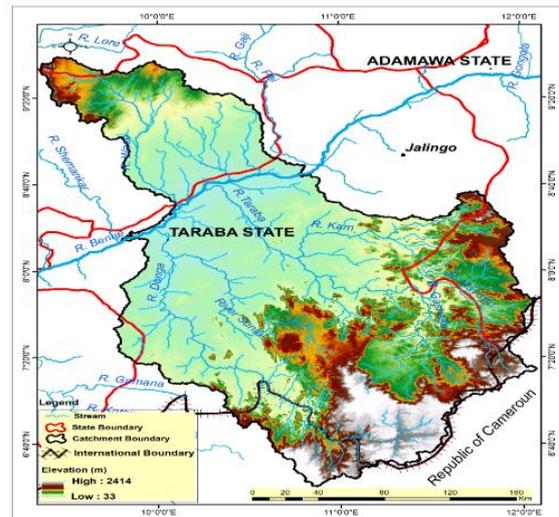
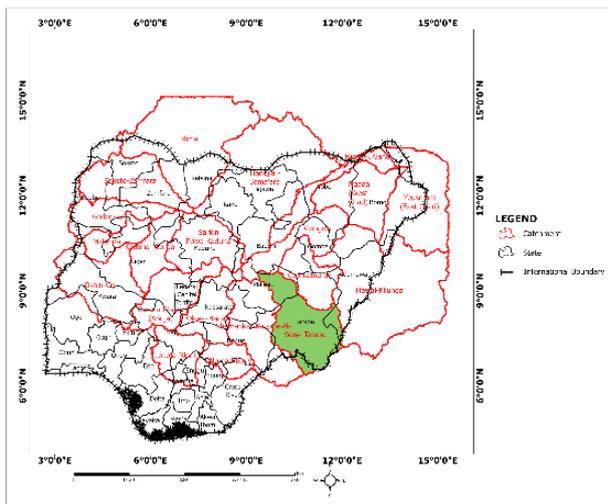


# WASE-TARABA STRATEGIC CATCHMENT MANAGEMENT PLAN

## REPORT



**MARCH 2025**

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## ABBREVIATIONS AND ACRONYMS

| <b>Symbol</b>                    | <b>Description</b>   |
|----------------------------------|--|
| °C                               | Degree Celsius   |
| °F                               | - Fahrenheit   |
| <b>Abbreviation/<br/>Acronym</b> | <b>Description</b>   |
| ADP                              | Agriculture Development Program                            |
| AfDB                             | African Development Bank                                   |
| AFOLU                            | Agriculture, Forestry, and Other Land Use                  |
| AMSL                             | Above Mean Sea Level                                       |
| ATA                              | Agricultural Transformation Agenda                         |
| AWF                              | African Water Facility                                     |
| BCM                              | Billion Cubic Metre  |
| CCAFS                            | Climate Change, Agriculture and Food Security              |
| CHIRPS                           | Climate Hazards Group InfraRed Precipitation with Station. |
| CJTF                             | Civilian Joint Task Force                                  |
| CMCs                             | Catchment Management Committees.                           |
| CN                               | Curve Number   |
| DEM                              | Digital Elevation Model                                    |
| EA                               | Executing Agency   |
| EC                               | Electrical Conductivity                                    |
| EIA                              | Environmental Impact Assessment                            |
| ESIA                             | Environmental and Social Impact Assessment                 |

|                   |   |
|-------------------|---|
| EU                | European Union  |
| FAO               | Food and Agriculture Organization of United Nations   |
| FDC               | Flow Duration Curve                                   |
| FDF               | Federal Department of Fisheries                       |
| FEPA              | Federal Environment Protection Agency                 |
| FGD               | Focus Group Discussion                                |
| FMAFS             | Federal Ministry of Agriculture and Food Security     |
| FME <sub>nv</sub> | Federal Ministry of Environment                       |
| FMWR              | Federal Ministry of Water Resources                   |
| GBV               | Gender-based violence                                 |
| GCM               | Global Climate Model                                  |
| GEFC              | Global Environmental Flow Calculator                  |
| GHG               | Greenhouse gas  |
| 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                                   |
| LGP    | Length of Growing Period   |
| LUA    | Land Use Act   |
| LULC   | Land Use Land Cover  |
| M      | Metres   |
| M&E    | Monitoring & Evaluation  |
| masl   | Metres above sea level   |
| MCM    | Million Cubic Metre  |
| MDG    | Millennium Development Goal  |
| MSF    | And Médecins Sans Frontières   |
| MSL    | Mecon Services Limited   |
| NCWR   | National Council on Water Resources                                      |
| NDVI   | Normalized Different Vegetation Index                                    |
| NESREA | The Nigerian Environmental Standards and Regulations Enforcement Agency. |
| NFDP   | National Fadama Development Program                                      |
| NGO    | Non-Governmental Organization  |
| NGSA   | Nigerian Geological Survey Agency  |
| NHISA  | Nigeria Hydrological Services Agency                                     |
| NIMET  | Nigerian Meteorological Agency   |
| NIP    | National Implementation Plan   |
| NIR    | Net irrigation requirement   |
| NIWRMC | Nigeria Integrated Water Resources Management Commission                 |

|        |  |
|--------|--|
| NNJC   | Nigeria-Niger Joint Commission                               |
| NRCS   | Natural Resources Conservation Service                       |
| NRW    | Non-Revenue Water  |
| NSE    | Nash-Sutcliffe Efficiency                                    |
| 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                                   |
| PSWB   | Plateau State Water Board                                    |
| 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                |
| SGS    | Streamflow Gauging Station                                   |
| SHA    | Sub Hydrologic Area  |
| SMA    | State Ministry of Agriculture                                |

|         |   |
|---------|---|
| SME     | Small Medium Enterprise   |
| SMM     | Soil Moisture Method ( <i>Hydrology rainfall-runoff model within WEAP</i> ) |
| SMWR    | State Ministry of Water Resources   |
| SSEA    | Strategic Social and Environmental Assessment                               |
| SUBEB   | Small Medium Enterprise   |
| SWA     | State Water Agencies  |
| TADP    | Taraba State Agricultural Development Programmed                            |
| TAP     | Technical Advisory Panel  |
| TOR     | Terms of Reference  |
| TRIMING | Transforming Irrigation Management in Nigeria                               |
| TSEDP   | Taraba State Economic Development Plan                                      |
| TSWSA   | Taraba State Water Supply Agency  |
| UBE     | Universal Basic Education   |
| UNESCO  | United Nations Educational Scientific & Cultural Organization               |
| UNFCCC  | United Nations Framework Convention on Climate Change                       |
| UNICEF  | United Nations Children's Fund  |
| UTM     | Universal Traverse Mercator   |
| VAPP    | Violence against Persons Prohibition  |
| WASH    | Water, Sanitation, and Hygiene  |
| WB      | World Bank  |
| WEAP    | Water Evaluation and Planning   |
| WHO     | World Health Organisation   |
| WMO     | World Meteorological Organization   |

|        |   |
|--------|---|
| WRA    | Water Resources Act                                 |
| WRM    | Water Resources Management                          |
| WSS    | Water Supply and Sanitation                         |
| WSSSRP | Water Supply and Sanitation Sector Reform Programme |

## EXECUTIVE SUMMARY

The Wase-Taraba catchment, stretches across Plateau, Taraba, and Adamawa States in the Northeastern and Central Nigeria, it is an ecologically and hydrologically significant region characterized by diverse landscapes, including rivers, valleys, and highlands.

The catchment is primarily defined by the Wase River its tributaries, and the Taraba Rivers which serve as key water sources for agriculture, livestock, and domestic use. The northern zone of the catchment, located in Plateau State, features undulating terrain with hills and valleys. One of the notable landmarks is the Wase Rock, a massive volcanic inselberg rising 350 meters above the surrounding plains. The area around Wase Rock is marked by rocky outcrops, grasslands, and small watercourses. Moving southward, the catchment extends into Taraba State, where the land becomes more rugged, with higher elevations, including sections of the Mambilla Plateau in the eastern part of the catchment.

In the southeastern part of the catchment, the land transitions into Adamawa State, with a combination of highlands and plains. The area includes portions of the Adamawa Plateau, which forms part of the larger Cameroon Mountain chain. This section of the catchment is defined by steep slopes and fertile valleys

This region is well-known for its agricultural potential, with fertile floodplains supporting the cultivation of staple crops like maize, millet, and sorghum, alongside cash crops such as groundnuts and cotton. Livestock rearing is also a crucial economic activity, with the vast grazing lands supporting cattle, sheep, and goats. The catchment also holds great potential for tourism and ecotourism.

This plan marshals various activities and initiatives to enhance climate resilience, promote socio-economic development, and protect natural resources in the Wase-Taraba 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 Wase-Taraba 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 depicts some past and ongoing development initiatives by different partners in the Wase-Taraba Catchment.

Table ES1: Past and Ongoing Initiatives by Governments and Development Partners in the Catchment

| LOCATION   | PAST INITIATIVES  | ONGOING INITIATIVES  | AGENCIES  | FOCUS                             |
|--|---|--|---|-----------------------------------|
| <b>Plateau State</b>   |   |  |   |                                   |
| <b>Jos/Bukuru</b>  | Rehabilitation of 3No. water treatment plants (Yakubu Gowon, Yelwa-Dorowa, and Laminga) | Expansion of water pipeline distribution network within Jos/Bukuru metropolis                  | Plateau State Water Board                                     | Urban Water Supply                |
| <b>Yakubu Gowon Dam</b>  | Purchase of 2MVA Transformer to improve water supply                                    | Procurement and installation of ten thousand units of prepaid meters                           | Plateau State Government                                      | Water Infrastructure              |
| <b>Various Rural Areas (e.g., Rafiki Foundation, Rukuba Barracks, Vom)</b> | Provision of rural water supply and sanitation equipment                                | Collaboration with Federal Ministry of Water Resources for Mangu Regional Water Supply Project | Federal Ministry of Water Resources, Plateau State Government | Rural Water Supply and Sanitation |
| <b>Miango Town, Bassa LGA</b>  | Laying of water pipes and tap points  |  | Plateau State Water Board                                     | Water Distribution                |
| <b>Gwarandok and Longwa, Jos South LGA</b>                                 | Extension of water supply under UN-Habitat Water for African Cities Phase II            |  | UN-Habitat, Plateau State Government                          | Urban Water Supply                |
| <b>Mangu</b>   | Design of pipeline distribution network for Mangu Regional Water Project                | Completion of Mangu Regional Water Supply Project  | Federal Ministry of Water Resources                           | Regional Water Supply             |
| <b>Shendam, Langtang, Pankshin</b>   | Rehabilitation of water treatment plants  |  | Plateau State Water Board                                     | Water Treatment                   |
| <b>Riyom</b>   | Award of contract for detailed engineering design of Riyom Regional                     | Feasibility study and detailed engineering design for Riyom Regional Water Supply Project      | Federal Ministry of Water Resources                           | Regional Water Supply             |

|                                   |  |  |  |                            |
|-----------------------------------|--|--|--|----------------------------|
|                                   | Water Supply Project   |  |  |                            |
| <b>BEPCO Building</b>             | Repairs and replacement of damaged water facilities                          |  | Plateau State Government                   | Water Infrastructure       |
| <b>Dengi</b>                      | Strengthening and improvement of embankment of Dengi Earth Dam               |  | Federal Ministry of Water Resources        | Dam Rehabilitation         |
| <b>Yelwa &amp; Rabin-du Ponds</b> | Dredging and expansion   | Consultancy services for dredging/expansion  | Plateau State Government                   | Water Resources Management |
| <b>Plateau State</b>              | Hosting of National Council on Water Resources (2010)                        | Validation workshop for water, sanitation, and hygiene policy in partnership with WaterAid Nigeria | WaterAid Nigeria, Plateau State Government | Policy Development         |
| <b>Plateau State</b>              | Establishment of hydro-meteorological stations in flood-prone zones          |  | Federal Ministry of Environment            | Climate Monitoring         |
| <b>Bukuru</b>                     | Resuscitation of Bukuru Central Nursery (80,000 assorted seedlings)          |  | Plateau State Government                   | Afforestation              |
| <b>Plateau State</b>              | Resuscitation of tree nurseries across three senatorial zones                |  | Plateau State Government                   | Forestry                   |
| <b>Plateau State</b>              | Reclamation of gully erosion sites (e.g., Gold and Base, Rikkos, Gasen Kuru) | Nigeria Erosion and Watershed Management Project (NEWMAP) participation                            | NEWMAP                                     | Erosion Control            |
| <b>Plateau State</b>              | Establishment of environmental conservation clubs in secondary schools       | Flood/climate change awareness campaign  | Plateau State Government, NGOs             | Environmental Awareness    |
| <b>Plateau State</b>              | Reclamation of 15 identified gully erosion sites                             | Monitoring of environmental impact assessment activities   | Federal Ministry of Environment            | Erosion Control            |

|   |   |   |  |                                 |
|---|---|---|--|---------------------------------|
| <b>Taraba State</b>                       |   |   |  |                                 |
| <b>Jalingo</b>                            | Completion of ecological project works at NYSC Orientation Camp                       | Ongoing erosion and flood control works                 | Federal Ministry of Environment              | Ecological Protection           |
| <b>Taraba Central Senatorial District</b> | Terrain analysis for environmental sustainability                                     | Implementation of green projects for sustainability     | Taraba State Government                      | Environmental Sustainability    |
| <b>Taraba State</b>                       | Challenges of state institutions in environmental protection study                    |   | Federal Ministry of Environment              | Institutional Capacity Building |
| <b>Taraba State</b>                       | Partnership with Federal Ministry of Regional Development for sustainable development |   | Federal Ministry of Regional Development     | Sustainable Development         |
| <b>Taraba State</b>                       | Reforestation project (planting 1 million trees)                                      | Expansion of tree-planting campaigns                    | Taraba State Government, NGOs                | Afforestation                   |
| <b>Taraba State</b>                       | NEWMAP's erosion control project  | Erosion and watershed management under NEWMAP II        | NEWMAP, Federal Ministry of Environment      | Erosion Control                 |
| <b>Taraba State</b>                       | USAID climate change adaptation project   | Continuation of climate resilience programs             | USAID, Taraba State Government               | Climate Change Adaptation       |
| <b>Taraba State</b>                       | Taraba State's waste management project   | Expansion of solid waste management strategies          | Taraba State Environmental Protection Agency | Waste Management                |
| <b>Taraba State</b>                       | UNDP sustainable land management project  | Soil erosion control and sustainable land use practices | UNDP, Taraba State Government                | Land Management                 |
| <b>Taraba State</b>                       | FG ecological fund projects (drainage, erosion, flood control)                        | Expansion of ecological fund projects                   | Federal Government of Nigeria                | Environmental Protection        |
| <b>Taraba State</b>                       | Forest reserve management project   | Strengthening of forest conservation efforts            | Taraba State Forestry Commission             | Forest Conservation             |

|  |   |  |                                  |                             |
|--|---|--|----------------------------------|-----------------------------|
| <b>Taraba State</b>                        | GIZ climate change resilience project                                   | Capacity building for climate adaptation                   | GIZ, Taraba State Government     | Climate Resilience          |
| <b>Taraba State</b>                        | Produce and Sell (PROSELL) project                                      | Rural economic empowerment through sustainable agriculture | Oxfam, Taraba State Government   | Agriculture and Livelihoods |
| <b>Taraba State College of Agriculture</b> | Infrastructure development projects                                     | Expansion of college infrastructure                        | Taraba State Government          | Educational Development     |
| <b>Taraba State</b>                        | Ecological projects addressing erosion and flood control                | Ongoing erosion control projects                           | Federal Ministry of Environment  | Erosion Control             |
| <b>Taraba State</b>                        | Taraba CARES Project (water, health, education, erosion, flood control) | Expansion of intervention areas                            | Taraba State Government          | Multi-Sectoral Development  |
| <b>Kashimbila</b>                          | Kashimbila Multipurpose Dam (40MW hydropower, water supply, irrigation) | Hydropower generation and irrigation expansion             | Federal Government of Nigeria    | Water and Energy Supply     |
| <b>Jalingo, Ibi-Wukari</b>                 | Taraba State Water Supply Agency projects                               | Pipeline expansion and water treatment plant upgrades      | Taraba State Water Supply Agency | Urban Water Supply          |
| <b>Wukari</b>                              | Wukari Water Supply Project   | Expansion of water distribution network                    | Taraba State Water Supply Agency | Water Supply                |
| <b>Taraba State</b>                        | Spring water development for community water supply                     | Borehole drilling and water infrastructure expansion       | Taraba State Government          | Rural Water Supply          |
| <b>Taraba State</b>                        | AFDB intervention for water sector development                          | Investment in water infrastructure projects                | African Development Bank         | Water Sector Development    |

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 so as 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 Wase-Taraba Catchment:

1. **Water resources deterioration:** Climate change-induced extreme events of flooding and drought, as well as inadequate infrastructure, have negatively impacted the fragile and limited water resources of the catchment. Declining groundwater recharge rates and limited surface water due to siltation and upstream diversions exacerbate the limited water availability and quality issue. During the short rainy season, a significant problem faced by the local people is the turbidity and sediment particles in the drinking water,
2. **Environmental degradation:** Deforestation, desertification, and the encroachment of invasive species into wetland areas have degraded ecosystems critical for biodiversity and livelihoods of the catchment. As there is a high dependency on forest resources for cooking, the felling of trees around the water resources is negatively impacting the biodiversity and ecosystem services (including water services) and contributing to a high rate of sedimentation and turbidity of the Wase-Taraba Catchment.
3. **Unsustainable agriculture and livestock practices:** The current over-reliance on irrigation for agriculture is depleting the catchment's water resources. Using inorganic fertilizers also leads to soil degradation and groundwater pollution. Poor water use practices upstream result in imbalances in water distribution.
4. **Climate change:** Increasing temperatures, erratic rainfall, and frequent floods and droughts threaten the catchment's agricultural productivity and water security. The catchment's temperature and rainfall are projected to increase in variability towards the end of the century, with attendant climatic extremes that are likely to impact the watershed's biophysical characteristics and ecosystem functions with critical socio-economic implications. The region's lack of adaptive measures exacerbates these vulnerabilities.
5. **Socio-economic disparities and unsustainable livelihood practices:** High poverty rates, weak governance, and limited infrastructure access hinder the catchment's sustainable development. Over 70% of local government areas (LGAs) in the catchment experience high or very high poverty levels.

6. **Weak governance:** Weak institutional frameworks, a lack of coordinated water management, ineffective enforcement of existing policies, and a lack of funding for infrastructure maintenance are limiting the sustainable development of the catchment. Also, there is limited stakeholder engagement and poor involvement of traditional governance structures in managing the catchment’s resources. Moreover, although institutions in the watershed are meant to be inclusive, they do not allow women and other socially marginalized groups in institutions to challenge the existing power structures and cultural values that have shaped gender differentials and norms. For the sustainable development of the Catchment, active participation and inclusiveness of all stakeholders are vital, as implementing the watershed plan needs stakeholder convergence in the implementation phase with a good horizontal coordination mechanism. Similarly, mechanisms for robust upstream and downstream linkages need to be scaled up within the watershed as a model for upstream and downstream linkages for other river basins in the country.

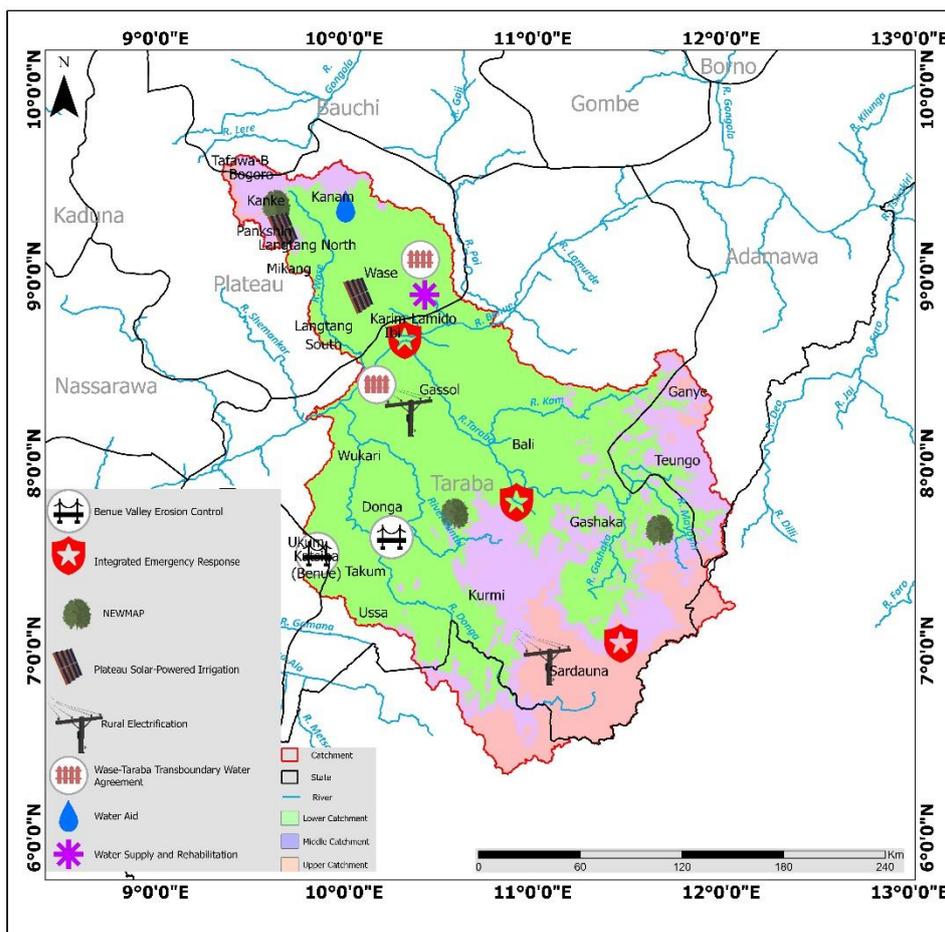


Figure E.S.1: Wase-Taraba Catchment Showing Past Interventions (Source: MSL, 2024)

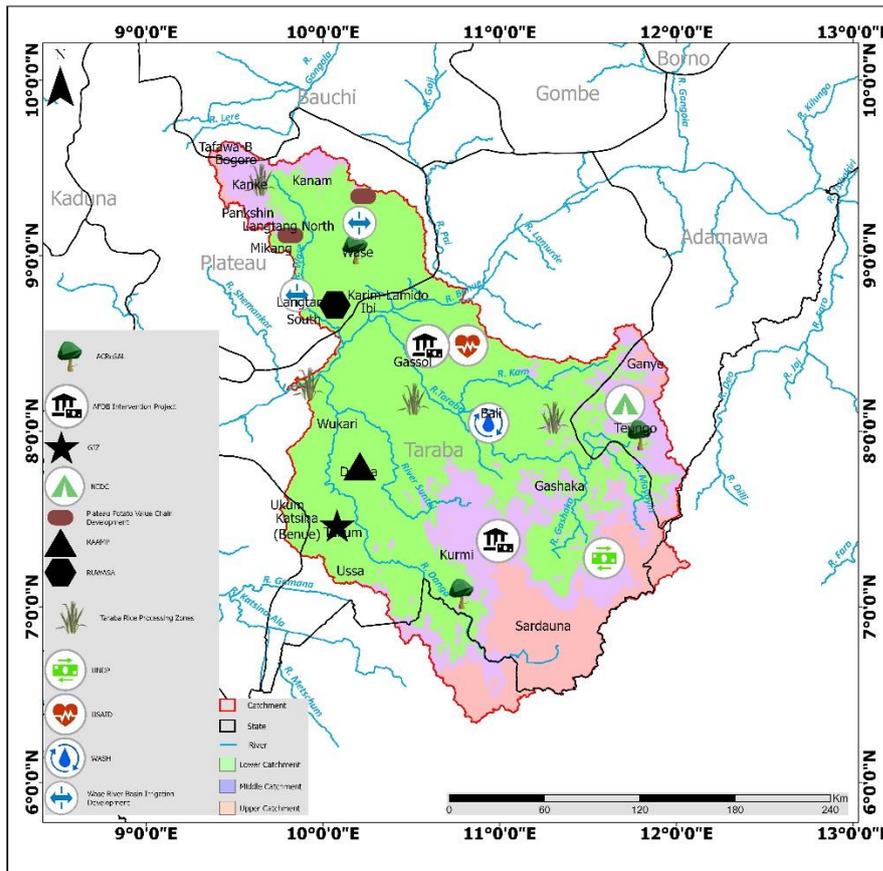


Figure E.S.2: Wase-Taraba Catchment Showing Ongoing interventions (Source: MSL, 2024)

## Elements of the Catchment Management Plan

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

### Strategic Vision

The strategic vision for the Wase-Taraba catchment is to attain a comprehensive, sustainable, efficient, and equitable use of all the resources within the catchment area.

### Strategic Objectives

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

- 1) the specific objectives are to”:
  - a) Develop a sustainable livelihood within the catchment in 5 years (2025-2030)
  - b) Establishment of new 7 Dams within Wase-Taraba River basin within 5years namely river lamurde for agriculture, river Lau for agriculture, River Ibi, River

Zurak for agriculture, River Namnai for agriculture, river Dapshi in Kanam LGA for domestic/ Agriculture

- c) Dredging/river draining of the basin for Agricultural purposes, Expansion, and flood control
  - d) Gender & Social Inclusion in all interventions
  - e) Restoration of Forest Reserves/ Wildlife Parks in Wase, Kanam, and Wuakari
  - 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
- 
- i. **Enhance water resource management and flood risk strategies: by promoting** sustainable water practices. This includes safeguarding water sources, optimizing usage, and addressing flood and drought challenges.
  - ii. **Safeguard and rejuvenate essential ecosystems and their services:** by conserving and rehabilitating natural areas such as forests, wetlands, and wildlife habitats. This effort aims to uphold biodiversity, bolster ecosystem services, and enhance ecological resilience.
  - iii. **Encourage sustainable farming and livestock methods:** such as conservation agriculture, agroforestry, and integrated water management, to mitigate environmental harm and enhance productivity livelihoods.
  - iv. **Boost climate resilience:** through the adoption of climate-smart agriculture, disaster risk reduction strategies, and ecosystem-based adaptations, all aimed at strengthening the catchment's ability to withstand climate change.

- v. **Enhance the livelihoods and well-being of all stakeholders:** by providing better access to education, healthcare, and economic opportunities.
- vi. **Enhance inclusive governance and stakeholder partnerships:** to achieve coordinated and efficient catchment management by building institutional and technical capacity at all governance levels: Federal, State, Local Government, and Communities. Leading to enduring security and governance in every location within the catchment.

This strategic vision and objectives provide a framework for managing the Wase-Taraba 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 relationship and engagement of stakeholders regarding equitable utilization of inter-state water resources the following treaties, policies, and laws need to be recognized, and ratified treaties further domesticated.

### Treaties

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

### International Policies That Affect Water Resources

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

### National Laws and Policies

- 1999 Constitution of Federal Republic of Nigeria

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

## **Plan Components**

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

**Component 1: Conservation, management, and sustainable use of water resources:** The focus will be on optimizing water resource use for sustainable development, ensuring fair distribution and utilization to minimize conflict, reducing environmental degradation and disasters, enhancing water storage for post-wet season economic activities, and implementing sustainable monitoring of groundwater and surface water.

**Component 2: Protecting and revitalizing essential ecosystems and services for sustainable land practices, including responsible agriculture and livestock management practices:** The ecosystems of the Wase-Taraba Watershed are vital for its sustainable development. Nonetheless, human activities have put considerable strain on the basin's land resources. The reliance on forest resources for cooking has led to extensive tree felling, particularly near water sources, resulting in forest fragmentation and degradation. This situation threatens biodiversity and ecosystem services, including crucial water supply, while also increasing sedimentation and turbidity within the watershed. Improving land resource quality through ecosystem restoration will be a key initiative of this component Plan.

**Component 3: Enhanced diversification to strengthen sustainable livelihoods and well-being:** Agriculture is the main livelihood for many in the Wase-Taraba Watershed. Small landholdings and poor practices lead to low income and increased resource dependency. This often drives men to migrate to urban areas, creating labor shortages in agriculture and natural

resource management. Key initiatives include capacity building, expanding economic opportunities, and improving access to sustainable resources.

**Component 4: Climate change, disaster management, and resilience to climate impacts infrastructure:** The Wase-Taraba Watershed is highly vulnerable to climate change, with rising temperatures and increased rainfall expected by the century's end, along with extreme weather events. Such changes could impact the watershed's functions and lead to socio-economic challenges, particularly an increase in climate-related disasters and a need for resilient infrastructure. This component will focus on initiatives for sustainable, climate-resilient development in the Catchment to mitigate the impacts of climate change disasters.

**Component 5: Enhancing institutional frameworks and improving project collaboration mechanisms:** Many institutions manage initiatives but often lack coordination for effective stakeholder engagement, especially during implementation. Establishing strong linkages, clarifying roles, and enhancing capabilities for watershed management are essential, as is engaging local leaders. This Plan component will address the developmental challenges posed by existing institutional structures and mechanisms in the water basin.

**Component 6: Effectively incorporating gender equality and social inclusion (GESI) mechanism:** In the watershed, gender roles have evolved, with women taking on more household duties and participating in agriculture due to men's migration, largely driven by insecurity. The shift from subsistence to commercial farming enhances women's entrepreneurship, making their economic empowerment essential. However, this change may bring unexpected socio-economic impacts that must be addressed in the vulnerability of the new sustainable natural resource management strategy.

**Component 7: Investigation and extension:** This component will highlight action research addressing key topics such as Indigenous knowledge and practices, nature-based solutions, the effectiveness of soil conservation measures, watershed services for integrated water management (IWM), sediment yield, the impact of climate change on vegetation and pests, micro-finance, and more, all contributing to an evidence-based watershed management plan and strategies.

**Component 8: a system for efficient oversight in tracking, assessing, and documenting outcomes.** The focus will be on enhancing capacity to effectively conduct periodic assessments of watershed services and the monitoring and evaluation of the plan.

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



Table ES2: Summary of Components and Activities of the Wase-Taraba Catchment Plan

| <b>Component</b>   | <b>Activities</b>  | <b>Key Indicators</b>  | <b>Responsibility/<br/>Partners</b>  |
|--|--|--|--|
| <p><b>Conservation, management, and sustainable use of water resources</b></p> | <p>Construct small water conservatories and reservoirs, to improve water retention and release.</p> <p>Install small-scale water storage facilities and enhance rainwater harvesting techniques.</p> <p>Establish water allocation plans that balance upstream and downstream needs.</p> <p>Build embankments and enhance drainage systems in areas at high risk.</p> <p>Establish early warning systems and perform flood risk evaluations regularly.</p> <p>Strengthen the network of groundwater monitoring systems and hydromet stations</p> | <p>Reports, implementation and supervisions</p> <p>Reports on a comprehensive water study, policy enactment, implementation and enforcement.</p> <p>Reduction in environmental risk and disaster</p> <p>Better Socio-economic engagement</p> | <p>Three tiers of government encompassing the RBDA 's, FMWR and allied agencies</p> <p>As above, NIWRMC</p> <p>NHISA, NIMET</p> <p>NHISA, The three tiers of government encompassing the RBDA 's, FMWR and allied agencies</p> |



|  |  |                                       |                                 |
|--|--|---------------------------------------|---------------------------------|
|  | <p>Enhance public awareness and preparedness for flood events.</p> <p>Adopt comprehensive water management strategies that tackle seasonal changes, improve groundwater replenishment, and better distribute surface water for agricultural, domestic, and industrial demands.</p> <p>Establish and implement technical standards for water efficiency, including conservation, reuse, and recycling, in recreational settings. and -</p> <p>other uses based on best practices</p> <p>Assessment of demand and supply of drinking water</p> <p>Construction and maintenance of pipelines and water tanks</p> <p>Construction of recharge structures to rejuvenate drying and dried springs.</p> | <p>Routine Reports</p> <p>Reports</p> | <p>NHISA, NIMET, MOA, CBO's</p> |
|--|--|---------------------------------------|---------------------------------|



|   |   |  |   |
|---|---|--|---|
|   | <p>Roof rainwater harvesting and improved water use efficiency</p> <p>Conserving and preserving water recharge zones, while also planting suitable tree and plant species, enhances the abundance of water sources.</p>   |  |   |
| <p><b>Protecting and revitalizing essential ecosystems and services for sustainable land practices, including responsible agriculture and livestock management Practices.</b></p> | <p>Restoring 30% to 40% of degraded land by means of afforestation.</p> <p>Revitalize 25% of agricultural land that has suffered degradation.</p> <p>Revitalize and preserve wetlands to stabilize water cycles and enhance biodiversity.</p> <p>Enforce the protective boundaries of national parks and valuable forest reserves</p> <p>Boost agricultural productivity by 40% using climate-smart techniques, enhancing capacity, and collecting data.</p> <p>Enhance soil fertility practices and implement soil and water</p> | <p>Increase in agricultural productivity</p> | <p>Federal, state and local government MDA's on agriculture and food security, livestock, water resources and environment</p> <p>As above</p> |



|   |   |  |   |
|---|---|--|---|
|   | <p>conservation strategies to minimize erosion.</p> <p>Support smallholder farmers through training and access to improved technologies</p> <p>Encourage the use of micro-irrigation facilities</p>   | <p>As above</p> <p>Increase in number of farmers.</p> <p>Increase in agricultural productivity</p>   | <p>Bank of agriculture, NGOs and other international agencies. CBOs</p> <p>As above</p>   |
| <p><b>Enhanced diversification to strengthen sustainable livelihoods and well-being</b></p> | <p>Create suitable conditions for efficient multiple crop and animal farming in river floodplains and both natural and artificial reservoirs;</p> <p>Provide training initiatives that emphasize sustainable methods in agriculture, fishing, and aquaculture.</p> <p>Enhance access to credit and market opportunities for smallholder farmers and fishermen.</p> <p>Create tourism that supports the community and promotes eco-friendly economies activities.</p> <p>Improve access to sustainable natural resources, low-cost energy,</p> | <p>Improved quality of living.</p> <p>Improved funding</p> <p>Improved income/job creation.</p> <p>Availability of renewable energy and improved standard of living.</p> | <p>Federal, state and local government MDAs, CBOs</p> <p>Donor agencies, banks and cooperatives</p> <p>CBOs and the three tiers of government</p> <p>As above</p> |



|  |  |  |  |
|--|--|--|--|
|  | <p>better sanitation and hygiene practices</p> <p>Encourage the cultivation of high-value crops like climate-resilient seeds, including maize, sorghum, SAMNUT-22, and millet.</p> <p>Offering thorough education on irrigation methods, compost manure preparation, and water pond management for irrigation.</p> <p>Provide Integrated Pest Management (IPM) and other technical skills to women, men, and marginalized communities to decrease pollution in primary water resources.</p> <p>Promote of multi-year crops to improve the average income of the people living in the catchment.</p> <p>Promote the use of water as an alternative to road transport system</p> |  |  |
|--|--|--|--|



|   |  |   |  |
|---|--|---|--|
| <p><b>Climate change, disaster management, and resilience to climate impacts infrastructure</b></p> | <p>Encourage leveraging local runoff from small rivers to organize water bodies and implement strategies to address droughts caused by climate change.</p> <p>Expand early warning systems and enhance the capacity for disaster response</p> <p>Construct resilient infrastructure to address flood risks and water distribution challenges.</p> <p>Support the adoption of drought-resistant crop varieties and efficient irrigation technologies.</p> <p>Promote afforestation programs to combat desertification and stabilize soils.</p> <p>Implement community-based initiatives for floodplain management and watershed protection.</p> | <p>Reduction in climate change induced disaster</p> <p>Reduction in environmental degradation and climate change disaster</p> <p>Improved agricultural output and increased employment</p> <p>Decrease in soil erosion, improved NDVI</p> <p>Reduction in environmental degradation.</p> <p>Designated livelihood areas and updated reports</p> | <p>Federal, State and local Government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs</p> <p>Federal, State and local Government MDAs, NGOs, donor agencies.</p> |
|---|--|---|--|



|  |  |  |  |
|--|--|--|--|
|  | <p>Prepare risk sensitive Land-use Plan (RSLUP) and implementation for identified degraded areas</p> <p>Revitalise erosion-affected areas, including stream banks and gully stabilization in the upstream micro-catchment vulnerable areas</p> <p>Promote green roads through bioengineering in erosion-prone areas</p> <p>Creating a green infrastructure system to protect ecosystems, ecologic corridors and natural landscapes in the water bodies</p> <p>Focus on both structural (bioengineering, retaining walls) and non-structural (hazard/susceptibility, vulnerability, risk maps, early warning systems) measures for infrastructure failure mitigation and preparedness</p> | <p>Increase in land resources available for livelihoods in updated reports.</p> <p>As above</p> <p>Updated reports</p> <p>Updated reports and increase in harmonious engagement with stakeholders</p> <p>Updated reports</p> |  |
|--|--|--|--|



