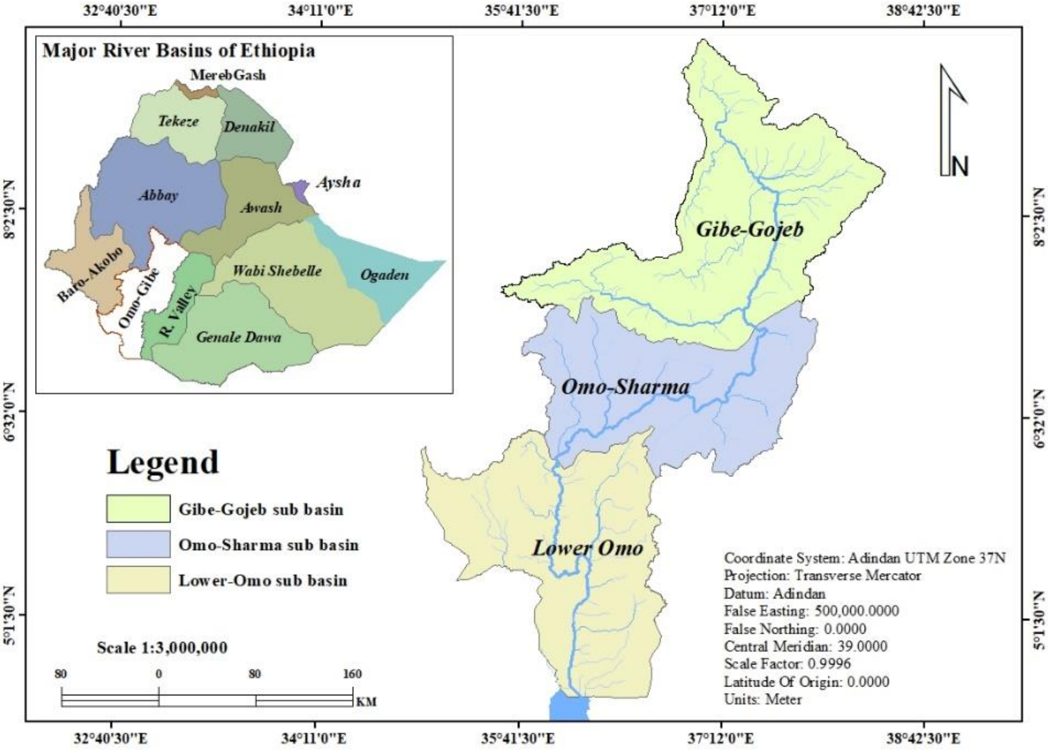
ውሃና ኢነርጂ ሚኒስቴር
MINISTRY OF WATER AND ENERGY
የኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ | Federal Democratic Republic of Ethiopia

ወላይታ ሶዶ ዩኒቨርሲቲ
WOLAITA SODO UNIVERSITY

THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF WATER AND ENERGY



THE BASIN PLAN OF THE OMO GIBE RIVER BASIN, ETHIOPIA

MAY, 2024

WOLAITA SODO, ETHIOPIA

ACKNOWLEDGEMENT

In developing Basin Plan of Omo-Gibe River Basin, several people and offices at different levels have contributed to the development of this Plan. The plan has benefited from the initiative and hard work of the Ministry of Water and Energy of the Federal Democratic Republic of Ethiopia. The Wolaita Sodo University has contributed its utmost effort for preparing this plan and brought the basin plan document to this level.

In addition to financial support, the Water Resources Administration Sector of the Ministry of Water and Energy has reviewed and provided valuable comments on the basin plan document at its different levels of preparation. Furthermore, the different stakeholders have played a crucial role in provision of revelant data, and constructive comments through stakeholder consultations at different stages of this basin plan development process.

Moreover, the Research and Community Services Vice President Office, and Administration and Development Vice President Office of Wolaita Sodo University have supported this project consistently in deliveling vehicles and other administrative supports. The World Resource Institute has also supported the project through undertaking various technical meetings particularily at Lower Omo sub-basin.

Finally, the integration of different governmanetal and non-governmental organizations as well as various relevant bodies has relialied this plan to happen. Therefore , we hope that this Basin Plan will contribute a lot to the development of Omo Gibe River basin in particular and the country in general.

ACRONYMS

ADD	Average Daily Demand
BCM	Billion Cubic Meter
CBOs	Community Based Organizations
CIWD	Commercial and Institutional Water Demand
CRGE	Climate Resilient Green Economy
DBS	Database System
DEM	Digital Elevation Model
DRR	Disaster Risk Reduction
DWD	Domestic Water Demand
EEPCo	Ethiopian Electric Power Corporation
EPA	Environmental Protection Authority
EU	European Union
FDRE	Federal Democratic Republic of Ethiopia
GCM	Global Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIZ	German Agency for International Cooperation
GTP	Growth and Transformation Plan
HEIs	Higher Education Institutions
HERIs	Higher Education and Research Institutes
HH	Household
HRUs	Hydrologic Response Units
IWD	Industrial Water Demand
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
LULC	Land Use Land Cover
MCM	Million Cubic Meter
MILD	Ministry of Irrigation and Lowlands Development
MoA	Ministry of Agriculture
MoI	Ministry of Industry
MoT	Ministry of Tourism
MoTRC	Ministry of Trade and Regional Cooperation
MoWE	Ministry of Water and Energy
NMS	National Meteorological Services
OGR	Omo Gibe River
RBHC	River Basin High Council
RCMs	Regional Climate Models
RCPs	Representative Concentration Pathways
SWC	Soil and Water Conservation
SB	Sub Basin

SIDA	Swedish International Development Cooperation Agency
SIWI	Stockholm International Water Institute
SLM	Sustainable Land Management
SNNPR WRIDB	South Nations, Nationalities and Peoples Region
SWAT	Soil and Water Assessment Tool
TWD	Total Water Demand
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WB	World Bank
WHO	World Health Organization
WRDF	Water Resource Development Fund
WRI	World Resource Institute
WRIDB	Water Resources and Irrigation Development Burea
WRM	Water Resource Management
WUAs	Water User Associations

CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The Omo Gibe River course is entirely contained within the boundaries of Ethiopia. The Omo Gibe River Basin is located in the southwest of Ethiopia, between 4°30'and 9°30' N and 35° and 38° E. The basin covers a total area of about 79,000 km^2 Sq. km. The basin is bounded by Lake Turkana to the south, Rift Valley Lakes Basin to the east, Bako Akobo to the West and Awash and Abay Basins to the north. The Omo-Gibe River Basin consists of major perennial rivers including: Gibe, Gojeb, Wabe, Walga, Woybo, Deme, Zigna, Kako, Neri, Sharma and others. The basin has wider wetlands at the periphery of Rivers. Rainfall in Omo-Gibe basin varies from over 1900 mm per annum in the north central areas to less than 300 mm per annum in the south. The mean annual temperature in Omo-Gibe basin varies from 16 ^{0}C in the highlands of the north to over 30^{0}C in the lowlands of the south.

The Omo-Gibe River Basin has huge natural resource potentials. But, the resource utilization base of the basin is unwise. Due to this, the basin is prioritized to prepare the basin plan that aims mainly on the basin's clear roadmap for effective water resources management/development, utilization, allocation, and conservation so as to ensure sustainable socio-economic development while protecting the environment/ecosystem. The preparation of this basin plan has used various approaches including: intensive literature review, stakeholder consultation, and preliminary field survey, and different models including climate and hyrological models. In addition, all recommended interventions are checked for the conformation with the Country's policies and legal frameworks as well as international conventions which the country has signed.

The basin plan of the Omo-Gibe River Basin went through four integrated stages: (i) conducting situation assessment where basin's physical, biological, social, and economic situations are assessed to gain an understanding of the current and future conditions in the basin as well as to identify and prioritize the key issues; (ii) formulating the vision and goals to provide the long-term inspirational desired state for the basin together with goals and principles to achieve this over time; (ii) developing the strategies to specify a coherent suite of strategic objectives, outcomes, and actions related to protection and use of water resources in the basin; (iv) detailing the implementation to define actions that give effect to the basin strategies and ultimately achieve the vision and objectives.

The sub-basin scale assessment in the Omo-Gibe River Basin revealed major basin scale related issues that need immediate interventions. The issues include lack of effective management/ development, efficient utilization, and proper allocation of water resources, deterioration of surface and groundwater resource quality and potential, vulnerability of the community to natural disaster, lack of active stakeholder participation in planning, decision making, implementation, monitoring, and evaluation of integrated water resources management. In general, increase in human and livestock population, adoption of irrigation practices by the community, and evolvement of private agricultural farms resulted in abstraction of more water from rivers. Furthermore, unregulated water abstraction, no agreed water sharing principle among users, limited commitment in law enforcement, water-inefficient irrigation practices, growing crops not matching local conditions, limited effort to develop water sources other than rivers, soil erosion and river course siltation, reservoir sedimentation and associated flooding due to extensive deforestation and over grazing, poor stakeholder involvement and integration in areas of water resources utilization and conservation, and lack of awareness of stakeholders on use of catchment and water resources management are identified as key issues.

To solve the identified issues/problems, a number of activities were organized under five major goals including: 1) Enhance availability, sustainable management, proper allocation and optimum utilization of water resources in the basin for sustainable social, economic and environmental benefits; 2) Ensure the availability of good water quality for sustainable economic and social development; 3) Improve water resource potential, conservation and community livelihoods through

integrated watershed management; 4) Ensure active stakeholder participation to improve planning, implementation, monitoring and evaluation of projects related to IWRM and 5) Reduce flood, drought and climate change risks in the basin to improve social, economic and environmental benefits.

Through the active participation of all stakeholders, Policy makers and regulatory bodies (Parliament of Federal Democratic Republic of Ethiopia, Council of Ministers, Basin High Council, Ministry of Water and Energy, Ministry of Agriculture, Ministry of Finance, and Regional Administrative Councils), the high level decisions could be achieved. These include: revision of legal issues, take political leadership and coordination, allocate resources, guide implementers, monitor implementation, evaluate performance and outcome. The basin plan implementation is only possible when all the concerning bodies of the federal, regional, zonal, woreda level, kebele (community) and other stakeholders will share and implement the plan. The implementing offices take responsibility to create and strengthen awareness, supervise, and consult users, organizing capacity building trainings, mobilize the public and support community effort. They also take part in law enforcement and resource mobilization. On the other hand, knowledge institutions provide technical support, capacity building trainings, and innovative research. Civic organizations, international funding institutions, and NGOs provide concerted technical and financial support. All water user community in the basin provide required information, reflect their interests and opinions, attend awareness raising trainings, and use the adopted new technologies.

Finally, effective implementation of the Omo-Gibe River Basin plan could be possible if the MoWE take its major role. This could be through coordinating the activities via developing the schedule and structure of the plan. In addition, the said institution should bring the stakeholders and the community on-board to take preventive measures for potential problems and corrective actions to manage unforeseen risks and uncertainties. The major mitigation options for the risks and uncertainty is through taking different intervention mechanisms to manage the challenges and unpredictable problems by the discussions among the MoWE, Regional and zonal offices. They include: anticipation of potential problems ahead and design different preventive options and strategies and managing effectively of any unpredicted risk which could be effectively managed through strong team spirits among the stakeholders. The basin plan implementation body, specifically, shall share experiences from experienced IWRM based basin plan executing basins nationally and internationally and use the lessons obtained as a useful inputs.

The Ministry of Water and Energy shall coordinate the project activities in each goal and manage the possible risks in consultation with regional states, higher education and research institutions and the proposed Basin Administration offices in the Omo-Gibe River Basin. Critical success factors to implement the basin plan could be commitment of the top management, communication of the basin plan with the stakeholders, organization of the components of the basin plan for implementation, creating awareness training, and community participation and acceptance. The basin plan is formulated to serve for 15 years (2024 to 2038) and the total cost required for its implementation is estimated at about ***605,165,000,000 ETB****.*

1. INTRODUCTION

1.1 BACKGROUND OF THE PROJECT

Basin planning is the process by which decisions are made over the competing uses and different demands for water resources and associated systems within a basin. Basin plans set objectives and the measures for developing, protecting and harnessing the resources of the basin in order to achieve these objectives and health and safety of the river itself (Pegram et al., 2013). Water has always played a central role in Ethiopian society. It is an input, to a greater or lesser extent, to almost all production. It is also a force for destruction. In Ethiopia, as in all societies, there has always been a struggle to reduce the destructive impacts of water and increase its productive impacts.

Ethiopia has twelve river basins: Abbay, Awash, Baro Akobo, Genale Dawa, Mereb, Omo Gibe, Rift Valley, Tekeze, Wabe Shebele, Afar Denakil, Ogaden and Aysha with a total amount of 122 Billion Meter Cubic (BMC) annual runoff (Awulachew et al., 2007; Ayalew, 2018). The Omo Gibe River Basin is one of the twelve river basins in Ethiopia. In terms of hydropower development potential, it is the second largest and it is a basin in which most of the current hydropower development takes place. The basin is also endowed with a variety of wildlife with Omo and Mago parks being located in the basin, its tourism potential will be further exploited as infrastructure develops in the area (Ayalew, 2018). Recreational and scenic use sites in the basin consists of waterfalls, parks, Artificial Lakes, wetlands, fishing areas of the artificial lakes, water transportation, topographic contrasts in the basin and etc.

The management of the basin's natural resources can only be held to be sustainable when viewed against a holistic and systematic analysis that defines all the inherent inter-relationships. Decision makers would thus be provided with clear statements of cause and effect; with development of natural resources in one area materially affecting resource availability in another. These arguments are particularly important for the allocation and management of water resources. Yet, for other resources such as land, labor and capital such as systems approach would not apply. Approaches developed through both regional planning and land use planning would be more appropriate.

Regional planning has evolved from an economic development viewpoint and traditionally seeks to project the impact of alternative economic scenarios on a region defined by political and administrative boundaries; land use planning seeks to analyze the agricultural capabilities of rural areas. Together these approaches provide a more appropriate planning framework for agriculture, industry, infrastructure, and tourism and service sector development. There are several competing water uses in the basin which resulted in decreased water level of rivers and reservoirs. As a result, people in the basin are suffering from water shortages. Thus, managing water is important. The effectiveness of strategies for dealing with water availability, quality, and variability is a major determinant of the survival of species, the functioning and resilience of ecosystems, the vitality of societies, and the strength of economies. Therefore, an integrated water resource management should be implemented to balance the competing water uses in basin.

1.2 PURPOSE AND SCOPE OF THE RIVER BASIN PLANNING

River Basins Management is one of the integrated water resources management areas. River basin management (RBM) may be defined as the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximize the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems. Conducting RBM is generally understood as a spiral process; each cycle of the spiral comprising several steps. It is expected that the next cycle of the spiral will be better managed than the previous one, after evaluation and lessons learned. The key steps are globally as follows : (i) establishing a river basin profile and mapping the stakeholders; (ii) develop water dialogue amongst the stakeholders for identifying issues and opportunities and developing shared vision ; (iii) together with the stakeholders, develop a road map with short, middle and long term strategies; (iv) from the road map, develop actions plans that will be mainstreamed into the socio-economic development plan at different level (national, provincial and district) or that may be part of the legal framework; (v) monitor and evaluate the implementation of the actions plans which will be an entry for updating each of the steps during the next cycle. A cycle may reasonably cover a period of 5 years.

The basin plan is a basin-wide strategy; its main purpose is to guide all actors involved in Omo Gibe River Basin water resources and related issues towards achieving improvements in the environmental, social and economic state of the River Basin for the coming fifteen years. The plan will contribute to a wider adaptive planning process linking regional and national plans towards realizing the common vision of an economically prosperous, socially just, environmentally sound, and climate resilient Omo Gibe River Basin. It provides an integrated basin perspective for enhancing national plans and projects to ensure an acceptable balance between economic, social and environment outcomes, with benefits to all basin regions and its people. In its most developed form, basin planning can bring together a range of different disciplines and themes from hydrology and engineering to ecology and economics.

Basin planning has been undertaken over many years, for many different purposes and in different types of basins in many countries. Some of this planning has been very formal and organized; on other occasions it is more sporadic, less organized, or develops organically over time. As a result of this history, our understanding of the process, nature, methodologies and techniques for basin planning has developed. While there are some common themes and principles that have emerged, there is no universally applicable template or roadmap for river basin planning. By nature, basin planning must reflect, consider and respond to the historical, physical, political, social, economic and institutional characteristics of the basin and country. It is this feature that complicates the development of generic guidelines for basin planning. Despite such evidences, however, no strategic plan has been done and implemented. Therefore, it is an urgent issue to conduct Omo Gibe River Basin plan for sustainable and integrated water resources management of the basin.

1.3 GOAL AND OBJECTIVES OF THE OMO GIBE RIVER BASIN PLAN

Goal

- To provide a comprehensible strategy to address the priority water resources concerns in the basin

Objectives

- To identify, analyze and prioritize significant water resources issues in the basin
- To formulate thematic actions
- To prioritize and categorize action plans in terms of short, medium and long term

1.4 APPROACH AND METHODOLOGY OF BASIN PLANNING

1.4.1. Approaches of Basin Planning

The basic approach used in the development of the Omo Gibe River Basin plan was participatory, consultative with consensus building and based on the understanding of the key water issues having impact on integrated water resources management. Consultations and dialogue between the key national, regional and local stakeholders was conducted for the development of the basin plan.

Considerations in Preparing the Basin Plan

The process of basin plan preparation for WRM in Basin wide considers the need to produce a Basin plan which is operationally realistic in the present Ethiopian context and that is sustainable in the future. The functions, structures and procedures are designed to be pragmatic and take into account the resources constraints existing in Basin in particular in water resources management, development and use, existing institutional structures and the management capacity available for implementation. The basin will also be flexible as much as possible to meet the immediate needs and leave the possibility open for further improvement whenever deemed necessary and appropriate.

Regarding institutional and capacity building, the Basin plan considers the proposed institutional reform and corresponding capacity needs as a long term process which require more discussion, revision and reaching consensus with key stakeholders. Moreover, basic but necessary sequences need to be followed prior to developing any Basin plan to facilitate its implementation. However, Basin plan necessary to improving the existing institutional and human capacity which are supportive for the planning and implementation of WRM and act as a spring board for any eventual institutional reform are developed.

All efforts were made for a genuine and unfailing involvement of the interested groups and beneficiaries right from the outset of the action plan formulation process. This will ensure the success during the implementation of the action plans by clarifying the role and responsibilities of water sector institutions, addressing the gaps in the legal and institutional frameworks, institutional and human resource capacity and water management instruments. Identification of ministries, departments, institutions and water supply services, creating dialogue between stakeholder and institutions having conflicting interests was employed as an approach as a means of clarifying issues relevant to integrated water resources management and developing strategy to be followed in the action plan development process.

1.4.2. Methodology of Basin Planning

Using the approach stated above, the following basic methodologies were applied to develop strategy and basin plan that facilitate the planning and implementation of Integrated Water Resources Management: secondary data reviews, discussions and consultations.

1.4.2.1. Literature Review

At the initial stage of the development of strategy and Basin plan, all relevant documents were identified, collected and reviewed. Special emphasis was given to the draft documents entitled as Country Strategy for WRM, Situation Analysis Report, Ethiopian Water Resources Policy, Ethiopian Water Resources Proclamation and Institutional Framework for the Water Sector. By reviewing the existing documents (Master Plan) and summarizing the findings and drawbacks of these documents, it was possible to clearly analyze and present the gaps and their relevance in the preparation of the Basin plan. In addition, all documents relevant to the situation of the resources base, national and sectoral policy documents, strategy papers, Basin plans, regional development plans and other relevant documents were reviewed and used in the preparation of this Basin plan.

1.4.2.2. Discussions and Consultations

Discussions and consultations with relevant stakeholders in the regional administrative centers and at national level were made. As the gaps are identified from review of documents, the development of Basin plan was started.

1.4.2.3. Hydrological Modeling

A physically-based semi-distributed Soil and Water Assessment Tool (SWAT model) that operates on a continueos time scale was used to simulate the current and future hydrological processes. The SWAT model operates on daily time steps in watersheds with land use, soils and management conditions. The major SWAT model components were LULC, DEM, soil, hydrology and management practices. SWAT uses the water balance approach to simulate watershed hydrological processes. The hydrologic routines replicated by the SWAT model are established on the water equilibrium equation:

$$SW_t = SW_0 + \sum_{i=1}^{t}(\boldsymbol{Pday - Qsur - Ea - Wseep - Qgw}) \qquad (1)$$

Where SW_t is the last soil water content (mm), SWo is the primary soil water content on the day i (mm), t is the time (days), P_{day} is the quantity of precipitation on the day i (mm), Q_{surf} is the quantity of surface runoff on the day i (mm), Ea is the quantity of evapotranspiration on the day i (mm), W_{seep} is the quantity of water entering the vadose zone from the soil profile on the day i (mm), and Q_{gw} is the quantity of return flow or base flow on the day i (mm). The SWAT run was performed on a daily climatic data basis.

1.4.2.4. Climate Change Modeling

Climate change modeling was performed by using the ensemble mean of three regional climate models (RCMs) for the present (2021-2045) century under two emission scenarios relative to the baseline (1992-2016) over Omo-Gibe River Basin. The data downscaling was performed through two representative concentration pathways (RCPs) scenarios; mid-range emission mitigation scenario (RCP4.5) and high emission scenario (RCP8.5). The RCMs used in this modeling were: CCLM4-ICHE, CCLM4-CNMR and REMO2009-MPI, in which the RCMs were downscaled under Global Circulation Models (GCMs) as boundary conditions. The projected change in monthly rainfall and temperatures were put in the present (2021-2045) century under RCP4.5 and RCP8.5 emission scenarios relative to the base period (1992-2016). The Climate Model data for hydrological modeling (CMhyd) was used for extraction of Coordinated Regional Climate Downscaling Experiment (CORDEX-Africa) Net-CDF file and bias correction of rainfall and temperature (Rathjens et al. 2016). The bias correction of rainfall and temperature employed power transformation and delta change methods, respectively.

1.4.2.5. LULC Analysis

During the classification of the LULC types of the sub-basins of the GibeGojeb sub basin, the following LULC classification schemes were used. Accordingly, the major LULC classes used in this study included agriculture, bare soil, built up, bushland/shrubs, forest, flooded field, grassland, plantation, water body and wetland.

Table 1: Land-use and land-cover classification scheme

LULC classes	Description
Agriculture	This class represents growing agricultural crops and appeared cultivated during growing season
Bare soil	This refers to areas with no vegetation cover or degraded agricultural lands. In the study basin, bare land mainly found in mountainous areas which is mainly covered by bare soil and exposed rocks
Built up	Areas covered with water such as rivers and lakes
Bushland/Shrubs	This refers to land covered by small trees, bushes and shrubs; in some case mixed with grasses, less dense than forests. Bush lands are mainly found in marginal soils in the study area
Forest	These areas are regions covered with big trees of different species, with little or

	no human activities.
Flooded field	This class represents sediment composed of clay, sand, and silt on the land adjacent to the river, flat land areas adjacent to a stream, composed of unconsolidated sedimentary deposits (alluvium) and subject to periodic inundation by the stream.
Grassland	This category is dominated by the grasses, fobs, and grass areas used for communal grazing. This class refers to an area covered with grass that is used for grazing, usually communal. In the study area, grazing lands (grass lands) are found mainly in the high land areas
Plantation	This class includes eucalyptus plantation and temporary clear field stand a waiting replanting within in eucalyptus plantation.
Water body	Areas consists of open water, generally with greater than 95% cover of water, including streams, rivers, lakes, reservoirs and bays.
Wetland	The area where the water table is near or above the land surface covered by marshes, swamps, bogs, rivers and streams.

Source: Adopted from FAOs LULC classification system, 2016

Accuracy Assessment

Accuracy assessments essentially determine the quality of the information derived from remotely sensed data. These assessments can be either qualitative or quantitative. Qualitative is usually a quick comparison to see if the remote sensed data or map "looks right" and corresponds to what is on the ground through a stratified random sampling scheme.

In this study, the accuracy assessment is performed by using the high-resolution Google Earth imagery from Google Earth Pro. Three Google Earth imageries of March 1999, 2009, 2020 were taken to validate the LULC maps of the same corresponding years. By using a stratified random sampling method, a total of 350 points were selected from different LULC classes in ERDAS IMAGINE version 2015. At least 35 test points per class were taken for each class and then it is reviewed with Google images. Error matrix is a common tool that is used to compare pixel or polygon of the classified image with the ground truth data (Peacock, 2014). The matrices reflect the overall accuracy and the Kappa coefficient value for each year. Accuracy value greater than 70% is considered acceptable and the Kappa value ranging from 0.40 to 0.85 represents the good correspondence (Congalton, 1991).

1.4.2.6. Population and Water Demand Projection

Population projections are simply mathematical formulas that use current populations and rates of growth to estimate future populations. Many equations are used to project future populations. In projecting the future population of the basin, the basic mathematical equation was used:

$$\mathbf{Nt = Pe^{(r * t)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where "Nt" represents the number of people at a future time; "P" is the population at the beginning time; "e" is the base of the natural logarithms (2.71828); "r" is the rate of increase (natural increase divided by 100) and "t" represents the time period involved.

In estimating domestic water demand (DWD), general design standards in Goal 4.6 of GTP-2 were adopted. As per the GTP-2 water supply service level standard, it is required to provide safe water in minimum of 25 l/c/day within a distance of 1 km for rural areas while in urban areas it is required to provide safe water in minimum 100 l/c/day for category 1 towns/cities (towns/cities with a population more than 1 million), 80 l/c/day for category 2 towns/cities (towns/cities with a population in the range of 100,000- 1million), 60 l/c/day for category 3 towns/cities (towns/cities with a population in the range of 50,000 - 100,000), 50 l/c/day for category 4 towns/cities (towns/cities with a population in the range of 20,000- 50,000) up to the premises, and 40 l/c/day for category-5 towns/cities (towns/cities with a population less than 20,000) within a distance of 250m. For both rural and urban areas, the per capita water demand is assumed to increase over the program period.

In estimating commercial and institutional water demand (CIWD), 5 per cent of the DWD was taken for small and medium sized towns, and for large towns, the CIWD estimate was 10 per cent of DWD. In estimating industrial water demand (IWD), 30 per cent of DWD was taken in large and medium towns and 10 per cent of DWD was taken in small towns. Concerning system losses (SL), SL equivalent to 25 per cent of the total domestic, commercial and institutional, and industrial water demand was assumed for urban schemes whereas for rural schemes, a nominal 5 per cent allowance was made to account for spillage at hand pumps. While computing average daily demand (ADD), urban ADD is considered to be the combined total of demand from domestic, commercial and institutional, industrial, and system losses. But, rural ADD for water supply is the combined total of domestic demand, livestock demand and system losses.

1.4.2.7. Multi-criteria Analysis

In order to prioritize the basin key issues, the multi-criteria analysis was employed. Accordingly, the following basin plan development steps were used: Preparing list of possible actions/programs for the main theme/ action area; Identification of relevant and high priority basin's actions/programs through a consultative process; Develop criteria for priority ranking based on national and regional consultations and Using multi-criteria analysis rank action /programs in the order of priority.

Step 1: Preparing List

Initially, list of possible action /programs for the main theme/ action area based on previous works were made to identify gaps and recommended functions to deal with the prioritized water resources management and development issues. The situation analysis will identify gaps, constraints and challenges for WRM. The strategy document will summarize and present strategies, intended immediate goals, outputs with indicative activities in logical framework format. The previous works on institutional and legal frameworks have been completed by drafting new water resource policy, proclamations and regulations. During the process of Basin plan preparation, these documents are being reviewed to make sure that all gaps, challenges and constraints towards achieving WRM are addressed, and identified all type of barriers at all level (systemic, institutional and individual).

Step 2: Identify High Priority Issues

Following the identification of list, Basin consultative meetings with key stakeholders will be held in regional and national level. Thorough discussions on the proposed actions will be held and finally all Basins relevant to the Region, University's and Research centers will be presented and categorized under each main themes/Basin areas. In the consultative meeting, each Basin action will be classified as short, medium and long term, and appropriate implementing bodies will be identified. Detailed Basin plan that includes objectives, strategies, and indicative activities including logical strategic framework will be prepared for the Basin's priority issues. The logical strategic framework will cover all the necessary components of a project profile.

Step 3: Develop Criteria for Priority Ranking

To further refine criteria for prioritization, multiple criteria which reflect national policies and strategies, consider the international process underway, relevance with promoting WRM have been identified through a consultative process and applied to rank basin issues in the order of priority and their importance. The criteria used to evaluate the basin key issues are: 1) A barrier to resolving other significant problems; 2) Impact on a large number of people; 3) Impacting on vulnerable people; 4) Preventing people escaping from poverty; 5) Significantly impacting on socio-economic development; 6) Significantly hindering efficiency and effectiveness; 7) Having a negative effect on the environment; 8) Resulting in water shortages in areas of low rainfall and 9) Synergy with national policies, national and regional strategies and development plans, and Synergy with SDGs.

Step 4: Rank Basin Issues in the Order of Priority

Using the criteria, identify the top priority issues/projects/Basins and categorize them as medium and long term interventions. Short to medium term projects/Basins are those which their needs are immediate and their impact is quick. Long term projects/Basins are those their planning period is long, i.e, more than 15 years.

2. BASIN DESCRRIPTION

2.1. LOCATION

The Omo Gibe River course is entirely contained within the boundaries of Ethiopia. It is the principal stream of an endorheic drainage basin. The Omo Gibe River Basin is located in the southwest of Ethiopia, between 4°30'and 9°30' N and 35° and 38° E. The basin has an area of 79,000 km^2. The Omo-Gibe River drains to the south from Ethiopia's humid highlands of Kaffa and West Shoa zones to arid lowlands of South Omo zone terminating in the Omo-Delta passing through undulating gorges of Gurage, Hadiya, Wolaita and Dawuro zones.

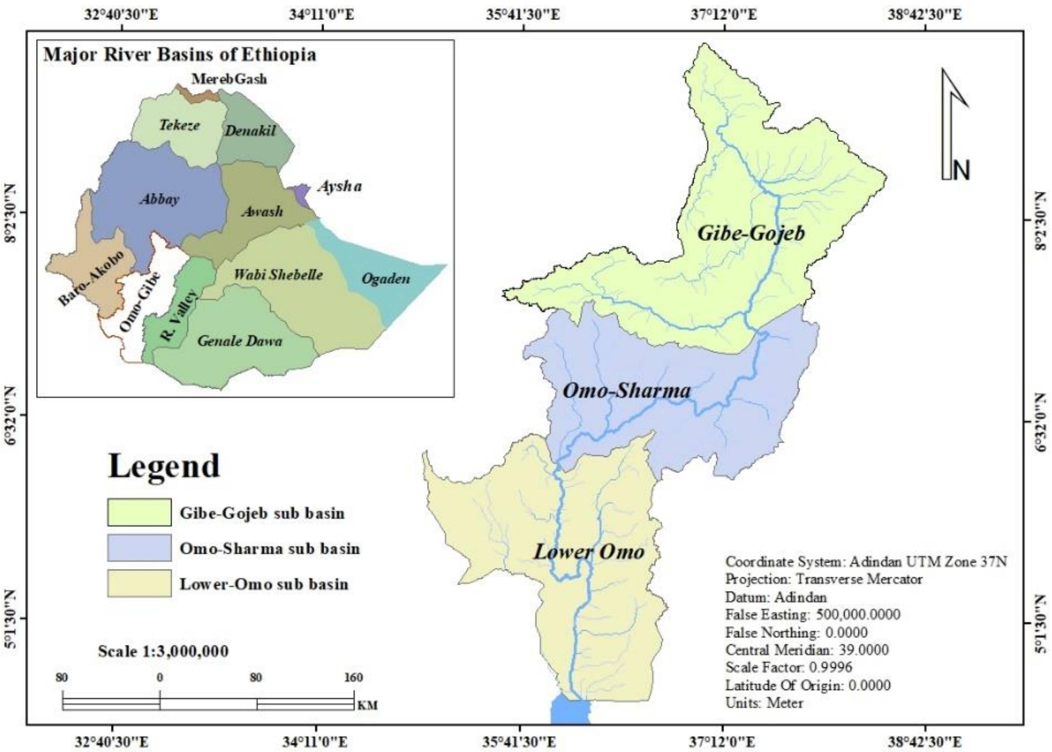


Figure 1: Location Map of Omo Gibe River Basin

The Omo Gibe River Basin is classified into three sub basins: Gibe-Gojeb, Omo-Sharma and Lower Omo Sub Basins, based on geomorphology, agroecological zone and hydrological units for ease of management systems. The sub basins' area coverage is 31,105.50 (38.92 %), 22,311.76 (27.92 %), 26,499.17 (33.16 %) square kilometer respectively.

2.2. Topograpghy of Omo Gibe River Basin

The topography of Omo Gibe basin as a whole is characterized by its physical variation. The northern two-thirds of the basin has mountainous to hilly terrain cut by deeply incised gorges of the Omo, Gojeb, and Gilgel-Gibe Rivers, while the southern one-third of the basin is a flat alluvial plain punctuated by hilly areas. The northern and central half of the basin lies at an altitude greater than 1500masl with maximum elevation of 3360masl (located between Gilgel- Gibe and Gojeb tributaries), and the plains of the lower Omo lies between 400-500masl. The northern part of the catchment has a number of tributaries. Most of the rivers from upper part of the catchment drain largely cultivated land. The head waters of the Great-Gibe River are at an elevation of about 2200masl. Although there are some important tributaries from different directions, the general direction of flow of the Gibe River is southwards, towards the Omo River and then to Lake Turkana a fault feature, filled with alluvial sediments of recent origin associated with the Great Rift Valley. The Gibe River is known as the Omo River in its lower reaches, south westwards from the confluence with the Gojeb River. This is the reason behind the name Omo Gibe River Basin.

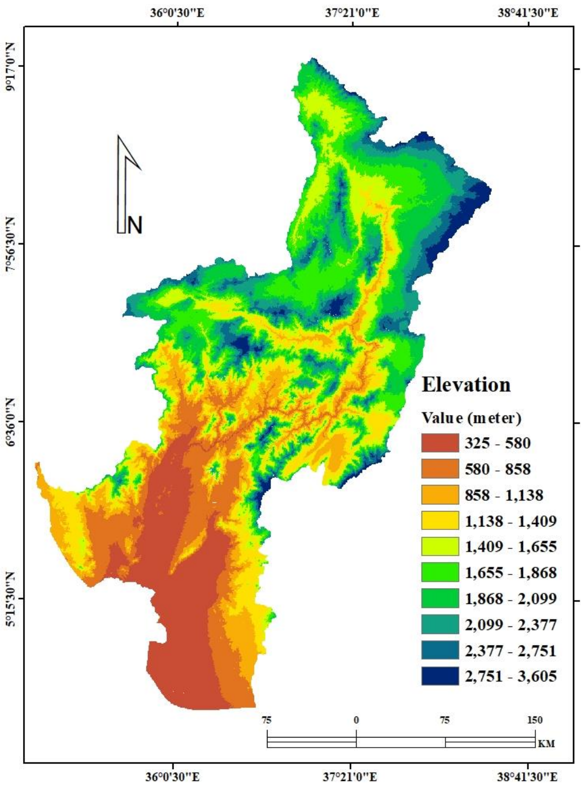


Figure 2: DEM of Omo Gibe River Basin

2.3. ADMINISTRATION

Omo Gibe River Basin is administratively shared by four regional states namely South Ethiopia regional state, Central Ethiopia regional state, South Western Ethiopia People regional state and Oromia regional state. Currently, the basin has a total of about 20 Administrative Zones, 83 Woredas and 2,385 kebeles.

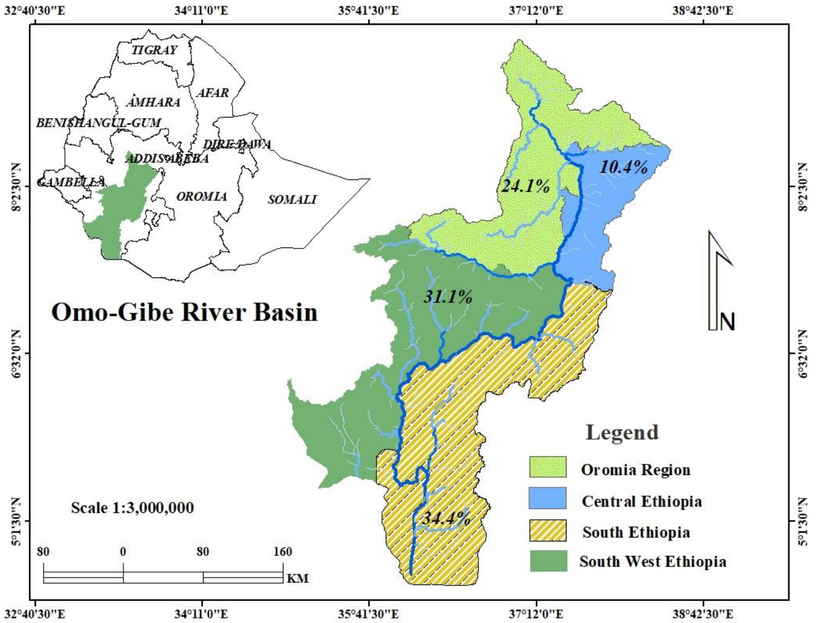


Figure 3: Administrative Regions of Omo Gibe River Basin

2.4. POPULATION

The current population of the basin is about 11 million and about 50.3% of the population is female. About 5% and 2.9% of the total population live in the lowlands and in urban areas respectively. Average population density is about 77persons/km^2. However, wereda level population densities vary from about 300 to 600persons/km^2. Average family size ranges from 4.1 in lowlands to 6.9 in the highlands. The basin's labour force of the economically active population is about 2.8 million, representing 43.6% of the total population.

2.5. CLIMATE

As climate is associated with altitude, the highlands have cool climate with moderate temperature and sufficient rainfall while the lowlands have harsh climate of high temperature and low to medium rainfall. The mean annual temperature in the basin varies from less than 17°C in the west highlands to over 29°C in the south lowlands. Rainfall in Omo-Gibe basin varies from over 1900 mm per annum in the north central areas to less than 300mm per annum in the south. The amount of rainfall decreases throughout the Omo-Gibe catchments with a decrease in elevation. Moreover, the rainfall regime is unimodal for the northern and central parts of the basin and bimodal for southern part. Based on the altitude and temperature, the basin can be classified into four agro-ecology zones namely, Wurch, Dega, Weina Dega and Kolla.

2.6. AGRO-ECOLOGICAL ZONE

An Agro-ecological Zone is a land resource mapping unit, defined in terms of climate, landform and soils, and/or land cover, and having a specific range of potentials and constraints for land use (FAO, 1996). Agro-ecologically, the basin is dominantly classified as 16 (Sixteen) major agroecological zones (AEZs); namely: Tepid sub-humid mid highlands, Warm sub-humid lowlands, Warm humid lowlands, Tepid humid mid highlands, Warm moist lowlands, Warm semi-arid lowlands, Hot semi-arid lowlands, Hot moist lowlands, Warm per-humid lowlands, Tepid moist mid highlands, Tepid per-humid mid highland, Cool sub-humid mid highlands, Cool moist mid highlands, Water body, Cool humid mid highlands, and Hot per-humid lowlands. The three most dominant AEZs in the OGRB are Tepid sub-humid mid highlands (19893.41 sq.km, 24. 82 %), Warm sub-humid lowlands (15144.91 Sq.km, 18.89 %) and Warm humid lowlands (8102.19 Sq.km, 10.11 %).

Table 2:Agroecological Zones (AEZs) within OGR Basin

S.No.	Symbol	Major AEZs	Area_Ha	Area_Sq_Km	Area_%
1	H2	Warm humid lowlands	810219.07	8102.19	10.11
2	H3	Tepid humid mid highlands	709170.79	7091.71	8.85
3	H4	Cool humid mid highlands	26584.73	265.85	0.33
4	M1	Hot moist lowlands	395683.63	3956.84	4.94
5	M2	Warm moist lowlands	714973.90	7149.74	8.92
6	M3	Tepid moist mid highlands	299803.01	2998.03	3.74
7	M4	Cool moist mid highlands	54365.49	543.65	0.68
8	PH1	Hot per-humid lowlands	13087.58	130.88	0.16
9	PH2	Warm per-humid lowlands	380693.28	3806.93	4.75
10	PH3	Tepid per-humid mid highland	91872.10	918.72	1.15
11	SA1	Hot semi-arid lowlands	426396.09	4263.96	5.32
12	SA2	Warm semi-arid lowlands	456742.93	4567.43	5.70
13	SH2	Warm sub-humid lowlands	1514490.68	15144.91	18.89
14	SH3	Tepid sub-humid mid highlands	1989341.39	19893.41	24.82
15	SH4	Cool sub-humid mid highlands	90764.73	907.65	1.13
16	WB	Water body	41965.81	419.66	0.52
					100.00

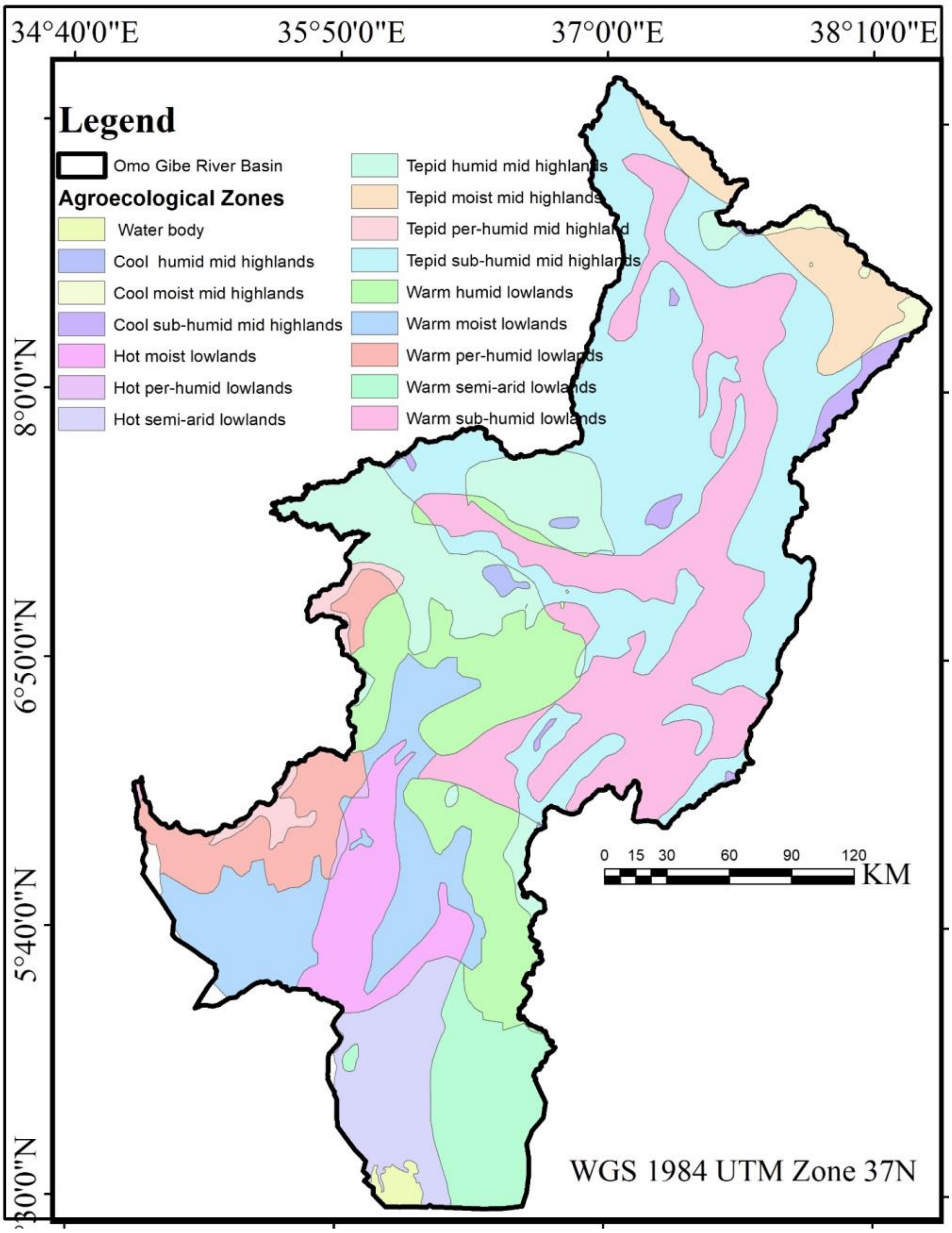


Figure 4:: Agroecological Zones (AEZs) within Omo-Gibe River Basin

2.7. SOILS OF OMO GIBE RIVER BASIN

The major soil types (22 types) of OGR Basin are *Dystric nitisols, Eutric fluvisols, Eutric cambisols, Pellic Vertisols, Orthic acrisols, Chromic vertisols, Chromic cambisols, Dystric fluvisols, Leptosols* and others. The major soils of the basin are *Dystric Nitisols* (20329.84 Sq.km, 25.44 %,), *Eutric Fluvisols* (10604.44 Sq.km, 13.27 %), *Eutric Cambisols* (8009.04 Sq.km, 10.02 %) and so on. The Land Use and Land Cover (LULC) changes due to natural and anthropogenic interferences have altered the hydrological processes of the OGRB, Ethiopia (Chaemiso et al., 2021). Land cover within the Omo-Gibe Basin segregates almost perfectly into highland and lowland categories. The break between the two is marked by a band of woodland. It is considered that the changes for the observed hydro-meteorological variables might be related to both changes in climate variability, either local or global (Jaweso et al., 2021).

Table 3: The major Soil types in the Omo Gibe River Basin, Ethiopia

S.No	Major soil type	Area_Sq.Km	Area_Ha	Area_ %
1	Calcaric Fluvisols	22.72	2272.00	0.03
2	Calcic Fluvisols	250.40	25040.02	0.31
3	Calcic Xerosols	603.46	60345.55	0.76
4	Chromic Cambisols	5423.91	542391.22	6.79
5	Chromic Luvisols	1593.74	159373.50	1.99
6	Chromic Vertisols	6170.52	617051.95	7.72
7	Dystric Cambisols	288.93	28892.65	0.36
8	Dystric Fluvisols	3292.74	329273.70	4.12
9	Dystric Gleysols	493.79	49378.76	0.62
10	Dystric Nitisols	20329.84	2032983.91	25.44
11	Eutric Cambisols	8009.04	800903.61	10.02
12	Eutric Fluvisols	10604.44	1060443.98	13.27
13	Eutric Nitisols	703.55	70354.93	0.88
14	Gypsic Yermosols	111.44	11144.01	0.14
15	Haplic Xerosols	1512.95	151295.29	1.89
16	Leptosols	2255.30	225530.30	2.82
17	Orthic Acrisols	7233.10	723309.80	9.05
18	Orthic Luvisols	1123.97	112397.23	1.41
19	Orthic Solonchaks	1758.62	175862.23	2.20
20	Pellic Vertisols	7969.52	796951.68	9.97
21	Phaeozems	39.40	3940.01	0.05
22	Vertic Luvisols	122.52	12252.07	0.15

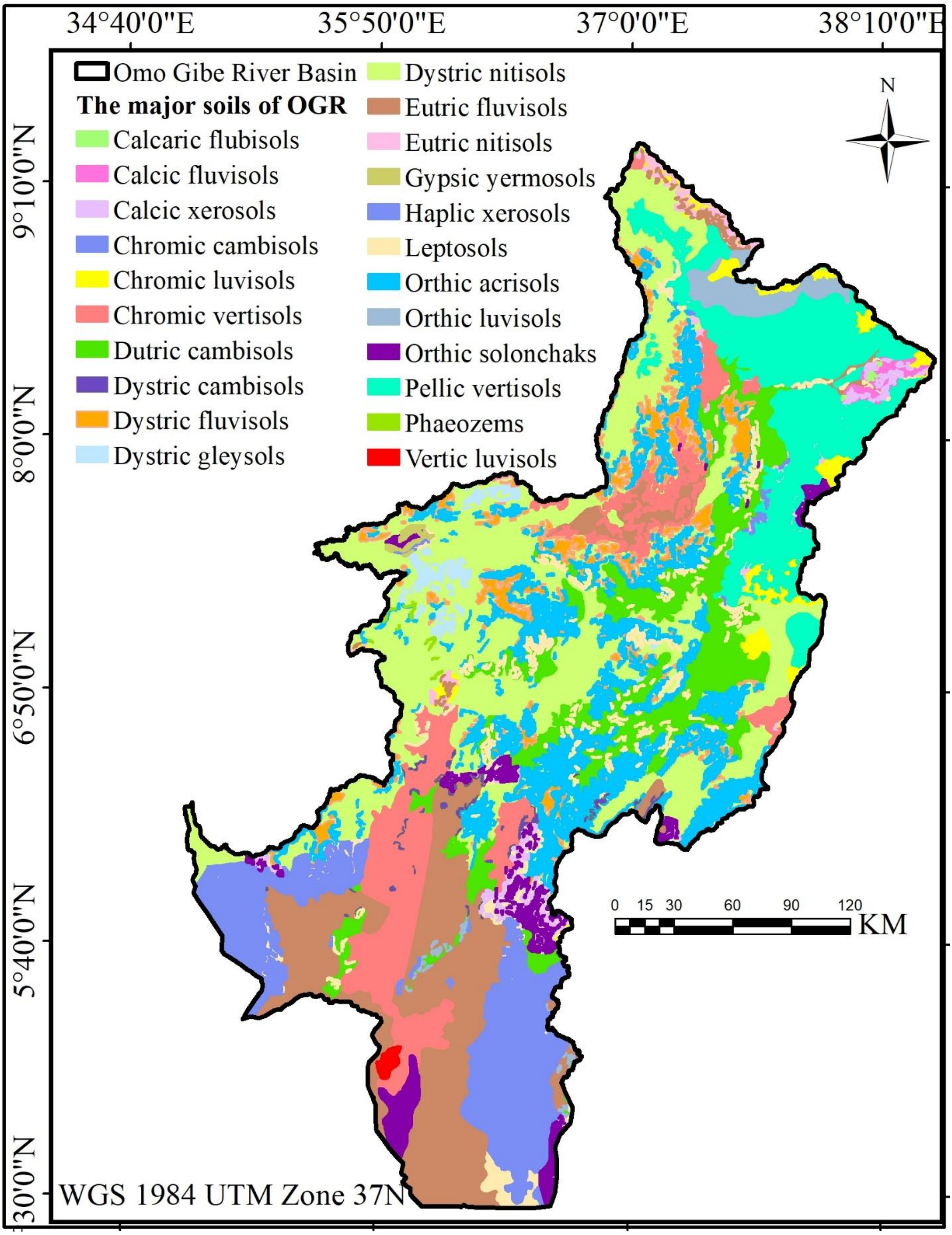


Figure 5:The map of the major soils of Omo-Gibe River Basin

3. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORKS ASSESSMENT

The government of Ethiopia has issued numerous legal and policy documents that frame the nexus between peoples' socio-economic needs, utilization of natural resources and environment for sustainable development. Accordingly, this chapter outlines the policy, legal and administrative frameworks governing environmental issues in Ethiopia. It highlights other relevant policies, laws and institutions and reviews applicable international policies.

3.1. POLICY FRAMEWORKS

3.1.1. Water Resource Management Policy and Strategy

3.1.1.1. National Water Resources Management Policy (2000)

The National Water Resources Management Policy (NWRMP) has been put in place since 2000 with the overall goal "to enhance and promote all national efforts towards the efficient, equitable, and optimum utilization of the available water resources of Ethiopia for significant socio-economic development on a sustainable basis". To realize this goal, the policy spelled out five key water management objectives: (a) Development of the water resources of the country for economic and social benefits of the people on equitable and sustainable basis; (b) Allocation and apportionment of water resources based on comprehensive and integrated plans; (c) Managing and combating drought through *inter-alia*, efficient allocation, redistribution, transfer, storage, and efficient use of water resources; (d) Combating and regulating floods through sustainable mitigation measures; and (e) Conserving, protecting and enhancing water resources and the overall aquatic environment on a sustainable basis.

3.1.1.2. Ethiopian Water Sector Strategy (2001)

Ethiopian Water Sector Strategy (EWSS) devised a short, medium and long-term action programs that intent to translate the above stated objectives of the NWRMP into effect. Among other things, the EWSS focuses on *water resources development* and *water resources management.* Regarding the former, the key strategy is the integration of water resources development and utilization with Ethiopia's overall socio-economic development objectives. In view of this, the strategy proposed several actions including: undertake assessment and development of the country's surface water resources; develop ground water resources and ensure its optimal utilization for different water uses; make effective and optimum use of available water resources by giving priority to multipurpose water resources development projects; follow the integrated approach rather than the fragmented approach for water resources development; strengthen and expand hydrological and hydro-meteorological activities for attaining long-term reliable records for safe, effective and sustainable water resources development; harvest rainwater through the construction of small check dams to meet domestic water supply and irrigation needs at the local level; reclaim existing wetlands, and prevent the formation of the new ones by using appropriate mechanisms; undertake proper assessment, preservation and enrichment of aquatic resources in rivers and lakes; and incorporate aquatic resources development in large scale water resources master plan studies; include the development of tourism and recreation resources associated with water in all water resources development master plan studies.

In water resources management strategy, water allocation for drinking and sanitation purposes hold the highest priority followed by water requirements for livestock and water uses for projects yielding highest socio-economic benefits. Besides, it states the following strategic actions for the protection of water quality: Ensure that water allocation is based on efficient use of water resources; takes into account special consideration of the needs of drought-prone and water-scarce areas; and gives the highest priority to water supply and sanitation; promote appropriate watershed management practices to promote water conservation, maximize water yields, improve water quality, and reduce reservoir siltation; co-ordinate the development and enforcement of appropriate mechanisms and standards to protect national water resources from pollution; develop a coherent, efficient and streamlined process of information management in the water sector.

3.1.2. Sectoral Policies and Strategies

Several sectoral policies and strategies have been issued by ministries that are aimed for protection of environment and promote sustainable development in the country.

3.1.2.1. Conservation Strategy of Ethiopia

The Conservation Strategy of Ethiopia (CSE) sets out detailed strategies and action plans as well as institutional arrangements required for the implementation of sectoral as well as cross-sectoral interventions for the management of Ethiopia's natural, man-made and cultural resources. The CSE provides a strategic framework detailing principles, guidelines and strategies for the effective management of the environment.

The most important areas that are considered in the strategy document include the following: improvement of soils, crop and animal husbandry for sustainable agricultural production;

management of forest and woodland resources; development of water resources for irrigation, hydroelectric power and water supply; rangeland management and pastoral development; promotion of individual participation in sustainable development of natural, artificial and cultural resources and environmental protection; land resource use policy and strategies and physical land use planning; integration of social, cultural and gender issues in sustainable resources and environmental management and development of environmental education, public awareness and human resources.

3.1.2.2. Regional Conservation Strategy

At the regional level, the regions have also formulated their own Regional Conservation Strategy. The overall policy goal of the regional conservation strategy is to improve and enhance the health and quality of life of all the people in the region. It also promotes sustainable social and economic development through sound management and use of natural, human made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of future generation to meet their own needs.

3.1.2.3. Environmental Policy of Ethiopia (EPE)

The major policy framework document with respect to environmental management of Ethiopia is the Environmental Policy of the FDRE approved by the Council of Ministers in April 1997. The policy supports Constitutional Rights through its guiding principles. The principles are guiding all development proposals in the country.

The principles include many important issues to be taken into account the most relevant with respect to Omo Gibe River Basin Plan being: every person has the right to live in a healthy environment; full environmental and social costs (or benefits foregone or lost) that may result through damage to resources or the environment as a result of degradation or pollution shall be incorporated into public and private sector planning and accounting and decisions shall be based on minimizing and covering these costs; regular and accurate assessment and monitoring of environmental conditions shall be undertaken and the information widely disseminated within the population and natural resource and environmental management activities shall be integrated laterally across all sectors and vertically among all levels of organization.

The principal features of the Environmental Protection Policy of Ethiopia are: provides for protection of human and natural environments; provides for an early consideration of environmental impacts in projects and program design; recognizes public consultation; includes mitigation plans and contingency plans; provides for auditing and monitoring; establishes legally binding requirements and institutionalizes policy implementation.

The overall goal of the EPE is to improve and enhance the health and quality of life of all Ethiopians and to promote sustainable social and economic development through sound management and use of natural, human-made and cultural resources and the environment as a whole (Environmental Protection Authority (EPA, 1997). The policy seeks to ensure empowerment and participation of people and their organizations at all levels in environmental management activities and to raise public awareness and promote understanding of the essential linkage between environment and development.

EIA policies are included in cross-sectoral policies of the EPE (EPA, 1997). It emphasizes among others early recognition and incorporation of environmental issues and mitigation plans in project design and implementation, public participation in EIA process, development of EIA tools and capacity building at all levels of administration. The policy establishes the authority, EPA, to harmonize Sectoral Development Plans and implement an environmental management program for the country. It also imparts political and popular support to sustainable use of natural, human-made and cultural resources at the Federal, Regional, Zonal, Woreda and Community levels.

3.1.2.4. Wildlife Policy and Strategy

The Wildlife Policy and Strategy was developed by the Ministry of Agriculture in 2005.
The specific objectives of the policy include: properly developing and administering the country's wildlife resources; enabling the sector to contribute fully to the nation building process; protecting the wildlife resources and their habitats and maintaining the balance of nature for posterity in accordance with international wildlife conventions and agreements to which the country is a signatory.

The policy and strategy has five major sections dealing with wildlife development and protection, utilization of wildlife resources, participation of the community and investors in the sector, conservation, education and information network. The major policy issues stipulated in the policy include: protection and conservation of threatened and endemic species; establishing conservation mechanisms to protect wildlife from disasters; establishing proper control over trafficking of wildlife and wildlife products; undertaking necessary measures on “ problem” animals in defence of human life and reduce or prevent damage to domestic animals and crops.

3.1.2.5. National Policy on Biodiversity Conservation, Research and Development

The policy contains directives with regard to the need to explore, collect, characterize, evaluate, conserve and utilize biodiversity. The need to regulate access to genetic resources through various measures including legislation and building appropriate institutional structures and mechanisms are also mentioned. Strengthening capacity for information collection and documentation, encouraging networking and generally integration of biodiversity conservation, research and development elements in education and general awareness programs are considered important. The policy directives emphasize the importance of community participation in the conservation and sustainable utilization of biodiversity resources together with the need to provide for access and benefit sharing for communities to and from biodiversity resources. The National Biodiversity Policy (NBP) was established in 1998 based on a holistic ecosystem approach to conserve, develop and utilize the country's biodiversity resources. Integration of biodiversity conservation and development in federal and regional, sectoral development initiatives and mobilization of international cooperation and assistance have been identified as the principal strategies for implementation of the policy.

The policy provides guidance towards effective conservation, rational development and sustainable utilization of the country’s biodiversity and contains comprehensive policy provisions for the conservation and sustainable utilization of biodiversity. Protection of biodiversity related to traditional indigenous knowledge and communities' benefit sharing arrangements which are not yet effective. Similarly the potential of biodiversity-related opportunities has not yet been exploited to enhance sustainable livelihood to the desired level.

However, there is a general understanding with respect to changing the management approach in order to bring about the desired benefits. The government of Ethiopia has developed a National Biodiversity Strategy and Action Plan (NBSAP) in 2005 as a required action under the Convention on Biological Diversity to put in practice the biodiversity policy.

