

- Greater efforts should be made to educate and raise awareness of the issues, to understand how physical modifications impact the environment, how they can be managed, and what benefits they offer society.
- Providing strong support for nature-based solutions and their role in flood risk and coastal erosion management.
- Acknowledging the importance of broader landscape management and the value of looking at catchments as an entire system – all elements working together.
- The overwhelming majority of respondents recognize that well-designed drainage and green infrastructure provide multiple benefits for people and the environment, including better integration and connections across towns and cities.
- Identify appropriate riparian corridors for designation to protect the primary drainage paths and provide for riparian cover.
- Identifying floodplain areas and putting in place rules to avoid inappropriate development in those floodplains
- provide as far as possible for enhancement of groundwater and interflow to assist in maintaining stream base flows
- Protecting the important habitat qualities of streams including provision for fish passage
- Planning for appropriate measures for both primary (on-site control) and secondary (off-site backup) management of erosion and sediment runoff during the development phases
- Providing for both targeted source control of contaminants and general catchment-wide removal of contaminants in stormwater.
- Sustaining public support and stakeholder engagement under the CMP through open and honest communication about progress.
- Being prepared to revise strategies in response to new scientific findings or changes in socio-economic conditions affecting the catchment area.

In order to guarantee that a catchment management plan not only addresses current issues but also fosters the long-term sustainability of natural resources within the catchment area, these steps should be followed methodically while maintaining the flexibility to adjust as necessary.

7.6 Conclusion

The Yedseram catchment is vital for the region's socio-economic and environmental health. The Strategic Catchment Management Plan, developed collaboratively with stakeholder input, offers a framework for sustainable management, balancing stakeholder needs and ensuring long-term resilience.

By strategically prioritizing, aligning with larger initiatives, and establishing strong funding mechanisms, the plan provides a definitive roadmap for sustainable development. Executing these recommendations will improve resource management, empower communities, and strengthen resilience against environmental and socio-economic challenges, guaranteeing the catchment's long-term vitality and prosperity.

Call to Action for Stakeholders

We call on all stakeholders to join us in implementing this plan and working towards a sustainable and prosperous future for our catchment. Specifically, we ask that:

Government agencies: Provide support and resources for the implementation of this plan, and work with us to develop and implement policies and regulations that support sustainable catchment management.

Local communities: Take an active role in implementing this plan, and work with us to develop and implement community-led initiatives that support sustainable catchment management.

Landholders and farmers: Adopt sustainable land management practices, and work with us to develop and implement initiatives that support sustainable agriculture and conservation.

NGOs and community groups: Provide support and resources for the implementation of this plan, and work with us to develop and implement initiatives that support sustainable catchment management.

Private sector: Invest in sustainable initiatives and practices that support the implementation of this plan, and work with us to develop and implement initiatives that support sustainable catchment management.

Together, we can achieve a sustainable and prosperous future for our catchment. Let us work together to implement this plan and make a positive impact on our environment, our communities, and our economy.

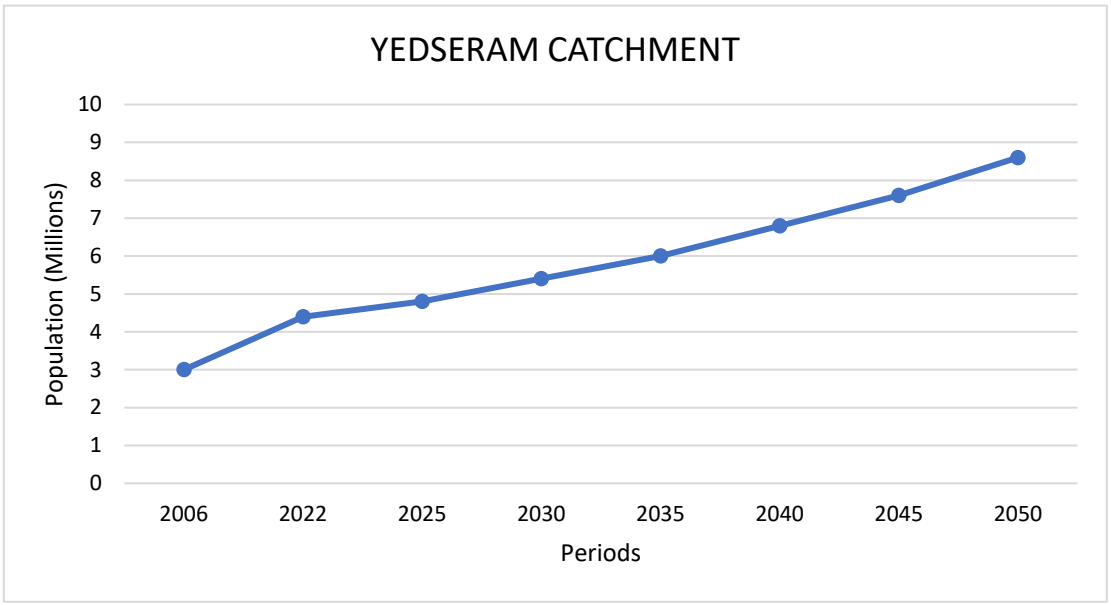
ANNEXES:

Annex 1: Population projection for Yedseram Catchment

State	LGA	2006	2022	2025	2030	2035	2040	2045	
Adamawa	Hong	169,183	260,900	280139	315409	355119	399828	450166	506842
Adamawa	Madagali	135,142	208,400	223768	251940	283659	319372	359581	404852
Adamawa	Maiha	110,175	169,900	182429	205396	231256	260371	293152	330059
Adamawa	Michika	155,238	239,400	257054	289417	325854	366879	413070	465075
Adamawa	Mubi North	151,515	233,600	250826	282405	317960	357991	403062	453807
Adamawa	Mubi South	129,956	200,400	215178	242269	272770	307112	345777	389311
Borno	Abadam	100,065	146,600	157411	177229	199542	224664	252949	284795
Borno	Askira/U	143,313	210,000	225486	253874	285837	321824	362342	407960
Borno	Bama	270,119	395,800	424987	478493	538735	606562	682928	768908
Borno	Damboa	233,200	341,700	366898	413090	465098	523654	589582	663810
Borno	Dikwa	105,042	153,900	165249	186054	209478	235851	265545	298977
Borno	Gwoza	276,568	405,200	435080	489857	551530	620967	699147	787169
Borno	Kala/Balge	60,834	89,100	95670	107715	121277	136545	153736	173092
Borno	Konduga	157,322	230,500	247497	278657	313740	353240	397713	447785
Borno	Kukawa	203,343	297,900	319868	360139	405480	456530	514008	578721
Borno	Mafa	103,600	151,800	162994	183515	206619	232633	261921	294897
Borno	Marte	129,409	189,600	203581	229212	258070	290561	327143	368330
Borno	Monguno	109,834	160,900	172765	194516	219006	246579	277623	312575
Borno	Ngala	236,498	346,500	372052	418893	471631	531010	597864	673135
TOTAL		**2,980,356**	**4,432,100**	**4,758,931**	**5,358,080**	**6,032,662**	**6,792,173**	**7,647,307**	**8,610,103**

2006	2022	2025	2030	2035	2040	2045	2050
3.0	4.4	4.8	5.4	6.0	6.8	7.6	8.6

Population projection Graph of the Catchment (Source:MSL, 2024)



Annex 2. Threats, Challenges, Socio-Economics and Policies Linked to Water Infrastructure in the Catchment as indicated by the stakeholders

Table A-2-3. Threats, Challenges, Socio-Economics and Policies Linked to Water Infrastructure in the Catchment from Stakeholders

Thematic Focal Points	Details
Natural Resources	Large sandstone and sand deposits in the entire catchment
	There are reports of oil and gas deposits in Jere LGA
	Common tree species include Acacia, Baobab, Doum palm, Shea Butter tree (Vitellaria paradoxa), and Neem (Azadirachta indica)
	Rich biodiversity (fishes, birds, amphibians, gazelles, primates, grazing fields like Gujba and Fune reserves).
	Cash crops: sesame, groundnut, cowpea, wheat, beniseed
	The wetlands and savannas of the catchment are important habitats for birdlife, including migratory species that travel from Europe and Asia to spend the winter. Key area for water birds, such as the African jacana, herons, storks, and various species of ducks.
	There are abundant groundwater resources across the catchment that occurs at 3 well known aquiferous zones. These groundwater resources are characterized by artesian, sub artesian, hydrothermal and mineral characteristics.
	Minerals: diatomite, silica sand, gypsum, limestone, kaolin, uranium, potash, iron ore, and chromium.
	Fish species such as tilapia, catfish, and Nile perch
	Presence of hydromorphic soils along the Yedseram river and its tributaries. Areas with this type of soil get flooded easily.
Threats and Challenges	Cattle rustling, amphibian species decline.
	Forced migration due to receding rivers and insecurity.
	Desertification, siltation, flooding, and droughts.
	Child labor, low sensitization on laws.
	Wrong fishing practices, poor storage for farmers, poor transportation, and loss of self-sufficiency in farming due to insecurity.
	Poor governance, lack of local infrastructure (dams, weather stations).
	Climate change effects: flooding, desert encroachment, ecosystem destruction.
	Cases of Cholera outbreaks and malnutrition are reported
	Due to very limited knowledge on the resources within the catchment, those resources are underutilized and mismanaged.
	There are very poor mining practices in the catchment.
	There are reports that some near surface aquifers have poor recharge capacities.
	There are reports of general decrease in the production of agricultural produce that has been attributed to the destruction of crops by migrant quelea birds and elephants.
	There is general insecurity in the catchment which are classified into four:

	• Insurgency • Farmer herder clashes • Communal clashes • Banditry
Socioeconomics	The prevalent livelihood activities in the community include Pottery, Animal husbandry, fishery, crop production etc. However, these have been negatively impacted by the insecurity in the catchment.
	Youth empowerment farming: seeds, fertilizers, support provided.
	Socioeconomic activities: soap making, tie and dye, poultry farming, tailoring, knitting, snack making, handicrafts, spaghetti making, and pottery.
	Large-scale trading of crops, livestock, and pottery.
	Locals in the catchment are being trained by UNDP and the Borno state government on alternative sources of fuel such as briquettes over charcoal so as to reduce deforestation.
	The Ministry of Agriculture acquired solar powered dryers which they plan to give out to farmers. They also have recruited people to go to various LGAs to distribute and train farmers on how to use them.
	Dry season farming (Firgi) is prominent in some areas where a lot of sorghum is planted.
Policies	Tree nurseries for afforestation, positive water and fishing laws, but poor enforcement.
	Policy to recruit more forest guards by the Borno State Government to protect reserves against indiscriminate felling of trees.
	The ministry of Agriculture has proposed policies to provide solar powered dryers, and improved extension contact for the farmers.
	Mineral Resources and Environmental Management Committee (MIREMCO) established.
	NESREA, an agency under the Federal Ministry of environment monitors activities regarding pollution and related phenomena.
	A challenge on mining policies is the way the federal laws are made. The extractive industry is in the exclusion list, hence states have very little to do in this regard.
	There's a policy on gender equality, and empowerment. • VAP – Violence Against Person's Law • Child Rights Act 2003
	Call for bottom-up policy formulation and frequent policy reviews every 3-5 years.
	Shared vision for sustainable resource use under the North East Development Commission.
	Formulation of Enhanced Food Security Policy.
	Climate Smart Agriculture is another scheme that trains and empowers farmers.
	The Lake Chad Basin commission has a policy that binds the four parties that share the Lake Chad (Nigeria, Niger, Chad, and Cameroon)

Annex 3: SHARED VISION

YEDSERAM CATCHMENT

Shared Vision

1) **Goal**: The main goal is to attain a comprehensive, sustainable, efficient and equitable use of all the resources within the catchment
2) **Objectives**: the specific objectives are to":
   a) Develop a sustainable livelihood within the catchment in the 5 years (2025-2030)
   b) Establishment of 3 Dams along River Yedseram in Bama, Mbulu River (Mainok & Ngamdu Axis) and Mega Dam in Alau (5years)
   c) Expansion/ Development of Arable lands for Agriculture, grazing & Agroforestry (in Jere bowl, Dusuman, Zabarmari, Bama- Dikwa, Ngala etc)
   d) Gender & Social Inclusion in all intervention
   e) Restoration of Forest Reserves/ Wildlife Parks (Chad Basin National Park & Chudgurumi)
   f) Establishment of Shelterbelts using drought resistance tree species & Economic Trees
   g) Development of water resources potential
   h) Ensure Community involvement (Participatory Approach) through Design, Planning & Implementation processes
   i) Develop a hydro- Meteorological database for monitoring Quantity & Quality of Water and early warning system and gauging Stations
   j) Ensure Sustainability & regulation of all resources
   k) Develop community infrastructure e.g electricity, roads, health centers, market, schools, solar powered boreholes etc.
   l) Development & implementation of guidelines regarding Dams
   m) Enforce Floodplain Management
3) **Stakeholder Engagement**: Cascading stakeholder engagement from bottom top Approach (Communities, L.G.A, State, Federal, CSO/NGO/CBO, Traditional/gatekeepers
4) **Water Management**: Effective Utilization of water resources
   a) Establishment of 3 Dams along River Yedseram in Bama, Mbulu River (Mainok & Ngamdu Axis) and Mega Dam in Alau (5years)
   b) Expansion/ Development of Arable lands for Agriculture, grazing & Agroforestry (in Jere Bowl, Dusuman, Zabarmari, Bama- Dikwa, Ngala etc)
   c) Development of water resources potential
   d) Develop a hydro- Meteorological database for monitoring Quantity & Quality of Water and early warning system and gauging Stations
5) **Land Use**: Sustainable Utilization of Land for farming, forest reserve, Urban development, Mining Activities within the scope of domesticated Land use act
6) **Environment Protection**
   a) Restoration of Forest Reserves/ Wildlife Parks (Chad Basin National Park & Chudgurumi)
   b) Establishment of Shelterbelts using drought resistance tree species & Economic Trees
   c) Development of water resources potential
   d) Development & implementation of guidelines regarding Dams

e) Enforce Floodplain Management

7) Economic Development:
   a) Develop a sustainable livelihood within the catchment in the 5 years (2025-2030)
   b) Establishment of 3 Dams along River Yedseram in Bama, Mbulu River (Mainok & Ngamdu Axis) and Mega Dam in Alau (5years)
8) Climate Change Resilience: to develop and implement an action plant for managing climate change impact