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



|   |  |   |  |
|---|--|---|--|
|   | <p>Implementing production-based incentives and monitoring mechanisms for agricultural land management.</p> <p>Developing mechanisms to ensure effective implementation and management of springshed and recharge areas, particularly on public and private land.</p>  | <p>Increase in agricultural output</p> <p>Policy formulation and Implementation</p>   |  |
| <p><b>Effectively incorporating gender equality and social inclusion (GESI) mechanism</b></p> | <p>Ensure equitable distribution of roles and responsibilities to women, men and marginalized communities during the planning, implementation and evaluation of any projects/plans/activities</p> <p>Provide training and exposure visits to both women and men in order to enhance their understanding on water conservation technologies and economic development.</p> <p>Identify vulnerable areas and communities (with gender and social disaggregated data) to disaster and climate risk and</p> | <p>Comprehensive participation of all stakeholders</p> <p>Better outputs of environmental conservation</p> <p>Updated Reports on key social issues within a community</p> | <p>Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs.</p> |



|   |  |  |  |
|---|--|--|--|
|   | <p>develop focused projects to address identified challenges</p> <p>Promote women and marginalized communities to leadership positions through participatory approaches.</p> <p>Establishing counseling centers for handling domestic violence, grievances, and psychosocial services for supporting the well-being of women, men, and marginalized communities.</p>                     | <p>More women participation</p> <p>Improved psycho-social status of victims of abuse</p> |  |
| <p><b>Investigation and extension</b></p> | <p>Undertake action research on pertinent issues such as:</p> <ul style="list-style-type: none"> <li>✓ accounting of water resources and regulation of their flow</li> <li>✓ Indigenous knowledge and practices,</li> <li>✓ nature-based solutions,</li> <li>✓ effectiveness of soil conservation measures,</li> <li>✓ watershed services for IWM,</li> <li>✓ sediment yield,</li> </ul> | <p>Increased awareness</p>   | <p>Federal, state and local government MDAs, NGOs, donor agencies, multi-lateral financial institutions, CBOs.</p> |



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

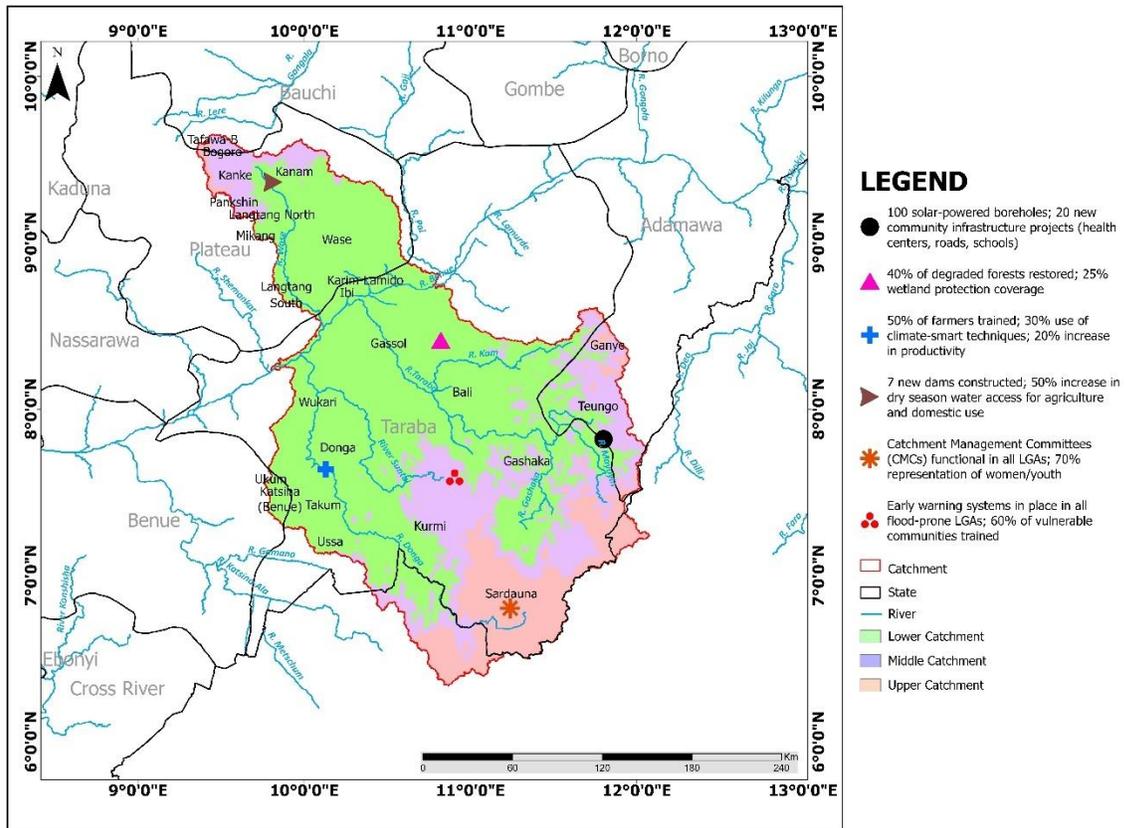


Figure E.S.3: Wase-Taraba Catchment showing the Recommended interventions (Source: MSL, 2024)

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

| Section         | Town           | Key Challenge                                 | Proposed Interventions  | Appropriate Tool(s) For Sustained Monitoring and Evaluation               | Responsible Agencies   | Expected Outcomes   |
|-----------------|----------------|---|---|---|--|---|
| Lower Catchment | Wukari         | Annual flooding affecting homes and farmlands | - Construction of embankments and levees - Relocation plans for flood-prone settlements - Community-based early warning systems | Flood hazard mapping, hydrological modeling, GPS-based flood alert system | NIHSA, NEMA, Taraba State Emergency Agency, FMOWR, ACRoSAL, FMAFS, NIWRMC, | - Reduced flood losses - Safer settlements                |
|                 | Langtang South | Poor access to healthcare and education       | - Mobile health & education units - Upgrade of rural clinics & schools - Recruitment of local service providers                 | GIS mapping of underserved areas, logistics planning tools                | Plateau State Ministries of Health & Education, UNICEF, WHO,               | - Improved service access - Reduced rural-urban migration |
|                 | Karim-Lamido   | High youth unemployment and rural-urban drift | - Vocational training centres (agri-based, carpentry, ICT) - Youth agribusiness incubation hubs - Rural enterprise grants       | Youth demographic mapping, enterprise development kits                    | FMYSD, SMEDAN, Taraba State Ministry of Youth Dev.                         | - Increased rural employment - Reduced migration pressure |



|  |                    |   |  | CBO Focus Group   |  |   |
|--|--------------------|---|--|---|--|---|
|  | <b>Katsina-Ala</b> | Riverbank erosion damaging farmland & settlements | - Bioengineering (vetiver grass, bamboo planting) - Riverbank reinforcement with gabions - Land use planning enforcement | Erosion hotspot mapping, drone-based monitoring                           | FMEnv, NASRDA, Benue State Ministry of Environment | - Stabilized riverbanks - Preserved agricultural land       |
|  | <b>Takum</b>       | Intercommunal conflict disrupting farming & trade | - Peacebuilding dialogue platforms - Reinforcement of local security outfits - Inclusive land access frameworks          | Conflict vulnerability mapping, participatory planning tools              | NSCDC, Peace Building Agency, Traditional Councils | - Improved social cohesion - Safer farming environment      |
|  | <b>Bali</b>        | Water scarcity during dry season                  | - Borehole drilling and solar-powered pumps - small dam construction for livestock and irrigation - WASH campaigns       | Groundwater surveys, water quality testing kits, hydrological assessments | RUWASSA, WaterAid, FMOWR                           | - Reliable water access year-round - Improved public health |
|  | <b>Ukum</b>        | Post-harvest losses due to lack of storage        | - Construction of solar-powered storage facilities - Farmer cooperatives for processing & transport                      | Agricultural logistics planning tools, market mapping                     | FMARD, IFAD, State Agricultural Dev. Programs      | - Reduced food loss - Improved farmer income                |



|  |              |  |   |   |   |  |
|--|--------------|--|---|---|---|--|
|  |              |  | - Agricultural extension services   |   |   |  |
|  | <b>Ussa</b>  | Insecurity from borderland cattle rustling             | - Strengthening community policing - Grazing control and livestock monitoring systems - Conflict mediation with nomadic herders           | Livestock tracking (RFID), conflict hotspot mapping | NSCDC, Taraba State Security Council, FMAFS               | - Reduced attacks - Harmonized pastoral-agricultural relations |
|  | <b>Ibi</b>   | Fishing decline due to water pollution and overfishing | - Introduction of fish sanctuaries and seasonal bans - Promotion of aquaculture for inland farmers - Pollution control from agrochemicals | Water quality monitoring, fish stock assessments    | NIFFR, FMAFS Taraba & Benue Ministries of Water Resources | - Restored fish populations - Sustainable livelihoods          |
|  | <b>Kanam</b> | Gully erosion threatening infrastructure               | - Construction of check dams and culverts - Gully backfilling with vegetation cover - Community gully monitoring groups                   | Drone topography, erosion modeling software         | ACReSAL, FMEnv, Plateau State Ministry of Works           | - Controlled erosion - Infrastructure preservation             |



|  |               |  |  |   |  |  |
|--|---------------|--|--|---|--|--|
|  | <b>Mikang</b> | Market inaccessibility for smallholder farmers | - Rural road improvement projects - Formation of market clusters - Cooperative marketing strategies                              | Road network analysis, rural logistics optimization tools | FERMA, IFAD, State Rural Development Agencies          | - Boosted rural trade - Increased farm profits       |
|  | <b>Donga</b>  | Deforestation from fuelwood collection         | - Promotion of clean cookstoves - Tree nursery programs & farmer-managed regeneration - Awareness on sustainable wood harvesting | Remote sensing (NDVI), deforestation alerts               | FMEnv, FAO, Taraba State Forestry Dept.                | - Slowed deforestation - Improved energy access      |
|  | <b>Gassol</b> | Low literacy among women and girls             | - Adult education and girl-child programs - Incentives for school attendance (e.g., feeding) - Recruitment of female educators   | Education access mapping, gender-focused indicators       | UNICEF, UBEC, Taraba State Ministry of Education       | - Increased female literacy - Empowered rural women  |
|  | <b>Wase</b>   | Artisanal mining causing land degradation      | - Introduction of sustainable mining practices - Reclamation of mined lands - Alternative livelihoods                            | Mine site mapping, land degradation assessment            | Mines Inspectorate, FMEnv, Artisanal Mining Initiative | - Reduced environmental impact - Diversified incomes |



|  |  |  |                           |  |  |  |
|--|--|--|---------------------------|--|--|--|
|  |  |  | (beekeeping, soap-making) |  |  |  |
|--|--|--|---------------------------|--|--|--|

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

| Section                 | LGA/Towns              | Challenge                               | Proposed Intervention   | Appropriate Tool(s) For Sustained Monitoring and Evaluation     | Responsible Agency                                | Expected Outcome                            |
|-------------------------|------------------------|---|---|---|---|---|
| <b>Middle Catchment</b> | <b>Gashaka, Kurmi</b>  | Deforestation from logging & farming    | Community forestry, agroforestry, afforestation drives                      | Satellite monitoring, tree nurseries, agroforestry demos        | FMEnv, State Forestry Dept, NGOs, ACRoSAL, FMAFS, | Restored forest cover, reduced soil erosion |
|                         | <b>Ganye, Teungo</b>   | Human-wildlife conflict (near reserves) | Wildlife corridor management, compensation schemes, community sensitization | GPS wildlife tracking, participatory land use planning, ACRoSAL | National Park Service, State Env. Ministry        | Reduced conflict, coexistence with wildlife |
|                         | <b>Pankshin, Kanke</b> | Gully erosion and land degradation      | Gully reclamation, soil conservation structures, watershed management       | Aerial imagery, biotechnical erosion control                    | ACRSAL State Ministry of Environment<br>FMEnv     | Stabilized land, protection of farmlands    |



|  |               |                               |   |                                       |                            |                                 |
|--|---------------|-------------------------------|---|---------------------------------------|----------------------------|---------------------------------|
|  | <b>Bogoro</b> | Low agricultural productivity | Soil fertility management, improved seed distribution, extension services | GIS soil mapping, demonstration plots | Agric Ministry, ADPs, NGOs | Increased yields, food security |
|--|---------------|-------------------------------|---|---------------------------------------|----------------------------|---------------------------------|

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

| Upper Catchment | LGA/Towns | Challenge                                      | Intervention  | Tool/Approach  | Responsible Agency                         | Expected Outcome                                   |
|-----------------|-----------|--|---|--|--|--|
|                 | Sardauna  | Soil erosion and landslides on steep slopes.   | Terracing, contour farming, reforestation of critical slopes.       | Drone mapping, GIS slope analysis, community nurseries.        | ACreSAL, FMEnv, State Min. of Env.         | Stabilized slopes, reduced soil loss.              |
|                 |           | Climate variability impacting tea/coffee farms | Climate-smart agriculture, irrigation support, crop diversification | Climate data models, drip irrigation, resilient crop varieties | Agric Ministry, FMAFS, Research Institutes | Stable farm incomes, resilience to climate shocks. |



|  |               |  |   |   |                                 |   |
|--|---------------|--|---|---|---------------------------------|---|
|  | Tafawa-Balewa | Unregulated farming on fragile highlands       | Sustainable land use planning, farmer education, agroforestry integration | Land use mapping, agroforestry demo plots   | Agric Extension Services, FMEnv | Sustainable farming, preservation of highland ecology |
|  |               | Inadequate rural connectivity (due to terrain) | Rural road rehabilitation, footbridge construction                        | GIS road planning, labor-based construction | FERMA, State Works Ministries   | Improved market access, safer transport               |

## **Expected Outcomes**

The successful implementation of these interventions will result in:

- a) Enhanced water access and diminished seasonal fluctuations scarcity.
- b) Increased climate resilience of agricultural systems variability.
- c) Revival of key ecosystems and improved biodiversity.
- d) Decreased flood risk and lessened socio-economic impacts from severe weather events
- e) Improved ecosystem services and biodiversity conservation.
- f) Enhanced resilience to climate change and diminished greenhouse gas emissions.
- g) Enhanced quality of life coupled with diminished poverty and inequality.
- h) Enhanced collaboration and engagement with stakeholders.

## CHAPTER 1 : INTRODUCTION

### 1.1 Purpose of the Plan

The Wase-Taraba 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.
- v. Insecurity: Clashes between farmers and herders competing for land resources are very common in the catchment.

#### 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:

- Enhanced water access and diminished seasonal fluctuations scarcity.
- Increased climate resilience of agricultural systems variability.
- Revival of key ecosystems and improved biodiversity.
- Decreased flood risk and lessened socio-economic impacts from severe weather events
- Improved ecosystem services and biodiversity conservation.
- Enhanced resilience to climate change and diminished greenhouse gas emissions.
- Enhanced quality of life coupled with diminished poverty and inequality.
- Enhanced collaboration and engagement with stakeholders.

The Strategic Catchment Management Plan (SCMP) for Wase-Taraba will ensure the sustainable management of the catchment's natural resources. Some of the key roles are as follows:

### **1.1.3 Environmental Roles**

1. Resource conservation: the SCMP aids in preserving natural resources like water, soil, and biodiversity for future generations.
2. Ecosystem services protection: The strategy safeguards ecosystem services such as water filtration, flood management, and carbon capture.
3. Climate Change Mitigation: The SCMP addresses climate change impacts by encouraging sustainable land use, conserving water resources, and safeguarding biodiversity.

### **1.1.4 Socio-Economic Roles**

1. Enhanced livelihoods: The SCMP enhances livelihoods by advocating for sustainable practices in agriculture, forestry, and fisheries.
2. Improved food security: This initiative aims to boost food security through the promotion of sustainable agricultural practices, better water management, and the safeguarding of biodiversity.
3. Improved economic advantages: The SCMP can boost economic benefits by fostering eco-tourism, sustainable forest management, and various eco-friendly initiatives.

### **1.1.5 Governance and Institutional Roles**

1. Coordination and collaboration: The SCMP will promote the coordination and collaboration among stakeholders, including government agencies, local communities, and civil society organizations.
2. Policy and legislative framework: The plan will provide a policy and legislative framework for managing the catchment's natural resources.
3. Monitoring and evaluation: The SCMP 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 relationship and engagement of stakeholders regarding equitable utilization of inter-state resources including water, the following treaties, policies, and laws need to be recognized, and ratified treaties further domesticated.

## **Treaties**

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

## **International Policies That Affect Water Resources**

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

## **National Laws and Policies**

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

The Strategic Catchment Management Plan can integrate with existing regional and national policies in Nigeria by aligning with their stated objectives. For instance, the SCMP can do so with the policy objectives of the National Water Resources Policy (2016) which is to ensure sustainable water resources management and protecting the environment. Another policy is that of the National Environmental Policy (1999) which the SCMP can integrate with to promote conservation, protection, and restoration of the environment. For the National Agricultural Policy (2016), the SCMP can align with the policy's objectives, such as promoting sustainable agricultural practices and improving food security.

On a regional scale, the SCMP can be integrated with the Niger Basin Authority's (NBA) Water Charter: which aims to promote sustainable water resources management in the Niger Basin. It can also integrate with the Economic Community of West African States (ECOWAS) Water Resources Policy objectives, such as promoting regional cooperation and sustainable water resources management. There are sectoral policies such as the Nigeria's Agricultural Transformation Agenda (ATA) and the Nigeria's National Forest Policy (2006). The SCMP can integrate with these two policies by promoting sustainable agricultural practices and improving food security for the former while promoting sustainable forest management and conservation for the latter.

### **Integration Mechanisms**

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

- Engage stakeholders: Involve stakeholders, including government agencies, regional organizations, and local communities, in the planning and implementation process to ensure ownership and buy-in.

The Wase-Taraba catchment has witnessed various development and intervention initiatives aimed at improving infrastructure, environmental sustainability, and water resources management. Key projects include the Nigeria Erosion and Watershed Management Project (NEWMAP) for erosion control, the African Development Bank (AfDB) intervention for water sector development, and the Taraba CARES Project addressing water, health, education, and flood control. The Kashimbila Multipurpose Dam serves as a major initiative, providing hydropower, water supply, and irrigation. Additionally, agencies such as the Federal Ministry of Water Resources, the Upper Benue River Basin Development Authority, and international partners like USAID and GIZ have implemented programs focused on climate resilience, reforestation, and sustainable land management within the catchment.

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 Dik Catchment Management Plan are prominent initiatives in Kenya.

## CHAPTER 2 : CATCHMENT CHARACTERISTICS

### 2.1 Location

#### 2.1.1 Location and Boundaries

The Taraba-Wase River catchment is located in north central Nigeria, spanning parts of Taraba and Plateau States. The landscape varies from savannah woodlands to grasslands and hills. The terrain is generally flat with occasional hills and valleys. The catchment lies between latitudes 6°29'35"N to 9°39'22"N and longitudes 9°21'30"E to 12°3'3"E, covering an area of approximately 5,445,600 Hectares.

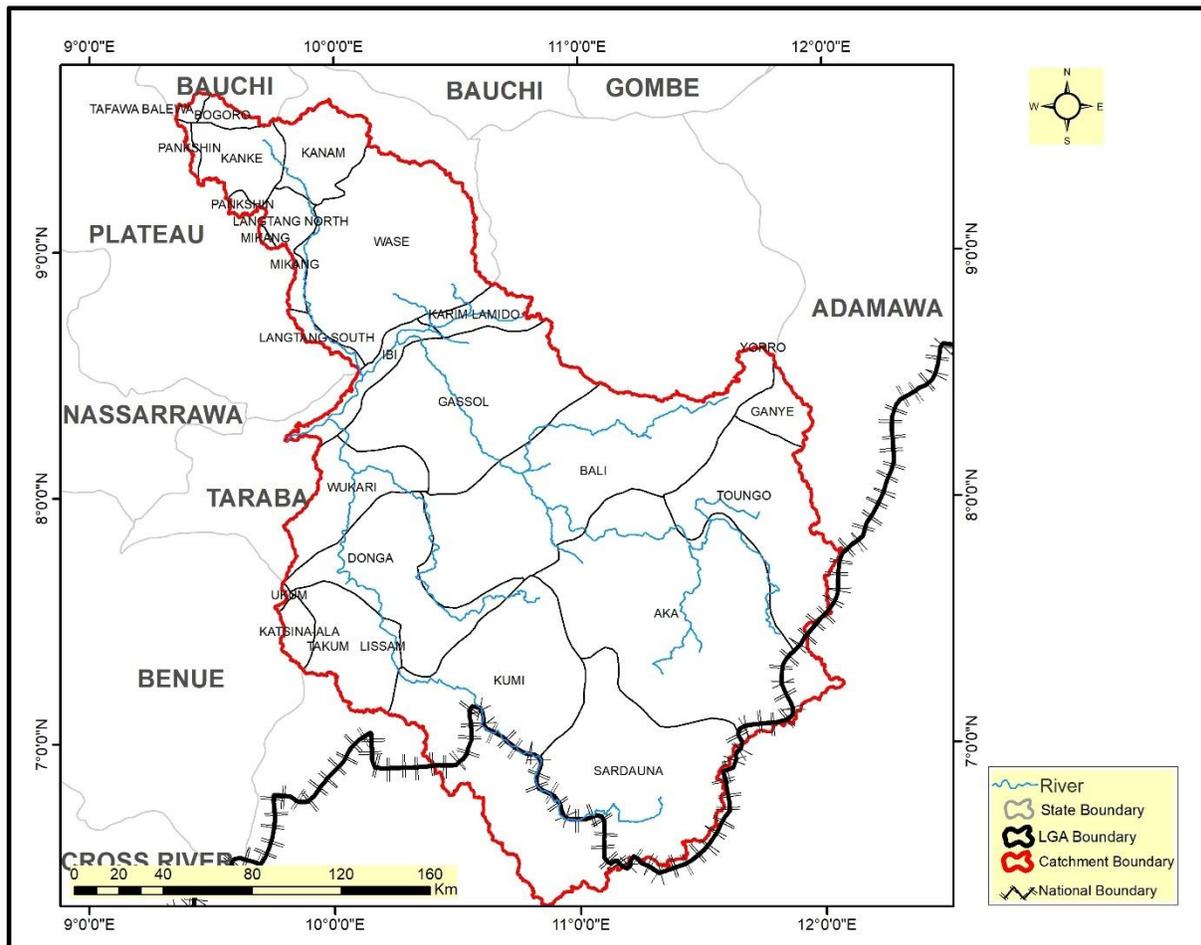


Figure 2.1: Wase-Taraba Catchment showing the LGAs (Source: MSL, 2024)

- The catchment area is bordered by the Ghali-Lamurde and Hawal-Kilunga catchments to the east, the Gongola catchment to the north, and the Shemankar-Katsina-Ala catchment to the west.
- It is primarily defined by the Wase River and its tributaries, alongside the Taraba Rivers, which are vital for agricultural, livestock, and domestic use.
- The northern region, located in Plateau State, features undulating terrain with hills and valleys, prominently highlighted by Wase Rock, a volcanic inselberg rising 350 meters above the plains.
- The area around Wase Rock includes rocky outcrops, grasslands, and small watercourses. Moving south into Taraba State, the terrain becomes rugged, particularly in the Mambilla Plateau. Transitioning into southeastern Adamawa State, the landscape features both highlands and plains, with sections of the Adamawa Plateau characterized by steep slopes and fertile valleys.

## **2.2 Precipitation, Temperature, Sunshine and Relative Humidity**

The catchment has a tropical climate with distinct wet and dry seasons, where precipitation, temperature, sunshine, and humidity influence its hydrological and ecological dynamics.

### **2.2.1 Precipitation**

The wet season in the state lasts from April to October and accounts for a significant portion of annual rainfall. Southern regions, particularly the Benue River basin, can receive over 1,600 mm, while northern and central areas get between 1,200 and 1,500mm. Thunderstorms signal the season's start, with peak rainfall occurring in July and August. The terrain, including the Jos and Mambilla Plateaus, causes orographic rainfall, which supports agriculture but can also lead to soil erosion and flooding.

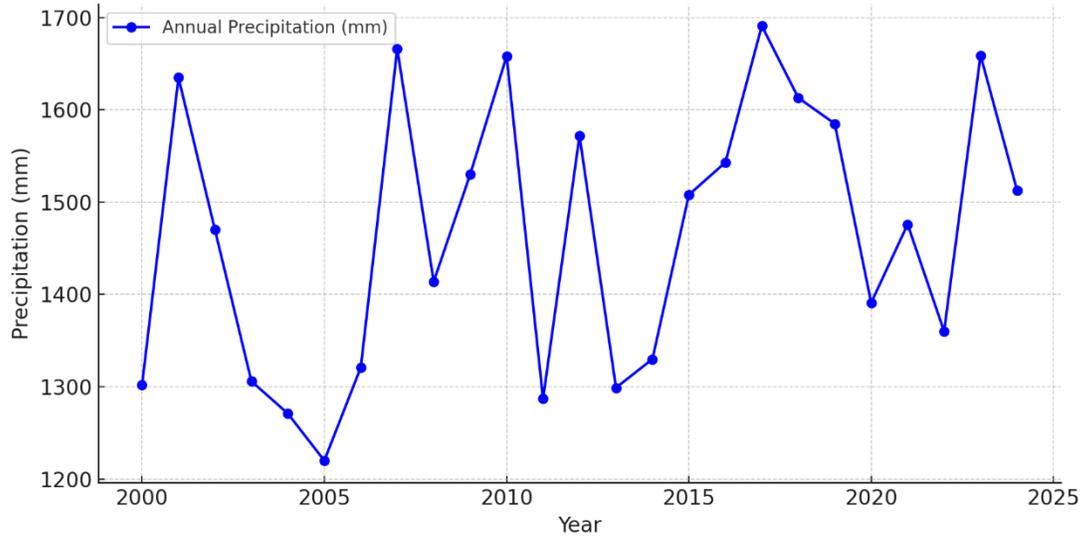


Figure 2.2: Annual Precipitation of the Catchment (Source: NIMET, 2024)

### 2.2.2 Temperature

Temperatures in the catchment area are typically high year-round, with daytime averages of 28°C to 35°C during the dry season from November to March. The harmattan winds from the Sahara bring dry conditions and cooler nighttime temperatures, particularly in December and January [Olaniran, 1983].

- In the wet season, cloud cover and precipitation moderate temperatures, which typically range from 25°C to 30°C. Conversely, the highland areas, particularly the Jos and Mambilla Plateaus, experience significantly cooler climates due to their elevation, with temperatures ranging from 16°C to 25°C.
- The Jos Plateau, the highest point in the state, can see nighttime temperatures as low as 11°C during the Harmattan season (December to February) [Mallo, 2019]. This cooler climate supports the cultivation of temperate crops such as tea, coffee, and Irish potatoes [Olowolafe, 2002], while also attracting tourists seeking relief from higher temperatures.

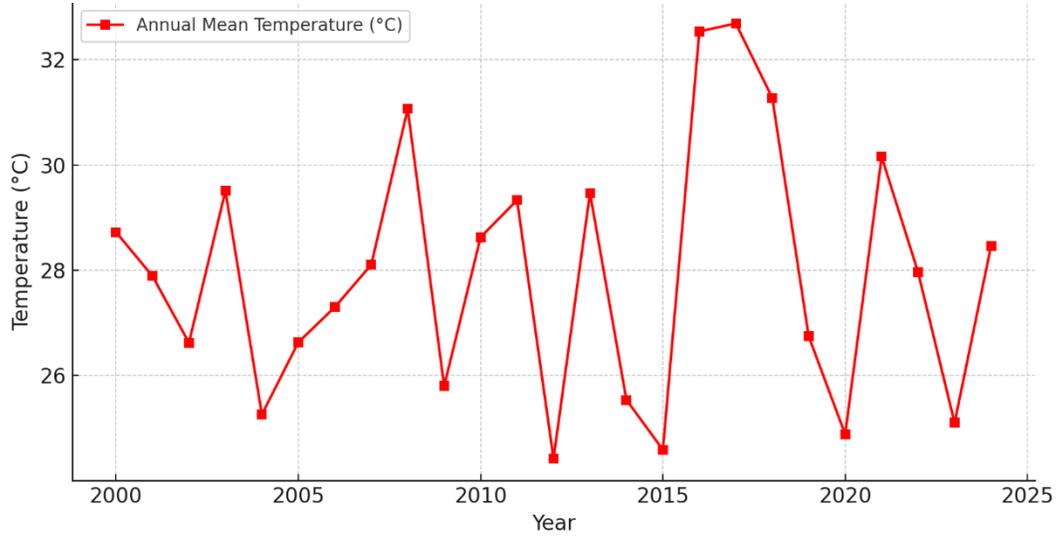


Figure 2.3: Annual temperature Chart of the Catchment (Source: World Bank Climate Change Portal, 2023)

### 2.2.3 Sunshine Duration

The region enjoys 6-9 hours of sunshine daily, especially during the dry season, leading to high evaporation rates and potential water loss. This climate significantly impacts crop growth and the choice of drought-resistant varieties.

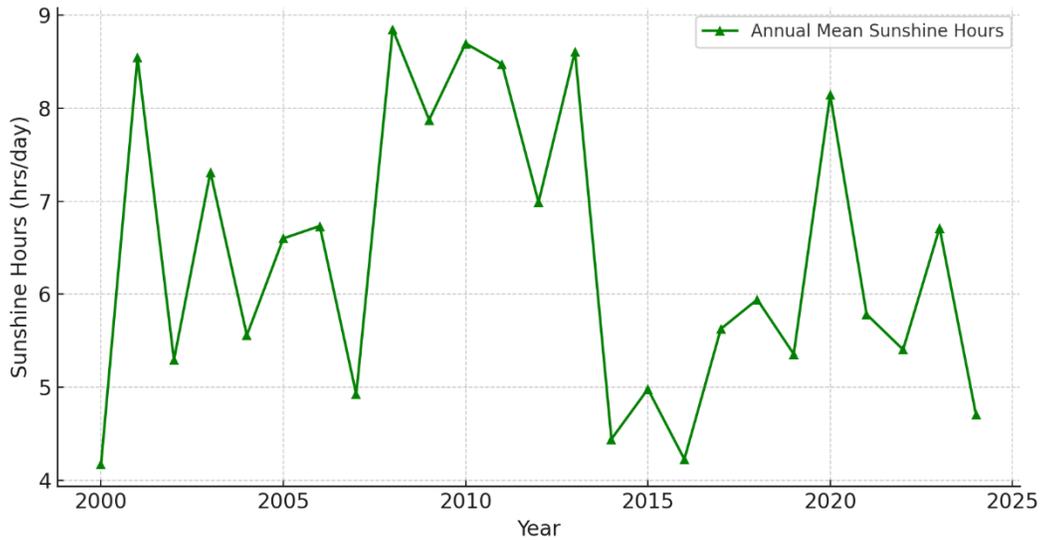


Figure 2.4: Annual Sunshine Duration Chart (Source: NIMET, 2024)

### 2.2.4 Relative Humidity

Humidity levels in the catchment fluctuate greatly between seasons. During the rainy season, humidity can reach 80-90% in the south due to dense vegetation, while the harmattan season sees levels drop to 20-30% in the north and central areas. These variations impact agriculture, water management, and human comfort.

During the dry season, particularly during Harmattan, humidity drops and the air becomes dry and dusty due to north-east trade winds, causing reduced visibility and cooler temperatures that impact transportation and outdoor activities.

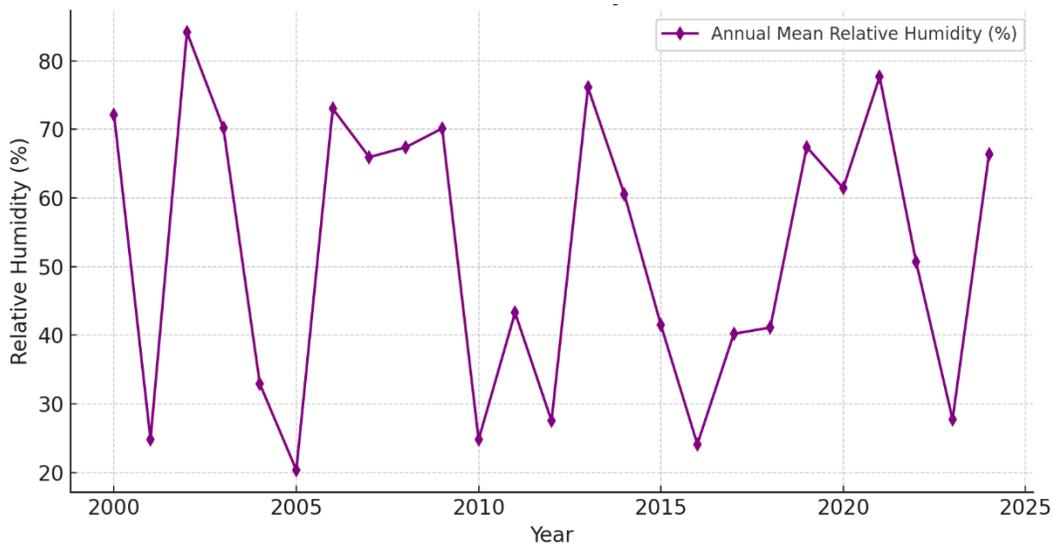


Figure 2.5: Annual Relative Humidity Chart (Source: World Bank Climate Change Portal, 2023)

## 2.3 Topography, Drainage, Geology and Soils

### 2.3.1 Topography

The landscape features savannah woodlands, grasslands, and hills. The terrain is mostly flat with some hills and valleys, characterized by highlands in the north and south and lowlands in the middle. Figure 2.6 shows the digital elevation model of the catchment area.

- The Jos Plateau in central Nigeria averages about 1,200 meters (3,937 feet) in height, with the Shere Hills reaching 1,829 meters (6,001 feet).
- This elevation provides a cool climate that differs from surrounding lowlands and supports the cultivation of crops like potatoes, vegetables, and fruits.
- The Mambilla Plateau in Taraba State is Nigeria's highest point, with elevations between 1,600 and 2,400 meters. Known as Nigeria's "highland paradise," it features a temperate climate and stunning landscapes [Olofin, 2018].
- The Mambilla Plateau is vital for agriculture and hydrology in the state, providing cooler temperatures and increased rainfall for temperate crops like tea, coffee, and potatoes. It also acts as a watershed for major rivers, including the Taraba River, which feeds into the Benue River [Olofin, 2018].