3.1.2.6. Pastoral Development Policies (PDPs)

One of the distinguishing features of the Omo Ghibe River Basin as compared to other River Basin in Ethiopia is that pastoral communities occupy the larger part of the basin. Out of the administrative zones which the Omo Ghibe River Basin traverses, Keffa, South Omo, Bench Maji,Dwro and others are occupied by pure and semi-pastoralist or agro-pastoralist. This urges for proper pastoral development policies (PDPs) if to achieve sustainable interaction between the people, water resources and environment. To this end, there are various pastoral development policies, strategies and programs that have been put in place over years. The broader development imperative endorsed in the Ethiopian Constitution laid down the cornerstone for all subsequent pastoral policies, strategies and programs. *Article 40 (4)* states "Ethiopian pastoralists have a right to free land for grazing and cultivation as well as a right not to be displaced from their own lands". Likewise, *Article 41(8)* affirms that "Ethiopian pastoralists have the right to receive fair prices for their products, that would lead to improvement in their conditions of life and to enable them to obtain an equitable share of the national wealth commensurate with their contribution".

3.1.2.7. Rural Development Policies and Strategies (2001)

The 2001 Rural Development Policies and Strategies (RDPS) contain intervention measures on pastoral development. As the long-term plan, the strategy aims to sedentary pastoralists by developing irrigation, implementing settlement programs, and changing their way of life. As short and medium intervention terms, the RDPS underscores the need to prevent natural resource degradation through consultation with pastoralists with regard the location of water points. It recommends that rangeland management and conservation be based on traditional management systems as a way of improving water availability. Yet, the RDPS intends that a wide range of other activities be made in cooperation with pastoralists' clan leaders and elected representatives.

3.1.2.8. National Development Plans

Different from the previous two regimes, the current government in Ethiopia has attempted to incorporate pastoral development measures in its five year national development plans that have been put in place since 2000. The Sustainable Development and Poverty Reduction Program (SDPRP) implemented between 2000 and 2004 forwards different pastoral development strategies: mobile pastoralists should be sedentarised on a voluntary basis, reliable river courses should be selected for sedentarization based on capacity to support irrigation; settled or semi-settled pastoralists should be encouraged to stay settled through improved water supply, pasture, social services, and access to roads and other communication lines; mobile social services, including health and education should be provided as a united package for those that continue to be mobile; and the need for water development and environmental protection and management in the areas of settled, semi-settled and mobile pastoral communities.

3.1.2.9. Policies and Legislations of Regional Governments

Based on the Federal Proclamation No. 456/2005 cited above, the Regional States where the pastoral communities occupy issued relevant policies and legislations specifically targeting the development agendas of the pastoral communities. Of paramount importance for the purpose of the basin planning at hand includes Rural Land Administration and Proclamation of Ethiopian Somali Region (128/2013), SNNP Proclamation No 110/2007, and Oromia Proclamation No 130/2007. In general, the pastoral development measures and strategies in these proclamations are the exact replica of those in the federal government. Among other things, these are the need to: strengthen the right of pastoralists and agro-pastoralists, create a sense of ownership, ensure equal rights of women and the disabled, create a conducive atmosphere for investment in pastoral areas, establish a system of rural land administration that promotes the conservation and management of natural resources in pastoral areas, and provide basic social services, road infrastructure and other means of communication.

3.1.2.10. National Food and Nutrition Security Policy (2019)

The goal of the National Food and Nutrition Security Policy (NFFSP) is to attain optimal nutritional status at all stages of life and conditions to a level that is consistent with good health, quality of life and productivity. Its objectives are: (a) improve the availability and accessibility of adequate food to all Ethiopians at all times, (b) improve access to quality and equitable nutrition and health services to all Ethiopians at all, (c) improve consumption and utilization of diversified and nutritious diet throughout the life cycle, (d)improve the safety and quality of food throughout the value chain, (e) improve food and nutrition emergency risk management, preparedness and resilience systems, (f) improve food and nutrition literacy of all Ethiopians.

3.1.2.11. National Disaster Risk Management Policy and Strategy (2013)

The Government of Ethiopia has endorsed a new National Disaster Risk Management Policy and Strategy (NDRMPS) in 2013 that amends the earlier National Policy on Disaster

Prevention and Management, which has been under implementation since 1993. The new NDRMPS marks a paradigm shift in doing business differently moving away from a system focused on drought and emergency assistance to a comprehensive disaster risk management approach.

3.1.2.12. Climate Resilient Green Economy (CRGE)

It understands water management as key element in achieving a green economy because of the role of water for developing hydropower and agriculture. It considers Ministry of Water, Irrigation and Energy (MoWIE) as one of the actors with a role in encouraging the formulation and implementation of green economy.

3.1.2.13. National Population Policy

National Population Policy was issued in April 1993. It aims at closing the gap between high population growth and low economic productivity through a planned reduction in population growth combined with an increase in economic growth. With reference to natural resources the main objectives of National Population Policy are: making population and economic growth compatible and the over-exploitation of natural resources unnecessary; ensuring spatially balanced population distribution patterns with a view to maintaining environmental security and extending the scope of development activities; improving productivity of agriculture and introducing off-farm / non-agricultural activities for the purpose of employment diversification and maintaining and improving the carrying capacity of the environment by taking appropriate environmental protection and conservation measures.

3.1.2.14. Health Policy of Ethiopia

Ethiopia's health policy was issued in 1993 and revised in April 1998 with the aim of giving special attention to women and children to neglected regions and segments of the population and to victims of man-made disasters. The priority areas of the policy are in the field of Information, Education and Communication (IEC) of health to create awareness and behavioural change of the society towards health issues, emphasis on the control of communicable disease, epidemics and on diseases that are related to malnutrition and poor living condition, promotion of occupational health and safety, the development of environmental health, rehabilitation of health infrastructures, appropriate health service management system, attention to traditional medicines, carrying out applied health research, provision of essential medicines and expansion of frontline and middle level health professionals.

3.1.2.15. National Policy on Women

The National Policy on Women formulated in 1993 aimed at creating appropriate structures within government offices and institutions to establish equitable and gender-sensitive public policies. The policy goals are to ensure women's right to create favourable environment for women, to ensure the supply of basic services to women and to eliminate gender based discriminations. The policy has five major objectives and it is stated that these objectives should be part of other policies, plans or laws regarding women.

The Policy objectives are: laws, regulations, systems, policies and development plans that are issued by the government should ensure the equality of men and women; special emphasis should be given to the participation of rural women; economic, social, political policies and programs as well as cultural and traditional practices and activities should ensure equal access of men and women to the country's resources and the decision making process; the central government and regional administrations should ensure that women participate in and benefit fully from all activities carried out by central and regional institutions and development institutions, programs and projects should ensure women's access to and involvement in all interventions and activities.

The Government of Ethiopia has taken active steps to promote the welfare and role of women in Ethiopian society, commencing with the National Policy on Ethiopian Women (NPEW, 1993) and reinforcing this with the gender equality provisions of the Constitution (1995). The Women's Policy aimed to institutionalise the political, economical and social rights of women largely by creating appropriate structures in government organisations to ensure that public policies and interventions are gender-sensitive. Consistent with this policy, Article 25 of the Constitution of the FDRE guarantees all persons equality before the law and prohibits discrimination on grounds of gender. In addition, Article 35 reiterates the principles of equality in access to economic opportunities including the right to equality in employment and in land ownership.

3.2. LEGAL FRAMEWORKS

3.2.1. Water Resource Legislative Frameworks

3.2.1.1. Constitution of the FDRE (1995)

The Constitution of the Federal Democratic Republic of Ethiopia reflects different enactments. It starts by declaring the governing principles: the rights of the citizens to improved living standard and sustainable development (Article 43 (1)), to be consulted with respect to policies and projects affecting their community (Article 43 (2)), and to live in a clean and healthy environment (Article 44 (1)). Article 40 stipulates the public ownership of both rural and urban land as well as all natural resources for common social and economic well-being of a society. Yet, Article 51 (5) asserts the mandate of the federal government to enact laws for the proper utilization and conservation of land and other natural resources including water. Backdrop to the aforesaid general principles, several specific legal and policy interventions have been designed for friendly society-environment interaction.

3.2.1.2. Ethiopian Water Resource Management Proclamation

This Proclamation (Proc. No. 197/2000) was issued in March 2000 and provides legal requirements for Ethiopian water resources management, protection and utilization. The aim of the proclamation was to ensure that water resources of the country are protected and utilized for the highest social and economic benefits to follow up and supervise that they are duly conserved, ensure that harmful effects of water use prevented and that the management of water resources are carried out properly. The proclamation defines the ownership of water resources, powers and duties of the supervising body, inventory of water resources and registry of actions, permits and professional licenses, fees and water charges. According to the proclamation all water resources of the country are the common property of the Ethiopian people and the State. As provided in the proclamation the Supervising Body (the Ministry pertaining to water resources at central level or any organ delegated by the Ministry) shall be responsible for the planning, management, utilization and protection of water resources. It shall also have the necessary power for the execution of its duties under the provisions of this proclamation. Regarding inventory of water resources and registry of actions, the Supervising Body shall prepare or cause to be prepared and maintain the inventory of water resources of the country. The inventory would include; identification and description of the occurrence, availability, location, amount and quality of water resources, identification and description of seasonally expected demand of water supply and periodically compile data on consumptive and non-consumptive use of water.

According to Sub-Article 1 of Article 11, no person shall perform the following activities without a permit from the Supervising Body without prejudice to the exceptions specified under Article 12: construct water works; supply water whether for his own use or for others; transfer water which he/she abstracted from a water resource or received from another supplies and release or discharge waste into water resources unless otherwise provided for in the regulations to be issued for the implementation of this Proclamation. As defined in Article 12 any person shall utilize water resources for the following purposes without requiring a permit from the supervising body: dig water wells by hand or use water from hand-dug wells and use water for traditional irrigation, artisanal mining and for traditional animal rearing as well as for water mills.

3.2.1.3. Ethiopian Water Resources Management Regulations No. 115/2005

Ethiopian Water Resources Management Regulations (EWRMRs) is a further detailed version of the Proclamation No. 197/2000. On the one hand, it declares yet detailed legal procedures regarding water resources utilization, water works permit, certification of professional competence and classification, and fees and water charges. On the other hand, it fills the gaps of the Proclamation No. 197/2000 by providing legal requirements and procedures on water quality control, formation of water users cooperative societies, dispute settlement procedures, and certificate of competence for water related consultancy services.

3.2.1.4. River Basin Councils and Authorities Proclamation No. 534/2007

The River Basin Councils and Authorities Proclamation (RBCAP) issued the legal grounds of the establishment of River Basins Councils and Authorities. Accordingly, 12 River Basin Authorities (RBAs) are established in Ethiopia including the Omo Ghibe River Basin Authority. The goal of establishing these River Basin Authorities is to promote and monitor the integrated water resources management process in the river basins falling under their authority with a view to using of the basins' water resources for the socio-economic welfare of the people in an equitable and participatory manner, and without compromising the sustainability of the aquatic ecosystems.

3.2.2. Sectoral Legislative Framework

3.2.2.1. Environmental Legislative Framework

Proclamation for the Establishment of Environmental Protection Authority

Proclamation (Proc. No. 295/2002) re-established the Environmental Protection Authority (EPA), Sectoral Environmental Units and Regional Environmental Agencies of Ethiopia. The objective of this proclamation is to formally lay down the institutional arrangements necessary to ensure environmentally sustainable management and development both at Federal and at Regional level. A series of institutional mandates, which describes the powers and duties of EPA, regional environmental agencies and sectoral environmental units are stipulated in the proclamation.

Environmental Impact Assessment Proclamation

The aim of this Proclamation (Proc. No. 299/2002) is to make an EIA mandatory for specified categories of activities undertaken either by the public or private sectors and is the legal tool for environmental planning, management and monitoring. The proclamation elaborates considerations with respect to the assessment of positive and negative impacts and states that the impact of a project shall be assessed on the basis of the size, location, nature, cumulative effect with other concurrent impacts or phenomena, trans-regional context, duration, reversibility or irreversibility or other related effects of a project.

Categories of projects have been defined that will require full EIA, partial EIA or for which study of EIA is not called for. To effect the requirements of this Proclamation EPA has issued a Procedural and Technical EIA Guidelines which provides details of the EIA processes and its requirements. The guidelines follow conventional patterns adopted in many other countries and make provision for screening, scoping, identification and evaluation of impacts, the development of environmental management and monitoring plans, consideration of alternatives, EIA report structure and information requirements, etc.

Environmental Pollution Control Proclamation

This Proclamation (Proc. No. 300/2002) is mainly based on the right of each citizen to have a healthy environment as well as on the obligation to protect the environment of the country. Its primary objective is to provide the basis from which the relevant ambient environmental standards applicable to Ethiopia can be developed and to make the violation of these standards a punishable act. The proclamation states that the “polluter pays” principle will be applied to all persons. Under this proclamation the EPA is given the mandate for the creation of the function of Environmental Inspectors. These inspectors (to be assigned by EPA or regional environmental agencies) are given the authority to ensure implementation and enforcement of environmental standards and related requirements.

3.2.2.2. Proclamation on Fisheries Development and Utilisation

Fisheries Development and Utilisation proclamation (Proc. No. 315/2003) was issued in January 2003. The objective of the proclamation is to ensure fish biodiversity and its environment as well as to prevent and control over exploitation of fishery resources, increase supply of safe and quality fish and ensure sustainable contribution of fisheries towards food security and expand aquaculture development. The proclamation has established with a requirement that a person who undertakes commercial fishing or aquaculture should first obtain permit. In addition, it establishes a requirement for a permit for subsistence fishing in national parks or fishery reserved areas for fishery research and for transferring fish between different water bodies.

The Proclamation envisages that proclamations on fisheries will be enacted by others (i.e. the Regional States) and has an article that gives power to the Ministry of Agriculture and regional states to issue their own regulations and laws for implementing the proclamation. It states that any fisheries law that may be issued pursuant to it shall make clear stipulations about protected fishery areas, annual fish catch, types and number of fishing gears, fishing seasons, procedures for issuing, renewal and suspension of fishing license, fish transfer, aquaculture fish trade, safety and quality standards of fish products, prohibited activities, community participation, environmental impact assessment and other related matters.

3.2.2.3. Proclamation on Conservation, Development and Utilization of Forests

Conservation, Development and Utilization of Forests Proclamation (Proc. No. 94/1994) was issued in 1994 to provide for the conservation, development and utilisation of forests. The objective of this proclamation is to provide basis for sustainable utilisation of the country's forest resources and ensure conservation of existing forests and establishment of State Forests. The proclamation categories types of forest ownership (State, Regional and Private Forests). One of the objectives for the establishment of State Forests is to conserve forest resources within their ecosystems. The law prohibits felling of *Hagenia abyssinica*, *Cordia Africana*, *Podocarpus gracilior*, *Juniperus procera* and *Olea europaea* ssp. *Cuspidate* from their natural habitats. It provides the power for designation, demarcation, and registration of forests to the Ministry of Agriculture and Regional Governments. The proclamation then goes on to give some specific direction for the utilisation of State and Regional Forests and lists prohibited activities within protected forests.

3.2.2.4. Genetic Resource Proclamation

Following the Convention on Biological Diversity, the government of Ethiopia enacted legislation which provides community rights and access to genetic resources and traditional knowledge (Proclamation № 482/2006). The objective of the proclamation is to ensure that the country and its communities obtain fair and equitable share from the benefits arising out of the use of genetic resources so as to promote the conservation and sustainable utilization of the country's biodiversity resources.

The proclamation subjects access to genetic resources and community knowledge in the country to the requirement of permit from the Institute of Biodiversity Conservation and stipulates the conditions under which access to genetic resources may be denied. Though the proclamation does not directly stipulate that an access application should first go through an EIA process as such, it does contain provisions meant to ensure that access to genetic resources is carried out without causing harm to the environment. In this regard it states that access may be denied if the planned use may cause, *inter alia*, an undesirable impact on the environment, ecosystem, human health and cultural values of local communities.

It also obliges an access permit guarantee to respect the laws of the country particularly those relating to sanitary control, bio-safety and environmental protection. Article 10 of the proclamation states that the rights of local communities over their genetic resources and community knowledge shall be protected as they are enshrined in the customary practices and norms of the concerned communities.

3.2.2.5. Wildlife Development, Conservation and Utilisation Proclamation

This proclamation, Proc. No. 541/2007 builds on the 2005 Wildlife Policy and Strategy. The 2007 proclamation has four parts and twenty articles. The Policy on which it is based has five main elements: wildlife resources development, protection and administration of protected areas, conservation of endemic and threatened wildlife, wildlife resources utilization which enables the country in promoting ecotourism and marketing of wildlife resources, encouraging investors especially private ones to participate in the conservation of wildlife, strengthening research, education and training on wildlife, establishing a network to compile and disseminate information to national and international users. The proclamation is supported by regulations issued in 2008 by Council of Ministers that is cited as Wildlife Development, Conservation and Utilisation Regulations, No. 163/2008. The execution of the proclamation is the responsibility of the Ethiopian Wildlife Conservation Authority (EWCA) which was established recently pursuant to Proclamation No. 575/2008 on "Establishment of the Ethiopian Wildlife and Development Authority". The Authority reports to the Ministry of Culture and Tourism.

3.2.2.6. Proclamation on Rural Land Administration and Land Use

Rural Land Administration and Land Use Proclamation (Proc. No. 456/2005) came into effect in July 2005. The objective of the proclamation is to conserve and develop natural resources in rural areas by promoting sustainable land use practices. In order to encourage farmers and pastoralists to implement measures to guard against soil erosion, the proclamation introduces a rural land holding certificate, which provides a level of security of tenure. The Ministry of Agriculture is charged with executing the proclamation by providing support and coordinating the activities of the regional authorities.

Regional governments have an obligation to establish a competent organization to implement the rural land administration and land use law. At regional level including SNNPRS, Bureau of Agriculture is responsible to implement the same. Part three of the proclamation presents regulations relating to the use of rural land particularly as it relates to soil and water conservation and watershed management. The proclamation also addresses environmental concerns, including non-compliance with directives on environmental protection. An important feature of this proclamation is that it stipulates rural land use and restrictions based on proper land use planning providing for the proper use of various types of land, such as slopes, gullies and wetlands, as well as the utilization of rural land for villages and social services. In addition, it is envisaged that the proclamation will create a sense of ownership among the vast majority of the rural population and enable them to take initiatives and collectively engage in environmental management activities.

In line with the national proclamation, SNNPRS has issued the regional Rural Land Administration and Use Proclamation (Proc. No. 66/2007). The Proclamation established various articles with respect to rural land administration and use in the region. Included among the important points are the following: right to land holding, land re-distribution, land holding procedures and minimum land holding and conditions leading to deprivation of holding rights.

3.2.2.7. Proclamation on Expropriation of Land Holdings and Payment of Compensation

The Proclamation, Proc. No. 455/2005 was issued in July 2005 and deals with appropriation of land for development works carried out by the government and determination of compensation for a person whose landholding has been expropriated. It includes provisions on power to expropriate landholdings, notification of expropriation order, and responsibility for the implementing agency and procedures for removal of utility lines. According to the proclamation the power to expropriate landholdings mainly rests on woreda or urban administration authorities.

Article 3(1) of the proclamation states that a Woreda or an urban administration shall, upon payment in advance of compensation in accordance with this proclamation, have the power to expropriate rural or urban landholdings for public purpose where it believes that it should be used for a better development project to be carried out by public entities, private investors, cooperative societies or other organs or where such expropriation has been decided by the appropriate higher regional or federal government organ for the same purpose." The proclamation deals also with determination of compensation having articles on the basis and amount of compensation, displacement compensation, valuation of property, property valuation committees, complaints and appeals in relation to compensation. As per this proclamation, a land holder whose holding has been expropriated shall be entitled to payment for compensation for his property situated on the land for permanent improvements he made to such land and the amount of compensation for property situated on the expropriated land shall be determined on the basis of replacement cost of the property. For houses in urban areas, the amount of compensation should not be less than the current market value of construction. In addition to the amount of compensation for the property expropriated, the proclamation also gives a provision for cost of removal, transportation and erection.

3.2.2.8. Public Health Proclamation

Public health proclamation (Proc. No. 200/2000) was issued in 2000. Among the objectives of the proclamation related to environmental health and applicable during the construction phase of irrigation and similar projects are: prohibiting discharge of untreated liquid waste generated from septic tanks, seepage pits and industries (including sugar factories) into water bodies, or water convergences, prohibiting disposal of solid or liquid or any other waste in a manner which contaminates the environment or affect the health of the society, etc.

3.2.2.9. Proclamation on Research and Conservation of Cultural Heritage

Proclamation No. 209/2000 provides legal framework for research and conservation of cultural heritage. The proclamation establishes the Authority for Research and Conservation of Cultural Heritage (ARCCH) as a government institution with a juridical personality. At regional, zonal and Woreda levels, heritage issues are managed and administered by the respective Bureaus and Offices of Culture and Tourism. The proclamation has provisions for management, exploration, discovery and study of cultural heritage and miscellaneous provisions. The proclamation defines the objectives, powers and duties of the Authority (ARCCH). It also has provisions on management of cultural heritage. Among these are provisions on ownership and duties of owners, classification, registration, conservation and restoration, removal, the use and expropriation of cultural heritage, preservation of cultural heritage situated on land given in usufruct and establishment of museum.

Furthermore, the proclamation provides articles on exploration, discovery and study of cultural heritage. Article 41 is on Fortuitous Discovery of Cultural Heritage and Sub-Article (1) states that, any person who discovers any cultural heritage in the course of an excavation connected to mining explorations, building works, road construction or other similar activities or in the course of any other fortuitous event, shall forthwith report same to the Authority, and shall protect and keep same intact, until the Authority (ARCCH) takes delivery thereof. Connected to this, Sub-Article (2) states that, the Authority shall, upon receipt of a report submitted pursuant to Sub-Article (1) hereof, take all appropriate measures to examine, take delivery of and register the cultural heritage so discovered.

Under Miscellaneous Provisions, the proclamation states that, unless otherwise specifically decided by the Council of Ministers, no person may, without a permit issued by the Authority, carry out building or road construction, excavations of any type or any operation that may cause ground disturbance in an area declared reserved. It also stipulates that any person who holds permit to conduct construction works in a reserved area; an area declared to be containing an assemblage of immovable cultural heritage or an archaeological site; and who discovers cultural heritage in the course of construction activities shall stop construction and shall forthwith report same in writing to the Authority. Key international organisations with Ethiopian representation are the International Council on Monuments and Sites (ICOMS) and UNESCO. Ethiopia is a party to the UNESCO World Heritage Convention.

3.2.2.10. Labour Proclamation

The principal source of labour law in Ethiopia is Labour Proclamation No. 377/2003. This covers standard topics such as freedom of association and the right to collective bargaining and to strike and brings the legal code closer to international norms, based on the ILO's Freedom of Association and Protection of the Right to Organise Convention of 1948 (No. 87). *Inter alia*, the proclamation establishes a normal working week of 40 hours with two days of rest, normally Saturday and Sunday, overtime rates, paid leave, the 12 national public holidays and maternity leave. Under Article 89, the statutory minimum age for young workers is 14 years and young workers may be protected by special measures. The responsible government ministry is the Ministry of Labour and Social Affairs with Bureaus of Labour and Social Affairs at regional level and corresponding offices at zonal and woreda levels. Occupational health and safety is governed by the Occupational Safety and Health Directive (2008). This is also administered by MoLSA which has an Occupational Safety, Health and Working Environment Department (OSHWED). The Labour Proclamation (377/2003) made provision for the establishment of a Tripartite Labour Advisory Board, with responsibility for studying and examining matters concerning employment service, working conditions, the safety and health of workers, labour laws in general and giving advice to the Ministry.

3.2.2.11. Pesticides Proclamation

Pesticides are administered under the Pesticide Registration and Control Council of State Special Decree No. 20/1990. Under the decree a Pesticide Registration Council has been established. This registers pesticides and issues provisional permits for importation and use of non-registered pesticides especially for use in the new floriculture industry and other huge mechanized farms. An inter-agency National Pesticide Advisory Committee has been established to advise Ministry of Agriculture on implementation of the Special Decree.

3.2.2.12. Environmental Assessment Guidelines

With a view to implement the environmental laws, environmental guidelines have been issued by EPA. Among these are the technical and procedural EIA guidelines which were issued in 2000 and 2003 respectively. They are intended to guide developers, competent agencies and other stakeholders in carrying out EIA. The procedural guideline details the required procedures for conducting an EIA, the permit requirements, the stages and procedures involved in EIA process and the roles and responsibilities of parties involved in the EIA process. It also includes the categories of projects (schedule of activities) concerning the requirement of EIA and list of project types under each category. The technical guideline specifies tools, particularly the standards and guidelines that may be considered when undertaking the EIA process and details key issues for environmental assessment in specific development sectors.

The other valuable document is the Guideline for Reviewing EIA Reports (2003). This is a generic guideline prepared to facilitate the EIA report reviewing and decision-making processes and it includes review approaches and outlines a minimum report structure and information requirements. It is intended to help the reviewers to assess the content, comprehensiveness, adequacy and accuracy of information in the report as well as its organizational and presentation qualities. The review guideline is principally meant to be used by EPA and regional environmental agencies in addition to Sectoral environmental units and the proponents. It is believed that the guideline will help to make decisions in good time and faith, whether and under what conditions the project shall proceed.

3.3. INTERNATIONAL ENVIRONMENTAL AND SOCIAL AGREEMENTS

Ethiopia has ratified the following international conventions on natural resources and environmental management:

- Convention on International Trade in Endangered Species (CITES) (ratified through Proclamation No. 14/1970);
- Framework Convention on Climate Change (UNFCC: ratified through Proclamation No. 97/1994);
- Convention on Biological Diversity (CBD: ratified through Proclamation No. 98/1994);
- The UN Convention to Combat Desertification (UNCCD: ratified through Proclamation No. 80/1997);
- The Cartagena Protocol on Bio-Safety to the Convention on Biological Diversity (ratified through Proclamation No. 362/2003);
- Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention), ratified in 1977;
- International Treaty on Plant Genetic Resources for Food and Agriculture;
- Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their disposal (Basel Convention): ratified in 2000;

- Stockholm Convention on Persistent Organic Pollutants (Stockholm Convention): ratified in 2002 and
- Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn Convention): entered into force 01 January 2010 together with the Agreement on the Conservation of African-Eurasian Migratory Water birds (AEWA).

3.4. ADMINISTRATIVE AND INSTITUTIONAL FRAMEWORK

3.4.1. Federal and Regional Administration

The Federal Democratic Republic of Ethiopia comprises the Federal Governments and the state members. There are twelve National Regional States and two City Administrative Councils who are the members of the Federal Democratic Republic of Ethiopia. The form of government of Ethiopia is parliamentarian. There are two kinds of representation in the federal government. These are the House of Peoples' Representatives and the House of the Federation. Both the Federal Government and the Regional States have legislative, executive and judicial powers.

A policy of decentralization of authority to regional administration has been pursued since 1991. The powers and functions of the Federal Government are defined in the constitution under article 51. The regional governments have legislative, executive and judicial power over their administrative areas, except in matters of defence, foreign relations, citizenship, etc, which fall under the jurisdictions of the Federal Government. The powers and functions given to the regional states by the constitution under article 52 include enacting and executing the state constitution and other laws to formulate and execute economic, social and development policies, strategies and plans of their respective regions and to administer land and other natural resources. The administrative structures in regional governments are zone, woreda and kebele.

3.4.2. Environmental Council

Environmental council was established by provision of Environmental Protection Organs Establishment proclamation No. 295/2002. The environmental council consists of representative from prime Minster office, Federal and regional governments, Ethiopian chamber of commerce, local environmental non-government organizations, the confederation of Ethiopian Trade Unions and the director general of EPA. The Council is responsible to 1) review proposed environmental policies, laws and issue recommendations to the government;

2) evaluate and provide appropriate advice on the implementation of the environmental policy of Ethiopia and 3) review and approve directives, guidelines and environmental standards prepared by EPA.

3.4.3. Environmental Protection Authority

The Federal Environmental Protection Authority (EPA) was re-established under the Proclamation No. 295/2002 as an autonomous public institution of the Federal Government of Ethiopia entrusted with the protection and conservation of natural resources in the country. The Authority (EPA) is the competent environmental agency at the Federal level in Ethiopia with one of its objectives stipulated in Article 5 of the Proclamation No. 295/2002 indicating that the authority is established "to ensure that all matters pertaining to the country's social and economic activities are carried out in a manner that will protect the welfare of human beings as well as sustainably protects, develops and utilizes the resources base on which they depend for survival."

The federal EPA is the key national level environmental agency with a mandate to address environmental issues. The environmental legislation gives the EPA powers to fulfil its role support all federal agencies in establishing environmental units and develop skills in strategic environmental analysis of policies and public instruments. The EPA is involved in the development of environmental policy and legislation setts environmental quality standards for air, water and soils, monitoring pollution, establishing EIA procedures and an environmental information system and undertaking capacity development in relevant agencies to ensure the integration of environmental management in policy development and decision making.

As a Competent Agency, the responsibilities of this authority in EIA process are to:

- establishment of a system for environmental assessment of public and private sector projects as well as social and economic development policies, strategies, laws and programs of federal level functions;
- review decision-making and follow-up implementation of environmental impact study reports for projects as well as social and economic development programs or plans where they are subject to federal licensing, execution or supervision; also proposed activities subject to execution by a federal agency, likely to entail inter- or trans-regional and international impacts;

- notification of its decision to the concerned licensing agency at or before the time specified in the appropriate law or directives;
- ensure that the proponent complies with requirements of the EIA process;
- auditing and regulation of implementation of the conditions attached to the decision;
- provision of advice and technical support to the regional environmental agencies, sectoral institutions and proponents;
- making its decisions and the EIA report available to the public;
- resolution of complaints and grievances in good faith and at the appropriate time and
- development of incentives or disincentive structures required for compliance with regional environmental agency requirements.

3.4.4. Sectoral Environmental Protection Unit

Proclamation No. 295/2002 requires at the Federal level each Sectoral ministry to establish in-house Environmental Protection Unit to ensure harmony with respect to implementation of the environmental proclamations and other environmental protection requirements. The duties and responsibilities of these Sectoral Environmental Units are to co-ordinate and follow up of the integration of environmental requirements in a proactive manner so as to ensure environmental sustainability of sectoral development efforts. Based on this provision different ministry such as Ministry of Water and Energy, Ministry of Mines, Ministry of Agriculture etc has established sectoral environmental units. Recently the federal EPA has delegated its power to review EIS to these institutions.

3.4.5. Regional Environmental Protection Agencies

The Environmental Protection Organs Establishment Proclamation (Proclamation № 295/2002) requires regional states to establish or designate their own regional environmental agencies. The regional environmental agencies are responsible for coordinating the formulation, implementation, review and revision of regional conservation strategies and for environmental monitoring, protection and regulation. Regarding EIA, specifically, the Environmental Impact Assessment Proclamation (Proclamation Nr. 299/2002) gives regional environmental agencies the responsibility to evaluate EIA study reports on projects that are licensed, executed or supervised by regional states and that are not likely to entail inter-regional impacts. Regional environmental agencies are also responsible for auditing and regulating the implementation of such projects.

The responsible body for environmental protection in SNNPRS is structured under the Regional Rural Land Administration and Use Bureau. The objectives of the Bureau include ensuring that matters pertaining to the region's social and economic development activities are carried out in a manner that will protect the welfare of human beings as well as sustainably protect, develop and utilize the resource; regulate implementation of any development activities to be accomplished with the knowledge of land use planning and environmental protection and organize and manage data of land administration, use and environmental protection. Among the powers and duties vested to the Bureau the following are related to environmental protection and management:

- adoption and interpretation of federal level EIA policies and systems or requirements in line with their respective local realities;
- establishment of a system for EIA of public and private projects as well as social and economic development policies, strategies, laws and programs of regional level functions;
- notification to the federal EPA about malpractices affecting environmental sustainability and cooperation with the federal EPA in investigation of complaints;
- administration, oversight and major decision-making regarding assessment of the possible regional impact of projects in the process of licensing and execution;
- formulate policies and strategies pertinent to land and environment protection and implement or cause to be implemented upon approval, regulate and follow up its implementation and take legal action for breach of law pertinent to land and environmental protection;
- based on the objective situation of the region prepare environmental standards; after approval regulate and follow up its implementation by the concerned bodies;
- regulate and follow up that any development activity is planned and implemented without damaging the environment;
- regulate and follow up that any development body shall conduct environmental impact assessment prior project implementation, prepare environmental standards and make them available for use and regulate its implementation;
- regulate disposal of different pollutants and waste materials from factories, cities not to pollute the environment and take or cause to be taken proper action if it caused any damage;
- collect, store, analyze and administer the land resources and environmental data and information and make them available for use as required;

- undertake environmental auditing on the manner of liquid and toxic wastes disposal management by factories and industries so that it may not damage the environment; and
- promote and develop public awareness on land use and environmental protection at all levels.

At Zone level, environmental bodies are structured under Zonal Agriculture and Pastoralist Development Departments. Generally, there are encouraging environmental policy and legislative frameworks that promote proper engagement in the development of the country with emphasis on harmonizing with the environment. Besides this, the policy is based on promoting proactive engagement with development promoting nature rather than adopting a reactive policing stance to reconcile the development need of the country with environmental requirements on efficient basis.

Table 4. List of key institutions in the water sector in Ethiopia

S/N	Institution	Role
1	Ministry of Water and Energy (MoWE)	Develops overarching policies and laws; is responsible for overall planning and coordination as well as monitoring the implementation of WRM and development programs within the sector. Issues licenses for large and medium-scale irrigation schemes.
2	Ministry of Finance (MoF)	Responsible for all spending with regard to WRM and WRD, including investments under the Water Master Plan/Strategy. MoF also sets development priorities and strategies in cooperation with the other ministries, formulates strategies for managing foreign aid and loans, negotiates and signs aid and loan agreements and monitors their implementation
3	Environmental Protection Authority (EPA)	The EPA is in charge of EIAs at the federal level and decides on EIAs for projects that are likely to produce trans-regional impacts. Regionally, EIAs are a competence of the regional state environmental agencies. The monitoring and evaluation of EIAs is delegated to different sector institutions like Ministry of Mines; Ministry of Health; Ministry of Transport and Logistics; Ministry of Water and Energy; Ministry Industry; and Ministry of Agriculture. EPA together with MoF is also a Coordinating Entity for the CRGE; in this role, it has focused on putting in place the overall technical approach and system for coordination for CRGE implementation and the monitoring of progress.
4	Ministry of Agriculture (MoA)	Responsibility for watershed management, water harvesting and small-scale irrigation schemes.
5	Ministry of Industry	Issues licenses and permits to industrial development projects.
6	National Meteorological Service	Establishes and operates a national network of meteorological stations.

8	The Ethiopian Electric Power Corporation (EEPCo)	EEPCo is a government-owned utility responsible for the generation, transmission, distribution and sale of electric energy throughout Ethiopia 'in accordance with economic and social development policies' (EEPCo, 2014). The main energy source of the national grid ('Interconnected System') is hydropower plants, as well as some mini-hydro and diesel power generators allocated in various areas of the country
9	Regional Bureaus/ Authorities, Zonal and woreda offices	According to the Ethiopian Constitution (art. 52 c), states have the power to administer land and natural resources in accordance with laws enacted by the Federal Government. Proclamation 197/2000 further provides for the possibility of the Federal Government delegating its powers to manage water and other resources to regional states.
10	RBHC	Management and regulatory functions as set out in Proclamation 534/2007; RBHC: direct the preparation of the basin plan in a participatory way and submit it to the government for approval; it has final responsibility for coordination of stakeholders at basin level.

Source: Report on building adaptive water resource management in Ethiopia, 2015.

3.4.6. Policy, Legal and Institutional Gap Analysis

Ethiopia has a large number of policy, legal and institutional documents with regard to water, land and environmental management. However, the existing policies and legal frameworks of the country were not fully implemented. The challenges hindering successful implementation of Ethiopian sectoral policy include poor autonomy, weak regulatory capacity, inadequate political support, loose policy enforcement at national, regional, and local levels. Regarding to legal frameorks, the enforcement status is very weak. With regard to the institutional establishment, there is limited number of institutes in the water sector to undertake overall the water sector development programs.

3.4.7. Responsible Basin Level Administration Office

Eventhough the Omo-Gibe River Basin has huge natural resource potential, it has no a basin administration office. Ensuring the implementation of integrated water resources management in the Omo-Gibe River basin is at its infant stage since the basin is lacking its own basin administration office. The results of field survey, key informant interview, focus group discussion and stakeholder consultations showed the necessity of the establishment of the basin administration office within the basin. Consequently, establishing the Omo-Gibe River Basin Administration office will have a significant impact on the development and management of the basin’s water resources and will be used as a tool to ensure the implementation of the integrated water resources management in the basin.

3.4.8. The Proposed Omo-Gibe River Basin Administration Office (OGRBAO)

The Ministry of Water and Energy has planned to establish the Omo-Gibe River Basin administration office so as to ensure the economic, social, and environmental benefits of water resources for the present and future generation in the basin through equitable and effective utilization of the resources. Among the three sub-basins namely Gibe-Gojeb, Omo-Sharma and Lower Omo sub-basins, large number of development activities is taking place in Omo-Sharma sub-basin, the middle course of the river basin. In the Omo-Sharma sub-basin, there are three cascade hydropower plant projects, large irrigation projects, national parks, protected areas, “Gebeta-Lehager” projects and other proposed ecotourism projects. Besides, frequent flood and drought hazards are takig place in this sub-basin. Moreover, the sub-basin is experiencing high water use conflict due to high socio-economic activities. Therefore, taking the socio-economic and biophysical situations into account, it is ideal to establish the Omo-Gibe River Basin Administration Office in the Omo-Sharma sub-basin. Consequently, the Wolaita Sodo City is proposed to be the headquarter of the proposed the Omo-Gibe River Basin Administration Office as it is located in the Omo-Sharma sub-basin, the middgle course of the river basin, and the political and administrative city (headquarter) of the South Ethiopia Regional State.

4. SOCIO-ECONOMIC ASSESSMENT OF THE BASIN

The right of people to food, improved living standard, property, sustainable development, environmental protection and rehabilitation, who live on it, are internationally protected human rights as well as theses fundamental rights are also protected under the constitution of the Federal Democratic Republic of Ethiopia (FDRE, 1995). Socio-economic analysis is a well-established method of understanding the existing basin situations and plays a vital role for estimation of social development as well as economic growth rates during the scheduled basin plan implementation period. Moreover the analysis of socio-economic framework has important significance to investigate the potential effect of economic growth on the increasing water demand in the basin.

Among the major community life style and livelihoods condition in the basin, crop production is the main livelihood of communities, supplemented by modest livestock production. Communities located on the fringes of the farming system neighboring the agro pastoral communities tend toward rearing livestock rather than being totally depending on crop production for their livelihoods. Landless and poor households in the farming system generate most of the necessary income for their family sustenance from casual, mostly nonfarm labor and petty trade. Furthermore the rural areas of the Basin are characterized by low agricultural productivity and small landholding size. Many households therefore need to meet their basic food and household requirements through off farm and nonfarm activities. Most people in rural areas are dependent directly or indirectly on the natural resources of the area for their livelihood. Cash cropping is generally regarded as a means of increasing income, and thus of reducing poverty.

4.1. GIBE-GOJEB SUB BASIN SOCIO-ECONOMIC SITUATION

4.1.1. Administrative Structures of Gibe Gojeb Sub Basin

The Gibe-Gojeb sub-basin is administratively shared by three regional states: Oromia, Central Ethiopia and South West Ethiopia regional states. The sub basin is mostly found in Oromia regional state consisting of different zones and towns. The Oromia regional state part of the sub basin has a total of 4 Administrative Zones namely East Wollega, Jimma, West Shewa and South West Shewa zones and 1 city administration, Jimma city which have a total of 992 kebele administrations. Besides, some portion of the sub basin is located in Central Ethiopia regional state. The administrative zones of the region that share Gibe-Gojeb sub basin with Oromia regional state are Gurage, Hadiya, Yem and Kembata zones, and Tambaro special woreda. Moreover, the sub-basin is shared by South West Ethiopia Regional state, particularly Dawro and Konta zones are located in this sub basin.

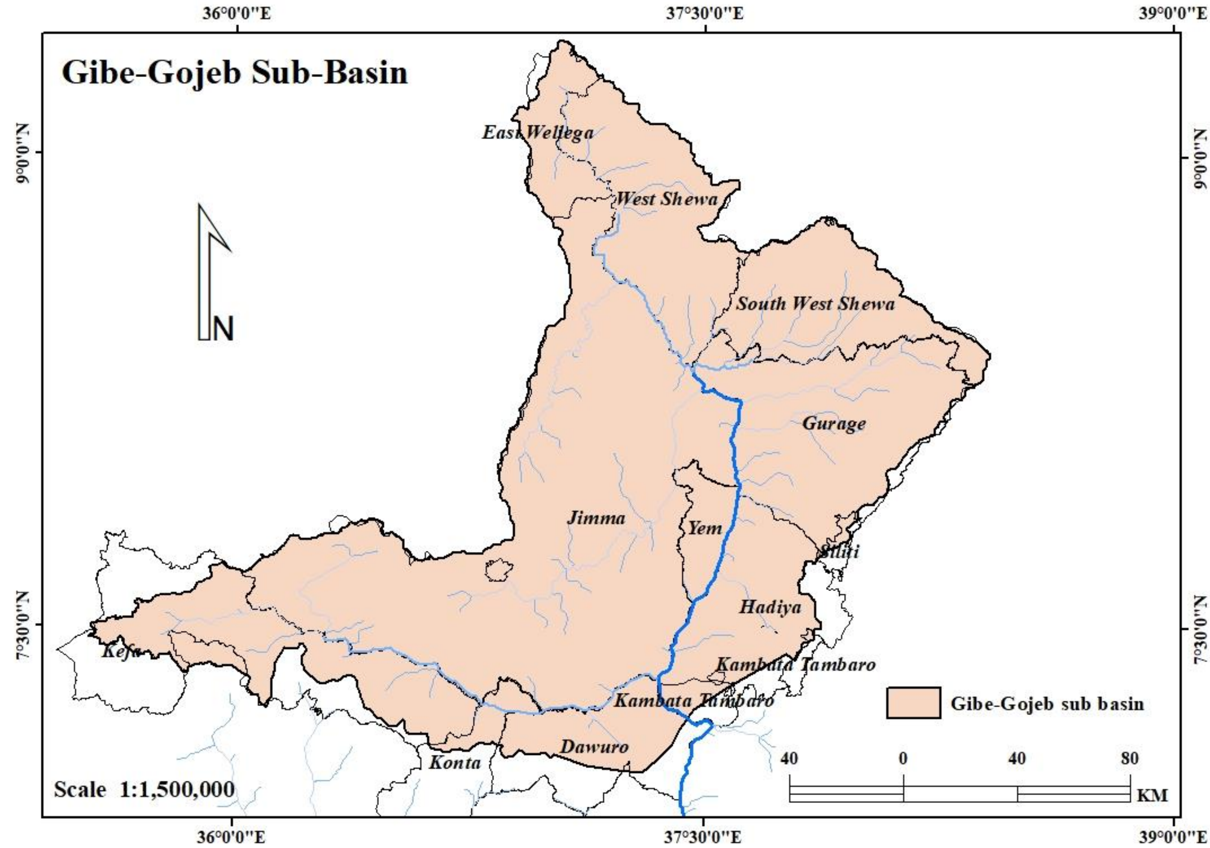


Figure 6: Administrative Map of Gibe- Gojeb Sub Basin

4.1.2. Population of Gibe-Gojeb Sub-Basin

Among different demographic variables, information on population size is highly indispensable for planning, monitoring and evaluation of any development programs. Since population has direct relationship with development efforts, planning and implementation, any development programs require the actual size of population and other major population dynamics. The population size of the sub basin is increasing at an alarming state through time. The population size of the Gibe-Gojeb sub basin is presented in appendix 1.

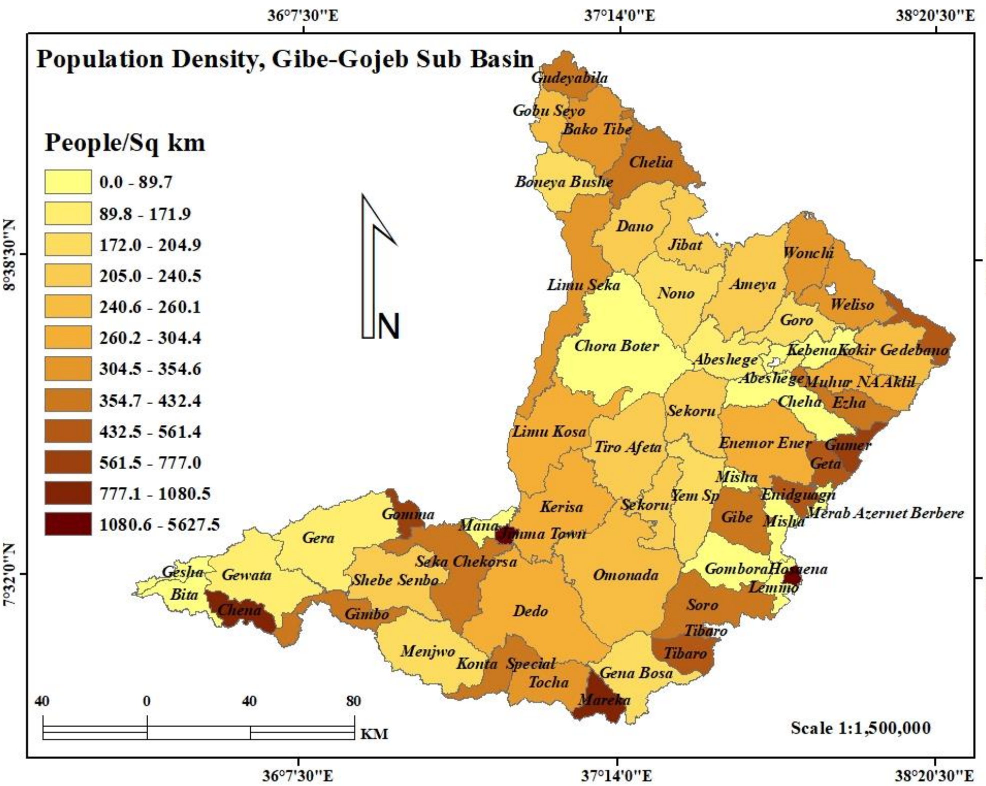


Figure 7: Population Density of Gibe-Gojeb Sub-Basin (2025)

The population distribution in the sub-basin is inconsistent and varies spatially. As shown in figure above, the population density of major towns in Gibe-Gojeb sub-basin is higher than that of rural areas and small towns.

4.1.3. Economic Basis of the Community

4.1.3.1. Agriculture

The agricultural production constraints and/or problems in the area vary in composition and magnitude of its harshness across each zone and woredas due to slight variation in agro ecologies and production systems; there are also considerable overlaps and similarities. However, in most of the basin area, limited and/or lack of improved varieties for most crops, poor irrigation, agricultural extension service, limited improved technology (pesticides, fertilizers, seeds, water pump, etc), low soil fertility, prevalence of insect pests, weeds and diseases, problem of wild animals/mammals (apes, monkey, porcupine, buffalo, wart hog and pigs), limited improved agronomic practices such as appropriate seeding rate and planting method, cropping system, frequency and time of irrigation has vastly raised by farmers and professional personnel during discussion as agricultural production constraints.

Generally, they were identified and prioritized into two major groups of constraints: agricultural and non-agricultural problems. In the sub basin, limited infrastructure and general services around the community certainly constrains the performance of agricultural production and productivity directly or indirectly.

4.1.3.2. Industry

A country that only depends upon agriculture sector cannot achieve stability. There is an imbalance, only the man-power i.e. labor-intensive technology is being used. Hence, industrialization provides economic stability to the country where in the country is not solely dependent on only one sector. There is a balance between the contributions of both the sectors to the economy. It is a proven fact that a country with strong industrial sector have shown more economic growth, had improved national income and promoted living standard of people. The development of industrial sector has many contributions in terms of import substitution, economic stability, increase foreign exchange reserve, utilization of natural resource, improving investment and spending etc. Industries can be grouped under large, medium, and small scale. Across the sub basin there are some limited large, medium and small scale industry are under operating on different areas for instance agro-industry, manufacturing, livestock, metal work, wood work, hand craft, furniture, construction, and so on. These indicate that industrial sector development is at infant stage and it needs promotion.

4.1.4. Gender

Gender, refer to social differences and relations between men and women which are learned, changeable over time and have widely variations within and between cultures (ILO, 2000). Since women and men have historically played different roles in a society, they often face very different cultural, institutional, physical and economic constraints many of which are rooted in a systematic biases and discrimination. Hence, differences between men and women, which looks at their specific activities, conditions and needs and access and control over resources as well as access to development benefits needs to be diagnosed and analyzed. With current development thinking gender issues is the most critical variable in designing and implementing development projects and programs.

Women constitute half of the population; the representation of women in water sector institutions in the sub basin is still very low. As guardians of family health and hygiene and providers of domestic water and food, women are the primary stakeholders in household water and sanitation. Also the societies in the sub basin area were patrilineal which implies that the kinship and descent is traced on the male line of the members of the society. The social structure thus basically makes it clear that women have a subordinate position and are devoid of inheritance of property as well as any degree of decision-making power, be it at household or community levels

4.1.5. Health Institutions

The ultimate goal of health sector development program is to improve the health status of the people through provision of adequate and optimum quality of health service. Hence, the prime objective of health sector development is to make the people conscious of preventing various diseases or exercising self-help primary health care. However, provision of health services as set standard and quality still remains the big assignments of the concerned body. The main constraint for low standard and quality health service is associated with insufficient budget, qualified personnel, services and infrastructures. In general, there are 11 hospitals are there in the sub basin. In terms of health center facility there are 101 health centers are there in the sub basin. To measure the availability of enough health institutions for a certain catchment area of population computing each institution service against population size is very curtail. Hence, to see the standard of service each institution provides at regional level in 2012 E.C on average, one hospital serves 578,529 people, and one health center serves 63,008 people. Thus, it is possible to conclude that each institution is serving the national standard, that one hospital to 100,000 people and, one health center for 25,000 people. In general, the number of health infrastructure particularly the number of hospitals is few and have low capacity comparing to the increasing number of population from year to year. Therefore the health sector facility in the sub basin is very low and below the given standard.

4.1.6. Water Supply

Improved water supply and sanitation and improved water resources management boost countries economic growth and contribute greatly to poverty eradication. However, the water supply and sanitation coverage in the Gibe-Gojeb sub-basin is low. Although basic water service coverage of the sub-basin is increasing from time to time, most of the households still use an unimproved water source.

4.1.7. Energy Supply

Electricity is one of the modern sources of energy used as a source of Power in industries and for residents it is used as a fuel replacing Wood and cow dung. Electricity is one of the modern sources of energy used as a source of power. In the Gibe Gojeb sub basin, the distribution of electric service as a source of energy is expanded through both inter-connected system/ICS/ and sb- connected system/SCS/.

4.1.8. Road Infrastructure

The basic purpose of transport is to overcome the effects of the physical separation of areas of supply from areas of demand by reducing the economic distance between them. The exchange of goods and services is a central feature of economic activities. But, since natural resources, manufacturing capacity and market products are not all located at the same place, this exchange involves movement to link areas of demand with areas of supply, transport facility have to be provided. The principal forms of transportation within Gibe-Gojeb sub basin zones comprised of road vehicles and pack animals.

4.1.9. Telecommunication and Postal services

Telephone service is the vital communication tools for social, economic, educational, business, investment and other activities. The quantity of telephone service in the sub basin increases from time to time. Thus, establishment of fast electronic communication systems through internet and telephone in Gibe-Gojeb sub basin increasing.

4.1.10. Education

Education is taken to be essential for sustainable development and participation in democratic, social and political processes. It is also currently becoming the most important contributor to the national economic growth. The overall goal of Education is to provide relevant and quality education for all citizens most especially for disadvantaged, to enable those acquiring skills which will make them functionally literate and productive to facilitate poverty alleviation and promote the rapid socio-economic growth in the country. Education is very crucial and its coverage in Gibe-Gojeb Sub Basin is 100%.

4.1.11. Historical, Cultural, Archaeological, Recreational and Religious Sites

The tourism industry generates revenue to host country, provides employment opportunity for many people, brings sustainable development, enhances development of infrastructures and services, and strengthen exchange of knowledge and experiences between tourists and hosts. The development of tourism will give rise to the construction and expansion of accommodation facilities, food services, night clubs, cinemas, museums, parks, handcraft and souvenir shops, horticulture farms, tourist guides. As it is well known, tourism also known as smokeless industries are sources of income for a given country. In the sub basin, there are so many tourist attraction sites like hot springs, the palace of kings, museums and the like. The major cultural and heritage sites in Oromia region of the Gibe-Gojeb sub-basin are presented in appendix 2.

4.2. OMO-SHARMA SUB BASIN SOCIO-ECONOMIC SITUATION

4.2.1. Administrative Structures of Omo-Sharma Sub-Basin

Omo-Sharma Sub Basin is administratively shared by three regional states namely South West Ethiopia, South Ethiopia and Central Ethiopia regional states. Currently, the sub basin has a total of about 10 administrative zones: Wolayta, Kembata, Benchi Maji, Kafa, Konta, Basketo, Gofa, Dawro, Gamo and Hadiya Zones as well as Tambaro special woreda.

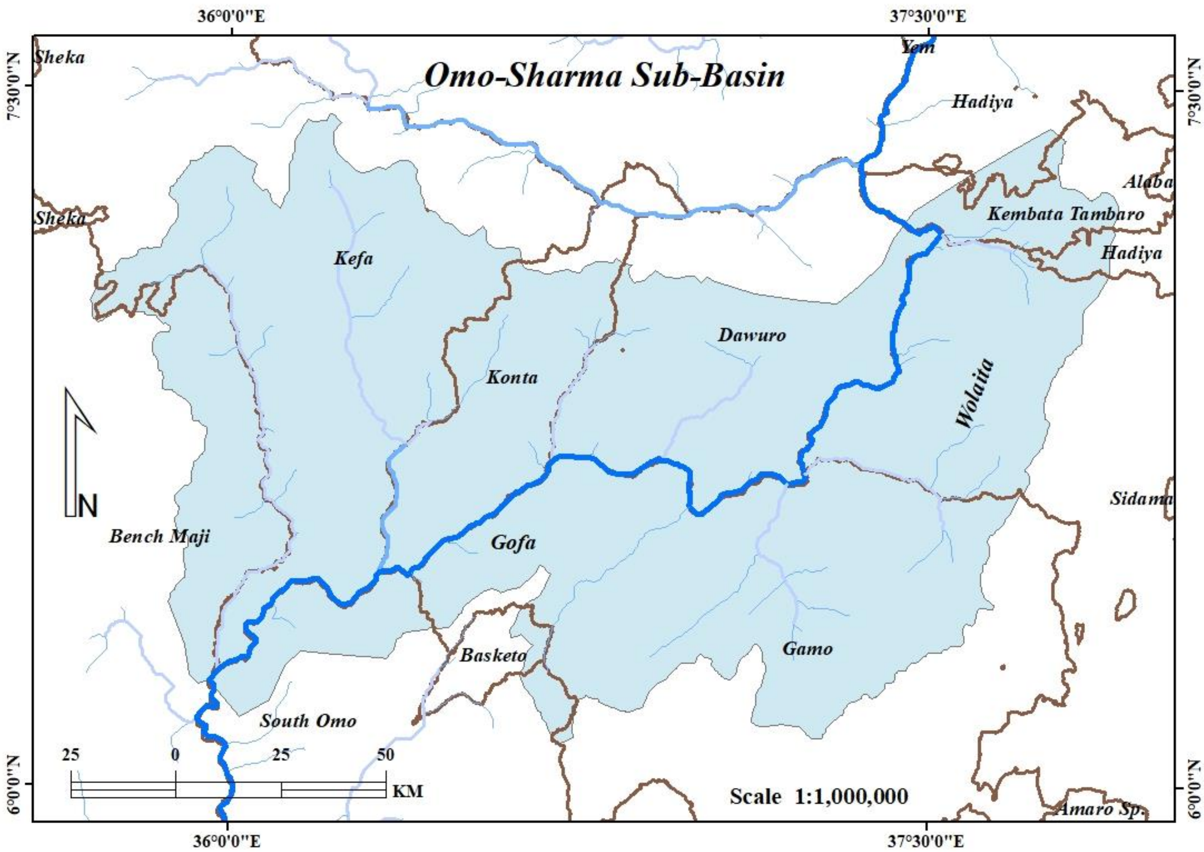


Figure 8: Administrative Map of Omo-Sharma Sub-Basin

4.2.2. Population of Omo-Sharma Sub-Basin

Population dynamics and its effect on economic outcomes have been an age long debate among demographers, planners and economists. Although Population growth raises the productive labor force since more human activities drive the economy that in turn accelerate economic growth, also population growth enlarges market size and increase completion in marketing activities. On the other hand, it has its own demerits on the fact that as population increases has negative consequence on economic and social development such as the demand for food, agricultural land (over farming), deforestation, settlement, dependency, poor living standard etc. increases. This in turn leads to decrease in productivity and aggravate environmental degradation and overutilization of resources. Appendix 3 presents the population size of Omo-Sharma sub-basin.

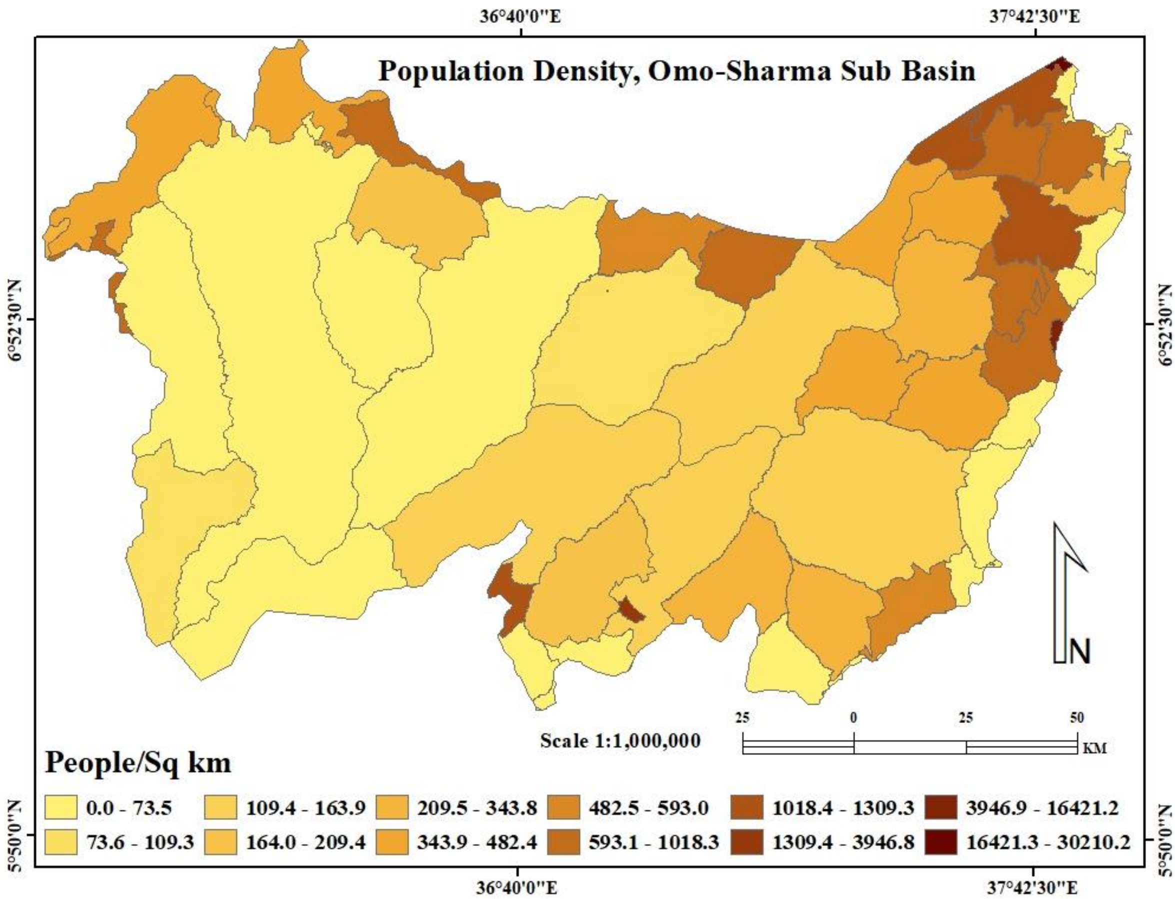


Figure 9: Population Density of Omo-Sharma Sub-Basin

In Omo-Sharma Sub-Basin, the northern and eastern parts are highly densiley populated. The density of population in the remaining parts of the sub-basin is sparce.