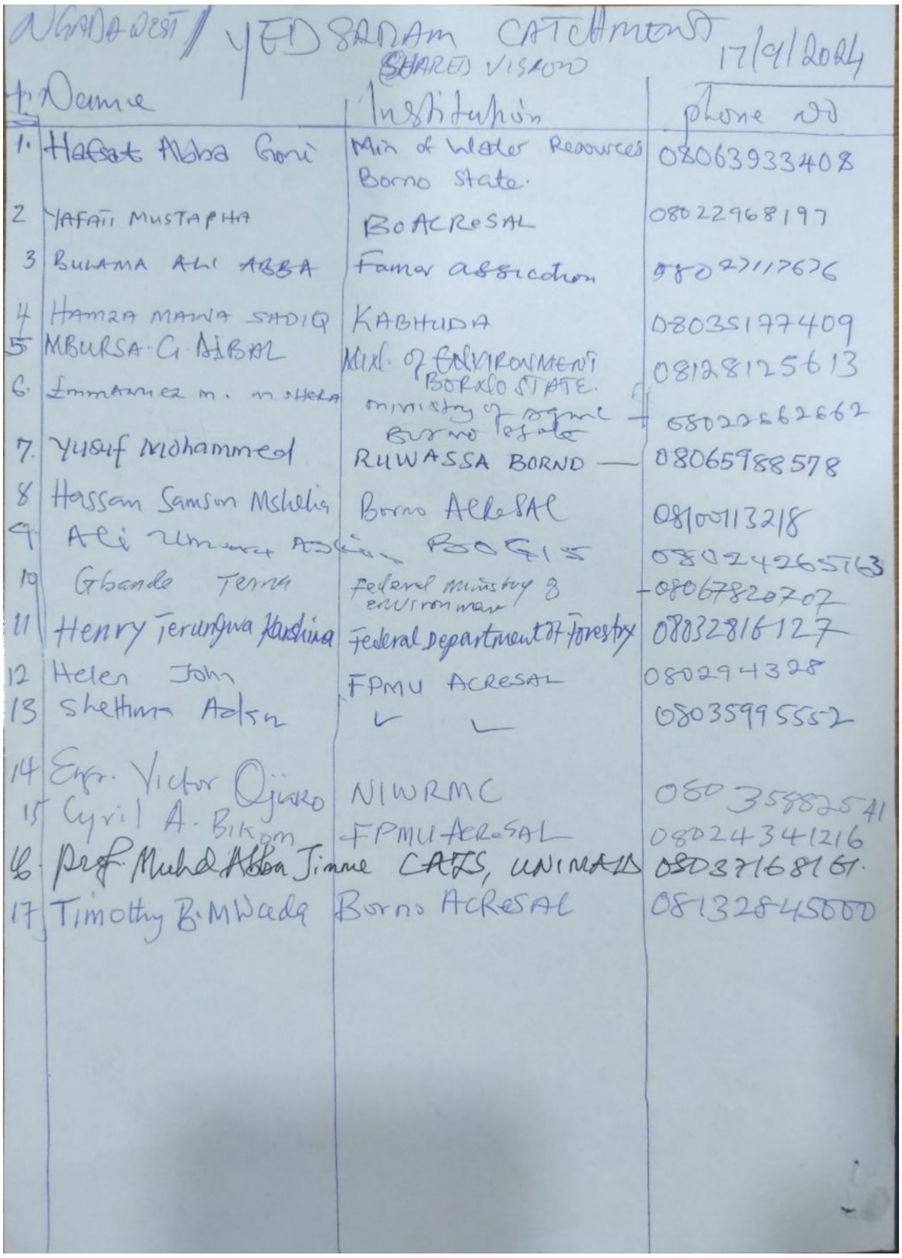
9) **M&E**: to develop M&E framework that involve all stakeholders (federal, state, local government, CSO/NGO/CBO, Communities/communities leaders

Chairman

Name: Prof. Mohd Kyari Jimme Signature/Date: 18/09/24

Secretary

Name: Samson Hassan Mshelia Signature/Date: 18/09/24



NGADA WEST / YED SARAM CATCHMENT 17/9/2024
SHARED VISION

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STAKEHOLDER ENGAGEMENT YEDSERAM CATCHMENT







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.

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