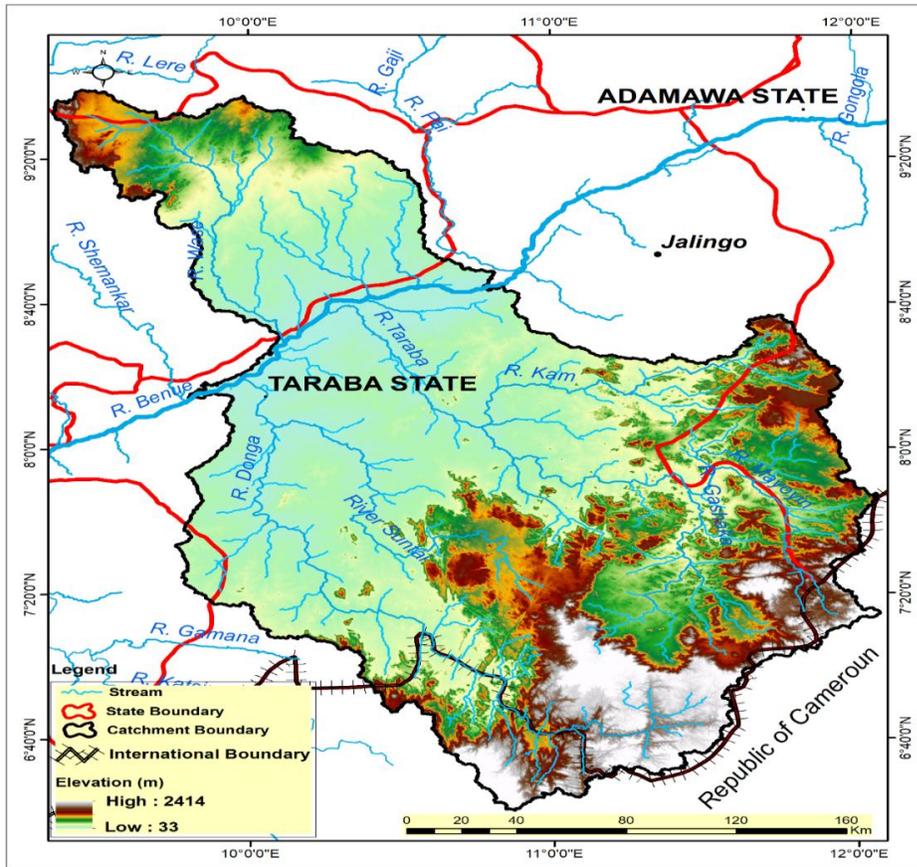


Figure 2.6: Digital Elevation Model of the Catchment (Source: MSL, 2024)

### 2.3.2 Drainage

The drainage system of the Wase-Taraba Catchment is complex, shaped by its diverse topography and geology. Key rivers, including Kaduna, Gongola, and Benue, flow from the Jos Plateau highlands into the Niger and Benue River basins (Eze & Abubakar, 2015). The drainage map is seen in fig 2.7, while the catchment map showing the recorded gauging stations is seen in figure 2.8 then the map of the meterological stations in fig 2.9 Below

#### States of Influence

1. Plateau
2. Taraba
3. Adamawa

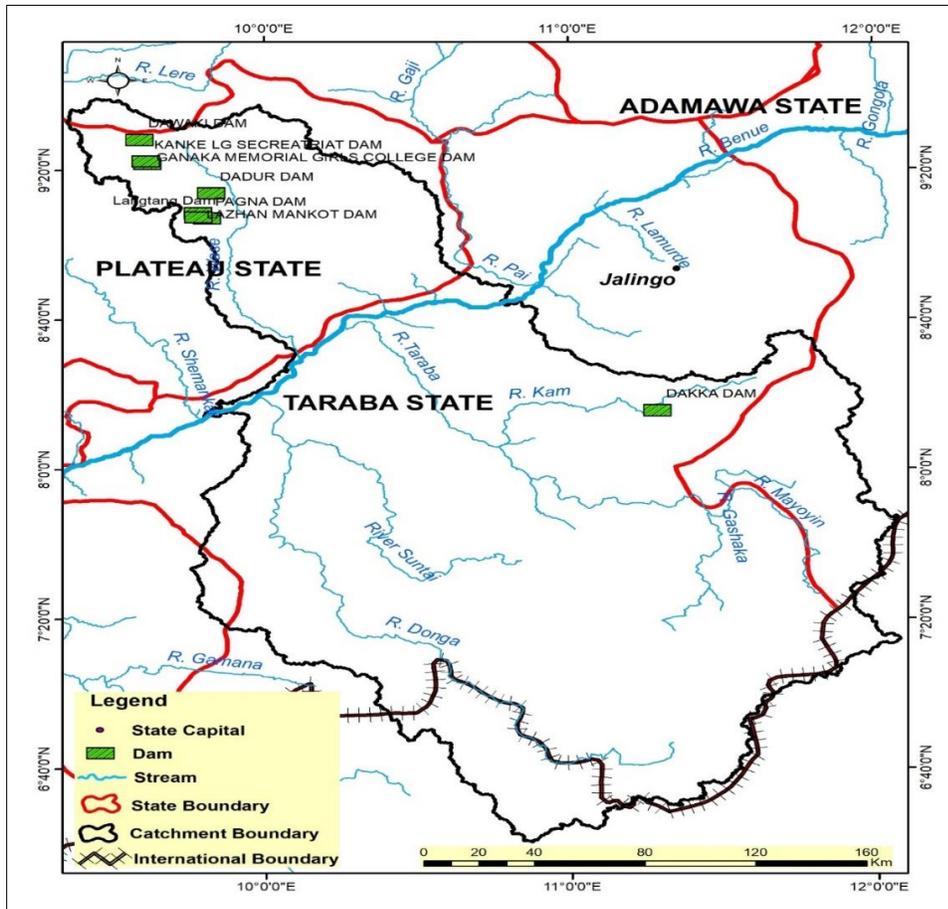


Figure 2.7: Drainage Map of Wase-Taraba Catchment (Source: MSL, 2024)

- In Taraba State, rivers like the Taraba, Donga, and their tributaries support agriculture, provide domestic water, and contribute to the Niger-Benue River Basin. The Taraba River is essential for irrigation and sustains both livestock and wildlife.
- Originating from the Mambilla Plateau, these rivers flow into fertile alluvial plains [Udo, 2020].

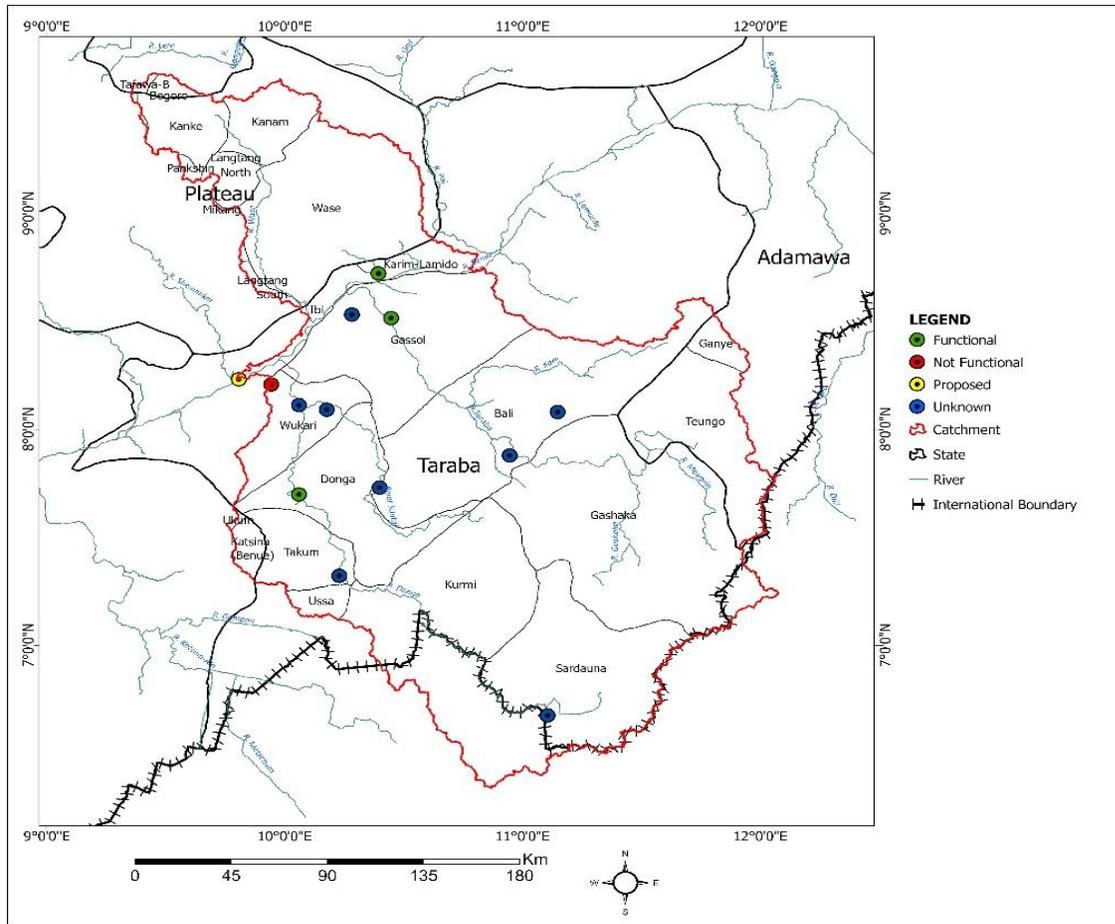


Figure 2.8: Map of the recorded gauging stations (Source: MSL, 2024)



- The rocks mainly consist of granites, gneisses, migmatites, and schists [Adeoye, 2013]. Large granite intrusions are prominent on the Jos Plateau, forming its core. These granites have weathered into rolling hills and inselbergs across the landscape.
- Taraba State's geology is significant as it lies in a transition zone between the Basement Complex and sedimentary basins, featuring diverse rocks from Precambrian formations to younger sedimentary deposits. This diversity impacts the state's natural resources and land use.

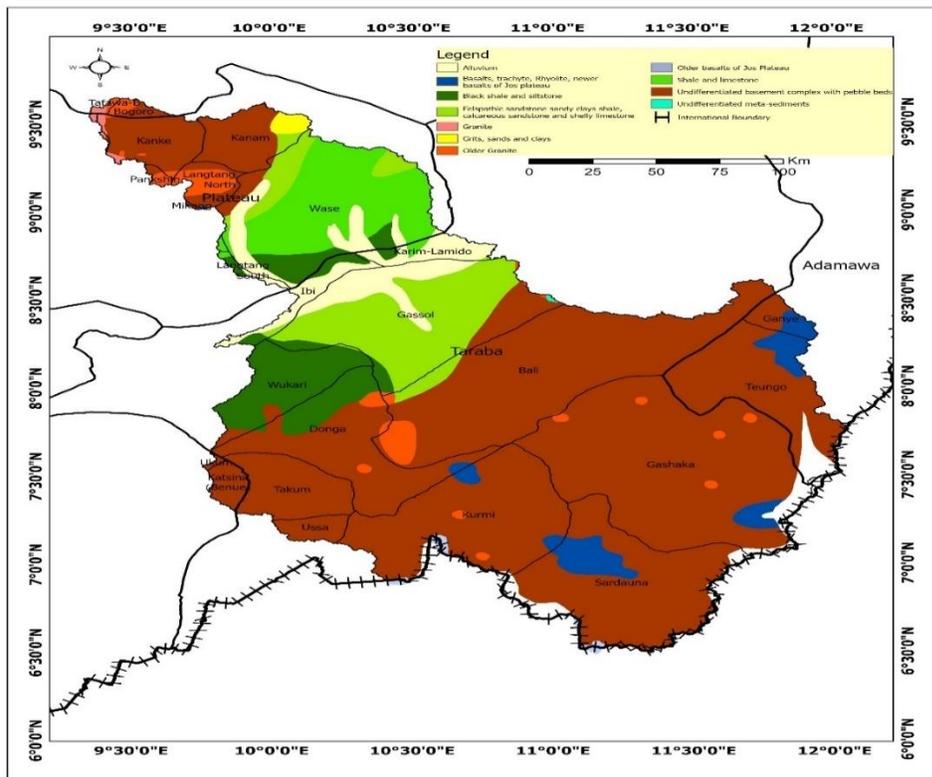


Figure 2.10: Geologic map of the catchment area (source: MSL, 2024)

### 2.3.3.2 Soils

- In the Wase-Taraba catchment, soils have been classified using the FAO framework, highlighting key factors like formation processes and landscape positions.

- This classification reveals primary soil types, including Vertisols and Arenosols, which affect water retention and nutrient availability.
- Understanding these properties aids in developing sustainable land-use practices, promoting optimal resource utilization and ecological resilience.
- The diverse geology of catchment gives rise to various soil types, each with distinct characteristics and suitability for different land uses.
- The soils can be broadly categorized into ferruginous tropical soils, hydromorphic soils, and volcanic soils.

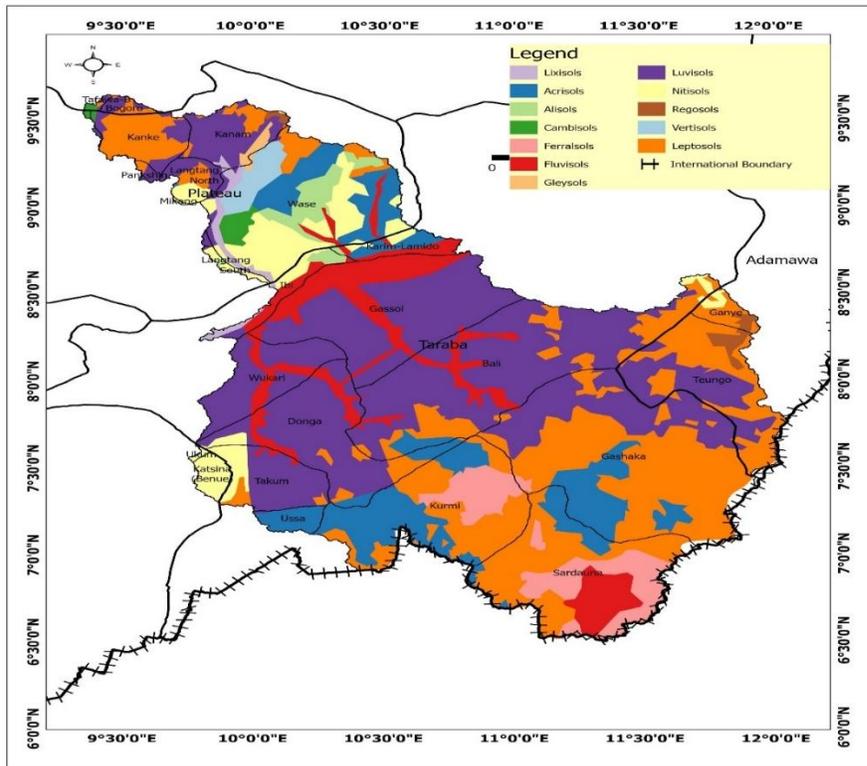


Figure 2.11: Soil Map of the catchment area (Source: MSL, 2024)

## 2.4 Land Use and Land Cover

- The land use and land cover in the catchment are shaped by its diverse topography, climate, and soil types.
- Human activities such as agriculture, mining, and urbanization have significantly transformed the natural landscape, leading to a variety of land use patterns across the state (Fig 2.12).

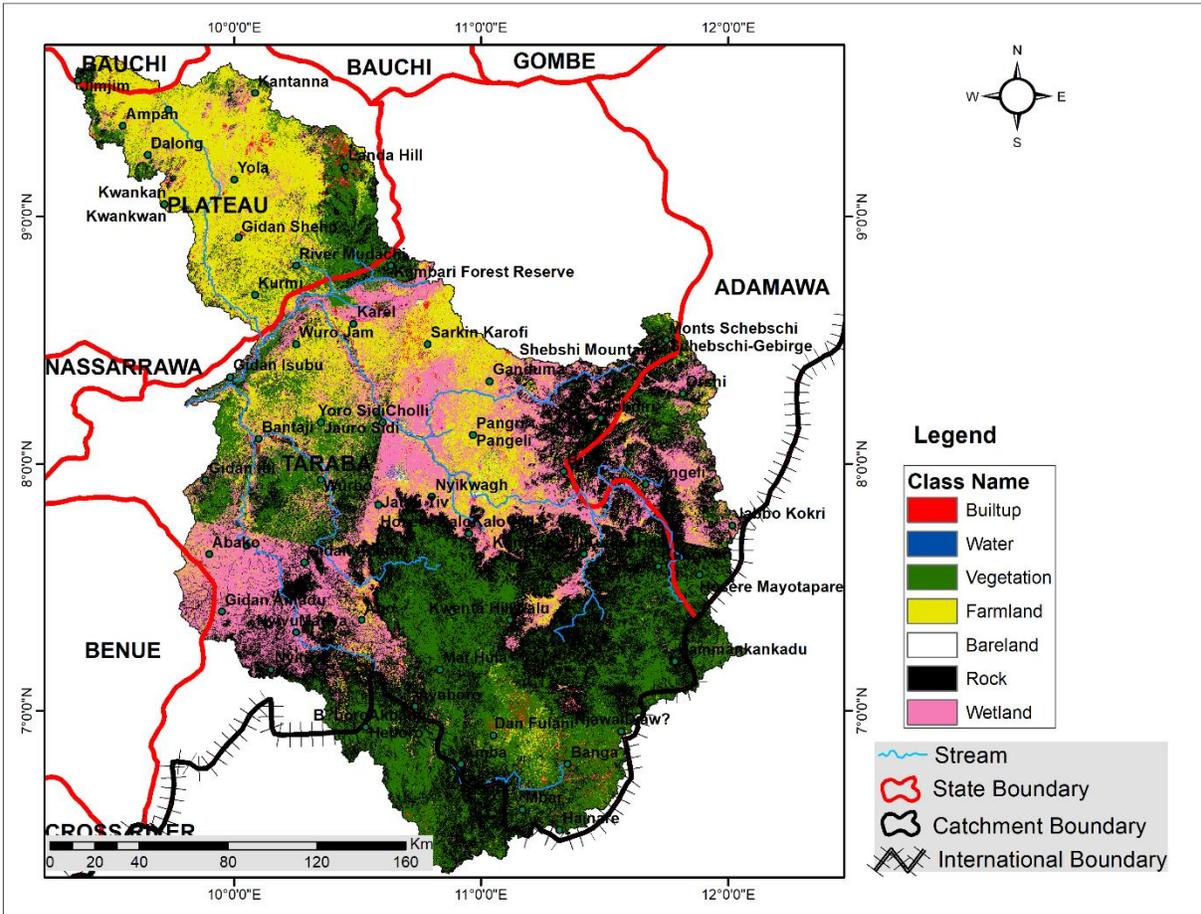


Figure 2.12: Land use/Land cover map of the catchment (Source: MSL, 2024)

### 2.4.1 Agricultural Land Use

- Agriculture is the primary land use in the region, with a focus on crop farming.
- The Jos Plateau's cooler climate supports diverse crops like cereals (maize, sorghum, millet), tubers (potatoes, yams), and legumes (beans, groundnuts).
- The highland areas around Jos are particularly known for growing vegetables such as tomatoes, cabbage, and carrots for local and broader markets.
- In northern Taraba state, farmers primarily grow millet, sorghum, and maize, while the southern and central regions, with richer soils, are suited for crops like yam, cassava, rice, and groundnuts.
- The catchment is also an important area for livestock farming, particularly cattle, sheep, and goats.
- The vast grasslands and open savannas provide ample grazing grounds. Livestock farming is particularly prominent among the pastoral Fulani communities, who practice transhumance, moving their herds seasonally in search of pasture and water [Udo, 1994].

### 2.4.2 Mining Activities

Mining has significantly impacted the Jos Plateau region, historically a major producer of tin and columbite. Extensive activities have created mine pits, spoil heaps, and tailings, altering the landscape and drainage patterns [Oyeniya & Hassan, 2018].

### 2.4.3 Forestry and Conservation

- Conservation efforts in the catchment aim to preserve natural vegetation and protect the environment from degradation.
- It features savanna grasslands in the lowlands and montane forests in the highlands.
- The catchment includes several protected areas like Pandam Wildlife Park, Jos Wildlife Park, and Gashaka-Gumti National Park in eastern Taraba state.
- These reserves are essential for conserving biodiversity and promoting eco-tourism, protecting wildlife such as primates, elephants, and rare birds. However, issues like encroachment, poaching, and logging pose significant threats to their management [Ezekiel, 2017].

- Extensive forests in the southern and eastern regions include tropical rainforests and savanna woodlands. They offer vital ecosystem services like biodiversity conservation, carbon sequestration, and provide timber and non-timber products.

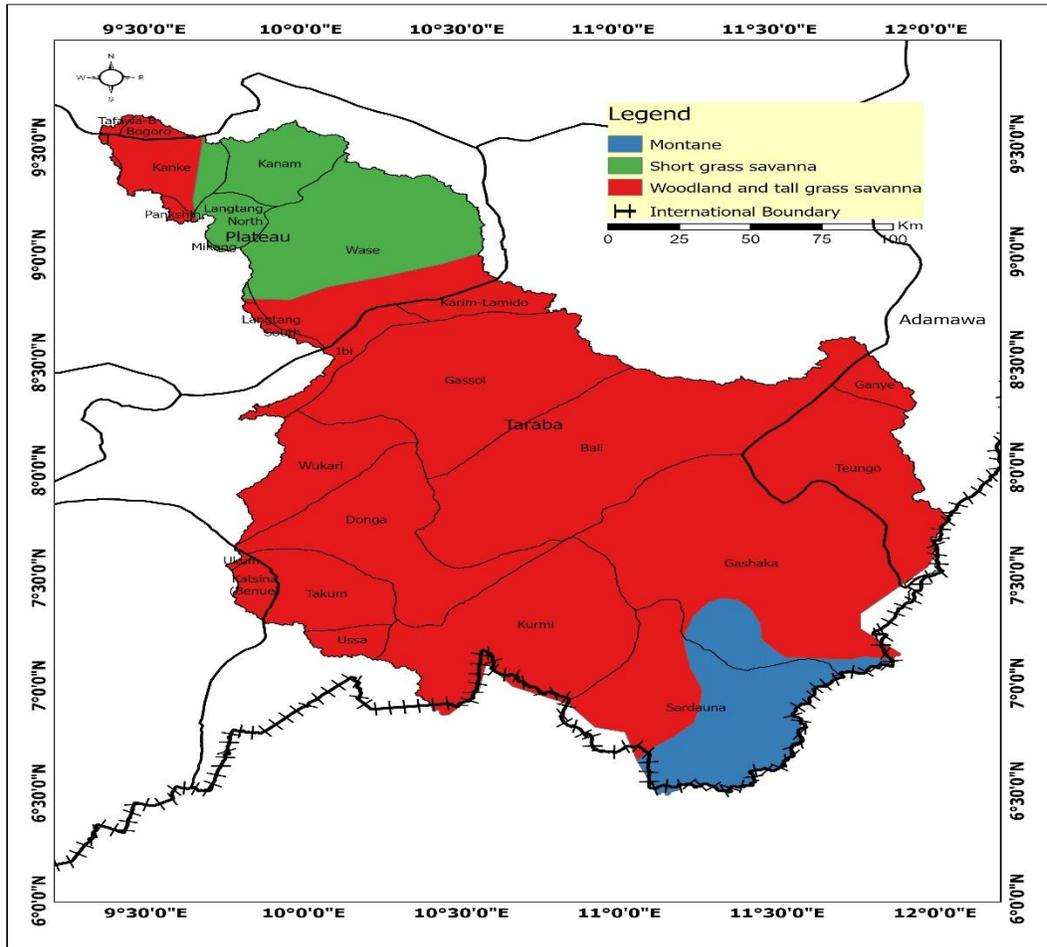


Figure 2.13: Vegetation cover in the catchment area (Source: Mecon Services, 2024)

### 2.4.4 Urbanization and Infrastructure Development

- Urban growth significantly impacts land use in catchments, particularly in state capitals that have evolved into major urban centers for administrative, commercial, and educational purposes.
- This expansion has converted agricultural land and natural vegetation into residential, commercial, and industrial zones [Adeoye, 2013].

- The development of infrastructure, including roads, schools, hospitals, and markets, has also influenced land use patterns in the catchment. Improved road networks have facilitated access to remote areas, leading to the expansion of agricultural activities and the establishment of new settlements [Udo, 1994].

## 2.4.5 Biodiversity

Table 2.1: Biodiversity Summary Table – Wase-Taraba Catchment

| <b>Ecosystem Type</b>                      | <b>Key Flora and Fauna</b>   | <b>Ecosystem Services</b>                                    | <b>Conservation Challenges</b>                | <b>Location</b>                     |
|--|--|--|---|-------------------------------------|
| <b>Savanna Woodland</b>                    | Shea tree ( <i>Vitellaria paradoxa</i> ), baobab, tamarind, antelope, warthog, ground squirrel                   | Fuelwood, grazing, NTFPs, cultural uses                      | Overgrazing, bush burning, deforestation      | Plateau & Taraba                    |
| <b>Montane Forests</b>                     | Mambilla monkey ( <i>Cercopithecus campbelli</i> ), olive pigeon, civets, mosses, ferns                          | Carbon storage, endemic species habitat, climate regulation  | Logging, encroachment, hunting                | Jos Plateau & Mambilla              |
| <b>Riparian Forests</b>                    | Raffia palm, <i>Ficus</i> spp., herons, kingfishers, African clawless otter                                      | Erosion control, habitat corridor, water filtration          | Pollution, deforestation                      | Plateau & Taraba                    |
| <b>Wetlands and Floodplains</b>            | Amphibians, migratory birds, aquatic plants ( <i>Phragmites</i> , <i>Cyperus</i> ), fish (e.g. tilapia, catfish) | Groundwater recharge, flood mitigation, habitat for wildlife | Agriculture encroachment, wetland degradation | Wase Wetlands, Taraba               |
| <b>Game Reserves &amp; Protected Areas</b> | Elephants, antelopes, monkeys, rare birds (e.g., in Ngel Yaki GR), Nigerian mole-                                | Biodiversity conservation, ecotourism, cultural values       | Poaching, habitat loss, poor enforcement      | Gashaka Gumti NP, Gyanyaki GR, Ngel |

|                               |  |  |  |                                    |
|-------------------------------|--|--|--|------------------------------------|
|                               | rat, Plateau indigo snake  |  |  | Yaki GR, Jos Wildlife Park         |
| <b>Lakes &amp; Reservoirs</b> | Amphibians, fish, aquatic birds (e.g., ducks, cormorants), aquatic plants            | Fisheries, water supply, irrigation, migratory bird habitat            | Overfishing, invasive species, pollution     | Lamingo Dam, Kura Falls, Tunga Dam |
| <b>Forest Ecosystems</b>      | Endemic plants in Jos Plateau highlands, medicinal plants, fuelwood species          | Timber, NTFPs, carbon sequestration, spiritual and recreational values | Logging, farmland expansion                  | Plateau State                      |
| <b>Cultural Landscapes</b>    | Sacred groves, culturally significant species (e.g., baobab), ritual flora and fauna | Cultural identity, tourism, recreation                                 | Modernization, loss of traditional knowledge | Plateau & Taraba                   |

Table 2.2: Special Biodiversity Conservation Zones in the Catchment

| Protected Site                     | Description & Significance   |
|------------------------------------|--|
| <b>Gashaka-Gumti National Park</b> | Nigeria’s largest national park, rich in flora and fauna diversity, including chimpanzees, leopards, and elephants.        |
| <b>Mambilla Plateau</b>            | Biodiversity hotspot with montane forests and endemic species; crucial for eco-climatic stability in the Taraba Highlands. |
| <b>Gyanyaki Game Reserve</b>       | Located in Sardauna LGA, Taraba – supports wildlife conservation and local tourism.  |
| <b>Ngel Yaki Game Reserve</b>      | Known for diverse bird species and small mammals; critical for birdwatching and avian migration studies.                   |
| <b>Jos Wildlife Park</b>           | Plateau’s major conservation facility; houses various indigenous species and supports public environmental education.      |

## 2.5 Hydrology and Water Resources

### 2.5.1 Hydrology

The Wase-Taraba catchment features numerous rivers and water bodies essential for its hydrology, supporting agriculture, domestic water supply, and hydroelectric power generation. Its hydrology is shaped by river systems, floodplains, and these water bodies.

**River Systems:** The catchment is traversed by several major rivers, including the Kaduna River, the Gongola River, the Hadejia-Jama'are River and the Benue River and its numerous tributaries.

- These rivers originate from the Jos Plateau and flow through various parts of the state, providing water for irrigation, fishing, and other economic activities [Olanrewaju *et al.*, 2017].
- The rivers are fed by numerous smaller streams and tributaries, which are replenished during the wet season.
- The Kaduna River, in particular, is a significant watercourse that flows southwestward and is a major tributary of the Niger River.
- Several important tributaries feed into the Benue River in Taraba State. These include the Donga River, Taraba River, and Katsina-Ala River, all of which contribute to the hydrological complexity of the region. [Adakole, 2000].

**Dams and Reservoirs:** The catchment has several dams and reservoirs that play a crucial role in water storage and regulation.

- The Lamingo Dam, located near Jos, is one of the major reservoirs in the catchment, providing water for domestic and agricultural use.
- Other notable dams include the Kura Falls Dam and the Pankshin Dam, which also support irrigation and water supply [Ayuba & Shehu, 2016]. These dams are critical for managing water resources in the state, particularly during the dry season when river flows decrease.

**Floodplains, Wetlands and Lakes:** The catchment is also home to floodplains, wetlands and small lakes, which provide important habitats for wildlife and support biodiversity.

Flood risks in the catchment are worsened by climate change and human activities, increasing vulnerability for communities, especially those in low-lying areas. Protecting these populations and integrating flood control measures into development strategies are key priorities in the management plan.

- The extensive floodplains of the Benue River and its tributaries create wetland ecosystems that are rich in biodiversity and provide essential ecosystem services.
- These floodplains support a variety of plant and animal species, including migratory birds, fish, and amphibians.
- Wetland areas such as the Donga River basin are important for flood control, groundwater recharge, and carbon sequestration [Adakole, 2000].
- The Pandam Wildlife Park, located in the southern part of Plateau state, includes a large wetland area that is important for birdlife and other species. These wetlands are also crucial for groundwater recharge and flood mitigation [Obot et al., 2016].

## 2.5.2 Hydrograph/Water Budget of The Catchment

The Wase Taraba strategic catchment consists of primarily three independent river systems namely, Wase to the northeast of the Rive Benue and Donga and Taraba to the southwest of the River Benue, but they all empty into the Benue. The hydrology of each will be presented and then summarized for the strategic catchment.

### 2.5.2.1 Wase Catchment

- As illustrated in Figures 2.14 to 2.18, a distinct seasonal discharge pattern emerges. The rising limb of the hydrograph begins in March, reaching peak discharge by August. Subsequently, a gradual decline in discharge occurs in September, followed by a sharper reduction from October to November as rainfall diminishes, transitioning to dry-season baseflow sustained by groundwater.
- Discharge remains significantly reduced between November and April, relying primarily on groundwater contributions and ephemeral streams.
- The catchment exhibits five months of water surplus, with an average water budget of 177.61 mm.
- This modest surplus suggests limited long-term water storage capacity. Consequently, prioritizing alternative water supply interventions—such as enhanced groundwater management or rainwater harvesting—is critical to ensure sustainable water availability in this catchment.

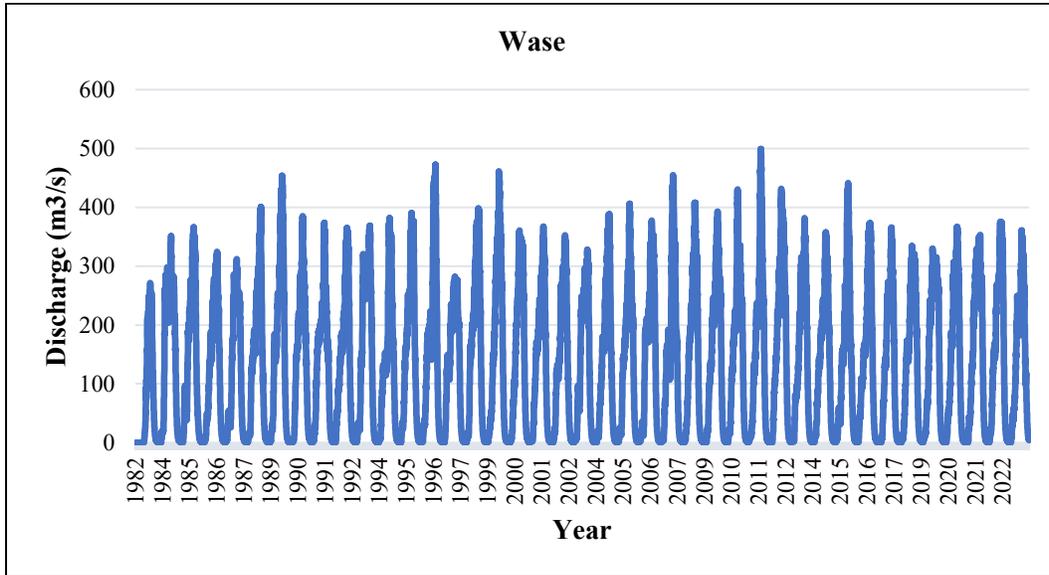


Figure 2.14: Hydrograph of Wase Catchment Based on HEC-HMS modelling for Strategic catchment.

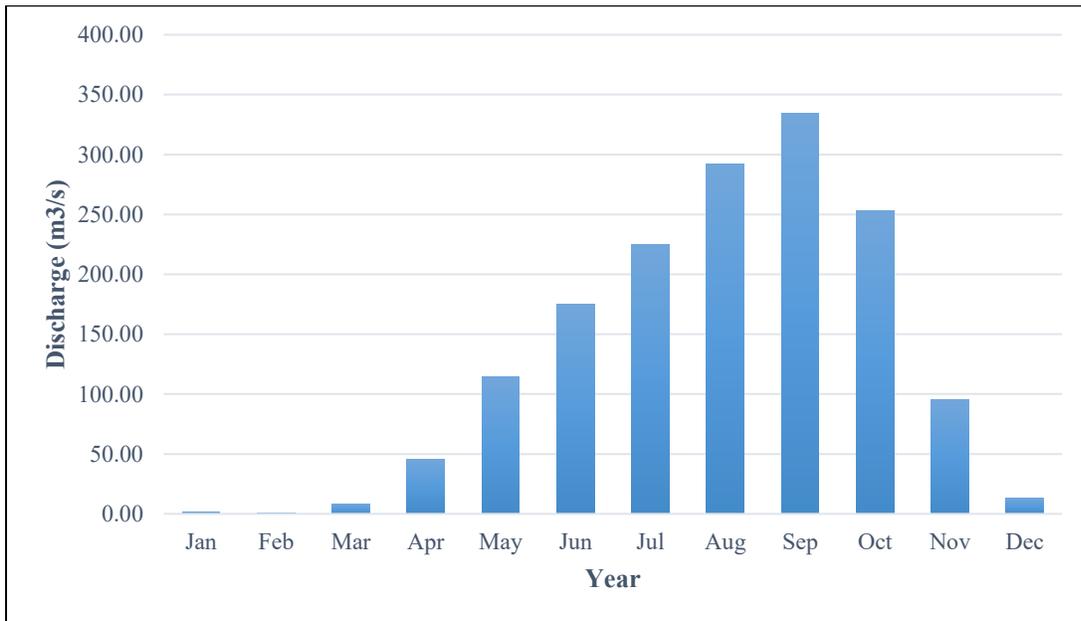


Figure 2.15: 40 - Year Summary Hydrograph of Wase Catchment

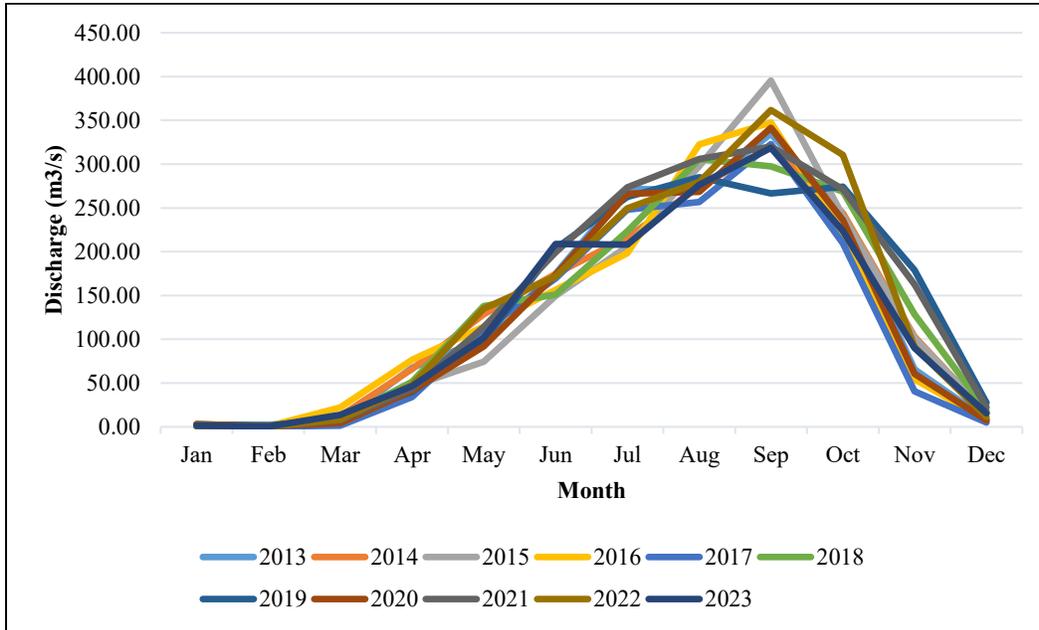


Figure 2.16: Hydrograph of Wase Catchment for Specific Years

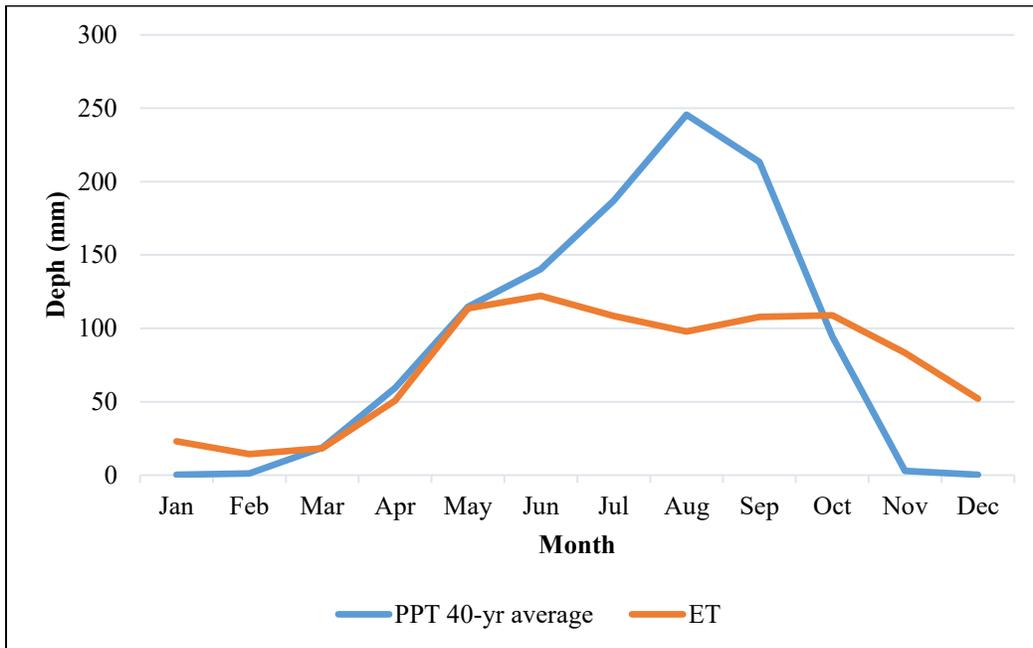


Figure 2.17: Water Budget for Wase Catchment

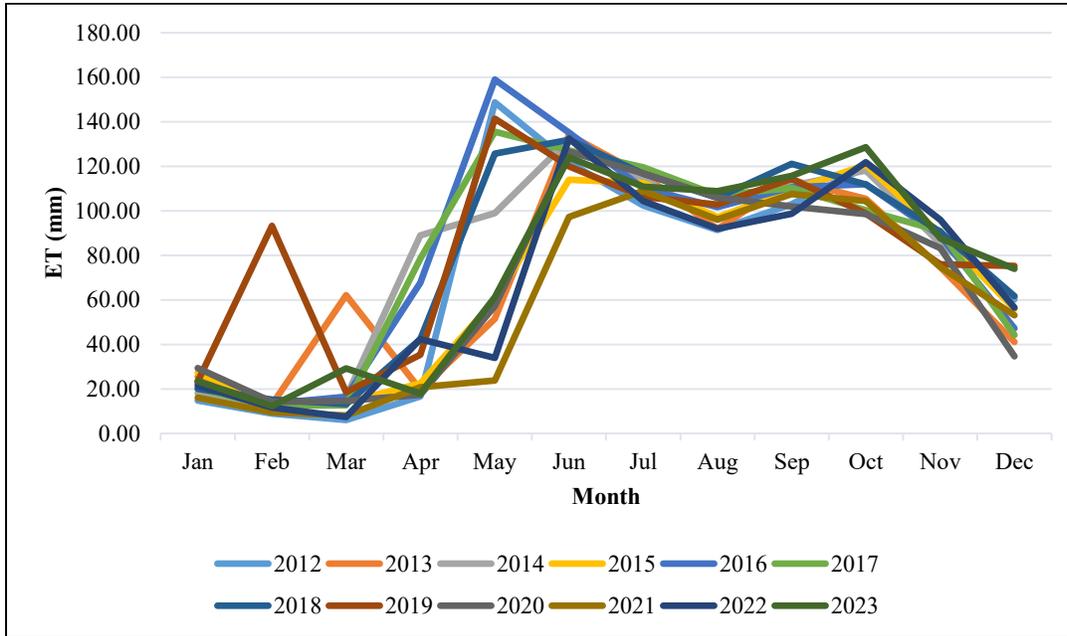


Figure 2.18: Monthly Actual Evapotranspiration Distribution for Wase Catchment

Source: TerraClimate

Table 2.3: Summary of Discharge, Rainfall and Evapotranspiration Data for WASE Catchment

| Month | PPT 40-yr average (mm) | ET (mm) | Discharge M3/s |
|-------|------------------------|---------|----------------|
| Jan   | 0.34                   | 23.02   | 1.70           |
| Feb   | 1.05                   | 14.32   | 0.77           |
| Mar   | 18.76                  | 18.29   | 8.59           |
| Apr   | 59.37                  | 50.85   | 45.74          |
| May   | 114.70                 | 113.57  | 114.63         |
| Jun   | 140.45                 | 122.19  | 174.86         |
| Jul   | 186.87                 | 108.51  | 224.77         |
| Aug   | 245.63                 | 97.83   | 291.97         |

|     |        |        |        |
|-----|--------|--------|--------|
| Sep | 213.33 | 107.90 | 334.11 |
| Oct | 94.37  | 108.80 | 253.43 |
| Nov | 2.88   | 83.42  | 95.64  |
| Dec | 0.24   | 52.09  | 13.42  |

### 2.5.2.2 Donga Catchment

- The hydrograph and water-budget graph of the Donga catchment reveal a seasonal flow pattern typical of Nigerian hydrological regimes. Unlike the previously analyzed catchments, Donga experiences four months of minimal to no rainfall (January–March and November–December) followed by eight months of sustained flow.
- Discharge begins rising steadily in March, peaks in September, and undergoes a rapid two-month recession (September–October) as flows diminish. Evapotranspiration dominates during the dry seasons, while precipitation persists for eight months, generating a substantial water surplus.
- The catchment’s notably large water budget of 754.91 mm highlights abundant water availability even during seasonal deficits, underscoring its resilience to short-term dry spells.