4.2.3. Economic Basis of Omo-Sharma Sub-Basin

4.2.3.1. Multiple Cropping Systems

There are a number of farming systems within the Sub Basin. These have evolved as a response to a number of factors, not always strictly agro-climatological. Socio-economic constraints particularly, pressure on land availability have often influenced their evolution. This process is continuous and is currently taking place in the sub basin. Farmers are modifying their cropping systems to cope with the loss of many draught oxen and consequent reduction in their ability to cultivate all of their land. This is well demonstrated by Kucha wereda where although the average farm size is 3-4 ha, food shortages are now the norm mainly because farmers are unable to make full use of their land. This also applies to many other weredas in the middle part of the sub basin. In the affected areas, 60-70% of the farmers no longer possess even one ox.

Increasing population density has also resulted in the evolution of complex multiple cropping systems, notably of the *enset*-roots-cereals-cash crop system found in the Welayita area. Here farm sizes may be as small as 2000 m^2 and families consist of up to 10 or more members. The arable area in such farms may contain as many as twenty different crop plants, many occupying specific niches in the farming ecosystem. Coffee and fruit trees are under planted with tubers, roots, vegetables and spices. Around the homestead *enset* is grown which provides a high proportion of the basic staple for the family. Stalled animals provide butter and other products a further source of income for the family. Appendix 4 presents the main farming systems in Omo-Sharma sub basin.

4.2.4. Industry

Investment is a placement of capital in expectation of deriving income or profit from its use and also without doubt it is one of the primary engines of growth in all economies. However, its effectiveness rests on strong complementarities with other elements in the growth process, most notably technological progress, skills acquisition and the development of innovative capability. Also its one of the important macro-economic variable in the process of economic growth and development of the basin since it enhance skills formation, technological change, competitiveness, employment opportunity, capital formation or accumulation and economic growth. Across the sub basin there are some limited large, medium and small scale industry are under operating on different areas and the activity in expanding industry is encouraging.

4.2.5. Gender

Gender analysis refers to the variety of methods used to understand the relationships between men and women, their access to resources, their activities, and the constraints they face relative to each other. Gender analysis provides information that recognizes that gender, and its relationship with race, ethnicity, culture, class, age, disability, and/or other status, is important in understanding the different patterns of involvement, behavior and activities that women and men have in economic, social and legal structures.

An understanding of socio-economic relations and with it gender relations, is an integral part of policy analysis, and is essential in creating and implementing effective development co-operation initiatives. Analysis of the different situations of men and women can provide an understanding of the different impacts that legislation, cultural practices, policies, and programs can have on women and men. Also gender analysis offers information to understand women's and men's access to and control over resources that can be used to address disparities, challenge systemic inequalities (most often faced by women), and build efficient and equitable solutions. Women constitute half of the population; the representation of women in water sector institutions in the Basin is still very low.

4.2.6. Health Institutions

Health is a prerequisite for increases in productivity. It is readily understood that access to quality of health care is one of the major factors determining the ability of individuals and communities to obtain a secure livelihood. In one way or another, ill-health of the members of the working population in particular, may disrupt development activities in an area. Health policy in Ethiopia is rooted in the primary health care approach, which has health education, education in personal and environmental hygiene, nutrition, immunization and family planning for standard components.

In general, there are 35 hospitals are there in the sub basin. In terms of health center facility there are 331 health centers are there in the sub basin. To measure the availability of enough health institutions for a certain catchment area of population computing each institution service against population size is very curtail. Hence, to see the standard of service each institution provides at regional level in 2012 E.C on average, one hospital serves 327,423 people, and one health center serves 34,621 people. Thus, it is possible to conclude that each institution is serving the national standard, that one hospital to 100,000 people and, one health center for 25,000 people. In general, the number of health infrastructure particularly the number of hospitals is few and have low capacity comparing to the increasing number of population from year to year. Therefore, the health sector facility in the sub basin is very low and below the given standard.

4.2.7. Water Supply

Better access to clean water, sanitation services and water management creates tremendous opportunity for the poor and is a progressive strategy for economic growth. As a result the water service coverage has shown encouraging increment in various water schemes in the sub basin.The water supply access condition at Omo- Sharma Sub Basin is indicated in appendix 5.

4.2.8. Energy Supply

Electricity is one form of modern sources of energy used as a source of Power in industries and for residents it is used as a fuel replacing Wood and cow dung. The distributions of electric service expanded through both /ICS/ inter- connected system and SCS sub connected system. Electrification in sub basin only in 2010 E.C. 124 towns and Villages canters have got electric service through the system and number of customers reached to 177,218 generating annual revenue of birr 25, 8647,097.13 in the sub basin.

4.2.9. Road Infrastructure

From government transport policy aspect, at national and regional level, the government has a vital role in transport decision for economic, political and social service reasons. Land transport is very important because most movement takes place over land by expanding motor roads and railway. Federal and regional government has allocated huge investments for the construction of roads which could provide transport service in most part of the basin.

4.2.10. Telecommunication and Postal services

The quantity and quality of telephone service in the sub basin is increasing from year to year. The fixed lines Capacity are above 70,000 and capacity of 2G, 3G and 4G network are increasing. The establishment of fast electronic communication systems through internet and telephone are overwhelming; currently there are more than 300 towns having different level postal services. In the sub basin district post offices are founded and more than 150 post offices are distributed.

4.2.11. Education

Education is a human right and is central to achieving many other sustainable development outcomes. Education is particularly important to communities that are fragile or rebuilding. Also it provides stability, structure and hope for the future. A quality basic education give children and youth the knowledge and skills they need to face daily life challenges, and take advantage of economic and lifelong learning opportunities. It is also a key driver for reducing poverty, fostering economic growth, achieving gender equality, and social development. It is obvious that primary education is very crucial to avoid illiteracy and bringing over all socio-economic development of a nation and its coverage was 100%. Also the coverage of secondary schools reached 100% in the sub basin.

4.2.12. Historical, Cultural, Archaeological, Recreational and Religious Sites

The range of altitude in the region permits varied climatic types and agro ecological zones that support immense varieties of fauna and flora having great potential for tourism expansion. Natural forests are the habitats of endemic trees and wild life resources, different kinds of wild life varieties of tropical plants and highland vegetation grow in the sub-basin. Major natural, paleo anthropological, cultural and social attractions, and protected areas in the Omo-Sharma sub basin are presented in appendix 6.

4.3. LOWER-OMO SUB BASIN SOCIO-ECONOMIC SITUATION

4.3.1. Administrative Structures of Lower Omo Sub-Basin

Lower-Omo sub basin is found in South West Ethiopia and South Ethiopia regional states. Currently, the sub basin has a total of 5 administrative zones: Ari Zone, Pastorals’ Zone, Benchi Maji Zone, Gofa Zone, and Basketo Zone. In the sub basin, there are about 571 kebeles.

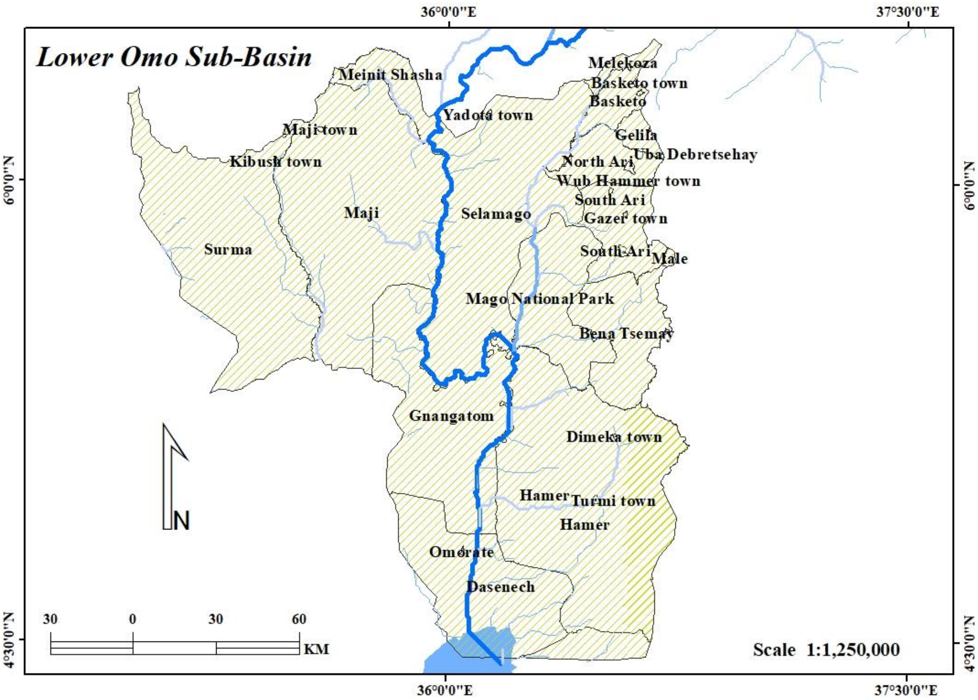


Figure 10: Administrative Map of Lower Omo Sub-Basin

4.3.2. Population of Lower Omo Sub-Basin

Demography examines the size, structure, and movements of populations over space and time. Demography analysis is useful for governments and private businesses as a means of analyzing and predicting social, cultural, and economic trends related to population. High population increase the demand for resource use, particularly it will limit the amount of water available per person, because an increase in per capita water consumption driven by development will intensify water demand, straining the local water supply**.** Moreover, this population growth will also lead to increased cases of water pollution, deforestation, overgrazing and clan and ethnic conflict through resource competition. This in turn leads to decrease in productivity and overutilization of resources. The Lower Omo sub-basin is mostly inhabited by the pastoral communities. Consequently, the lower omo sub basin is characterized by low population density. The population density of the sub-basin ranges from 1.4 to 39444 people/sq. km. The population data of Lower Omo sub basin is indicated in appendix 7.

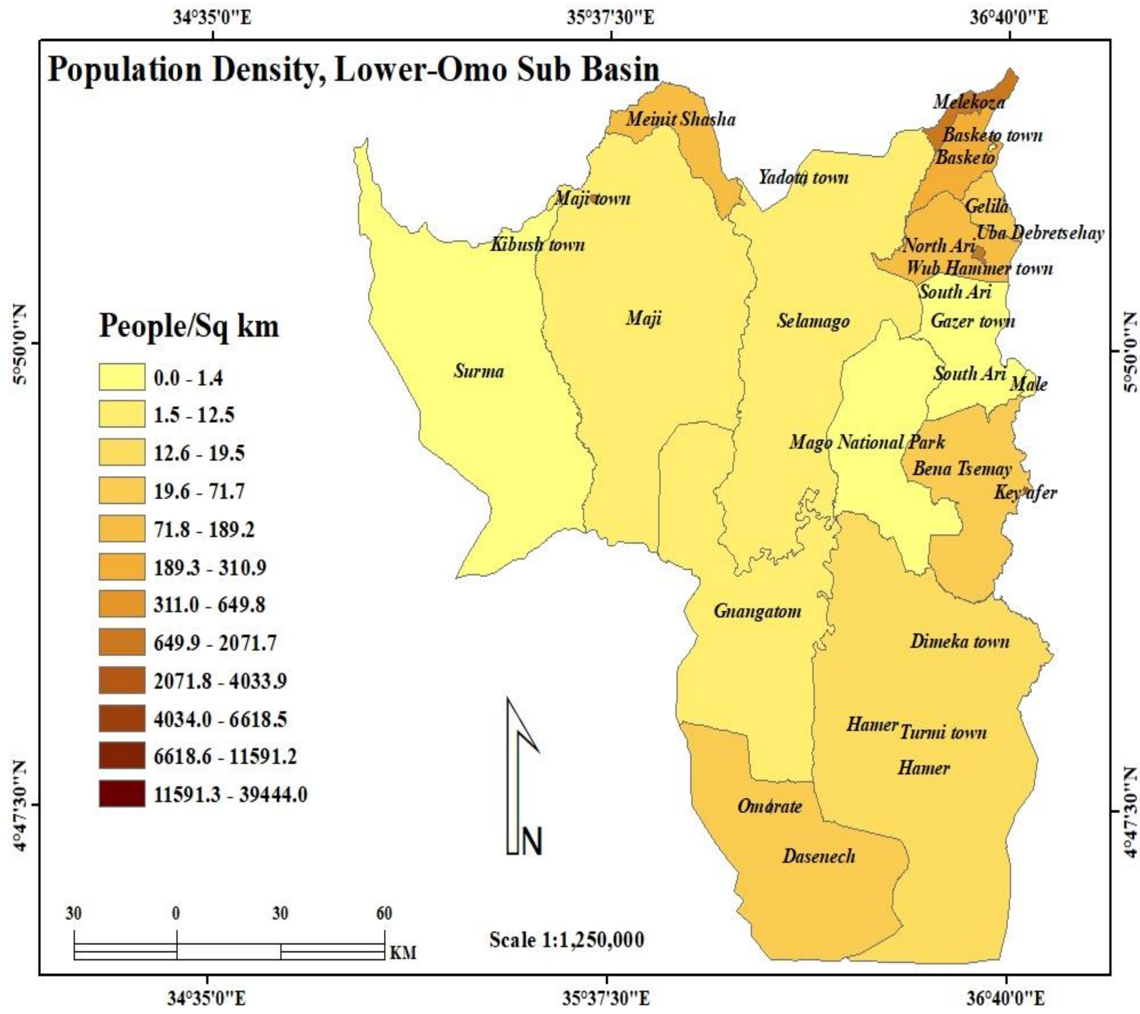


Figure 11: Population Density of Lower Omo Sub-Basin

4.3.3. Economic Basis of the Lower Omo Sub-Basin

4.3.3.1. Agriculture

Agricultural sector is the predominant economic activity in the sub basin as well as in the region. It is the largest contributor of the gross domestic product (GDP) at regional as well at national level. However, agriculture has been prominent source of lively hood in the sub basin, it is still said to be subsistent, and that is mainly for personal consumption. The local government has intensively involved in various to improve the economic and social wellbeing of the sub basin population as well as to realize the growth and development. The presence of wide range of agro- climate in the sub basin would allow the growing of varieties of crops. The major food crops produced at sub basin level are maize, sorghum, teff, coffee, vegetables, root crops, pulses and oil seeds etc.

4.3.4. Gender

Gender analysis is an essential element of socio-economic analysis. A comprehensive socio-economic analysis would take into account gender relations, as gender is a factor in all social and economic relations. An analysis of gender relations provides information on the different conditions that woman and men face, and the different effects that policies and programs may have on them because of their situations. Such information can inform and improve policies and programs, and is essential in ensuring that the different needs of both women and men are met. It has become increasingly accepted that women should play an important role in water management and this role could be enhanced through the strategy of gender mainstreaming. Involving both women and men in integrated water resources initiatives can increase project effectiveness and efficiency. As guardians of family health and hygiene and providers of domestic water and food, women are the primary stakeholders in household water and sanitation. However, women participation in water sector institutions in the Sub Basin is still very low.

4.3.5. Health Institutions

The number health institutions such as (posts, centers and hospitals) across the country are very low as compared to the total number of population who need their services. Health is a prerequisite for increases in productivity. It is readily understood that access to quality of health care is one of the major factors determining the ability of individuals and communities to obtain a secure livelihood. The number of health facilities tells something about the health of the community and the commitment of the government to ensure the wellbeing of its citizens.

In general, there are 10 hospitals are there in the sub basin. In terms of health center facility there are 90 health centers are there in the sub basin. To measure the availability of enough health institutions for a certain catchment area of population computing each institution service against population size is very curtail. Hence, to see the standard of service each institution provides at regional level in 2012 E.C on average, one hospital serves 438,141 people, and one health center serves 48,682 people. Thus, it is possible to conclude that each institution is serving the national standard, that one hospital to 100,000 people and, one health center for 25,000 people. In general, the number of health infrastructure particularly the number of hospitals is few and have low capacity comparing to the increasing number of population from year to year.

4.3.6. Water Supply

Water is not only a vital source for all natural life but also a natural resource that is at the core of sustainable development. It is critical for socio-economic development, healthy ecosystems and for human survival itself. Water can pose a serious challenge to sustainable development but if it is managed efficiently and equitably, water can play a key enabling role in strengthening the resilience of social, economic and environmental systems in the light of rapid and unpredictable changes.

Table 5:Drinking Water Supply Coverage of Lower Omo sub basin

N.o	Zone Name	Population Numbers (2010E.C)			Drinking Water Supply Beneficiary		
		Urban	Rural	Total	Urban	Rural	Total
1	South Omo (Ari and Pastorals' Zones)	33,944	756851	790795	18395	308477	326872
2	Basketo		76729	76729		26315	26315
3	Goffa Zone	91,808	578615	670423	30730	242559	273289
4	Benchi Maji Zone	28,513	254,620	283,133	18,170	87,266	105,436

Source: SNNPR Annual Socio-economic Data, 2020

4.3.7. Energy Supply

Ethiopia has an abundant renewable energy resource that potentially generates 60,000 megawatts (MW) of electric power from hydroelectric, wind, solar and geothermal sources. This boosted the GDP growth over past decades and increased electricity demand for public. However, the country is experiencing energy shortages and load shedding as it strive to offer supply for over 110 million people and predicted to grow 30% per year. Across the sub basin the distribution of electric service expanded through both inter-connected system and sub-connected system. However, there are numerous restraints over electrification with most people in rural areas utilize traditional biomass energy sources and lack of modernized transmission and distribution.

4.3.8. Road Infrastructure

Transport ensures everyday mobility of people and is crucial to the production and distribution of goods. Adequate infrastructure is a fundamental precondition for transport systems. The economy needs reliable infrastructure to connect supply chains and efficiently move goods and services across market. Infrastructure connects households across different city areas to higher quality opportunities for employment, healthcare and education.

The principal forms of transport within the basin comprise road vehicles, pack animals, and pedestrian traffic. Besides, there is very limited air service and the very confined water transport in the lower course of Omo River. Land transport particularly, road basically plays vital role in making easy communications, transporting freights and passengers. But, efforts made to improve transportation accessibility of the road transports within the region still found to be underdeveloped and under maintained resulting in considerable isolation of large areas.

4.3.9. Telecommunication and Postal services

With the advancement of technology, it is increasingly becoming clear that communications services are permeating all aspects of life. Technology enabled communications services are being deployed to facilitate various economic transactions, thereby playing critical roles in the economy in general and in the digitized economy in particular. Ethiopia's recent efforts to regulate the sector with a view to enhancing the economic and social development are a step in the right direction. Regulating the communications service will not be an easy task as the delivery of the service is highly dependent on the ever dynamic technology. The quantity of telephone service in the lower omo sub basin is increases from time to time and the postal service also commonly used by local people.

4.3.10. Education

Education helps one to develop critical skills like decision-making, mental agility, problem-solving, and logical thinking. People face problems in their professional as well as personal lives. In such situations, their ability to make rational and informed decisions comes from how educated and self-aware they are. Education also breeds creativity and innovation. Education is imperative when it comes to building a modern society. When people learn about things like culture, history, and science, they can view problems from a much-informed perspective. Education teaches values and helps in the development of society as a whole. It gives people a chance to mold themselves into more responsible members of society.

Education helps us create equal opportunities. People from different genders, religions, castes, races, and cultures have multiple possibilities laid out in front of them because of education. They in turn strive to create more opportunities for others, even if only within their community. Education has made filling an irrational rift possible by making merit the only criterion for judgment. Education makes people more tolerant of others. It makes them more open-minded, so they can accept different views and opinions. This further opens the gates for equal opportunities and a better standard of living for everyone. Furthermore education access currently in the lower omo parts both in primary and secondary school levels are increasing, also more children are attending school than ever before. This achievement is the result of enormous efforts being exerted by government and non-governmental organizations and the communities. The primary and secondary education in the sub basin in terms of coverage was 100%.

4.3.11. Conflicts among Indigenous Communities

The conversion of wetland pastures into cultivated land engenders conflicts between livestock and crop farmers expanding their private landholding. The cultivation at the edges of wetlands by farmers with plots adjacent to the wetland seems to be a more silent form of continuous encroachment. The conversion may be more obvious when parts of formerly uncultivated wetland encroach. Due to land scarcity, all eyes focus on the redistribution of wetlands for cultivation. Consequently, conflicts are seen between various parties. Long term draining interferes with the ecological recovery of the wetland system and will fasten its drying up.

On the highland areas of the river basin there is high interest of the farmers in utilizing irrigation water but there is limited surface water potential particularly in districts South-Omo found. Due to limited surface water resources and increased use of water for irrigation, the available water during dry season river flows may significantly reduce and this will impair existing and potential dry season water users, including community water supply, livestock and wild life resources. The conflict among the community arises over water rights. Traditional irrigation development practice and pump irrigation is common in the area following the river courses in patches.

However, the practice is traditional both in terms of river diversion and irrigation water application methods. Traditional River diversions are constructed every year and made at different places on the same river that resulted in wastage of water and water use conflicts. The above problems are associated with poor extension services related to irrigation agriculture, lack of knowledge and capital among the farming community to develop available potential surface water resources

4.3.12. Historical, Cultural, Archaeological, Recreational and Religious Sites

In 2020, Ethiopia generated around 2.28 billion US dollars in the tourism sector alone. This corresponds to 2.1 percent of it's the gross domestic product and approximately 54 percent of all international tourism receipts in Eastern Africa. On average, each of the tourists arriving in 2020 spent about 4,184 US dollars. The tourism industry in Ethiopia could be legitimately described as one that is still in its infancy. Its current low level of development is often attributed to changes in governance systems and development policies, weak promotion, lack of trained manpower, finance, and knowledge and management capacity.

The sub basin encompasses national park, wild life reserves, controlled hunting areas and different cultural and natural attraction sites and so on. It is believed that the sub basin has varieties of wild life. The sub basin comprises significant percent of the countries and regions ethnic composition. Each ethnic group has its own culture, reflected by their hair style, body decoration, dressing jewelry, and cultural ceremonies. Within the sub basin has many hotels which give sufficient service for the society; it also has enormous tourism investment opportunity potentials.

5. BASIN SITUATION ASSESSMENT

5.1. WATER RESOURCE SITUATION ASSESSMENT

Understanding of the water resources occurrence, distribution and qualiy of both surface water and groundwater is crucial for livelihoods in natural systems, societies and economies. In countries like Ethiopia, where agriculture serves as a back-bone of the economy as well as ensures the wellbeing of the people, the availability of water resource is quite essential.

Surface water is the primary source of water for human use. Knowing the potential, availability and use of surface water would help to increase the productivity of agriculture, improved ways and means of the traditional water management systems, increase drinking water supply and the hydroelectric power generation in the coming future. The water resources in the Omo Gibe river basin are used as an important source for drinking, agriculture, wildlife, grazing and water for livestock and as a power generation. This makes the issue of water resource availability very crucial for effective water resources management. Based on the current study, the total surface water resource of the Omo Gibe River Basin is estimated 17.02BCM.

Groundwater is an important resource contributing significantly in total annual supply. Assessing the potential zone of groundwater recharge is extremely important for the protection of water quality and the management of groundwater systems. Ground water has emerged as an important source to meet the water requirements of various sectors including the major consumers of water like irrigation, domestic and industries. The sustainable development of ground water resource requires precise quantitative assessment based on reasonably valid scientific principles. Concerning the groundwater resource of the basin, it was estimated to be 1BCM.

5.1.1. Gibe-Gojeb Sub-Basin Water Resource Situation

5.1.1.1.Drainage System of Gibe-Gojeb the Sub-Basin

Rivers provide a multitude of services such as water supply, waste assimilation, fisheries, energy production, flood attenuation, spiritual, cultural and recreational benefits, and the habitat that supports a wide range of ecosystems so that planning for their use is so complex. The demands on rivers increasingly exceed their natural capabilities, resulting in over abstraction, pollution, alien infestation, floodplain alteration and habitat destruction.

These failures are usually the consequence of poor decision-making, inadequate management and inappropriate planning. The Gibe River rises on the Ethiopian Plateau just north of latitude 9^0 N at an elevation of about 2200m. There are some important tributaries, but the general direction of flow of the river is southwards towards the Omo River. The Gibe River is called the Omo River in its lower reach, south and south westwards from its confluence with the Gojeb River. The Gojeb River is a major right-bank tributary to the Omo River, draining the uplands that have been less intensively cultivated than other parts of the Basin. Thus, it drains most of the western extension of the Basin, including much of the area of highest rainfall but also the area with the most complete natural forest cover. The tributaries of Gibe River in Jimma zone are all perennial and include Gojeb, Gilgel Gibe, Kersa, Kelecha, Unta, Kewe, Anderacha, Dembi, Nada, Abbonno, Busa and Nedi.

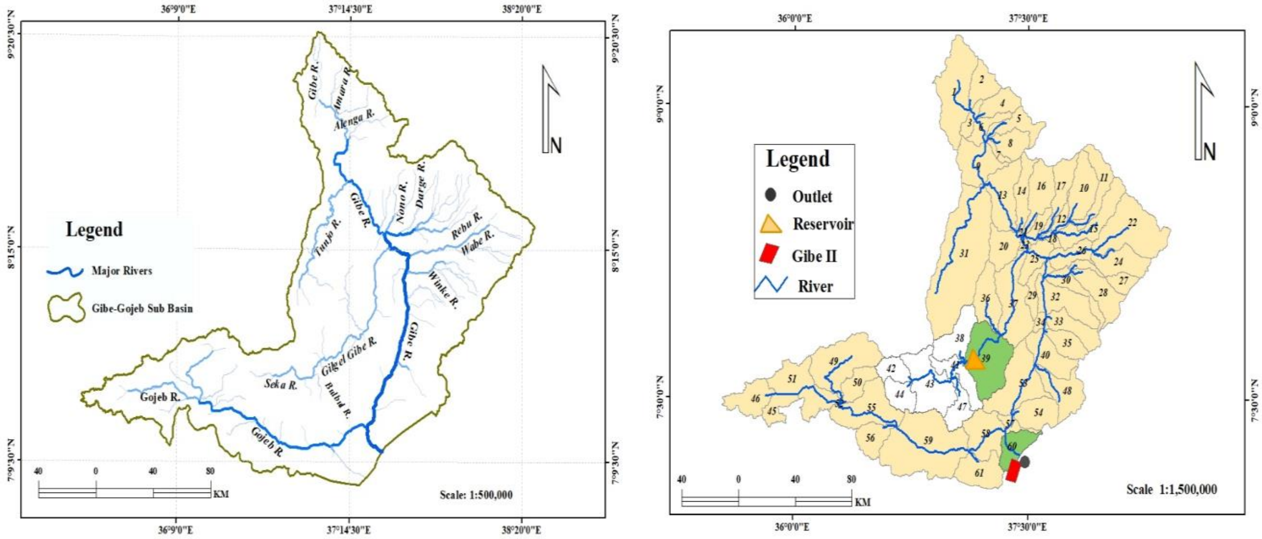


Figure 12: Rivers' Network and Watersheds of Gibe-Gojeb Sub-Basin

5.1.1.2.Wonchi Crater Lake

Wenchi Crater Lake is one of the important lakes in Ethiopia. The lake is located in Western Shoa region, which extends between latitude 15^0N-3^0S and longitudes 48^0E-33^0W. It is situated at the major topographic feature in the country, being 130 km south-west of the capital city, Addis Ababa. It is surrounded by Kelela region in the north, Dera region in the east, Goro Wenchi region in the south and Haro Gebeya region in the west. This lake, 1,600 square metres in total area, is ecocologically, recreationally, and aesthetically important as well as a popular place for tourists.

5.1.1.3. Hydrology and Water Resources of the Sub-Basin

Historical Hyrological Modeling

In the Gibe-Gojeb sub-basin, the SWAT model simulations were performed to show the hydrological processes. The mean annual surface runoff contributed by the sub-basin is found to be 9.67BCM.

Table 6: The mean monthly hydrological processes of Gibe-Gojeb sub-basin

Months	PREC (mm)	SURQ (mm)	LATQ (mm)	GWQ (mm)	LATE (mm)	SW (mm)	ET (mm)	PET (mm)	Water Yield (mm)
Jan	26.6	0.96	5.03	39.47	10.59	180.48	19.26	31.97	51.65
Feb	6.1	0.48	2.99	19.91	5.14	162.25	18.25	41.41	26.57
Mar	75.7	14.69	4.66	21.59	25.54	165.11	24.71	34.82	33.67
Apr	201.4	44.39	9.74	36.06	50.12	189.1	18.93	19.25	108.7
May	288.3	96.77	16.65	75.99	44.5	195.38	13.03	13.07	221.58
Jun	188.2	46.05	16.6	108.51	59.51	193.66	8.38	8.57	213.12
Jul	123.2	21.19	13.47	106.98	65.73	190.98	9.8	10	187.77
Aug	202.6	18.62	11.5	86.83	58.68	194.04	9.87	10.12	166.82
Sep	230.3	20.38	12.9	77.18	69.89	192.34	11.91	12.01	141.24
Oct	101.4	23.97	10.68	74.04	39.7	189.56	18.27	19.68	112.75
Nov	140.9	30.66	14.51	65.75	61.24	191.54	12.61	13.61	122.59
Dec	2.2	0.13	5.42	53.26	4.05	171.61	18.66	24.88	62.49
Total	**1586.9**	**318.29**	**124.17**	**765.57**	**494.69**	**2216.05**	**183.68**	**239.39**	**1448.95**

The average daily stream flow into or out of reach during time step (m^3/s) and sediment transported with water into reach or out of reach during time step (metric tons) were quantified. Accordingly, the mean annual flow in (cm) and flow out (cm) of the whole reach were quantified as 4,399,507.3 and 4,398,889.0 respectively. The mean annual sediments in (tons) and out (tons) of the whole reach/outlet was estimated as 401,626,252.4 and 208,789,866.8 respectively. In this sub-basin, sediment transported with water into and out of hydropower dams/ and or reach were evaluated from the simulation results in metric tons. Sediment loads into and out of Gibe I hydropower power dam respectively were enumerated as 19,797,281 tons and 7,830,375 tons. Hence, soil and water management measures in the catchments of the Gibe-Gojeb sub-basin need to be performed to reduce sediment load of Gibe I dam.

Future Hydrological Modeling

Changes in rainfall and temperature in the future (2024-2045) was used to forecast the effects of climate change on hydrologic components of Gibe-Gojeb Sub-Basin. The simulated hydrological processes of the future and historical period were compared to show their variations. SWAT simulations in the future period showed a decrease in soil water content, percolation, groundwater and water yield, while an increase in potential evapotranspiration, actual evapotranspiration and surface runoff.

Table 7: Mean annual hydrological processes in the future period

Name of SB	Emission scenario	PET (mm)	ET (mm)	SW (mm)	PER (mm)	SUR_Q (mm)	LAT_Q (mm)	GW_Q (mm)	WYLD (mm)
Gibe-Gojeb	RCP4.5	266.49	193.70	161.98	450.04	373.67	132.91	694.98	1370.74
	RCP8.5	290.16	211.71	156.71	467.12	378.8	137.95	906.43	1425.82

In this sub basin, water yield and groundwater are likely to decrease under RCP4.5 and RCP8.5 in the future period. These variations follow the path of rainfall change**.** Soil water content, potential and actual evapotranspiration are likely to increase under RCP4.5 and RCP8.5 in the future period.

Table 8: Changes of the annual hydrological processes under climate change

Sub-basin name	Emission scenario	PET (%)	ET (%)	SW (%)	PER (%)	SUR_Q (%)	GW_Q (%)	WYLD (%)
Gibe-Gojeb	RCP4.5	11.32	5.06	-7.50	-9.08	17.40	-9.22	-5.39
	RCP8.5	21.21	15.26	-10.51	-5.63	19.01	18.40	-2.76

5.1.1.4. Rainfall Projection

The projected change in rainfall during the present (2021-2050) century relative to baseline (1992-2016) under RCP4.5 and RCP8.5 scenarios of Omo-Gibe Basin was performed by using a multi-model ensemble of regional climate models. It seems that the rainfall is likely to feature increased and decreased under RCP4.5 and RCP8.5 scenarios over the Gibe-Gojeb sub-basin. This is true especially over the upper part of the basin where rainfall is expected to decrease in the range of 32.9 to 1139.7mm under the RCP4.5 scenario, in the current (2021-2050) century. While the increase in rainfall ranges between 8.3 to 1578.4 mm under RCP4.5 scenario. Similarly, rainfall is expected to decrease in the range of 114.5 to 1244.3 mm under the RCP8.5 scenario in the current (2021-2050) century.

Decreasing rainfall is more pronounced in the upper parts of the basin under two emission scenarios. For example, under RCP4.5 projected decline in rainfall is featured in May June, July and August. Similarly, under RCP85 projected decline in rainfall is featured in May, June and August. The projected rainfall in 2021-2045 of the Gibe-Gojeb Sub-basin is indicated in figure below.

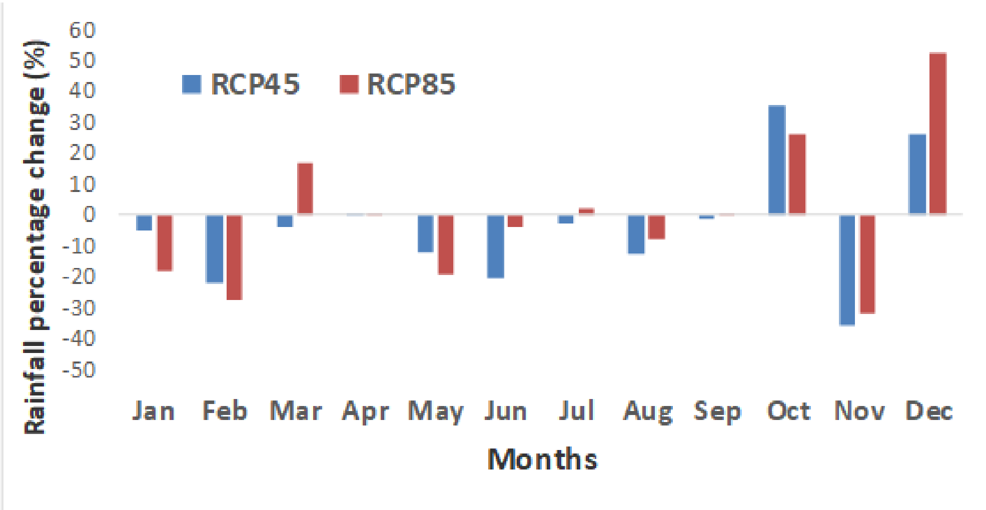


Figure 13: Percentage change of rainfall in Gibe-Gojeb Sub-Basin in 2021-2045 under RCP4.5 and RCP8.5 scenarios

The projected decrease in rainfall during the low rainy season (February-May) and the high rainy season (June-September) affects the Omo-Ghibe Basin, because of subsistence rain-fed agriculture of the most parts and the three hydroelectric power stations (Gibe I, II and III).

5.1.1.5. Temperature Projection

The mean monthly temperatures are projected (expected) to increase in the current (2021-2045) century compared to the baseline (1992-2016). The mean monthly maximum and minimum temperatures were projected under RCP4.5 and RCP8.5 scenarios in the present century. The maximum and minimum temperature in the present century (2021-2045) increased in the range of 0.3 to 1.2 ºC and 0.4 to 1.7 ºC under RCP4.5, respectively over the Gibe Gojeb Sub-Basin of the Omo-Gibe River Basin. Similarly, under RCP8.5 the maximum and minimum temperature increased in the range of 0.3 to 1.5 ºC and 0.8 to 2.0 ºC, respectively.

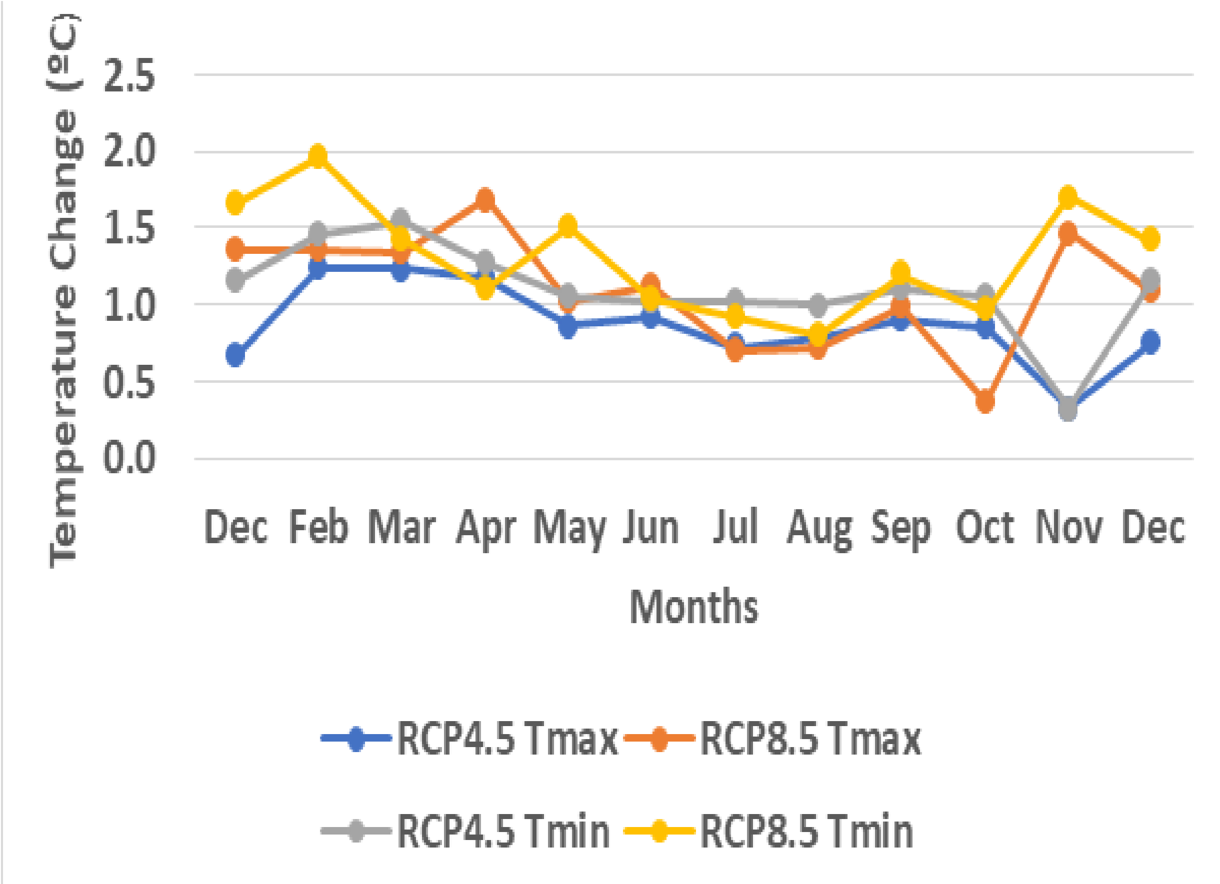


Figure 14: Change in mean monthly maximum and minimum temperatures in 2021-2045 under RCP4.5 and RCP8.5 scenarios in Gibe-Gojeb Sub-Basin

5.1.2. Omo-Sharma Sub-Basin Water Resource Situation

5.1.2.1. Drainage System of the Omo-Sharma Sub-Basin

In the Omo-Sharma sub-basin, several rivers are draining to the sub-basin. The Sana, Woybo, Soke, Deme, Morka, Gogara and Zage Rivers drain the uplands on the eastern side of the Omo-Sharma sub-basin where the rainfall is relatively high. The Gecha, Sharma, Guma, Dinchiya and Zigna rivers drain on the western side of the Omo-Sharma sub-basin. Most of these rivers are are perennial.

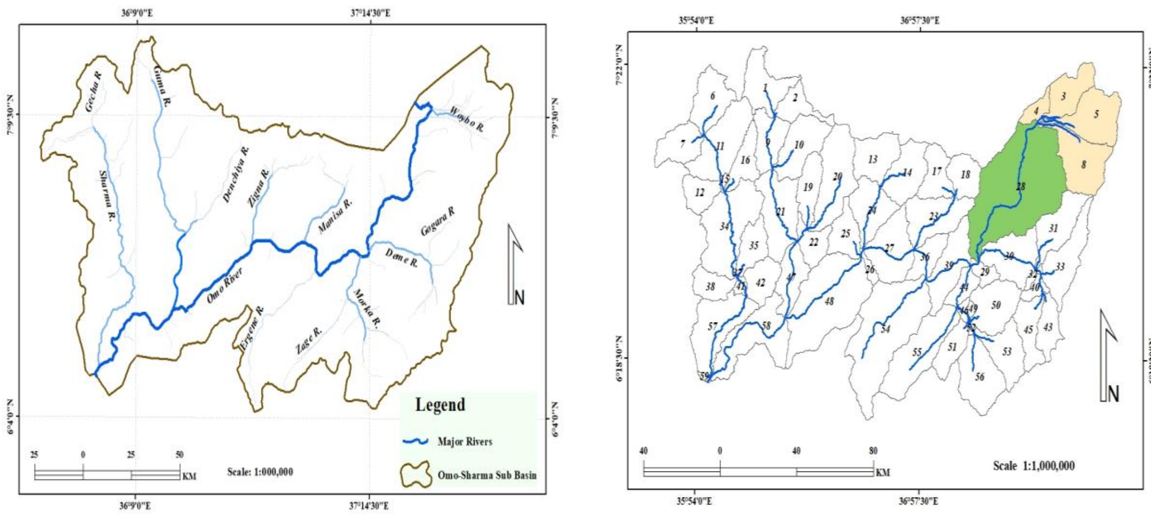


Figure 15: River Networks and Watersheds of Omo-Sharma Sub-Basin

5.1.2.2. Hydrology and Water Resources of the Sub-Basin

Historical Hydrological Modeling

In the Omo-Sharma sub-basin, the SWAT model simulations were performed to show the hydrological processes. The mean annual surface runoff contributed by the sub-basin is found to be 5.32BCM.

Table 9: Mean monthly hydrological processes of Omo-Sharma Sub-Basin

Month	**PREC (mm)**	**SURQ (mm)**	**LATQ (mm)**	**GWQ (mm)**	**PERCO (mm)**	**SW (mm)**	**ET (mm)**	**PET (mm)**	**WATER YIELD (mm)**
1	13.69	1.34	2.4	17.78	2.47	161.46	11.92	25	24.37
2	112.8	33.73	4.1	8.5	38.15	173.35	17.17	24.37	50.23
3	59.37	9.08	4.29	21.28	20.48	172.54	24.15	25.72	36.96
4	207.13	57.05	9.27	31.41	94.82	186.56	16.33	16.34	102.69
5	246.16	89.81	11.93	55.23	103.3	194.57	14.36	15.1	163.07
6	219.79	62.54	15.71	82.05	111.12	193.03	8.74	8.97	168.1
7	111.34	15.17	12.11	92.07	64.52	192.96	9.56	9.75	123.67
8	157.78	40.12	12.15	78.61	81.85	191.95	10.29	10.84	136.83
9	69.29	11.32	9.38	71.4	33.77	188.25	15.77	17.38	96.29
10	86.29	22.59	7.63	54.7	40.48	183.85	15.73	18.17	89.65
11	69.7	13.63	7.09	43.9	34.56	183.2	15.08	18.23	68.39
12	6.16	0.06	3.7	34.22	2.98	167.1	14.54	24.74	40.73
Total	**1359.5**	**246.15**	**146.4**	**721.16**	**469.5**	**2188.82**	**381.22**	**417.7**	**1193.02**

The average daily stream flow into or out of reach during time step (m^3/s) and sediment transported with water into reach or out of reach during time step (metric tons) were quantified in the sub-basin. Accordingly, it was found that the mean annual flow in (cm) and flow out (cm) values of the sub-basin were 2,065,181.1 and 2,057,926.5 respectively. The sediment in and sediment out of the whole reach/outlet was estimated respectively as 159,370,479.4 tons and 82,190,727.1 tons. In this sub-basin, the sediment loads into and out of Gibe III hydropower power dam was estimated to be 385,647,261 tons and 202,969,086 tons respectively.

Future Hydrological Modeling

In Omo-sharma sub-basin, there is variation in rainfall and temperature in the sub-basin. These variations in the rainfall and temperature were associated to the variations in hydrological processes in the sub-basin. The simulated hydrological processes of the future and historical period were compared to show their variations in the sub-basin. SWAT simulations in the future period showed a decrease in soil water content, percolation, groundwater and water yield, while an increase in potential evapotranspiration, actual evapotranspiration and surface runoff.

Table 10: Mean annual hydrological processes in the future period

Sub-basin name	**Emission scenario**	**PET (mm)**	**ET (mm)**	**SW (mm)**	**PER (mm)**	**SUR_Q (mm)**	**LAT_Q (mm)**	**GW_Q (mm)**	**WYLD (mm)**
Omo-Sharma	RCP4.5	1089	261.97	112.37	445.12	395.53	135.5	655.32	1042.19
	RCP8.5	1057.5	339.27	108.01	450.36	341.26	165.94	749.89	1153.53

Table 11: Changes of the annual hydrological processes under climate change

Sub-basin name	**Emission scenario**	**PET (%)**	**ET (%)**	**SW (%)**	**PER (%)**	**SUR_Q (%)**	**GW_Q (%)**	**WYLD (%)**
Omo-Sharma	RCP4.5	-23.19	-4.04	-0.75	-5.12	24.26	-9.12	-4.26
	RCP8.5	-25.41	-11.0	-4.56	-4.12	7.22	-3.98	-3.31

5.1.2.3. Rainfall Distribution Analysis

Over Omo-Sharma sub-basin, rainfall is likely to decrease in the range of 40.5 to 952.3 and 92.1 to 905.4mm, respectively under RCP4.5 and RCP8.5 scenarios. An increasing rainfall features in the ranges between 85.4 to 608.5 mm and 50.5 to 604.4 mm, respectively under RCP4.5 and RCP8.5 scenarios.

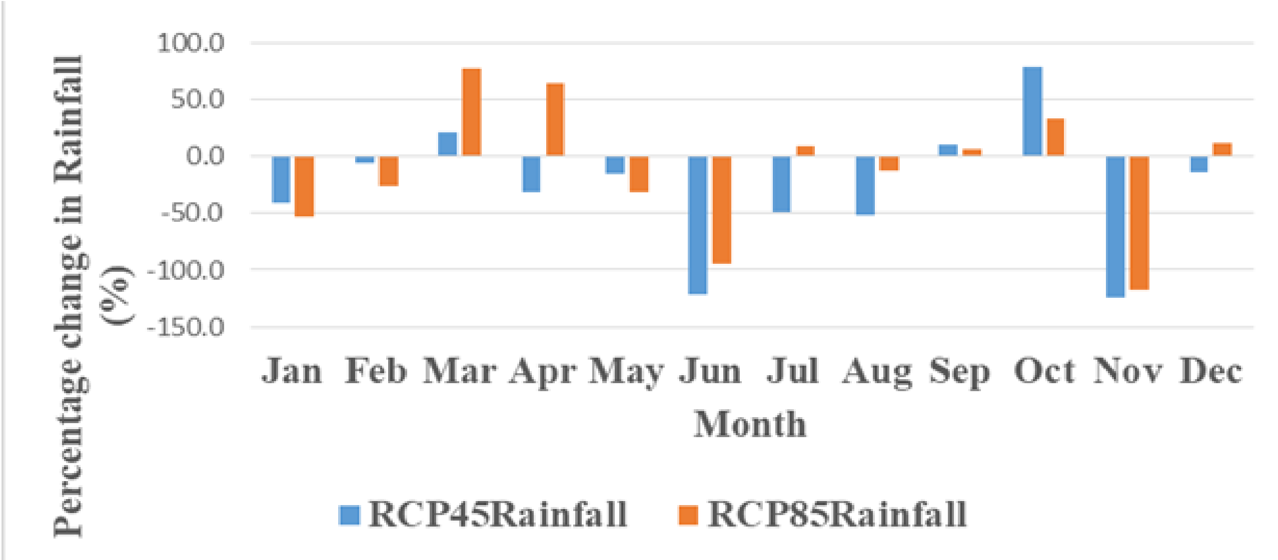


Figure 16: Percentage change of rainfall in Omo-Sharma Sub-Basin in 2021-2045 under RCP4.5 and RCP8.5 scenarios

5.1.2.4. Temperatue Distribution Analysis

Maximum and minimum temperatures are likely to increase over the Omo-Sharma Sub-Basin. In the sub-basin, maximum temperature in the present century (2021-2045) increased in the range of 0.5 to 1.4 ºC and 0.7 to 1.6 ºC under RCP4.5 and RCP8.5 scenarios respectively. Similarly, the minimum temperature is likely to increase in the range of 0.3 to 1.5 ºC and 0.3 to 1.8 ºC, respectively under RCP4.5 and RCP8.5 scenarios.

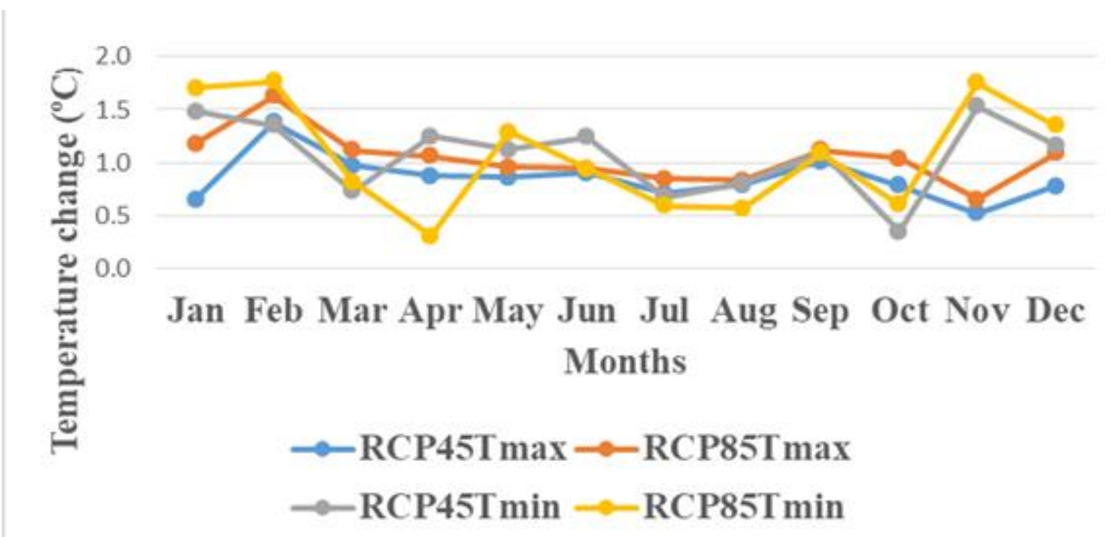


Figure 17: Change in mean monthly maximum and minimum temperatures in 2021-2045 under RCP4.5 and RCP8.5 scenarios in Omo-Sharma Sub-Basin

5.1.3. Lower Omo Sub-Basin Water Resource Situation

5.1.3.1.Rivers in Lower Omo Sub-Basin

Omo Gibe Master Plan Study indicates that lower Omo Plain is mostly characterized by poor drainage. The major tributaries of Omo River at the lower omo plain are Maki, Berso, Neri, Muwi, Kako and Kibish rivers.

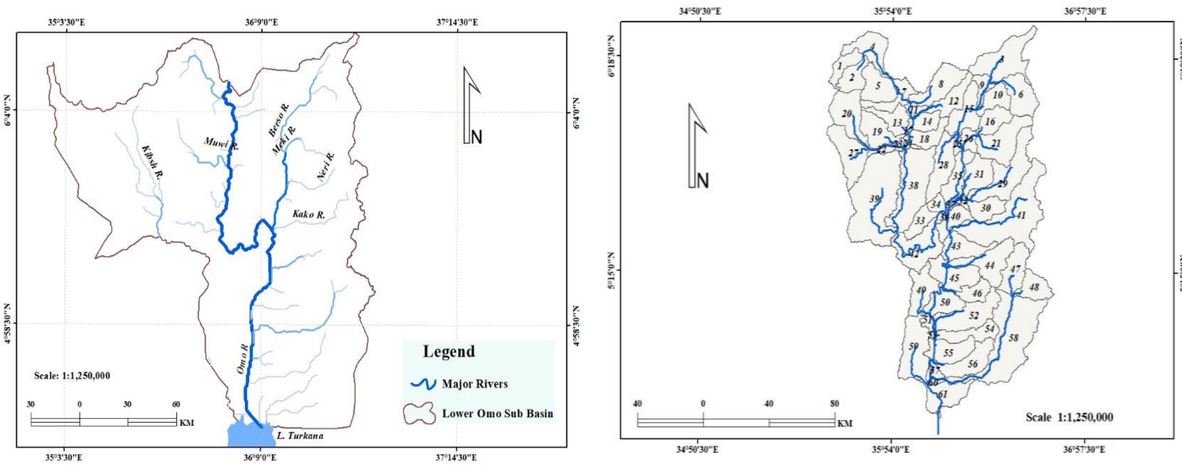


Figure 18: Major Rivers and Watersheds in Lower Omo Sub-Basin

5.1.3.2. Hydrology and Water Resources of the Sub-Basin

Historical Hydrological Modeling

The SWAT model simulations were performed to show the hydrological processes in the Lower Omo sub-basin. The mean annual surface runoff contributed by the Lower Omo sub-basin is found to be 2.03BCM.

The average daily stream flow into or out of the reach during time step (m^3/s) and sediment transported with water into the reach or out of the reach during time step (metric tons) were quantified. Accordingly, it was found that the mean annual flow in (cm) and flow out (cm) values of the sub-basin were 1,867,179.3 and 1,866,301.0 respectively. The sediment in and sediment out of the whole reach/outlet was estimated respectively as 50,616,109.0 tons and 33,388,893.6 tons. Furthermore, the hydrological processes of the sub-basin were quantified using the SWAT hydrological model. The mean annual hydrological processes values (in mm) of the sub-basins were provided in the table below.

Table 12: Mean monthly hydrological processes of Lower Omo Sub-basin

Month	PREC (mm)	SURQ (mm)	LATQ (mm)	GWQ (mm)	PERCOLAT (mm)	SW (mm)	ET (mm)	PET (mm)	Water YIELD (mm)
1	0	0	0.03	1.72	0	122.98	26.41	40.14	1.88
2	4.2	0.04	0.09	26.36	0	109.46	24.56	61.37	28.24
3	56	2.75	0.8	13.47	1.32	118.73	50.91	62.62	13.05
4	279.8	59.62	4.29	16.52	117.36	142.67	24.78	28.98	73.76
5	183.2	25.64	6.59	91.47	98.33	140.51	20.75	24.89	125.07
6	51.5	0.81	2.33	97.88	10.08	141.08	19.71	24.18	105.91
7	50.5	0.71	1.97	75.12	6.24	140.43	24.7	29.98	82.71
8	91	3.12	2.62	56.54	26.69	136.42	32.52	39.53	68.87
9	84.5	2.34	1.91	45.35	23.57	141.15	32.85	40.57	55.51
10	178.3	10.78	4.9	61.22	81.13	139.34	26.45	31.63	83.86
11	80.9	4.89	2.5	77.53	16.66	141.18	25.18	41.32	90.93
12	14.1	0.94	2.01	69.14	6.72	120.41	28.36	61.24	76.98
Total	**1074**	**111.64**	**30.04**	**632.32**	**388.1**	**1594.36**	**337.18**	**486.45**	**806.77**

Future Hydrological Modeling

The projected change in climate indicated that the decline of rainfall and increase of temperature in the Lower Omo sub-Basin. Variations in the rainfall and temperature were associated to the variations in hydrological processes in the sub-basin. In the sub-basin, changes in rainfall and temperature in the future period was used to forecast the effects of climate change on hydrologic components.

Table 13: Mean annual hydrological processes in the future period for Lower Sub-basin

Sub-basin name	PET (mm)	ET (mm)	SW (mm)	PER (mm)	SUR_Q (mm)	LAT_Q (mm)	GW_Q (mm)	WYLD (mm)	Emission scenario
Lower Omo	500.10	395.61	121.33	306.41	139.77	27.96	614.59	795.74	RCP4.5
	491.64	356.09	127.62	398.23	146.25	40.02	626.27	840.33	RCP8.5

Water yield and groundwater are likely to decrease under RCP4.5 and RCP8.5 in the future period. Soil water content, potential and actual evapotranspiration are likely to increase under RCP4.5 and RCP8.5 in the future period. The highest likely increase in surface run off under RCP4.5 and RCP8.5 in the Lower Omo sub-basin may result in flooding.

Table 14: Changes of the annual hydrological processes under climate change

Sub-basin name	PET (%)	ET (%)	SW (%)	PER (%)	SUR_Q (%)	GW_Q (%)	WYLD (%)	Emission scenario
Lower Omo	2.87	17.32	-6.43	-21.04	25.19	-2.80	-1.38	RCP4.5
	1.13	5.61	1.58	2.61	31.01	-0.95	4.16	RCP8.5

5.1.3.3. Rainfall Distribution Analysis

Over the lower omo sub-basin, rainfall is expected to decrease and increase in the range of 311.4 to 1474.6 mm and 3.7 to 207 mm, respectively under the RCP4.5 scenario. Under this scenario, rainfall is expected to decrease from the month of March to December. Besides, under RCP85 scenario rainfall is expected to decrease and increase in the rage of 71.9 to 1247.8 mm and 2075.8 to 2459.7 mm, respectively in two months. Decreasing rainfall is more pronounced in the upper, middle and lower parts of the basin under two emission scenarios. To the lower part in the basin, under RCP4.5 projected decline in rainfall is featured in May June, July, August and September; under RCP85 projected decline in rainfall is featured in May, June, August and September.

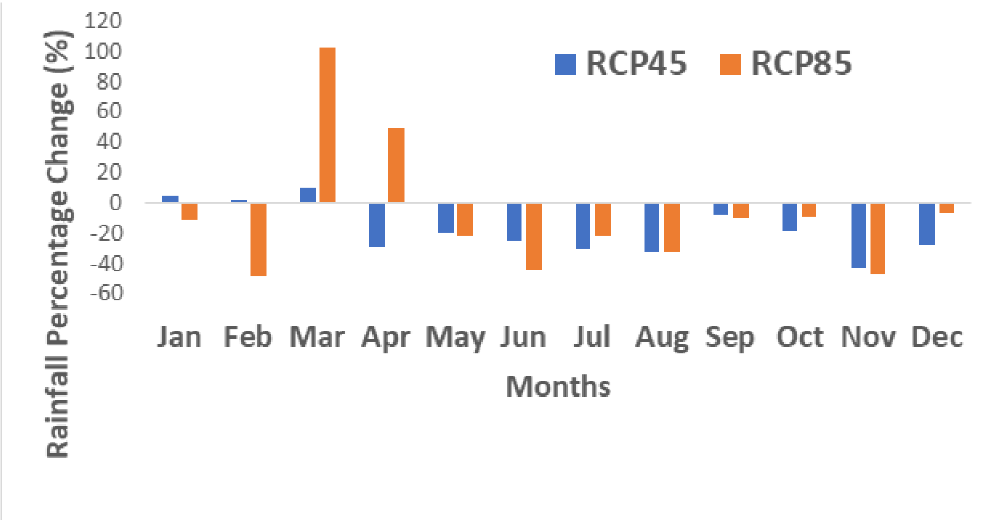


Figure 19: Percentage change of rainfall in Lower Omo Sub-Basin in 2021-2045 under RCP4.5

5.1.3.4. Temperature Distribution Analysis

Over the lower omo sub-basin, maximum temperature in the present century (2021-2045) increased in the range of 0.4 to 1.0 ºC and 0.3 to 1.3 ºC under RCP4.5 and RCP8.5 scenarios, respectively. Similarly, the minimum temperature is likely to increase in the range of 0.7 to 1.3 ºC and 0.5 to 1.5 ºC, respectively under RCP4.5 and RCP8.5 scenarios.