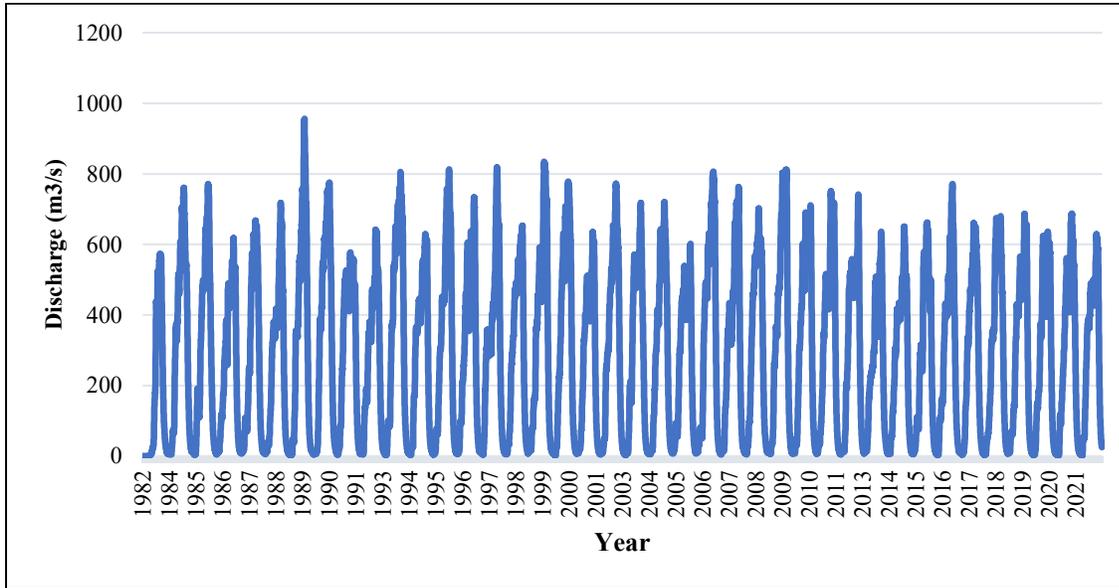


Figure 2.19: Hydrograph of Donga Catchment Based on HEC-HMS modelling for Strategic catchment.

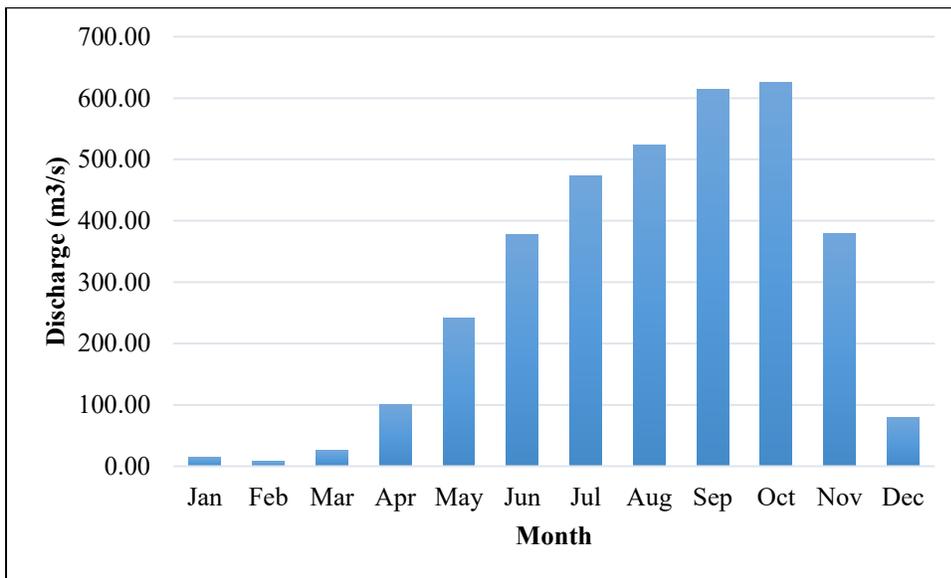


Figure 2.20: 40 - Year Summary Hydrograph of Donga Catchment

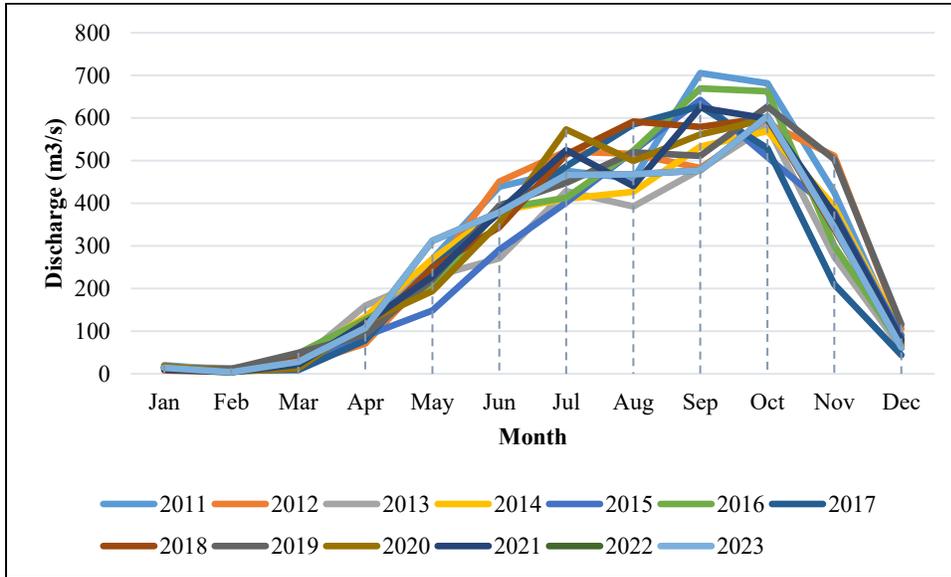


Figure 2.21: Hydrograph of Donga Catchment for Specific Years

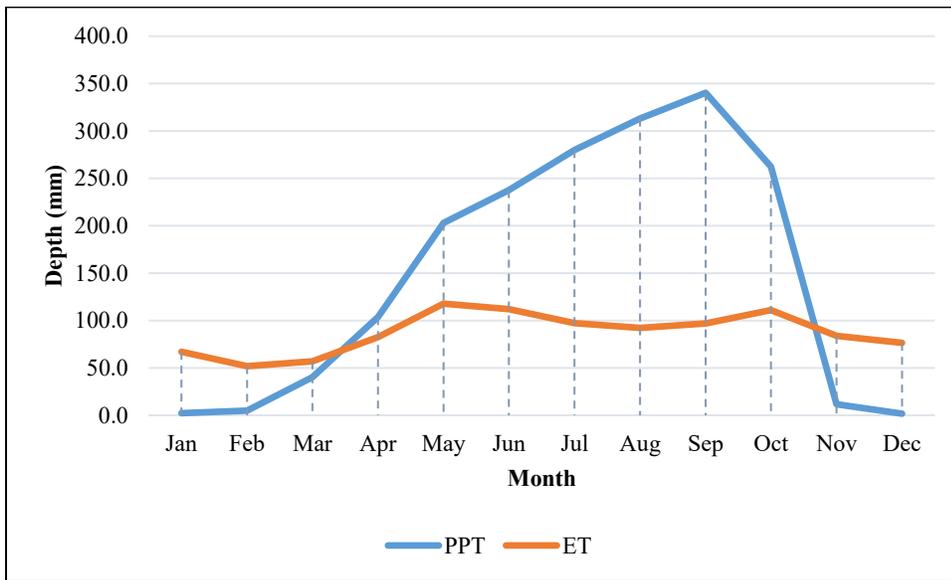


Figure 2.22: Water Budget for Donga Catchment

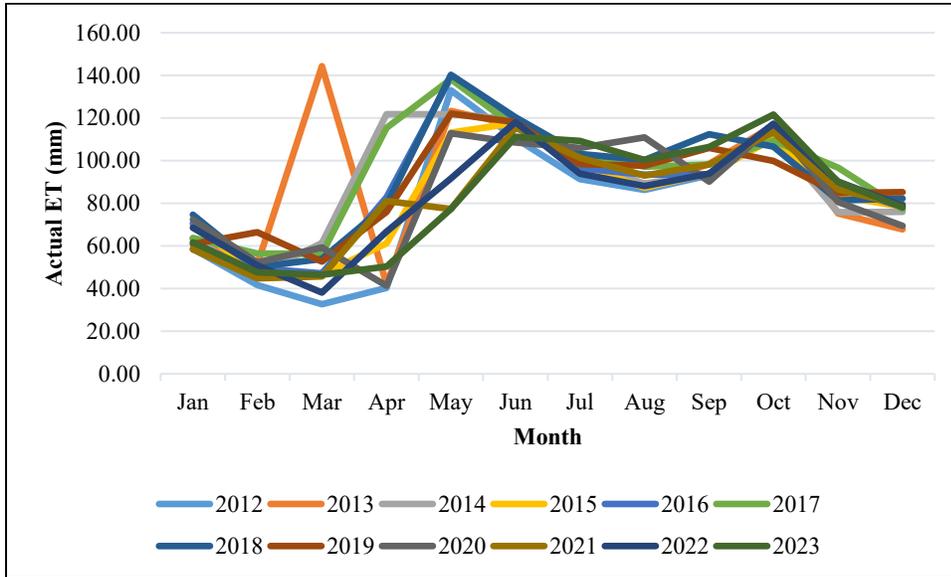


Figure 2.23: Monthly Actual Evapotranspiration Distribution for Donga Catchment

Source: TerraClimate

Table 2.4: Summary of Rainfall and Evapotranspiration Data for DONGA Strategic Catchment

| Month | PPT   | ET     | Discharge |
|-------|-------|--------|-----------|
| Jan   | 2.3   | 66.98  | 14.65     |
| Feb   | 5.0   | 51.82  | 7.57      |
| Mar   | 40.3  | 57.04  | 25.47     |
| Apr   | 103.6 | 82.37  | 99.93     |
| May   | 202.9 | 117.78 | 241.51    |
| Jun   | 237.4 | 112.07 | 377.51    |
| Jul   | 279.9 | 97.25  | 473.29    |
| Aug   | 313.0 | 92.11  | 523.81    |
| Sep   | 340.3 | 96.80  | 614.10    |
| Oct   | 262.3 | 110.90 | 625.97    |

|     |      |       |        |
|-----|------|-------|--------|
| Nov | 11.8 | 83.93 | 378.80 |
| Dec | 1.7  | 76.54 | 79.46  |

### 2.5.2.3 Taraba Catchment

- The Taraba catchment’s hydrograph and water budget (Figures 2.24–2.28) exhibit a consistent seasonal pattern, characterized by four months of minimal to no discharge (November–February) followed by eight months of active precipitation-driven flow (March–October). Unlike other catchments, Taraba’s peak discharge occurs in September, followed by a sharp recession from October to November.
- The water budget graph (Figure 2.27) reveals brief periods of evapotranspiration dominance (January–March and November–December), contrasting with eight months of elevated runoff.
- This prolonged water surplus—culminating in a notably high water budget of 810.16 mm—supports year-round agricultural productivity in the region.

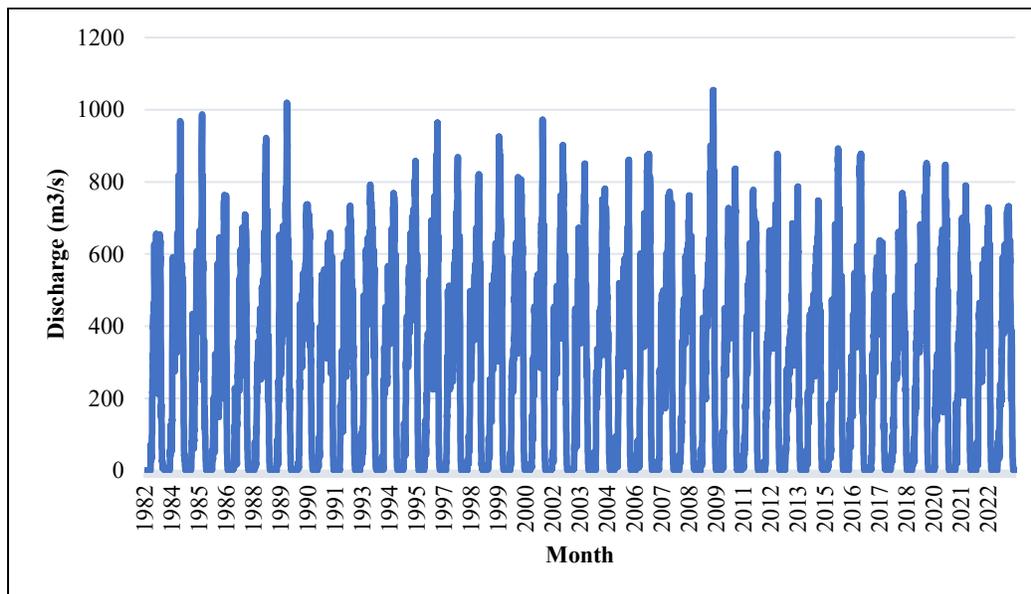


Figure 2.24: Hydrograph of Taraba Catchment Based on HEC-HMS modelling for Strategic catchment.

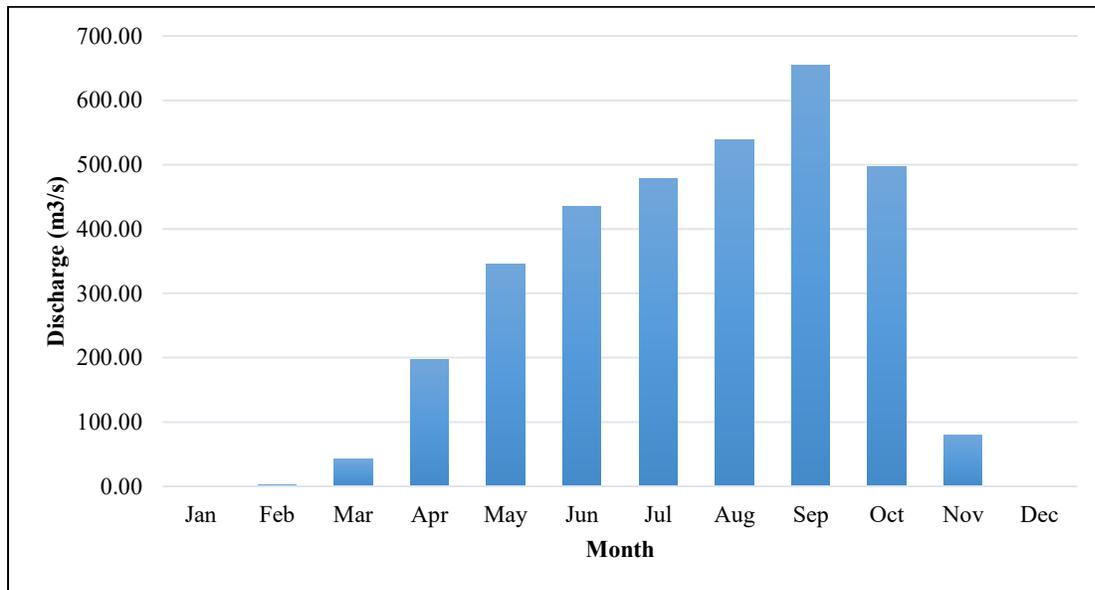


Figure 2.25: 40 - Year Summary Hydrograph of Taraba Catchment

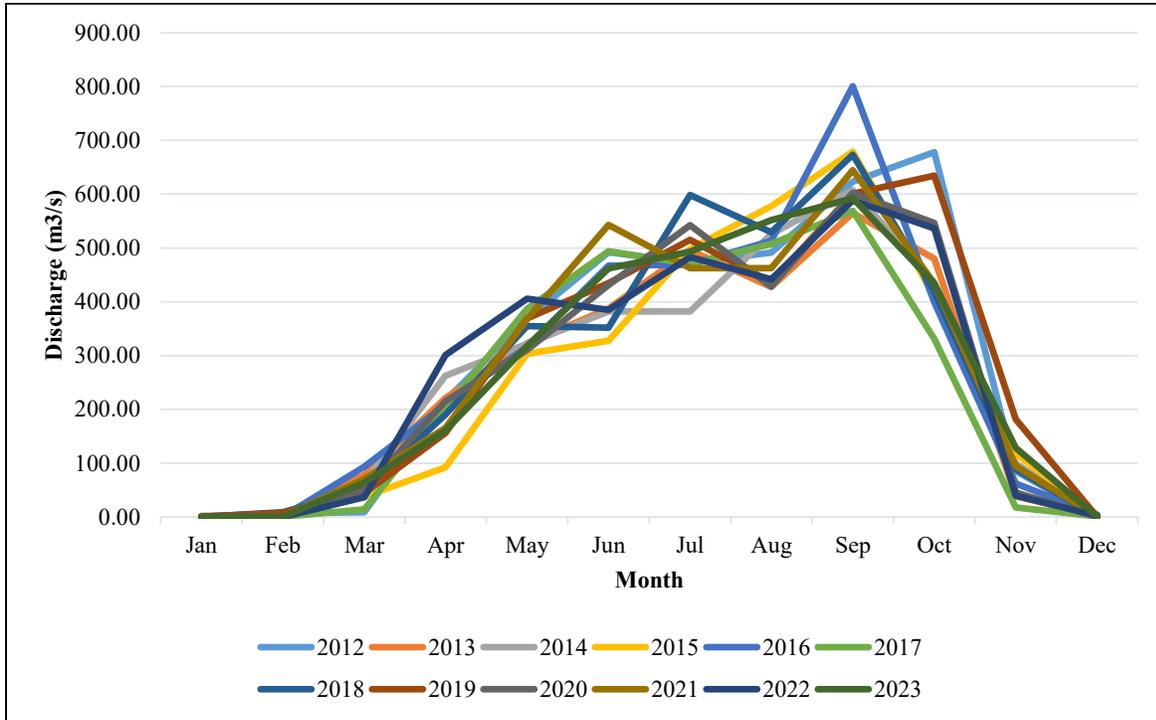


Figure 2.26: Hydrograph of Taraba Catchment for Specific Years

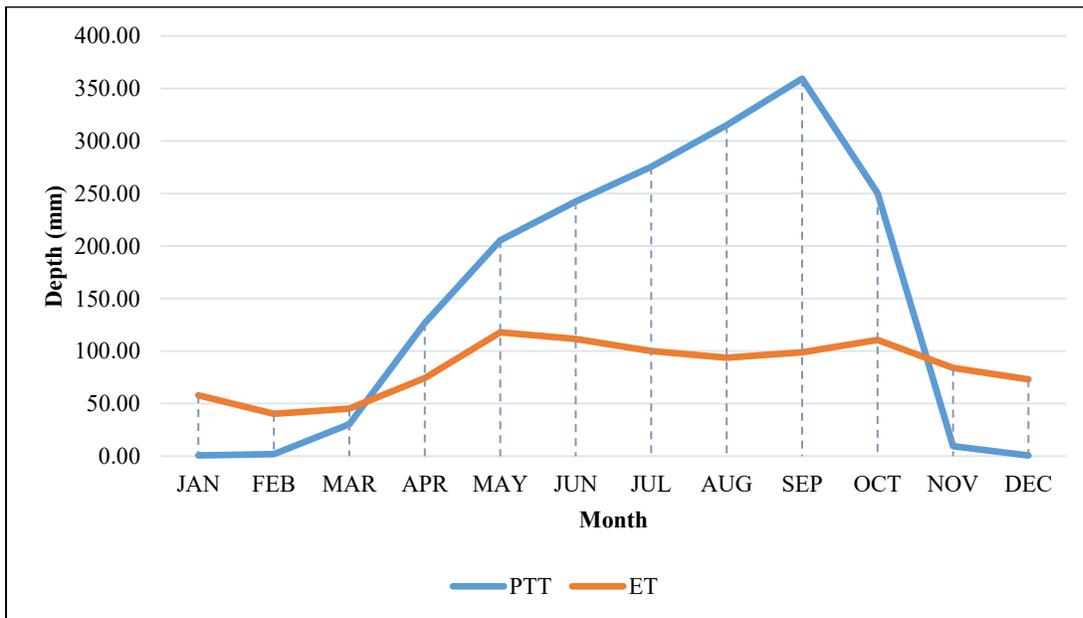


Figure 2.27: Water Budget for Taraba Catchment

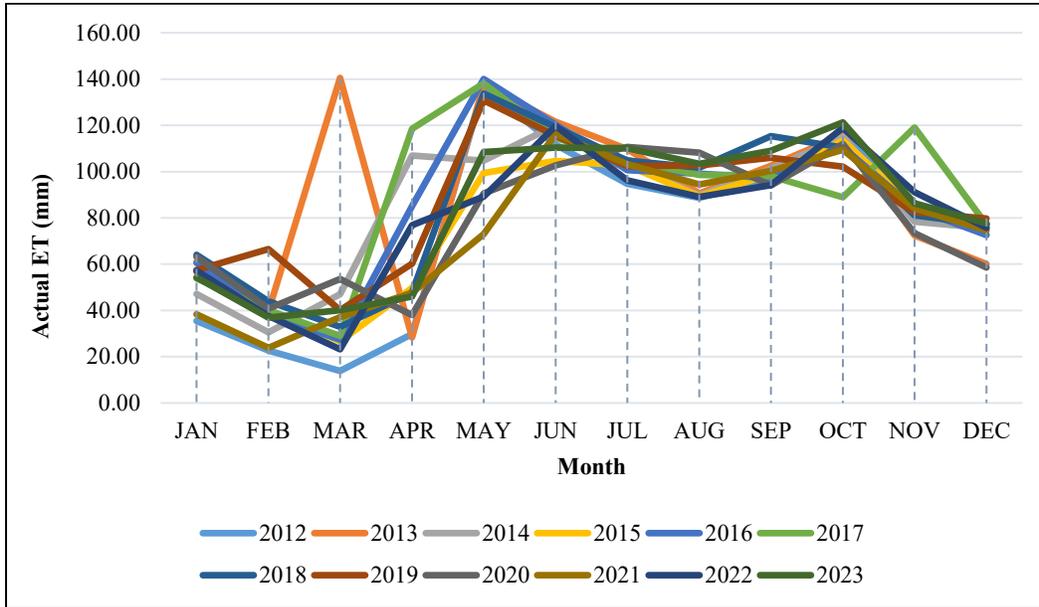


Figure 2.28: Monthly Actual Evapotranspiration Distribution for Taraba Catchment

Table 2.5: Summary of Discharge, Rainfall and Evapotranspiration Data for TARABA Strategic Catchment

| Month | PPT    | ET     | DISCHARGE |
|-------|--------|--------|-----------|
| JAN   | 0.74   | 57.96  | 0.96      |
| FEB   | 1.98   | 40.31  | 2.79      |
| MAR   | 30.43  | 45.12  | 42.09     |
| APR   | 126.88 | 74.43  | 196.63    |
| MAY   | 205.49 | 117.90 | 345.37    |
| JUN   | 242.34 | 111.71 | 434.31    |
| JUL   | 275.58 | 100.08 | 478.81    |
| AUG   | 315.02 | 93.57  | 538.41    |
| SEP   | 359.38 | 98.93  | 653.84    |
| OCT   | 250.34 | 110.83 | 497.46    |

|     |      |       |       |
|-----|------|-------|-------|
| NOV | 9.61 | 84.16 | 80.09 |
| DEC | 0.65 | 73.26 | 1.35  |

**2.5.2.4 Wase-Taraba Strategic Catchment Summary**

- The Wase-Taraba strategic catchment—comprising three sub-catchments—displays distinct seasonal hydrologic characteristics.
- Both its hydrograph and water budget graph (Figures 2.29 and 2.30) exhibit a cyclical pattern, with peak discharge occurring in September after seven months of sustained flow (March–September).
- This is followed by a rapid two-month recession (October–November). The catchment experiences an eight-month water surplus period (March–October) contrasted with a four-month water deficit (November–February), suggesting sufficient storage capacity to buffer seasonal shortages.
- With a water budget of 620.90 mm, the catchment retains adequate water reserves to support year-round agricultural and municipal demands.

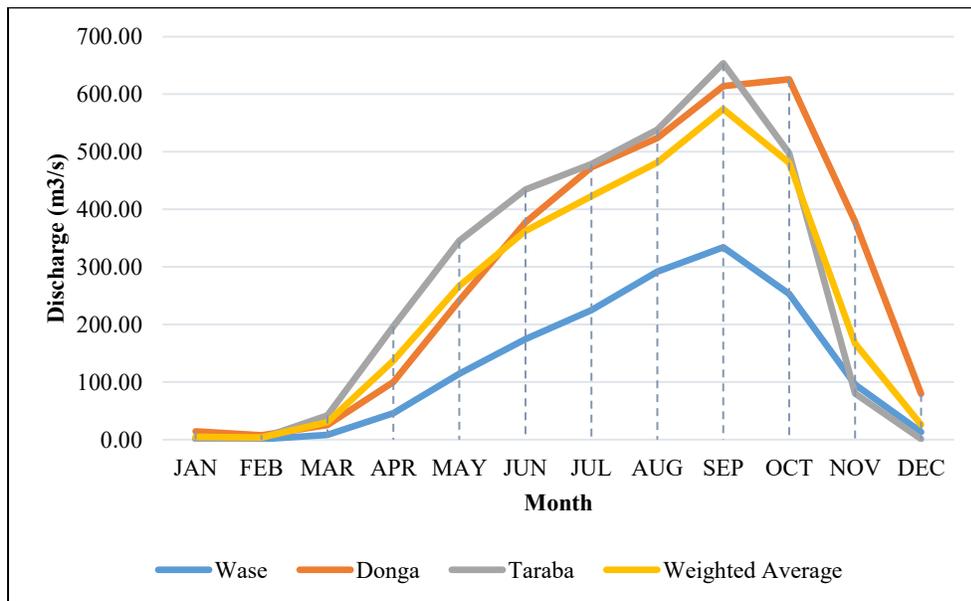


Figure 2.29: Hydrograph of Taraba Strategic Catchment for Specific Years

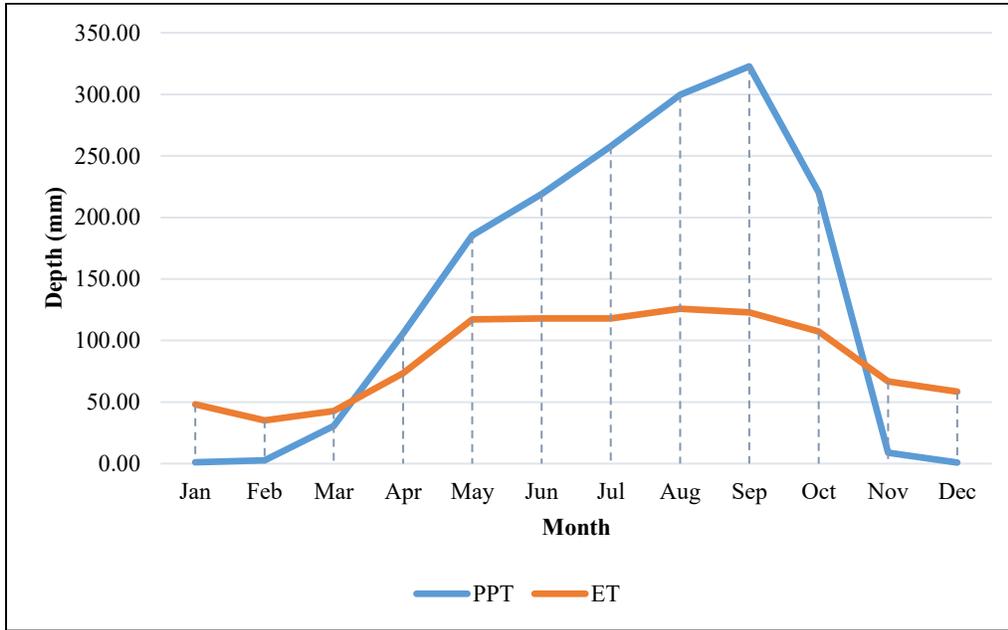


Figure 2.30: Water Budget for Taraba Strategic Catchment

### Prospects

Based on the hydrological characteristics of the Wase-Taraba strategic catchment (8-month water surplus, 4-month deficit, and a water budget of **620.90 mm**), there are promising prospects for sustainable agricultural water management.

1. **High Water Budget (620.90 mm):** Indicates sufficient water reserves to sustain **supplemental irrigation** during short dry spells within the wet season. It also allows for **water storage infrastructure** (e.g., small reservoirs, check dams, or farm ponds) to capture peak flows (September) for use during the 4-month deficit (November–February).

2. **Rapid Recession (October–November):** Strategic harvesting of late-season rains (September–October) can extend water availability for early dry-season crops (e.g., vegetables, and legumes).

#### 2.5.2.5 Water Resources Assessment in the Catchment

- The Wase-Taraba catchment is defined by its numerous rivers and streams, which are essential for agriculture, fishing, and domestic use.
- The Wase River and its tributaries provide the primary water source for irrigation, sustaining year-round farming activities.
- The wetlands, provide critical habitats for wildlife and serve as important grazing areas for livestock.
- The region also has significant groundwater reserves, which are tapped through wells and boreholes to provide water for drinking, irrigation, and livestock, particularly during the dry season

#### 2.5.2.6 Stream Flow and Seasonal Variability

- The hydrology of the catchment is characterized by seasonal variations in stream flow and discharge, which are closely linked to the state's rainfall patterns.
- During the wet season, rivers and streams experience high flows due to the influx of rainwater, while the dry season is marked by reduced flows and in some cases, the drying up of smaller streams

##### a. **Wet Season Flows:**

- The wet season, from April to October, is the period of peak flow for most rivers and streams in the catchment.
- The heavy rainfall during this season leads to increased river discharge, which can result in flooding, particularly in low-lying areas [Olanrewaju et al., 2017].

- The high flows are essential for replenishing reservoirs and maintaining the ecological health of wetlands and riparian zones.
- However, the intensity of rainfall during this period can also lead to soil erosion and sedimentation in rivers, which affects water quality and aquatic habitats.

**b. Dry Season Flows:**

- During the dry season, river flows decrease significantly as rainfall diminishes and temperatures rise.
- Many smaller streams and tributaries may dry up completely, while larger rivers such as the Kaduna River experience reduced discharge.
- The decreased flow during this period can lead to water shortages, affecting agriculture, domestic water supply, and hydropower generation [Ayuba & Shehu, 2016].
- The catchment relies on its dams and reservoirs to store water during the wet season for use during the dry season, but these water bodies are often under pressure due to increasing demand and climate variability.

### 2.5.2.7 Stream Flow and Discharge

#### Plateau

#### Stream Flow Characteristics

The catchment is characterized by a network of rivers and streams, most of which are part of the larger Niger and Benue River basins.

- The state's topography, with its elevated plateaus and hills, plays a significant role in the flow characteristics of these water bodies. Rivers such as the Kaduna, Benue, and Gongola originate from the Jos Plateau and flow outward, draining the surrounding areas.

#### Seasonal Variations:

- Stream flow in Plateau State shows significant seasonal variations, with increases during the rainy season (April to October) due to high rainfall.
- In contrast, stream flow decreases during the dry season (November to March), impacting water availability.
- This variability is crucial for water resource management in agriculture, industry, and domestic use.

#### Stream Discharge:

- The discharge of rivers and streams in Plateau State is also subject to significant seasonal fluctuations.
- During the peak of the rainy season, rivers can experience discharge rates that are several times higher than those observed during the dry season. For example, the Kaduna River, one of the major rivers in the state, has a discharge rate that can vary from less than 100 cubic meters per second ( $m^3/s$ ) during the dry season to over 1,000  $m^3/s$  during periods of heavy rainfall [Iloeje, 2017].
- These fluctuations present challenges for water storage and flood management, as the infrastructure must be capable of handling both extremes.

## Impact of Topography on Stream Flow

The topography of Plateau State, particularly the Jos Plateau, influences the velocity and direction of stream flow. The steep gradients in some areas lead to fast-moving streams, which can result in higher rates of erosion and sediment transport.

In contrast, flatter areas, particularly in the lowlands, experience slower stream flow, which can lead to sediment deposition and the formation of floodplains [Ogunleye & Ayoade, 2016].

## Taraba

### Stream Flow and Discharge

Streamflow in Taraba State is dominated by the Benue River and its numerous tributaries. The flow of these rivers is highly seasonal, reflecting the state's distinct wet and dry seasons.

- During the wet season, which occurs between May and October, rainfall contributes significantly to river discharge, leading to higher stream flows.
- The Benue River, in particular, experiences peak discharge during this period, with flow volumes reaching their maximum in August and September.
- Average streamflow rates for the Benue River at Wuro-Bokki, one of the key monitoring stations, range from 1,000 to 1,500 cubic meters per second ( $\text{m}^3/\text{s}$ ) during the rainy season [Ayoade, 2004].

In contrast, the dry season (November to April) is characterized by drastically reduced streamflow. The discharge of rivers during this period often falls to as low as  $200 \text{ m}^3/\text{s}$  in the case of the Benue River, while smaller rivers and streams may even dry up completely. This seasonal variability creates challenges for water availability, particularly for agriculture and domestic use in areas dependent on surface water sources.

- Groundwater sources, particularly in the low-lying areas of the state, help supplement water availability during the dry season. However, excessive reliance on groundwater extraction during periods of low streamflow can lead to depletion and long-term sustainability issues.

### 2.5.2.8 Surface Water Resource Potential

The average precipitation in Nigeria is about 1,150mm, with only 24% becoming runoff. Total internal runoff generation is 244BCM/year, while surface water resource potential is estimated at 330BCM/year. The total groundwater resources potential is about 142 BCM/year based on recharge estimates. Table 2.6 indicates water resources of hydrological area 4, of which the Wase/Taraba abides, while table 2.7 shows the run off yield.

Table 2.6: Water Resources Potential

|   |            |       |
|---|------------|-------|
|   |            | HA-4  |
| Water Resources Potential                                     |            |       |
| Total Water Resources Potential <sup>1)</sup>                 |            |       |
| Including inflow from<br>outside Nigeria                      | (BCM/year) | 60.1  |
| Only internal generation in Nigeria                           | (BCM/year) | 38    |
| Surface Water Resources Potential                             |            |       |
| Including inflow from<br>outside Nigeria                      | (BCM/year) | 56.6  |
| Only internal generation in Nigeria                           | (BCM/year) | 34.5  |
| Groundwater Resources Potential                               |            |       |
| Groundwater Recharge  | (BCM/year) | 14.5  |
| <b>Runoff Condition</b> (Only internal generation in Nigeria) |            |       |
| Precipitation<br>(P)  | (mm/year)  | 1,055 |

|   |            |      |
|---|------------|------|
| Total Runoff<br>(RO)                    | (mm/year)  | 221  |
| Groundwater Recharge (GRE)              | (mm/ year) | 93   |
| Loss of Recharge<br>(LOS)               | (mm/year)  | 22   |
| Runoff Rate<br>(RO/P)                   | (%)        | 20.9 |
| Recharge Rate (GRE/P)                   | (%)        | 8.8  |
| Loss Rate<br>(LOS/P)                    | (%)        | 2.1  |
| Total Water Res. Rate<br>$((RO+LOS)/P)$ | (%)        | 23   |



Table 2.7: Runoff Yield by for Wase and Taraba Catchments

| 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   |                                       |  |                         |
|    | 304   | 304                              | 80 | 4,997.2    | 3.6  | 1.7 | 0.8 | 0.4  | 1.7  | 6.8  | 16.6  | 53.8  | 74.1  | 33.6  | 15.5 | 7.4  | 216                                   | 1,088                                  | 19.9                    |
|    | 30601 | 30601                            | 82 | 2,266.4    | 0.8  | 0.3 | 0.1 | 0.1  | 3.8  | 13.0 | 20.4  | 42.0  | 64.8  | 23.2  | 6.6  | 2.2  | 177                                   | 1,135                                  | 15.6                    |
|    | 30602 | 30602                            | 83 | 5,395.0    | 1.2  | 0.4 | 0.1 | 0.7  | 6.1  | 15.9 | 40.6  | 86.0  | 102.6 | 36.3  | 10.7 | 3.6  | 304                                   | 1,203                                  | 25.3                    |
|    | 30603 | 30603_e                          | 84 | 559.0      | 3.4  | 1.1 | 1.9 | 11.5 | 22.0 | 53.4 | 143.9 | 177.9 | 182.7 | 106.9 | 30.6 | 10.2 | 746                                   | 1,592                                  | 46.8                    |
|    |       | 30603_i                          | 85 | 13,799.2   | 2.2  | 0.7 | 0.6 | 4.6  | 15.4 | 30.5 | 83.4  | 126.7 | 141.1 | 71.0  | 19.9 | 6.6  | 503                                   | 1,408                                  | 35.7                    |

### 2.5.3 Hydrogeological Disposition of the Catchment

The hydrogeological disposition of the catchment and its hydrogeological units and aquiferous layers make up part of the water resources of the catchment, as seen and explained in Figure 2.31

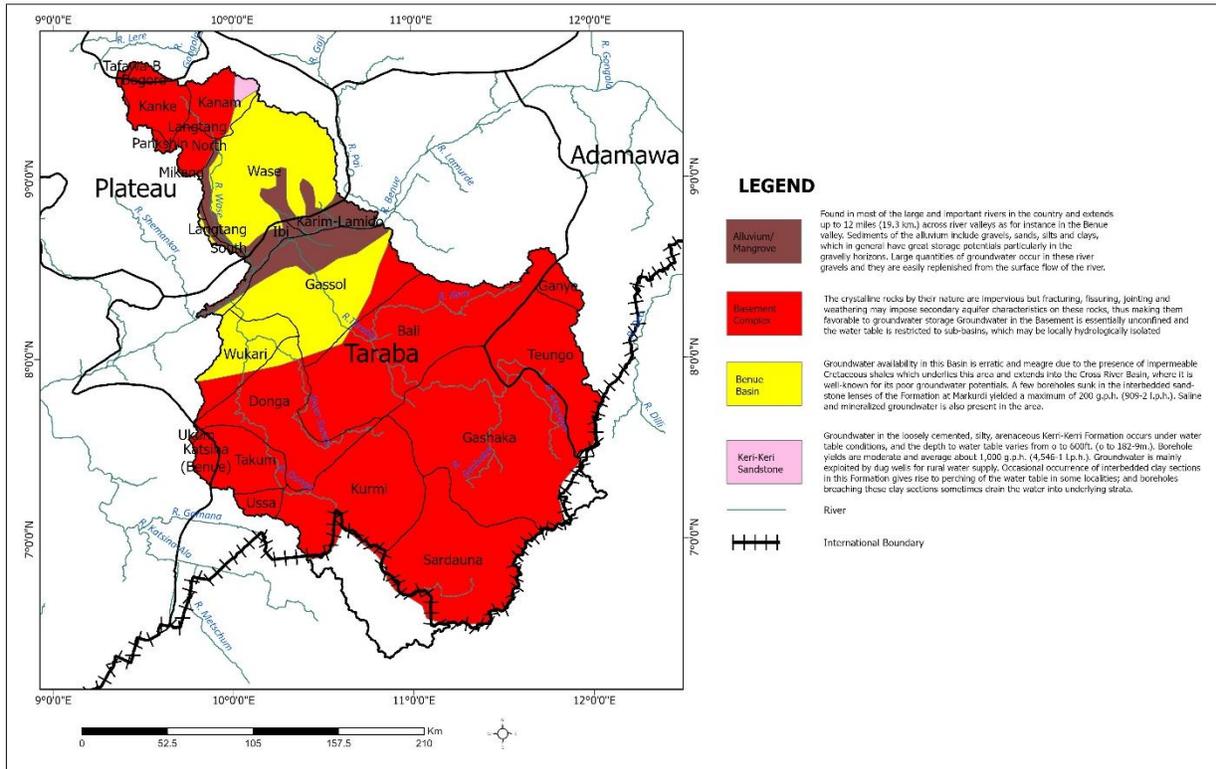


Figure 2.31: Hydrogeological provinces of the catchment (Source: MSL 2024)

Groundwater storage is crucial in areas with limited surface water resources. Aquifers in the catchment hold significant water accessed via boreholes and wells. However, over-extraction and poor recharge raise sustainability concerns, as declining groundwater levels indicate that current extraction rates may not be viable long-term (Musa et al., 2020).

### **2.5.3.1 Groundwater Recharge**

- Groundwater recharge is impacted by climate change, with varying decreases across regions. Areas with lower recharge levels will feel a greater effect from equivalent reductions than those with higher recharge levels.
- Groundwater level declines will be minimal near riverbeds, remaining relatively constant. However, areas farther from rivers, particularly inland plateaus, will experience greater .
- reductions in groundwater recharge. Countermeasures for climate change should consider this disparity.
- Groundwater recharge is decreasing due to climate change, with varying impacts by region. Areas with initially low recharge will experience greater effects than those with higher recharge, even if the decrease is the same. Table 2.8 shows the ground water recharge/demand projection for 2030.



Table 2.8: Groundwater Recharge and Groundwater Demand (2030)

| No    | State   | Groundwater Recharge (MCM/year) | Groundwater demand (2030) (MCM/year) |                    |            |             |       | Groundwater Demand/recharge |
|-------|---------|---------------------------------|--------------------------------------|--------------------|------------|-------------|-------|-----------------------------|
|       |         |                                 | Water Supply                         | Private irrigation | Live stock | Aquaculture | Total |                             |
| 1     | Adamawa | 3,707                           | 96                                   | 26                 | 17         | 4           | 142   | 4%                          |
| 2     | Bauchi  | 3,970                           | 205                                  | 69                 | 13         | 3           | 290   | 7%                          |
| 3     | Benue   | 10,655                          | 152                                  | 50                 | 1          | 3           | 206   | 2%                          |
| 4     | Plateau | 3,917                           | 113                                  | 31                 | 10         | 27          | 181   | 5%                          |
| 5     | Taraba  | 13,147                          | 81                                   | 41                 | 4          | 0           | 127   | 1%                          |
| Total |         | 35,396                          | 647                                  | 217                | 45         | 37          | 946   | 3%                          |

Source: National Water Resources Master Plan (JICA)

- Balance of groundwater recharge and demand is shown in Table 2.9 in case of the Climate Change (scenario case-1).
- Ratio of groundwater demand/recharge is 7% in national average, which is small increase from 5% of the case without Climate Change. However, it is 1 to 136% state by state, showing large difference.
- Effect of the Climate Change will make difference larger in water balance among states.

Table 2.9: Groundwater Recharge and Demand by effect of climate (2030)

| NO | State   | Groundwater Recharge (MCM/year) | Groundwater demand (2030) (MCM/year) |                    |            |             |       | Total | Groundwater Demand/recharge |
|----|---------|---------------------------------|--------------------------------------|--------------------|------------|-------------|-------|-------|-----------------------------|
|    |         |                                 | Water Supply                         | Private irrigation | Live stock | Aquaculture |       |       |                             |
| 1  | Adamawa | 2,567                           | 96                                   | 29                 | 17         | 4           | 145   | 6%    |                             |
| 2  | Bauchi  | 2,841                           | 205                                  | 78                 | 13         | 3           | 299   | 11%   |                             |
| 3  | Benue   | 9,182                           | 152                                  | 55                 | 1          | 3           | 211   | 2%    |                             |
| 4  | Plateau | 2,945                           | 113                                  | 34                 | 10         | 27          | 184   | 6%    |                             |
| 5  | Taraba  | 10,723                          | 81                                   | 46                 | 4          | 0           | 132   | 1%    |                             |
|    | Total   | 124,178                         | 5,964                                | 1,409              | 241        | 875         | 8,486 | 1%    |                             |

## 2.6 Water Demand for Wase-Taraba Catchment

Water demand estimates for the Wase-Taraba Catchment were made using the NWRMP methodology (JICA Team, 2014), based on state-level data from Adamawa, Bauchi, Benue, Plateau, and Taraba. Fig 2.32 and fig 2.33

shows the annual population growth and water demand projection charts accordingly.

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.
- Hydropower water demand.
- Environmental water demand.

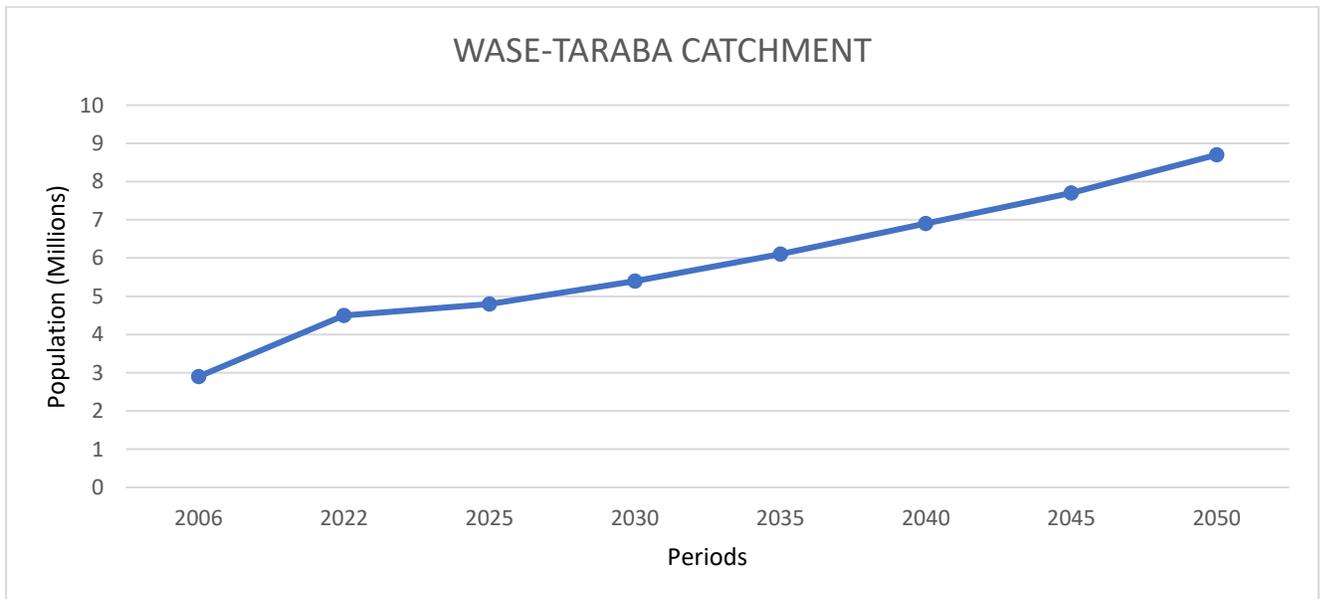


Figure 2.32: Average annual rate of population growth (UN, 2012)

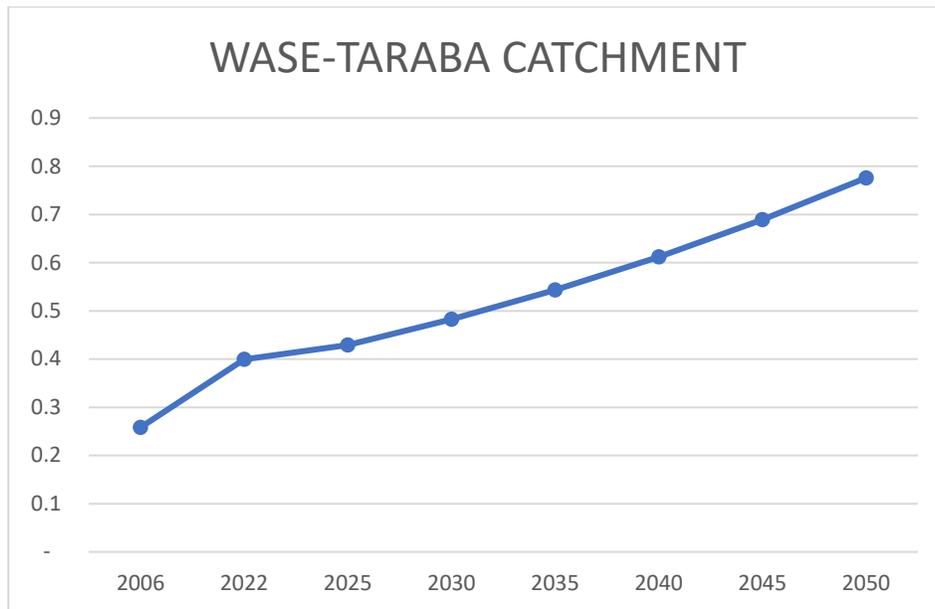


Figure 2.33: Water Demand Projection Graph

### **2.6.1 Municipal water demand**

- Municipal water demand in the basin is primarily met by groundwater due to surface river pollution. Some urban areas have existing water supply schemes.
- Projecting future water demand is crucial for balancing demand with resource potential and developing adequate infrastructure.
- This project focuses on enhancing 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 projections are essential for estimating water demand, aiding in infrastructure planning and assessing water source adequacy within a catchment. Daily average demand is calculated by multiplying the intended population by per capita consumption (lit/cap/day).

### **2.6.2 Human Domestic Water Requirement**

When estimating water requirements in catchments, factors such as population size, per capita consumption (50 liters in rural areas, 100 in peri-urban, and 200 in urban), and water source availability were considered. The annual domestic water demand for each catchment was calculated by multiplying the estimated population by the average daily requirement (70 to 116 liters) and then by 365 days.

### **2.6.3 Animal Water Requirement**

A combination of some of the factors listed below determines the quantity of water intake by animals:

- i. Physiological state of the animal. Lactating cows for instance require an extra litre of water per litre of milk. Lactating cows require up to twice the water of dry (non-lactating) cows. Water consumption in pregnant and growing animals also increases by some percentages.
- ii. Level of animal activity. Activity by the animal is directly proportional to water intake. The more the activity, the more the water requirement.
- iii. Type of diet & dry matter intake. Dry diets such as hay, require more water than moist diets such as silage or lush pasture with higher moisture contents. Also, dry matter intake is linked to water. That is, reducing water intake will reduce feed intake.

- iv. Water Temperature. Water with lower temperature / not hot, is most desirable.
- v. Water trough number and space. In adequate number of troughs and animals crowding at a trough may limit water to some of them.
- vi. Air temperature / season/ temperature around the animals. Water consumption by animals will increase on hot/sunny days. Water requirements on very hot days can double their requirements in cool weather.

### 2.6.4 Livestock

- Livestock numbers are much higher in the northern regions due to reliance on livestock farming during frequent droughts. Low annual precipitation limits surface water, making wells essential for their survival.
- Livestock water consumption depends on temperature, weight, and grazing availability. An adult cow weighing 240 kg needs about 16 liters of water when grazing 20 kg of grass daily, which is 80% water. During extreme droughts, with annual rainfall below 400 mm, grass availability drops to 5 kg per day, requiring at least 11 liters of water.
- Moving livestock need about 25 to 35 liters of water daily, depending on weight and activity. Goats and sheep have similar needs. A FAO livestock guidebook from the 1960s offers further standards for water requirements in tropical regions.

Table 2.10: Case of water requirement per head of livestock

| Livestock specie | Live Weight (kg) | Maintaining* need (L/day) | Uptake from grazing Grass/ feeds (L/day) | Gross water Drink (L/day) | Annual requirement (m <sup>3</sup> ) |
|------------------|------------------|---------------------------|--|---------------------------|--------------------------------------|
| Cattle           | 250              | 60                        | 38.4                                     | 21.6                      | 7.9                                  |
| Goat             | 30               | 6.6                       | 4.3                                      | 2.3                       | 0.8                                  |
| Sheep            | 40               | 8.8                       | 6.8                                      | 2.0                       | 0.7                                  |
| Pig              | 90               | 20                        | 16.7                                     | 3.3                       | 1.2                                  |
| Donkey           | 110              | 24                        | 15.6                                     | 8.4                       | 3.1                                  |
| Camel            | 350              | 80                        | 55.4                                     | 24.6                      | 9.0                                  |
| Horse            | 300              | 70                        | 47.8                                     | 22.2                      | 8.1                                  |
| Fowl             | 2                | 0.4                       | 0.292                                    | 0.108                     | 0.039                                |

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

Table 2.11: Corresponding livestock water requirement projected in 2050

| Livestock Water | Cattle     | Goats     | Sheep     | Pigs      | Poultry | Donkeys | Camels | Horses |
|-----------------|------------|-----------|-----------|-----------|---------|---------|--------|--------|
| Adamawa         | 15,217,031 | 4,287,869 | 1,919,791 | 1,755,230 | 4,792   | 27,718  | 0      | 0      |
| Bauchi          | 10,179,352 | 5,717,042 | 3,561,737 | 269,495   | 232,821 | 0       | 332    | 0      |

|         |            |            |           |            |         |        |       |        |
|---------|------------|------------|-----------|------------|---------|--------|-------|--------|
| Benue   | 410,013    | 256,036    | 62,704    | 325,035    | 69,070  | 9,701  | 7,830 | 7,130  |
| Plateau | 6,545,924  | 2,359,589  | 669,616   | 5,476,889  | 160,247 | 0      | 0     | 0      |
| Taraba  | 2,281,233  | 2,036,064  | 429,774   | 2,332,257  | 190,478 | 0      | 0     | 8,708  |
| Total   | 34,633,553 | 14,656,600 | 6,643,622 | 10,158,906 | 657,408 | 37,419 | 8,162 | 15,838 |

## 2.6.5 Aquaculture Water Requirement

- Data on aquaculture were obtained from the Federal Department of Fisheries (FDF, 2008), including projections for Nigeria's population, fish demand, and supply from 2000 to 2015.
- The correlation between fish demand and supply relative to population growth assisted in estimating fish demand for various catchment areas.
- Water demands for aquaculture came from the Food and Agriculture Organization (FAO, 2024) and studies by Obassi and Adeoye (2022). The formula for estimating water requirements is:  $\text{Water required} = \text{Quantity of fish} \times 10,000 \text{ cubic meters per tonne}$
- This calculation method assumes that traditional pond systems require approximately 10,000 cubic meters of water per tonne of fish produced.

### 2.6.5.1 Inland Fishery

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

Table 2.12: Fish Farm Pond

| State   | Number of Fish Farm | Water Area of Farm Pond (ha) | Brackish Water Area of Farm Pond (ha) |
|---------|---------------------|------------------------------|---------------------------------------|
| ADAMAWA | 4                   | 30.2                         | 0.0                                   |
| BAUCHI  | 16                  | 21.9                         | 0.0                                   |
| BENUE   | 198                 | 19.3                         | 0.0                                   |
| PLATEAU | 18                  | 186.7                        | 0.0                                   |
| TARABA  | 8                   | 2.8                          | 0.0                                   |
| TOTAL   | 244                 | 260.9                        | 0.0                                   |

- Annual water supply per hectare is 0.03 MCM, primarily sourced from shallow wells (75-85%). Water can be replaced if it meets quality standards: free from detergents and chemicals, neutral pH, and dissolved oxygen above 4 ppm. Groundwater is preferred due to higher oxygen content in colder temperatures.
- The inland fish farming project aims to supply 1.73 kg/year/person by 2030, higher than the current sweet water fish consumption of 1.62 kg. With a target yield of 10 t/ha, it surpasses rice yields, but requires significant initial investments.

### 2.6.6 Irrigation water demand

Irrigation water demand is calculated by multiplying the gross irrigation requirement by the cropped area, assuming a 50% irrigation efficiency across the basin. If all schemes have drainage systems, half of the abstracted water re-enters the surface water.

## 2.6.7 Water Capacity for LGA within the Catchment.

Table 2.13 depicts the projected water capacity within the basin, also represented by a chart, fig 2.34, while table 2.14 shows the summary of water demand for each constituent within the catchment.

Table 2.13: Water Capacity

| State   | LGA             | Water Capacity<br>m3/d<br>2006 | 2022  | 2025  | 2030  | 2035  | 2040  | 2045  | 2050  |
|---------|-----------------|--------------------------------|-------|-------|-------|-------|-------|-------|-------|
| Adamawa | Ganye           | 15465                          | 23851 | 25610 | 28834 | 32464 | 36552 | 41154 | 46335 |
| Adamawa | Teungo          | 4748                           | 7326  | 7866  | 8856  | 9971  | 11226 | 12640 | 14231 |
| Bauchi  | Bogoro          | 7627                           | 13623 | 14627 | 16469 | 18542 | 20877 | 23505 | 26464 |
| Bauchi  | Tafawa-B        | 20139                          | 35963 | 38615 | 43477 | 48951 | 55113 | 62052 | 69865 |
| Benue   | Katsina (Benue) | 20518                          | 29621 | 31805 | 35809 | 40317 | 45393 | 51108 | 57543 |
| Benue   | Ukum            | 19745                          | 28510 | 30613 | 34467 | 38806 | 43692 | 49193 | 55386 |
| Plateau | Kanam           | 15253                          | 22441 | 24095 | 27129 | 30545 | 34390 | 38720 | 43595 |
| Plateau | Kanke           | 11308                          | 16635 | 17861 | 20110 | 22642 | 25493 | 28702 | 32316 |
| Plateau | Langtang North  | 12951                          | 19055 | 20461 | 23037 | 25937 | 29202 | 32879 | 37018 |
| Plateau | Langtang South  | 9571                           | 14078 | 15116 | 17019 | 19162 | 21574 | 24290 | 27348 |
| Plateau | Mikang          | 8771                           | 12904 | 13855 | 15600 | 17564 | 19775 | 22265 | 25068 |
| Plateau | Pankshin        | 17300                          | 25453 | 27330 | 30770 | 34644 | 39006 | 43917 | 49446 |
| Plateau | Wase            | 14547                          | 21403 | 22982 | 25875 | 29133 | 32800 | 36930 | 41579 |

|        |              |         |         |         |         |         |         |         |           |
|--------|--------------|---------|---------|---------|---------|---------|---------|---------|-----------|
| Taraba | Bali         | 19203   | 30212   | 32440   | 36524   | 41122   | 46300   | 52129   | 58692     |
| Taraba | Donga        | 12113   | 19055   | 20461   | 23037   | 25937   | 29202   | 32879   | 37018     |
| Taraba | Gashaka      | 7932    | 12476   | 13396   | 15083   | 16982   | 19120   | 21527   | 24237     |
| Taraba | Gassol       | 22303   | 35081   | 37667   | 42410   | 47749   | 53761   | 60529   | 68150     |
| Taraba | Ibi          | 7671    | 12067   | 12956   | 14588   | 16424   | 18492   | 20820   | 23441     |
| Taraba | Karim-Lamido | 17647   | 27764   | 29811   | 33565   | 37791   | 42548   | 47905   | 53936     |
| Taraba | Kurmi        | 8307    | 13068   | 14031   | 15798   | 17787   | 20026   | 22547   | 25386     |
| Taraba | Sardauna     | 20416   | 32114   | 34482   | 38823   | 43711   | 49214   | 55410   | 62387     |
| Taraba | Takum        | 12246   | 19265   | 20685   | 23290   | 26222   | 29523   | 33240   | 37425     |
| Taraba | Ussa         | 8271    | 13013   | 13973   | 15732   | 17712   | 19942   | 22453   | 25280     |
| Taraba | Wukari       | 21684   | 34107   | 36622   | 41233   | 46424   | 52269   | 58849   | 66258     |
| TOTAL  |              | 335,738 | 519,082 | 557,360 | 627,532 | 706,538 | 795,491 | 895,643 | 1,008,405 |

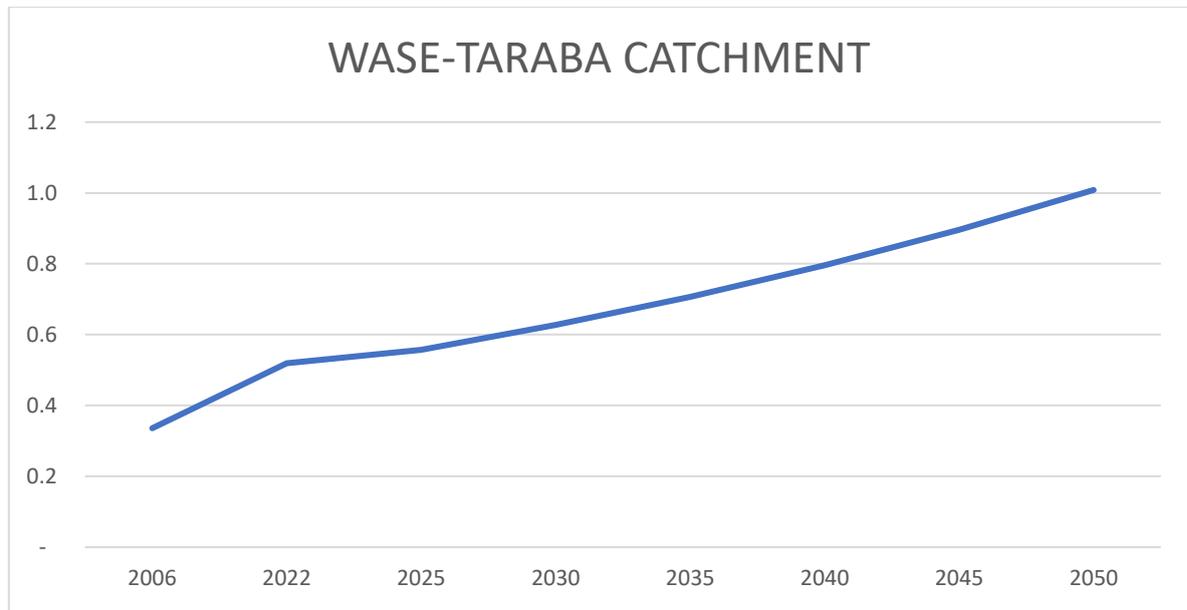


Figure 2.34: Graphical Representation of the Water capacity in the Catchment

Table 2.14: Water Demand for HA 4 2030 (Source: JICA, 2014)

|   |                  |
|---|------------------|
| <b>WATER DEMAND FOR LIVESTOCK (MCM/YEAR)</b>              |                  |
| 2030 Projected demand for surface water                   | 3.0 mcm/per year |
| 2030 Projected demand for ground water                    | 8.0 mcm/per year |
| <b>WATER DEMAND FOR FRESH WATER AQUACULTURE(MCM/YEAR)</b> |                  |
| 2030 Projected water demand from surface water            | 9.0 mcm/per year |
| 2030 Projected water demand from ground water             | 27 mcm/per year  |
| <b>WATER DEMAND FOR MUNICIPAL(MCM/YEAR)</b>               |                  |
| 2030 Projected water demand from surface water            | 147 mcm/per year |
| 2030 Projected water demand from ground water             | 292 mcm/per year |
| <b>WATER DEMAND FOR IRRIGATION(MCM/YEAR)</b>              |                  |
| 2030 Projected water demand from surface water            | 568 mcm/per year |

|  |                    |
|--|--------------------|
| 2030 Projected water demand from ground water            | 93 mcm/per year    |
| <b>PROJECTED TOTAL WATER DEMAND BY SOURCES(MCM/YEAR)</b> |                    |
| Projected total water demand for surface water           | 727 mcm/per year   |
| Projected total water demand for ground water            | 420 mcm/per year   |
| Annual precipitation (mm/year)                           | 1,341 mcm/per year |
| Annual mean temperature (Degree Celsius)                 | 26.8 mcm/per year  |
| Annual Pet (mm/year)                                     | 1,338 mcm/per year |
| Projected population for 2030                            | 13.9 million       |

Table 2.15: Water Balance Analysis for the Catchment

| <b>WATER BALANCE ANALYSIS FOR WASE-TARABA CATCHMENT</b> |  |                       |                       |
|---|--|-----------------------|-----------------------|
| <b>WATER DEMAND (CUBIC METER)</b>                       |  | <b>2025</b>           | <b>2050</b>           |
| <b>MUNICIPAL</b>  |  | 156,489,614           | 283,129,052           |
| <b>LIVESTOCK</b>  |  | 51,342,893            | 73,163,235            |
| <b>AQUACULTURE</b>                                      |  | 14,763,559            | 17,049,044            |
| <b>IRRIGATION</b>                                       |  | 34,100,000            | 943,800,000           |
| <b>TOTAL</b>  |  | <b>256,696,066</b>    | <b>1,317,141,330</b>  |
| <b>AVAILABLE WATER RESOURCES (CUBIC METER)</b>          |  | <b>24,773,295,300</b> | <b>24,773,295,300</b> |
| <b>WATER BALANCE (CUBIC METER)</b>                      |  | <b>24,516,599,234</b> | <b>23,456,153,970</b> |

Source: JICA 2014 MP As Analysed

## 2.6.8 Infrastructure and Assets Within the Catchment

Table 2.16: Infrastructure and Assets

| Infrastructure      | Location           | Importance  | Risk Factor  |
|---------------------|--------------------|---|--|
| Treatment Plants    | Plateau State      | Supports water supply,  | Environmental degradation, Unsustainable socioeconomic practices, Climate change effects, Unchecked population rise and density, Unregulated water use upstream and Lack of Policy implementation, enforcement and.      |
| Dams and Reservoir  | Plateau,<br>Taraba | Supports irrigation farming, Hydropower generation, water supply,                         | Environmental degradation, Unsustainable socioeconomic practices, Climate change effects, Unchecked population rise and density, Unregulated water use upstream and Lack of Policy implementation, enforcement           |
| Irrigation Schemes  | Taraba State       | Enhance agriculture and animal husbandry, food production and improved trade and commerce | Unsustainable farming practices, Use of inorganic fertilizer, policy gaps and lack of funding, lack of extension services, land degradation, insecurity. Lack of agricultural trunk roads, lack of processing facilities |
| Boreholes           | Plateau,<br>Taraba | Improved Water supply   | Unsustainable farming practices, Use of inorganic fertilizer, policy gaps and lack of funding, lack of extension services, land degradation, insecurity. Lack of agricultural trunk roads, lack of processing facilities |
| Hydro power station | Taraba<br>Plateau  | Electricity generation,<br>Boosts Industrial activity and economic growth                 | Environmental degradation, climate change effects, Rainfall variability, high evapotranspiration, unregulated water use upstream   |

|  |  |   |  |
|--|--|---|--|
| Electricity grid/<br>Rural<br>electrification                          | Plateau,<br>Taraba   | Electricity generation,<br>Boosts Industrial activity and economic growth   | Frequent collapse, Insecurity.   |
| Grain storage<br>Facility  | Taraba,<br>Plateau   | Food storage and security, reduces post-harvest<br>loses  | Insecurity, vandalization.   |
| Research institute   | Plateau State  | Support research innovation to enhance crop/soil<br>productivity  | Lack of research grants and unreliable data sources.   |
| Local Markets<br>and Abattoir  | Plateau State.   | Enhance trade of livestock, provide processing<br>facilities for meat industry  | Insecurity and lack of perennial produce, Source of<br>Pollution   |
| Tourism<br>(National Parks<br>and Games<br>reserve and<br>Ramsar site) | Gashaka-Gumti<br>National Park,<br>Kashimbila Game<br>Reserve,<br>Kambari Game<br>Reserve,<br>Jos-Wildlife Park. | Promotes regions cultural heritage, Tourist site,<br>Source of forex income, Carbon sequestration sites<br>and biodiversity conservation. | Insecurity, lack of funds for management, Lack of<br>implementation of protective policies, overgrazing,<br>agrarian and poaching encroachment |

## 2.7 Water quality data for surface and groundwater

### 2.7.1 Surface Water Quality

Table 2.17 below shows a Study conducted in 2011 on the request of NIWRMC. The Study summarized the general condition of water quality based on some available data on water quality at various locations all over Nigeria.

Table 2.17: Water Quality Status of Some Rivers in the Northern States of Nigeria

| N  | State   | River Name                           | Code   | Wet Season | Dry Season      | NFA            |
|----|---------|--------------------------------------|--------|------------|-----------------|----------------|
| 1  | Plateau | Lamingo Dam at JOS WTP               | SW/001 | Good       | Poor            | Ni, Pb, As, Cd |
| 2  | Benue   | Yandev Dam                           | SW/002 | Good       | Moderate        | Cu, Ni, Pb, Cd |
| 3  |         | River Benue at Makurdi               | SW/001 | Good       | Poor            | Fe, As, Cd     |
| 4  |         | River Katsina Ala at Katsina Ala     | SW/003 | Good       | Moderate        | Ni, As, Cd     |
| 5  | Bauchi  | River Gaidan Maiwa at the Bridge     | SW/001 | Good       | To be confirmed | As, Pb, Cd     |
| 6  |         | Wikki spring at Yankari Game Reserve | SW/001 | Poor       | Moderate        | Fe, As         |
| 7  |         | Gubi Dam at intake to Bauchi WTP     | SW/003 | Good       | Moderate        | As, Cu, Ni     |
| 8  | Adamawa | River Benue at intake to Yola WTP    | SW/003 | Moderate   | Poor            | Fe, As, Cd     |
| 9  |         | River Gongola at Kiri Dam            | SW/001 | Moderate   | Moderate        | Cd, Pb         |
| 10 | Taraba  | River Ibi at intake to Ibi WTP       | SW/004 | Poor       | Poor            | Pb             |
| 11 |         | River Donga at Donga Bridge          | SW/003 | Moderate   | Moderate        | -              |
| 12 |         | River Taraba at A4 Bridge, Tella     | SW/001 | Poor       | Poor            | Pb             |

Note: The sampling was done only twice, in the wet and dry season. This table shows only preliminary evaluation based on the results of these limited samples.

#### Criteria:

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

NFA: need further assessment because of the presence of higher values in the samples than the standard.