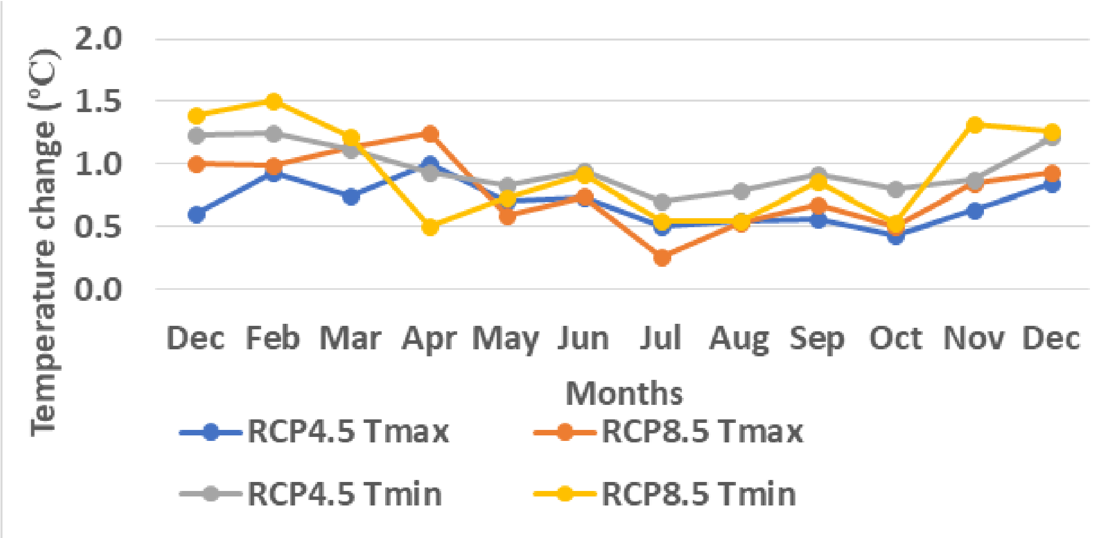


Figure 20: Change in mean monthly maximum and minimum temperatures in 2021-2045 under RCP4.5 and RCP8.5 scenarios in Lower Omo-Sub-Basin

5.1.4. Groundwater Resources Situation in the Basin

The groundwater studies conducted so far are related to local characterisics identification than regional and more wide characterization of the flow system. All the studies conducted in different parts of the country describe more of qualitative data. When it comes to regional hydrogeologic characterization that suite to groundwater resource valuation and the studies demonstarte a huge gap in the Omo Ghibe basin. The studies are : very specific in location that, one can't get knowledge/information about the regional even the local potential, the studies have never indicated the possible groundwater flow direction, the studies lack the regional aquifer characters when it comes to hydrogeologic parameters estimation (*MoWE, 2018)*. Therefore, the current basin plan study of omo Ghibe tries to plan the issues discussed as gap in the above.

Different studies exist on Ethiopian water resources; but little has been conducted on groundwater (MoWR, 1999; Romilly et al., 2011). The country is also endowed with substantial amount of groundwater resource which is not quantified accurately due to lack of sufficient hydrogeological data. Moreover, groundwater development is complicated by highly variable hydrogeological conditions rendering its management fraught with uncertainty (Nyagwambo, 2006). However, the nationwide preliminary water resources master plan study estimates groundwater of Ethiopia to be 2.6 billion cubic meters, and to date, only a small fraction of this resource is in use, mainly for local water supply purposes (MoWR, 2002; UNESCO, 2004). According to the Ministry of Water and Energy (MoWE) the annual recharge rate of the river basins in Ethiopia is about 28 billion cubic meters (MoWE, 2012) and some others estimate groundwater reserve to be about 36 billion cubic meters (MoWR, 1998a). Detailed groundwater investigations will estimate this rate to be even more as (Alemayehu, 2006). The aquifer type distribution, depth to water table, type of permeability, and potential uses of the aquifers is as shown below (Kebede, 2013).

The Omo Ghibe areas have some of the best aquifers as a result of degree of faulting and fracturing and the occurrence of relatively permeable, unconsolidated sediments. On the contrary, the highland volcanics of older age have relatively lower fracturing and higher amount of clay filling and therefore, are moderate to low productivity aquifers. Most of the groundwater in these rocks is under water table conditions while some are semi-confined. Productive aquifers occur in river valleys and flood plain of Omo ghibe basin. Fluvial and Lacustrine sediments produce productive aquifers in the unconsolidated sediments and weathered profile which is exploited using hand-dug wells.

Groundwater is an important resource contributing significantly in total annual supply. Assessing the potential zone of groundwater recharge is extremely important for the protection of water quality and the management of groundwater systems. Ground water has emerged as an important source to meet the water requirements of various sectors including the major consumers of water like irrigation, domestic and industries. The sustainable development of ground water resource requires precise quantitative assessment based on reasonably valid scientific principles. To understand the groundwater resource of the basin, understanding of the geologic and hydrogeologic factors is highly essential.

5.1.4.1. General Geology of the Omo-Gibe river basin

The geology of Omo Ghibe basin is mainly Pre-cambrian to south of latitude 6°15' N as to the report compiled in the *Omo River Project* at 1:250,000 and 1:500,000 scales (Davidson, 1983). The geology of the Tertiary volcanic areas north of latitude 6°15' N was compiled from published regional scale maps and reports, aerial photos, Landsat TM and Landsat MSS imagery and limited field surveys using vehicles and helicopters (Master plan of Omo Ghibe, 1998). Approximately 80% of the Omo-Gibe Basin is underlain by Tertiary volcanic rocks. These have been sub-divided into four groups, where possible: 1) Early Flood Basalts; 2) Lower Felsic Volcanics and Sediments - comprising basaltic, andesitic and more felsic lavas; 3) Upper Felsic

Volcanics - includes thick rhyolites, trachytes and felsic ignimbrites up to 2000 m thick and 4) Nazareth Group - comprises a series of rhyolite-trachyte plugs, flows, ignimbrites and other pyroclastics, as well as some lacustrine sediment containing coal and lignite deposits.

The Omo-Gibe Basin occupies the combined Omo and Usno rift valleys which are 'failed' northern extensions of the Lake Turkana-Ethiopian Rift System. In the northern part of the Basin, the rivers have exploited the extensive fault zones to cut deep gorges. The eroded material has been deposited in the lower part of the Basin as a thick (>3 km) sequence of Quaternary alluvial deposits. The structural features mainly faults, circular and sub-circular collapses form the areas of the Omo Ghibe basin

5.1.4.1.1. General Geology of Gibe-Gojeb and Omo-Sharma Sub-Basins

The geology of the Tertiary volcanic areas north of latitude 6°15' N was compiled from published regional scale maps and reports, aerial photos, Landsat TM and Landsat MSS imagery and limited field surveys using vehicles and helicopters (Davidson, 1983). The geology of upper and middle part of the Omo Ghibe basin covers approximately 80% of the Basin and is underlain by Tertiary volcanic rocks. These have been sub-divided into four groups as: Early Flood Basalts (PNv), Lower Felsic Volcanics and Sediments, Upper Felsic Volcanics (NQs), and Nazareth (NMm) Group. In the northern mid part of the Basin, the rivers have exploited the extensive fault zones to cut deep gorges. The eroded material has been deposited in the lower part of the Basin as a thick (>3 km) sequence of Quaternary alluvial deposits.

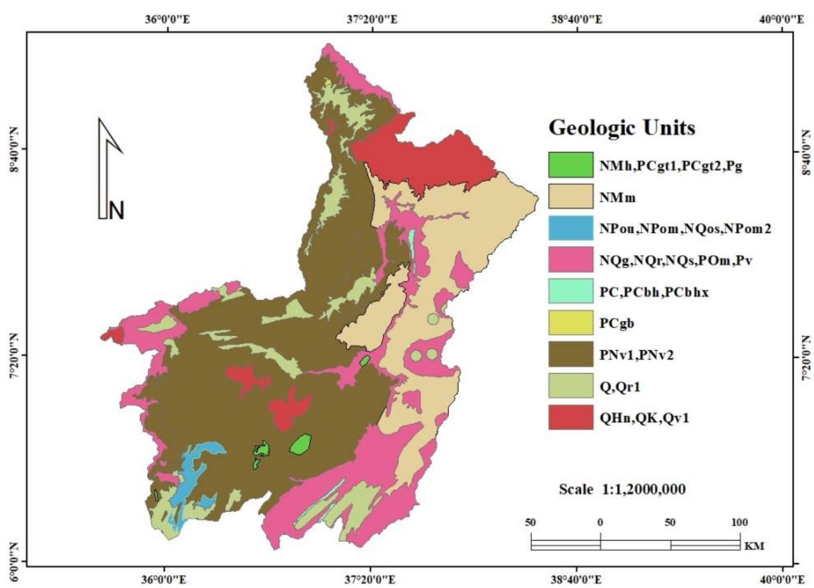


Figure 21: The geologic map of Ghibe Gojeb and Omo Sharma sub-basins

The Main Volcanic Sequences are Eocene to Oligocene consisting of basalt, rhyolite, trachyte, tuff and ignimbrite. The whole area of Jima to Kaficho was mapped simply as Jima volcanites flood basalts (Merla et al., 1979). Jima volcanites are Oligocene to Miocene in age and consists of rhyolites and trachy-basalts. This rocks exposed in southwest Dawuro, Ilubabur in one part, and in Gamo Gofa and southwest of Wolaita are classified as Jima volcanic (Lower part)(Davidson, 1983). These rocks are slightly and moderately fractured basaltic flow which is sporadically outcropped in low topographic study area.

Jima Volcanics (Upper Part) are very common and widely exposed rock unit of rhyolite, Tuff and ignimbrite with minor ash. The rhyolitic ignimbrite is pyroclastic flow containing rock fragments of pumice and trachyte gravels. The rock is often layered, but is mainly fractured and weathered. They are now exposed at higher elevations throughout the area.This unit are spans the Ecocene-Oligocene boundary and it is main volcanic sequence of basalt, rhyolite, trachyte, tuff and ignimbrite. Much of the recharge in the study area is concentrated in this unit. This happens as a result of weathering and fracturing processes.

5.1.4.1.2. General Geology of Lower Omo Sub-Basin

Lower Omo-Gibe Basin is underlain by Pre-cambrian metamorphic gneisses consisting of felsic meta-sediments and mafic meta-volcanics that represent an older 'cratonic' granite-gneiss terrain to the west and a younger 'oceanic' terrain to the east. The younger oceanic 'greenstones' have been overthrust (obducted) to the west onto the older craton. The main thrust zone, in the Surma region west of the lower Omo River, is marked by intense shearing and cataclasis (Davidson, 1983).

The Lower Omo area is situated in the southern portion of the Omo-gibe basin. This part is mainly covered with different fluvial, lacustrine sediments and basement rock sequences. Following the regression of the Mesozoic Sea to the south-east a major uplift occurred called as the Arebo-Ethiopian Swell resulting in upraised and up arched land mass fissuring of which under tension permitted the ascension of voluminous basaltic magma to form the Ethiopian flood basalt province (Mengesha et al., 1996). Concerning the local geology of the lower part of the basin, two major groups of rock units occurs based on age. These include: Unconsolidated Cenozoic-QuaternarySediment and Precambrian crystalline basement succession as described as follows.

Cenozoic-Quaternary Sediments in Lower Omo: mainly occur in the lower part of the Omo Ghibe basin. Cenozoic sediments are found in lower Omo valley. The Quaternary deposits including alluvial, and colluvial deposits occur along the river lines and expanded along flushy flood areas. The alluvial deposits are of two types: those spread out in alluvial plains and those strips along rivers and streams. Alluvial plains are filled up grabens and large stretches of flat land in the Omo valley and along the whole length of the Keske River. These are troughs in the lowlands where during the pluvial period streams deposited large amounts of sediments carried down from the highlands. The thin strips of alluvium along streams occur in most places both in the highlands and in the lowlands.

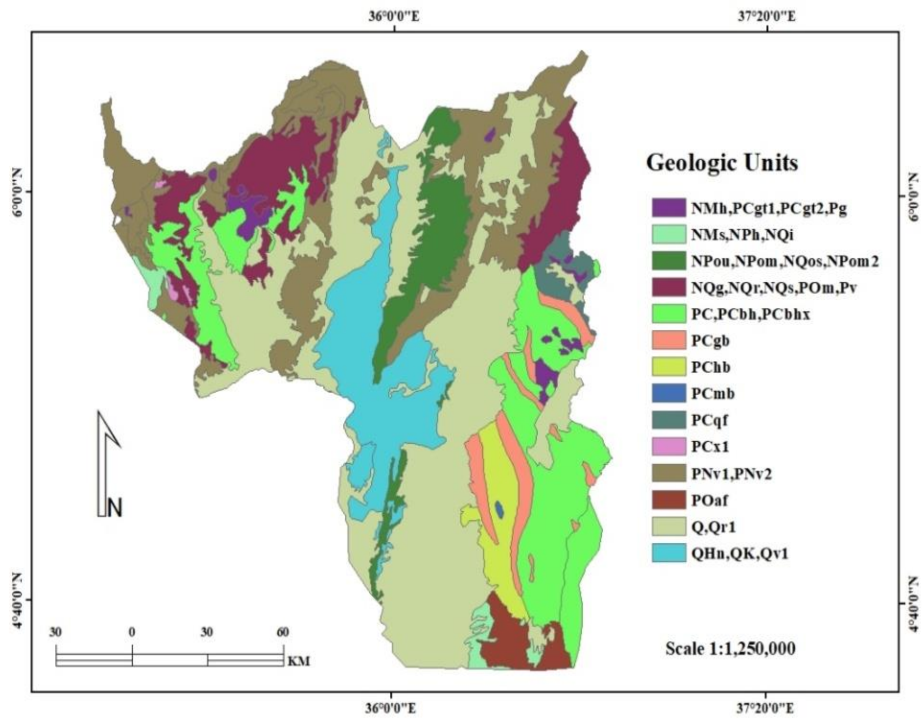


Figure 22: The geologic map of Lower Omo sub-basins

In the alluvial plains along Kaske River, the alternating layers of fine and coarse sediments are the major rock units and the lacustrine sediments could be found beneath. The alluvial plains have moderate to high permeability. Some alluvial plains, which are surrounded by coarse-grained metamorphic and plutonic rocks such as granitic gneisses and granites, consist of course materials and, therefore, have high permeability and productivity. These form local productive shallow aquifers in Demeka and many places in Hammer Area.

Precambrian basement Rocks in Lower Omo: The basement rocks in the southern and south western part are grouped under Mozambique Belt, which is a Neoproterozoic, polycyclic, collisional belt. It is characterized by folds and metamorphic fabrics that trends between NNE and NNW and consists of high grade, amphibolites to granulite facies rocks forming a gneissic migmatitic complex (Asfawossen Asrat and Barbey, 2003). The Hammer domain (Davidson et al, 1979) corresponds to eastern sector of the south western metamorphic terrain of Ethiopia contains two major rock groups as an older gneissic complex and several generations of plutonic suites. The plutons intrude across the contact between folded mafic granulites and mafic gneisses and amphibolites.

Geological Structural analysis in the lower Omo part of the basin suggests that N-S striking features are younger than NNE structures which in turn are younger than the NNW features. The fact that recent eruptive volcanic centres and a concentration of earthquake epicentres are associated with local basins bounded by N-S faults suggest that other NNE and NNW trends are older (Asfaw, 1990). Geological evidence indicates that, accompanying the volcano-tectonic processes, there were intermittent lake level rises with associated lacustrine sediment deposition in the region (Watkins, 1986)

5.1.4.2. Groundwater/Hydrogeology of the Omo Gibe River Basin

5.1.4.2.1. Aquifer Classification in the Basin

There are three types of aquifers in the basin which aided in classification of the Omo Gibe basin into two major sub-basins: the Gibe Gojeb and Omo Sharma, and Lower Omo sub-basins. The Gibe-Gojeb and Omo Sharma sub basins have almost similar geological and hydrogeological natures and characteristics and are categorized as one sub-basin; where as the Lower Omo sub-basin has unique difference due to its positions and tectonic natures. Based on the physical characteristics, the basic volcanic rock masses could be considered as having double permeability-storativity systems. Such a system could result from: the presence of permeable, granular sediments interbedded with the lavas, and Jointed blocks, forming a relatively small scale fracture network. These components act in conjunction with the main permeable fracture and fault systems to form the double permeability-storativity system.

Basement crystalline rocks and acidic volcanic rocks are considered as having a single permeability-storativity system. The ground water flow in these rocks is controlled by the network of open fissures, with the mass permeability depending on factors such as the number, length, width, depth and the degree of inter-communication between the fractures. Based on the above concepts, the various geological units in the Omo-Gibe Basin are broadly classified into three aquifer systems, namely: single permeability-storativity, double permeability-storativity and intergranular permeability-storativity systems. Each system in turn could be sub-divided further depending on recorded yield, areal extent, topographical features and availability of recharge, thicknesses of lava flows, fracture characteristics, thicknesses of clay mantle, etc. In the analysis, all these factors are taken into consideration while classifying the permeability and productivity of the rock units. For the sub-basin classification of the aquifer types, the Double Permeability-storativity Aquifer Systems occupy the Gibe Gojeb and Omo Sharma sub-basins where as the Intergranular Aquifer System and Single Permeability-storativity Fissured Hard Rock Aquifers occur in the Lower Omo sub-basin.

5.1.4.2.2. Aquifers in the Gibe Gojeb and Omo Sharma sub-basins

Double Permeability-storativity Aquifer System

The geographical distribution of this double permeability-storativity aquifer occurs dominantly in the central and northern part of the Omo-Gibe Basin. Basic volcanic rocks and ignimbrites could be divided into aquifer sub-classes ranging from very low to very high permeability and productivity potentials of this system. Almost all the formations in the Ghibe Gojeb and the Omo Sharma sub-basins are double permeability –storativity aquifer systems except some formations to the lower part of the sub-basin as shown in the hydrogeological map below.

i) *Highly permeable Makonnen Basalt* ***(Pom)***, is a double permeabltiy storativity aquifer which is up to 700 m thick, crops out in a high recharge area of the Ghibe Gojeb and Omo Sharma Sub-basins, but its upper 40-50 m may be weathered to clayey sediment. The unweathered, jointed basalt has measured transmissivities of 0.67 - 54 m^2/day and yields of 0.5 to 5.0 litres/second of good quality water have been achieved. Under favourable conditions of recharge and aquifer penetration, the optimum recommended depth of drilling is 40-150 mbgl.

ii) *Highly permeable volcanic sand of the Nazareth Group* ***(NMn)-*** intercalated with trachyte, rhyolite, ignimbrite, tuff and minor basalt flows having double permeablity. These volcanic sands are the principal aquifers with yields up to 4 l/s, transmissivity is high (18-50 m^2/day), but water tables are generally deep (60m). Recommended depth of drilling is 100-180 mbgl.

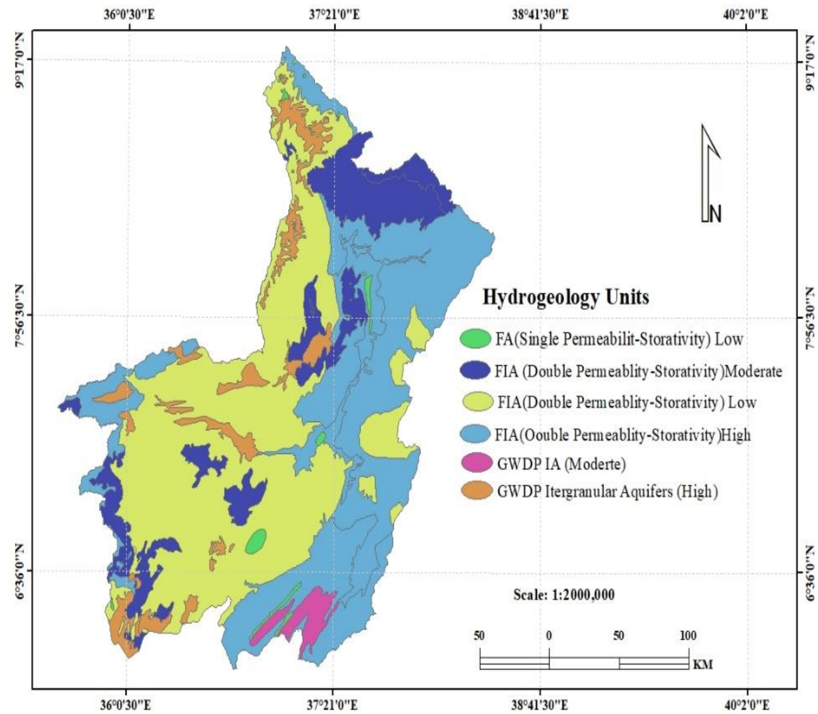


Figure 23: Generalized hydrogeological map of Gibe Gojeb and Omo Sharma Sub-Basins

iii) *Highly permeable,'undifferentiated Flood Basalts* ***(Pv)***, mainly composed of degraded basalts with minor rhyolite, trachyte, tuff and ignimbrite. These have transmissivities of up to 25m^2/day and potentially large storage properties. Deep boreholes into the basalts and ignimbrite could yield up to 4 litres/second.

iv) *Highly permeable Mursi Basalt* ***(NPom2)*** which is up to 100 m thick and areally extensive on the Omo plain. It has thin columnar joints and thin layers of lava flows, which may allow recharge of the underlying Mursisediments.

v) *Moderately permeable Lower Felsic Volcanics and Sedimentary Formation* ***(PNv1)***, dominantly trachytes, welded tuffs (ignimbrite) with basalts at the bottom. The ignimbrite is the primary aquifer yielding 0.1-0.2 l/s from springs and dug wells, and 0.3-3 l/s from boreholes, but transmissivity is poor (3 m^2/day) which may result in large drawdowns. Recommended depth of drilling is 50 -100 mbgl.

vi) *Moderately permeable sandy pyroclastic sediments* of the *Pleistocene-Holocene Volcanic group* ***(Qv1)***, which are interbedded with massive trachy-rhyolite horizons, and are the primary aquifers. Boreholes located in sunken areas have their water levels >100 mbgl. The boreholes may yield up to 3 l/s but drawdown could exceed 70 m due to low transmissivities (1.3 m^2/day). Recommended depth of drilling is in the range of 150-200 mbgl.

vii) *Poorly permeable Upper Felsic Volcanics* ***(PNv2)*** which form high relief, rugged topography. Although they are fractured and faulted, the very few springs that exist discharge at only 0.05 to 0.3 litres/second.

5.1.4.2.3. Aquifers in the Lower Omo Sub-Basin

1. Intergranular Aquifer System

The geographical distribution of intergranular aquifer systems occur dominantly in the southern part of the Omo-Gibe Basin and scantly along the river channels in northern part volcanic sand unit (Q4) occuring in the potentially important part of the Basin.The Quaternary superficial deposits and the sediments of the Omo Group represent Intergranular aquifer system. The permeability of these sediments is generally high to moderate, but the depth to the saturated aquifer, productivity and quality of water could vary from one unit to the other.

The characteristics of the intergranular aquifer systems in are summarized as:

i) *Very highly permeable alluvial and colluvial aquifers of the Danan Plain* **(Q3)**, comprising sands and gravels. Generally, the ground water table does not exceed about 50 mbgl, and boreholes yield at least 4 litres/second of excellent quality ground water with drawdowns of only 4 m. The recommended depth of drilling is 50-100 mbgl.

ii) *Highly Permeable fan deposits* **(Q1)** composed of sand and gravely beds at least 40 m thick, having calculated transmissivities of the order of 60 m^2/day. Good quality water has been abstracted from depths of 25-40 mbgl.

iii) *Highly Permeable, thick (50 m), sandy aquifer of the Gojeb and Gilgel Gibe depressions* **(Q4)** yields 1.0-3.0 litres/second, with transmissivity varying between 0.6-2.2 m^2/day. Drilling to a depth of about 50 mbgl is recommended to achieve full aquifer penetration.

iv) *Highly Permeable aeolian sands and coarse fluviatile sediments within the 90 m thick Nkalabong Formation* **(NPon)**. These aquiferous sediments are confined by an aquiclude formed fromtuffaceous sediments, which give rise to artesian wells. Optimum recommended depth of drilling is 50-90 mbgl.

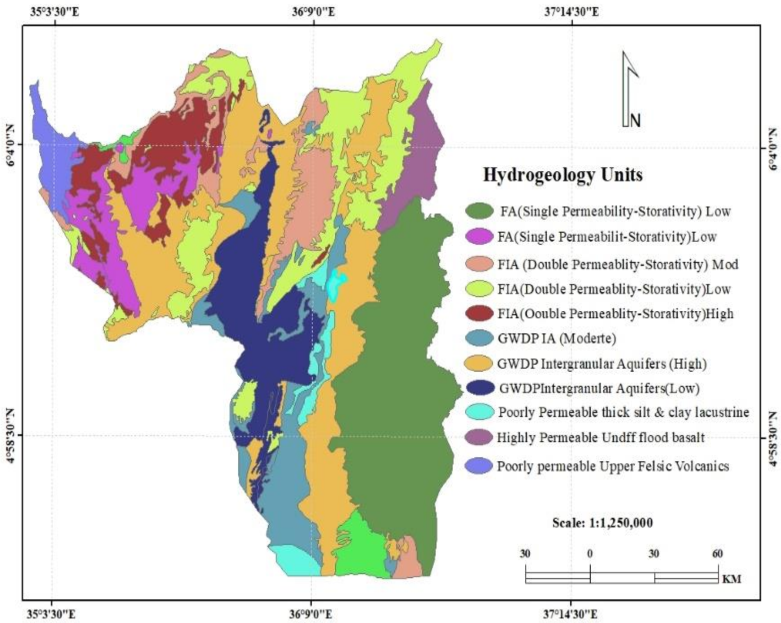


Figure 24: Generalized hydrogeological map Lower Omo sub-basin

v) *Highly permeable sands and gravels interbedded*, in a 760 m thick sequence, with clay silts, tuffs, marls and fresh water limestone beds of the **Shungura Formation (NQos)**. Depth to saturated aquifer could be more than 200 meters.

vi) *Highly permeable*, 150 m thick sediments of the *Mursi Sediments* (**NPom1)** composed of clay, silts and sands with intercalations of tuff. These underlie the 100 m thick Mursi Basalts, although recharge of the sediments may be facilitated through fissures in the basalt. Drilling through the basalt into the saturated aquifer is required to the depths of 100-200 mbgl.

vii) *Moderately permeable, fluviatilesilty sand aquifer* **(Q2)**. Clayey silts (35 m thick) and marl beds confine ground water in the silty sand aquifer at depths of 40 to 70 m. Although conditions could be artesian.

viii) *Moderately permeable*, 200 m thick fluvial and lacustrine sediments of *Usno Formation* **(NPou)** composed of white sand with intercalations of tuff horizons. Development of both shallow (0-50m) and deep ground water (up to 200m) might be possible.

ix) *Moderately permeable sediments of the Kibbish Formation* **(Qk)** isabout 120 m thick. The sediments are alternating clays, silts and sand, becoming more permeable in its upper units. The recommended depth of drilling is 30 to 70 mbgl.

x) ***Poorly permeable***, thinly stratified, thick silt and clay *lacustrine origins* **(Q5)**. These contain ground water at shallow levels, but the sediments are poorly permeable and the ground water is of poor quality.

2. Single Permeability-storativity Fissured Hard Rock Aquifers

The distribution of fissured hard rock aquifers are dominantly distributed in the south of the basin and aquifers formed by their weathered products. All Precambrian basement rocks are considered to be poorly permeable. However, fractures in granite, diorite, pegmatite and gneiss of the high plateau and their weathered products yield large quantities of very good quality water. Schists and phyllites may yield limited groundwater (<0.5 l/s).

5.1.4.3. Groundwater Depth, Head and Flow

A water table contour map of an aquifer is a very vital tool in groundwater studies as one can derive from it the gradient and the direction of the groundwater flow. It is a graphic representation of the hydraulic gradient of the potentiometric surface. Hence the direction of the groundwater flow, being perpendicular to the equipotential lines, can be directly deduced from the maps. Furthermore, an effluent (gaining) or influent (losing) from a source (upper lands or River) and artesian effect can be determined using these maps (Freeze and cherry, 1979). The groundwater head of the basin is constructed for different flow systems. Groundwater hydrology of the Omo Ghibe basin was studied through analysis of data of existing boreholes (more than 430 deep wells). Boreholes drilled in different parts of the basin have depth range 3 to 458meters. The variation in the depth in the basin could be due to the variation in the topography, nature of aquifers, availability of surface water infiltration and etc.

Wells in the basin could be shallow to deep (>458meters) drilled in various hydrogeological formation types. The groundwater wells distribution, depth map, static water level map, the dynamic water level map and the yield (Q in l/s) map of the Omo Gibe basin and the sub-basins is indicated in sections below. The distribution of the wells is representative in the Ghibe Gojeb and Omo Sharma sub-basins where as it in the Lower Omo sub-basin the wells are few. The borehole data of Omo-Gibe river basin is presented in appendix 8.

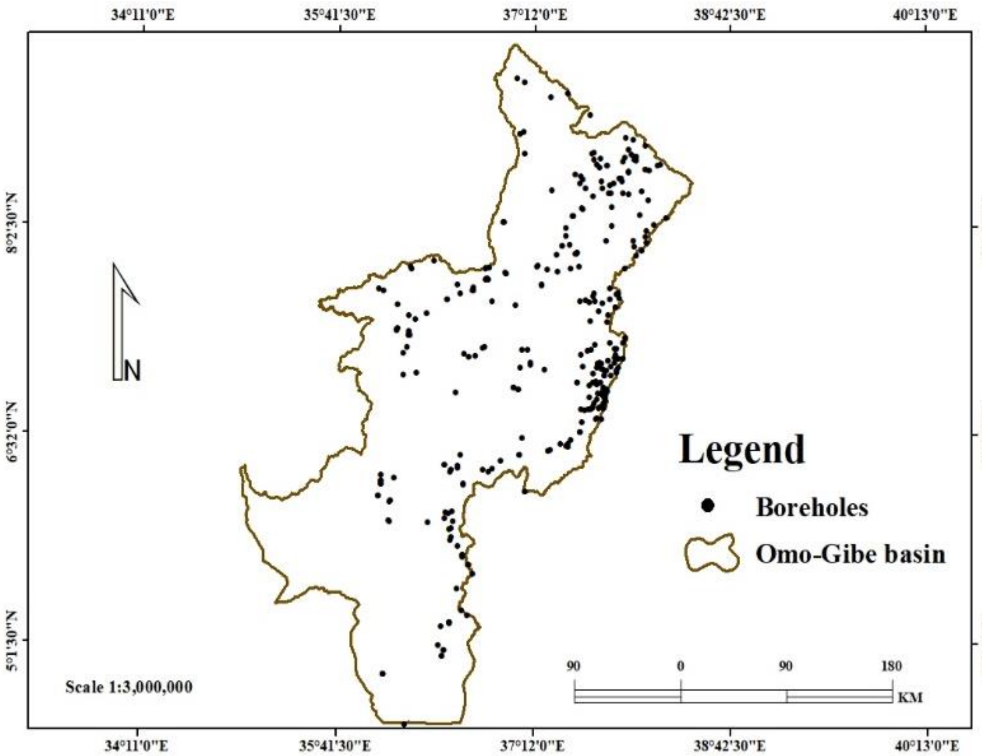


Figure 25: The water wells distribution map of the basin

5.1.4.3.1.Groundwater Level and Well Discharge of Gibe Gojeb and Omo Sharma Sub-Basins

The groundwater level maps of the Ghibe Gojeb and Omo Sharma sub-basins showed great variability is the upper sub-basins. As to the figure indicated above in the wells map, it is already indicated that there is good distribution to map the groundwater level in the sub-basin. More wells mapped/plotted in the northern (Woliso, Jimma and Bonga) areas have higher groundwater level where as water wells plotted as in the eastern and northern centeral parts of the sub-basin showed less. The groundwater depth in the sub-basin is with in the range of 1400 to 3400mbgl towards the areas of deeper groundwater areas where as it ranges 300 to 1390mbgl to the shallower areas.

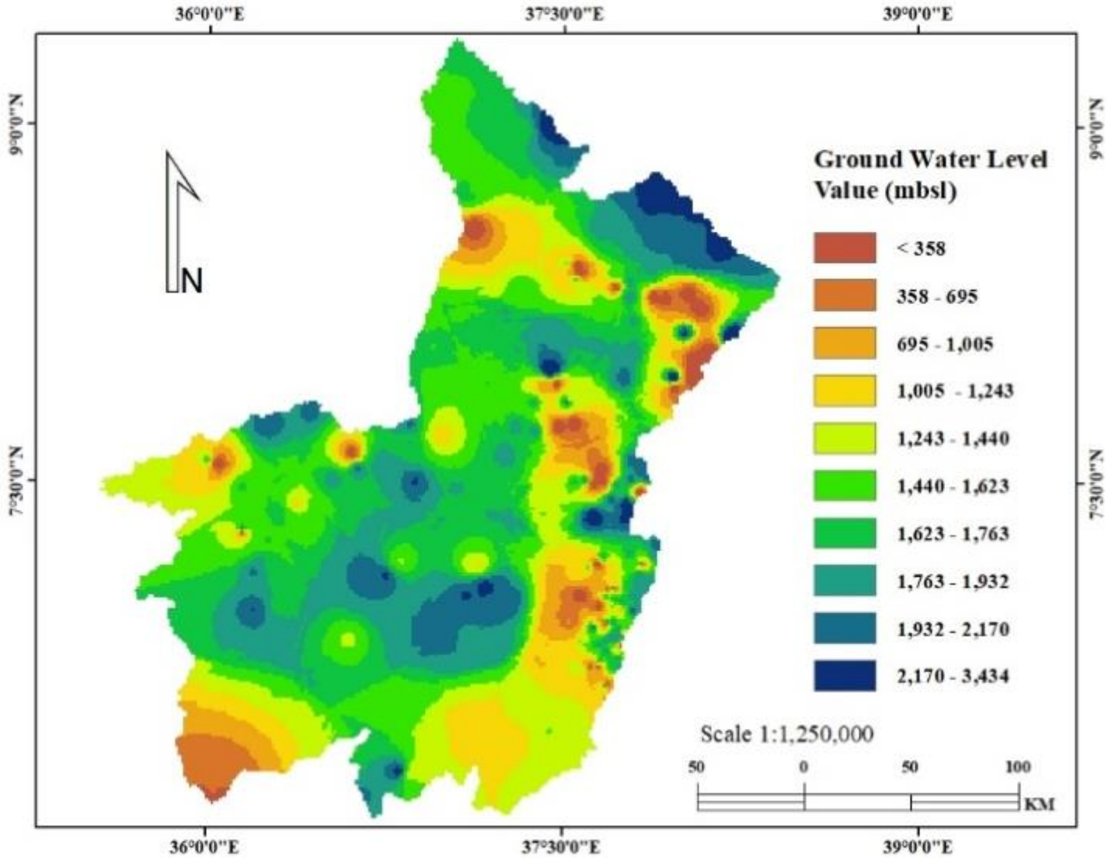


Figure 26: The groundwater levels in the Gibe Gojeb and Omo Sharma Sub- Basin

The well discharge map in the area showed that water wells discharging relatively higher (up to 26lit/sec) are observed towads Wolaita Sodo, North west of Jima and Bonga areas. The groundwater discharge map in the area showed that water wells relatively higher discharging wells (up to 13lit/sec) are observed towads Hossana and in places which are the recharging towards eastern central parts of the basin. Towards the central parts of the sub- basin, the groundwater discharge increased up to more than 8.9lit/sec in selected areas in the basin. In the northern parts of the basin, the groundwater data availability is rich but the yield is lesser and is related to the partial penetration of the aquifer systems.

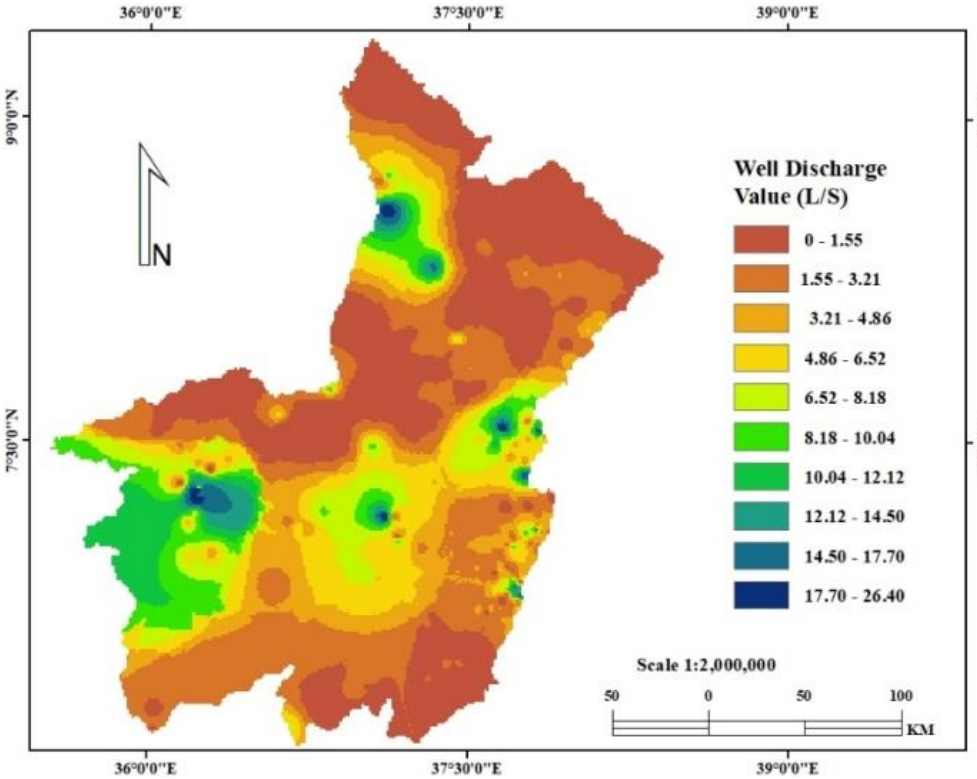


Figure 27: The well Discharge in Gibe Gojeb and Omo Sharma Sub-Basins

5.1.4.3.2.Groundwater Level and Well Discharge of Lower Omo Sub-Basin

The groundwater level maps of the Lower Omo sub-basins showed variability in the range of 370 to 2000mbgl. As to the map shown in the figure below, the groundwater is deeper to the east of the Lower Omo compared to the western part of Lower Omo. Though the distribution of wells is few towards western part of lower Omo, it is representative that there is the groundwater flow to the western part of Lower Omo sub-basin. Several wells are mapped / plotted in the eastern part towards Jinka town have higher relative groundwater depth compared to the western part of South Omo area.

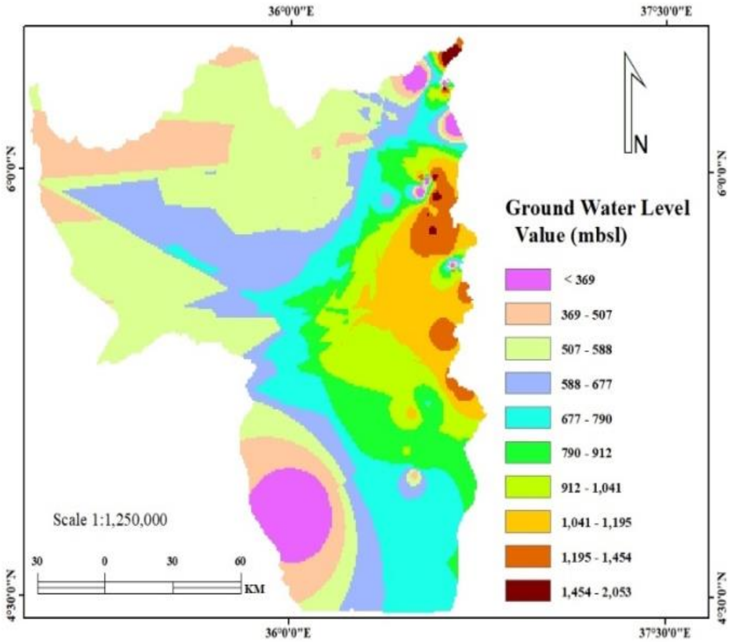


Figure 28: The groundwater levels in Lower Omo Sub-Basin

The well discharge map in the area showed that water wells discharging relatively higher (up to 8lit/sec) towards Jinka town areas where as it is less than 2lit/sec to the southern part of the Lower Omo areas. The less yield in the southern part of the Omo Ghibe basin have yields less than 3lit/sec could be related to the Precambrian formations which remain resistant to weathering and fracturing and low porous sediments accumulated in the lower Omo.

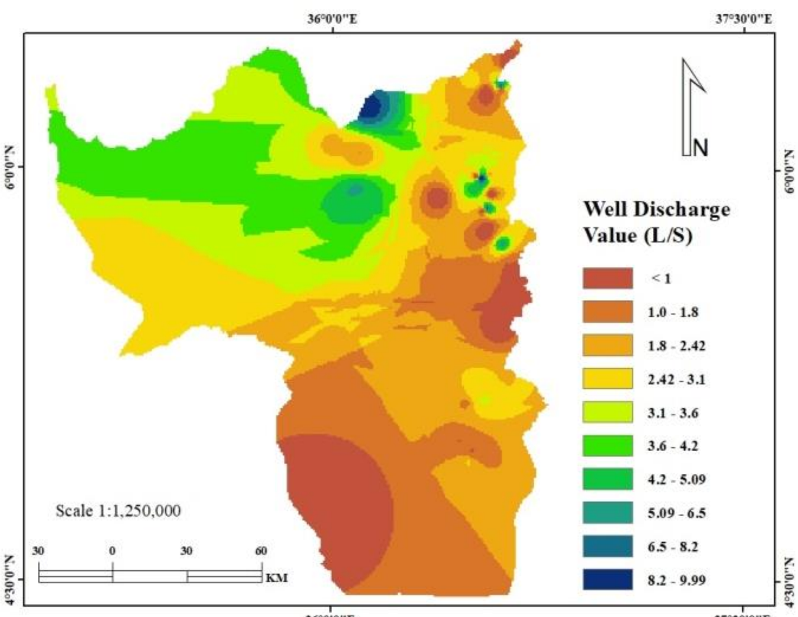


Figure 29: The Well Discharges in the Lower Omo Sub- Basin

5.1.4.4. Groundwater Recharge

Groundwater occurrence in Tertiary and Quaternary Volcanic rocks is due to the differences in mineralogy, texture and structure of volcanic rocks. Water bearing potential also varies. Groundwater circulation and storage in the volcanic rocks depend on the type of porosity and permeability formed during and after the rock formation. All rock structures possessing a primary porosity may not have necessarily permeability; i.e. without the original interconnection, the primary porosity may not give rise to the primary permeability, but the letter connection, by means of weathering or fracturing may results a secondary permeability.

The (OGRBMP, 1999) has determined the groundwater recharge for each sub-basins of the basin. Determination of recharge rates to the aquifers is one of the most important aspects of ground water resource evaluation. Several other methods are available to estimate recharge, and although the results produced are liable to show very high variations, indirect approaches such as water balance methods, baseflow separation method, recharge area estimation method and well level fluctuation could be employed to obtain acceptable recharge rates. The annual recharge rates are estimated based on measured or simulated hydro-meteorological data for all sub-catchments in the Basin. The approach adopted is as follows. An initial value for infiltration is obtained by subtracting surface run-off from precipitation. By removing the evapotranspiration losses from this initial infiltration, an estimate of the recharge rate is obtained. This relationship is defined by a simple empirical formula, i.e.:

$\mathbf{R_f = E_a + R_o + S}$ where R_f = rainfall; R_o = runoff; E_a = actual evapotranspiration and S = change in storage, i.e. recharge.

The water balance technique, indicates that there is of the order of $10x10^9$ m^3 (10,084 MCM) of recharge to ground water systems throughout the Omo-Gibe Basin. However, the estimated recharge is not evenly distributed, with 20 sub-catchments having an annual water balance in deficit, while some 18 sub-catchments have a surplus, making water available for recharge. Appendix 9 presents the groundwater recharge estimation of the Omo Gibe river basin.

5.1.4.5. Groundwater Use

The quantities of water used in any activity are jointly determined by the supply of water available to support that activity and the demand for water in that activity. Both the supply and the demand of the water are determined by variables that tend to be location specific.

Nevertheless, a number of overarching factors influence levels of water use independent of location. These factors will undoubtedly be critical in determining future levels of water uses in the in the Omo Ghibe basin. Currently, lack of reliable data and information on the groundwater resources management and development recognized as critical gaps on determination of the current and future consumed water in the basin.

5.1.5. Hydropower Potential Assessment

Access to energy is among the key elements for the economic and social developments of Ethiopia. As more than 80% of the country's population is engaged in the small-scale agricultural sector and live in rural areas, traditional energy sources represent the principal sources of Energy in Ethiopia. Domestic energy requirements in rural and urban areas are mostly met from wood, animal dung and agricultural residues. At the national level, it is estimated that biomass fuels meet 88% of total energy consumed in the country (MoWE, 2012). As stated by World Energy Council (2007), Ethiopia stands second in hydropower potential next to the Congo Republic and according to recent studies hydropower potential of the country is estimated to be 160,000 GWh/year. However, the per capita electricity consumption will still remain among the lowest in the world. The Omo Gibe River Basin has long been recognised as an area of great potential for the development of a hydropower resource (OGRB Master Plan Study, 1995). The Gibe cascade project is one of the most attractive potential hydroelectric developments in the country and it has been selected by EEPCO as one of its key hydroelectric development areas. Currently, the surface water resources of the Omo Gibe River has three functional hydropower development plants such as Gibe I (184 MW), Gibe II (420 MW), and Gibe III (1870 MW) as well as the on going Gibe IV (2160 MW) and Gibe V (560 MW) dams.

A survey by the Central Statistics Agency (CSA) in 2004 showed that about 71.1% of the total households use kerosene for lighting followed by firewood (15.7%) and electricity (12.9%). The study by CSA at the country level, suggests that about 81.4 % of the households use firewood, around 11.5 % cook with leaves and dung cakes and only 2.4 % use kerosene for cooking. The majority of rural households use firewood (84.4 %) and few of them (12.7 %) use leaves and dung cakes. The use of modern source of cooking fuel such as butane gas, electricity and kerosene for cooking is uncommon in the rural areas (0.4 %). Use of kerosene is common in urban areas and stands at 13.8 % following firewood (65.4 %). Charcoal (7.7 %), electricity (2.4 %) and leaves (5.3 %) are also used by urban households. On the other hand, only 0.2 % of the households in rural areas are observed to use charcoal for cooking (MoWE, 2012). Like the other rural areas of the country, majority of the population in the Omo Gibe River basin rely on traditional energy sources to meet their energy demand. In most parts of the basin, the supply of electricity is in its infant stage. However, in spite of all its available potentials, the energy sector is still in its infancy stage and the majority of the basin's population has no access to modern energy.

5.1.5.1. Hydropower Potential of Gibe-Gojeb Sub-Basin

The existing hydropower plants in Gibe-Gojeb sub-basin are Gilgel-Gibe Cascaded Hydropower (Gibe I and Gibe II) plants. The Gilgel Ghibe I dam is located at 7°49'53''N 37°19'18''E and Gilgel Ghibe II diversion tunnel is located at 7°45'25''N 37°33'44''E. These two power plants have the capacity of generating 184 MW and 420 MW respectively. The Gilgel Gibe system is a purely hydroelectric scheme including two power plants located on the Gilgel Gibe and Omo rivers, about 250 km South-West of Addis Ababa and 80 km North East of Jimma. The Gilgel Gibe is a tributary of the Great Gibe River, known as the Omo River downstream of the bridge of the Highway from Addis Ababa to Jima. The first two stages of the Gibe cascade development include two power plants, namely the Gibe I and Gibe II. The first plant, Gibe I, is a conventional hydroelectric power plant with a capacity of 220 MW.

The downstream power plant, Gibe II conveys the flow, regulated by the Gibe I dam, through a 26 km long hydraulic tunnel to the great gibe river about 150 km downstream of Gibe I dam. The plant produces about 420 MW. The planned hydropower plants in Gibe-Gojeb sub-basin are Hallele –Warabesa Stage I and Hallele –Warabesa Stage II. The Halele-Werabesa Stage I Hydropower Project comprises a large earth core, rock fill dam and an underground power scheme at Halele. The power scheme comprises a short 360 m headrace arrangement of inclined shaft and tunnel, an underground powerhouse accommodating 2x 48 MW Francis turbine generator units, a tailrace surge chamber and a 5 km tailrace tunnel. The scheme exploits a total head of 103 m to generate 460 GWh of firm energy per year. This energy will be fed into the 230kV national grid by a 30 km transmission line tying in to the existing Gilgel Gibe to Gedo line. The Halele-Werabesa Stage I Hydropower Project is feasible from the technical, economic and environmental viewpoints.

There are no legal obstacles to its development. Such a worthwhile scheme, which will bring net benefits to the nation in general and the local communities in particular, should be implemented at the earliest possible date. The Hallele –Warabesa Stage II project area is located some 200km (air distance) east-south-east of Addis Ababa. The scheme, including the reservoir and power waterways, extended over a corridor some 25km long. The approximate centroid of the project area lies at latitude $8^0$24'north and longitude $37^0$23'east. The Halele-Warabesa Stage II hydropower project comprises a medium sized composite dam (Roller-Compacted concrete central block, rock/clay, rock fill embankment flanks) and an underground power scheme. The power scheme comprise along 4,260m headrace tunnel, a 77m high surge shaft, a steeply inclined 295m long pressure shaft, a 230m long high pressure headrace tunnel ,an underground power house accommodating 4x81.5MW Francis turbine generator unites , a tailrace surge chamber and a 4090m long tailrace tunnel. The scheme exploits a total gross head of some 313m to generate 1570GWh of firm energy per year. As its name implies, Halele-Werabesa Stage II scheme will be the second development in cascade.

5.1.5.2. Hydropower Potential of Omo-Sharma Sub-Basin

The existing hydropower plant in Omo-Sharma sub-basin is Gibe III Hydropower Project. The approximate geographic coordinates of the location of the dam axis is between 312,044E and 757,343N and 312,542E and 757,107N (6°50'50''N 37°18'5''E). The downstream area extends from the dam site down to Lake Turkana. The Gibe III hydropower plant is the third plant of the Gibe cascade developing the hydroelectric potential of the Gibe-Omo River including Gibe IV and Gibe V projects, for hydropower and agricultural uses, currently being planned. Gibe III Hydroelectric Project comprises a 230m high dam and will create a huge reservoir with a surface area of some 200km² and a total storage of some 11,750 million m³, the second largest in Africa (EEPCO, 2009). The Gibe III Hydropower Project is planned to generate 1870 MW of electricity.

The planned hydropower plant in Omo-Sharma sub-basin is Gojeb OM19 hydropower project. The proposed OM19 hydropower dam project is located in the Omo-Gibe river system, which drains an area of 79,000 km² in south-west Ethiopia before discharging into Lake Turkana in Kenya. The dam site is situated in the middle reaches of the Gojeb river, a principal tributary of the river Omo, and has a catchment area of 5,390 km².The project involves the construction of a rock fill dam across the Gojeb river and a downstream power house. Appendix 10 the priority sites for hydropower development in Omo Gibe River Basin (Daniel A., 2015).

5.1.5.3. Hydropower Potential of Lower Omo Sub-Basin

Almost all of the hydropower plants in omo gibe basin are located in Gibe-Gojeb and Omo-Sharma sub-basins. In the Lower Omo sub-basin, the land is plain and not suitable for the construction of hydropower dam. In this sub-basin, there is a proposed hydropower plant on Omo River.

5.1.6. Irrigation Potential Assessment

Based on the present indicative information sources, the potential irrigable land in Ethiopia is about 3.7million hectares (World Bank, 2006; Awulachew *et al*. 2007). Omo Ghibe River Basin has been a candidate for a number of irrigation development projects. There are many small scale, medium scale and large scale irrigation development projects (both constructed and under construction) in the basin (SNNPR WRIDB, 2019).

5.1.6.1. Irrigation Potentials in Gibe-Gojeb Sub-Basin

There are several irrigation projects in the Gibe-Gojeb sub-basin. Some of the large scale irrigation projects in the sub-basin are Bako irrigation project (1,350 ha), and Walga irrigation project (5,300 ha). There are also many small and medium scale irrigation projects in the sub-basin. Besides, there are planned irrigation schemes in this sub-basin to be applicable in the future. During the survey, it was impossible to know the command area of most of the planned irrigation projects in the sub-basin. The existing and planned irrigation projects in the sub-basin are presented in appendix 11.

5.1.6.2. Irrigation Potentials in Omo-Sharma Sub-Basin

Omo-Sharma sub-basin has also a potential irrigation development. However, due to undulating topography of the sub-basin, irrigation practices are largely practiced. Unlike the Lower Omo sub basin, this sub basin is highly suitable for hydropower development. In this sub-basin, a number developed and ongoing irrigations projects are there. The existing and planned irrigation projects in the sub-basin are presented in appendix 12.

5.1.6.3. Irrigation Potentials in Lower Omo Sub-Basin

5.1.6.3.1. History of Irrigation Development in Lower Omo Sub Basin

The Omo-Rate farm was originally called The Tringole state farm and was established by the Ethio-Korea Agricultural development venture project. The project was designed for cotton production and the seed cotton was designed for the Arbaminch Ginnery. The project was originally designed for 10,000 ha to be irrigated by four pump station of which only two were constructed. A pilot farm of 75 ha was also established. Pump station no.1 was completed in October 1989 and has a nominal command area of 800ha. The area has now been formed since 1992/1993 and the farm has now been transferred to the North-Omo Agricultural Development Enterprise based in Arbaminch. This Enterprise includes a cotton ginnery, Bilate farm, Abaya farm and Sile farm, all of which are located in the vicinity of Arbaminch. The enterprise is a self-supporting and independent of the regional government and the ministry of state farm (Richard Wood roof and Associates, 1996).

In the Lower Omo Sub basin, there are a highly potential sites suitable for irrigation development. Generally, the present level of irrigation development in the sub basin is really quite low. The damage caused by annual flooding, low river levels in the dry season (too low for pumping), and limited market development are probably some of the reasons, but another may simply be the traditional, nomadic, pastoralist way of life of the people.

According to Meshesha and Abdi (2019), agricultural water demand for irrigation is dominant in lower parts of Omo Gibe River Basin, unlike in the upper and middle parts. Most of the large scale irrigation projects are found in the Lower Omo sub-basin at low land area. Currently, in Lower Omo sub- basin, about 313,843.3ha of land is under large scale irrigation development by the government of Ethiopia and private company.

Table 15: Large scale irrigation development projects in Lower Omo Sub-Basin

S/N	Name	Area (ha)	Production	Remark
1	Kuraz Block 1	82,603.3	Sugar	Upstream of ONP
2	Kuraz Block 2	81,254.6	Sugar	Below ONP
3	Kuraz Block 3	81,329.4	Sugar	Nyangatom Woreda
4	Daniel Fasil Bihon	5,000	Cotton and grains	
5	Lucci	4,003	Cotton	Dasenech, Rate
6	Mela	5,000	Cotton	Dasenech, Borkonech
7	White Field Cotton Farm	10,000	Cotton	Dasenech
8	Reta	2,137	Cotton and grains	
9	Rahewa	3,000	Cotton and grains	Dasenech, Borkonech
10	Tsegaye Demoze Ag. Dev.	1,000	Cotton, sesame and soya bean	Dasenech
11	Tamil H-adgu	5,000	Cotton and grains	
12	Adama	18,516	Cotton	
13	Friel Ethiopia Farm PLC	15,000	Banana	Dasenech, Rate
	Total	**313,843.3**		

5.1.7. Irrigation from Groundwater

In the Omo Gibe River Basin, very little groundwater is currently used for irrigation. However, groundwater is ideally suited to small-scale irrigation development. Medium-scale schemes are also possible when they are treated as a collection of single wells each serving a discrete area (OGRB Master Plan Study, 1995).

5.1.8. Water Demand Assessment of Omo Gibe River Basin

Water demand is the quantity of water that the water source must produce in order to meet all water needs in the community. Water demand includes water delivered to the system to meet the needs of consumers, water supply for firefighting and system flushing, and some leakage. Water demand estimation is one of the basic inputs to select source of water supply and to find the amount of water required to fill the gap between supply and demand. Water demand forecasting is the process of making predictions about future water use. Water utilities develop forecasts for a range of different time scales, ranging from hours to decades, depending on the intended application (Matthew et al, 2016).

5.1.8.1. Previous Studies on Water Demand Analysis of the Basin

Several studies were conducted on the water demand analysis of Omo Gibe River Basin. Accordingly, T.P. Orkodjo et al. (2022) used the WEAP hydrological model to project the water demands in Omo Gibe river basin and estimated the water demands under different scenarios.

Table 16: Scenarios used to estimate water demands in Omo-Gibe river basin (T.P. Orkodjo et al., 2022)

S/N	Scenarios	Definitions/Description of Scenarios
1	Reference/Baseline Scenario	• Refers to the current (2017) account of the business-as-usual scenario • Continuous streamflow of 60m^3/s continues to be released downstream
2	Irrigation area expansion	• Current irrigated area of 208,655 ha is expected to reach 417,310ha, an increase of 100% in irrigable land
3	Population Growth Increase	• The current (2017) population of the river basin is 14,580,516 with a population growth rate of 2.4%.
4	Hydropower energy production Increase	• If the current two reservoir numbers are increased by 50% and hydroelectric generation is prioritized for reaching peak capacity by 2100.
5	Livestock population growth increase	• A 2.6–4% growth rate for the cattle population was chosen
6	Industrial and commercial sectors increase	• A 50% increase in the industrial and commercial sectors was assumed
7	Institutions and Businesses and recreational activities increase	• 50% increase in institutional, commercial, and recreational scenarios

The combined climate and water use scenarios for each water use sector were projected in the RCP 4.5 and RCP 8.5 emission scenarios, along with changes in water demand. Accordingly, water demand in the basin will rise in the future (2017–2100).

Table 17. The reference scenario projected water demand (million cubic meters, Mm3) for each sector under RCP 4.5 and RCP 8.5 from 2017 to 2100 (T.P. Orkodjo et al., 2022).

Year	Climate scenario	Irrigation	Domestic	Hydropower	Industrial and Commercial	Livestock	Recreational	Institute and Business	Total water demand
2017	RCP 4.5	5032	258.30	91.00	28.90	28.00	4.11	1.23	5443.54
	RCP 8.5	5032	258.3	91	28.9	28	4.11	1.23	5443.54
2024	RCP 4.5	5273.85	421.61	249.64	31.22	35.31	4.59	12.89	6029.11
	RCP 8.5	6328.62	505.93	299.57	37.46	42.37	5.51	15.47	7234.929
2031	RCP 4.5	5515.70	584.91	408.28	33.54	42.62	5.07	24.56	6614.67
	RCP 8.5	6618.84	701.89	489.94	40.25	51.14	6.08	29.47	7937.61
2038	RCP 4.5	5757.55	748.22	566.92	35.86	49.93	5.55	36.22	7200.24
	RCP 8.5	6909.05	797.86	580.30	33.03	49.91	5.66	33.47	8409.291
2045	RCP 4.5	5000.39	911.52	925.56	38.18	57.24	6.03	47.89	6986.81
	RCP 8.5	7799.21	1184.98	943.23	49.63	74.41	7.84	62.25	10121.55

5.1.8.2. Water Demand Projection

5.1.8.2.1. Domestic Water Demand

In estimating domestic water demand (DWD), general design standards in Goal 4.6 of GTP-2 were adopted. As per the GTP-2 water supply service level standard, it is required to provide safe water in minimum of 25 l/c/day within a distance of 1 km for rural areas while in urban areas it is required to provide safe water in minimum 100 l/c/day for category 1 towns/cities (towns/cities with a population more than 1 million), 80 l/c/day for category 2 towns/cities (towns/cities with a population in the range of 100,000- 1million), 60 l/c/day for category 3 towns/cities (towns/cities with a population in the range of 50,000 - 100,000), 50 l/c/day for category 4 towns/cities (towns/cities with a population in the range of 20,000- 50,000) up to the premises, and 40 l/c/day for category-5 towns/cities (towns/cities with a population less than 20,000) within a distance of 250m. For both rural and urban areas, the per capita water demand is assumed to increase over the program period.

5.1.8.2.2. Commercial and Institutional Water Demand (CIWD)

In estimating commercial and institutional water demand (CIWD), 5 per cent of the DWD was taken for small and medium sized towns, and for large towns, the CIWD estimate was 10 per cent of DWD.

5.1.8.2.3. Industrial Water Demand (IWD)

In estimating industrial water demand (IWD), 30 per cent of DWD was taken in large and medium towns and 10 per cent of DWD was taken in small towns.

5.1.8.2.4. System Losses (SL)

Concerning system losses (SL), SL equivalent to 25 per cent of the total domestic, commercial and institutional, and industrial water demand was assumed for urban schemes whereas for rural schemes, a nominal 5 per cent allowance was made to account for spillage at hand pumps.

5.1.8.2.5. Environmental Demand

Environmental demand of the sub basin includes the water required to sustain aquatic ecosystems, flows needed for ecological conservation, and water needed to maintain minimum Lake Levels.

Water allocation therefore, should include provisions for maintaining the sustainability of freshwater ecosystems, including the need to maintain minimum in-stream flows and to anticipate the impact of hydrologic modifications on downstream environments.

Table 18: Minimum environmental flow release from existing and planned reservoirs (m3/s)

Hydropower	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gilgel Gibe I and II	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Gilgel Gibe III	22	21.5	21.5	21.5	21.5	21.5	21.5	22	22	21.5	21.5	22
Halele Warabesa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gojeb OM19	9.8	9.2	8.9	9.3	13.2	23.1	22.4	22.4	23.1	22.4	22.6	13.1

5.1.8.2.6. Irrigation Water Demand

In this paper, the irrigation water requirent was not estimated. It was very difficult to get the necessary data at each diversion in order to estimate the irrigation water demand at the sub-basins level. Hence, the basin's projected irrigation water demand of the recent studies was taken for preparing the Omo Gibe River basin plan.

5.1.8.3. Water Demands of Gibe-Gojeb Sub-Basin

In this paper, the domestic, commercial and institutional, and industrial water demands of Gibe-Gojeb sub-basin were estimated for the period of 2020 to 2045. As indicated in table below, the water demand of the sub-basin is increasing through the planning period due to popution and socio-economic development.

Table 19: Water Demand Projection of Gibe-Gojeb Sub-Basin (2020-2045)

Water Demands	2020	2025	2030	2035	2040	2045
Rural DWD(lpd)	146,581,750	166,091,750	188,198,525	213,247,825	241,631,100	273,792,225
Urban DWD(lpd)	37,128,580	49,916,940	70,098,490	96,742,430	133,109,270	181,798,760
CIWD(lpd)	3,712,858	4,991,694	7,009,849	9,674,243	13,310,927	18,179,876
IWD(lpd)	11,138,574	14,975,082	21,029,547	29,022,729	39,932,781	54,539,628
Urban SL(lpd)	9,282,145	12,479,235	17,524,622.5	24,185,607.5	33,277,317.5	45,449,690
Rural SL(lpd)	7,329,087.5	8,304,587.5	9,409,926.25	10,662,391.25	12,081,555.	13,689,611.25
Urban ADD(lpd)	61,262,157	82,362,951	115,662,508.5	159,625,009.5	219,630,295.5	299,967,954
Rural ADD(lpd)	153,910,837.5	174,396,337.50	197,608,451.25	223,910,216.25	253,712,655.00	287,481,836.25
TWD(lpd)	215,172,994.50	256,759,288.5	313,270,959.75	383,535,225.75	473,342,950.50	587,449,790.25
TWD(lpy)	78,538,142,992.5	93,717,140,302.5	114,343,900,308.75	139,990,357,398.75	172,770,176,932.5	214,419,173,441.25
TWD (Mm^3py)	**78.54**	**93.72**	**114.34**	**139.99**	**172.77**	**214.42**

5.1.8.4. Water Demands of Omo-Sharma Sub-Basin

During the survey, the different water demands of Omo-Sharma Sub-basin were estimated until the period of 2045. Due to the increasing socio-economic growth, the demand of water for different secors in the sub-basin is becoming higher and higher.

Table 20: Water Demand Projection of Omo-Sharma Sub-Basin (2020-2045)

Water Demands	2020	2025	2030	2035	2040	2045
Rural DWD(lpd)	134,807,550.0	152,750,400.0	173,081,550.0	196,118,700.0	222,222,150.0	251,799,900.0
Urban DWD(lpd)	59,259,040.0	67,665,620.0	79,789,060.0	93,933,420.0	107,273,160.0	122,264,460.0
CIWD(lpd)	5,925,904.0	6,766,562.0	7,978,906.0	9,393,342.0	10,727,316.0	12,226,446.0
IWD(lpd)	17,777,712.0	20,299,686.0	23,936,718.0	28,180,026.0	32,181,948.0	36,679,338.0
Urban SL(lpd)	14,814,760.0	16,916,405.0	19,947,265.0	23,483,355.0	26,818,290.0	30,566,115.0
Rural SL(lpd)	6,740,377.5	7,637,520.0	8,654,077.5	9,805,935.0	11,111,107.5	12,589,995.0
Urban ADD(lpd)	97,777,416.0	111,648,273.0	131,651,949.0	154,990,143.0	177,000,714.0	201,736,359.0
Rural ADD(lpd)	141,547,927.5	160,387,920.0	181,735,627.5	205,924,635.0	233,333,257.5	264,389,895.0
TWD(lpd)	239,325,343.5	272,036,193.0	313,387,576.5	360,914,778.0	410,333,971.5	466,126,254.0
TWD(lpy)	87,353,750,377.5	99,293,210,445	114,386,465,422.5	131,733,893,97	149,771,899,597.5	170,136,082,710
TWD(Mm^3py)	**87.35**	**99.29**	**114.39**	**131.73**	**149.77**	**170.14**

5.1.8.5. Water Demands of Lower-Omo Sub-Basin

Unlike the Gibe-Gojeb and Omo-Sharma sub-basins, the municipal water demand of the Lower Omo sub basin is lesser. But, the highest water using sector in Lower Omo sub basin is irrigation/agriculture.

Table 21: Water Demand Projection of Lower-Omo Sub-Basin (2020-2045)

Water Demands	2020	2025	2030	2035	2040	2045
Rural DWD(lpd)	44,272,725.00	50,165,425.00	56,842,450.00	64,408,150.00	72,980,900.00	82,694,675.00
Urban DWD(lpd)	12,503,340.00	14,167,520.00	16,053,220.00	18,189,960.00	21,292,410.00	26,554,750.00
CIWD(lpd)	1,250,334.00	1,416,752.00	1,605,322.00	1,818,996.00	2,129,241.00	2,655,475.00
IWD(lpd)	3,751,002.00	4,250,256.00	4,815,966.00	5,456,988.00	6,387,723.00	7,966,425.00
Urban SL(lpd)	3,125,835.00	3,541,880.00	4,013,305.00	4,547,490.00	5,323,102.50	6,638,687.50
Rural SL(lpd)	2,213,636.25	2,508,271.25	2,842,122.50	3,220,407.50	3,649,045.00	4,134,733.75
Urban ADD(lpd)	20,630,511.00	23,376,408.00	26,487,813.00	30,013,434.00	35,132,476.50	43,815,337.50
Rural ADD(lpd)	46,486,361.25	52,673,696.25	59,684,572.50	67,628,557.50	76,629,945.00	86,829,408.75
TWD(lpd)	67,116,872.25	76,050,104.25	86,172,385.50	97,641,991.50	111,762,421.50	130,644,746.25
TWD(lpy)	24,497,658,371.25	27,758,288,051.25	31,452,920,707.5	35,639,326,897.5	40,793,283,847.5	47,685,332,381.25
TWD(Mm^3py)	**24.50**	**27.76**	**31.45**	**35.64**	**40.79**	**47.69**

5.1.8.6. Water Demand Management

The water resources of the Omo Gibe River Basin are essentially unmanaged. In other words, water is used without regulation and without monitoring. In other areas, this may work as the water resources are in abundance. The basin is very sensitive to changes in the water use regime. The problem to date has been that there is no organization within the MoWE structure or within the regional bureau of water resources which has the responsibility to control water use and manage water at a basin level according to the basin principles of Integrated Water Resources Management (IWRM).

Water demand management aimed to conserve scarce water by reducing its consumption rates. This is an important and relevant issue in the industrial, domestic and agricultural sector because of the rapid growth in water demand in densely populated areas. There is an increase for irrigation water competition in the basin. There is a limitation on demand and demand managements to be in place in the basin: limited data on historic actual water use; high levels of uncertainty in establishing efficiency of water use with significant losses likely in irrigation and urban water use and uncertainties in the basic economic, social and demographic assumptions required for water demand forecasts. If demand management system applied, it can maximize the irrigation land without any additional water abstraction and increase the economic value of water resource in the basin.

Thus, the recommended water demand management will be: Awareness creation and capacity building on water use; Establish water user associations (WUAs) to use common water pumping and canal; Implementing water rationing specially during drought time; Carrying out old irrigation system maintenance; Promoting water fees; and Shifting water use trend from flooding and furrow irrigation system to sprinkler/drip irrigation systems by developing the capacity of WUA's .

5.2. WATER QUALITY AND POLLUTION ASSESSMENT

According to WHO estimation, about 1.1 billion people globally drink unsafe water and the vast majority (88%) of diarrheal disease reported across the globe is attributable to unsafe water, sanitation and hygiene (WHO, 2002). The Changes in water quality can have adverse impacts on aquatic species such as fish, plants, and microbes. Increased turbidity, temperature, velocity of flow, and pollutant loads can have direct impacts on species and their habitat. Sediment load generated during construction phase may effectively shield the light penetration into water bodies and thus disturb the prevailing aquatic ecosystem. This in turn will affect the temperature regime, the scale and rate of reproduction, dissolved oxygen and carbon dioxide equilibrium, etc, all of these may have significant implication to water quality of the Basin (FDRE Kuraz Sugar Project, 2013).

In Omo Gibe River Basin, pesticides are a more common source of poisons associated with irrigation schemes. They are poisonous to plants, fish, birds and mammals including humans. Persistent chemicals are a threat to aquatic systems even when not soluble, as many bond chemically to soil particles and may be transported by erosion. Persistent organo chlorine insecticides (eg. dieldrin and endosulfan) are particularly hazardous to aquatic systems and become rapidly concentrated in food chain. Non-specific herbicides can rapidly affect supply of food. Pesticide risks are likely to increase if a monoculture is practiced, so that weeds and pests are not controlled by rotation, or if the method of agricultural management requires high applications, such as low tillage methods (FDRE Kuraz Sugar Project, 2013).

In Omo Gibe river basin, water pollution can also occur through discharge of liquid effluents and process cooling water from the industrial plants/sugar factory directly into water bodies. Wastes from these sources lower stream PH, increase organic load, depletes oxygen contents of water bodies and decolorize, destructs aquatic life and create bad smell in natural water bodies. Similarly, such wastes pollute groundwater, create charring of vegetation and crops, accumulate and increase salts, increase in cropping period and in electrical conductivity of soil on land. Water pollution can also occur through surface runoff flowing through waste piles or landfills (FDRE Kuraz Sugar Project, 2013).

5.2.1. Water Quality and Water Pollution Situation of Gibe-Gojeb Sub-Basin

In the Gibe-Gojeb sub-basin, the quality of surface water is deteriorated mainly due to rapid population and urbanization rate which contributed to increased discharge of domestic and industrial wastes. The existing coffee processing induatries also contributed to poor water quality in the sub-basin. Besides, livestock rearing and intensive agricultural activities have resulted in the dischage of pesticides, herbicides and insecticides into the surface water bodies. Moreover, lack of sanitary landfill and wastewater treatment plants in the health and higher education isntitutions have great contribution to poor water quality in the sub basin.

Table 22: Chemical Analysis of Gilgel Gibe River (EEPCO, 2004)

	Gilgel Gibe Upstream Dam	*Gilgel Gibe Weir Zone*	*Gilgel Gibe Factory Zone*	*Gilgel Gibe Outcoming turbined water*
Altitude (m.a.s.l)	1640	1640	1200	1000
Chemical Ions(mg/l)				
Ca^{2+}	3.173	2.753	2.723	2.433
Mg^{2+}	2.024	1.699	1.692	1.297
Na^{+}	0.738	0.856	0.781	0.776
K^{+}	0.823	0.319	0.873	0.513
NO_3^{-}	4.378	9.457	3.833	2.161
Cl^{-}	3.284	4.506	2.437	3.105
SO_4^{2-}	2.118	4.527	1.763	1.357
PO_4^{3-}	0.24	0.597	0.29	0.402
Fe^{2+}	1.655	2.085	1.144	1.196
Salinity	Nil	Nil	Nil	Nil
Dissolve inorganic Content	48	41	39	37
Oxygen content	9.5	7.5	9.5	9.5
PH	7.15	6.99	7.13	6.93
EC(uS/cm)	101	88	82	79
Temperature(^{o}C)	21.8	21.8	21.8	21.8

Table 23:Physical and Chemical characteristics of the Gibe River (EEPCO, 2004)

Parameter	*Temperature (°C)*	*Dissolved Solids (mg/l)*	*TS (mg/l)*	*Ca2+ (mg/l)*	*Na+ (mg/l)*	*K+ (mg/l)*	*Mg2+ (mg/l)*	*Cl^- (mg/l)*	*CO_3^- (mg/l)*	*SO_4^{2-} (mg/l)*	*Total salinity*	*Oxygen content (ppm)*
Value	21°-24°	58.5	177.5	4.4	2.47	1.61	1.27	1.13	11.32	1.94	24.14	5.2-6.8

5.2.2. Water Quality and Water Pollution Situation of Omo-Sharma Sub-Basin

In the Omo-Sharma sub-basin, water quality deterioration is mainly due to sedimentation. In the sub-basin, due to high population density, the need for farm land is increasing which resulted in deforestation and buffer zone cultivation. Furthermore, rapid urbanization rate in the sub-basin resulted in increased domestic waste disposal. As stated by Meshesha and Abdi, (2019), recurrent land sliding due to undulating topography leads to land degradation in the sub-basin. This in turn leads to water ecosystem pollution in Omo-Sharma sub-basin.

Table 24:Results of chemical and physical analysis of Omo River (EEPCO, 2009)

	Gilgel Gibe 2 Power House	***Bele Bridge***	***Gibe 3 Dam Site***
Altitude (m.a.s.l)	*1000*	*900*	*730*
Ca^{2+}	*10.6*	*12.3*	*14.08*
Mg^{2+}	*5.94*	*6.48*	*4.32*
Na^+	*4.6*	*5.4*	*6.7*
K^+	*2.9*	*3.2*	*3.6*
NO_3^-	*1.19*	*1.6*	*1.0*
Cl^-	*2.82*	*1.88*	*1.88*
SO_4^{2-}	*5.3*	*15.4*	*4.75*
PO_4^{3-}	*0.948*	*1.58*	*0.759*
Fe^{2+}	*2.04*	*2.9*	*0.76*
Salinity	*Nil*	*Nil*	*Nil*
Dissolve Organic Content	*70*	*78*	*82*
PH	*7.34*	*7.33*	*7.5*
EC(uS/cm)	*109.9*	*104.7*	*126.1*
Turbidity (NTU)	*198*	*218*	*116*

5.2.3. Water Quality and Water Pollution Situation of Lower Omo Sub-Basin

In the Lower Omo sub basin, the surface and groundwater quality is affected by residuals of agro-chemicals used in the irrigation areas. Chemical fertilizers and pesticides used in the sugar plantations are expected to increase pollutions of surface and ground water thus leading to deterioration of water quality in the sub-basin. Moreover, the water quality problem in the sub-basin is associated with the discharge of industrial effluents from sugar factory (FDRE Kuraz Sugar Project, 2013).

Table 25:Water Samples Analysis Results for Omo River at Lower Omo-Sub Basin

Description	**Limit***	**Sampling Site Locations and Analytical Results**			
Sample source	FAO Maximum allowable concentration in (mg/l) for irrigation	**Omo River**	**Omo River**	**Omo River**	**Omo River**
Sampling site		Omo River at Proposed Weir Site	Omo River in Omo National Park	Omo River at Kangaten Town Site	Omo River at Omo Ratte Town site (Downstream)
Location		E – 693942 N – 171519	E – 829137 N – 648565	E – 572958 N – 177403	E – 531486 N – 172521
Altitude, m.a.s.l.		458	410	375	362
Sample Collection Date		21/05/2011	07/06/2011	31/05/2011	25/05/2011
Sample Submission Date		21/07/2011	21/07/2011	21/07/2011	21/07/2011
Total Dissolved Solids 105 ^{0}C (mg/l)	450-2 000	136.00	79.00	80.00	108.00
Electrical Conductivity (µS/cm)	700-3 000	186.00	108.00	110.00	152.00
P^{H}	6.5 – 8.4	6.64	6.36	6.12	6.71
Ammonia (mg/l NH_3)	-	1.99	2.95	1.00	3.34
Sodium (mg/l Na)	230.00	9.60	6.40	6.80	9.80
Potassium (mg/l K)	-	12.50	6.80	7.00	4.20
Calcium (mg/l Ca)	200.0	22.40	12.80	14.40	24.00
Magnesium (mg/l Mg)	150.0	6.24	4.32	5.28	0.96
Chloride (mg/l CI)	350.0	5.68	4.73	0.95	0.95
Nitrite (mg/l NO_2)	-	Trace	Trace	0.29	0.19
Nitrate (mg/l NO_3)	50.0	2.56	13.13	11.28	6.11
Bicarbonate (mg/l HCO_3)	520	109.80	62.59	69.54	83.45
SAR (calculated)	3-9	2.54	2.18	2.17	2.8
% Na (calculated)		43.56	43.54	41.22	35.93

5.3. WATERSHED SITUATION ASSESSMENT

5.3.1. Gibe-Gojeb Sub Basin Watershed Situation

5.3.1.1. Soils of Gibe-Gojeb Sub Basin

The major soils of Gibe-Gojeb sub basin are *Dystric nitisols* (9137.44 Sq.km, 29.38 %), *Pellic vertisols* (7473.13 Sq.Km, 24.03 %), *Dytric cambisols* (2991.67 Sq.Km, 9.62 %), *Dystric fluvisols* (2246.92 Sq.Km, 7.22 %) and so on. The soils of Gibe-Gojeb River Sub Basin are presented in appendix 13.

5.3.1.2. Land Use Land Cover

Changes in area and change rate of LULC type of Gibe-Gojeb sub-basin revealed that agricultural land was remained the dominant land use class (19,442.85 Sq. Km) in 2000 and covered about 62.23 % of the total geographical area of the watershed followed by forest land, another important land cover type (6,290.17 Sq. Km) which occupied about 20.19 % of the total land. However, agricultural land coverage decreased at an annual rate of 0.24% during the study period. Bushlands, grasslands and wetlands has also shown negative changes at an annual rate of 1.9%, 2.4% and 4.9% respectively. Most of land under these categories of LULC converted into plantations, built-up areas and water bodies. There was also significant expansion in urban lands and farming processes in the area associated with the natural increase of population in the study area. Changing rate is positive and strongest in this class of LULC.

Table 26. Area and percentage share of Land Use and Land cover classes (2000, 2010 and 2021)

Class Name	Year 200 Area (Km2)	%	Year 2010 Area (Km2)	%	Year 2021 Area (Km2)	%	Change b/n 2000 &2021	%
Agriculture	19,442.85	62.23	19,534.60	62.52	18,970.60	60.72	-472.24	-2.48
Bare soil	921.27	2.95	1,013.75	3.24	1,077.30	3.45	156.03	+14.5
Built-up	109.55	0.35	110.04	0.35	144.72	0.46	35.18	+24.3
Bush land	4,093.20	13.10	4,081.91	13.07	3,416.91	10.94	-676.30	-19.8
Forest	6,290.17	20.13	5,587.56	17.88	6,676.88	21.37	386.72	+5.8
Grassland	87.78	0.28	92.15	0.29	70.74	0.23	-17.04	-24
Plantation	165.39	0.53	679.21	2.17	747.40	2.39	582.01	+77.8
Water body	91.35	0.29	106.36	0.34	110.75	0.35	19.40	+17.5
Wetland	41.43	0.13	37.40	0.12	27.67	0.09	-13.76	-49.7
Total	**31,242.98**	**100.00**	**31,242.98**	**100.00**	**31,242.98**	**100.00**		

Table 27. Classification Accuracy Assessment Report

	Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Year 2000	Agriculture	104	105	101	97.12%	96.19%	0.9394
	Bare soil	23	24	21	91.30%	87.50%	0.8638
	Built up	22	20	19	86.36%	95.00%	0.9457
	Bush land	36	36	33	91.67%	91.67%	0.9044
	Forest	38	35	33	86.84%	94.29%	0.9339
	Grassland	15	20	15	100.00%	75.00%	0.7358
	Water body	22	20	18	81.82%	90.00%	0.8915
	Wetland	20	20	18	90.00%	90.00%	0.8923
	Totals	280	280	258			

Overall Classification Accuracy = 92.14% Overall Kappa Statistics = 0.9018

	Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Year 2010	Agriculture	105	105	99	94.29%	94.29%	0.9086
	Bare soil	25	24	20	80.00%	83.33%	0.8170
	Built up	21	20	18	85.71%	90.00%	0.8919
	Bush land	35	36	32	91.43%	88.89%	0.8730
	Forest	38	35	33	86.84%	94.29%	0.9339
	Grassland	14	20	14	100.00%	70.00%	0.6842
	Water body	22	20	18	81.82%	90.00%	0.8915
	Wetland	19	20	17	89.47%	85.00%	0.8391
	Totals	280	280	251			

Overall Classification Accuracy = 89.64% Overall Kappa Statistics = 0.8704

	Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Year 2021	Agriculture	104	105	98	94.23%	93.33%	0.8939
	Bare soil	25	24	20	80.00%	83.33%	0.8170
	Built up	22	20	18	81.82%	90.00%	0.8915
	Bush land	33	36	29	87.88%	80.56%	0.7796
	Forest	38	35	32	84.21%	91.43%	0.9008
	Grassland	15	20	15	100.00%	75.00%	0.7358
	Water body	22	20	17	77.27%	85.00%	0.8372
	Wetland	20	20	17	85.00%	85.00%	0.8385
	Totals	280	280	246			

Overall Classification Accuracy = 87.86% Overall Kappa Statistics = 0.8484

LULC Change (2000-2021)

Based on the interest of the study, spatial resolution of the satellite imageries and field survey in the study area major land use/land cover classes have been identified that shows an impression of the major land use and land cover types of the area. For the purposes of identification of land use/cover features and its surrounding environment; the satellite images were interpreted, analyzed, and classified into ten different major classes. These include agriculture, bare soil, built up lands, bushlands, forest, flood deposit, grassland, plantations, water bodies and wetlands. The total areas of each LULC class of the sub basin were computed for three different periods from 2000 to 2021.

From 2000 to 2021, the wetland and its surrounding environment has dynamically transformed into different LULC categories. One of the most marked changes were the rapid decline of wetland and forested lands from 17.7% in 2000 to 3.5% in 2021 and from 23.8% in 2000 to 10.6% 2021, respectively. This was mainly due to dramatic expansion of farmland and plantation towards wet and forest lands. The farmland had occupied 30.8% of the study area in 2000 and increased to 58 % in 2021. Similarly, plantation cover has increased from 4.3% in 2000 to 19.5% in 2021. However, the other LULCs such as grass and shrub lands have shown irregular trend (increment at one period and decrement at other) over the study periods.

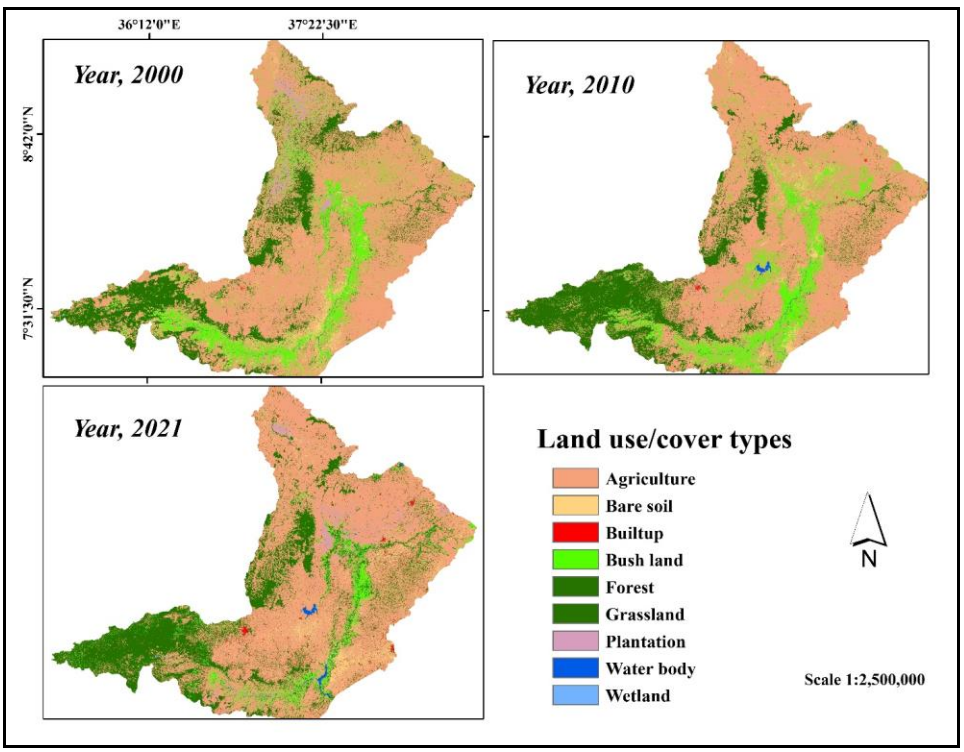


Figure 30. Land Use Land Cover Types of Gibe Gojeb sub-basin

5.3.1.3.Land Degradation and Erosion Hazard Assessment

5.3.1.3.1. Soil loss and sedimentation

The Gibe sub-basin covers four administrative zones of Jimma, S/W/Shoa, West Shoa and East Wollega. The four zones of sub-basin embrases 39 districts. Jimma zone of the sub basin covers the largest part of the sub basin whereas East Wollega covers the least. The forestry and wildlife resources study has been carried out to general forest and wildlife resources of the sub basin. Land degradation and partially land slide/mass movement of the soil, gully erosion are the most sever types of problems threatening the sub basin; some of soil erosion features, and degradations in sub basin are presented in picture below. Due to vegetation disturbance, land pressure and inadequate soil and water conservation practices in the majority district wide gully formation were observed which in turn affected infrastructures such as asphalt road, electric poles and homesteads. The most common forms of water erosion observed in the sub-basin are splash, sheet and rills on cultivated lands. Soil erosion is spectacular particularly during the early times of land preparation and planting. It is exacerbated by traditional tillage methods that are practiced in up-down direction along the slope and improperly laid and developed drainage ditches aimed at removing excess run-off.

Gibe sub basin was characterized by slight, moderate and severe degree of soil erosion, thus clearly indicate that the problem related to land degradation need for effective management practices so as to minimize the risk. The existences of moderate to severe erosion clearly indicate the problem of land degradation and the need for management practices in the area. Through continuous sheet and rill erosion without any mitigation measures, the soil lost its physical and chemical properties which were suitable for crop production, as a result of this land will be left abandoned without any type of use in some districts. Similarly, when the degree of soil erosion became developed, wider gully were formed which mostly occurred due to insignificant/no drainage line along road side constructed, cultivation along river banks, cultivation on steep land, vegetation clearance, limited soil and water conservation practices, and expansion of eucalyptus plantation on agricultural land which consequently dry up soil moisture.

Land degradation has become an increasingly serious problem, especially in the highlands of Gera, Deda, Omo Beyam, Kersa Malima, Dawo, Jibat, and Gudeya Bila districts where many soils are inherently poor in nutrients and at high risk of degradation due to erosion. The main causes for land degradation include improper land use, poor agricultural practices, deforestation and overgrazing, among others. Soil erosion is among the most important surface processes that result in severe land degradation in the tropics. Trees influence soil erosion mainly through intercepting of rainfall which dissipates its kinetic energy to detach the soil particles. However, the rain drops that are intercepted eventually drop to the soil surface with different erosive energy, which depends on the size and orientation of the leaves.

Gulley erosion is one of the main causes of severe land degradation observed in the Gibe sub basin. This happens during the rainy season when soils are waterlogged and subsoil drainage is inadequate, which is the case for most of the Vertisols and/or soils with vertic properties in the plateau landforms. Runoff in the cultivated fields cuts the soil and forms incisions, which become larger and cut their beds, resulting in large gullies. Therefore, this extensive area of land surface is drained by gullies require appropriate measures of erosion control on a large scale.

Table 28: Some of erosion classes and their coverage in the Gibe Sub Basin of OGRB

Erosion		**Area**	
At Site	**Surroundings**	**Ha**	**Percent**
Gully	Gully	194277	9.9
Rill	Rill	694422	33.3
Sheet	Gully	67316	3.4
Sheet	Rill	119153	5.1
Sheet and Rill	Gully	8453	0.4
Sheet	Sheet	864919	42.9
LU/LC		107859	5.0
Grand Total		**2,056,398**	**100**

5.3.1.4.Impacts and Causes of Land Degradation in the Sub Basin

The most common human causes of land degradation includes: inappropriate land use, resettlement, cultivation along river bank, vegetation clearance for sake of charcoal production, Population growth (both livestock and human) that leads to overgrazing of range land and expansion of cultivation into marginal lands i.e. marginal to cropping i.e. on to steep slopes and hills are related causes of human induced accelerated erosion. The sub-basin is characterized by rugged terrain and steep slopes specially Gera, Chekorsa, Dedo, Sokoru, Limmu-Kosa, Kersa-Malima, Limmu-Kossa and Boter Woreda. These characteristics coupled with poor farming practices flavored land degradation, especially soil erosion by water. The ruggedness and steepness of the land influences not only rainfall infiltration but also the development of soil and water conservation measures particularly that of physical measures. This is attributable to the small cross sectional area of the channel of the structures, which otherwise need deep excavations. Thus the structures become filled with sediment within one shower of rainfall. Population growth is familiar characters that highly influence the natural resource sustainability and the highest driving force for soil erosion and land degradation. In Gibe sub basin, population growth is becoming higher from year to year as a result of this crop cultivation even on steep lands (>30%) is widely increasing which consequently caused higher soil erosion/nutrient depletion, vegetation clearance and drying-up of springs.

Similarly, overgrazing is becoming the most notable factor in causing de-vegetation and land degradation. During the focus group discussion, the communities indicated that the total livestock population becoming increased in the area with those limited grazing land, and also indicated that an increase in human population caused livestock population too. They believed that this would result in a heavy grazing pressure of rangeland resource of the study area in general. The traditional herd mobility and grazing systems (dry and wet seasons grazing systems) interrupted due to expansion of bush encroachment and crop production the herders force to keep their livestock on the limited grazing orbits and this result into overstocking. This present rangeland coverage of the study area characterized into over dominance of bare exposed soil surfaces and domination of unpalatable bushes and herbs. Thus, the excessive removal of vegetation cover through grazing as well as the trampling of the soil surface by animals adversely affect the rangeland and decrease the productive potential of livestock that the communities told the study team the productivity of their livestock decreased from time to time.

One form of land degradation is removal of vegetation cover which leads to soil erosion, especially deforestation of the existing forest areas by the people who are seeking cultivated land. During discussions with the communities, it was observed that such activities are becoming the daily practice. It is attributed to the need of having new productive land and increased population in rural areas aspiring to hold land. Another important reason for forest clearing is the need to produce charcoal and to collect firewood for sale and home consumption. Cutting of trees for construction material is also another reason for deforestation. Woodland clearing for agriculture involves a complete change in land cover from shrub land, woodland or forest to “non-forest land” or bare land by the almost complete removal of wood in the cleared areas.

The impacts of land degradation in Gibe Sub basin are variable, depending on ecological, landscape, management, and climatic characteristics i.e. from upper part of the sub-basin to the lower part where precipitation and temperature patterns are as variable as their effects on soil erosion. The sandy clay loam soils are found to be more vulnerable to erosion than Clay. Similarly, based on information from panel discussion and metrological data; the Sub basin has got irregular rainfall distribution and intensity, and increased temperature, which consequently aggravated the soil erosion, decreased vegetation biodiversity, decrease in recharge of ground water river flow, these in turn also influenced their agricultural activity. This irregular rainfall pattern has imposed uncertainty on crop growing schedule especially in sowing and harvesting periods and made-up to negatively influence management of the agricultural activities. Generally, those identified sub-basin problems have caused both economic and environmental impacts. These impacts have imposed a significant adverse effect on the human and livestock population of Gibe Sub basin such as serious draught, death of human being and livestock, unemployment, shortage of drinking water, poor crop production.

Therefore, the Gibe-Gojeb sub-basin is also highly affected by deforestation and degraded soils on steep and exposed soil surface, which affected the resource base and influence the food shortages caused by drought. This impacts and resultant changes has to be anticipated from climate change on all the natural features and processes to be managed on a sub-basin basis over a time frame stretching.

5.3.1.5.Soil Loss and Sedimentation

Soil erosion is considered as a main contributor to land degradation around the sub basin due to its impact on the ability of soils to perform a range of functions. The erosion processes can be categorized as inter rill erosion (or sheet flow erosion), rill erosion, and gully erosion. As a widespread phenomenon, gully erosion has become a serious land management issue in many parts of the sub basin. The loss of nutrients and organic matter mainly occurred during the active stage of the collapsing gully. Gibe sub basin is affected by deforestation and degraded soils, which have eroded the resource base and aggravated sediment deposition, flooding, repeated food shortages, and caused by drought. Gully formation is very common especially in the Gibe sub basin within the farm land and also along river banks and road sides. One form of land degradation is removal of vegetation cover which leads to soil erosion, especially deforestation of the existing forest areas by the people who are seeking cultivated land. Vegetation degradation includes loss of biomass, biodiversity, and range resources. The most common types of vegetation degradation in Gibe Sub Basin are loss of vegetation cover and rangeland degradation mainly due to human influence. Soil erosion is a global environmental threat (Montanarella et al., 2016), that leads to a reduction of provisioning and regulation services (Aneseyee et al., 2019; Bezabih et al., 2016).

Sediment is an integral and dynamic part of aquatic systems and it plays a major role in the hydrological, geomorphological and ecological functioning of river basins, defined here to include lakes, reservoirs, estuaries and the coastal zone. In natural and agricultural systems, sediment originates from the weathering of rocks, the mobilization and erosion of soils and river banks, and mass movements such as landslides and debris flows. In most river basins there are also important contributions to the sediment load of organic-rich material from a range of sources such as riparian trees, macrophytes and fish. Sediment provides the substrate for organisms and through interaction with the overlying waters (e.g., nutrient cycling) plays an essential role within aquatic ecosystems. In addition, after flooding, fine-grained sediments are left as a deposit on floodplains, creating fertile soils that are often highly suited for agricultural production. On the other hand, the removal of sediments from harbors, navigation channels, locks, floodplains and river stretches is a high capital cost for authorities and agencies responsible for their maintenance and water quality. Sediments are material of varying size of mineral and organic origin. Erosion is the process of carrying away or displacement of sediment by the action of wind, water, gravity, or ice (Smith & Smith 1998). The process of deposition of sediment from a state of suspension or solution in a fluid is called sedimentation (http://en.wikipedia.org/wiki/Sediment).

The available sediment data showed a negative correlation between river flow and sediment concentration, i.e., sediment concentrations diminish with increasing flows. This is very clearly discernible with the Great Gibe Station and is contrary to normal expectations. To explain this anomaly, the data were also plotted as a time series from which it appears that the early rains are effective in causing sediment discharge, but with the re-growth of vegetation, the sediment discharge is much reduced. This also correlates with data from the Soil Conservation and Research Project, which found that early rains tended to be of highest intensity and caused greatest erosion. This observed negative correlation is in place of the expected positive correlation between river flow and sediment concentration, and is more or less clearly evident in the results from all six stations. These data were incorporated into the water resources systems model. However, the data also point directly to the importance of maintaining ground cover in managing soil erosion in the Basin; in this regard, the particular management practices for *tef*, with the field kept bare for much of the rainy season, are particularly relevant. It is recommended that additional sediment sampling be carried out at other stations in the Basin, particularly in connection with any project proceeding to the feasibility stage. In addition, it is recommended that the amendments to the sampling programme suggested elsewhere in this report should be implemented in any future programme.

Siltation of reservoirs or dams in Omo Gibe River basin is increased by soil erosion arising from agricultural practices from the upper feeding catchment, deforestation and overgrazing. The creation of artificial reservoirs not only results in water retention by inhibiting water outflows, but also has serious implications on qualitative and quantitative changes in the circulation of matter and energy in the whole river system (Szatten et al., 2018). The process of soil erosion cause on-site soil deterioration at an irreversible scale and is measured using average quantity of removed soil from an area within a defined period. The level of soil detached and transported to surface water bodies within a time scale over a specific area is known as the sediment yield, and it serves as an important procedure in catchment erosions (Guo, Hao, & Liu, 2015; Sutherland & Ziegler, 2007). The nonpoint nutrient contaminants, heavy metals, and chemicals are also transported with soil particles, causing higher sediment levels which eventually lead to water eutrophication and disturbance of delicate aquatic ecosystems (Bing, Wu, Liu, & Yang, 2013; Wilson, Cullum, & Römkens, 2008). Severe soil erosion which leads to excessive silt export to waters or reservoirs result in disturbances of life in water bodies as well as reduced quality of the environmental (Zhai, 2010). Soil erosion usually occurs in places that are susceptible, the topography is sloped and when long duration rainfall coincides with inadequate vegetative cover (Rohrmann, Heermance, Kapp, & Cai, 2013; Vrieling, Steven, Sterk, & Rodrigues, 2009; Lee & Lee, 2006; Marques, Bienes, Jimenez, & Perez-Rodriguez, 2007; Zhao et al., 2014). Soil erosion monitoring is a very key to recognizing vulnerable areas and for measuring the yield of deposits in the field. Sediment yield and soil erosion constitute key factors which may be used for water quality control activities. Therefore, siltation from erosion of the river basin has direct adverse effects on fish by covering spawning sites, destroying benthic food sources, and reducing water clarity to visual feeding animals (Leveque, 2001). Hence, the adoption of technologies, including engineering measures, afforestation, relevant market development, policy changes, etc., and their impacts could be taken as the intermediate benefits to halt siltation of reservoirs so as to improve the quality and quantity of water resources in a basin.

Natural sources of sediments transported to the sea include erosion of bedrock, soil and decomposition of plants and animals (UNEP and Gems Water Programme 2006). Natural sediment mobilization is an important process in the development and maintenance of coastal habitats, including wetlands, lagoons, estuaries, sea-grass beds, coral reefs, mangroves, dunes and sand barriers (UNEP/GPA 2006). However, anthropogenic activities or those which are carried out by man, often change the processes of erosion and sedimentation as well as modifying the flow of rivers and the amount of sediments it can carry.

Most land-based activities that occur in sectors such as agriculture, forestry, urbanization, and mining contribute to these changes. Another significant cause of changes in sedimentation and erosion patterns is through hydrological modifications that may occur from construction of reservoirs, dams and causeways, dredging of water bodies and development of large-scale irrigation schemes (UNEP/GPA 2006).

The effects of changes to erosion and sedimentation patterns will depend on whether the change results in an increase or decrease in sediment availability. Both effects have various physical and chemical consequences for water quality and aquatic ecosystem health (UNEP/GPA 2006a, UNEP & Gems Water Programme 2006). Sedimentation effects are usually local, but trans boundary impacts may occur where major river systems form a common border and where littoral currents carry inputs across international boundaries (http://www.fao.org/gpa/sediments/sedintro.htm).

One of the processes disturbed by human interference is sediment transport. Rivers play a significant role in the global hydrological cycle, providing about 20 billion t year−1 of sediments to the world's oceans. Moreover, the hydrological cycle also reflects climate change occurring as a result of human activity (Syvitski et al., 2011). Therefore, artificial reservoirs are filled with sediments and thus can no longer fulfill the main functions they were created for, for example, hydropower generation, water retention, flood control, recreational purposes, etc. Dams accumulate transported sediments, which results in a decrease of their operating capacity and water storage (Kondolf et al., 2014). The impacts of reservoirs on the dynamics of sediment transport are quite significant (Szatten et al., 2018; Hu et al., 2009; Magnuszewski et al., 2010 and Habel et al. 2017).

The annual soil loss rate was determined by a cell-by-cell analysis of the soil loss surface by multiplying the respective RUSLE factor values interactively in Arc GIS 10.4 using Equation.

A (tons/ha/year) =R*K*L*S*C*P

The major part of Gibe sub basin is characterized by very high degree of soil erosion, which accounts 1,098,918.3 ha (53.2%) followed by very slight, high, moderate and slight degree of soil erosion which account 949,742.6 ha (46%), 11,485.8 ha (0.6%), 4,757.0 ha (0.2%), and 1,555.8 ha (0.1%), respectively (Table 2.5). Gizaw and Degifie (2018), reported mean annual soil loss of 62.98 t ha^{-1} yr^{-1} in the central part of Omo Gibe River Basin (Gilgel Gibe-I catchment). For the year 2013, 60.9 t ha^{-1} yr^{-1} mean soil loss was recorded in Jimma Zone ranged from 1.6 to 232.4 t ha^{-1} yr^{-1} (Beshir and Awdenegest, 2015). In the Ethiopian highlands, soil erosion ranges from 16–300 t ha^{-1} yr^{-1} (Hurni, 1988). According to Tesfaye and Bogale (2019), high amount of soil loss rate was recorded in the upper catchment of OGRB (Gilgel Gibe -III watershed) due to deforestation; spares land cover, shallow soil depth and high rainfall intensity.

Table 29: Soil erosion potential (soil loss) in Gibe Sub basin

Degree of Erosion	**Area (ha)**	**Area (%)**
Very Slight (0-5 t/ha/yr)	949742.6	46.0
Slight (5-12 t/ha/yr)	1555.8	0.1
Moderate (12-25t/ha/yr)	4757.0	0.2
High (25-60t/ha/yr)	11485.8	0.6
Very High (>60t/ha/yr)	1098918.3	53.2
Total	2066459.6	100.0

5.3.1.6.Wetlands and forest resources

Wetlands are rich in highly diversified biological resources and the most valuable ecosystems on our planet (Mitsch and Gosselink, 2015). They deliver a wide range of direct and indirect benefits both locally and globally (de Groot et al. 2012; Russi et al. 2013). These include supporting (e.g., nutrient recycling, soil formation, biodiversity support), regulating (e.g., hydrological flows, erosion regulation), provisioning (e.g., fish and fiber, genetic materials), and cultural services (e.g., tourism, source of inspiration) (MEA (Millennium Ecosystem Assessment) 2005).

Ethiopia, like as many countries in the world, has immense wetland resources. The wetlands in Ethiopia include many forms such as lakes, swamps, marshy wetlands, peat wetlands, flood plains, high mountain lakes, natural and manmade ponds. These wetlands have been contributing for the well-being of many Ethiopians for generations and still they are contributing and this will continue for years in the future. Wetlands, according to the Ramsar Convention are defined as "areas of marsh, fen, peat land or water as, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water, the depth of which at low tide does not exceed six meters". In Ethiopia there are large areas of wetlands which are distributed in various parts of the country almost all altitudinal ranges from lowland (the Dallol depression) up to top of high mountains. Wetlands are of enormous socioeconomic and environmental values and attract a number of users that get benefited directly or indirectly. They are source of water, food, reed, medicinal plants and other income generating activities for the rural community. Wetlands generally classified into 3 major classes: freshwater, saltwater and manmade wetlands According to the FAO in 1984, two types of wetlands (swamps and marshes) dominate in Ethiopia and some studies show that based on scattered information, wetlands are estimated to cover about 2% of the total land mass of the country. Though wetlands in the country is poorly studied and recorded more than 40 wetlands are identified as important bird areas for the nation, and these sites support some of the endemic bird life and biodiversity of Ethiopia. The main objective of this paper is to discuss the importance, distribution and threats to wetlands of Ethiopia. Wetlands are valued for high biological productivity; as filters, sinks, and transformers for sediments, nutrients, and pollutants; and as buffers between aquatic systems and human activities on upland areas (Donald, 1993). Wetland ecosystems are a natural resource of global significance and historically, their high level of plant and animal (especially birds) diversity is perhaps the major reason why wetland protection has become a high priority (Jos et al., 2006).

Wetlands are "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Secretariat of the Ramsar Convention, 2013). Wetlands provide multiple ecosystem services such as storing and regulating water flows and water quality, providing unique habitats to flora and fauna, and regulating micro-climatic conditions (Teferi et al., 2010). The major flood plains of Ethiopia as implied by various authors (EPA, 2004), include Wabe-shebele-Genale flood plains, Awash River flood plains, Omo River flood plain, the permanent swamps and flood plains along Akobo, Baro and Gilo Rivers, Fogera and Dembia flood plains on the shores of Lake Tana, Borkena and Cheffa flood plains are few to mention.

The Ramsar Convention on Wetlands defines wetlands as “areas of marsh, fen, peat, and or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.” Wetlands are ecotones (transition zones) between terrestrial and aquatic environments (Hatvany, 2009). Wetlands therefore include the following: marine-coastal wetlands such as coastal lagoons, rocky shores, and coral reefs; estuarine-for example, deltas, tidal marshes and mangrove swamps; lacustrine-wetlands associated with lakes; riverine—wetlands along rivers and streams; palustrine-marshes, swamps, and bogs; human-made wetlands such as reservoirs, fish ponds, flooded mineral workings, saltpans, sewage farms, and canals because wetlands are dynamic systems and occupy the transitional zone between aquatic and terrestrial habitats. The abundance and distribution of wetlands throughout Ethiopia remains unclear not least because of inconsistencies in the ways they are identified or delineated. Recent work (Bezabih and Mosissa 2017; EWNHS 2018) tends to either draw on reports by wildlife conservation organizations or those of government departments which have focused on Ethiopia’s large lake-wetland complexes or river valleys, hence identification of what constitutes a wetland often reflects the agenda of those undertaking the survey (Dixon et al., 2021). The role and importance of wetlands in Ethiopia is often underestimated, which leads to conversion by draining to allow grazing and agriculture.

5.3.1.7.Native Vegetation and non- native species

The main ecological problems within the Basin are identified as deforestation and loss of biodiversity, which are directly linked. These are primarily highland issues, although lowland riverine forests are also noted to be under threat. Ethiopia has an important role to play in biodiversity conservation. About 12% of its flora is endemic, which can be attributed to the extreme diversity of ecological conditions determined by the country’s topography and location. Endemism is particularly high in the mountains, in the Ogaden and in the forests of the southwest - that is, in the Omo-Gibe Basin. Ethiopia is also unique for the diversity of plants which have been manipulated by man (ie crop plants). It is the sole or most important centre of diversity for arabica coffee (centred in the Basin), tef, *enset* and anchote. It is the main centre for noug and Ethiopian rape, and one of the main centres for sorghum, finger millet, field pea, chick pea, perennial cotton, safflower, castor oil bean and sesame. Because of genetic erosion in other parts of the world it is now the most important centre for durum wheat, barley and linseed. Finally, the medicinal and other potential uses of the Basin's diverse flora remain largely unknown, except for local uses; no ethno-botanical study of the useful plants of south-west Ethiopia has been conducted.

The highland forests fall largely into two categories - upland sub-humid and humid forests, and upland rain forest. The former are represented in the Jibat and Tiro Botor-Becho forests, which form the last significant remnants of these forests within the Basin. Both are recommended as biodiversity conservation areas. The upland rainforests are the most extensive forests of the Basin comprising the forested area in the Jima - Bonga - Mizan Teferi axis. They are very species rich (flora and fauna) and of utmost biodiversity significance. They are also thought to be the source of arabica coffee. It is recommended that a specific study of coffee genetic resource conservation be initiated. All these forests are under threat, primarily from conversion to agriculture; this in turn is underlain by poverty and increasing population. Although designated NFPAs include the Jibat and Botor-Becho forests, and large parts of the upland rainforests, this designation provides inadequate protection and active exploitation (for wood and for land use conversion) is continuing. Associated with the forest loss is the loss of forest fauna. Riverine forests in the highlands are also critical, both for watershed protection and to preserve amenity value

In Gibe sub-basin, the natural forest is utilized by local residents for firewood, livestock grazing, medicinal herbs and coffee production. Currently, in Belete- Gera national forest priority area collecting firewood is allowed, but only dead trees and branches can be collected. Grazing in natural forest is prohibited and restricted to plantations. Coffee (*Coffee arabica*) is a native species and grows wild in the natural forest. It has been the major cash crop for the region and country. Coffee production activities in the forest range from collecting coffee beans without disturbing the forest to coffee plantations which significantly open up the forest. Coffee production is more prevalent in the Gera Forest area than in the Belete Forest area. Currently, undisturbed closed highland rain forest can only be found in mountainous areas far from villages. Most of the accessible forest has been heavily disturbed. Selective cutting, encroachment of farming, grazing and coffee production has reduced the area of forest cover and caused deterioration of the forest. Enrichment plantings of indigenous species on the selective cutting sites have been carried out with some success. Encroachment of natural forest and the coffee production activities are major challenges to forest management.

In Gibe sub-basin integrated land use planning study project, there are some natural remnant forest such as Belete-Gera national forest priority area, Botor-Becho national forest priority area and Jibat-Gedo national forest priority area. In addition to these natural forests, there are also highly disturbed forests and plantations in the sub-basin. According to the study carried out in this project area, the total area of all these forest coverages in the Gibe sub-basin can be estimated to be 208, 192.39 hectares which is 10.16% of the sub-basin. But, there are bush and shrub land areas in the sub-basin which can be estimated to be 211,828.293 hectares (10.34%) of the total area coverage of the sub-basin.

5.3.1.8.Ecosystem Situation Assessment

Ecosystem provides a wide range of direct and indirect services that are fundamental for human-wellbeing (MEA 2005; Tolessa et al. 2017). Ecosystems provide a wide range of multiple services that vary in quantity and quality depending on the type of ecosystems and their status (MEA, 2005). In Ethiopia, very few studies have been conducted on mapping and valuation of ecosystem services (ES) in the context of LULC changes (Arowolo et al. 2018; Hulme et al. 2013; Leh et al. 2013; Kindu et al. 2016; Tolessa et al. 2017). Almost all studies indicate that this region is under severe pressure of degradation with significant consequences for rural livelihoods (Scholes et al. 2018). For example, Sutton et al. (2016) estimated for Ethiopia a loss of 17.7% in ecosystem service values (ESVs) due to land degradation, which is also reflected in studies conducted in different parts of Ethiopia (Gashaw et al. 2018; Kindu et al. 2016; Tolessa et al. 2017). Drivers of land degradation in sub-Saharan Africa include the expansion of crop production, unsustainable grazing and forestry practices and climate change (Scholes et al. 2018).

Ecosystems in the Omo Gibe River Basin provide a host of provisioning, regulating, supporting and cultural services to people (Kleinschroth et al., 2021). They enable the rearing of 20% of the

Ethiopian cattle population, 5% of the Kenyan fish production, and support drinking water, sediment retention and soil fertility for millions of people dependent on subsistence agriculture and pastoralism (Kleinschroth et al., 2021). Most importantly, ecosystems provide a home and identity to the diverse people who live in the dynamic and at-times challenging conditions of the Basin. The basin's social-ecological system is constantly changing due to regional demand for water, energy and food. The demand for hydropower and irrigated agriculture, in particular, drives many of the large-scale development interventions in the South Omo River Basin, which in turn impact rural livelihoods especially for indigenous peoples in the Lower Omo Valley.

In recent decades, two main trends have occurred in ecosystem services across the basin: first, since the 1980s, 5.5% of the highlands experienced a net loss of closed-canopy forests and all the services they provide, probably due to agricultural expansion. At the same time, 12% of the lower-lying areas experienced an increase in open woodlands due to changing climate (Kleinschroth et al., 2021). Second, since construction of the Gibe III dam, typical seasonal hydrological oscillations – e.g., water-level patterns in the Omo River – have been reduced, which has resulted in a reduction in temporarily flooded areas normally used for recession agriculture and grazing (Kleinschroth et al., 2021).

According to Aneseyee et al. (2020), a study was conducted to investigate the trend of ES valuation (ESV) associated with land use/land cover (LULC) change in the Winike watershed, Omo Gibe basin, Ethiopia. The agricultural provisioning ESVs were also collected from the field to compare with the global ESV data. Accordingly, their findings revealed that the total ESV decreased from US$481.85 million in 1988 to US$445.5 million in 2018, with a decreasing rate of US$1.21 million per year. Within this period, the largest ESV increment was observed in cultivated land with an increasing of US$33.47 million, and the largest decreasing was observed in grazing land with a decreasing of US$47.35 million. Based on local and global data, Aneseyee et al. (2020) found that the agricultural land ESV were US$8,610.34 and US$1.34 million ha^{-1} $year^{-1}$, respectively. Moreover, their findings revealed that the major contributor for the reduction of ESV was decreasing of grazing land by US$47.35 million (9%) followed by forest land by US$15.8 million (4.56%) throughout the study period. However, cultivated land was increased by US$33.47 million (9.23%). The result of the study also indicated that almost all the ecosystem functions valuation in response to LULC changes were decreased except for food production, sub category of provisioning ES. In the last three decades, the regulating ESV have been lost largely followed by provisioning and cultural ES. Accordingly, Aneseyee et al. (2020) concluded that the decreasing of ESVs following environmental degradation could be resulted from land conversion and they suggested the requirement of introducing interventions, like integrated landscape management.

Shiferaw et al. (2021), in the Gojeb River Catchment of Gibe-Gojeb River Sub Bain quantified LULC transformations and associated ESVs during 1986 and 2016 using satellite images, field observations and ancillary datasets. They carried out Ecosystem's service valuations of different land use types using benefit transfer method. Accordingly, they reported the summarized LULC classes as: bareland, cropland, grassland, forest, plantation, settlement, shrub, water-body and woodland and evaluated the ESVs for each LULC based on these LULC classes. Forests had the highest cover (> 423,000 ha ~ 60%) in 1986 but it reduced to 317,000 ha (~ 45%) in 2016. About > 56,000 ha of forests were changed to cultivated land, and > 105,000 ha to different classes. Cultivated land increased to > 258,000 ha (~ 37%) in 2016 compared to 150,000 ha (~ 21.5%) in 1986. The sub-basin had ESVs of US$2.52 billion in 1986 but decreased to US$ 1.97 billion in 2016; losing about US$ 0.551 billion within the last 30 years (annual loss rate of US$ 18.4 million). Potential drivers would be agricultural expansion, land degradation/erosion, landslide and deforestation, indicating that requires concerted effort to restore and manage landscapes for sustainable socio-ecological and economic uses.

5.3.1.9.National Parks, Wildlife Reserves and Controlled Hunting Areas

Gibe Sheleko National Park is one of the conservation area located 178 km.from A.A. & 433 km South west of Hawassa. It is found in Gurage zone Abeshege,Cheha, Enemore and Ener woredas. It is etablished in 2001 E.C. and covers an area of 360 sq.km. The topography of Gibe Sheleko National park is mainly characterized by heterogeneous & hill terrain in which its larger proportion is hilly undulating interspersed with different valley floor. Besides, some flat lands & undulating to rolling plains with incised river & perennial streams, valley & gorges occur in the area. In the park there is different spectacular hot springs. The area has rich and intact vegetation cover. The area covers grasslands with scattered trees, woodland, mountain & reverine forest. The park is also inhabited by an extraordinary composition of fauna. Recent records show that about 16 species of larger mammals inhabit the park. The mammals include: Lesser kudu,Warthog, Common bushbuck, Lion, Leopard, and Black & White colobus & others. The

Gibe River that flows across the park hosts various species of fishes, Water fowls, Hippopotamus and Crocodile.

5.3.1.10. Forest Priority Areas

1. Botor-Becho National Forest Priority Area

Boter-Becho forest (08°21'56.4''N and 037°16'25.4''E) is one of the national forest priority areas located in Jimma Zone of Oromia Regional National State, Ethiopia. It lies in Chora Boter, Botor Tolay, Tiro Afeta and Limu Kosa districts of Jimma zone and 223 km southwest of Addis Ababa, the capital city of Ethiopia. It lies along a volcanic mountain ridge, running almost north to south, and rising to a series of small peaks, the highest of which is 3,100 m above sea level. The Eastern part of the ridge is sharply steep, but more gradual in western side. The hills are divided by numerous valleys. The forest is dominated by ***Acacia*** tree species in the lower altitude, high montane forest on slopes and in the valleys up to around 2,900 m above sea level. Most of the valleys along the forest ridge contain only seasonal water course but remain dry from December to March. Boter- Becho forest covers approximately a total area of 93, 793.13hectares. The mountains are drained by the Gilgel Gibe to the west which forms a wide valley supporting the lower parts of the forest, and the main Gibe River to the north and east.

The Boter-Becho forest is a mixed coniferous-broad-leaved forest, fairly species-rich, and structurally diverse. Above this is a mixed coniferous forest, comprising *Juniperus procera*, *Hagenia abyssinica* and other small trees. There are some patches of *Arundinaria alpina* in wet, sheltered valleys. *Aningeria adolfi-friderici* is the largest trees and is sought-after for their timber. Although the Boter-Becho forest covers 85,804 ha of forest and forest land, in 1988 only 15,957 ha was undisturbed forest, the remainder comprising 23,289 ha of disturbed forest and 46,558 ha of plantation and bushland. The tree species found in this forest are *Allophylus abyssinicus, Croton macrostachyus, Chionanthus mildbraedii, Ficus sur, Macaranga capensis, Milletia ferruginea Subsp., Olea capensis subsp. Olinia rochetiana, Podocarpus falcatus, Polyscias fulva, Pouteria adolfi-friedricii, Schefflera volkensii, Syzygium guineense Subsp., Albizia gummifera , Apodytes dimidiata , Brucea antidysentrica, Calpurnia aurea , Celtis africana , Chionanthus mildbraedii , Clausena anisata, Ehretia cymosa , Oxyanthus speciosus and Teclea nobilis.*

2. Belete-Gera National Forest Priority Area

Belete forest is located in Shabe Sombo district, Jimma Zone, southwest Ethiopia. It is found along Jimma-Bonga main road at 50 km from Jimma town. Geographically, it is found between 7°30’ and 7°45’ N latitudes, 36°15’ and 36°45’ E longitudes. The altitude of the area ranges between 1300 to 3000 m above sea level (Cheng et al., 1998). The annual precipitation ranges from 1800 to 2300 mm with maximum rainfall between the months of June and September. The mean annual minimum and maximum annual temperature of the area ranges between 15 and 22^{o}C, respectively (Hundera, Gadissa, 2008).