### **2.7.2 Groundwater Quality**

- The quality of groundwater in catchment is generally good, but it can be affected by factors such as mining activities, agricultural runoff, and the improper disposal of waste.
- In some areas, groundwater has been found to contain elevated levels of heavy metals, such as lead and arsenic, which pose health risks to the local population [Ayuba & Shehu, 2016]. The Government, through the State Water Board and other agencies, monitors groundwater quality and implements measures to protect and manage this vital resource.

### **2.7.3 Surface Water Resources**

The water resources within the Wase-Taraba catchment are varied, including surface water sources such as the Wase and Taraba Rivers, alongside groundwater aquifers.

- However, challenges related to water quality persist, influenced by both natural and anthropogenic factors. Regular monitoring indicates that several water bodies exhibit parameters exceeding national and international water quality standards, necessitating urgent intervention to protect public health and maintain ecological balance.
- There is Liberty Dam that contributes water to the Hadejia – Jama’are river system.
- There are two local dams in Karim Lamido, Taraba, which are used for irrigation activities.
- Richia in Plateau State has a wetland ecosystem that greatly supports irrigation farming, and both plant and animal development

### **2.7.4 Groundwater Resources**

- The catchment relies on groundwater, especially in rural areas where boreholes and wells supply drinking water.
- The underlying geology, particularly the Basement Complex, affects groundwater availability. Crystalline rocks like granites and gneisses have low porosity and permeability, which limits groundwater flow. However, weathered zones and fractures can act as aquifers, providing localized groundwater sources.
- In the sedimentary areas of the catchment particularly in the Benue Trough, groundwater is more readily available due to the presence of porous sandstones and alluvial deposits. These aquifers are recharged by rainfall and river systems, and they play a vital role in supporting agriculture and domestic water supply, particularly during the dry season when surface water resources are limited.

## 2.8 Climate Change Impact on Water and Land Resources

### 2.8.1 Historical and Future Climatic Trends

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

Growth Rate = (ending value - beginning value/beginning value) x 100.

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

#### a) Rainfall Patterns

- Rainfall in the catchment is highly seasonal, with the majority of precipitation occurring during the wet season, which lasts from April to October (Fig 2.35).
- The catchment receives an average annual rainfall of between 1,100 mm and 1,600 mm, with the highest amounts recorded on the Jos Plateau and other elevated areas [Obot *et al.*, 2016].
- The distribution of rainfall across the state is influenced by its topography, with higher elevations receiving more rainfall than the surrounding lowlands.
- The wet season is characterized by frequent thunderstorms and heavy rains, which are essential for agriculture but can also lead to soil erosion and flooding in some areas.
- The wet season typically lasts from April to October, with the state receiving a significant amount of its annual rainfall during this period. Rainfall varies considerably across the state due to its diverse topography.
- In the southern parts of the state, particularly around the Benue River basin, annual rainfall can exceed 1,500 mm. In contrast, the northern and central regions receive between 1,000 and 1,300 mm of rainfall annually [Ayoade, 2004].
- The onset of the rainy season is usually marked by thunderstorms, and rainfall tends to be heaviest in July and August.
- The presence of hills and mountains, such as the Mambilla Plateau, creates orographic rainfall, leading to increased precipitation in these highland areas. Fig 2.35 depicts the rainfall histogram of the catchment.

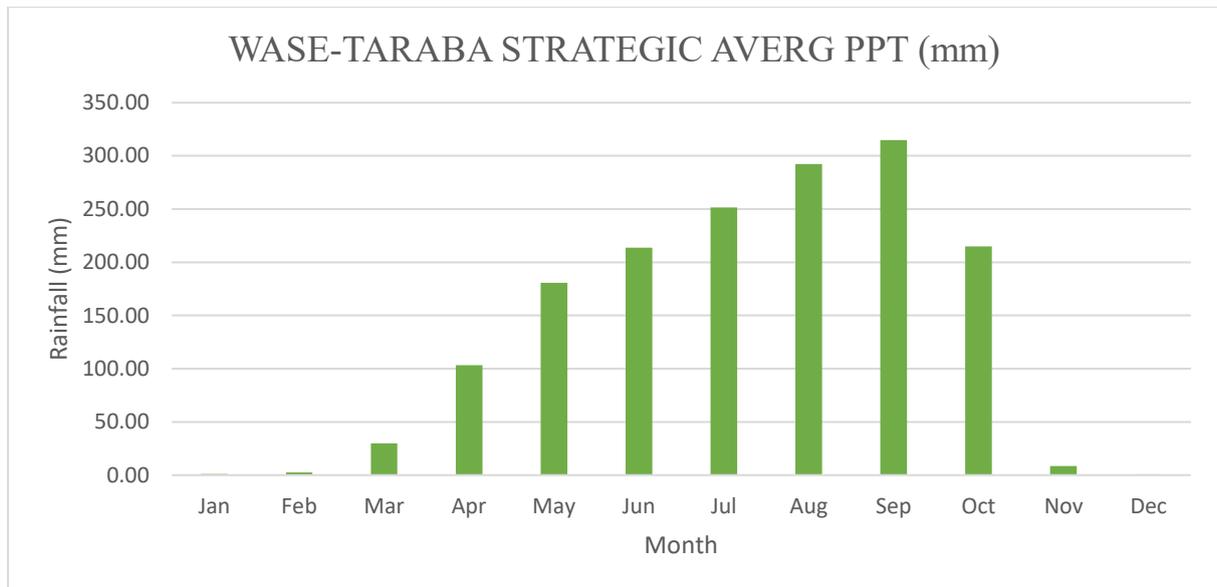


Figure 2.35: Rainfall Histogram for Taraba -Wase Strategic Catchment

### b) Temperature

- The average annual temperature in the catchment ranges from 18°C to 25°C, with cooler evenings in the Jos Plateau dropping to 11°C during the Harmattan season.
- The hot season (March to May) can reach around 38°C, making it milder compared to other parts of Nigeria. This climate supports temperate crops and attracts tourists seeking relief from heat.

However, temperatures in Taraba State are generally high throughout the year, although they fluctuate depending on the season.

- During the dry season (November to March), the region experiences high temperatures, with average daytime temperatures ranging from 28°C to 35°C.
- The harmattan winds, which blow from the Sahara Desert, bring dry, dusty conditions and can cause temperatures to drop at night, particularly in December and January [Olaniran, 1983].
- In the wet season, temperatures are moderated by cloud cover and rainfall, with average temperatures ranging from 25°C to 30°C. However, the highland areas, especially the Mambilla Plateau, have a much cooler climate due to their elevation.

- Temperatures on the plateau can range from 16°C to 25°C, making it one of the coolest regions in Nigeria. This cool climate supports the cultivation of temperate crops such as tea, coffee, and Irish potatoes [Olowolafe, 2002].

### c) Evapotranspiration

Evapotranspiration rates are high in the catchment, especially during the dry season, reaching 2,000 to 2,500 mm in northern areas. This often exceeds rainfall, worsening water deficits and increasing reliance on groundwater. Fig 2.36 shows the histogram chart of the ET within the catchment.



Figure 2.36: Evapotranspiration Histogram for Taraba - Wase Strategic Catchment

### 2.8.2 Mean Monthly Temperature Historical Period (1981 To 2022) and the Projected Period (2023 To 2050)

Fig 2.37 compares the mean monthly temperatures for the Wase-Taraba catchment over two periods:

- the historical period (1981-2022) and the projected period (2023-2050).
- It shows an overall warming trend, with each month in the projected period having a higher average temperature than the historical period.

- Each month in the 2023-2050 period is projected to be warmer than the corresponding month in 1981-2022, suggesting a consistent increase in temperatures throughout the year.
- March temperatures are expected to rise from 27.26°C to 29.39°C, and April from 27.27°C to 28.69°C. December will also warm from 23.34°C to 24.69°C. Overall, mean monthly temperatures could increase from 25.22°C to 26.60°C, indicating a broader warming trend affecting seasonal extremes.

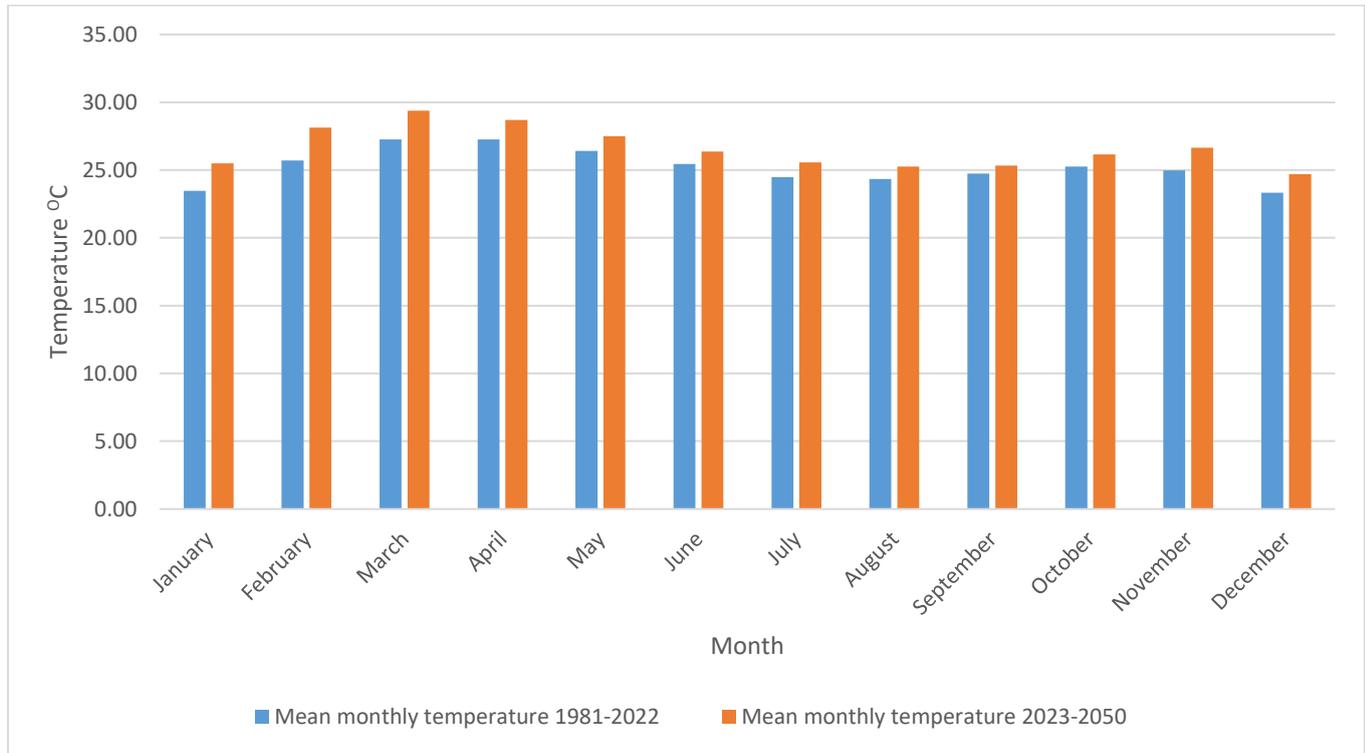


Figure 2.37: Mean monthly temperatures from 1981 to 2022 and 2023 to 2050

### 2.8.2.1 Projected Mean Annual Temperature

- Figure 2.38 shows the projected mean annual temperature trend for Wase-Taraba from 1981 to 2050 shows a clear upward trend, with an annual increase of about 0.0392°C ( $y=0.0392x+24.373$ ).
- The strong correlation ( $R^2 = 0.8902$ ) accounts for 89% of the variation. While historical data (1981-2022) shows variability, projections from 2023 to 2050 indicate a steadier rise.
- By 2050, temperatures are projected to exceed 27°C, up from 24.5°C in 1981, indicating significant warming.
- This trend could impact Wase-Taraba’s agriculture, water resources, and ecosystems due to increased evaporation and water stress.

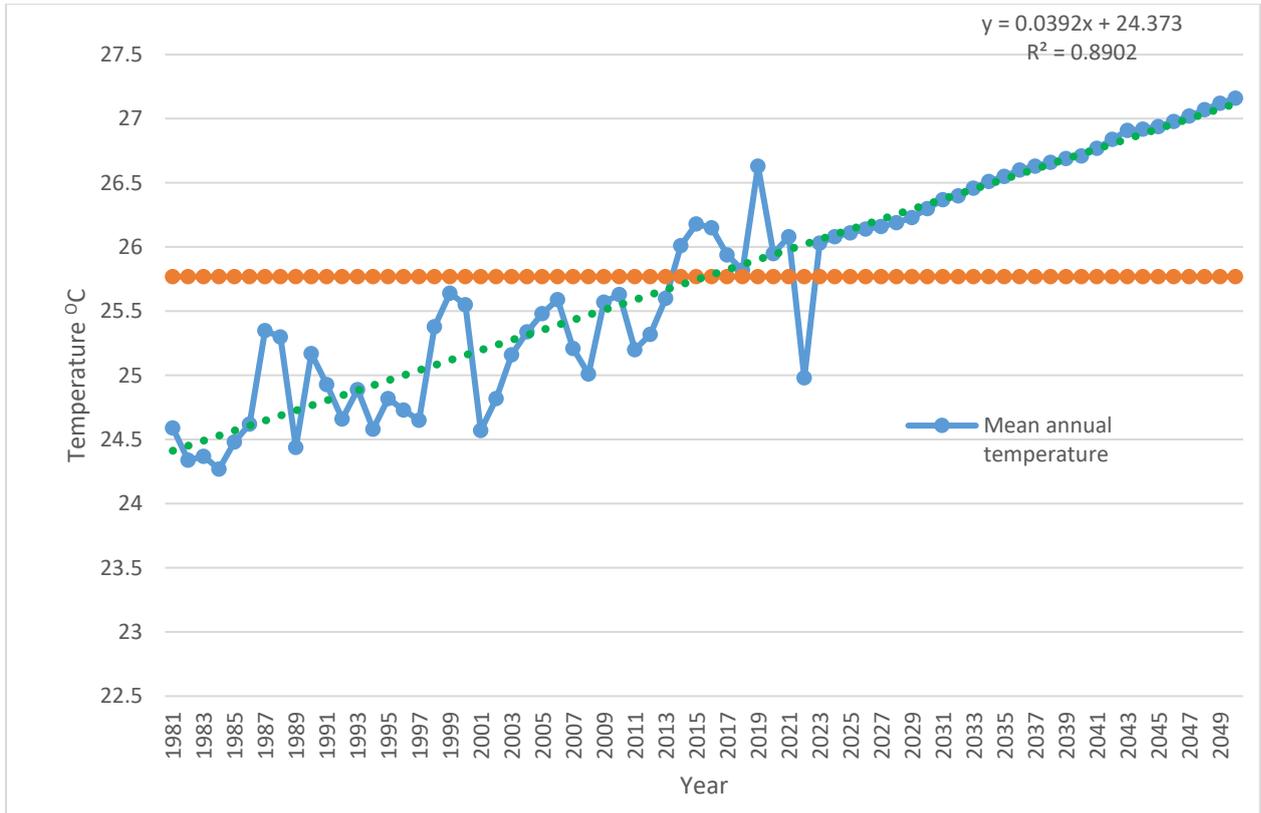


Figure 2.38: Projected Mean Annual Temperature Trend (1981-2050) for Wase-Taraba, while fig 2.39., shows the projected rainfall trend

### 2.8.3 Projected Annual Rainfall Trend

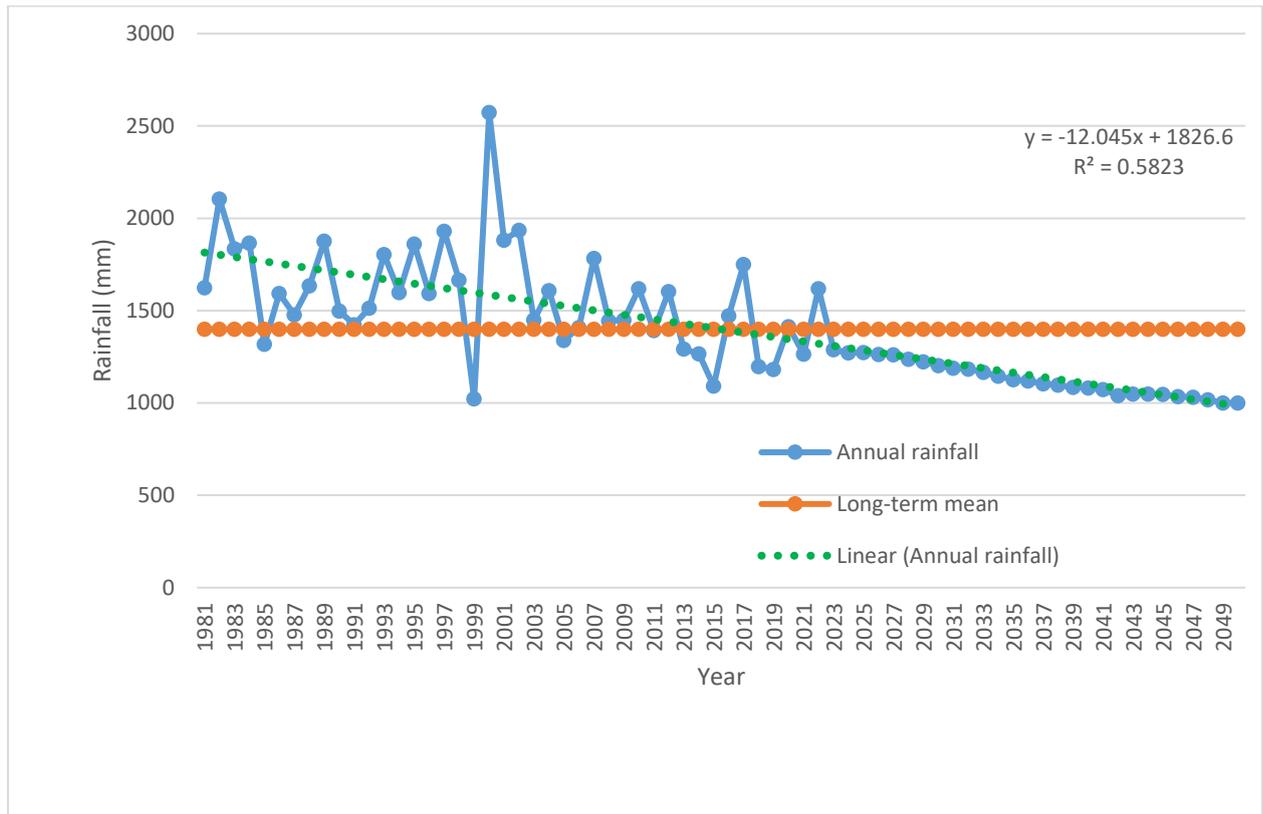


Figure 2.39: Projected annual rainfall trend (1981-2050) for Wase-Taraba catchment.

### 2.8.4 Analysis of Downscaled Output of GCMs

This study analyzes future climate change using statistically downscaled outputs from seven Global Climate Models (GCMs) under the A1B emission scenario, which assumes high economic growth with balanced energy sources.

- The analysis examines average monthly precipitation and air temperature from the 2020s to the 2080s, focusing on 2035, 2065, and 2085. Results indicate a decrease in precipitation from March to May and an increase from June to November.
- The rate of change in climate conditions gradually increases over time, amplifying initial trends.
- The study uses 30-year running averages to analyze the projected changes, with specific emphasis on changes in precipitation and annual mean temperature.
- The results will guide long-term planning for climate adaptation and resource management.

Table 2.18 below shows the change rate for precipitation and the absolute change in air

temperature for each case.

Table 2.18: Scenarios for Change in Precipitation and Air Temperature

| Case | Item   | Season | H-3  | HA-3e |
|------|--------|--------|------|-------|
| 1    | P (%)  | ANN    | 0    | 0     |
|      | T (°C) | ANN    | +2.4 | +2.4  |
| 2    | P (%)  | DJF    | +3.3 | +10.0 |
|      |        | MAM    | -2.8 | -2.2  |
|      |        | JJA    | +3.4 | +2.8  |
|      |        | SON    | +5.2 | +5.2  |
|      | T (°C) | ANN    | +2.4 | +2.4  |

Source: JICA Project Team

Remarks:

- 1) P = Precipitation, T=Air Temperature
- 2) HA-8e: Catchment area outside Nigeria whose runoff comes into HA-8

DJF= December, January, February, MAM=March, April, May, JJA=June, July, August, SON= September, October, November

### 2.8.5 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 2.19 gives some of the details of these impacts mentioned

Table 2.19: Key Impacts of Climate Change

| Impacts       | Details   |
|---------------|---|
| Economic      | Damage to infrastructure<br>Loss of property and assets<br>Disruption of businesses and services<br>Increased costs for emergency response and recovery |
| Social        | Loss of life and injury<br>Displacement and migration<br>Psychological trauma and stress<br>Social disruption and community cohesion                    |
| Environmental | Water pollution<br>Soil erosion and sedimentation<br>Loss of biodiversity   |

|                            |  |
|----------------------------|--|
|                            | Increased risk of waterborne diseases  |
| Health                     | Waterborne diseases<br>Vector-borne diseases<br>Mental health impacts<br>Injuries and trauma             |
| Infrastructure and Service | Power Outage<br>Transportation disruption<br>Water and sanitation disruption<br>Communication disruption |

### 2.8.6 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°C over the time frame.

#### 2.8.6.1 Climate Change Scenarios

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

According to the 4th IPCC report (2007), it is expected that the increase of air temperature in West Africa area in 2100 would be about 3-5 degree Celsius in the case of A1B scenario, which is about 1.5 times higher than the average in the world. As for the precipitation, the predictions of precipitation by different GCM models vary very much. It is difficult to conclude the general tendency for the change in precipitation.

### **2.8.6.2 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.

### **2.8.6.3 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, in accordance with the Paris Agreement and UNFCCC requirements.

It analyzes greenhouse gas emissions and outlines adaptation and mitigation strategies tailored to Nigeria's unique socio-economic and environmental context.

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

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

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

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

#### **2.8.6.4 Nigeria's Third National Communication on Climate Change**

The Third National Communication on climate change updates Nigeria's Greenhouse Gas (GHG) emissions and adaptation strategies, highlighting its commitment to climate action. Emissions mainly come from the Agriculture, Forestry, and Other Land Use (AFOLU) sector (60.1%) and energy sector (33.9%). Without intervention, emissions could increase by over 58% by 2035, while the country faces serious climate challenges such as drought, desertification, and flooding.

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

#### **2.8.6.5 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 by 196 Parties at COP21 on December 12, 2015, aims to limit global temperature rise to well below 2°C above pre-industrial levels, with efforts to limit it to 1.5°C. It took effect on November 4, 2016.

## 2.9 Flood and Drought Vulnerability

The Flood Vulnerability analysis used GIS and weighted Overlay to identify vulnerable locations based on multiple criteria. This method ranks areas by their vulnerability instead of simply categorizing them as vulnerable or not. We need to define the issue and break it into smaller sub-models.

- The study used a weighted overlay analysis to assess flood vulnerabilities across the catchment by combining datasets such as elevation, proximity to rivers, precipitation, slope, and land use.
- Each layer was categorized, weighted, and scored on a 1–9 scale. Proximity to rivers received the highest weight.
- The resulting flood risk map identified five flood vulnerability levels: Highly not vulnerable, Not Vulnerable, Moderate, Vulnerable, and Highly Vulnerable. The study area covers 123,365 km<sup>2</sup>, with a critical vulnerability area of 261.3 ha.
- Low vulnerability zones are found in high-elevation regions, while high-risk areas are concentrated in lower elevation zones near the highlands.

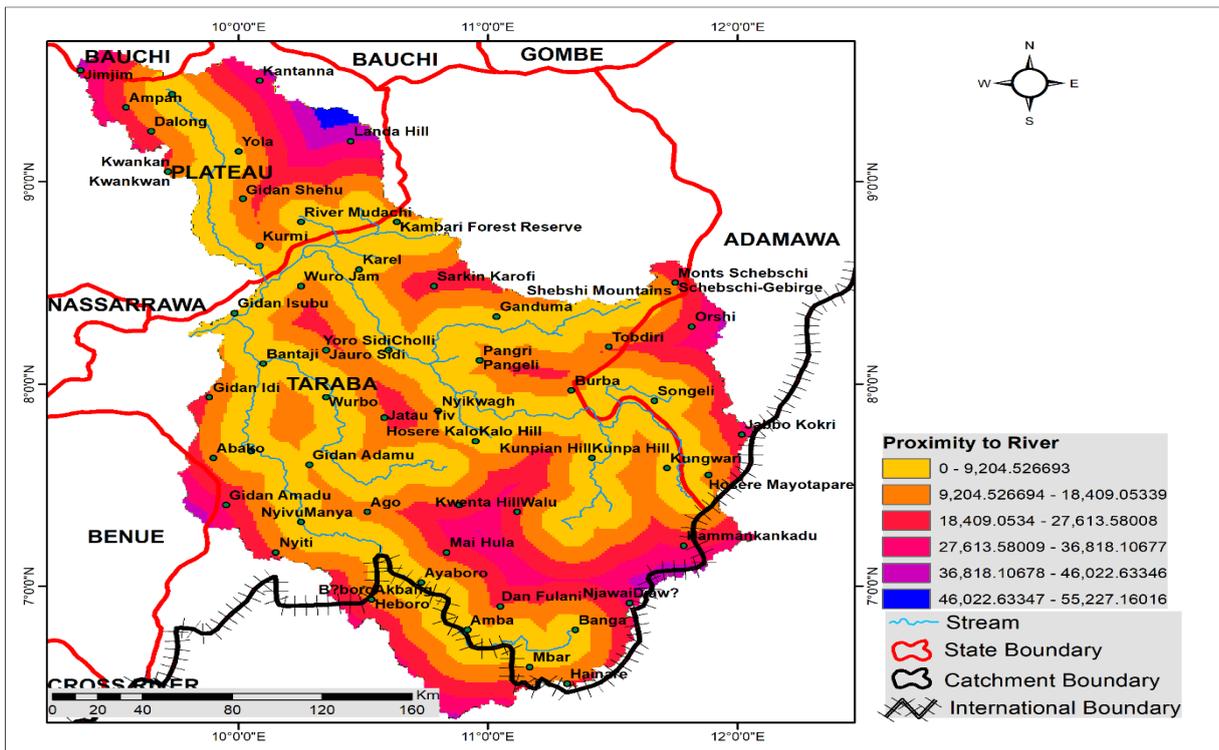


Figure 2.40: Proximity to River map of the catchment (Source: MSL, 2024)

Proximity to streams is also a very important variable to consider in flood vulnerability analysis because nearness to streams/rivers means a high probability to the risk of flooding.

This depicts uniform distances away from the river and for this study about 0-9km shows areas closest to the river while about 46-55km depicts areas far away from the river.

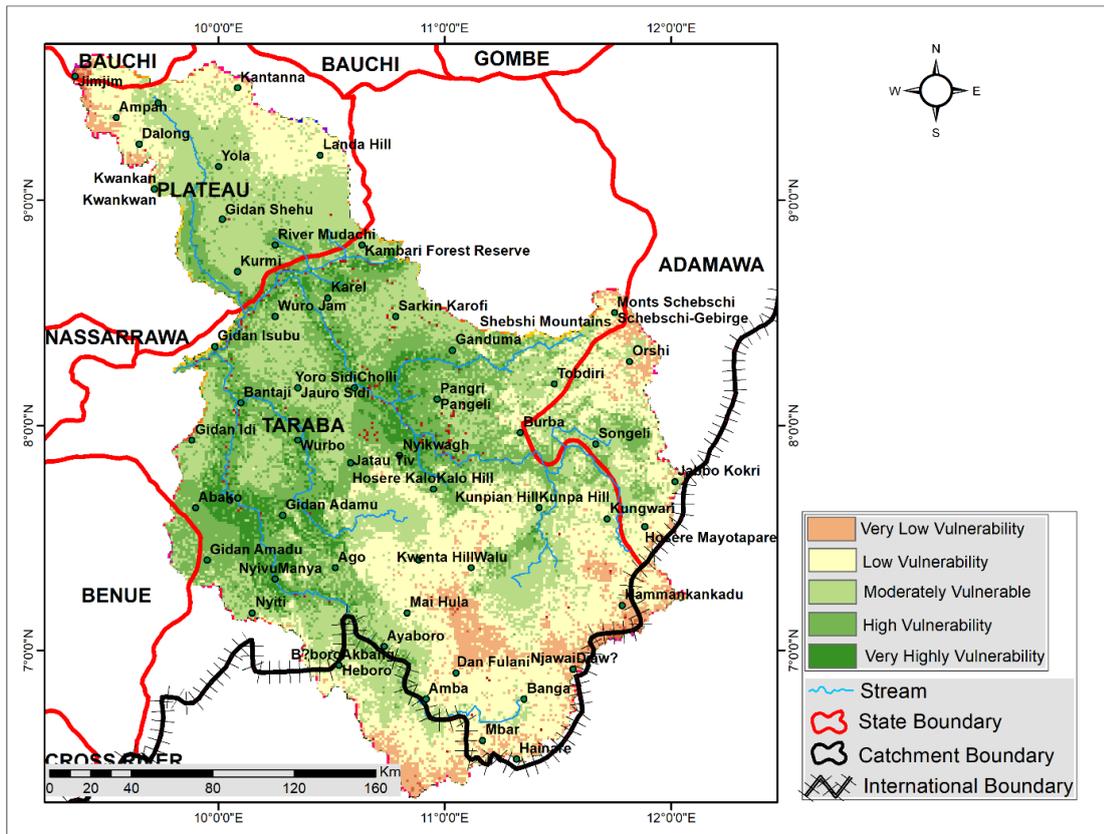


Figure 2.41: Flood vulnerability map (Source: MSL, 2024)

- Flooding in the Wase-Taraba region is primarily due to heavy rainfall from May to October and river overflows.
- The August 2012 flooding, triggered by intense rainfall and water releases from the Lagdo Dam in Cameroon, led to severe flooding, displacing thousands, destroying farmland, and impacting rural communities that depend on subsistence agriculture.

The September 2015 flooding, worsened by seasonal rainfall, poor drainage, and the overflow of the Benue River, severely affected riverbank communities, displacing thousands and causing significant agricultural loss and infrastructure damage.

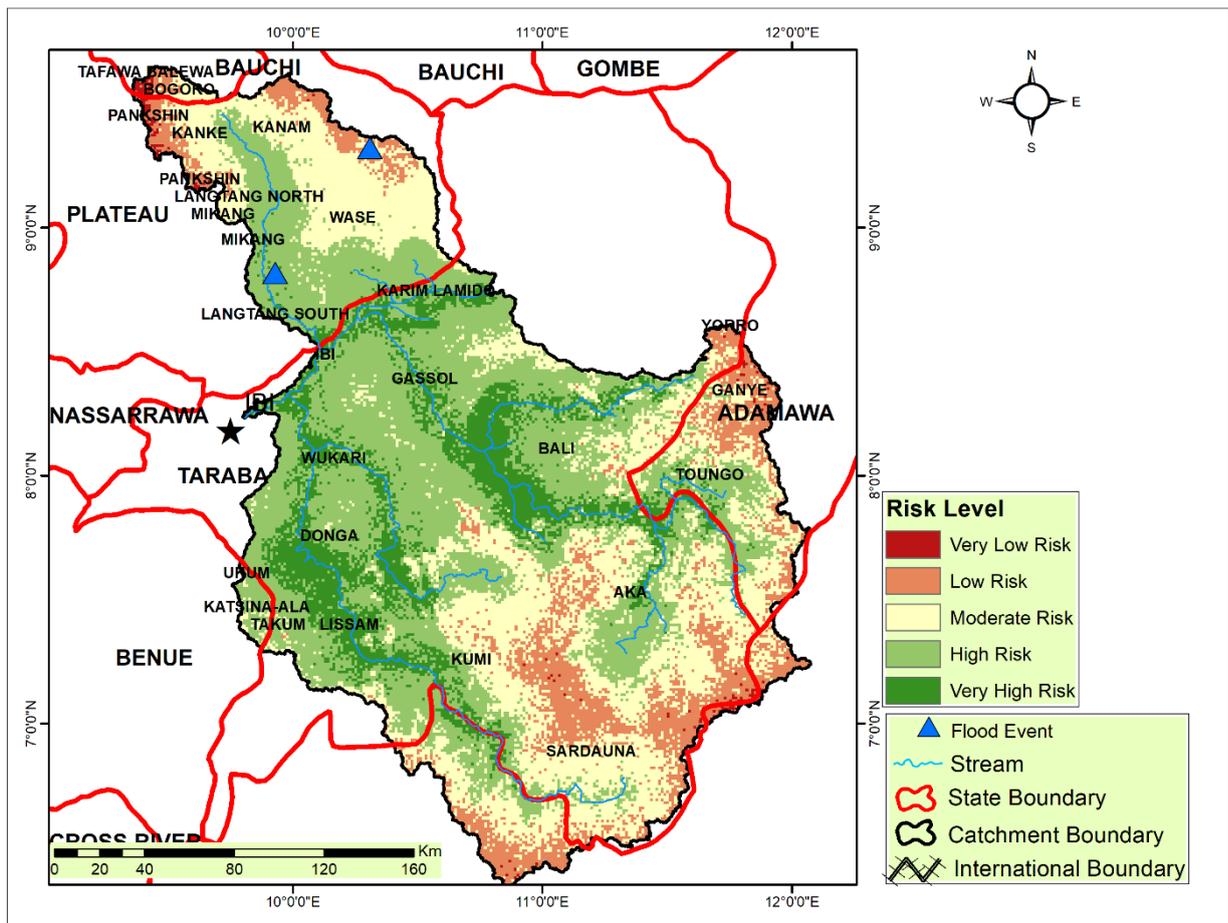


Figure 2.42: Flood Risk Level Map of the Catchment. (Source: MSL, 2024)

- The July 2018 flooding caused extensive damage, destroying farmlands and homes while displacing many.
- Emergency relief efforts were hampered by poor access routes. Similar flooding events occurred in August 2020, 2021, 2022, 2023, and 2024, albeit with less severity.
- Flooding in this area has become an annual phenomenon with significant effects.

The flood risk analysis shows farmland of 313,975.5Ha at 20% at high-risk and wetland 949,750.7 representing about 60%. The wetland areas are also farmlands where rice is mostly grown. Vegetation represents 10% at 163,146ha of the total land use/land cover at risk.