Belete forest is part of Belete Gera National Forest Priority areas in Oromia. The forest is part of the remnant moist evergreen Afromontane forest of southwest Ethiopia.For effective management, the forest is under participatory forest management since 2003, and currently, it is under the concession of Oromia Forest and Wildlife Enterprises. The total area of the forest is about 134, 761.65 ha. The forest is dominated by trees like *Syzigium guineense*, *Olea welwitschii*, *Prunus africana* and *Pouteria adolfi-friederici*. This forest is among the forests that are rich in biodiversity (Schmitt et al., 2010). As a result, it has a great importance for biodiversity conservation and socioeconomic contribution.

The major tree species found in Belete forest are *Syzygium guineense, Croton macrostachyus, Maytenus arbutiolia, Olea capensis, Celtis Africana, Pittosporum viridiflorum, Teclea nobilis,* Pouteria adolfi-friederici, *Flacourtia indica, Ehretia cymosa, Millettia ferruginea, Albizia gummifera,Ficus sycomorus, Ficus vasta, Cordia africana, Bersema abyssinica, Ehretia cymosa, Sapium ellipticum, Syzygium guineense.* Despite the absence of wildlife protected areas in this study area, different wildlife species have been recorded from the study area, such as, African Buffalo (*Syncerus caffer*), Lion (*Panthera leo*), Colobus monkey (*Colobus guereza*), Grivet monkey (*Chlorocebus aethiops*), Olive baboon (*Papio anubis*), Leopard (*Panthera pardus*), *Phacochoerus africanus*, Warthog (*Potamochoerus larvatus*), African civet (*Civettictis civetta*) and Menelik's bushbuck (*Tragelaphus scriptus*) are found in the study area.

3. Jibat-Gedo National Forest Priority Area

Jibat forest is in Jibat District of Western Shoa Zone, 200 km west of Addis Ababa. The majority of the forest is at 2,000-3,000 m.a.s.l., although the south-western portion extends to lower altitudes where the forest takes the form of a mosaic of small woodlands and farmland.

The forest is believed to be secondary in nature; primarily due to the existence of a ruined palace found in bamboo forest near the topwhich probably dates back to settlers who lived there during the fifteenth century. The forest has also been heavily exploited in more recent years for commercial timber production, although the sawmill in the forest now lies disused. Continued illegal logging and total deforestation of some areas by settlers from the north is causing significant damage and is preventing the forest from achieving its natural climax state. The two dominanttree species in this area are Juniperus*procera* and *Podocarpusfalcatus.* Additionally, *Hagenia* and *Rapanea* species, characteristic of the highest-altitude forest zone, are well developed in this forest. At the forest edge, where human influence is the most pronounced, pioneer tree species such as *Bersama abyssinica* and *Clausena anisata* are common.

4. Plantation forest in the sub-basin

Small-scale plantations have been expanded in the sub-basin, especially since the 1970s when the number of farming households planting trees began increasing significantly. They supply the largest volume of wood products used in the construction sector (such as poles and posts) and a significant portion of the biomass fuel consumed in the Gibe sub-basin. Small-scale plantations are established for two purposes: to satisfy household demands for wood and to generate additional household income from sales. A limited number of species from *Eucalyptus*, *Cuppressus* and *Pinus* account for the majority of plantation forests in the sub-basin. Typical biological attributes that attract farmers to *Eucalyptus* include fast growth, coppicing ability, ease of management (such as non-palatability to cattle), established market demand for its wood, its ability to grow well even on degraded landscapes and its better growth performance than most indigenous tree species on degraded lands.

5.3.1.11. Watershed Management Technologies

The integrated watershed management will have an imperative importance on reduction of sediment quantity and quality problems should initially recognize and delineate the erosion source of sediment and establish sediment delivery rates for each type of erosion. The rate of background erosion that which occurs in the undisturbed system should also be determined because this will become the target goal for restoration success. If the sediment problem is severe, then in stream restoration can also be addressed. If the problem is not or cannot be corrected in the water-shed, then treating the in stream symptoms will be an ongoing and costly exercise. Once sediment has been delivered from the hillslope to the valleys and associated channels, it becomes a fluvial problem. Several issues should be addressed: (1) natural watershed sediment yield; (2) temporary versus chronic sediment problems; (3) temporary problems such as construction sites; (4) separable sediment effects (see Table 1) and quantification of these effects, which could include capitalized benefits for any proposed treatment; (5) sediment's cumulative effects and quantification of these effects; and (6) potential ways to reduce the sediment for each type of effect and comparing their effects and potential treatment cost in the action and non-action condition.

5.3.1.12. Aquatic Ecosystems Management and restoration

Restoration is an integral part of sustainable water management and involves a wide range of stakeholders. Restoration refers to a large variety of measures and practices, which can vary considerably in size and complexity. These are aimed at restoring the natural state and functioning of the river system, lake or wetland to enable its sustainable and multifunctional uses. River restoration is thus an integral part of sustainable water management, and is also becoming more and more important in integrated river basin management. **Wetlands** improve water quality by trapping sediments, filtering pollutants and absorbing nutrients. Rivers, floodplains, lakes and wetlands perform financially and environmentally valuable functions related to the regulation of river discharge. Restoration measures can increase natural storage capacity and reduces flood risk by re-connecting brooks, streams and rivers to floodplains, former meanders and other natural storage areas, and enhancing the quality and capacity of wetlands. Environmental flow helps maintain downstream aquatic ecosystems. Human intervention has fragmented around 60% of the world’s rivers. The joint study of green and grey infrastructures constitutes a new paradigm. Natural Water Retention Measures provide a wide range of benefits for flood control and ecosystem services.

5.3.1.13. Integrated landscape management

A **landscape** is a social-ecological system that consists of a mosaic of natural and/or human-modified ecosystems, often with a characteristic configuration of topography, vegetation, land use, and settlements that is influenced by the ecological, historical, economic and cultural processes and activities of the area. (peoplefoodandnature.org). The mix of land cover and use types (landscape composition), their spatial arrangement (landscape structure) and the norms and modalities of its governance contribute to the character and functionality of a landscape, which as a mosaic usually includes agricultural lands, native vegetation, and urban areas. Depending on the management objectives of the stakeholders, landscape boundaries may be discrete, fuzzy or nested, and may correspond to watershed boundaries, distinct land features, and/or jurisdictional and administrative boundaries, or cross-cut such demarcations. Because of the broad range of factors a landscape may encompass areas of 100s to 10,000s square kilometers.

Integrated landscape management may encompass agricultural production, provision of ecosystem functions and services (such as water flow regulation and quality, pollination, climate change mitigation and adaptation, cultural values), protection of biodiversity, landscape beauty, identity and recreational value. Stakeholders seek complementary solutions to common problems and pursue new opportunities through technical, ecological, market, social and policy means that reduce trade-offs and strengthen synergies among different landscape objectives. Because landscapes are coupled socio-ecological systems, complexity and change are inherent properties in their management.

5.3.2. Omo-Sharma Sub-Basin Watershed Situation

5.3.2.1. Soils of Omo-Sharma Sub-Basin

The major soils of Omo-Sharma sub basin are *Dystric nitisols* (25.44 %), *Eutric fluvisols* (13.27 %), *Dytric cambisols* (10.02 %), Pellic vertisols (9.97 %) and so on (appendix 14).

5.3.2.2. Land Use Land Cover Classes of Omo-Sharma Sub-Basin

The patterns of LULC change for the year 2000, 2010, and 2021 have shown by the table below. It is revealed that agriculture was the predominant land use class (7,359.4 Sq. Km) in 2000 and covered about 33% of the total geographical area of the watershed followed by bush land coverage another important land cover type (6,313.8 Sq. Km) which occupied about 28.3% of the total land. Agricultural land and built up land coverage increased at an annual rate of 2.56 % and 7.8 % and reached to 25.6 % and 78.7 % in 2021 respectively. Negative changes occurred in another significant land cover type’s i. e. bare land, bush land, forestland and grassland and water bodies. Most of land under these land use/cover category converted into agricultural and built-up areas to support huge population pressure during this period. Process of urbanization enhanced the urban growth mainly through the migration as well as the natural increase of population in the study area.

Table 30: Area and percentage share of Land Use and Land cover classes (2000, 2010 & 2021)

LULC type	2000 Area Km2	%	2010 Area Km2	%	2021 Area (Km2)	%	Change b/n 2000 & 2021	%
Agriculture	7,359.39	32.98	9633.7279	43.18	9,895.59	44.35	2,536.20	+25.6
Bare soil	524.80	2.35	457.264	2.05	445.30	2.00	-79.50	-17.86
Built up	63.71	0.29	277.9822	1.25	299.18	1.34	235.46	+78.7
Bush land	6,313.80	28.30	6354.2601	28.48	6,300.52	28.24	-13.27	-0.21
Forest	5,069.23	22.72	3913.111	17.54	3,693.93	16.56	-1,375.3	-37.23
Grassland	1,594.80	7.15	496.7434	2.23	486.14	2.18	-1,108.66	-228
Plantation	473.55	2.12	616.1798	2.76	626.04	2.81	152.48	+24.35
Water body	339.73	1.52	264.1492	1.18	296.25	1.33	-43.48	-14.67
Wetland	572.74	2.57	298.3348	1.34	268.81	1.20	-303.93	-113
Total	**22,311.75**	**100.00**	**22311.752**	**100.00**	**22,311.75**	**100.00**		

Table 31: Classification Accuracy Assessment Report

	Class Name	Reference totals	Classified totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Year 2000	Agriculture	79	78	72	91.14%	92.31%	0.8973
	Bare soil	23	21	17	73.91%	80.95%	0.7945
	Built up	21	20	17	80.95%	85.00%	0.8393
	Bush land	59	57	53	89.83%	92.98%	0.9137
	Forest	50	49	45	90.00%	91.84%	0.9030
	Grassland	25	28	24	96.00%	85.71%	0.8448
	Plantation	19	21	17	89.47%	80.95%	0.7973
	Water body	19	20	17	89.47%	85.00%	0.8404
	Wetland	20	21	18	90.00%	85.71%	0.8475
	Totals	**315**	**315**	**280**			

Overall Classification Accuracy = 88.89% Overall Kappa Statistics = 0.8694

	Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Year 2010	Agriculture	77	78	69	89.61%	88.46%	0.8473
	Bare soil	24	21	16	66.67%	76.19%	0.7423
	Built up	23	20	17	73.91%	85.00%	0.8382
	Bush land	56	57	51	91.07%	89.47%	0.8720
	Forest	50	49	44	88.00%	89.80%	0.8787
	Grassland	25	28	23	92.00%	82.14%	0.8060
	Plantation	20	21	16	80.00%	76.19%	0.7458
	Water body	18	20	15	83.33%	75.00%	0.7348
	Wetland	22	21	18	81.82%	85.71%	0.8464
	Totals	**315**	**315**	**269**			

Overall Classification Accuracy = 85.40% Overall Kappa Statistics = 0.8289

	Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Year 2021	Agriculture	81	78	70	86.42%	89.74%	0.8619
	Bare soil	22	21	16	72.73%	76.19%	0.7440
	Built up	27	20	18	66.67%	90.00%	0.8906
	Bush land	60	57	54	90.00%	94.74%	0.9350
	Forest	47	49	44	93.62%	89.80%	0.8801
	Grassland	23	28	23	100.00%	82.14%	0.8074
	Plantation	20	21	16	80.00%	76.19%	0.7458
	Water body	16	20	14	87.50%	70.00%	0.6839
	Wetland	19	21	16	84.21%	76.19%	0.7466
	Totals	**315**	**315**	**271**			

Overall Classification Accuracy = 86.03% Overall Kappa Statistics = 0.8358

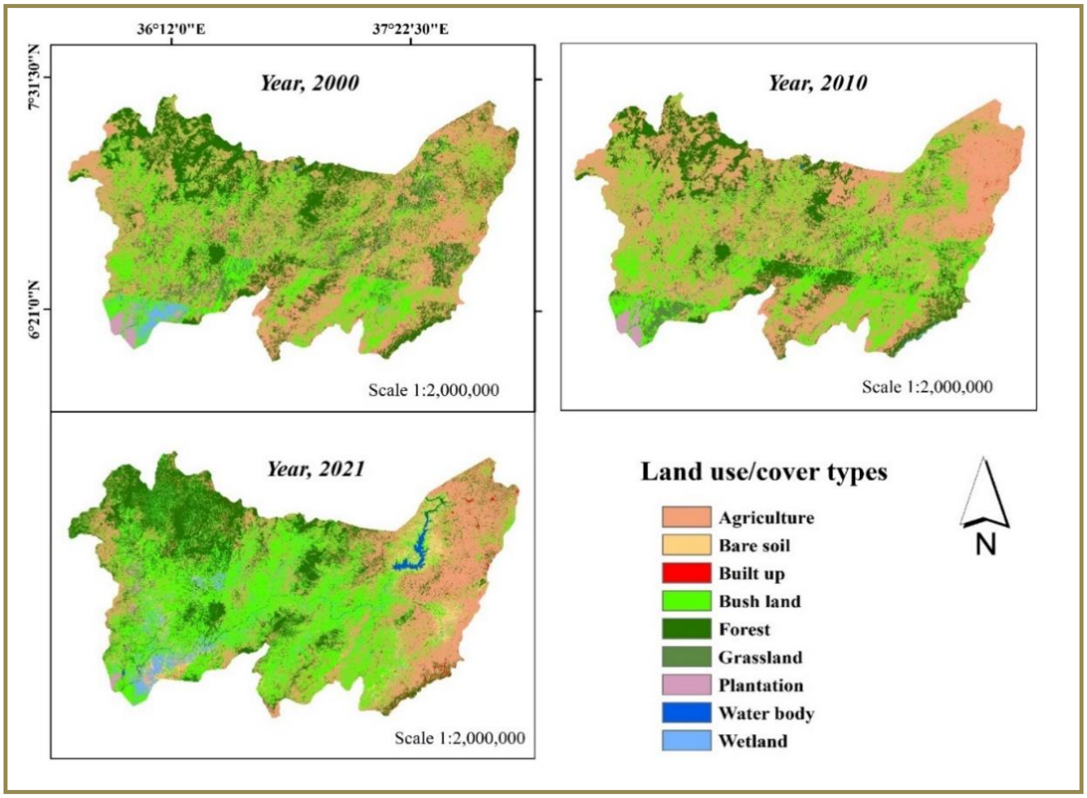


Figure 31. Land use/cover map of Omo-sharma sub-basin in 2000, 2010 and 2021

5.3.2.3. Land Degradation and erosion hazard assessment

5.3.2.3.1. Soil loss and sedimentation

In Omo-Sharma sub basin, the GIS-RUSLE based estimation (Girma and Gebre, 2020) in the SNNPR showed the annual soil loss ranging from 0 in flat terrain to 279 t ha-1 yr-1 in the steep slope central area and extended to the upper part of the basin. The mean annual soil loss is 69 t ha^{-1} yr^{-1} and the entire basin losses a total of about 89.6 Mt of soil annually. Compared with the tolerable soil loss limit (TSL), 26% (1,494,066.6 ha) of the entire basin area is by far higher than the maximum limit (18 t ha^{-1} yr^{-1}) determined by Hurni (1985). Most of the central parts of the Omo-Gibe river basin is characterized by steeply sloping terrain; hence higher soil loss was estimated in this area. Out of the total soil loss, 44% (highest amount) was contributed from Weyibe Zigna Zege subbasin where 35% of its slope exceeds 15^0 and the lowest amount (2.9%) was drown from Hamerkake Omo sub-basin where more than 95% of the sub-basin has a slope lower than 15^0. This denotes there was spatial soil loss variability and the influence of the combined LS factor for soil loss is significant in the central and upper part of OGRB than the lower part.

5.3.2.4. National Parks, Wildlife Reserves and Controlled Hunting Areas

Chebera Churchura national park is found on the western side of the central Omo Gibe basin, in between the Dawro zone and Konta Special Woreda of the SNNPRS, Ethiopia. The Park is fortunate in possessing numerous rivers and streams and four small creator lakes (Keriballa, Shasho, Koka) which are the reason for the rich wildlife resources of the area. So far, 37 larger mammals and 237 species of birds have been recorded in the different habitats (Highland & Riverine forest and savanna and bush lands) of the park. White-cliff chat, banded-barbet, wattled ibis, black-headed forest Oriole, and thick-billed Raven are endemic birds for the country. Common mammals include the African elephant, hippopotamus, Cape buffalo, lion, and leopard.

Currently, Chebera Churchura national park appears to be the least disturbed and reliable ecosystem for the African elephant and Buffalo in the country. The chebera Churchura national park is one of the best-preserved ecosystems in Ethiopia. The park keeps an important portion of wilderness and biodiversity. Mammals like the African elephant, hippopotamus, Cape buffalo, Lion and Leopard can be easily spotted. Currently, Chebera Churchura National park appears to be the least disturbed and reliable ecosystem for the African elephant and Buffalo in the country.

5.3.3. Lower Omo Sub-Basin

5.3.3.1. Soils of Lower Omo-Sub Basin

In the Lower Omo Sub basin 15 soil groups were identified. The major soils of Lower-Omo sub basin are *Eutric fluvisols* (33.55 %), *Chromic cambisols* (20.15 %), Chromic vertisols (13.69 %), *Dystric nitisols* (6.07 %), *Dytric cambisols* (4.48 %), *Haplic xerosols* (5.71 %), *Orthic solonchaks* (4.72 %), Leptosols (4.48 %) and so on (Appendix 15).

5.3.3.2. Land Use Land Cover Classes of Lower Omo Sub-Basin

In a classification algorithm, ten LULC classes are produced. These included; agriculture, bare-land, built-up, bush land, flood deposit, forest, grasslands, plantations, water body, and wetlands. The ten land use land cover types, area and percentage changes of Lower Omo Sub Basin across 2000, 2010 and 2021 are briefly presented in table below.

Table 32: Area and percentage share of Land Use and Land cover classes (2000, 2010 & 2021)

SN	LULC Type	2000 Area (SqKm)	%	2010 Area (SqKm)	%	2021 Area (SqKm)	%	Area of change b/n 2000 - 2021
1	Agriculture	1,776.96	6.71	3,128.89	11.81	3,285.68	12.40	1,508.72
2	Bare soil	3,709.09	14.0	1,342.33	5.06	1,958.46	7.39	-1,750.6
3	Built up	20.86	0.08	34.04	0.13	83.46	0.31	62.60
4	Bush land	10,175.58	38.40	14,783.85	55.78	10,936.44	41.27	760.86
5	Forest	4,848.28	18.3	1,223.50	4.62	1,202.47	4.54	-3,645.8
6	Flood deposit	77.41	0.29	1,812.00	6.84	2,118.07	7.99	2,040.66
7	Grassland	2,368.61	8.94	804.76	3.04	2,187.81	8.26	-180.8
8	Plantation	1,262.21	4.76	1,476.32	5.57	1,717.67	6.48	455.46
9	Water body	411.56	1.55	397.08	1.5	424.80	1.60	13.24
10	wetland	1,848.70	6.98	1,501.67	5.67	2,584.36	9.75	735.66
Totals		**26,499.23**	**100**	**26,499.23**	**100.00**	**26,499.23**	**100**	

The LULC analysis revealed a significant change in the proportions of the various LULC types from the year 2000 to 2021. Forest decreased from 4,848.2 sqkm in 2000 to 1,202.4 sqkm in 2021, indicating a 75% forest loss. In the same time, agricultural land increased from 1,776.96 sqkm in 2000 to 3,285.68sqkm in 2021, indicating an 85% increase. This is mainly due to expansion of agricultural area with increasing demand on investment land and population increments. This change was then propagated into the conversion of forestland to agricultural land.

The decreasing trend of change on bare lands is related the conversion to built-up and bushlands seem to be a transition from forest to agriculture. Built-up land on the other hand increased from 20.86 sqkm in 2000 to 83.46 sqkm in 2021, representing a 100% increase in built-up area. The trend showed that many rural villages have been expanded and increasingly growing by attracting different communities into the area. Grassland decreased rapidly between 2000 and 2010 but increased by 15% between 2010 and 2021.

The rapid decrease between 2000 and 2010 could be attributed to the rapid clearing of bush land for agriculture and the construction development that occurred in that time. The decline in bare land between 2000 and 2021 was due to its conversion to built-up and agricultural areas. Plantation areas are expanded as the result of the introduction of new state farms and private investment on agriculture between 2000 and 2021. This was due to conversion of watered areas to agricultural land through land reclamation and intensified irrigation.

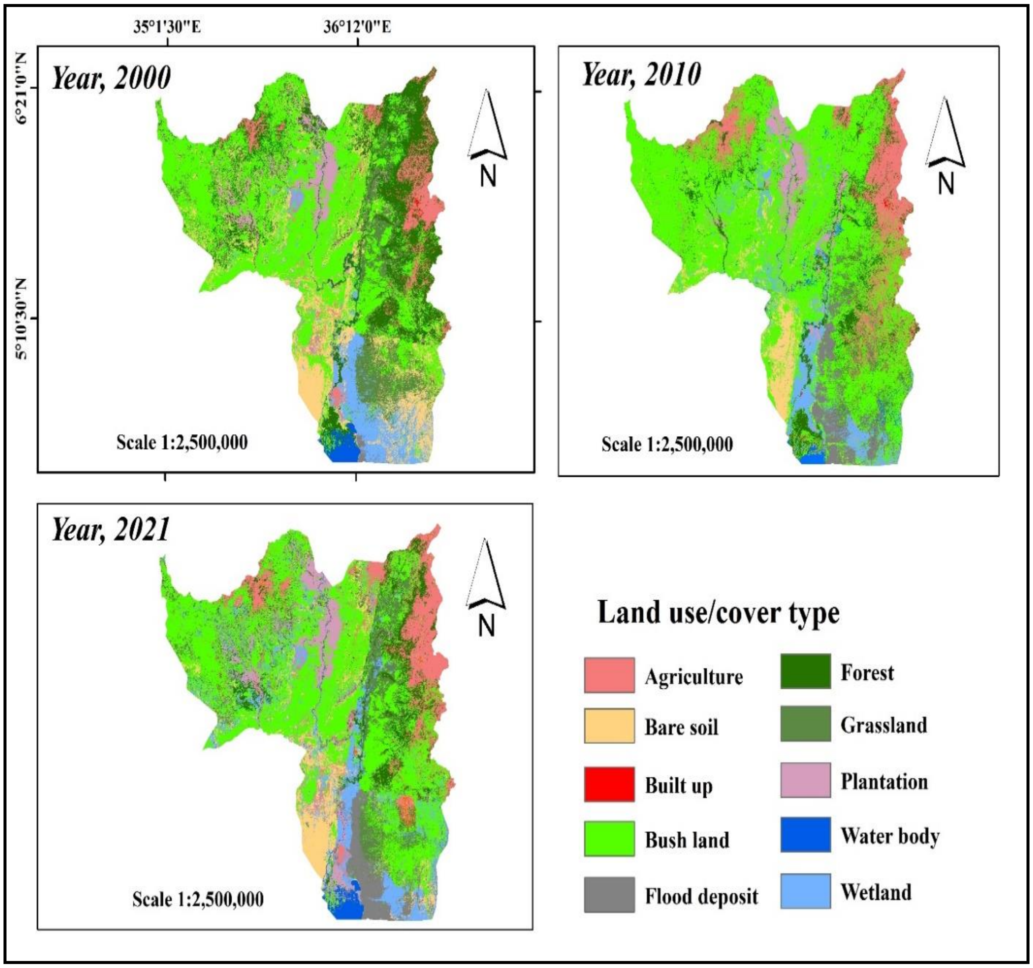


Figure 32: LULC Map of Lower-Omo Sub Basin

5.3.3.3. National Parks, Wildlife Reserves and Controlled Hunting Areas

National parks are protected areas of land for the protection of endangered plants, wildlife and their ecosystems, as well as sites of ecological beauty, historical heritage and indigenous cultures (Abate & Angassa, 2016; Mombeshora & Le Bel, 2009). Ethiopia's protected areas; particularly Omo National Park has been increasingly degraded due to land is being converted to settlement, subsistence and commercial agricultural practices such as sugar cane farm/plantation.

The natural resources and its product have been alarmingly degraded by the local community's influence for different purposes. The protection guarantee is not properly institutionalized and is not supported by local communities. The wildlife habitat of the park is strongly disturbed and some of the wild animals migrate to the neighbor countries national parks and Mago National Park. The Omo National Park is located between 35.380–36.140E longitude and 5.430–6.640 N latitude, with an altitude ranging from 500 to 1,541 m.a.s.l. It is found at 870 km southwest of Addis Ababa, and 324 Km far from the regional city of Hawassa. The park is the largest and most biologically rich in Ethiopia, and it was designated in 1966, but it was established in 1968 as a proposed National Park, it covers 4068 sqkm (Armaw & Molla, 2022). The national parks of the Lower Omo Valley in Southwest Ethiopia are among "the last unspoiled biodiversity hotspots in Africa" and constitute "resources of all people in the world." These are not the words of tree-hugging foreign environmentalists, but of Ethiopian government officials who recently prepared a report about the region. The Gibe III Dam and the sugar plantations associated with it are now putting these unique biodiversity hotspots at risk. The remote Lower Omo Valley is home to eight different indigenous peoples, three national parks and a World Heritage Site. According to the Ethiopian Wildlife Conservation Authority, the region preserves the "outstanding biodiversity of the country," with more than 300 bird and more than 80 large mammal species. It is a refuge for elephants, rhinos, lions, leopards, cheetahs, giraffes, buffaloes, gazelles and other species. The lands which have been designated as sugar plantations have been inhabited by indigenous peoples since time immemorial. The area has various geographical features; these include the Omo River, Maji Mountains, Sharum and Sai plains, ELilibai plains and Dirga Hills.

Vegetation composition includes savannah, riparian formation and deciduous woodland. The edges of the Omo River are covered by different tree species including *Tamarindus indica*, *Ficus sycamorus* and *salicifolia, Kigelia aethiopium, Phoenix reclinata, Terminalia brownii, Acacia polyacantha* etc. Besides, 325 species of birds and 75 species of mammals have been recorded so far in the park. A well-structured shrub layer combined with woody and herbaceous climbers provides dense cover along the edge of the Omo River (ONP annual report, 2018). Based on the ONP annual report (2018) since 2011, the ONP is the home for various tribes such as *Mursi*, *Surma, Chai, Nyangatom, Dizi, Me'en (Bodi)* and *Kwegu* tribes. But currently, it is home to only *Surma*, *Kwegu Nyangatom, and Dizzy*, the rest Mursi tribe was far away from the park due to the expansion of (KSF) kuraz sugar factories (ONP annual report, 2018).

The Omo National Park is under immense pressure as a result of the expansion of the Kuraz Sugar Factory and rapid population growth that resulted in illegal settlement and interferences (Armaw & Molla, 2022).

Mago national park is one of the parks in Ethiopia located in SNNPR of Ethiopia. It is about 782 km south of Addis Ababa and north of a large 90° bend in the Omo River. The Mago national park was established in 1979. The Mago Park covers area about 1869.95 km^2. Geographically, the park lies between latitude $05^0$20'- $05^0$50'N and longitude $36^0$00'-$36^0$30'E. The elevation ranges from 400 m.a.s.l on the plains in south, to 1,776 m on top of Mt Mago. The interior section of the park mainly consists of flat plains. However, periphery and boundaries, except to the south, are formed by the Mago and Mursi Mountains, associated ridges and chains of hills (Wola, 2023).

Mago national park is traversed by the permanently flowing Mago River and two of its tributaries, the Neri and Usno Rivers. The national park is bordered by three conservation areas: Tama Wildlife Reserve to the west, Omo National Park to the southwest and Murle Controlled Hunting Area to the south. Mago national park is surrounded by settled agriculturists and semipastoralists belonging to six tribal groups. The Park office is 115 km north of Omorate and 26 km southwest of Jinka. Its highest point is Mount Mago 2528 meters. All roads to and from the park are unpaved. The Mago River traverses through the middle of the park and goes on to link with the Neri River at Mago Swamp.

Mago National Park is on the route from Arba-Minch via Jinka to Lower Omo valley and it is a fascinating experience because of its isolated location and very few visitors and it gives a real feeling of how most of Africa was 50 years ago. The wildlife including most of the typical east African fauna and offers one of the wildest and most outstanding wildlife panoramas in Ethiopia. Mago National Park is considered an important habitat for animal populations particularly. Buffalo, Giraffe, Elephant (approximately 150), warthog, tiang, lewel's hartebeests, lesser-kudu. Greater-kudu, duiker, Burchell's Zebra, Swayne's Hartbeest, Oryx, Grant's gazelle, gerenuk, giraffe. Cheetah, wild dog, lions, leopards, guereza, common baboon and vervet monkey are common and conspicuous. The Mago National Park is home to some 81 larger mammals and 300 species of bird. Hippos are widely distributed in Mago National Park. Leopards/Panthers can survive both hunting pressure and habitat change like in Mago National Park. Although rare, Lions, Elephants, and African Buffalos still roam the plains of MNP. Unfortunately, Giraffes have almost disappeared from the National Park. (Africa-Expert.com) (Wola, 2023).

5.4. RISKS ASSESSMENT AND UNCERTAINTIES

5.4.1. Climate Change and its Impact in Omo Gibe River Basin

Ethiopia is one of the countries where climate change studies are rarely taking place because of different problems. One of the problems is lack of awareness between different societies regarding to climate change. To the contrary most African countries including Ethiopia are widely held to be highly vulnerable to future climate change and Ethiopia is often cited as one of the most extreme examples (Conway D. et al., 2011). Despite the prevalent view of Ethiopia 's high sensitivity, there have only been a few attempts to quantify the effects of climate change in different sectors like economy, hydropower, water supply availability of water in a basin and ecosystem.

In Omo Gibe river basin, Climate change poses a huge challenge to the basin and its people (USAID, 2015). This river basin has faced increasingly unpredictable rains, and sometimes the complete unseasonal rains-problems that are linked to climate change. According to Kemal and Teshome (2013) and USAID, 2015) traditional rural livelihoods in the area, including agriculture, pastoralism, and agro-pastoralism, are highly sensitive to climate variability and climate change because of their close links to the natural environment. Among others, climate change affects climate variables and trends which will have the capacity to alter the hydrological cycles. This leads to unexpected drought, frequent and flash floods, debris sow, and soil erosion are due to hydro-climatic variability and trend pattern variations.

The assessment of the climate change impact over hydro-climatic variables and trends represents an important issue for resources management. The observational records and climate projections provide abundant evidence that hydro-climatic variables and trends are dramatically changing and have the potential to be strongly impacted by climate change. Impact studies with hydrological models on the effects of climate change are important as they can indicate how the hydrological processes are likely to be affected and how strong they are going to be affected in the future in the area. Therefore, it alarms to upcoming water resource problems so that mitigation and adaptation strategies can be made ahead.

5.4.1.1. Trends in Meteorological Variables

The climate of Omo-Gibe River basin varies from a hot arid climate in the southern part of the floodplain to a tropical humid one in the highlands that include the extreme north and northwestern part of the basin. Intermediate between these extremes and for the greatest part of the basin the climate is tropical sub-humid (Abdella, 2013).

5.4.1.2. Trend and Changing Point of Temperature

The mean annual temperature was 22.64 ^{0}C, the mean minimum and the maximum temperature were 13.35 and 31.14 ^{0}C, respectively. The trend test result shows that the mean Belg, Kirmet, Bega season, and annual temperature exhibited a significant increase at change points in the year 1996, 2000, and 1999. The increasing temperature observed in the basin significantly impacts soil water demand and enhances the raising of evapotranspiration that makes more water loss (Anose et al, 2022).

The mean annual temperature in Omo-Gibe basin varies from 16 ^{0}C in the highlands of the north to over 30^{0}C in the lowlands of the south. The maximum temperature is higher at the southern part of the basin especially at Morka mean annual maximum temperature reaches up to 30.6 ^{0}C. There is a little variation in minimum temperature which varies from 9.2 ^{0}C in northern part of the basin example in Gedo to 16 ^{0}C in southern part of the basin at Jinka.

5.4.1.3. Trend and Changing Point of Rainfall

The Omo-Ghibe Basin experiences two rainfall regimes: mono and bimodal regimes. The middle part of the basin experiences an elongated monomodal rainfall pattern where the wet season extends from March to October (Degefu and Bewket 2013). The lower parts, Jinka, Omorate and Turmi in the basin experience bimodal rainfall occurring between March and May, and between September and November (MoWR 1996; Amsalu and Adem 2009; Degefu and Bewket 2013).

The mean annual rainfall was 1112.73 mm, ranging from 922.82 to 1289.81 mm. The Kiremt (JJAS) season is the primary rainy season, contributing 56.66% of the total rainfall. The Belg (FMAM) is the second rainy sea-son, contributing about 29.25% of the annual rainfall. In evaluating trends, mean seasonal and annual rainfall decreased in the basin. The Belg season rainfall decreased significantly by 2.97 mm/year. The Belg rainfall illustrated a significant downward at the change point in 1996 (Anose et al, 2022).

Rainfall in Omo-Gibe basin varies from over 1900 mm per annum in the north central areas to less than 300 mm per annum in the south. The amount of rainfall decreases throughout the Omo-Gibe catchments with a decrease in elevation. In terms of rainfall the regime can be summarized into four regions. The northern part of the basin, including Bako, Woliso, Wolkite, and south to just north of Jima, has rainfall for about seven months, from March to September with a range of 1100 – 1800 mm per annum. The small rains are from March to May and the main from June to September with a marked increase in July and August.

The north central area including Bonga, Jima and Sodo, has a more even distribution of rainfall over March to September with any peak in July and August. The region generally receives more than 1200 mm, rising to 2000mm on the western fringes north of Bonga. The Southern Central area, including Maji, Jinka and Sawula, has a prolonged rainy season of nine months. The amount varies from 600mm in the lower valleys to about 1800mm in the hilly areas around Maji and in the west. The far South of the basin is the area of bimodal rainfall with a pattern of February to July and September to October. Rainfall is low, less than 600mm and historically unreliable.

Study findings notified that the variability has been higher in the northern and central parts and decreasing towards the southern part of the Omo Gibe river basin to its southern part. Results also show that seasonal and annual mean temperatures have increased significantly in the recent two decades. The northern and central Omo Gibe river basin summer and autumn seasons' rainfall shows a statically insignificant positive trend. However, the basin has been experiencing less to high spatio-temporal seasonal and monthly rainfall variability. The decline in annual rainfall and rise in temperature affected the streamflow negatively.

Overall, the mean annual runoff and river flow observed an insignificant increasing trend in the entire basin. In general, the erraticity of rainfall, rising temperature, and the highest spatial and temporal variation of river flow and runoff witnessed in Omo Gibe river basin suggest that the basin water resource is at risk due to these reinforcing challenges, and much needs to be done by all the concerned actors to save water resources.

5.4.2. Flood Risk Assessment

Flooding is one of the most frequent and destructive environmental hazards that occur annually worldwide (United Nations International strategy for Disaster Reduction [UNISDR, 2015). The frequency and severity of flooding are also increasing in many parts of the world associated with population pressure, urbanization and climate change (Hirabayashi et al., 2013; Jongman et al., 2014). It causes physical suffering, economic losses, limit the efficiency of drainage, and disturb existence of life.

In Ethiopia, floods occur occasionally in all parts of the country, either as flash floods in the cities and highlands or in the form of downstream floods in large basins and lowlands. May be the worst flood disaster in the recent history of Ethiopia has occurred in August 2006 following heavy rains across East Africa. During this time, most parts of the country had flood incidents of a certain proportion. Dry streams in the east became full to a record level and the Omo River in the south ran out of its banks and inundated the surrounding regions. Several cases of flood occurrences and flood hazards were also reported from northwestern Ethiopia. While the floods were important to replenish soil nutrients, recharge soil moisture, and encourage high agricultural activity in many parts of the country, overflows in the Lower Omo basin killed 364 people, inundated 14 villages, and destroyed farmlands.

Flood hazards in every rainy season occur in different parts of Ethiopia. The existing land and water resources management system of the basin is adversely affected by the rapid growth of population, deforestation, and poor agricultural practices in combination with low adaptive capacity that entail a high vulnerability to adverse impacts of climate change. Communities in the downstream region of the catchment experience floods caused by heavy RF at upstream. Consequently, the unpredictable nature of the flooding combined with increased frequency and magnitude is resulting in crop failure and unprecedented human health impacts. The reasons provided for the increased frequency and magnitude of the flood events were attributed to land-use change (deforestation and over-cultivation) and climate change in the area (Kemal, 2013). The people around the Omo Gibe in general and downstream of the Omo river in particular still continue to practice traditional recession flood agriculture for crop production. Furthermore, the Omo river basin suffers frequent flooding that will affect crop production for significant period of time during the year.

According to Endalamaw (2015) a maximum of 19,000 ha in the lower Omo valley will be inundated for a depth of 2.5 m during the maximum peak flow. Moreover, the people are exposed to Malaria, different waterborne diseases, and benefited little from the economic development the country recorded in the last few years.

Figure 33: Flood Hazards in Lower Omo Sub Basin

5.4.3. Drought Risk Assessment

5.4.3.1. Temporal Evaluation of Drought Events in the Basin

In the basin for seasonal drought (SPI-4), moderate, severe, and extreme droughts occurred for 21, 15, and 6 years, respectively, whereas in 1987, 1991, 1994, 2000, and 2002 extreme droughts occurred. For annual drought (SPI-12), moderate, severe, and extreme droughts were found for 18, 14 and 3 years, respectively whereas in the years 1988, 2002, and 2003 extreme droughts were observed. For seasonal drought (SPEI-4), moderate, severe, and extreme droughts occurred for 25, 17 and 3 years, respectively, while extreme droughts were exhibited in 1991, 2002, and 2009. For annual drought events (SPEI-12), moderate, severe, and extreme droughts were detected for 18, 9, and 1 year, respectively, while in the year 1988, extreme drought was observed (Anose et al, 2022). The number of drought duration months shown in 12-month timescales was 78 and 88 for SPI-12 and SPEI-12, respectively, throughout the study period. In the basin, 1988, 1999, 2000, 2002, 2003, 2012, 2015, and 2016 were the driest years common in both indi- ces and in different timescales.

During the study period, the basin experienced 12.6% to 20.36% moder- ate and above moderate drought frequencies. In SPI-4 and SPEI-4, severe drought events were observed in the basin on March 2000 and July 2009, with the severity peak values of − 2.61 and − 2.24, respectively. For SPI-12 and SPEI-12, the basin experienced extreme drought in May 1988 (in both indices) with a severity value of − 3.13 and − 2.10, respectively (Anose et al, 2022)..

5.4.3.2. Duration and Frequency of Drought Events Distribution in the Basin

According to Anose et al, (2022), the duration and frequency of drought occurrence from moderate to extreme drought values were calculated for the Omo Gibe River Basin based on the threshold value (SPI/SPEI ≤ -1) in the whole study period. The duration of moderate drought events ranged from 34 to 62 for SPI/SPEI-4 and from 29 to 68 for SPI/SPEI-12. The duration of severe drought events ranged from 12 to 29 for SPI/SPEI-4 and 9 to 47 for SPI/SPEI-12. The duration of extreme drought events ranged from 2 to 20 for SPI/ SPEI-4 and from 0 to 18 for SPI/SPEI-12. The drought frequency was higher for SPEI-4 and SPEI-12 than SPI in both timescales. The higher frequency of drought events was exhibited for SPI-4 and the SPEI-4 almost in all parts of the southern sub-basin. The highest drought frequency was observed for different timescales in the southern part and decreased towards the northern and central parts of the basin.

Table 33: Range of duration (number of months) of moderate, severe, and extreme drought events in the sub-basins

Sub-basin	Drought category	SPI-4	SPEI-4	SPI-12	SPEI-12
Northern (Gibe-Gojeb)	Moderate	37–47	43–55	31–45	42–61
	Severe	14–29	21–25	9–41	9–32
	Extreme	5–15	2–6	6–17	1–9
Central (Omo-Sharma)	Moderate	33–54	46–55	29–62	35–59
	Severe	12–23	17–24	9–21	16–26
	Extreme	3–18	2–7	1–16	0–12
Southern (Lower Omo)	Moderate	34–57	47–62	38–48	38–68
	Severe	16–29	17–29	8–47	19–22
	Extreme	8–20	3–7	5–18	0–14

5.4.3.3.Temporal and Spatial Variation of Drought Characteristics in the Basin

5.4.3.3.1. Drought Characteristics in Gibe-Gojeb Sub-Basin

In this sub-basin of the basin, the most extended continuous duration (13-months) of drought event was observed at the Gibe Farm station for SPI-4, while 59 series months of drought duration were observed at the Gedo station SPI-12. Sixteen months of continuous drought events were observed at the Gedo station for SPEI-4. The most prolonged continuous drought duration (69-months) was observed in this sub-basin at the Wolkite station for SPEI-12. During the last 15 years, the droughts were longer and more intense than in the first 15 years period. In the northern part of the basin, the highest magnitude and intensity were observed at Gedo and Ambo stations − 84.88 and — 1.68, respectively.

5.4.3.3.2. Drought Characteristics in Omo-Sharma Sub-Basin

In Omo-Sharma sub basin, the most prolonged duration of drought event for SPI-4 was 14 months, which was shown at the Bonga station, while for SPI-12, 23-months of duration was observed at Yayaotona stations. In the central part, the most extended drought events for SPEI-4 were 20 months observed at Bele station, whereas for SPEI-12, the most extended continuous drought duration of 34 months was observed at Bonga station. In this sub-sub basin, the highest magnitude and intensity are shown at Bonga and Shebe stations of − 44.4 and − 2.24, respectively. The magnitude of drought events in this sub-basin was less than in the Gibe-Gojeb and the Lower Omo sub basins because the Omo-Sharma sub-basin is a humid region compared to the other parts of the basin.

5.4.3.3.3. Drought Characteristics in the Lower Omo Sub-Basin

In this sub-basin, the most extended duration of drought events for SPI-4 was 11 months, observed at Jinka station, whereas for SPI- 12 months, 53 months drought duration was observed at Sawla stations. The magnitude and intensity were enormous in these semi-arid and arid parts of the basin. In this sub- basin, long and intense drought events were observed from 1999 to 2015. In this sub-basin, the highest magnitude and intensity of droughts were shown at Sawla and Jinka stations, respectively. Moreover, the highest peak values in this sub-basin ranged from -3.02 to − 4.89.

The occurrence of drought during the wet seasons has caused significant socioeconomic and environmental problems, particularly in the south Omo lowlands, where drought is more recurrent. For instance, the occurrence of droughts in the southern lowland parts during the main rainfall (March–May) season often causes significant damage to the pastoral agricultural system and livelihoods in the area. The frequent occurrence of drought in this part of the basin has evidently been the underlying cause of chronic water and pasture shortages, which often result in mass livestock deaths, food shortages and infiltrate the usual patterns of pastoral seasonal migrations.

The chronic shortage of pasture and water has sometimes caused conflicts between pastoral communities due to the increasing competition for these resources (Gebremichael et al. 2005; WFP 2010; Gebresenbet and Kefale 2012). Other studies also reported the occurrence of conflicts between the Hamer people and the Omo-Mago national park and at times cross border conflicts between Ethiopia's Dasenech and Nyagatom ethnic groups and Kenya's Turkana and Gerba ethnic groups due to increasing competition for pasture and water resources (Amsalu and Adem 2009; South Omo Zone Agricultural Office 2012; Yntiso 2012).

5.4.3.4. Seasonal and Annual Trend Analysis of Drought Events in the Basin

The deficiencies have impacts on both surface and groundwater resources and lead to reductions in water supply and quality, agricultural productivity, and hydro-electric power generation and wetland habitat functions. The socioeconomic and environmental impacts of droughts are determined by their intensity, frequency, duration and spatial coverage (Bannayan et al. 2010). Droughts in the upstream part of the basin have also caused significant negative impacts on water availability of downstream and the level of Lake Turkana (MoWR 1996).

The reduction of water flow and limited flooding contributes to food insecurity among the Dasenech and Nyangatom pastoral communities who practice flood recession maize and sorghum production as a supplementary source of income to their flood plain use as pasturelands for their livestock (Gebremichael et al. 2005; Amsalu and Adem 2009; WFP 2010; Gebresenbet and Kefale 2012). Moreover, understanding the drought conditions in the head watershed is also very important for early warning response and food security management for the pastoral communities (Dasenech and Nyangatom) that depend on the downstream flood recession agriculture and pasture for their livestock (Amsalu and Adem 2009; Yntiso 2012). According to Anose et al (2022), the seasonal trend of drought indices in the basin was drawn by using both Z value and sens slope estimators. The negative value of Z represents a drying tendency and vice versa. All stations depicted a drying trend in the Belg (FMAM) season for SPI-4. Among these stations, Ambo, Bele, Bonga, Gedo, Jimma, Sawla, and Wolkite stations exhibited a significant drying trend. In the Belg season for SPEI-4, all stations showed an increasing drying trend.

The Belg season for SPEI-4, including Gibe Farm and the previous seven stations, depicted a significant increase in drought. The slopes of the drying rate at these eight sta- tions were − 0.045, − 0.42, − 0.05, − 0.03, − 0.05, − 0.04, -0.001 and − 0.05/year, respectively. All stations showed a drying trend for SPI/SPEI-4 in the Kiremt (JJAS) season except for Gibe Farm and Morka stations. However, these two stations showed an insignificant wetting tendency. In Kremt (JJAS) season, Ambo, Bonga, and Sawla stations depicted a significant increasing drought trend for SPI-4 and SPEI-4.

The Bega (ONDJ) is the second rainy season for the southern part of OGRB. For SPI-4 of Bega season, Buta- jira, Jinka, Morka, and Yayaotona stations illustrated decreasing drying events. In comparison, the rest of 70% of stations in the basin showed a drying tendency. In the Bega season (SPEI-4), except Jinka and Sawla station, 84% of the stations showed an increasing trend of drought events. However, a significant increase in drought was observed in Gibe Farm and Sawla for SPEI-4.

The annual drought trend evaluation for the SPI-12, a significant increasing trend was observed at Ambo and Sawla stations. For SPEI-12, a significant increase in drought tendency was observed in Ambo, Bonga, Jimma, Sawla, and Wolkite stations. The result of the trend analysis for SPI/SPEI-12 depicts the increase of drought events in the entire basin. This annual drought affects almost all the determinants of the hydrological cycle in the area.

5.4.3.5. Drought Impacts in the Basin

Drought is a climate phenomenon that has significant effects on environmental processes and human activities (Sheffield et al. 2009). In 2011, a widespread drought occurred over the Horn of Africa, affecting over nine million people in Ethiopia, Somalia and Kenya. Spatial distribution of drought episode indicates the southern, southeastern and northeastern parts of Ethiopia are most frequently affected by droughts and famines that occurred during the second half of the twentieth century (Webb et al. 1992). Viste et al. (2013) reported that drought and associated food shortages have occurred every year from 1999 to 2011, except 2001, over Ethiopia and other countries of east Africa.

Past droughts caused significant negative effects on human life and socio-economic development of the country. The greatest loss of life associated with drought in Ethiopia occurred in 1973, 1974 and 1984, while the greatest number of affected people was in 2002 (14.2 million affected, over 20% of the total population of the country) (World Bank, 2007). Evidence from empirical studies shows that drought episodes in Ethiopia are highly associated with crop damage and food insecurity in drought affected parts (Kiros 1991; Webb 1993; Kloos and Lindtjorn 1994; World Bank, 2007). The effects of droughts both on crop and livestock productions are often exacerbated by other drought induced phenomena, such as disease epidemics and insect infestations (Kiros 1991). Past drought episodes significantly affected rural communities that depend on small-scale rain-fed agriculture (Kloos and Lindtjorn 1994; Meze-Hausken 2000).

Figure 34. Drought Hazard in South Omo Zone, OGRB

5.4.4. Landslide

Landslide activity is very common particularly in the Highlands of Ethiopia. In the northern, western and southern highlands of Ethiopia the resulting damage due to landslides has been increasing due to various natural and man-made factors. Several studies have been conducted following various qualitative, analytical and empirical approaches to assess the causes and factors that trigger landslides in different parts of the highlands of the country. Study conducted in Betto, Goffa district, North Omo Zone, Southern Ethiopia suggest that the main cause for landslide hazards is identified to be the existence of old landslides on steep slopes that was covered by deeply weathered, closely jointed or sheared basaltic rocks (Getachew Lemmesa *et al.* (2000). There are different causative factors for evaluating landslide hazard easily and quickly. The major inherent causative factors of slope instability include; geology, slope morphometry, relative relief, land use and land cover and ground water conditions.

The landslide hazard zonation study conducted in the upper and middle streams in the basin indicated that most of the area fall under High Hazard or Moderate hazard zones (Engdawork et al, 2009). This assessment was made on the basis of geological factors and rating them based on their influence on landslide by using the landslide hazard evaluation factors (LHEF) rating scheme. Due to the geomorphological settings in the north east and north central parts along the river belts in the basin most of the slopes fall under the high or moderate Hazard zones. Therefore, the chances of slope failures are high in these areas. This implies that chances of slope failure within High Hazard Zone are high and the infrastructure section within this zone is likely to be affected by landslide activities.

5.4.5. Climate Change Impacts and Adaptive Strategies in the Basin

The Ethiopian government is making efforts to remedy these adverse conditions and has devised coping mechanisms of green economy program throughout the country. Some of these efforts have led to strategies that have induced changes in the attitudes of affected local communities. Despite these, it harms the country in countless ways by increasing existing threats and putting pressure on the environment. In combination, these adversely affects different sectors, like agriculture, ecology, infrastructure, disruption to human activities, loss of property, loss of lives and disease outbreak (UNICEF, 2015). For instance, currently the frequency of flash floods and drought have markedly increased all over Ethiopia and cause physical suffering, economic losses, limit the efficiency of drainage, and disturb the existence of life (Sintayehu, 2015). It is also expected to increase the risk in the future because of CC, population densities, deforestation, unsustainable farming practices, limited modernized protection and prevention (UNICEF, 2015 and Simane et al., 2016).

In Upper streams: Climate change affects the function and operation of existing water infrastructures including hydropower, structural, drainage and irrigation systems as well as water management practices. The existing land and water resource system of the area is adversely affected by the rapid growth of population, deforestation, surface erosion, and sediment transport and climate change impacts. Climate change increases the vulnerability of poor people, affects their health and livelihoods and undermines growth opportunities crucial for poverty reduction Extreme events due to anthropogenic climate change would cause forced migration and human resettlement resulting in the damage of the social cohesion including the loss of human lives and physical properties.

In order to maintain the sustainability of environment, communities should follow adaptive strategies and various techniques proposed at various levels. However, it always demands simpler techniques to uphold the problem. Sustainable land use planning that brings practical experience to solve environmental problems such as land degradation and land slide in response to climate resilience ecosystem reduction and better sustainable environment including climate change adaptation and mitigation should be considered.

In down streams: The increase in global temperature resulted in warming of ocean waters (Indian Ocean) particularly quickly. The rising air above it subsequently loses its moisture through rain sooner, moves west and descends over East Africa, bringing with it extremely dry conditions that particularly affect Ethiopia and Kenya (Williams and Funk 2011). Rainfall in these countries is predicted to continue to decrease, given the trend of increasing global temperatures. An April 2012 Climate Trend Analysis by USAID’s FEWS NET (Famine Early Warning Systems Network) states that Kiremt and Belg (entire growing season) rainfall have fallen by 15-20% across parts of southwest Ethiopia. Reductions in Belg rainfall have been especially significant which increases risks of growing long cycle crops, including sugarcane. Such reductions in rainfall are associated with lower agricultural harvests and worsened rangeland conditions, increasing people’s vulnerability.

6. BASIN ISSUE IDENTIFICATION, ANALYSIS AND PRIORITIZATION

Basin issues were identified and analysed by the relevant stakeholders in the basin through consultations. Issue prioritization was conducted by using multi-criteria analysis method.

6.1. BASIN ISSUE IDENTIFICATION AND ANALYSIS

6.1.1. Water Quantity Decline in the Basin

In omo gibe river basin, the quantity of water has been declined due to several socio-economic and bio-physical factors. Issues affecting water quantity in the basin are explained below.

i. Socio-Economic Factors

Population of the Omo Gibe River Basin is increasing from time to time. Most of rural communities in the basin are being urbanized fastly. Besides, huge investments are expanding mainly in the lower part of the basin. The pastoral and semi-pastoral communities in the Lower Omo sub basin are changing their life style to settle in villages. Population growth requires providing basic infrastructure like power, roads, communications, water supply, sanitation, schools, health centers and others. Development and provision of such basic infrastructures need additional amount of water. This indicates that socio-economic factors greatly affect the availability of water resources in the basin.

ii. Inefficient Irrigation and Increasing Irrigation Water Demand

The demand for irrigation development is a vital issue and the most top priorities in the basin. The use of irrigated farming in the basin is practiced both as state owned and farmers owned; irrigation is mainly practiced in the low land areas of the basin. For most of the irrigation land, surface water is abstracted from rivers. Most of existing irrigation system is flooding and furrow which has low water use efficiency. The use of water for irrigation in the basin does not consider the downatream water requirements for other purposes like environmental flow.

In general, irrigation development in the basin is affected by: Topographic features of the upper and middle parts of the basin; Lack of or inadequate baseline studies, data and information on potentials of different areas for the development of water resources; Poor technology choice; Property rights; Too small landholdings; Conflicts in water use and use rights; Marketing and market access; Institutional arrangements and instability; Lack of training to handle technologies; Lack of start-up capital or access to credit to initiate venture; Poor linkage between research and extension in the area of irrigation water management; Lack of water resource infrastructure and innovation; Gender disparities; Lack of resources for maintenance of irrigation structures; Resistance to the adoption of new technologies; Poor irrigation water management-related service delivery, particularly for small-scale farmers; Frequent drought leading to rapid depletion of some water resources; and Weak irrigation water use associations.

iii. Climate Change

Climate change has an impact on day to day human activities and natural phenomena which affect the global and regional economic and social wellbeing. Ethiopia is one of the impacted countries due to its dependency on rain feed agriculture. The basin is one of the sufferer of climate change and variability affecting up to community level. Climatic change is commonly described by characteristics of rainfall, temperature, evapo-transpiration, drought, flood and other related aspects. Such characteristics determine seasonal classification, water availability, type and potential of agricultural production, water consumption manner and others. These characterstics have an influence on water availability in the basin. Therefore, consideration of climate change impact in omo gibe river basin planning is very important.

iv. Buffer Zone Degradation

In Omo Gibe River basin, different anthropogenic actions like human settlement, small scale agriculture, grazing, urban construction and enclosure for private purposes are the predominant situations of river banks. This shows that all major rivers in the basin do not have buffer zone demarcation and protection. Thus, paying attention for buffer zone protection in basin plan development is very crucial.

v. Wetland Degradation

Wetlands in the basin have been improperly managed. They have been changing into farm lands. Consequently, siltation and sedimentation in the lakes and rivers is increasing from time to time. A number of wetlands in the basin need immediate action for protection and restoration. Hence, water resources allocation and management must consider wetland conservation and rehabilitation in the basin.

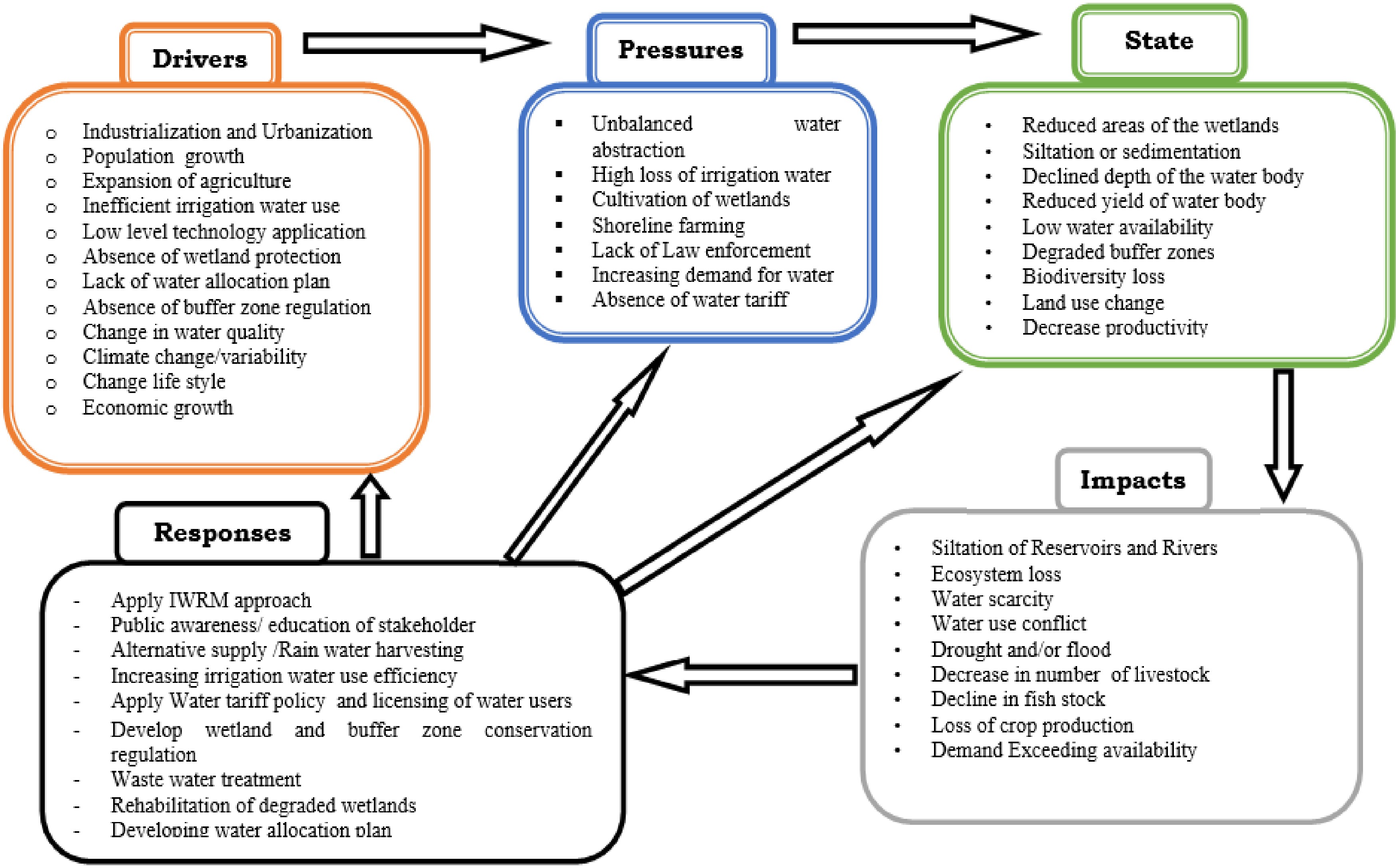


Figure 35 Analysis of Water Quantity Decline by DPSIR

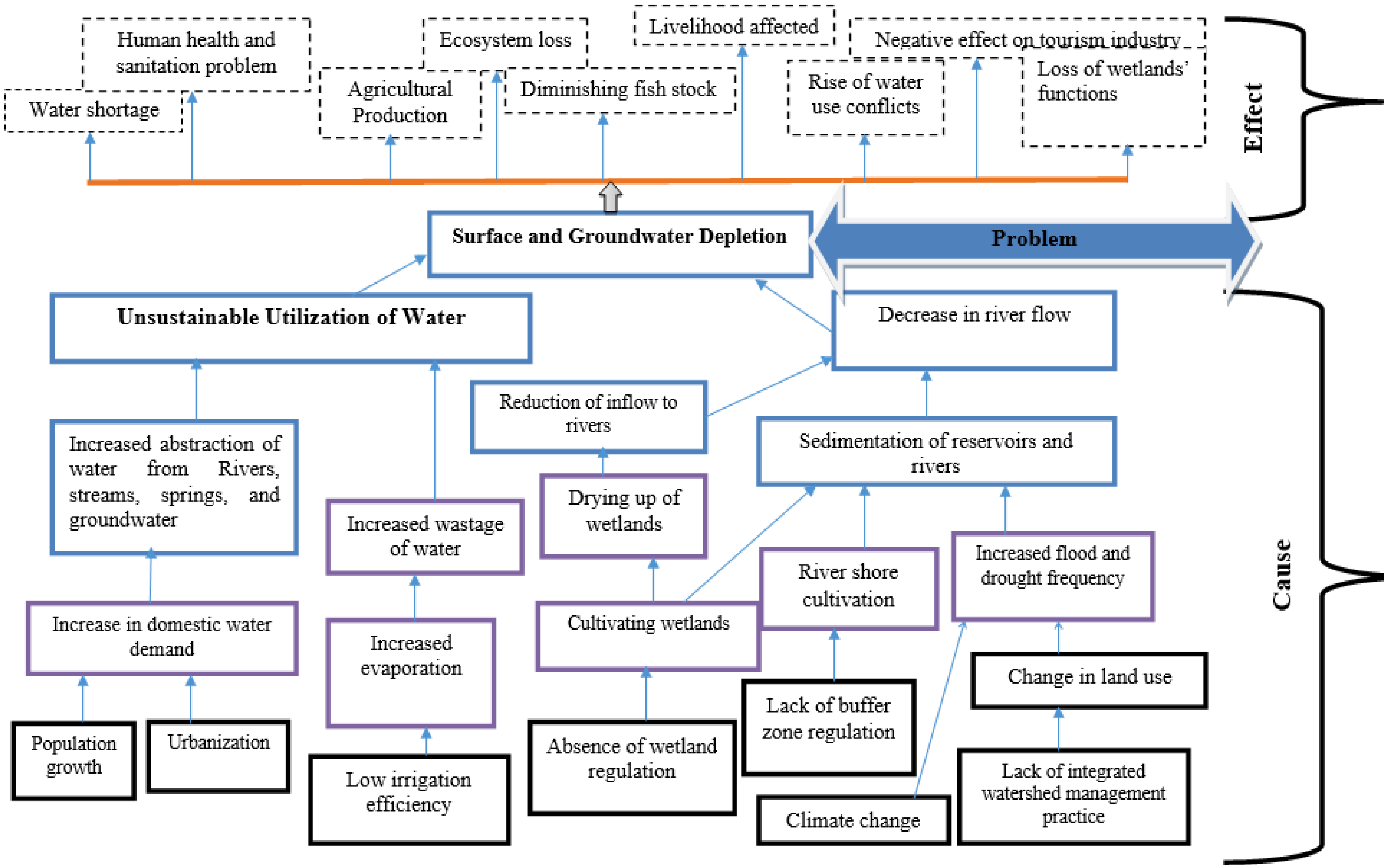


Figure 36: Problem tree for cause and effect relationship of water quantity decline

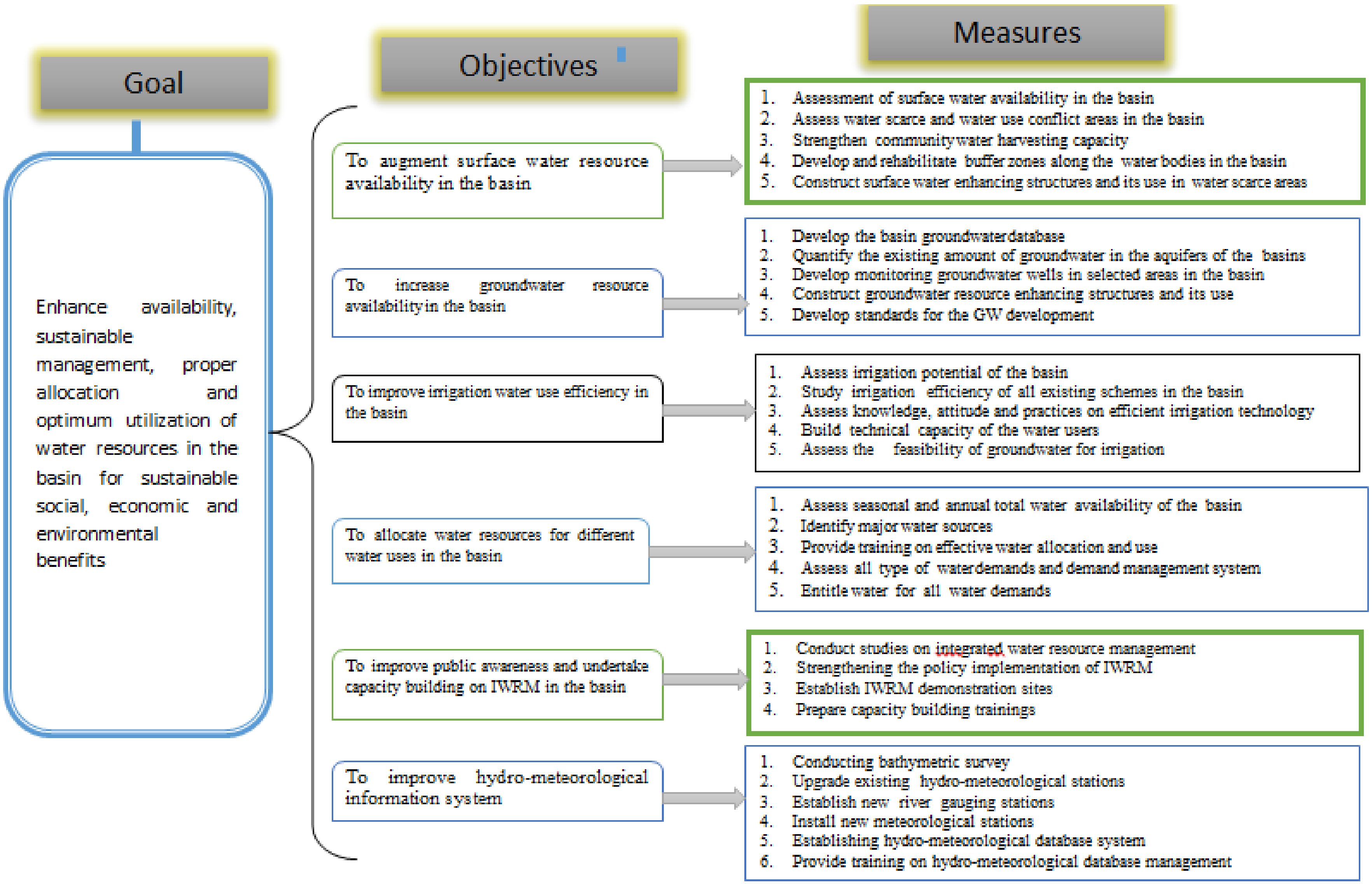


Figure 37 Objective tree for water quantity decline

6.1.2. Water Quality Deterioration

Issues affecting water quality in Omo Gibe River basin are socio economy, liquid and solid waste, wetland degradation, agricultural practice and river bank farming.

Socio Economic Factors

The landscape of the basin has been threatened due to socio economic factors like rapid population growth, resettlement, expansion of agricultural and irrigation activities resulting in poor water quality in the basin.

Agricultural Practice

The rapid expansion of agriculture led to conversion of natural or native vegetation to cultivated agricultural systems. Such changes to land use and agricultural practices have significantly increased leaching of chemicals to surface and ground waters. Livestock production practices, including riparian grazing, confined feeding operations, and manure management can also impact water quality.

River Bank Farming

Buffer zones should surround the upland portion of the core habitat to protect the terrestrial and aquatic habitats from surrounding land use practices that could damage these areas. Currently, almost all of perennial irrigation farmlands are found within the vicinity of the rivers in the basin. This results in intrusion of chemicals from the farmlands to the rivers.

Liquid and Solid Waste Discharge

Domestic solid waste, domestic waste water, municipal waste and diffused non-point pollution from agricultural land are the main sources of water pollution in the basin. Point sources from industries and public institutions like hospitals, universities, commercial centers also affect the water quality in the basin.

Wetland Degradation

Wetlands protect water quality by serving as biological filters (a natural water treatment plant) absorbing and fixing certain chemical and mineral contaminants that would otherwise flow directly into Rivers, Streams, and the reservoirs. Agricultural activities on wetland areas are converting swamps to agricultural land with long-term drainage and cultivation reduces the diversity of the wetland habitat; wetland species and replaced by non-wetland species. This has great impact on the quality of river water in the basin.

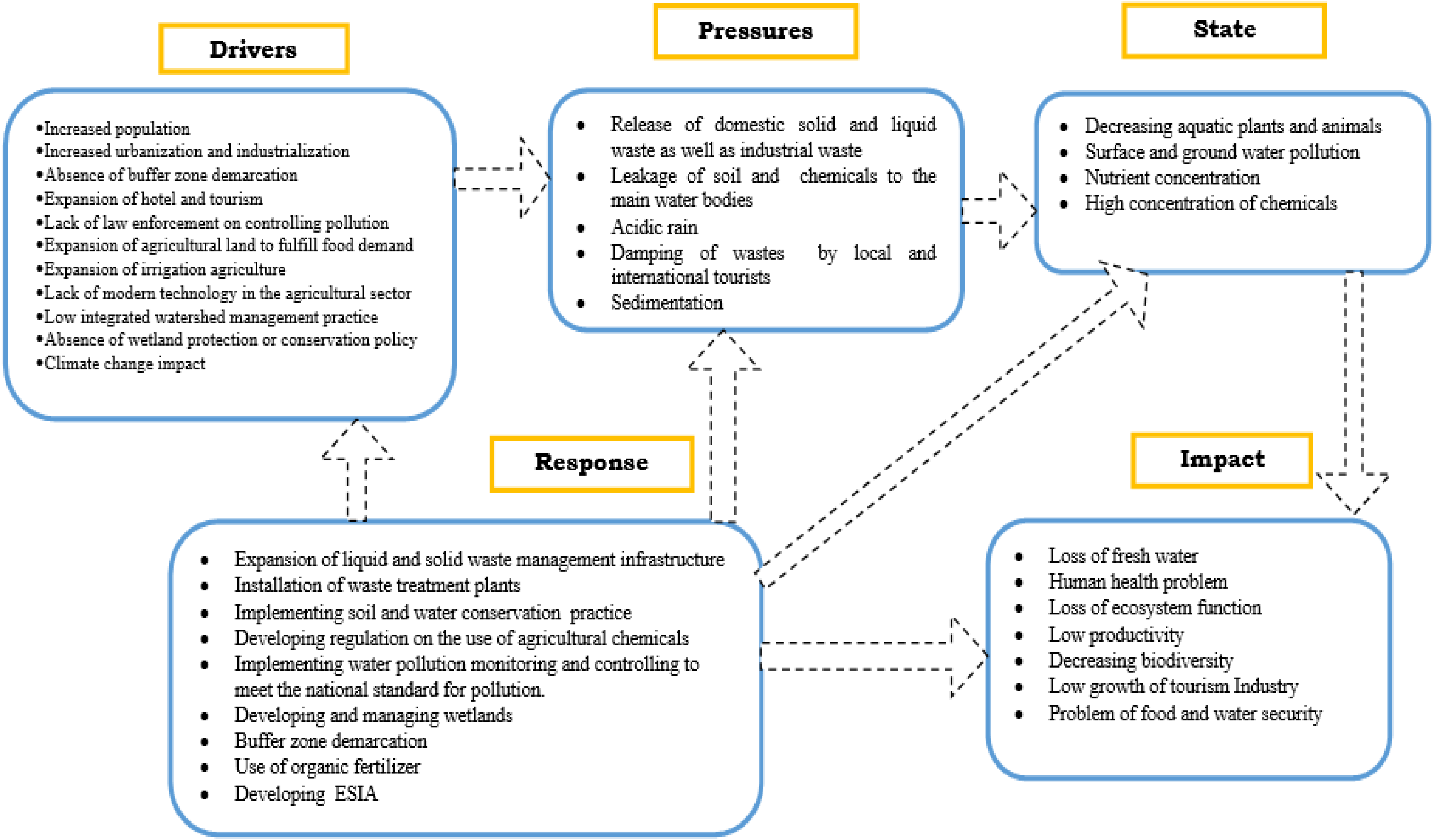


Figure 38 Analysis of water quality decline by DPSIR

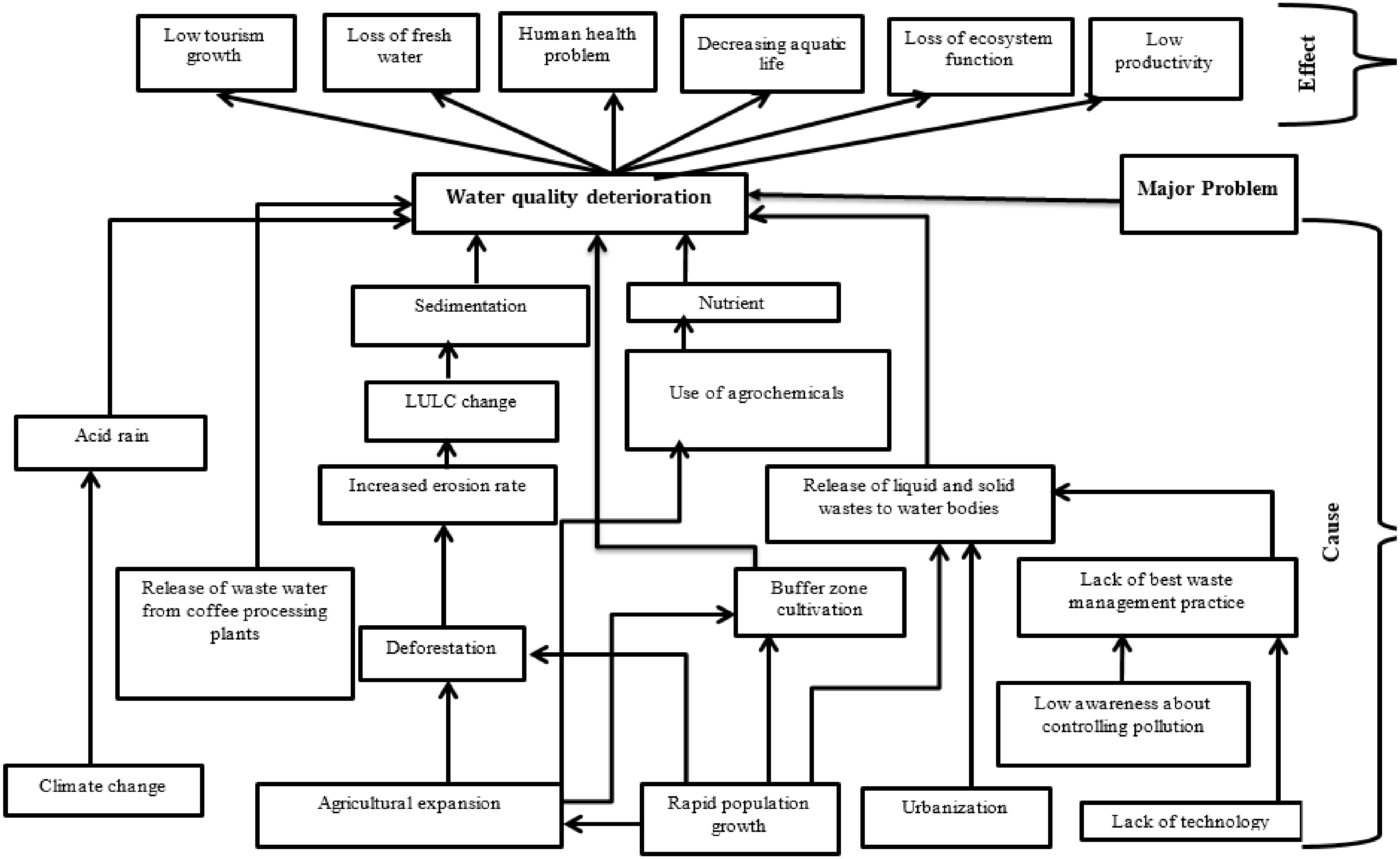


Figure 39 Problem tree for cause and effect relationship of water quality decline

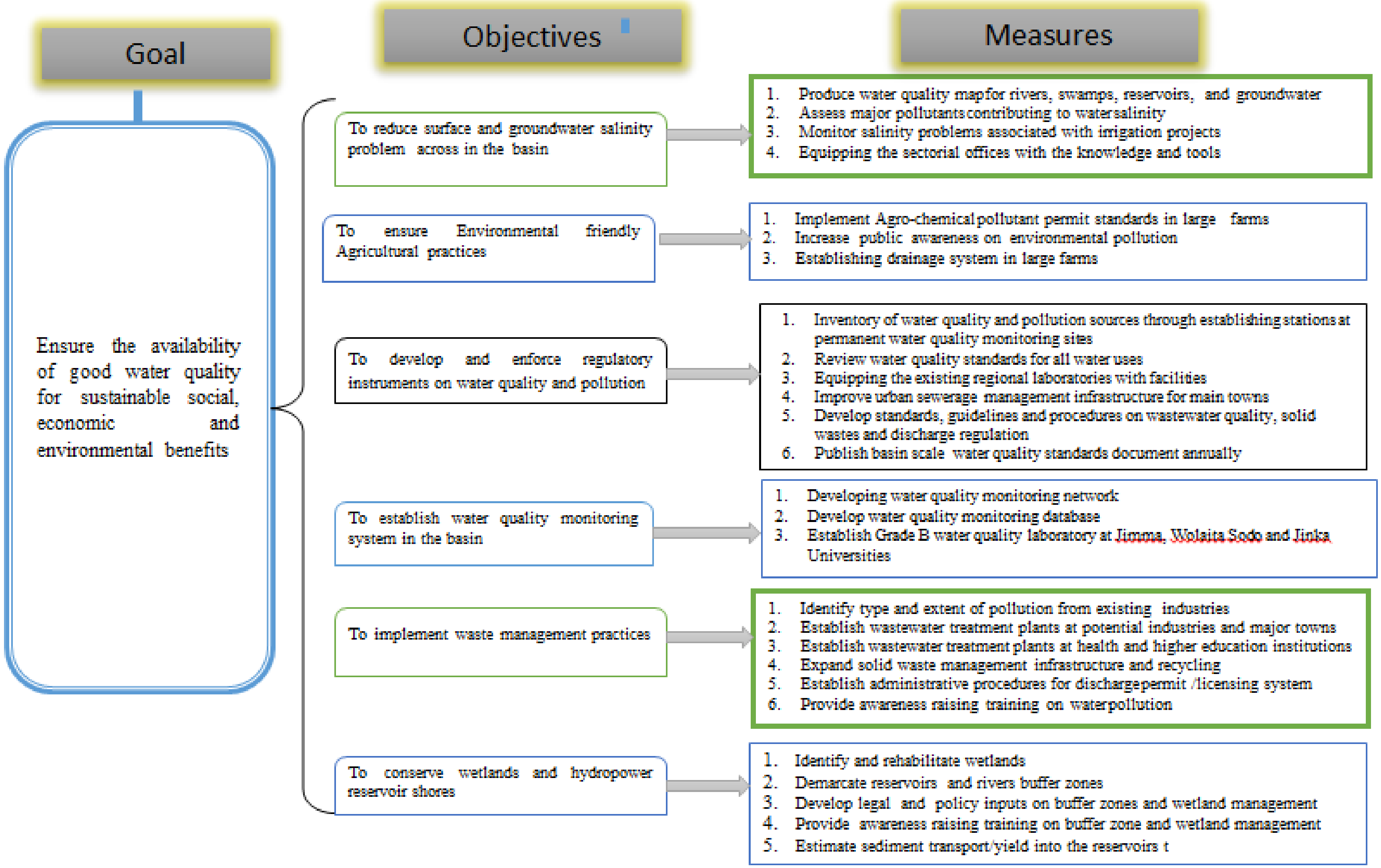


Figure 40 Objective tree to improve water quality in basin

6.1.3. Watershed Degradation

Watershed degradation is the loss of land value over time, including the productive potential of land and water, accompanied by marked changes in the hydrological behavior of a river system resulting in inferior quality, quantity and timing of water flow. In Ethiopia, watershed degradation has become a major environmental hazard and caused significant damages both in the natural environment and the development of human society (Moges and Bhat, 2020). Watershed degradation can have various forms: viz., depletion of water resources, soil erosion and land degradation, impoverishment of the vegetative cover, and damage to the infrastructure (Haregeweyn et al., 2015).

Nowadays, most parts of the basin are facing extreme watershed degradation due to the following factors but not limited due to lack of awareness, population pressure, lack of policy issue and law enforcement, poor agricultural practice, increased deforestation, overgrazing, land use change and soil erosion, intensive cultivation, climate change, rainfall and temperature variability and other human actions. According to many scholars, the most common types of watershed degradation are ecosystem alteration such as deforestation, land clearing, weed invasion, introduction of animal pests, and loss of wetlands; soil erosion and deposition viz., water erosion, wind erosion, siltation and sedimentation, mass movement of soil; and soil degradation like soil salinity, acidity, compaction, fertility, pollution and water logging.

6.1.3.1. Root Causes of Watershed Degradation in the Basin

Lack of Awareness/ Education and Training

Unawareness of government policies on soil and water conservation has immensely contributed for watershed degradation. Farmers independently cultivated on steep slopes with poor agronomic practices based on traditional knowledge for their livelihood. Many residents are unaware about the impacts of their activities on the watershed degradation. New generations of people do not realize what they have lost. They are not aware of the way things used to be here. Low level of awareness of the society about the linkage between watershed and livelihood improvement is coupled with poor participation of farmers in the planning and management activities of watersheds.

Population Pressure /Population Density

Population pressure is one of the underlying causes for deforestation in highlands. Increasing population pressure leads to increased demand for farm land and forest resource for fuel and home construction. The ever increasing population is a driving force for increased deforestation. Our growing population is putting pressure on land, leading to poor quality of productivity, deforestation (the loss of forest land so necessary for ecological balance and extinction of wild life leading to imbalance in the ecological order, loss of wild life heritage and ultimately dwindling of several species.

Lack of Policy Issue and Enforcement

National integrated Land Use Plan and policy is on process to be ratified. But, Ethiopia has so far developed different policies, regulations, proclamations and laws related to environment and natural resources. However, there are gaps in implementation of these policies due to lack of some directives, and institutional commitment.

Poor Agricultural Practice

The soils on steep slopes in the basin are mostly under intensive cultivation. The steep slopes coupled with an erodible nature of the soil, poor farming and grazing practice has resulted in the highest current erosion rates being found in different parts of the basin.

Deforestation

Deforestation is the most serious problem in the basin, which directly affects its water retention capabilities, increases runoff and hence causes erosion.

Over grazing

Overgrazing occurs when the number of livestock on a unit of land is too large. Resultant to this is the destruction of natural vegetation as well as soil compaction and erosion. Furthermore, the photosynthesis and hence biomass production and carrying capacity is decreased. High livestock population in the some parts of the basin has resulted the overgrazing of grazing lands which leads to accelerated soil erosion and the resultant siltation of the rivers and the surrounding wetlands.

Climate Change

Climate change has an impact on day to day human activities and natural phenomena which affect the global and regional economic and social wellbeing. Ethiopia is one of the impacted countries due to its dependency on rain feed agriculture. OGR lakes basin is one of the sufferer of climate change and variability affecting up to community level. Climatic change is commonly described by characteristics of rainfall, temperature, evapo-transpiration, drought, flood and other related aspects. Such characteristics determine seasonal classification, water availability, type and potential of agricultural production, water consumption manner and others. These characteristics have influence on water availability in the basin and consideration of climate change impact in basin planning is important.

6.1.3.2. Watershed Problems in Omo-Gibe River Basin

The primary watershed problems observed in Gibe Gojeb sub basin are soil acidity following high rainfall, and land degradation; land degradation (soil erosion: causing sedimentation of the dam; Soil degradation: soil physical , chemical, biological quality deterioration); water insecurity: loss of access, availability, quantity and quality of water; loss of biodiversity; loss of land productivity; sediment yield increment and fragile topographic situations.

Similar to the Gibe-Gojeb sub-basin, the major watershed problems observed in Omo-Sharma sub basin are: Soil acidity following high rainfall, and land degradation; land degradation (soil erosion causing sedimentation of the dams, soil degradation: soil physical, chemical and biological quality deterioration, loss of biodiversity, loss of land productivity; and fragile topographic situations.

The major watershed problems identified in Lower-Omo Sub basin are frequent flood hazard, frequent drought, land property rights , wildlife management, lack of proper National park management, and improper wildfire protection and management.

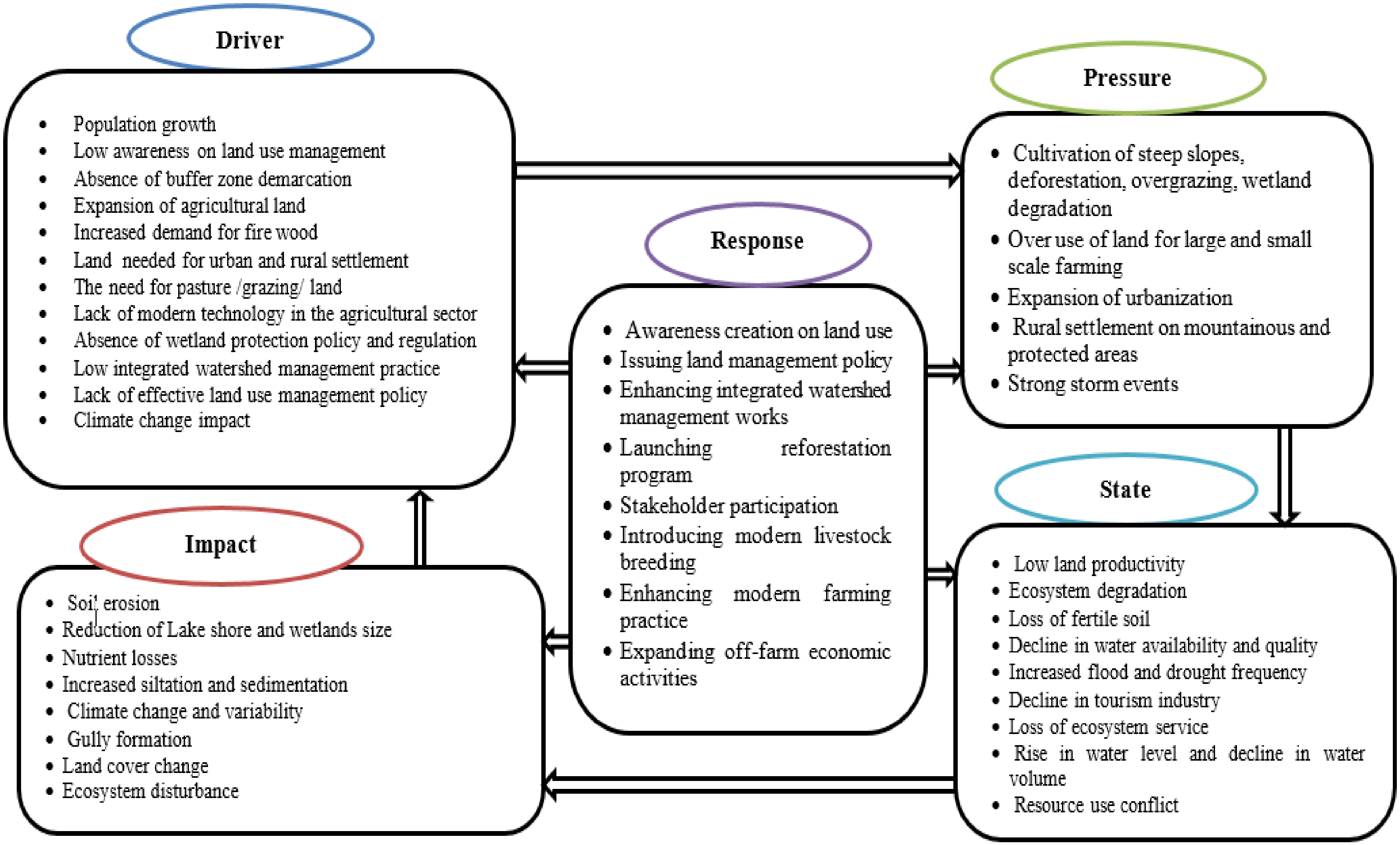


Figure 41 Analysis of Watershed Degradation by DPSIR

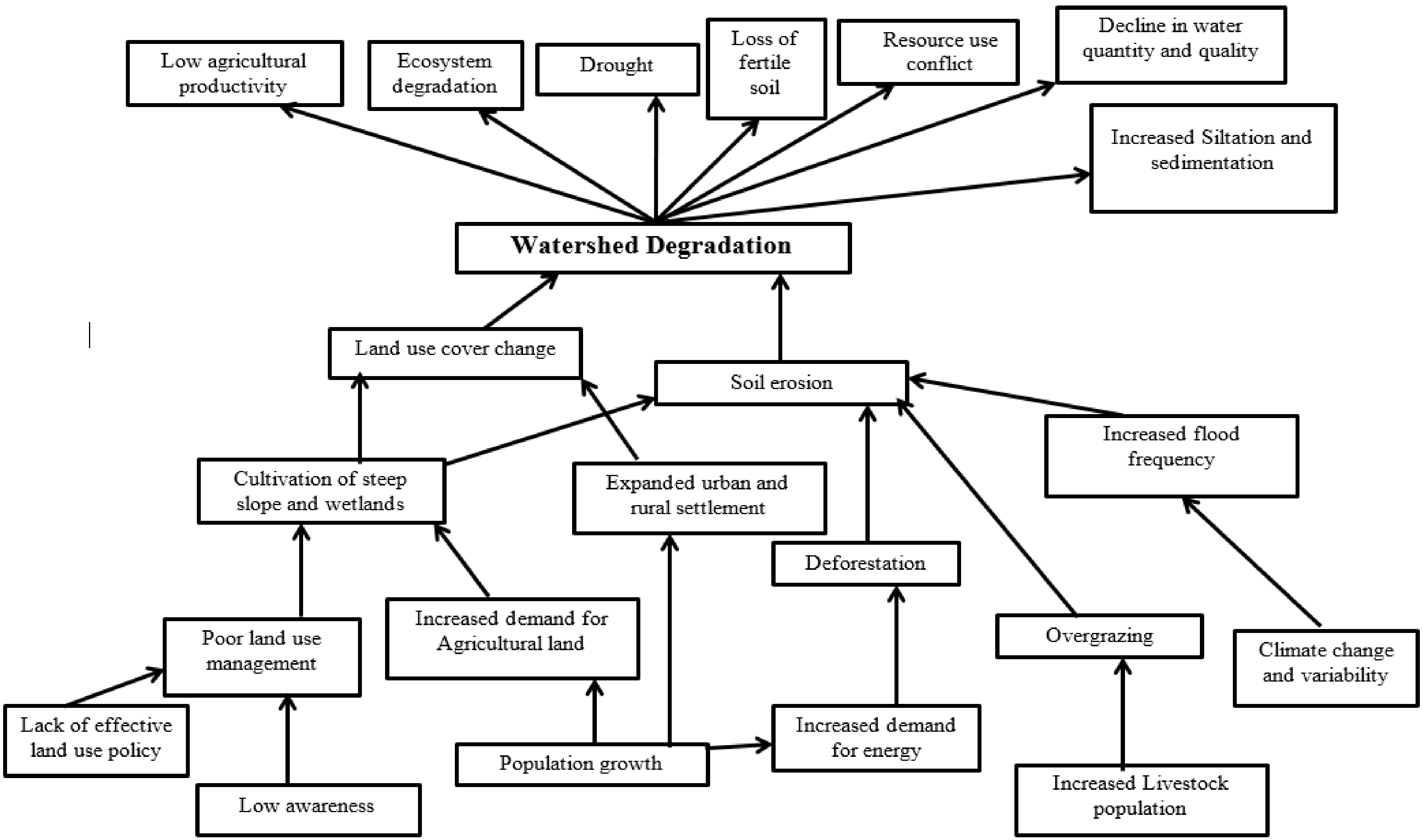


Figure 42 Problem Tree analysis on issues affecting watersheds

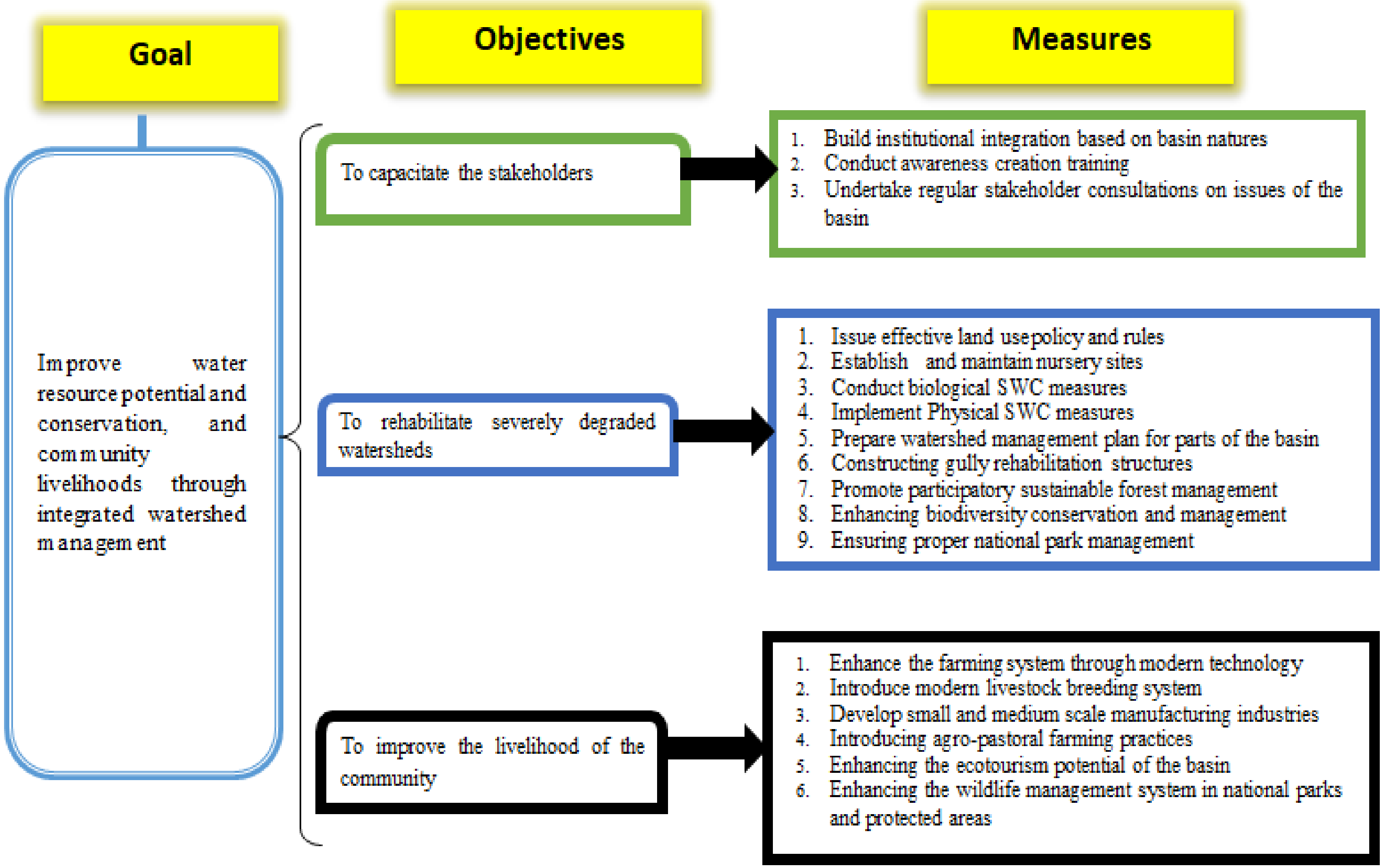


Figure 43 Objective tree analysis on issues affecting watersheds

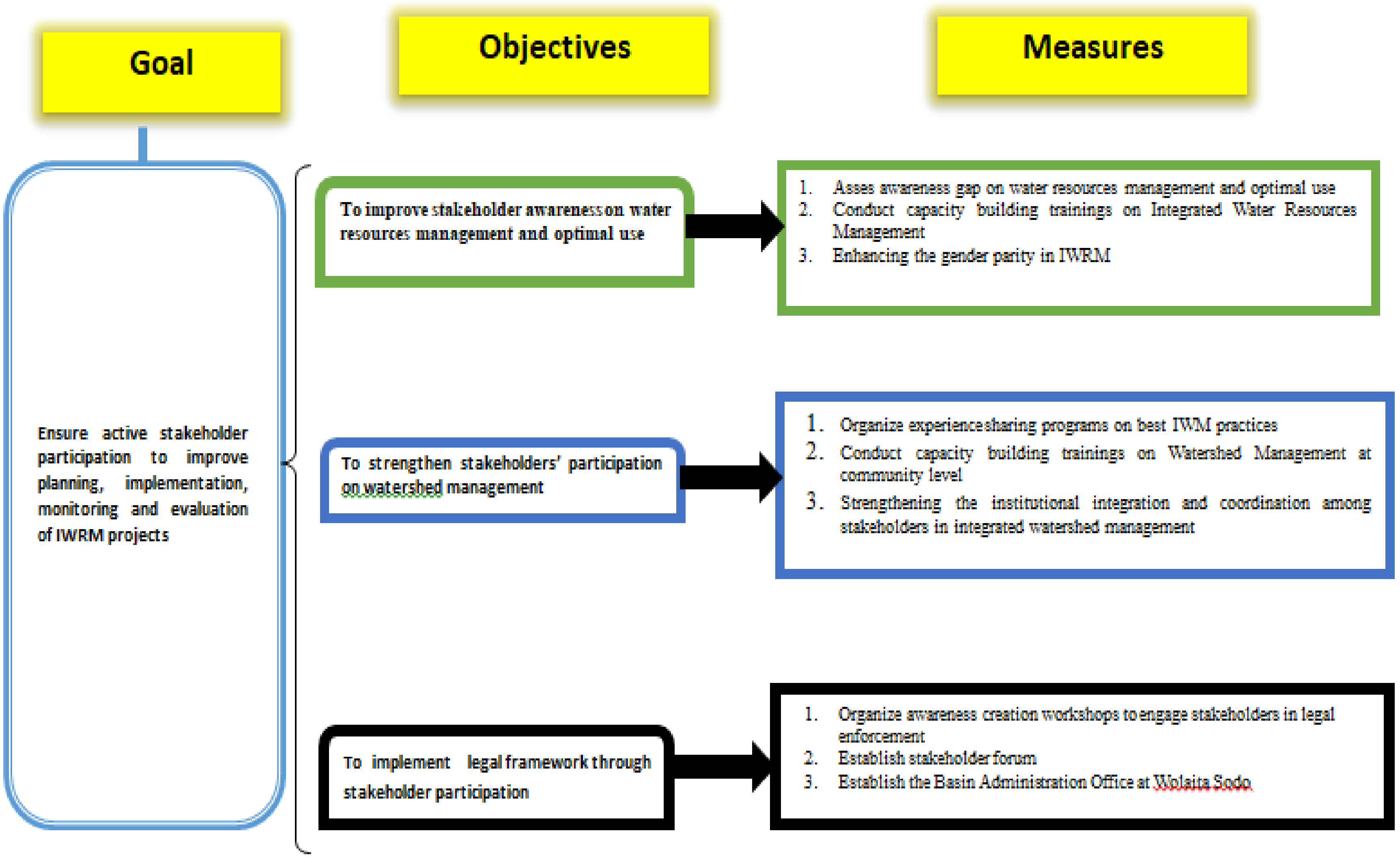


Figure 44 Objective tree analysis on issues affecting Stakeholder engagement

6.1.4. Climatic Hazards: Flood and Drought

In Omo-Gibe River Basin, there are natural hazards affecting water quantity, quality, and degradation of the resources. The major ones are flood, drought and land slides.

6.1.4.1. Flood Hazards in Omo-Gibe River Basin

In Ethiopia, floods occur occasionally in all parts of the country, either as flash floods in the cities and highlands or in the form of downstream floods in large basins and lowlands. May be the worst flood disaster in the recent history of Ethiopia has occurred in August 2006 following heavy rains across East Africa. During this time, most parts of the country had flood incidents of a certain proportion. Dry streams in the east became full to a record level and the Omo River in the south ran out of its banks and inundated the surrounding regions. Several cases of flood occurrences and flood hazards were also reported from northwestern Ethiopia. While the floods were important to replenish soil nutrients, recharge soil moisture, and encourage high agricultural activity in many parts of the country, overflows in the Lower Omo basin killed 364 people, inundated 14 villages, and destroyed farmlands.

Flood hazards in every rainy season occur in different parts of Ethiopia. The existing land and water resources management system of the basin is adversely affected by the rapid growth of population, deforestation, and poor agricultural practices in combination with low adaptive capacity that entail a high vulnerability to adverse impacts of climate change. Communities in the downstream region of the catchment experience floods caused by heavy RF at upstream. Consequently, the unpredictable nature of the flooding combined with increased frequency and magnitude is resulting in crop failure and unprecedented human health impacts. The reasons provided for the increased frequency and magnitude of the flood events were attributed to land-use change (deforestation and over-cultivation) and climate change in the area (Kemal, 2013).

In the upper Omo-Gibe sub-basin, Limu-Genet, Busa, Asendabo, Baco, Seyo, Algae, Kumbi, and Gibe-Farm weather stations contributed to the runoff for the Great Gibe river at Abelti, Wabi near Wolkite river gauging stations. Jinka, Dimeka, Hana, Maji and Omorate weather stations contributed to the runoff of the Omo river near Omorate gauging station. Flooding around Omo-Gibe River causes a considerable damage to life and property. Large coverage of the area with cultivated land makes the problem hard.

According to OCHA (UN Office for the Coordination of Humanitarian Affairs) Ethiopia, the most severe flooding has taken place in South Omo Valley, affecting over 14 villages in two remote woredas in Southern Nations Nationalities and People Regions (SNNPR) by July, 2006. The Government of Ethiopia confirmed on the 16th August that 364 people have been killed and approximately 6000 - 10,000 have been displaced by severe flooding in Kurez zone, South Omo. The affected area is in the isolated delta of the Omo River in both Daseneche and Nyngaten woredas, about 800 km away from the capital, Addis Ababa. 14 villages have been totally destroyed; houses, infrastructure, and agricultural crops were wiped out. All economic and livelihood activities are disrupted in the area. The flood is expanding as the result of continuing rain and release of overflow from the Gibe Dam. Nearly 3000 livestock have also perished.

Several studies indicated that the lower Omo valley has experienced repeated flood hazardous (EEPCO, 2009; Endalamaw, 2015). In the eye of these treats and the need to make benefit of the huge water resource of the basin, the Government of Ethiopia has embarked on the basin level master plan studies. As one of the top solutions, construction of dams is implemented. However, according to some, it seems as if the construction of the dam will affect the indigenous people and disrupt the ecology of the basin.

Omo river basin suffers frequent flooding that will affect crop production for significant period of time. The predominantly agro-pastoral population of the lower Omo valley depends heavily on flood-retreat cultivation along the banks of the Omo. According to Endalamaw (2015) a maximum of 19,000 ha in the lower Omo valley will be inundated for a depth of 2.5 m during the maximum peak flow. Moreover, the people are exposed to Malaria, different waterborne diseases, and benefited little from the economic development the country recorded in the last few years. There are, however, important question one has to raise: "how long they continue to survive sawing handful of seeds along the bank of the rivers?" Still they need to change and they also should change their life to a better way of living. Moreover, the country should benefit more from the immense natural resources of the basin at economic scale. Despite the challenge of flooding, the basin has one of the largest potential irrigable areas next to Abay. The potential Flood-based farming system command area is estimated as 1.5 million ha.

It is important to change the dependency alone on the traditional recession flood farming to other forms of farming practices especially that of modern flood irrigation farming practices to maximize the virtual water available for agricultural development. This could be achieved, among others, if the runoff is regulated. It is believed that the ongoing construction of the hydropower will provide regulated flow sufficient to meet Flood-based farming more than the traditional farming area. In general, Dasenech and Nyangatom woredas in the lower parts of Omo River are the flood-prone areas in the basin. Other flash flood and landslide-prone areas include Kindo Koisha (Wolayita), Dasenech, Nyangatom, Hamer, North Ari and South Ari woredas.

6.1.4.2. Drought Hazards in Omo-Gibe River Basin

In the basin for seasonal drought (SPI-4), moderate, severe, and extreme droughts occurred for 21, 15, and 6 years, respectively, whereas in 1987, 1991, 1994, 2000, and 2002 extreme droughts occurred. For annual drought (SPI-12), moderate, severe, and extreme droughts were found for 18, 14 and 3 years, respectively whereas in theyears 1988, 2002, and 2003 extreme droughts were observed. For seasonal drought (SPEI-4), moderate, severe, and extreme droughts occurred for 25, 17 and 3 years, respectively, while extreme droughts were exhibited in 1991, 2002, and 2009. For annual drought events (SPEI-12), moderate, severe, and extreme droughts were detected for 18, 9, and 1 year, respectively, while in the year 1988, extreme drought was observed (Anose et al, 2022).

The number of drought duration months shown in 12-month timescales was 78 and 88 for SPI-12 and SPEI-12, respectively, throughout the study period. In the basin, 1988, 1999, 2000, 2002, 2003, 2012, 2015, and 2016 were the driest years common in both indices and in different timescales. During the study period, the basin experienced 12.6% to 20.36% moderate and above moderate drought frequencies. In SPI-4 and SPEI-4, severe drought events were observed in the basin on March 2000 and July 2009, with the severity peak values of - 2.61 and - 2.24, respectively. For SPI-12 and SPEI-12, the basin experienced extreme drought in May 1988 (in both indices) with a severity value of - 3.13 and -2.10, respectively (Anose et al, 2022).

Studies reported that the frequency and magnitude of drought episodes were quite varied from place to place in the geographical area that they considered in their studies. The occurrence of drought during the wet seasons has caused significant socioeconomic and environmental problems, particularly in the south Omo lowlands, where drought is more recurrent. For instance, the occurrence of droughts in the southern lowland parts during the main rainfall (March–May) season often causes significant damage to the pastoral agricultural system and livelihoods in the area. The frequent occurrence of drought in this part of the basin has evidently been the underlying cause of chronic water and pasture shortages, which often result in mass livestock deaths, food shortages and infiltrate the usual patterns of pastoral seasonal migrations.

The chronic shortage of pasture and water has sometimes caused conflicts between pastoral communities due to the increasing competition for these resources (Gebremichael et al. 2005; WFP 2010; Gebresenbet and Kefale 2012). Other studies also reported the occurrence of conflicts between the Hamer people and the Omo-Mago national park and at times cross border conflicts between Ethiopia's Dasenech and Nyagatom ethnic groups and Kenya's Turkana and Gerba ethnic groups due to increasing competition for pasture and water resources (Amsalu and Adem 2009; South Omo Zone Agricultural Office 2012; Yntiso 2012).

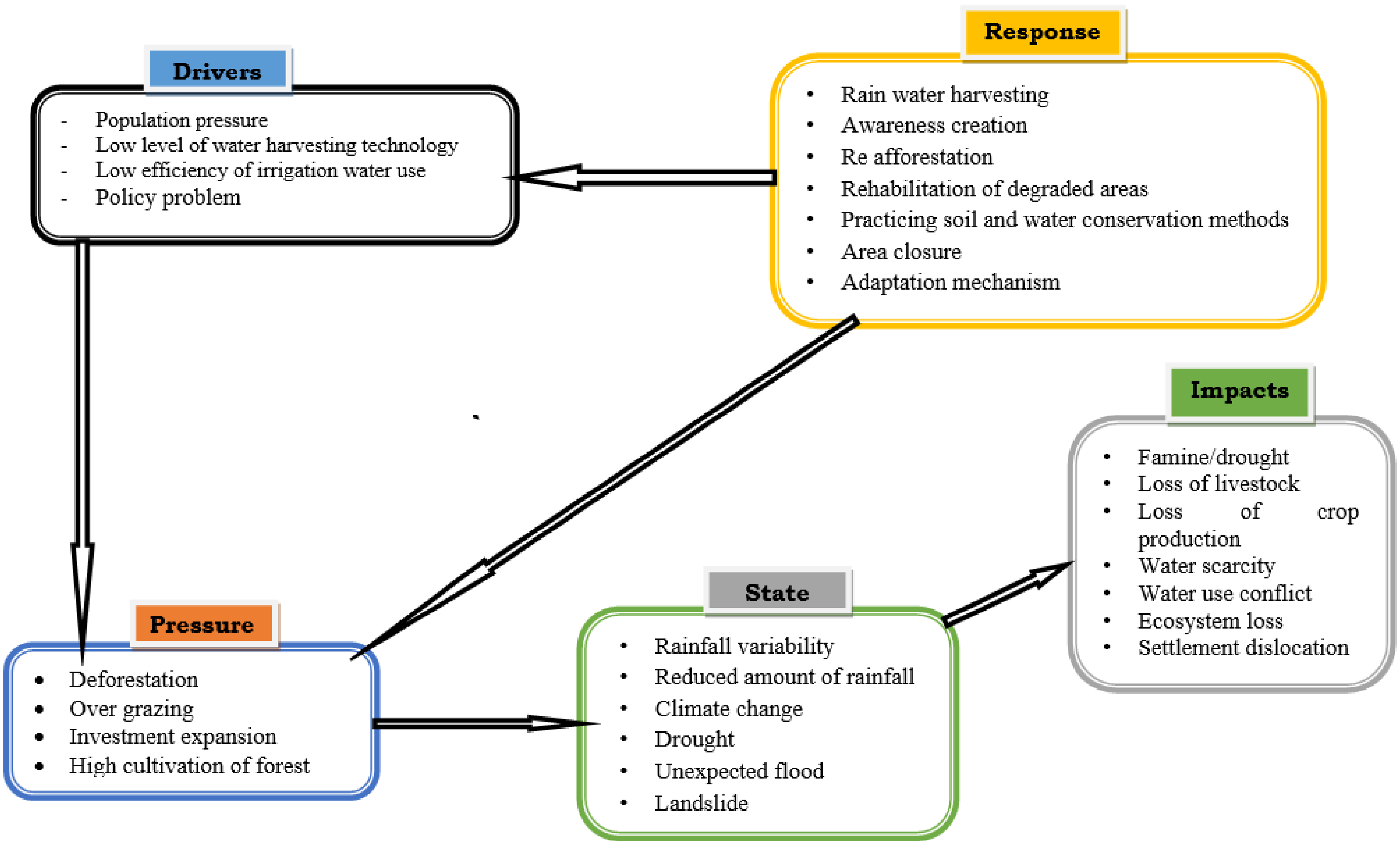


Figure 45 Analysis of Natural disaster By DSPIR

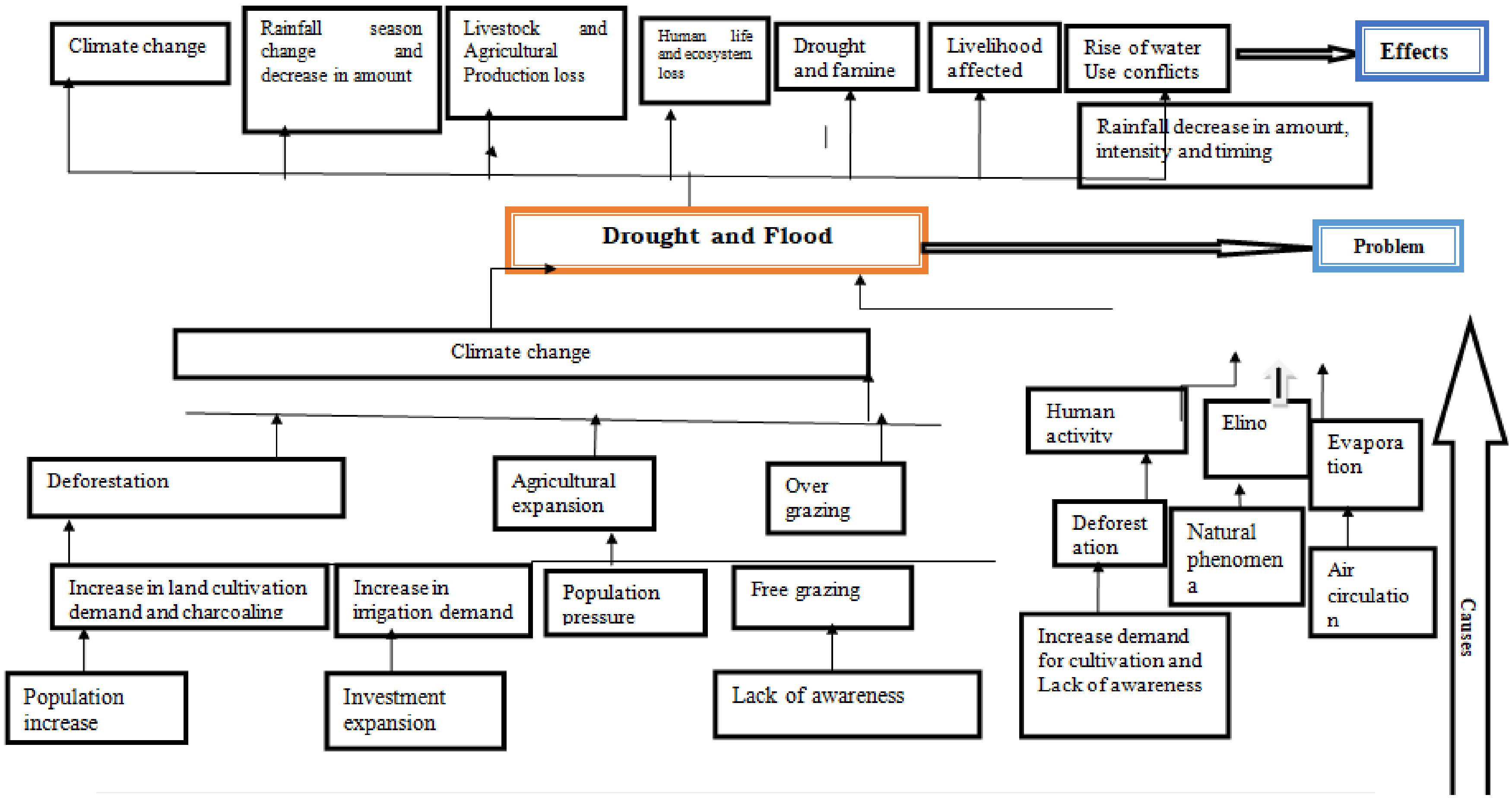


Figure 46: Problem tree for cause and effect relationship of natural disaster

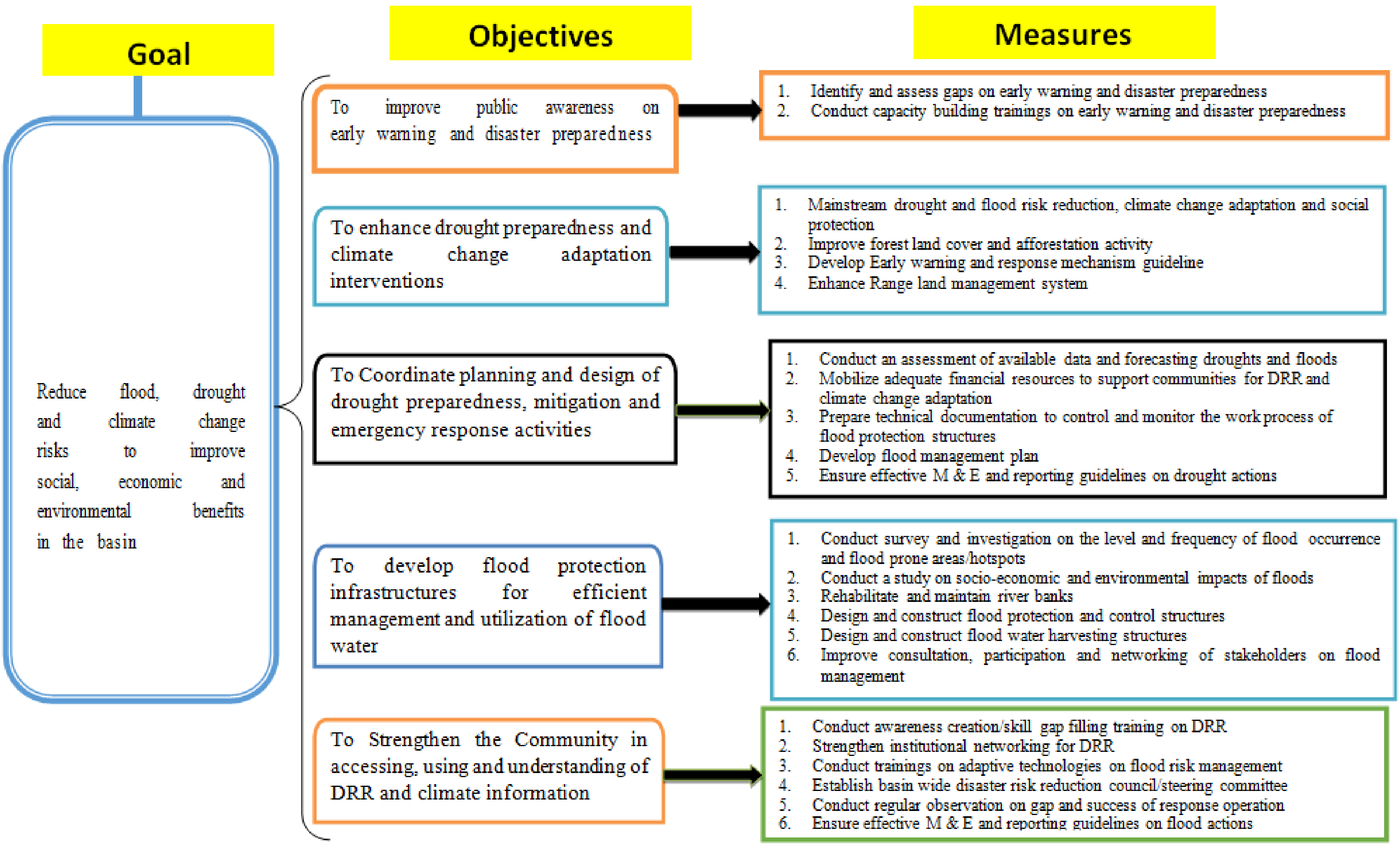


Figure 47:Oobjective tree for natural disaster (flood and drought) management

6.2. PRIORITIZATION OF BASIN ISSUES AT THE SUB BASIN LEVEL

The basin issues analysed were prioritized based on the multi-criteria analysis method. Accordingly, the issues were presented and given weight by the key stakeholders at the sub-basin level and ranked based on the average weighted value.

6.2.1. Prioritization of issues in Gibe-Gojeb and Omo-Sharma Sub-Basins

During the relevant stakeholder consultations, the issues of Gibe-Gojeb and Omo-Sharma sub basins were prioritized based on the multi-criteria analysis method. Accordingly, the issues were given weight and ranked by the key stakeholders; the key issues of the Gibe-Gojeb and Omo-Sharma sub basins in the order of priority are land degradation, deforestation and overgrazing, Inefficient water use and management, Reservoir Sedimentation, Wetland-Buffer zone degradation, Drought, Climate change , Water quality decline, salinity, Weak stakeholder engagement, flooding, Database Gap and Exotic plants.

6.2.2. Prioritization of issues in Lower Omo Sub-Basin

During the relevant stakeholder consultations, the issues of Lower Omo sub basin were prioritized based on the multi-criteria analysis method. Accordingly, the issues were given weight and ranked by the key stakeholders; the key issues of Lower Omo sub basin in the order of priority are flood, drought, deforestation, overgrazing, soil erosion, inefficient water use and management, basin database gap, reservoir sedimentation, wetland and bufferzone degradation, poor stakelder engagement, water quality decline, salinity and climate variability.