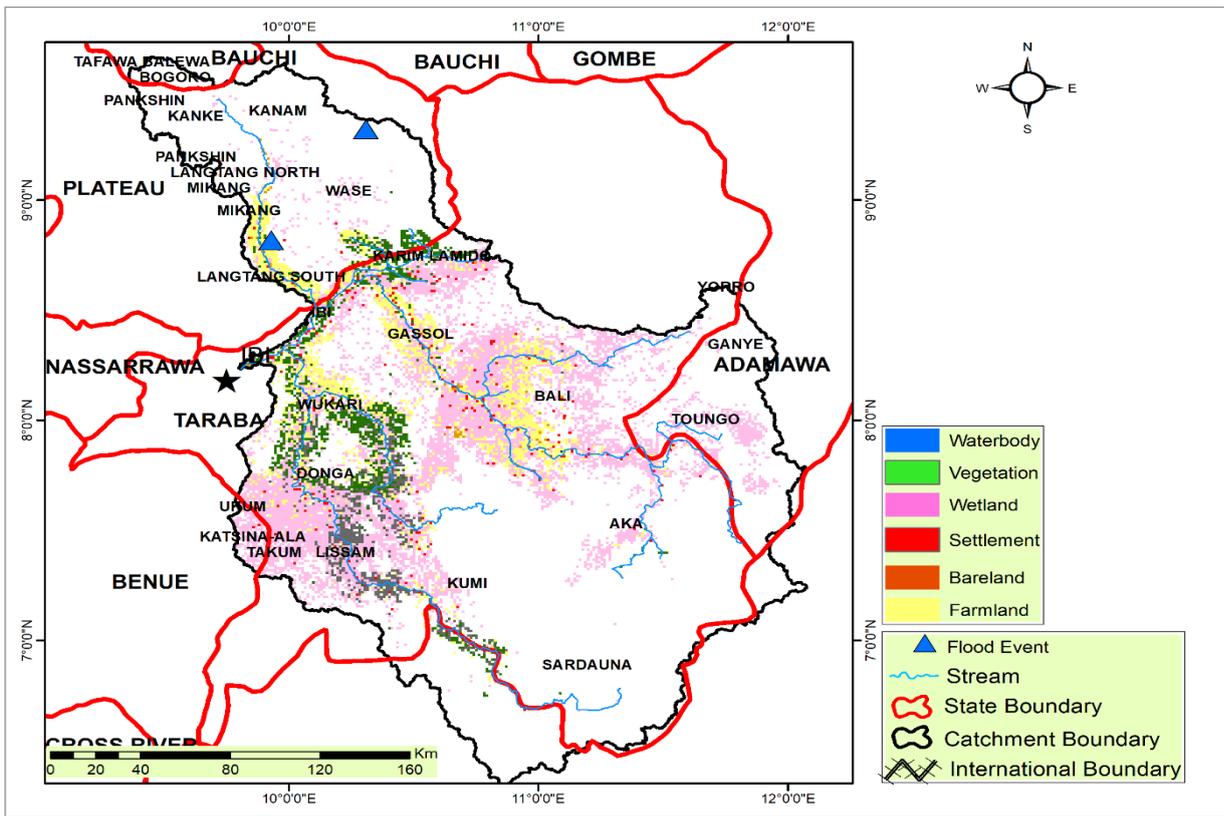


Figure 2.43: Recorded Flood Event Map of the Catchment. (Source: MSL, 2024)

## 2.10 Socio-Economic Dynamics

### 2.10.1 Population demographics and growth

- The current population in the catchment is approximately 5 million people (Fig 2.44).
- It is expected to grow to 9 million by the year 2050. More detailed tables with population by state and Local Government Area (LGA) is shown in Annex 1

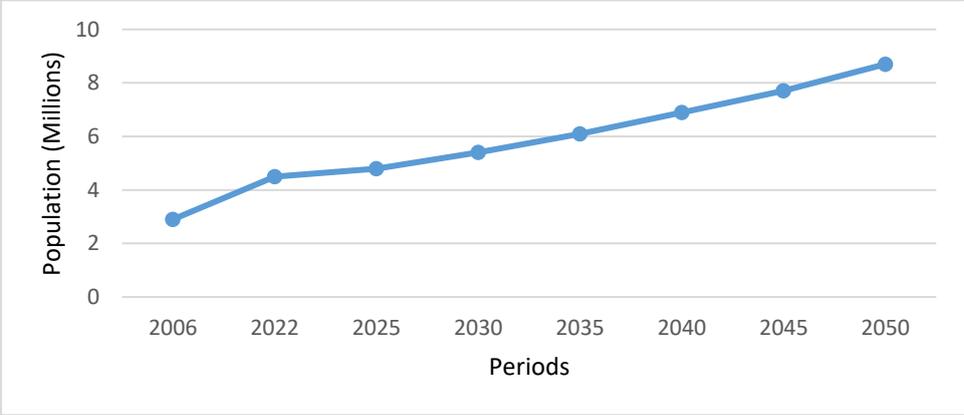


Figure 2.44: Projected population figures of the catchment

Table 2.20: Summary of the characteristics of Wase-Taraba Catchment

| NAME                  | STATES          | POPULATION   | GEOGRAPHY   | GEOLOGY   | HYDROGEOLOGY   | VEGETATION   | SOCIAL ECONOMICS   |
|-----------------------|-----------------|--|---|---|--|--|--|
| Wase-Taraba Catchment | Taraba, Plateau | The population in the Taraba-Wase River catchment is diverse, comprising rural communities engaged in agriculture, livestock rearing, and small-scale trade. Urban centers are limited, with towns serving as local markets and administrative centers | The Taraba-Wase River catchment is located in north central Nigeria, spanning parts of Taraba and Plateau States. The landscape varies from savannah woodlands to grasslands and hills. The terrain is generally flat with occasional hills and valleys | Geologically, the area consists of sedimentary rock formations with alluvial deposits along river valleys and floodplains.<br><br>Volcanic intrusions are sporadic, influencing soil fertility and agriculture in localized areas | The Taraba and Wase Rivers are major watercourses in the catchment, providing seasonal flows that support agriculture and local communities.<br><br>Groundwater resources are important for irrigation and domestic use, particularly during dry periods | Vegetation in the Taraba-Wase catchment includes savannah woodlands, grasslands, and shrubs adapted to semi-arid conditions.<br><br>Riparian vegetation along riverbanks includes trees such as acacias and doum palms, providing habitat for wildlife and shade for farming communities | Agriculture is the backbone of the economy in the Taraba-Wase catchment, with crops like maize, rice, yams, and cassava grown in the rainy season.<br><br>Livestock rearing (cattle, sheep, goats) is widespread, supporting pastoralist communities.<br><br>Trade in agricultural products and handicrafts contributes to local economies, with markets playing a central role in economic exchange |

## 2.10.2 Demographics and Poverty

Table 2.21: Catchment Demographics and Poverty for Wase-Taraba

| State   | Demographics and Poverty   |
|---------|--|
| Plateau | <ul style="list-style-type: none"> <li>• Plateau State has a population of approximately 4.7 million people (National Population Commission, 2023).</li> <li>• Population density is about 200 people per square kilometer, higher than many northern states due to its favorable climate and agricultural activities.</li> <li>• About 60% of the population is below the age of 25, while approximately 42% is under the age of 15.</li> <li>• The population has grown from around 2.2 million in 1991 to approximately 4.7 million in 2023 (National Population Commission, 2023).</li> <li>• The gender ratio is relatively balanced, with a male-to-female ratio of about 1.01:1 (National Bureau of Statistics, 2022).</li> <li>• Plateau has seen significant urbanization, particularly in Jos, the state capital, which serves as a commercial and administrative hub. Other major towns like Barkin Ladi, Pankshin, and Shendam have also experienced rural-urban migration due to better economic opportunities and social amenities.</li> <li>• The Total Fertility Rate (TFR) in Plateau is estimated at 5.6 children per woman, slightly above the national average of 5.3 (Nigeria Demographic and Health Survey, 2018).</li> <li>• Migration patterns show that Plateau has historically attracted settlers due to its temperate climate, fertile land, and commercial prospects. However, communal conflicts and security challenges have also caused displacement and migration in recent years.</li> <li>• If the current growth trend continues, Plateau’s population is projected to reach approximately 6.3 million by 2035 (United Nations, 2022).</li> <li>• Agriculture is a key sector, employing over 70% of the population. The state is known for producing potatoes, maize, tomatoes, yam, and fruits such as apples and strawberries due to its cool climate. Livestock rearing is also significant, particularly in the highland areas.</li> <li>• Plateau is ethnically diverse, home to over 40 ethnic groups, including the Berom, Afizere, Anaguta, Tarok, Mwaghavul, Ngas, and Ron. The state has a strong tradition of cultural festivals, crafts, and indigenous governance structures.</li> <li>• Christianity is the dominant religion in Plateau, particularly in Jos and surrounding areas, while Islam is practiced in some northern parts of the state. Traditional religions also persist in some communities.</li> <li>• The state has significant tourism potential, with attractions such as the Jos Wildlife Park, Riyom Rock formations, Kurra Falls, and the scenic hills and waterfalls of the Shere Hills.</li> <li>• Mining has historically been a major industry, with Plateau being rich in tin, columbite, and other minerals. However, mining activities have declined due to environmental concerns and reduced investment in the sector.</li> </ul> |

|                   |  |
|-------------------|--|
|                   | <ul style="list-style-type: none"> <li>• Infrastructure development is ongoing, but challenges remain in road networks, power supply, and industrial growth. Security concerns related to ethno-religious conflicts have also impacted economic activities.</li> <li>• Despite challenges, Plateau remains an important economic and cultural center in Nigeria, with strong potential in agriculture, tourism, and solid minerals development.</li> </ul>   |
| Taraba            | <ul style="list-style-type: none"> <li>• Approximately 3.7 million people (National Population Commission, 2023).</li> <li>• Population density is about 55 people per square kilometer.</li> <li>• Around 58% of the population is below the age of 25, while about 42% is under the age of 15.</li> <li>• The population has increased from 1.9 million in 1991 to approximately 3.7 million in 2023 (National Population Commission, 2023).</li> <li>• The gender ratio is relatively balanced, with a male-to-female ratio of approximately 1.02:1 (National Bureau of Statistics, 2022).</li> <li>• While the state remains largely rural, urban centers such as Jalingo, Wukari, and Takum have seen growing rural-urban migration due to better job opportunities, education, and access to healthcare.</li> <li>• Taraba has a Total Fertility Rate (TFR) of approximately 5.9 children per woman, higher than the national average of 5.3 (Nigeria Demographic and Health Survey, 2018).</li> <li>• The state has experienced population shifts due to migration from neighboring states and countries, particularly because of agricultural opportunities and conflicts in parts of Northeast and North Central Nigeria, leading to an influx of Internally Displaced Persons (IDPs).</li> <li>• If current trends persist, Taraba’s population is expected to reach around 5 million by 2035 (United Nations, 2022).</li> <li>• Over 80% of the population engages in farming. The state is a major producer of crops such as yam, cassava, rice, maize, sorghum, groundnuts, and cotton. It is also known for cattle rearing and fishing along the Benue River and its tributaries.</li> <li>• Taraba is one of the most ethnically diverse states in Nigeria, home to groups such as the Jukun, Mumuye, Tiv, Kuteb, Fulani, and Chamba. Traditional festivals and cultural heritage remain strong in the state.</li> <li>• Taraba has a mix of Islam, Christianity, and indigenous religions. The southern and central parts are predominantly Christian, while Islam is more common in the northern areas.</li> <li>• The state is home to the Gashaka Gumti National Park, the largest national park in Nigeria, known for its diverse wildlife and the conservation of chimpanzees. The Mambilla Plateau, with its cool climate, is another significant attraction.</li> <li>• The state faces infrastructure deficits, limited industrialization, and occasional communal conflicts over land and resources. However, its agricultural potential and natural resources present opportunities for economic growth and investment.</li> </ul> |
| Adamawa<br>Bauchi | <ul style="list-style-type: none"> <li>• The population of Adamawa is approximately 4.3 million, Bauchi has about 7.5 million, and Benue is home to around 5.8 million people (National Population Commission, 2023).</li> </ul>   |

|       |  |
|-------|--|
| Benue | <ul style="list-style-type: none"> <li>• All three states have a youthful population, with around 58–60% below the age of 25 and roughly 40% under 15 years old.</li> <li>• Population growth has been steady, with Adamawa growing from 2.1 million in 1991, Bauchi from 3.3 million, and Benue from 2.8 million, more than doubling over three decades.</li> <li>• Urbanization is increasing, especially in major cities like Yola, Mubi, and Jimeta in Adamawa; Bauchi, Azare, and Misau in Bauchi; and Makurdi, Gboko, and Otukpo in Benue. Rural-urban migration is driven by job opportunities, education, and better healthcare access.</li> <li>• Fertility rates are high, with Total Fertility Rates (TFR) ranging from 5.6 in Adamawa to 5.9 in Bauchi and Benue, all above the national average of 5.3 (Nigeria Demographic and Health Survey, 2018).</li> <li>• Migration patterns show inflows due to economic opportunities and conflict-related displacements. Adamawa and Bauchi have received Internally Displaced Persons (IDPs) from Boko Haram-affected areas, while Benue has seen migration linked to farmer-herder conflicts.</li> <li>• If current trends persist, the population is projected to reach 5.8 million in Adamawa, 9.5 million in Bauchi, and 7.2 million in Benue by 2035 (United Nations, 2022).</li> <li>• Agriculture is the backbone of all three states, engaging over 70–80% of the population. Bauchi and Adamawa are major producers of grains, groundnuts, and cotton, while Benue, known as the “Food Basket of the Nation,” leads in yam, cassava, rice, and fruits. Cattle rearing is significant in Adamawa and Bauchi, with Benue also having a thriving fishing industry along the Benue River.</li> <li>• Ethnic diversity is prominent, with Adamawa home to over 80 groups, including Fulani, Bachama, Kilba, and Chamba. Bauchi is predominantly Hausa, Fulani, and Gerawa, while Benue is dominated by the Tiv, Idoma, and Igede ethnic groups.</li> <li>• Religious composition varies, with Adamawa and Bauchi having a Muslim majority, particularly in the north, while Christianity is dominant in Benue and parts of southern Bauchi and Adamawa.</li> </ul> |
|-------|--|

### 2.10.2.1 Unsustainable Livelihoods

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

- **Unsustainable depletion of essential resources:** Poverty leads local communities to overharvest resources, such as overfishing and deforestation for firewood, resulting in environmental damage and illegal mining.

- **Lack of Alternative Livelihoods:** In numerous rural regions, opportunities for alternative income sources are scarce. This compels individuals to depend on agriculture and natural resources, which complicates the implementation of sustainable practices.

### **2.10.3 Gender Issues**

#### **Challenges**

Gender inequality in the region is influenced by cultural, social, and economic factors that disadvantage women and marginalized groups.

Limited access to education, skills, and financial services restricts their economic opportunities and participation in leadership and decision-making processes.

Socio-economic issues like poverty, conflict, and weak governance worsen climate change impacts.

Women are particularly vulnerable, facing increased risks of gender-based violence (GBV) during natural disasters and migration, which hinders their adaptation efforts. Despite policies like the Gender Policy and VAPP Law, challenges such as language barriers, lack of community engagement, and weak enforcement impede their implementation.

#### **Opportunities**

- Even with difficulties, the catchment offers possibilities for promoting gender equality.
- The involvement of government, civil society, and development organizations—driven by interventions related to insurgency—has led to greater funding and initiatives focused on 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.

## **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. The details from the respondents are as outlined in the Annex.

### **3.2 Key Stakeholders Engaged**

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

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

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

#### **Plateau State**

- i. Plateau Rural Water Supply and Sanitation Agency (RUWASA)
- ii. Plateau State Ministry of Environment, Climate Change & Mineral Development
- iii. Plateau State Ministry of Agriculture and food Security
- iv. Plateau State Ministry of Water Resources
- v. Plateau State Ministry of Lands
- vi. Plateau State Ministry of Tourism (Jos Wild Life Park)
- vii. Plateau State Ministry of Women Affairs
- viii. Plateau State Ministry of Solid Mineral Development
- ix. Plateau State Miners Association

#### **Taraba State**

1. Taraba Rural Water Supply and Sanitation Agency (RUWASA)

- ii. Taraba State Ministry of Water Resources
- iii. Taraba State Ministry of Lands
- iv. Taraba State Ministry of Women Affairs
- v. Taraba State Ministry of Solid Mineral Development
- vi. Taraba State Miners Association
- vii. Ministry of waste Management and resources Innovation
- viii. Taraba Farmers 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 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
- Community benefits
- Economic development
- Climate change resilience
- Monitoring and evaluation alignment of policies governing the catchment

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
- Dam and reservoir operating guidelines
- 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 2 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 Governance and Accessibility:**

- Stakeholders highlighted the significance of managing water resources sustainably, especially in tackling overexploitation and contamination resulting from activities upstream.
- There was a major emphasis on establishing and upholding operational guidelines for dams and reservoirs, in addition to river training to effectively manage sediment buildup and flow distribution.
- Improving climate resilience by implementing rainwater harvesting and broadening hydrometeorological monitoring networks was deemed essential.

#### **2. Land Utilization and Deterioration:**

- Worries were expressed regarding farming methods that are not sustainable, resulting in soil deterioration and a decline in productivity.
- The invasion of forest reserves for agricultural purposes was recognized as an urgent problem, adversely affecting biodiversity and leading to deforestation.

#### **3. Conservation of the Environment:**

- 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 Shortcomings and Policy Coordination:**

- 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. Enhancing Coordination Systems:**

- Create a multi-stakeholder platform to improve collaborative decision-making.
- Encourage capacity building for local institutions to enhance governance structures.

**7. Encouraging Eco-Friendly Methods:**

- 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. Improving Data and Oversight 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. Involving Communities:**

- Enhance community involvement with awareness initiatives focused on sustainability practices.
- Incorporate gender-sensitive strategies to empower marginalized groups, especially women, in resource management activities.

To ensure a comprehensive understanding of the results derived from the important contributions of the stakeholders, as noted above and detailed in the components of the plan (Fig .....-.....), recommendations for interventions were proposed:

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.

### **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 ACRoSAL 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 Wase-Taraba catchment is:

The strategic vision for the Wase-Taraba catchment is to attain a comprehensive, sustainable, efficient, and equitable use of all the resources within the catchment area

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)             |
|---|---|---|---|---|
| <p><b>1. Improved Oversight of Water Resources and Flood Hazards:</b><br/>Guarantee the sustainable management of water resources by safeguarding water sources, optimizing water usage, and reducing the</p> | <ul style="list-style-type: none"> <li>• Increase in year-round water availability for domestic, agricultural, and industrial purposes, expressed as a percentage.</li> <li>• Decrease in both the frequency and intensity of flooding events.</li> </ul> | <p><b>1. Perform an In-Depth Evaluation of the Catchment's Natural Assets, Ecosystem Functions, and Livelihood Opportunities.</b></p> | <ul style="list-style-type: none"> <li>• Finalizing the thorough assessment report within the established timeframe.</li> <li>• Count of evaluated natural resources, ecosystem services, and livelihood indicators.</li> </ul> | Enhanced water quality and availability |

|   |   |   |   |  |
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| <p>risks associated with floods and droughts.</p>   | <ul style="list-style-type: none"> <li>• Count of safeguarded and restored water sources (such as springs, boreholes, and rivers).</li> <li>• Decrease in water shortages caused by drought.</li> <li>• Proportion of water users implementing efficient water use practices, such as rainwater harvesting, drip harvesting, drip irrigation).</li> </ul> |   | <ul style="list-style-type: none"> <li>• Proportion of stakeholders engaged in the assessment process.</li> <li>• Total quantity of maps and datasets produced.</li> <li>• Identifying key challenges and opportunities documented in the assessment report.</li> </ul>   |  |
| <p><b>2. Protect and rejuvenate essential ecosystems and Services:</b> Safeguard and rejuvenate ecosystems like forests, wetlands, and wildlife habitats to sustain biodiversity, enhance ecosystem services, and foster ecological resilience.</p> | <ul style="list-style-type: none"> <li>• Enhancement of biodiversity metrics (e.g., count of observed species)</li> <li>• Protected and restored areas of vital ecosystems, including forests, wetlands, and wildlife habitats.</li> <li>• Growth in ecosystem services (such as water regulation, soil fertility, and carbon sequestration).</li> </ul>  | <p><b>2. Create a Collaborative Platform Involving Multiple Stakeholders for Unified Management of the Catchment.</b></p> | <ul style="list-style-type: none"> <li>• Rise in the variety of stakeholders included in the multi-stakeholder platform.</li> <li>• The frequency of platform gatherings (for instance, quarterly or twice a year).</li> <li>• Rise in the proportion of platform members engaging in meetings and activities.</li> <li>• Creation of a governance framework or terms of reference</li> </ul> | <p>Growth in tree coverage and variety of species.</p> |

|   |   |  |   |                                  |
|---|---|--|---|----------------------------------|
|   | <ul style="list-style-type: none"> <li>• Decreased deforestation and land degradation rates</li> <li>• Count of community-driven conservation initiatives</li> </ul>  |  | (TOR) for the platform.   |                                  |
| <p><b>3. Encourage Sustainable Farming and Animal Husbandry Practices:</b> Promote sustainable agriculture and livestock practices, including conservation agriculture, agroforestry, and integrated water management, to reduce environmental degradation and improve livelihoods.</p> | <ul style="list-style-type: none"> <li>• Growth in the percentage of farmers utilizing sustainable agricultural methods.</li> <li>• Decrease in soil erosion and land degradation rates</li> <li>• Boost in farming efficiency</li> <li>• Count of implemented integrated water management systems</li> <li>• Reduction percentage of harmful agrochemical usage</li> </ul> | <p><b>3. create and Execute a Water Resource Management Strategy</b></p>     | <ul style="list-style-type: none"> <li>• Finalizing and endorsing the water resources management plan on schedule</li> <li>• Total interventions for managing water resources implemented</li> <li>• Higher percentage of water users embracing efficient water conservation methods.</li> <li>• Decrease in disputes over water resources</li> <li>• Enhancement of water quality metrics</li> </ul> |                                  |
| <p><b>4. Improve Climate Resilience:</b> Adopt climate-resilient strategies such as</p>   | <ul style="list-style-type: none"> <li>• Proportion of households and farms implementing</li> </ul>   | <p><b>4. Initiate a Sustainable Agriculture and Livestock Initiative</b></p> | <ul style="list-style-type: none"> <li>• Growth in the number of farmers educated on sustainable agriculture and livestock methods</li> </ul>   | Lowered greenhouse gas emissions |

|  |  |  |   |   |
|--|--|--|---|---|
| <p>climate-smart agriculture, disaster risk reduction, and ecosystem-based adaptation to strengthen the catchment's resilience against climate change.</p> | <p>climate-smart agriculture practices.</p> <ul style="list-style-type: none"> <li>• Decrease in crop failure rates caused by climate variability.</li> <li>• Count of disaster risk reduction initiatives executed (e.g., early warning systems, flood barriers)</li> <li>• Growing adoption of ecosystem-based adaptation methods, such as reforestation and wetland restoration.</li> <li>• Proportion of communities benefiting from climate-resilient infrastructure, such as flood-resistant housing and drought-resistant water systems.</li> </ul> |  | <ul style="list-style-type: none"> <li>• Land area (in hectares) used for sustainable agriculture practices.</li> <li>• Increase in crop yield per livestock productivity.</li> <li>• Decrease in soil erosion and deterioration of land</li> </ul> |   |
| <p><b>5. Enhanced Livelihoods and Well-Being of diverse</b></p>  | <ul style="list-style-type: none"> <li>• Increase in household income percentage among</li> </ul>  | <p><b>5. Create a Program for Climate Change</b></p> | <ul style="list-style-type: none"> <li>• Count of climate change mitigation and</li> </ul>  | <p>Improved quality of life and human welfare</p> |

|   |  |   |  |   |
|---|--|---|--|---|
| <p><b>stakeholders in the catchment:</b> Improve the lives of local communities, particularly women and youth, by providing better access to education, healthcare, and economic opportunities.</p> | <p>local residents communities.</p> <ul style="list-style-type: none"> <li>• Enhanced access to education and healthcare services.</li> <li>• Increase in the percentage of women and youth involved in income-generating activities.</li> <li>• Decrease in poverty levels in the area</li> </ul> | <p><b>Mitigation and Adaptation</b></p> | <p>adaptation strategies applied</p> <ul style="list-style-type: none"> <li>• Rise in the number of households utilizing climate-resilient practices</li> <li>• Decreased susceptibility to climate-related disasters</li> <li>• Count of awareness campaigns on climate change mitigation and adaptation</li> <li>• Enhancements in climate resilience metrics (such as decreased crop failure rates and greater water availability during droughts)</li> </ul> |   |
| <p><b>6. Enhance inclusive governance and stakeholder collaboration:</b> Enhance governance and stakeholder participation by engaging local communities, civil</p>                                  | <ul style="list-style-type: none"> <li>• Rise in stakeholder engagement numbers</li> <li>• Growth in local communities engaging in</li> </ul>  |   |  | <p>Enhanced oversight and involvement of stakeholders</p> |

|   |  |  |  |  |
|---|--|--|--|--|
| society groups, and private sector organizations to promote inclusive decision-making and coordinated catchment management. | decision-making processes. <ul style="list-style-type: none"><li>• Increase in the effective enforcement of environmental regulations and policies.</li><li>• Decreased conflicts related to land use.</li></ul> |  |  |  |
|---|--|--|--|--|

## **CHAPTER 5 : STRATEGIC CHALLENGES AND PRIORITY INTERVENTIONS**

### **5.1 Key Issues**

Based on biophysical assessments and stakeholder engagement, the Wase-Taraba Catchment faces several interconnected environmental and socio-economic challenges:

#### **1. Management of Water Resources:**

- Seasonal fluctuations, flooding, and poor infrastructure hinder water management. Groundwater recharge declines, while surface water supply is limited by siltation and upstream diversions.
- Aging dams and reservoirs reduce their effectiveness, and unregulated water use impacts reservoir capacity and downstream flow. Low-lying communities are especially vulnerable to seasonal floods, damaging infrastructure, displacing residents, and disrupting local economies.

#### **2. Ecological Decline:**

- Deforestation, desertification, and invasive species are degrading ecosystems vital for biodiversity and livelihoods, causing river siltation and flooding. Invasive species like Typha grass hinder water flow.

#### **3. Unsustainable agricultural and livestock methods:**

- Excessive irrigation in agriculture depletes water resources, while inorganic fertilizers cause soil degradation and groundwater contamination. Additionally, inefficient water use in upstream areas disrupts water distribution.

#### **4. Climate Change:**

- Rising temperatures, unpredictable rainfall patterns, and more frequent droughts pose risks to agricultural output and water security.
- The absence of adaptive strategies intensifies the region's vulnerabilities.
- Elevated temperatures, inconsistent rainfall, and high rates of evapotranspiration diminish water availability and affect agricultural productivity.

**5. Socio-Economic Disparities and Unsustainable Livelihood Practices:**

- Significant poverty levels, ineffective governance, and restricted infrastructure access obstruct sustainable development.
- More than 70% of local government areas (LGAs) in the catchment are facing rapid population growth, resulting in high or very high poverty levels.

**6. Weak Governance:**

- Challenges in sustainable resource management arise from inadequate institutions, fragmented water management, poor policy enforcement, insufficient infrastructure funding, minimal stakeholder involvement, and a disregard for traditional governance frameworks, leading to insecurity.

## **5.2 Strategic Interventions**

To achieve the outlined goals, the Wase-Taraba Catchment Management Plan recommends the following strategic interventions:

**1. Enhance the management of water resources and the mitigation of flood risks.:**

- Restore current dams and reservoirs to enhance their capacity for water retention and discharge.
- Build small water storage systems and improve methods for collecting rainwater.
- Create water distribution strategies that harmonize the requirements of both upstream and downstream areas..
- Build embankments and enhance drainage systems in areas that are at high risk.
- Establish early warning systems and perform flood risk evaluations on a regular basis..
- Enhance the network of groundwater observation systems and hydrometeorological stations.
- Improve community knowledge and readiness for flooding situations..

**2. Safeguard and Revitalize Essential Ecosystems and Services.**

- Rehabilitation of 30% to 40% of degraded land through sustained tree planting.
- Rehabilitate 25% and enhance the quality of degraded agricultural land.
- Rehabilitate and preserve wetlands to stabilize water cycles and enhance biodiversity.
- Strengthen the protective limits of local and national parks and important forest and conservation reserves.

**3. Encourage eco-friendly farming and livestock methods.**

- Boost agricultural efficiency by 40% by implementing climate-smart farming practices, enhancing skills, and collecting data.

Enhance soil fertility practices and implement soil and water conservation techniques to minimize erosion.

- Assist small-scale farmers by providing education and access to advanced technologies.
- Promote the utilization of micro-irrigation systems.

**4. Improve Climate Adaptability:**

- Encourage the use of drought-tolerant crop varieties and effective irrigation methods..
- Encourage tree planting initiatives to address desertification and reinforce soil stability.
- Develop initiatives that involve the community for managing floodplains and safeguarding watersheds.

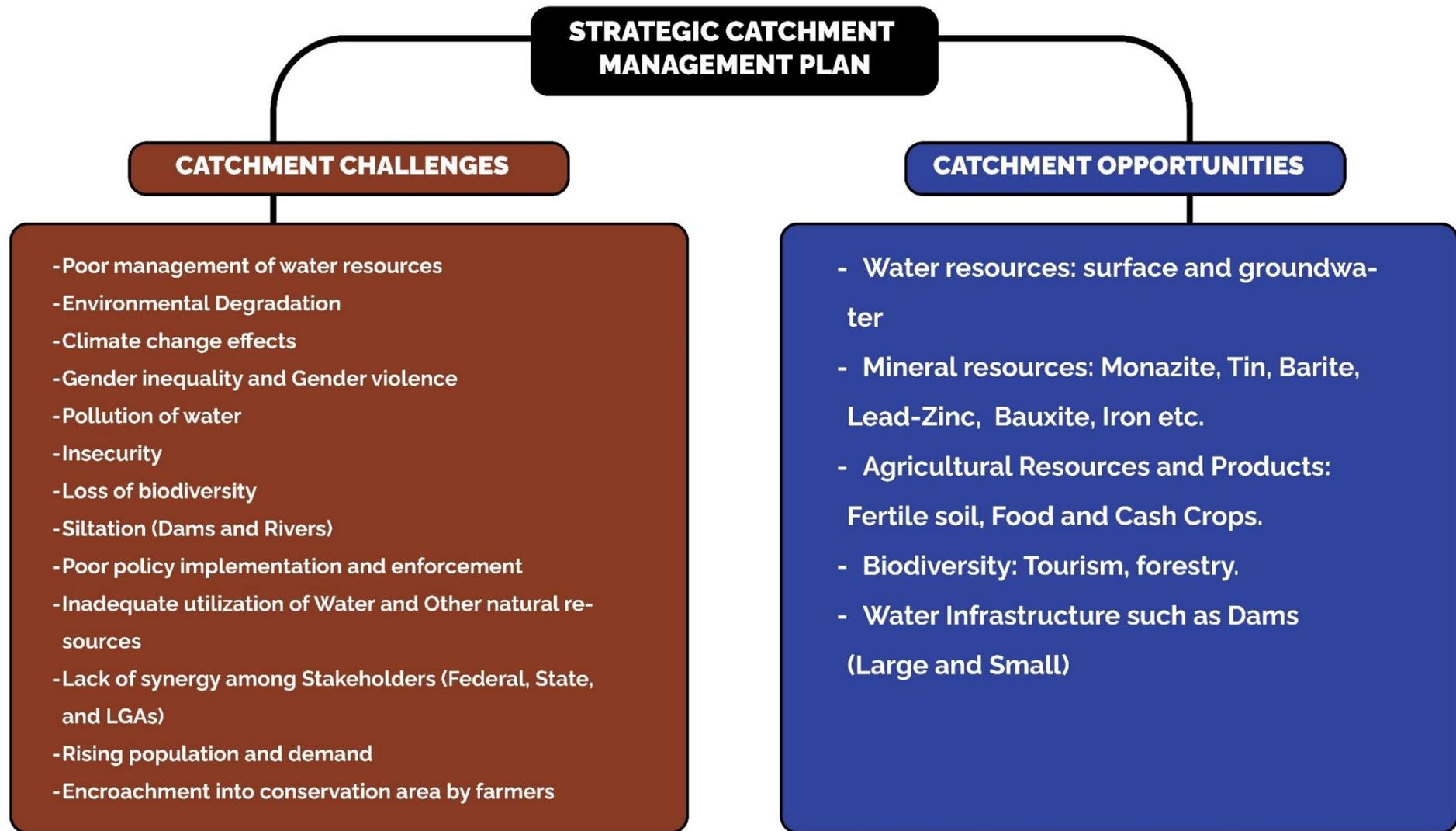
**5. Enhance Living Standards and Human Welfare.:**

- Provide training programs for sustainable farming, fishing, and aquaculture practices.
- Facilitate access to credit and market opportunities for smallholder farmers and fisherfolk.
- Develop community-based tourism and eco-friendly economic activities.
- Improve access to sustainable natural resources, low-cost energy, better sanitation and hygiene practices

**6. Enhance Governance and Collaboration with Stakeholders. Enhance Governance and Collaboration with Stakeholders.:**

- Establish a regulatory framework for integrated water resource management at the catchment level.
- Strengthen coordination among federal, state, and local agencies.
- Ensure community representation in decision-making processes and management committees.

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



*Figure 5.1: Strategic Catchment Management Plan*

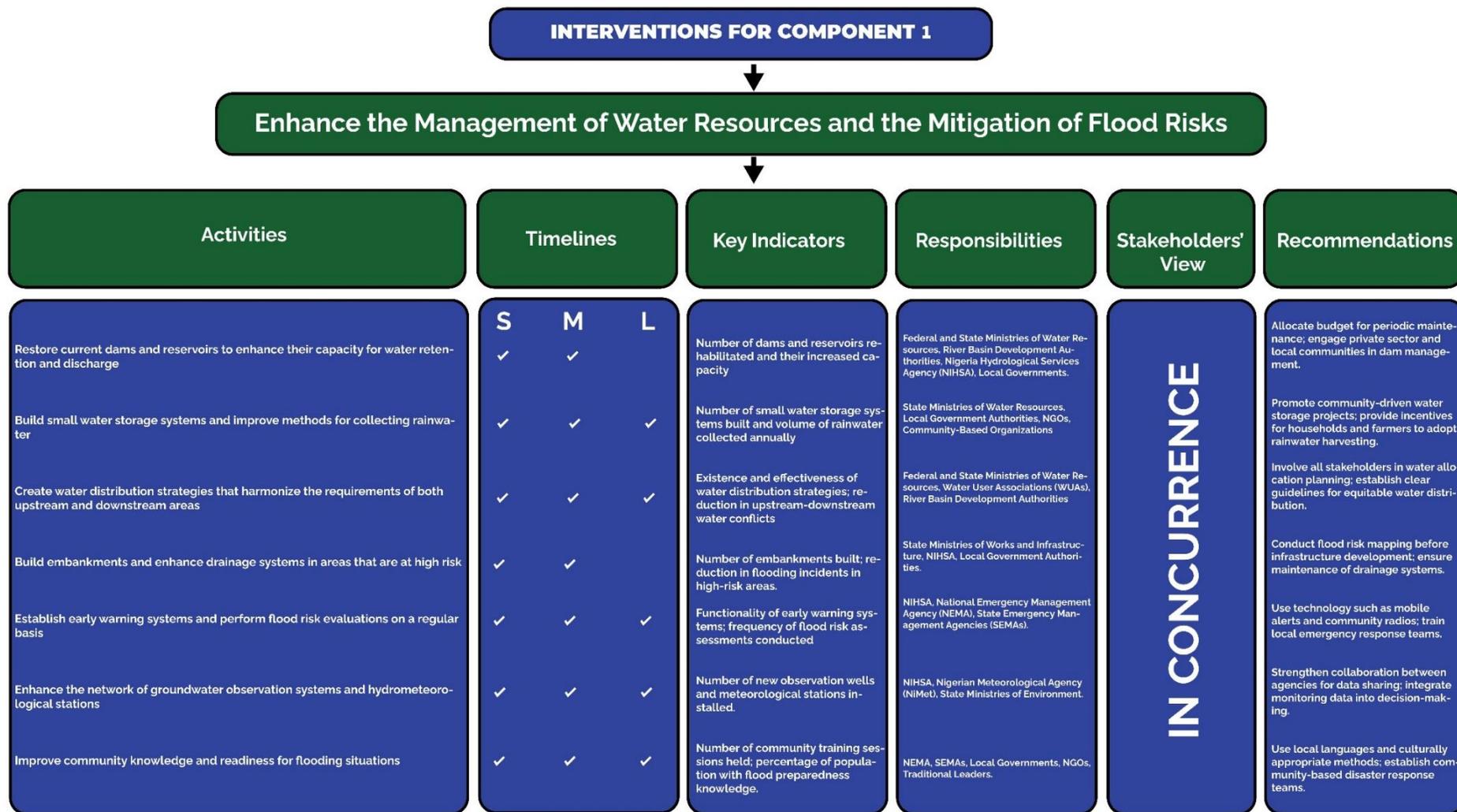


Figure 5.2: Component 1 (Enhance the Management of Water Resources and the Mitigation of Flood Risks)

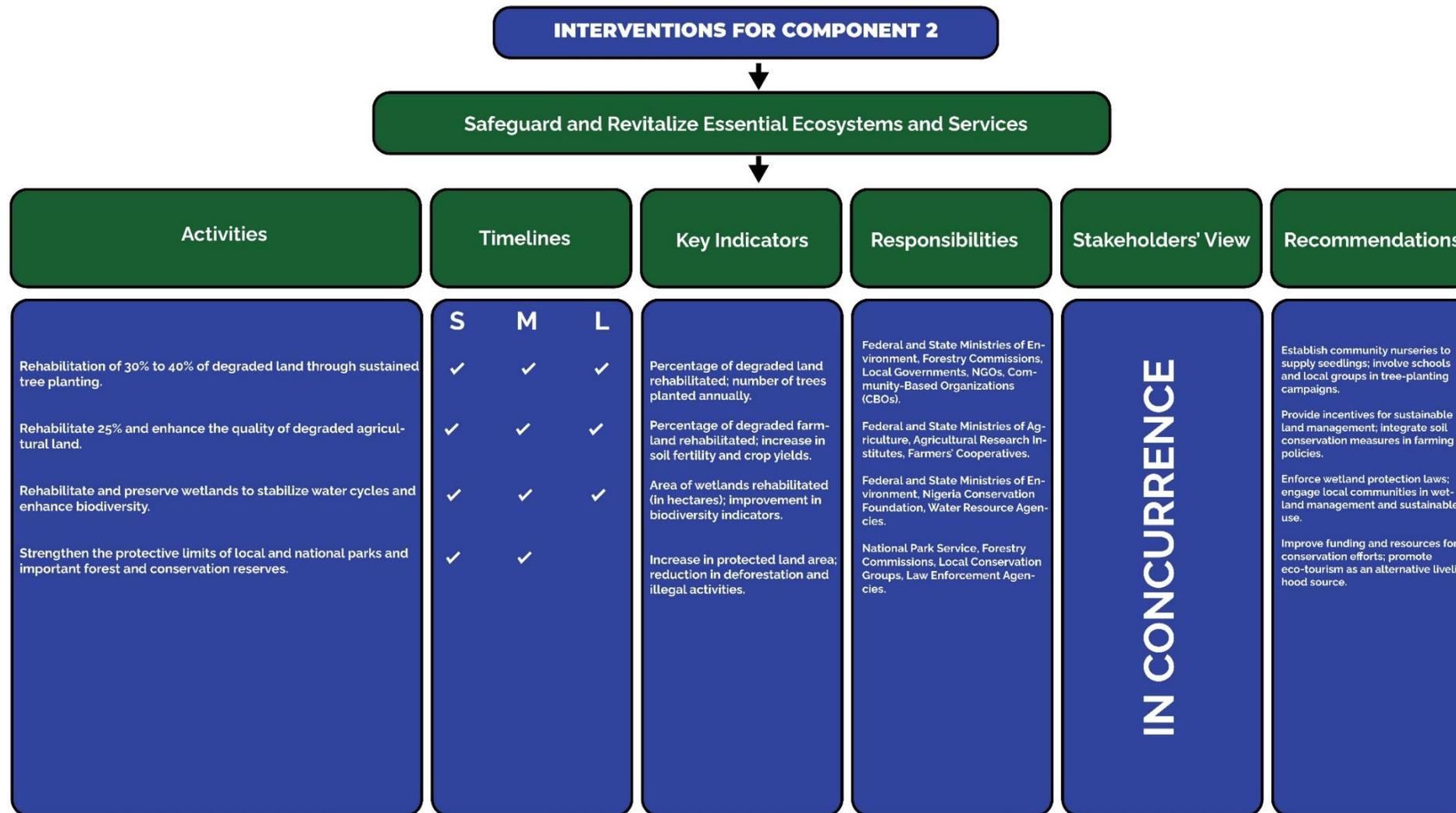


Figure 5.3: Component 2 (Safeguard and Revitalize Essential Ecosystems and Services)

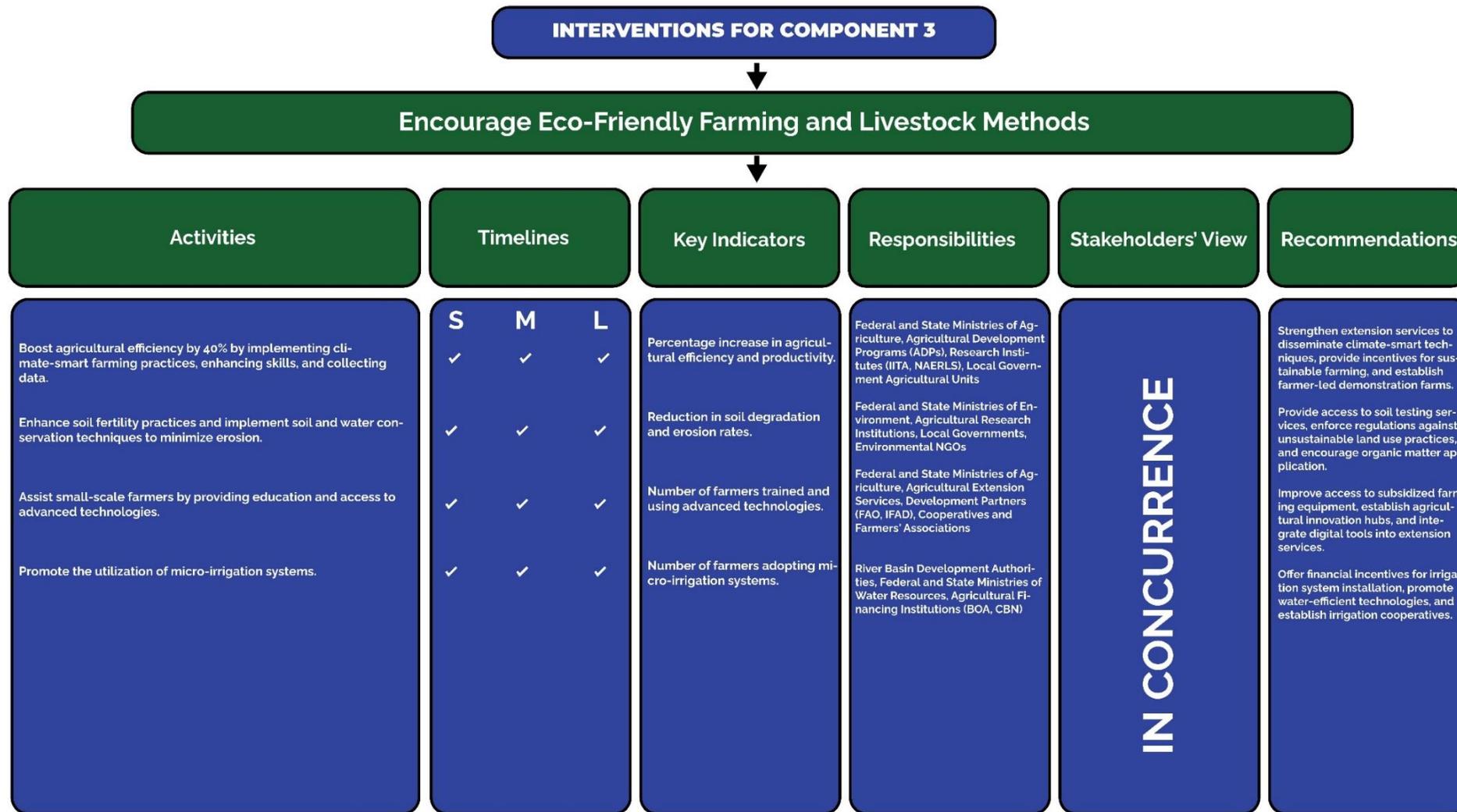


Figure 5.4: Component 3 (Encourage Eco-Friendly Farming and Livestock Methods)

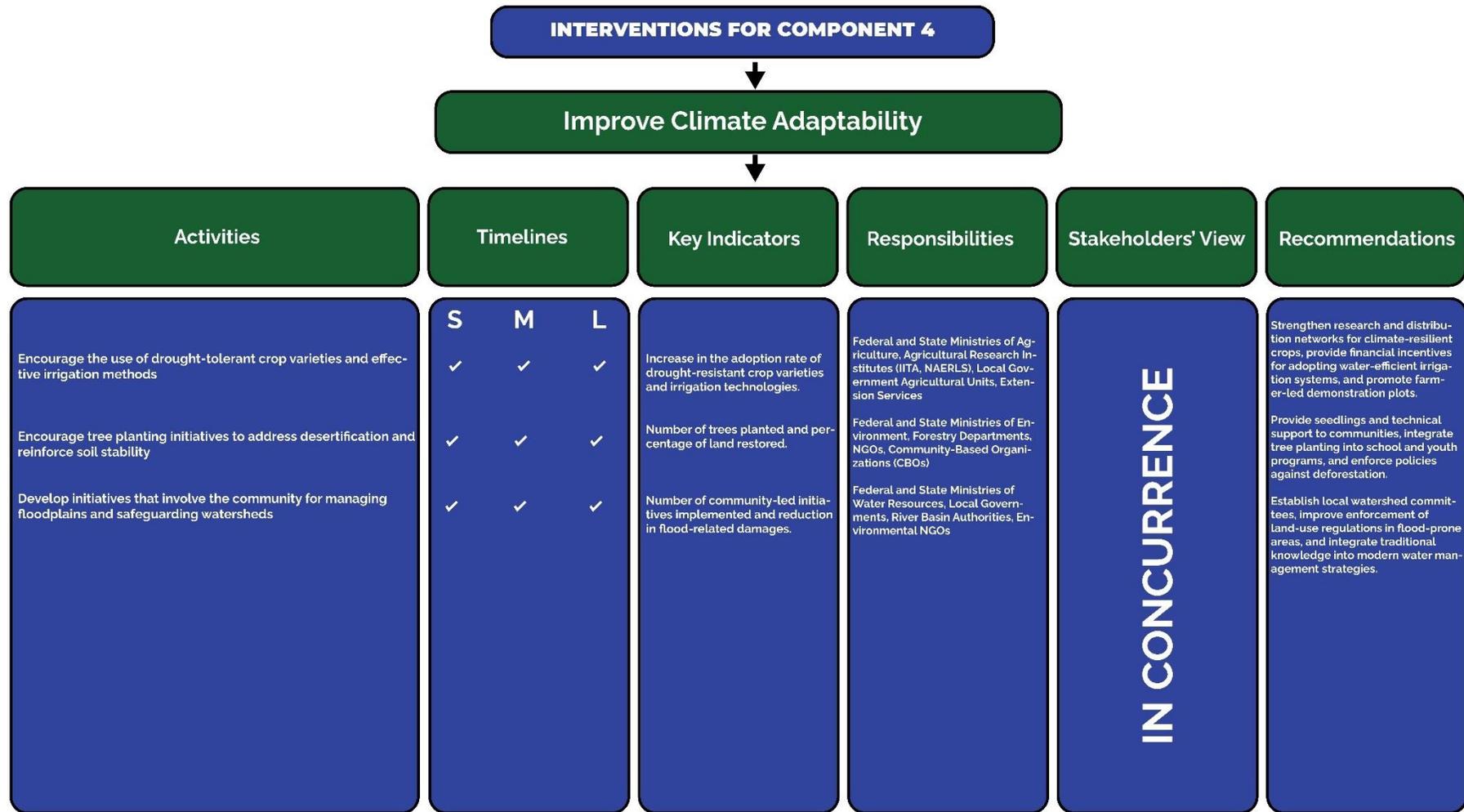


Figure 5.5: Component 4 (Improve Climate Adaptability)

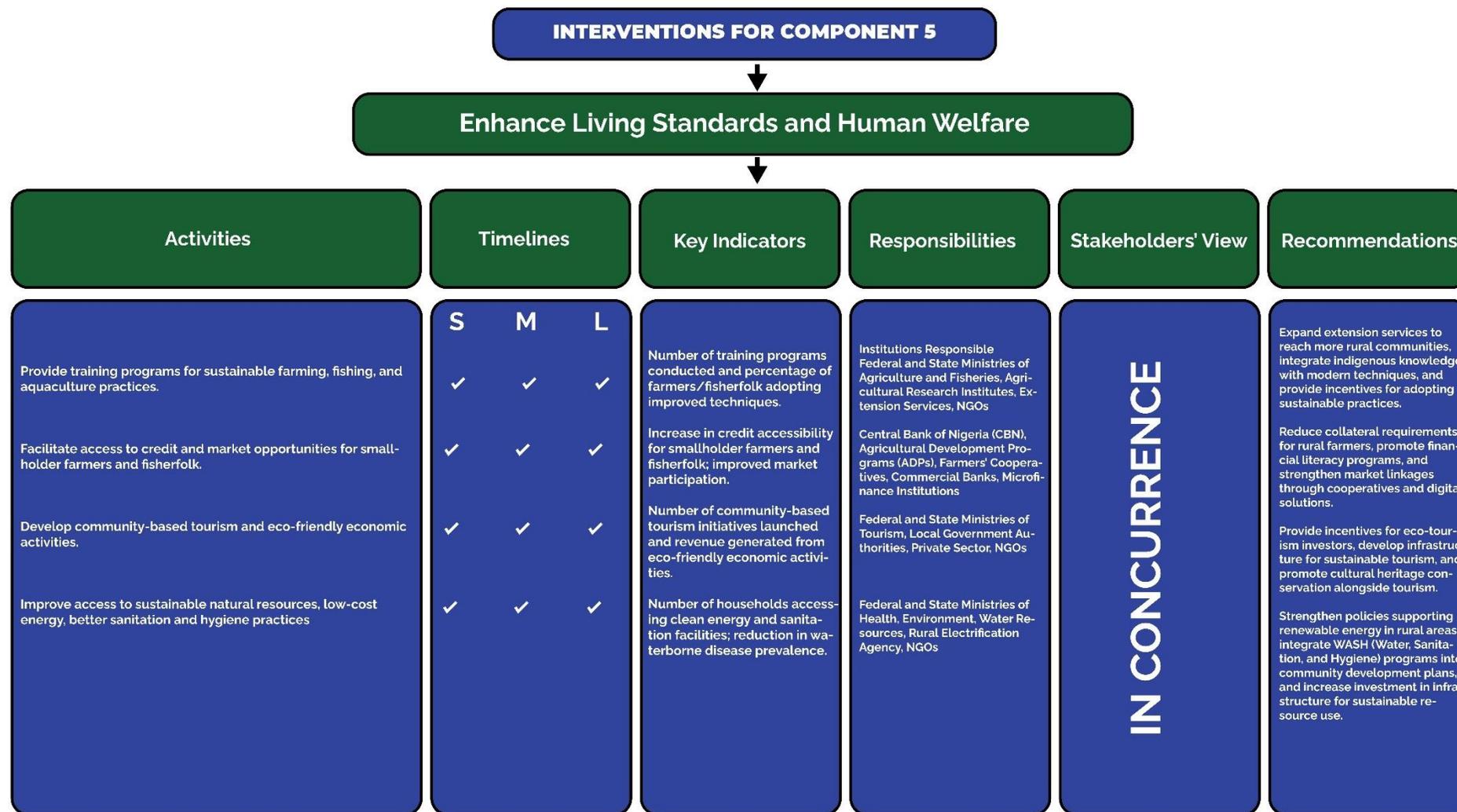


Figure 5.6: Component 5 (Enhance Living Standards and Human Welfare)

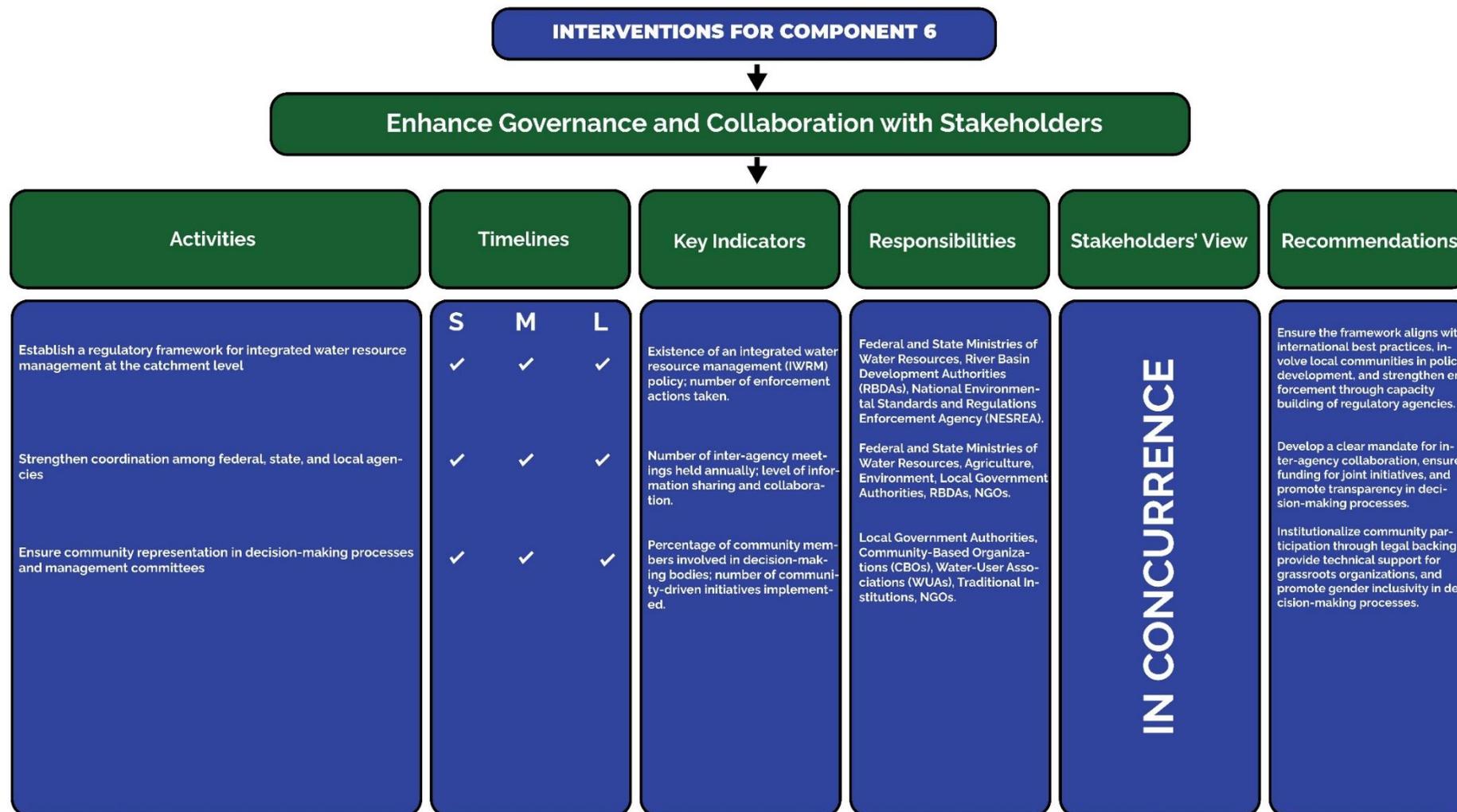


Figure 5.7: Component 6 (Enhance Governance and Collaboration with Stakeholders)

### **5.3 Expected Outcomes**

The successful implementation of these interventions will result in:

- a) Improved water availability and reduced seasonal scarcity.
- b) Enhanced resilience of agricultural systems to climate variability.
- c) Restoration of critical ecosystems and enhanced biodiversity.
- d) Reduced flood vulnerability and minimized socio-economic disruptions from extreme weather events
- e) Enhanced ecosystem services and biodiversity conservation.
- f) Increased climate change resilience and reduced greenhouse gas emissions.
- g) Improved livelihoods and reduced poverty and inequality.

Strengthened stakeholder engagement and collaboration

## **CHAPTER 6 : MONITORING, EVALUATION AND LEARNING**

### **6.1 Monitoring and Evaluation**

It is imperative to conduct ongoing monitoring and evaluation of strategic catchment plans to ensure their effectiveness and implement necessary adjustments. 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, actions are anticipated to be modified to reflect evolving priorities. Any amendments shall be documented in the appendix of the original management plan. Appropriate indicators will be identified for the monitoring process to assess catchment management activities and their impacts, encompassing biophysical and social dimensions. When relevant, these indicators will integrate multimedia elements, such as images, videos, and documents, and capture qualitative and quantitative data. The Monitoring and Evaluation Plan is shown in Table 6.1

### **6.2 Data Collection Methods**

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

- v. **Community-Based Monitoring:** Engagement of local communities in monitoring and reporting on environmental indicators, such as water quality and vegetation cover.
- vi. **Automated Sensors:** Installation of automated sensors to monitor water quality, flow, and other environmental parameters in real-time.

### **6.3 Feedback Mechanisms**

- i. **Regular Progress Reports:** Preparation and dissemination of regular progress reports to stakeholders, highlighting achievements, challenges, and future directions.
- ii. **Stakeholder Meetings:** Regular meetings with stakeholders to provide updates, gather feedback, and discuss emerging issues.
- iii. **Community Engagement Forums:** Hosting of community engagement forums to provide information, gather feedback, and build support for catchment management initiatives.
- iv. **Social Media:** Utilization of social media platforms to share information, gather feedback, and engage with stakeholders.
- v. **Online Feedback Mechanisms:** Establishment of online feedback mechanisms, such as surveys or comment boxes, to gather feedback from stakeholders.
- vi. **Independent Review Panels:** Establishment of independent review panels to provide objective feedback and assessment of catchment management initiatives.

### **6.4 Data Management and Analysis**

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

Table 6.1: Monitoring and Evaluation Plan for Wase-Taraba Catchment

| S/NO | Monitoring Tools and Techniques  | Target/Output  | Monitoring  | Evaluation  | Responsibility                                   |
|------|--|--|---|---|--|
| 1    | Geographical Information Systems<br><br>Tools: software, ArcGIS, QGIS, Mapbox etc  | Analyze and visualize spatial data use, water quality, and hydrological data.                            | Establish Key Performance Indicators to track progress.<br><br>Analyse data and come out with outputs.<br><br>Update visuals and maps on progress or otherwise.                                     | Mid-Term and End Term:<br>Conduct comprehensive evaluations at the midterm and end of implementations | WB/SPMU  |
| 2.   | Remote Sensing/Drone technology.<br><br>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.<br><br>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 stakeholder workshops | Land use and land cover monitoring are used to track changes.   | Environmental impact assessment.  | Consultant, NASRDA, NCRS                                     |
| 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. |

## **6.5 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:

### **6.5.1 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.

### **6.5.2 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.

### **6.5.3 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.

## **6.6 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 Wase-Taraba catchment area, which includes Plateau, Taraba and small parts of Adamawa and Benue States, is filled with various ecosystems and holds considerable socio-economic opportunities.

The Wase-Taraba Catchment Management Plan presents a holistic strategy to tackle the diverse challenges encountered in the region. The strategic actions detailed in this plan focus on the sustainable management of natural resources, improvement of livelihoods, and strengthening resilience to climate change, thereby promoting a balanced approach to socio-economic advancement and ecological preservation.

To enhance water management and reduce flood risks, the strategy emphasizes restoring critical infrastructure like dams and reservoirs, alongside developing small-scale water storage solutions. Improvements in drainage, flood risk assessments, and public education aim to safeguard communities and ensure equitable water distribution. Strengthening groundwater monitoring and promoting rainwater harvesting further supports sustainable water resource management.

Revitalizing essential ecosystems is crucial, targeting reforestation of 40% of damaged land and wetland rehabilitation. These efforts will stabilize water cycles, enhance biodiversity, and protect key habitats and resources for future generations.

Sustainable practices in agriculture and livestock management lie at the center of the approach to boost food security and economic stability. The objective is to revolutionize the agricultural sector by enhancing productivity through climate-resilient methods, improving soil health, and providing support to smallholder farmers via training and technology. Efforts like the implementation of micro-irrigation systems and measures to combat erosion highlight the dedication to sustainability.

Developing resilience to climate change is of utmost importance. Initiatives rooted in the community, tree planting programs, and the encouragement of drought-resistant crop types are essential in tackling desertification and vulnerabilities caused by climate change. At the same time, improving livelihoods through sustainable methods, availability of credit, and environmentally responsible economic activities will enable local communities, especially small-scale farmers and fishermen.

Achieving these goals requires strong financial and institutional support. The strategy emphasizes securing funding from state and federal governments for water, agriculture, and environmental projects. Establishing catchment development funds will help consolidate resources from various stakeholders. International donors, such as the World Bank and African Development Bank, play a vital role, particularly by aligning with initiatives like the Green Climate Fund. Additionally, public-private partnerships are essential for developing infrastructure and renewable energy, while local efforts can be enhanced through community contributions, cooperatives, and microfinance.

Ultimately, effective governance and collaboration among stakeholders are essential for the success of these initiatives. Creating frameworks for integrated water resource management, enhancing coordination between agencies, and guaranteeing that community members are included in decision-making will bolster the institutional basis for enduring success.

To summarize, the strategic initiatives and financial approaches offer a guide for promoting resilience, sustainability, and prosperity within the Wase-Taraba catchment, guaranteeing that both its natural and human systems can flourish despite upcoming challenges.

## **7.2 Recommendations for Aligning with Broader National and Regional Programs**

The catchment management plan should integrate with existing 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 of 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 Wase-Taraba catchment is a critical resource for the socio-economic and environmental well-being of the region. The Strategic Catchment Management Plan has been developed through a collaborative and inclusive process, with valuable inputs and contributions from stakeholders.

This plan provides a framework for managing the catchment in a sustainable and equitable manner, balancing the needs of different stakeholders and ensuring the long-term health and resilience of the catchment.

Through strategic prioritization, alignment with broader programs, and robust funding mechanisms, the plan sets a clear roadmap for sustainable development. Implementing these recommendations will enhance resource management, empower communities, and build resilience against environmental and socio-economic challenges, ensuring 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**

## **Shared Strategic Vision and Goals**

Based on the engagements with stakeholders, the following summarises the shared vision for the catchment;

- 2) **Goal:** The main goal is to attain a comprehensive, sustainable, efficient, and equitable use of all the resources within the catchment area
- 3) **Objectives:** the specific objectives are to”:
  - n) Develop a sustainable livelihood within the catchment in 5 years (2025-2030)
  - o) Establishment of new 7 Dams within Wase-Taraba River basin within 5years namely river lamurde for agriculture, river Lau for agriculture, River Ibi, River Zurak for agriculture, River Namnai for agriculture, river Dapshi in Kanam LGA for domestic/ Agriculture
  - p) Dredging’/river draining of the basin for Agricultural purposes, Expansion, and flood control
  - q) Gender & Social Inclusion in all interventions
  - r) Restoration of Forest Reserves/ Wildlife Parks in Wase, Kanam, and Wuakari
  - s) Establishment of Shelterbelts using drought resistance tree species & Economic Trees
  - t) Development of water resources potential
  - u) Ensure Community involvement (Participatory Approach) through Design, Planning & Implementation processes
  - v) Develop a hydro- Meteorological database for monitoring Quantity & Quality of Water and early warning system and gauging Stations
  - w) Ensure Sustainability & regulation of all resources
  - x) Develop community infrastructure e.g., electricity, roads, health centers, market, schools, solar powered boreholes etc.
  - y) Development & implementation of guidelines regarding Dams
  - z) Enforce Floodplain Management
- 4) **Stakeholder Engagement:** Cascading stakeholder engagement from bottom-top Approach (Communities e.g., youth, women organization, Traditional leaders religious, tribal organization, physically challenge etc) L.G.A, State, Federal, CSO/NGO/CBO etc.)
- 5) **Water Management:** Effective Utilization of water resources

- a) Rehabilitation of existing Old Muri in Taraba, Wanune Dam in Tarka LGA, Benue State, Tungo Dam, Gembu Taraba State, Timdore ganye LGA Adamawa state.
  - b) Establishment of new 7 Dams within Wase-Taraba River basin within 5years namely river lamurde for agriculture, river Lau for agriculture, River Zurak in Wase LGA, for agriculture, River Nammnai for agriculture, River Dapshi in Kanam LGA for domestic/ Agriculture
  - c) Dredging'/river dredging the basin for Agricultural purposes and grazing.
  - d) Enacting of water management laws across the catchment area
  - e) Establishment of regulatory bodies for enforcement and compliance.
  - f) Allocating and releasing of a dedicated budget for those regulatory bodies and for water quality in the catchment area.
  - g) Establishing and equipping of water quality testing laboratories within the catchment area.
  - h) Develop a hydro- Meteorological database for monitoring Quantity & Quality of Water and early warning system and gauging Stations
- 6) **Land Use:** Sustainable Utilization of Land for farming, forest reserve, Urban development, Mining Activities within the scope of Land use act and mining laws
- 7) **Environment Protection**
- a) Restoration of Forest Reserves/ Wildlife Parks
  - 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
- 8) **Economic Development:**
- a) Develop a sustainable livelihood within the catchment in the 5 years (2025-2030)
- 9) Establishment/rehabilitation of new and abandoned dams within the catchment area.
- 10) **Climate Change Resilience:** to develop and implement an action plan for managing climate change impacts

**M&E:** To develop M&E framework that involve all stakeholders (federal, state, local government, CSO/NGO/CBO/FBO, Community leaders, physically challenged etc).

WABE-TARABA CATCHMENT SHAREN USUWA

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WAAGE - TARABZA CATCHMENT SHARES NSICOW

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## STAKEHOLDER ENGAGEMENT AT TARABA-WASE CATCHMENT



## GLOSSARY

### Glossary of Key Terms

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

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|---|--|
| <b>Carrying Capacity</b>                    | The maximum population size of a species that an environment can sustain indefinitely, given the available resources.  |
| <b>Catchment Delineation</b>                | The process of defining the boundaries of a watershed using topographic and hydrological data.   |
| <b>Catchment Management Plan (CMP)</b>      | 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. |
| <b>Channelization</b>                       | The artificial straightening or modification of a river or stream, often to control flooding but sometimes leading to ecological harm.   |
| <b>Climate Adaptation</b>                   | Actions taken to adjust to the impacts of climate change, such as building flood defenses, developing drought-resistant crops, or improving water management systems.  |
| <b>Climate Mitigation</b>                   | Efforts to reduce or prevent greenhouse gas emissions, such as using renewable energy, improving energy efficiency, or reforestation.  |
| <b>Climate Resilience</b>                   | The ability of a system, community, or ecosystem to anticipate, prepare for, and adapt to climate-related risks and recover from their impacts.  |
| <b>Community-Based Organizations (CBOs)</b> | Local groups or associations that work to address community needs and challenges, often playing a key role in implementing development projects.   |
| <b>Desertification</b>                      | The process by which fertile land becomes desert, typically due to drought, deforestation, or inappropriate agriculture.   |
| <b>Discharge</b>                            | The volume of water flowing through a river or stream per unit of time (e.g., cubic meters per second).  |
| <b>Ecological Footprint</b>                 | A measure of human demand on Earth's ecosystems, comparing the resources consumed to the planet's capacity to regenerate them.   |
| <b>Ecosystem Services</b>                   | The benefits that humans derive from ecosystems, such as clean water, air, food, and climate regulation.   |
| <b>Environmental Degradation</b>            | The deterioration of the environment through depletion of resources, destruction of ecosystems, and pollution, often caused by human activities.   |

|  |  |
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| <b>Environmental Impact Assessment (EIA)</b> | A process used to evaluate the potential environmental effects of a proposed project or development before it is carried out.  |
| <b>Erosion</b>                               | 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.   |
| <b>Eutrophication</b>                        | 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.  |
| <b>Evapotranspiration (ET)</b>               | The combined process of water evaporation from soil and transpiration from plants, a key component of the water cycle.   |
| <b>Floodplain</b>                            | A flat area of land adjacent to a river or stream that is prone to flooding, often rich in biodiversity and fertile soil.  |
| <b>Geographic Information System (GIS)</b>   | A computer-based tool for mapping and analyzing spatial data, widely used in catchment management.   |
| <b>Greenhouse Gas (GHG)</b>                  | Gases that trap heat in the atmosphere, contributing to global warming and climate change. Examples include carbon dioxide (CO <sub>2</sub> ), methane (CH <sub>4</sub> ), and nitrous oxide (N <sub>2</sub> O). |
| <b>Groundwater Recharge</b>                  | The process by which water from precipitation or surface water percolates into the ground, replenishing aquifers and maintaining water availability.   |
| <b>Gully Erosion</b>                         | Severe erosion where water cuts deep channels into the soil, often due to poor land management.  |
| <b>Hydraulic Conductivity</b>                | A measure of how easily water can move through soil or rock, important for groundwater studies.  |
| <b>Hydrological Cycle</b>                    | The continuous movement of water on, above, and below the Earth's surface, including processes such as evaporation, condensation, precipitation, and runoff.   |
| <b>Hydrological Modeling</b>                 | The use of mathematical models to simulate and predict the movement and distribution of water within a catchment or watershed.   |
| <b>Infiltration</b>                          | The process by which water soaks into the soil from the surface.   |

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|---|---|
| <b>Instream Flow</b>                                | The water flow required to maintain aquatic ecosystems and downstream water needs.  |
| <b>Integrated Catchment Management (ICM)</b>        | A holistic approach to managing land, water, and other natural resources within a catchment, considering social, economic, and environmental factors.                               |
| <b>Integrated Water Resources Management (IWRM)</b> | A holistic approach to managing water resources that considers social, economic, and environmental factors, promoting sustainable and equitable use.                                |
| <b>Land Degradation</b>                             | The decline in land quality caused by human activities, such as deforestation, overgrazing, and poor agricultural practices, leading to reduced productivity and ecosystem health.  |
| <b>Land Tenure</b>                                  | The system of rights and institutions that govern access to and use of land, including ownership, leasing, and communal arrangements.   |
| <b>Land Use/Land Cover (LULC)</b>                   | Categories describing how land is utilized (e.g., forest, agriculture, urban) and its surface characteristics.  |
| <b>Livelihood Diversification</b>                   | 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.    |
| <b>Livelihood Resilience</b>                        | The ability of households or communities to withstand and recover from economic, environmental, or social shocks, often through diversified income sources and adaptive strategies. |
| <b>Microcredit</b>                                  | Small loans provided to low-income individuals or groups to support income-generating activities, often used to promote entrepreneurship and poverty alleviation.                   |
| <b>Multidimensional Poverty Index (MPI)</b>         | A measure of poverty that considers multiple deprivations in health, education, and living standards, providing a comprehensive understanding of poverty beyond income levels.      |
| <b>Non-Governmental Organizations (NGOs)</b>        | Non-profit organizations that operate independently of government, often focused on social, environmental, or developmental issues.   |
| <b>Normalized Difference</b>                        | A remote sensing indicator used to assess vegetation health and density by measuring the difference between near-infrared (NIR)   |

|   |  |
|---|--|
| <b>Vegetation Index (NDVI)</b>          | and red light reflectance. Higher values indicate healthier vegetation.  |
| <b>Participatory Approach</b>           | A methodology that involves stakeholders in decision-making processes, ensuring their perspectives and needs are considered.                     |
| <b>Peak Flow</b>                        | The highest discharge rate in a stream or river during a rainfall or snowmelt event.   |
| <b>Permeability</b>                     | The ability of soil or rock to allow water to pass through it.   |
| <b>Public-Private Partnership (PPP)</b> | A collaborative arrangement between government agencies and private sector entities to deliver public services or infrastructure projects.       |
| <b>Rainwater Harvesting</b>             | The collection and storage of rainwater for later use, such as irrigation, drinking water, or groundwater recharge.                              |
| <b>Reforestation</b>                    | The process of replanting trees in areas where forests have been depleted or degraded, aiming to restore ecosystem functions and biodiversity.   |
| <b>Resilience</b>                       | The capacity of a system, community, or ecosystem to absorb disturbances, adapt to change, and continue to function effectively.                 |
| <b>Riparian Zone</b>                    | The interface between land and a river or stream, often rich in biodiversity and critical for water quality and ecosystem health.                |
| <b>Rotational Grazing</b>               | A livestock management practice where animals are moved between different grazing areas to allow vegetation recovery and prevent overgrazing.    |
| <b>Runoff</b>                           | Water that flows over the land surface rather than infiltrating into the soil, often carrying pollutants.  |
| <b>Sediment Load</b>                    | The amount of sediment carried by a river or stream, affecting water quality and aquatic habitats  |
| <b>Sedimentation</b>                    | The deposition of soil, sand, and other particles carried by water, which can reduce water quality, clog waterways, and harm aquatic ecosystems. |
| <b>Socio-Economic Indicators</b>        | Metrics used to measure the social and economic conditions of a population, such as income levels, education, health, and employment rates.      |

|                                       |  |
|---------------------------------------|--|
| <b>Soil Conservation</b>              | Practices aimed at preventing soil erosion and degradation, such as contour plowing, terracing, and cover cropping.  |
| <b>Soil Fertility</b>                 | The ability of soil to sustain plant growth by providing essential nutrients, water, and a suitable physical structure.  |
| <b>Stakeholder Engagement</b>         | 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.  |
| <b>Stakeholder Forum</b>              | A platform for dialogue and collaboration among stakeholders, often used to share knowledge, discuss challenges, and develop solutions.  |
| <b>Stakeholder Mapping</b>            | The process of identifying and analyzing stakeholders to understand their interests, influence, and potential impact on a project.   |
| <b>Streamflow</b>                     | The flow of water in a natural channel, influenced by precipitation, groundwater, and land use.  |
| <b>Subsidence</b>                     | The sinking of land due to groundwater over-extraction or soil compaction.   |
| <b>Sustainable Agriculture</b>        | 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. |
| <b>Sustainable Development</b>        | 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.       |
| <b>Traditional Knowledge</b>          | Knowledge, practices, and beliefs developed by indigenous and local communities over generations, often used to manage natural resources sustainably.                                      |
| <b>Total Dissolved Solids (TDS)</b>   | A measure of the combined content of inorganic and organic substances dissolved in water, affecting quality.   |
| <b>Transboundary Water Management</b> | Cooperative management of shared water resources (e.g., rivers, aquifers) between countries or regions.  |
| <b>Water Allocation</b>               | The regulated distribution of water resources among competing users (e.g., agriculture, industry, households).   |
| <b>Water Balance</b>                  | An accounting of all water inputs (precipitation) and outputs (evapotranspiration, runoff) in a catchment.   |

|                                   |   |
|-----------------------------------|---|
| <b>Water Footprint</b>            | The total volume of freshwater used to produce goods and services consumed by an individual, community, or organization.  |
| <b>Water Quality</b>              | The chemical, physical, and biological characteristics of water, determining its suitability for specific uses such as drinking, irrigation, or ecosystem health.               |
| <b>Water Scarcity</b>             | A condition where the demand for water exceeds the available supply, often exacerbated by population growth, climate change, and poor water management.                         |
| <b>Water Table</b>                | The upper surface of the zone of saturation in the ground, where the soil or rocks are permanently saturated with water.  |
| <b>Water Use Efficiency (WUE)</b> | The ratio of beneficial water use (e.g., crop yield) to total water applied, indicating sustainable practices.  |
| <b>Watershed</b>                  | 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."                             |
| <b>Wetland</b>                    | 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. |
| <b>Wetland Restoration</b>        | The process of returning a degraded wetland to its natural state to improve water quality and biodiversity.   |
| <b>Zoning</b>                     | The process of dividing land into areas with specific land-use regulations, such as residential, agricultural, or conservation zones.   |

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