Table 34**:** Prioritization of issues in Gibe-Gojeb and Omo-Sharma Sub-Basins

Criteria	**Deforestation and overgrazing**	**Land degradation**	**Inefficient water use and management**	**Water quality decline**	**Flooding**	**Drought**	**Reservoir Sedimentation**	**Wetland-Buffer zone degradation**	**Weak stakeholder engagement**	**Exotic plants**	**Climate change**	**Salinity**	**Database Gap**
	0-5	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**		**0-5**
A barrier to resolving other significant problems	5	5	5	4	3	3	5	5	3	3	3	5	3
Impact on a large number of people	5	5	5	4	3	3	5	5	3	2	3	5	3
Impacting on vulnerable people	4.5	4	5	4	3	3	4	4	3	3	3	5	3
Preventing people escaping from poverty	4.5	5	4	4	5	5	4	4	3	3	5	4	3
Significantly impacting on socio-economic development	5	5	5	4	4	4	4	4	4	3	4	5	3
Significantly hindering efficiency and effectiveness	4	5	4	3	3	3	5	5	3	3	3	4	5
Having a negative effect on the environment	5	5	5	5	3	3	5	5	3	3	3	5	3
Resulting in water shortages in areas of low rainfall	5	5	4	0	1	5	5	5	5	3	5	4	1
Synergy with SDGs, national and regional policies, strategies and development plans	5	5	5	5	5	5	5	5	5	5	5	5	5
Score	43	44	42	33	30	34	42	42	32	28	34	42	29
Weighted Average	4.77	4.88	4.66	3.66	3.33	3.77	4.66	4.66	3.55	3.11	3.77	4.66	3.22
Rank	**2nd**	**1st**	**3rd**	**8th**	**11th**	**7th**	**3rd**	**3rd**	**10th**	**13th**	**7th**	**3rd**	**12th**

Scale: 0 is no impact; **1** is Very low impact; **2** is Low (have influence at specific areas) impact; **3** is Medium impact (High influence at sub basin level); **4** is High impact (high level of influence at basin level); **5** is Very high impact (high level of influence at basin level and out of the basin).

Table 35**:** Prioritization of issues in Lower Omo Sub-Basin

Criteria	Deforestation	Soil Erosion	Over-grazing	Inefficient water use and management	Water quality decline	Flooding	Drought	Reservoir Sedimentation	Wetland-Buffer zone degradation	Poor stakeholder engagement	Salinity	Climate variability	Database Gap
	0-5	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**	**0-5**
A barrier to resolving other significant problems	5	5	5	5	5	5	5	4	4	4	5	5	5
Impact on a large number of people	5	5	5	5	3	5	5	5	5	5	3	3	5
Impacting on vulnerable people	5	5	5	5	3	5	5	5	5	5	3	3	5
Preventing people escaping from poverty	5	5	5	5	3	5	5	3	3	3	3	3	5
Significantly impacting on socio-economic development	5	5	5	5	4	5	5	5	5	5	4	4	5
Significantly hindering efficiency and effectiveness	3	3	3	3	4	5	5	4	4	4	4	4	3
Having a negative effect on the environment	5	5	5	5	3	5	5	2	2	2	3	3	5
Resulting in water shortages in areas of low rainfall	5	5	5	4	o	5	5	1	1	1	o	o	4
Synergy with SDGs, national and regional policies, strategies and development plans	5	5	5	5	5	5	5	5	5	5	5	5	5
Score	43	43	43	42	30	45	45	34	34	34	30	30	42
Weighted Average	4.77	4.77	4.77	4.66	3.33	5	5	3.77	3.77	3.77	3.33	3.33	4.66
Rank	**3rd**	**3rd**	**3rd**	**6th**	**11th**	**1st**	**1st**	**8th**	**8th**	**8th**	**11th**	**11th**	**6th**

Scale: 0 is no impact; **1** is Very low impact; **2** is Low (have influence at specific areas) impact; **3** is Medium impact (High influence at sub basin level); **4** is High impact (high level of influence at basin level); **5** is Very high impact (high level of influence at basin level and out of the basin).

7. STAKEHOLDERS IDENTIFICATION, MAPPING AND ANALYSIS

7.1. INTRODUCTION

Stakeholders are generally considered to be a person, group, community or organization that are impacted by, or can influence, the implementation of River basin strategic plan. A "stakeholder" can be defined as any individual, group, or institution that has a vested interest in the natural resources of the project area and/or who potentially will be affected by policy, program or project activities and has something to gain or lose if conditions change or stay the same. They are all people and institutions which include local government, private industry, non-profit organizations (environmental and social service organizations), citizen groups, irrigators, and the general public and who have a strong interest in the future use of water resources. "Stakeholder" or "interested party" has been defined as 'any person, group or organization with an interest or "stake" in an issue, either because they will be directly affected or because they may have some influence on its outcome' (Rieu-Clarke et al., 2010). Public concerned, stakeholder and interested party may therefore be used synonymously. By stakeholder, we mean groups or persons who are directly or indirectly affected by any interventions in the OGRB planning and development processes; have the ability to influence the outcome of those interventions, either positively or negatively; and can actively influence the outcome of the process.

7.2. STAKEHOLDER ENGAGEMENT AND IDENTIFICATION

Stakeholder engagement is the systematic identification, analysis, planning and implementation of actions designed to influence stakeholders in River Basin planning. Stakeholder engagement is the process of interacting with and involving a person, groups, communities or organizations who may be affected by the policy, program or project, and inclusive stakeholder engagement should involve all disadvantaged target groups, including low-income, women and other marginalized groups, that are often at risk of being overlooked in stakeholder consultations. A structured and thorough stakeholder management approach identifies the relevant stakeholders for the specific policy, program or project of OGRB, and defines processes that establish a positive and transparent relationship with them. Modern River Basin planning involves the stakeholders' participation in various parts of the process, especially in the identification of issues, in setting environmental objectives, and in selecting appropriate measures for resolving water problems.

Stakeholder identification refers to the identification of persons, groups, communities or organizations that are at risk of being under-served or excluded during the development, implementation and operation of policy, program or project of Omo Gibe River Basin. It is critical to the entire stakeholder engagement process.

Stakeholder analysis is of great value when it is used to shape how the work is planned, delivered and governed. Effective stakeholder engagement requires the project professional to focus on understanding different perspectives and to address these in order to achieve the intended outcomes. In order to strengthen the institutional framework, appropriate linkage mechanisms will be planned and implemented to secure co-ordination of water resources development and management activities between the federal and regional governments. In view of installing decentralized management, the participation of user communities will be fostered by establishing the appropriate institutional framework at the lowest administrative structure. Relevant stakeholders will be encouraged to engage in joint management of basin authorities. No department or authority is likely to be able to implement a basin plan alone or impose its will on other institutions or independent bodies. Cooperation is therefore the most appropriate approach, and should be institutionally built through the basin planning process. As already noted, strategic basin planning requires alignment with other planning processes. To do so effectively, basin planning requires close cooperation between a range of organizations, institutions and groups.

Omo Gibe River Basin includes parts of Oromia National Regional State (ONRS), South Nations, Nationalities and Peoples Regional State (SNNPRS) and Southwest Ethiopia National People's Regional State (SWENPRS). Each public institutions from regions to Zones, Woreda and Kebele level are key stakeholders. As stakeholders public institutions at the federal and region level are identified and listed. Within source-to-sea framework, Granit et al. (2017) suggests the following five major categories of stakeholders to frame stakeholders in relation to their interests in the highlighted flow:

1. ***Primary stakeholders*** = individuals or groups that are affected by the altered condition and will directly benefit from its prevention.

2. ***Targeted stakeholders*** = individuals or groups are contributing to the altered condition and whose behaviors and practices must be directly targeted to prevent it.
3. ***Enabling stakeholders*** = institutions providing or should provide enabling conditions for behavioral changes and benefits to occur and be sustained over time.
4. ***Supporting stakeholders*** = development partners or financiers whose strategies are aligned with prevention of the altered condition.
5. ***External stakeholders*** = individuals or groups outside the system boundary who share an interest in the altered condition.

Table 36. Stakeholders categories and roles in the Omo Gibe River Basin

S/N	Categories	Role/position/interest/concern
Primary stakeholders		
1	Farmers	Ecosystem alteration such as deforestation, land clearing, weed invasion, introduction of animal pests; Soil erosion and deposition viz., Water erosion, wind erosion, siltation and sedimentation, mass movement of soil. Lost their land due to various forms of water erosion viz. raindrop, sheet, rill and gully erosion and decline of land productivity.
2	Fishermen	Ecosystem alteration due to sedimentation which in turns affecting the water quality and thereby affecting livelihoods of the stakeholders.
3	Resorts/Lodge/Hotel owners	Those hotels and resorts around the lakes and river sides affected by the physical and chemical pollutants in the OGR basin.
4	Boat renters and lakeside enterprises	Owners and operators of tourist boat and other lakeside businesses that depend on the lakes for attracting customers in the OGR Basin.
5	Fish sellers and consumers	Small businesses of fish selling as well as the consumers.
6	Urban community	Communities who are serving the lakes and river side as source of fish and recreation.
7	Rural community	Communities who are serving the lakes and rivers for fish; water supply; cloth washing.
8	Water pumping land owner	Farmers having lands near the rivers and lakes where they are pumping water from lakes/rivers.
Targeted stakeholder		
9	Farmers	Upstream of the river basin farmers who failed to properly manage their land
10	Miners	Illegal and few legal miners of the sand, construction minerals which are further activating the gully to be eroded
11	Firewood and charcoal traders	Retailers and wholesalers in the cities/towns are indirectly encouraging deforestation.
12	Contractors in the construction industry	Transport construction materials from mountains at the upstream of the gully network, heavy trucks are adversely driven through the gully system that in turn triggers further erosion.
Enabling stakeholder		
13	Ministry of Water and Energy	Enable the community to use water and alternative energy sources.
14	Basin development	Enable institution to implement IWRM in the basin at country level.

S/N	Categories	Role/position/interest/concern
	Desk	
15	OGR Basin Office/future	Mandated institution to implement IWRM in the OGR basin
16	Agriculture, Land, and Natural Resources offices	Mandated institution to manage the natural resources in the basin
17	Environmental Protection Authority	Mandated institution to protect the lakes and other resources from pollution
18	Municipality	Mandated for solid waste management and lakes and other parts of the OGR basin
19	Tourism sector	Lakes and river sides used for an attraction for tourists
20	Investment Bureau	Governing the investments around the water bodies (lakes, rivers)
21	Higher Education Institutions	Higher education institution (research, technology transfer, capacity building, and community services) in the OGR Basin
Supporting stakeholder		
23	Industry parks	Social responsibility of the institutions in the water bodies
24	Hotels and resorts	Social responsibility of the hotels and resorts in the water bodies
25	Universities	Research, technology transfer, university-industry linkage, and community service in the main Ethiopian OGR basin
27	GIZ	Conducting projects to benefit lakes and local communities.
External stakeholder		
28	GIZ; SIDA; GEF; USAID; EU	These organizations and their network are the potential donors for source-to-lake system management of the OGR basins

7.3. STAKEHOLDER MAPPING AND ENGAGEMENTS

7.3.1. Mapping the Stakeholders

Stakeholder mapping is a process of examining the relative influence that different individuals and groups have over a project as well as the influence of the project over them. The purpose of a stakeholder mapping is to: study the profile of the stakeholders identified and the nature of the stakes; understand each group's specific issues, concerns as well as expectations from the project that each group retains; and gauge their influence on the project.

Based on this understanding, the stakeholders are categorized as High Influence/ Priority, Medium Influence/ Priority and Low Influence/ Priority. The stakeholders who are categorized as high influence are those who are expected to have a high influence over the Project or are likely to be heavily impacted by the Project activities: they should thus be high up on the Project's priority list for engagement and consultation. Similarly, the stakeholders categorized as medium influence are those who are expected to have a moderate influence over the Project or even though they are to be impacted by the Project, such impact is deemed unlikely to be substantial: these stakeholders should thus be neither high nor low on the Project's engagement list. Lastly, stakeholders deemed with low influence are those who are expected to have a minimal influence on the decision-making process or are to be minimally impacted by the Project: they should thus be low on the Project's engagement list. Therefore, stakeholders important to this project have to be identified and analyzed in respect to location, interest, mandate, influence and vulnerability; and including level of literacy and potential mode of engagement.

A stakeholder engagement is arguably the most important ingredients for successful project delivery and yet is often regarded as a fringe activity. Project managers depend on people to respond to the outputs and benefits that they deliver. People will only respond if they are engaged. Designing a course of action for addressing alterations to priority flows requires a thorough understanding of the stakeholders within the system boundary and how these stakeholders are affected by changes to the primary flows identified (Mathews et al., 2019). Stakeholder mapping involves identifying, analyzing, categorizing and prioritizing the stakeholders and organizations according to their interest, needs and influence in the local planning and development processes. The stakeholder mapping will help to manage and communicate with the stakeholders effectively as well as to formulate appropriate forms of engagement with these groups.

Successful stakeholder engagement allows the concerned bodies including the sub-basin users to have opportunities for intensive involvement in planning, decision making and evaluation of all activities of basin plan preparation and implementation. In order to develop applicable engagement plans, primarily the stakeholders have to be categorized to facilitate the consultation and data collection process. Secondly the engagement stages should be formulated to specify stages where the stakeholders will participate. Accordingly, the potential stakeholders are grouped in to the following hierarchy (H) based on nature of their involvement in water resource planning, utilization and management.

Hierarchy (H_1):- these are policy makers, decision makers and regulatory bodies which include FDRE Parliament, Council of ministers, River Basin High Council, MoWE, MoA, MoFEC, South Ethiopia Regional state, South West Ethiopia regional state, Central Ethiopia regional state and Oromia regional state administrative councils.

Hierarchy (H_2):- these are implementers who are involved in planning and implementation of basin plan. The main stakeholders in this hierarchy are MOWE, MOA, EPA, Ministry of culture and tourism, Ethiopian Wild Life Conservation Authority, Regional, Zonal and wereda level Bureaus of Agriculture and Natural Resources, Water and Irrigation Development, Mines and Energy; Environmental Protection, Forestry, and Climate Change, Rural Land Administration.

Hierarchy (H_3):- this group of stakeholders is called media and knowledge Institutions like universities, public institutions, research institutes, that provide technical support, capacity building, innovative research and development works.

Hierarchy (H_4):- these include civic organizations and international funding institutions and NGOs which give a concerted technical and financial support of international organizations and NGOs work on natural resource, environment and climate change. Among them the main international organizations are WB, UNESCO, EU.

Hierarchy (H_5):- All water users in Omo Gibe River Basin are included in this group. They can be sub-grouped into four based on their resource use, level of intensification, purpose of water abstraction and socioeconomic nature in order to facilitate the engagement plan and implementation process.

7.4. STAKEHOLDER ANALYSIS

Considering the inconsistency of stakeholders' interest and influence levels, it is believed that mapping stakeholders have to be separately prepared based on such thematic issues as follows:

7.4.1. Stakeholders analysis for watershed management aspects

For understanding stakeholders and their interests, an engagement plan to further reinforce behaviours that profit Omo Gibe river basin watershed management and lessen interventions that add pressures to the basin. Small-scale farmers, medium to large-scale agri-business firms, construction material miners, quarry site owners, charcoal and firewood traders and contractors in the road and other construction industries were specifically identified as groups whose behaviours were further exacerbating one or more of the following: land degradation and deforestation, biodiversity loss, gully formation, erosion hazards, sedimentation, ecosystem service depletion of the reservoirs and rivers in the basin. Nevertheless, changes in these behaviours can likely be achieved with proper support via the enabling stakeholders such as the agricultural offices, natural resources and the environmental authorities, energy sectors, etc.

Table 37. Stakeholders categories and roles – watershed management aspects

Categories		**Role/position/interest/concern**
Primary Stakeholders		
1.	Farmers	Lost their land due to gully erosion and their productivity loss due to sheet and rill erosion, lost their land and flood damages etc
2.	Agri-business firms	Medium & large-scale firms may collapse as a result of land degradation and land productivity loss and physical damage
3.	Fishermen	Ecosystem alteration due to sedimentation affects the livelihoods affecting the stakeholders
4.	Irrigators	Land degradation induced hazardous (erosion & landslide) may cause alluvial floods, crop and irrigation infrastructure damage and hence water resources depletion
5.	Construction materials miners and quarry site owners	Land degradation induced hazardous (erosion & landslide) may cause landscape changes and inaccessibility
6.	Resorts/Lodge/Hotel owners	Those hotels and resorts around the lakes and Rivers sides affected by erosion induced changes of lakes in the OGR Basin
7.	Fish sellers and consumers	Small businesses of fish selling as well as the consumers.
8.	Residential areas	Communities of urban/rural residential areas affected by Land degradation induced hazardous (erosion & landslide)
Targeted stakeholder		
9.	Farmers	Upstream of the Lakes basin farmers who failed to properly manage their land
10.	Farmers	Upstream of the Lakes basin farmers who failed to properly manage their land
11.	Investment Bureau	Whose system may loosely contribute to proper allocation of investment sites & follow up
12.	Construction material Miners & quarry site owners	Illegal and few legal miners of construction minerals which are further activating Land degradation induced hazardous (erosion & landslide)
13.	Contractors of road	Road Contractors which are usually stay for longer time after site clearance and land cut further activating and create new erosion, gulley & landslide hazardous
14.	Charcoal and firewood traders	Retailers and wholesalers in the cities/towns are indirectly encouraging deforestation
15.	Other Contractors in the construction industry	Transport construction materials from mountains at the upstream of the gully network, heavy trucks are adversely drive through the gully system that in turn triggers further erosion.
	Enabling stakeholder	
16.	Ministry of water and energy	Enable the community to use water and alternative energy

		sources
17.	MoWRE Basin development Desk	Enable institution to implement IWRM in the basin at country level
18.	Basin Desk Office (MoWE)	Mandated institution to implement IWRM in the OGR basin
19.	OGR Basin Office (Future)	Mandated institution to implement IWRM in the OGR Basin
20.	Agriculture, land, and natural resources offices	Mandated institution to manage the natural resources in the river basin
21.	Environmental authority	Mandated institution to protect the lakes and other resources from pollution
22.	Municipality	Mandated for solid waste management and lakes and other parts of the OGR Basin
23.	Tourism sector	Lakes and River sides used for an attraction for tourists
24.	Investment Bureau	Governing the investments around the water bodies (Lakes, Rivers)
25.	Universities	Higher institution (research, technology transfer, capacity building, and community services) in the OGR Basin
26.	Alliance of friends of Lakes/rivers	Volunteer group who work in the River Basin
	Supporting stakeholders	
27.	Industry parks	Social responsibility of the institutions in the water bodies
28.	Hotels and resorts	Social responsibility of the Hotels and resorts in the water bodies
29.	Universities	Research, technology transfer, university-industry linkage, and community service in the OGR Basin
30.	World Bank_SLM, IWMI	Support projects implementations to improve basin development & local communities
31.	GIZ, IWMI	Support projects implementations to improve basin development & local communities
	External stakeholders	
32.	GIZ	Support projects implementations to improve basin development & local communities
33.	WRI; GIZ; SIDA; GEF; USAID; EU SIWI	These organizations and their network are the potential donors for source-to-lake system management of the OGR basins

7.4.2. Stakeholders analysis for Water resources use, allocation & management

Through a better understanding of stakeholders and their interests, an engagement plan to further reinforce behaviours that profit OGR basin water resources use, allocation and management and lessen interventions that add pressures to the basin. In the case of OGR basin farmers, fisheries, irrigators, industrial firms sand miners, firewood traders and contractors in the construction industry were specifically identified as groups whose behaviors were further exacerbating one or more of the following: land degradation, sedimentation, water abstraction, pollution and ecosystem service depletion of the Crater Lake and rivers in the basin. However, changes in these behaviors can likely only be achieved with proper incentivization and support through the enabling stakeholders such as the agriculture, land, and natural resources offices and the environmental authorities.

Table 38. Stakeholders' categories and roles - Water resources use, allocation & management

Categories		**Role/position/interest/concern**
Primary Stakeholders		
1.	Farmers-Particularly	Lost their productive land and cattle water supply due to water supply shortage as a result of over pumping, misuse etc
2.	Agri-business firms	Medium & large-scale firms may collapse as a result of water resources depletion
3.	Fishermen	Ecosystem alteration due to water resources depletion affects the livelihoods affecting the stakeholders
4.	Resorts/Lodge/Hotel owners	Those hotels and resorts around the lakes and Rivers sides affected by the water resources depletion in the OGR Basin
5.	Fish sellers and consumers	Small businesses of fish selling as well as the consumers
6.	Urban community (Municipalities)	Communities who are serving the Lakes and River side as source of fish and recreation
7.	Rural community	Communities who are serving the lakes and Rivers for fish; water supply; cloth washing are affected due to water resources depletion
Targeted stakeholder		
8.	Agri-business firms	Most medium & large-scale firms may participate in over pumping and generally mismanagement of water resources
9.	Farmers	Upstream of the Lakes basin farmers who failed to properly manage their land
10.	Firewood & charcoal traders	Retailers and wholesalers in the cities/towns are indirectly encouraging deforestation
11.	Contractors in the construction industry	Transport construction materials from mountains at the upstream of the gully network, heavy trucks are adversely drive through the gully system that in turn triggers further erosion.
12.	Municipalities	Whose system may loosely contribute to proper water use, allocation & management
Enabling stakeholder		

13.	Ministry of water, and energy	Enable the community to use water and alternative energy sources
14.	Basin development Desk	Enable institution to implement IWRM in the basin at country level
15.	Basin Desk Office (MoWE)	Mandated institution to implement IWRM in the OGR basin
16.	Agriculture, land, and natural resources offices	Mandated institution to manage the natural resources in the basin
17.	Environmental authority	Mandated institution to protect the lakes and other resources from pollution
18.	Municipality	Mandated for solid waste management and lakes and other parts of the OGR Basin
19.	Tourism sector	Lakes and River sides used for an attraction for tourists
20.	Investment Bureau	Governing the investments around the water bodies (Lakes, Rivers)
21.	Universities	Higher institution (research, technology transfer, capacity building, and community services) in the OGR Basin
22.	Alliance of friends of Lakes	Volunteer group who work in the River Basin
Supporting Stakeholders		
23.	Industry parks	Social responsibility of the institutions in the water bodies
24.	Hotels and resorts	Social responsibility of the Hotels and resorts in the water bodies
25.	Universities	Research, technology transfer, university-industry linkage, and community service in the OGR Basin
26.	World Bank_SLM, IWMI	Support projects implementations to improve basin development & local communities
27.	GIZ	Support projects implementations to improve basin development & local communities
External Stakeholders		
28.	WRI; GIZ; SIDA; GEF; USAID; EU	These organizations and their network are the potential donors for source-to-lake system management of the OGR basins

7.4.3. Stakeholders analysis for Emerging Issues and Natural disasters

Through a better understanding of stakeholders and their interests, an engagement plan to further reinforce behaviours that can benefit control over various emerging issues (like invasive species, water conflicts etc) and natural disasters and minimize basin pressures. small-scale farmers, medium to large-scale agri-business firms, construction material miners, quarry site owners, charcoal and firewood traders and contractors in the road and other construction industries were specifically identified as groups whose behaviours were further exacerbating one or more of the following: rapid urbanization and industrialization, land degradation and deforestation, construction material mining, biodiversity loss, water hyacinth and other invasive species, ecosystem services depletion, water insecurity and conflict, sedimentation, flood, drought, landslide, etc in the basin. Nevertheless, changes in these behaviours can likely be achieved with proper support via the enabling stakeholders such as the Agricultural offices, natural resources and the environmental authorities, energy sectors, legal offices etc.

Table 39. The diverse stakeholders categories, their role for Emerging issues & Natural disasters

Categories		**Role/position/interest/concern**
Primary Stakeholders		
1.	Farmers	Lost their land due to gully erosion and their productivity loss due to sheet and rill erosion, lost their land due to expansion of the lakes and flood damages
2.	Agri-business firms	Medium & large-scale firms may collapse as a result of land degradation and land productivity loss and physical damage
3.	Fishermen	Ecosystem alteration due to sedimentation affects the livelihoods affecting the stakeholders
4.	Irrigators	Land degradation induced hazardous (erosion & landslide) may cause alluvial floods, crop and irrigation infrastructure damage and hence water resources depletion
5.	Construction materials, miners and quarry site owners	Land degradation induced hazardous (erosion & landslide) may cause landscape changes and inaccessibility
6.	Resorts/Lodge/Hotel owners	Those hotels and resorts around the lakes and Rivers sides affected by erosion induced changes of lakes in the OGR Basin
7.	Fish sellers and consumers	Small businesses of fish selling as well as the consumers.
8.	Residential areas	Communities of urban/rural residential areas affected by Land degradation induced hazardous (erosion & landslide)
Targeted stakeholder		
9.	Farmers	Upstream of the river basin farmers who failed to properly manage their land due to erosion
10.	Investment Bureau	Whose system may loosely contribute to proper allocation of investment sites & follow up
11.	Construction material Miners & quarry site owners	Illegal and few legal miners of construction minerals which are further activating Land degradation induced hazardous (erosion & landslide)
12.	Contractors of road	Road Contractors which are usually stay for longer time after site clearance and land cut further activating and create new erosion, gulley & landslide hazardous
13.	Charcoal and firewood traders	Retailers and wholesalers in the cities/towns are indirectly

		encouraging deforestation
14.	Other Contractors in the construction industry	Transport construction materials from mountains at the upstream of the gully network, heavy trucks are adversely drive through the gully system that in turn triggers further erosion.
Enabling stakeholder		
15.	Ministry of water and energy	Enable the community to use water and alternative energy sources
16.	MoWRE Basin development Desk	Enable institution to implement IWRM in the basin at country level
17.	Basin Desk Office (MoWE)	Mandated institution to implement IWRM in the OGR basin
18.	OGR Basin Office (Future)	Mandated institution to implement IWRM in the OGR Basin
19.	Agriculture, land, and natural resources offices	Mandated institution to manage the natural resources in the river basin
20.	Environmental authority	Mandated institution to protect the lakes and other resources from pollution
21.	Municipality	Mandated for solid waste management and lakes and other parts of the OGR Basin
22.	Tourism sector	Lakes and River sides used for an attraction for tourists
23.	Investment Bureau	Governing the investments around the water bodies (Lakes, Rivers)
24.	Universities	Higher institution (research, technology transfer, capacity building, and community services) in the OGR Basin
25.	Alliance of friends of Lakes	Volunteer group who work in the River Basin
Supporting stakeholders		
26.	Industry parks	Social responsibility of the institutions in the water bodies
27.	Hotels and resorts	Social responsibility of the Hotels and resorts in the water bodies
28.	Higher education institutions	Research, technology transfer, university-industry linkage, and community service in the OGR Basin
29.	World Bank_SLM, IWMI	Support projects implementations to improve basin development & local communities
30.	GIZ, IWMI	Support projects implementations to improve basin development & local communities
External stakeholders		
31.	GIZ	Support projects implementations to improve basin development & local communities
32.	WRI; GIZ; SIDA; GEF; USAID; EU SIWI	These organizations and their network are the potential donors for source-to-lake system management of the OGR basins

7.4.4. Stakeholder Consultations Conducted So far

7.4.4.1. Start-up Meeting

The startup meeting on the “Omo-Gibe River Basin Strategic Plan Preparation” project was conducted on 04/09/2013 E.C at Wolaita Sodo University, Ethiopia. The meeting was aimed at launching the project and introducing the project to the concerned stakeholders. The stakeholders from federal, regional, higher education and research institutions, NGOs and others were participated in the start up workshop. In this workshop, all stakeholders in the Omo Gibe River Basin have shown their commitment to own the project and participate actively from its initial phase to its intervention stage as the basin development requires integration of experts and resources.

7.4.4.2. First Stakeholder Consultative Workshop

The first stakeholder consultative workshop on the “Omo-Gibe River Basin Plan Preparation” Project was undertaken on 15/02/2014 E.C at Getfam International Hotel, Addis Ababa. The agenda of the workshop was undertaking consultations on Basin plan of the Omo-Gibe river basin with the different stakeholders from federal organizations and the international NGOs. During this workshop, the very comments which can construct the basin plan were raised from the concerned stakeholders.

7.4.4.3. Second Stakeholder Consultative Workshop

The second stakeholder consultative meeting on the “Omo-Gibe River Basin Plan Preparation” Project was conducted on 22/2/2014 E.C at Jimma University College of Agriculture and Veterinary Medicine, Ethiopia. The workshop was aimed at conducting consultations on the issues of Omo-Gibe river basin with the stakeholders gathered from Oromiya, Central Ethiopia and South West Ethiopia regional states. In this workshop, several basin issues that should solved in the short, medium and long term were raised by the participants.

Figure 48: The second stakeholder consultative workshop participants, Jimma

7.4.4.4. Third Stakeholder Consultative Workshop

The third stakeholder consultative workshop on the "Omo-Gibe River Basin Plan Preparation" Project took place on 29/02/2014 E.C at Goh Hotel, Jinka, Ethiopia. In this workshop, the stakeholders mainly from the South Ethiopia regional state were participated. The workshop was aimed at undertaking the stakeholder consultations on issues of Omo-Gibe river basin, particularly the Lower Omo Sub-basin. During this workshop, the challenges of Lower Omo sub-basin such as flood and drought related issues were identified as the major problems of the sub-basin.

7.4.4.5. Fourth Stakeholder Consultative Workshop

The fourth consultative workshop on the "Omo-Gibe River Basin Plan Preparation" Project was conducted on May 26-27/2022 GC at Wolaita Sodo University, Ethiopia. The workshop agenda was stakeholder consultation in prioritization of the issues for basin planning in Omo-Gibe river basin. In this meeting, prioritization of the issues raised by stakeholders in the last three meeting (AA, Jimma and Jinka) was done by three groups. The issues were distributed for three groups and the issues prioritized were presented by the group presenters. The fourth stakeholder meeting mainly aims on prioritization of the agendas in sub basins. The basic issues within sub-basins is raised and prioritized for action.

Figure 49: Photos taken during fourth stakeholder consultation

7.4.4.6. Fifth Stakeholder Consultative Meeting

The fifth stakeholder meeting was happened on 22/06/2015 E.C in Jinka, Ethiopia. The consultative meeting was aimed at conducting consultation with stakeholders in Lower Omo Sub basin for the project prioritization and visit to Omorate, the lower rich of Omo River.

Figure 50: Photos taken during the meeting and field visit

The following Stakeholder involvement flow chart and stakeholder engagement frame work shows the successful engagement of all stakeholders in the Omo-Gibe River Basin.

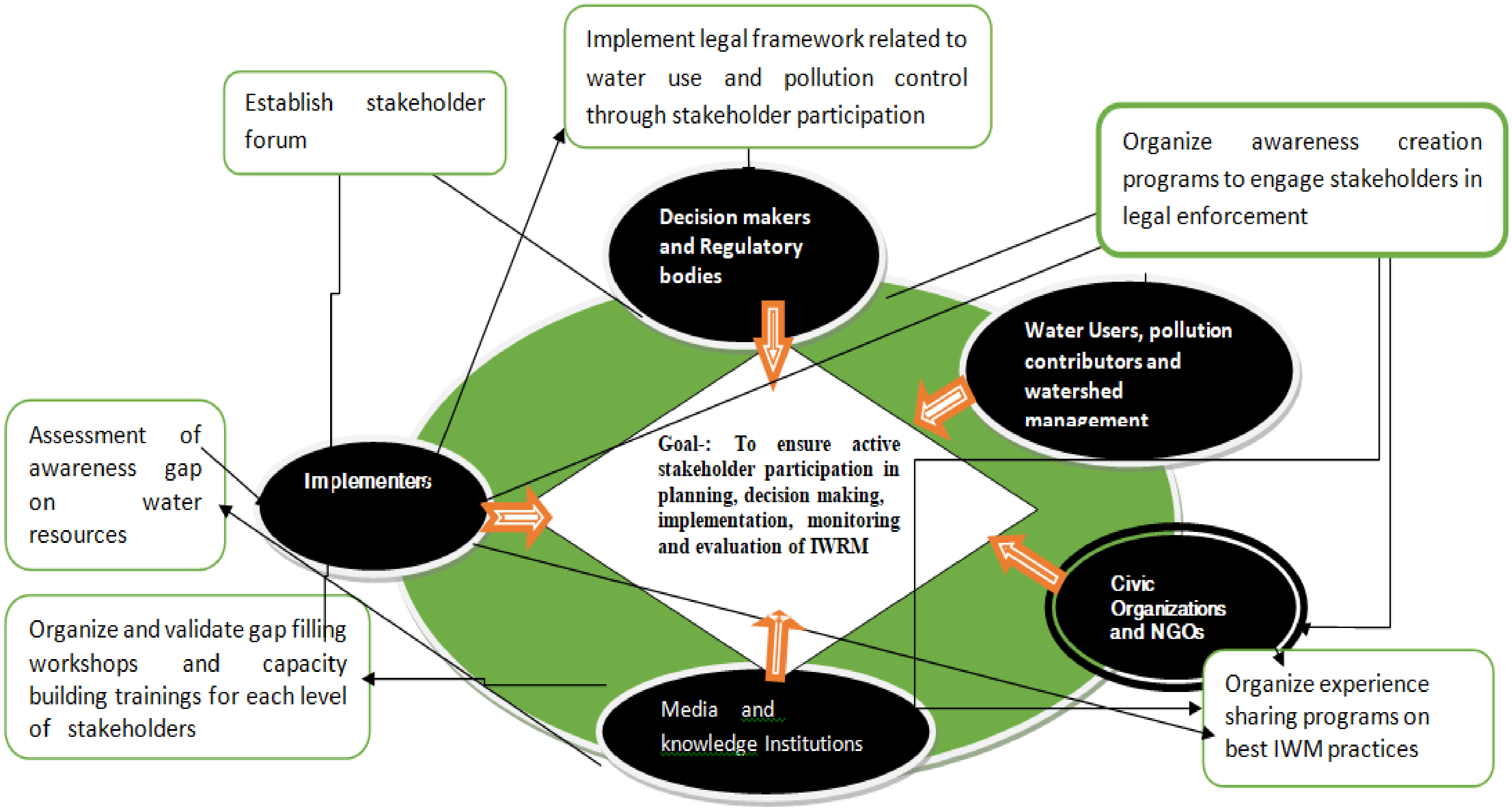


Figure 51 Stakeholder engagement towards the desired Goal/ Stakeholder engagement frame

8. SCENARIO ANALYSIS FOR THE BASIN PLANNING

The Omo-Gibe basin is characterized by increased population and insufficiently developed resources to support the rapidly growing population, inadequate food production, limited use of water for irrigation and poor management practice in the existing irrigation schemes; the basin is also characterized by severe erosion, loss of soil, loss of land due to combined effects of deforestation, overgrazing and poor-tillage, degradation of bed and bank. Flooding of areas surrounding the rivers, loss of possessions and damage of infrastructure are another problem that the basin is facing. When problems are complex, uncertainties are high; prediction is possible to a limited extent only to address these problems. To overcome Socio-economic and ecological challenges that emerge from this complexity, scenario planning is the key tool to prepare scientific technological, learning and adaptation, coping and mitigation mechanisms.

Scenarios are stories of the future that are intentionally diverse and stretch our thinking to accommodate both the expected and the unimaginable. By visualizing a broad range of potential futures rather than making specific predictions or following narrow forecasts, scenarios help to surface new opportunities and new risks and to explore plausible outcomes that could be game-changing. Scenarios can be used at many levels: nations, government, regions, sectors, multi-national companies, small and medium sized enterprises. They can be used over any time frame, depending on the primary objective for using them. Scenarios can fulfill several and different functions: explorative and knowledge function; communication function; aim building function; and decision making and strategy function. Scenarios are useful in formulating strategy and policy development, conflict resolution, group learning, and rehearsing management decisions.

The future scenario of Omo-Gibe River basin plan is developed as follow by using qualitative approach and narrative method. Qualitative or narrative scenarios describe plausible futures primarily in a non-numerical form, commonly taking the form of single sentences, storylines, or diagrams.

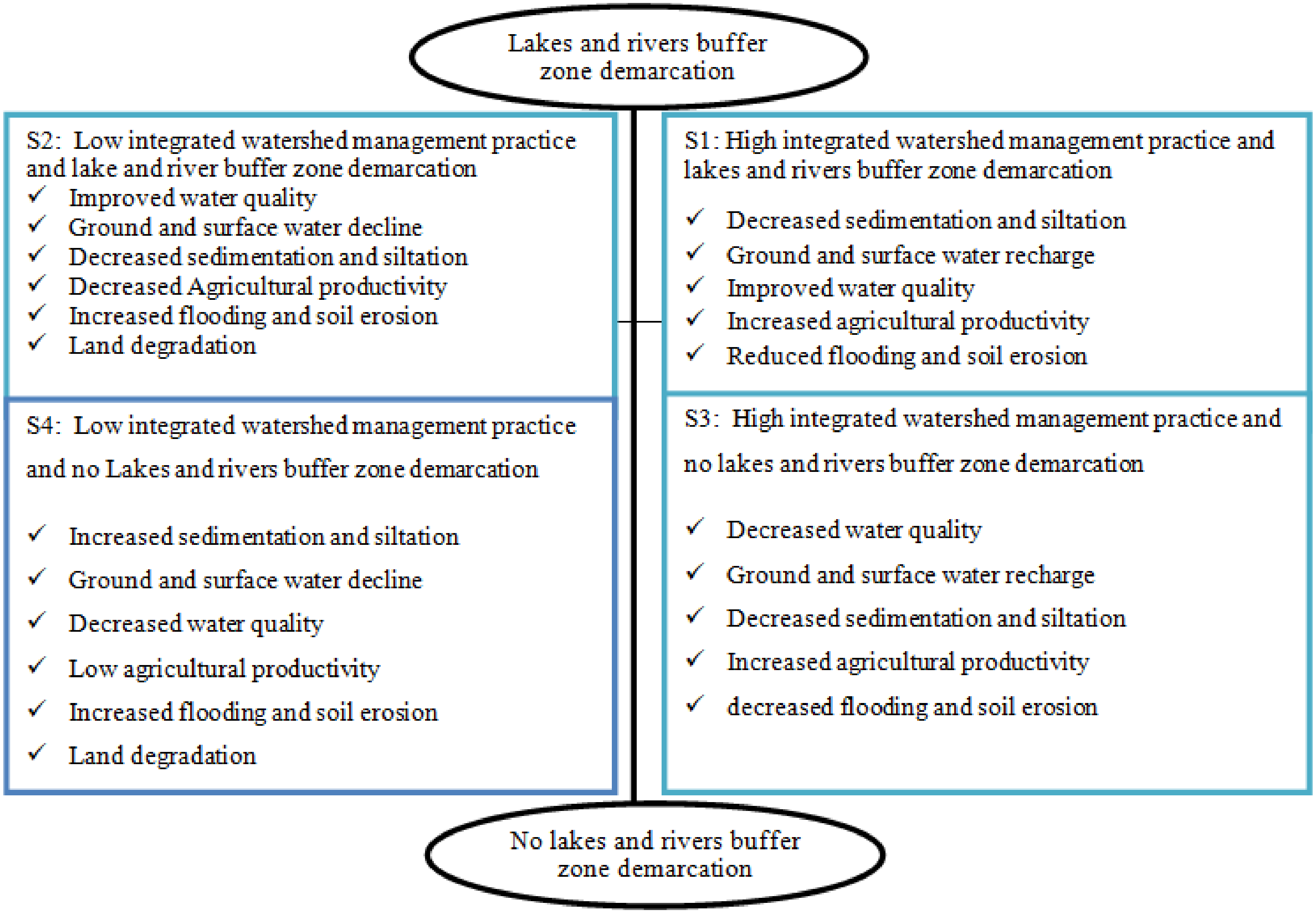


Figure 52 Scenario analysis flow chart of Omo-Gibe River Basin Plan

8.1. SCENARIO HISTORY LINE

S1: High integrated watershed management practice and lakes and rivers buffer zone demarcation

An intensive practice of integrated watershed management on the upper catchments accompanied by lakes and rivers buffer zone demarcation around the main water bodies resulted in ground and surface water recharge, water quality improvement, enhanced agricultural productivity, mitigation of land degradation, sedimentation, siltation, flooding and soil erosion. Water resource is available to fulfill environmental and socio-economic demand.

S2: Low integrated watershed management practice and lakes and rivers buffer zone demarcation

Low practice of integrated watershed management on the upper catchments with demarcation of lakes and rivers buffer zone around the main water bodies resulted in less recharge of ground and surface water, water quality improvement, enhanced agricultural productivity, less mitigation of land degradation, flooding and soil erosion but improved sedimentation and siltation. Water resource is available to fulfill environmental and socio-economic demand.

S3: High integrated watershed management practice and no lakes and rivers buffer zone demarcation

An intensive practice of integrated watershed management on the upper catchments lacking around the main water bodies resulted in enhanced ground and surface water recharge, decreased water quality, decreased sedimentation/ siltation, decreased flooding and soil erosion and increased agricultural productivity.

S4: Low integrated watershed management practice and no lakes and rivers buffer zone demarcation

Low practice of integrated watershed management on the upper catchments without demarcation of lakes and rivers buffer zone around the main water bodies resulted in less recharge of ground and surface water, water quality decline, decreased agricultural productivity, high land degradation, increased flooding and soil erosion and increased sedimentation and siltation. Water resource is available to fulfill environmental and socio-economic demand.

Some hierarchical/prioritized problem identification is made taking the duties of Ministry of Water and Energy into account.

i. Water scarcity – development of water infrastructure – dams, diversion, wells, ponds, flood harvesting, etc
ii. Water allocation – conflict management,
iii. Catchment degradation – water tower identification, afforestation, soil and water conservation, agroforestry,
iv. Demand management – irrigation managent, measuring, improved efficiency
v. Water Quality – Pollution, invasive weeds management/prevention, monitoring
vi. Wetlands/buffer zones – sustainable use
vii. Governace and stakeholders – water user organization, awareness creation

9. BASIN MISSION, VISION, GOALS AND OBJECTIVES

9.1. VISION

Realizing equitable, efficient and sustainable water resources development and utilization in Omo Gibe River basin by 2038.

9.2. MISSION

Institute appropriate legal and regulatory framework so as to establish effective mechanisms of water resources development, protection, and efficient utilization in Omo Gibe River basin.

9.3. GOALS AND OBJECTIVES

The overall goal is to ensure economic, social, and environmental benefits of water resources for present and future generation in the basin by 2038 through equitable and effective development and utilization of the resources by improving water quantity and quality, catchment management and allocation principle. The general goal is categorized into five strategic goals.

Goal 1: Enhance availability, sustainable management, proper allocation and optimum utilization of water resources in the basin for sustainable social, economic and environmental benefits

[1.1] To augment surface water resource availability in the basin

[1.2] To increase groundwater resource availability in the basin

[1.3] To improve irrigation water use efficiency in the basin

[1.4] To allocate water resources among different uses

[1.5] To improve public awareness on IWRM through capacity building training

[1.6] To Improve the hydro-meteorological information system

[1.7] To investigate the use of electric power from off grid electric energy and energy saving technologies

Goal 2: Ensure the availability of good water quality for sustainable social, economic and environmental benefits

[2.1] To reduce surface and groundwater salinity problem across in the basin

[2.2] To ensure Environmental friendly Agricultural practices

[2.3] Develop and enforce regulatory instruments focusing on maintaining water quality standards and control pollution

[2.4] To establish water quality monitoring system in the basin

[2.5] To implement integrated waste management practices

[2.6] To conserve wetlands and hydropower reservoir shores

Goal 3: Improve water resource potential and conservation, and community livelihoods through integrated watershed management

[3.1] To capacitate the stakeholders in integrated watershed management

[3.2] To rehabilitate severely degraded watersheds

[3.3] To improve the livelihood of the community

Goal 4: Ensure active stakeholder participation to improve planning, implementation, monitoring and evaluation of IWRM projects

[4.1] To improve stakeholder awareness on water resources management and optimal use

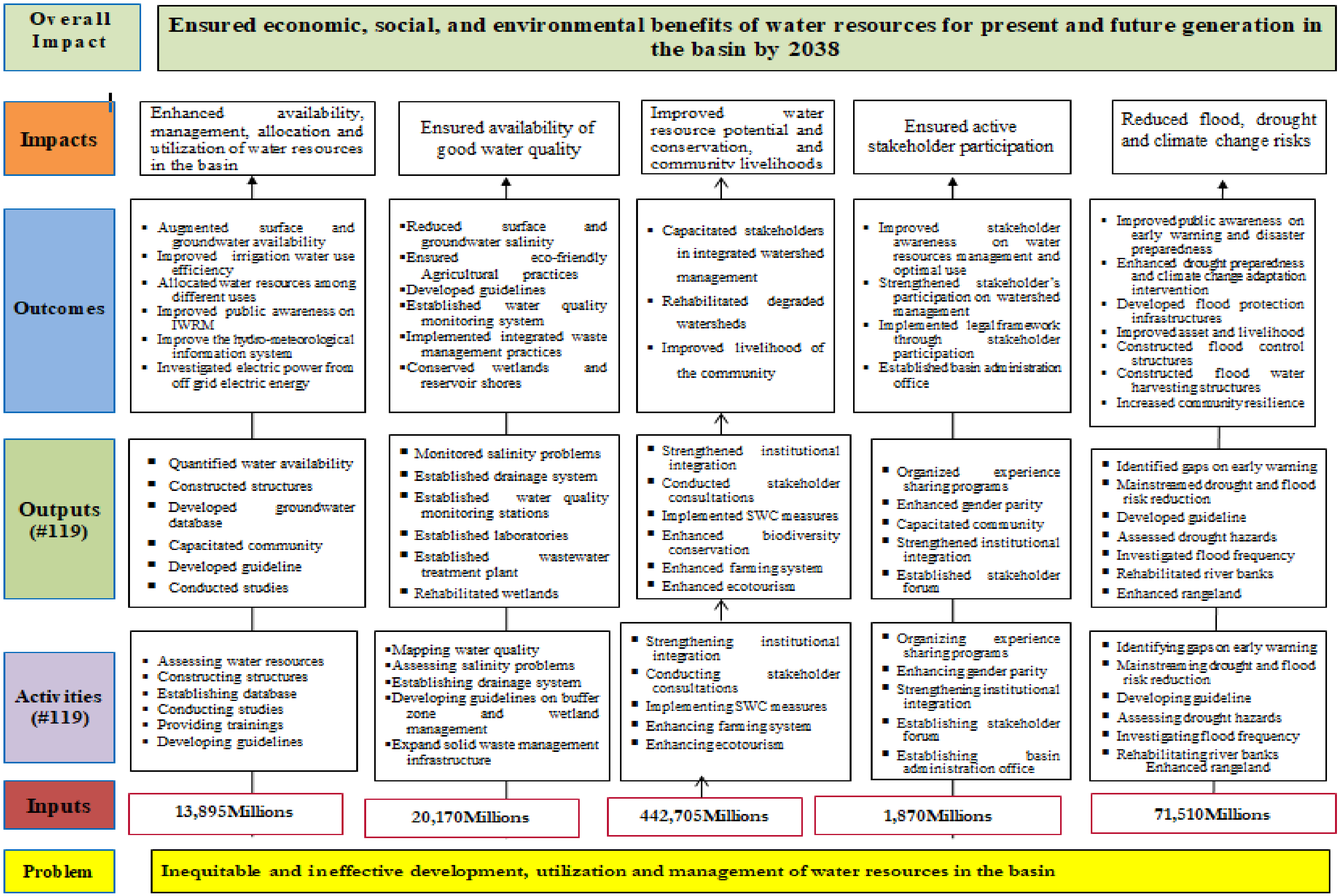
[4.2] To strengthen stakeholder's participation on watershed management

[4.3] To implement legal framework through stakeholder participation

Goal 5: Reduce flood, drought and climate change risks to improve social, economic and environmental benefits in the basin

1) To improve public awareness on early warning and disaster preparedness
2) To enhance drought preparedness and climate change adaptation interventions
3) To Coordinate planning and design of drought preparedness, mitigation and emergency response activities
4) To develop flood protection infrastructures for efficient management and utilization of flood water
5) To Strengthen the Community in accessing, using and understanding of DRR and climate information

9.4. THEORY OF CHANGE



9.5. IMPLEMENTATION AND FINANCIAL PLAN

9.5.1. DETAILS OF IMPLEMENTATION PLAN

Table 40: Details of Implementation Plan for the Period of 15 years (2024-2038)

No	Description of Goals, Objectives and Major activities	Unit	Qty.	Implementation Period									Action Owner	Main Implementers	Hotspot Areas
				2024-2028			2029-2033			2034-2038					
				Gibe Gojeb SB	Omo Sharma SB	Lower Omo SB	Gibe Gojeb SB	Omo Sharma SB	Lower Omo SB	Gibe Gojeb SB	Omo Sharma SB	Lower Omo SB			
Goal 1	**Enhance availability, sustainable management, proper allocation and optimum utilization ofwater resourcesin the basin for sustainable social, economic and environmental benefits**														
1.1	**To augment surfacewater resource availabilityin the basin**														
	Assessment of surface water availability in the basin	No. of Doc	18	2	2	2	2	2	2	2	2	2	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, HERI	All three sub-basins
	Assess water scarce areas and identify alternative sources in the basin	No. of Doc	18	1	2	3	1	2	3	1	2	3	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, HERI	All Sub-basins mainly Mihur Aklil(Gurage), Misha and Gibe (Hadiya), Kaffa Zone, Upper dawro, Tambaro S/Woreda, Hadaro Woreda, Ari Zone, Pastoral Zone
	Developing manual of rainwater harvesting technology	No. of Doc	3	1	1	1	0	0	0	0	0	0	MoA , Regional and Zonal Agriculture bureas	MoA , Regional and Zonal Agriculture burea, NGOs	
	Strengthen communitywater harvesting capacity	No of training	12	1	1	2	1	1	2	1	1	2	MoA , Regional and Zonal Agriculture bureas	MoA , Regional and Zonal Agriculture burea, NGOs	
	Assess water use conflicts for identification of alternative sources	No. of Doc	6	1	1	2	0	0	0	0	1	1	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs,	All sub-basins mainly in Ari Zone, Pastoral Zone, and other water scarce

														HERI	areas
	Develop and rehabilitate buffer zones along the dams reservoirs, rivers, wetlands in the basin	No. of buffer zone	16	2	2	2	2	2	2	1	1	2	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs,EPA, MoA,EEPCO, HERI, Urban Dev't sector	The shores of dams reservoirs, rivers, and wetlands in all sub-basins
	Undertake environmental and social impact assessment in areas related to water resources	No. of Doc	6	1	1	1	0	0	0	1	1	1	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs,EPA, MoA,HERI, Urban Dev't sector	Water centered investment and industrial development areas in all sub-basins
	Construct surface water enhancing structures and its use in water scarce areas	No. of structures	45	4	5	6	3	5	7	3	4	8	MoWE, MoA; regional and zonal water and agriculture bureas	MoWE, MoA; regional and zonal water and agriculture bureas	Mihur Aklil(Gurage), Misha and Gibe (Hadiya), Kaffa Zone, Upper dawro, Tambaro S/Woreda, Hadaro Woreda, Ari Zone, Pastoral Zone
1.2.	**To increase groundwater resource availabilityin the basin**														
	Develop the basin groundwater database (physical, chemical, electrical)	No. of Doc	3	1	1	1	0	0	0	0	0	0	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, ,Urban Dev't sector, MoA, Irrigation Development Burea	All three sub-basins
	Quantify the existing amount of groundwater in the aquifers of the basin	No. of Doc	6	1	1	1	0	0	0	1	1	1			All three sub-basins
	Develop monitoring groundwater wells in selected areas in the basin	No. of wells	10	2	2	2	2	1	1	0	0	0			All three sub-basins

	Construct groundwater resource enhancing structures and its use in water scarce areas	No. of structures	10	2	2	2	2	1	1	0	0	0			Mihur Aklil (Gurage), Misha and Gibe (Hadiya), Kaffa Zone, Upper dawro, Tambaro S/Woreda, Hadaro Woreda, Ari Zone, Pastoral Zone
	Develop standards for the GW development	No. of Doc	3	1	1	1	0	0	0	0	0	0			All three sub-basins
1.3.	**To improve irrigation water use efficiency in the basin**														
	Assess irrigation potential of the basin	No. of Doc	14	2	2	2	2	1	2	1	1	1	Ministry of Irrigation & Lowland, Regional and Zonal Irrigation sectors	Ministry of Irrigation & Lowland, Regional and Zonal Irrigation sectors, MoWE, Regional and Zonal Water sectors, NGOs, ,Urban Dev't sector, MoA, Irrigation Development Burea	All three sub-basins
	Study irrigation efficiency of all existing schemes in the basin	No. of Doc	50	6	6	6	6	6	5	5	5	5			All three sub-basins
	Assess knowledge, attitude and practices on efficient irrigation technology	No. of Doc	45	5	5	5	5	5	5	5	5	5			All three sub-basins
	Build technical capacity of the water users to avoid the use conflict	No of training	120	15	15	10	10	15	15	15	10	15			All three sub-basins
	Create model irrigation scheme for demonstration	No of model sites	10	1	1	1	1	1	1	1	1	2			All three sub-basins
	Assess the feasibility of groundwater for irrigation	No of doc	20	2	2	2	2	2	2	3	2	3			All three sub-basins
	Introduce drip irrigation technology	No of Scheme	20	2	2	2	2	2	2	3	2	3			All three sub-basins
	Introduce sprinkler irrigation technology	No of Scheme	10	1	1	1	1	1	1	1	1	2			All three sub-basins
1.4	**To allocate water resources among different uses**														
	Assess seasonal and annual total water availability of the basin	No. of Doc	6	1	1	1	0	0	0	1	1	1			All three sub-basins

	Identify major water sources and assess their existing water supply and delivery efficiency	No of docs	10	1	1	1	1	1	1	1	1	2	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, HERI	All three sub-basins
	Provide training to build professional capacity to perform appropriate and effective decisions on water allocation and use	No of trainings	15	2	2	2	2	2	2	1	1	1			All three sub-basins
	Assess all type of water demands and demand management system	No. of Doc	15	2	2	2	2	2	2	1	1	1			All three sub-basins
	Entitle/Allocate water for all water demands	No. of Doc	15	2	2	2	2	2	2	1	1	1			All three sub-basins
	Permit water use license	No. of License	100	13	13	14	10	10	10	10	10	10			All three sub-basins
	Enhancing the payment for water use/opportunity cost through training	No. of training	200	26	26	28	20	20	20	20	20	20			All three sub-basins
1.5	**To improve public awareness on IWRM through capacity building training**														
	Conduct studies on the application of integrated water resource management in the basin	No. of Doc	20	2	2	2	3	3	2	2	2	2	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, HERI	All three sub-basins
	Strengthening the policy implementation of IWRM	No. of training	15	2	2	2	2	2	2	1	1	1			All three sub-basins
	Establish IWRM demonstration sites for technologydissemination	No. of Sites	10	1	1	1	1	1	1	1	1	2			All three sub-basins
	Prepare capacity building trainings on the benefit of water user associations (WRUAs)	No of trainings	30	4	4	4	4	4	4	2	2	2			All three sub-basins
1.6	**To Improve the hydro-meteorological information system**														
	Conducting bathymetric survey of the reservoirs in the basin	No. of study	10	1	2	1	1	1	1	1	1	1	MoWE, Regional	MoWE, Regional and	Gibe I, Gibe II, Gibe III, Gibe IV, Gibe V

	Upgrade existing manual and automatic hydrological gauging stations	No of stations	20	3	3	2	3	3	1	2	2	1	and Zonal Water sectors	Zonal Water sectors, NGOs, HERI, NMA	All existing gauging stations in the three sub-basins
	Establish new river gauging stations and improve its coverage and status in the basin	No of stations	20	3	3	4	2	3	5	0	0	0			Omo-Sharma and Lower Omo Sub-basins. Eg. upstream of diversion canal to Kuraz irrigation scheme, etc
	Upgrade the existing meteorological stations	No of stations	20	3	3	2	3	3	1	2	2	1			All existing gauging stations in the three sub-basins
	Install new meteorological stations and improve its coverage and status in the basin.	No of stations	20	3	3	4	2	3	5	0	0	0			Omo-Sharma and Lower Omo Sub-basins.
	Provide training in collecting, processing and disseminating of hydro meteorological data	No of trainings	15	2	2	2	2	2	2	1	1	1			All sub-basins
	Establishing hydrological and meteorological database system for proper data registration and manageemnt at Wolaita Sodo, Jimma and Jinka Universities	No. of DBS	6	2	2	2	0	0	0	0	0	0			All sub-basins
1.7	**To investigate the use of electric power from off grid electric energy and energy saving technologies**														
	Study of solar energy potential	No. of doc	100	10	20	20	10	20	20	10	20	20	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, Energy Agency	All Sub-basins
	Study of wind energy potential	No. of doc	100	10	20	20	10	20	20	10	20	20			All Sub-basins
	Study of biogas energy potential	No. of doc	400	50	50	40	50	50	30	50	50	30			All Sub-basins
Goal 2	**Ensure the availability of good water quality for sustainable social, economic and environmental benefits**														
2.1	**To reduce surface and groundwater salinity problem across in the basin**														

	Produce water quality map for rivers, swamps, reservoirs, and groundwater	No of Packages	24	3	3	3	3	3	3	2	2	2	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, MoILD, EPA, MoH, MoA	All sub-basins
	Assess major pollutants contributing to water salinity	No of Doc	12	2	2	3	1	1	3	0	0	0			All sub-basins
	Monitor salinity problems associated with irrigation projects	No of Doc	6	1	1	1	0	0	0	1	1	1			All sub-basins
	Equipping the sectorial offices with the knowledge and tools to control the salinity problem in the basin	No of training	15	2	2	3	2	2	3	0	0	1			All sub-basins
2.2	**To ensure Environmental friendly Agriculturalpractices**														
	Implement Agro-chemical pollutant permit standards in large farms	No. of farms	30	2	2	6	2	2	6	1	1	8	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, MoILD, EPA, MoA	All sub-basins mainly Ari and Pastoral zones in South Ethiopia region
	Increase public awareness on environmental pollution	no. of training	36	4	4	4	4	4	4	4	4	4			
	Establishing drainage system in large farms	No. of farms	30	2	2	6	2	2	6	1	1	8			
2.3	**Develop and enforce regulatory instruments focusing on maintaining water quality standards and control pollution**														
	Inventory of water quality and pollution sources through establishing stations at permanent water quality monitoring sites	No. of stations	12	1	1	1	2	2	1	2	1	1	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, MoILD, EPA, MoA, MoH, Urban Dev't Bureaus	All sub-basins
	Review water quality standards for rural, municipal and irrigation water supplies	No of doc	3	1	1	1	0	0	0	0	0	0			All sub-basins
	Equipping the existing regional laboratories with facilities	No of Lab	5	1	1	1	1	1	0	0	0	0			All sub-basins
	Improve urban sewerage management infrastructure for main towns	No of towns	20	2	2	1	4	4	1	2	2	2			All sub-basins

	Develop standards, guidelines and procedures on wastewater quality, solid wastes and discharge regulation	No of doc	9	1	1	1	1	1	1	1	1	1			All sub-basins
2.4	**To establish water quality monitoring system in the basin**														
	Developing water quality monitoring network	No. of stations	6	1	1	1	0	0	0	2	1	0	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, MoILD, MoA, MoH, Urban Dev't Bureaus	All sub-basins mainly Gibe-Gojeb and Omo-Sharma sub-basins
	Develop water quality monitoring database	No. of database	6	1	1	1	0	0	0	2	1	0			
	Establish Grade B water quality laboratory at Jimma, Wolaita Sodo and Jinka Universities	No. of Lab	3	1	1	1	0	0	0	0	0	0			Jimma, Jinka and Wolaita Sodo Universities
2.5	**To implement integrated waste management practices**														
	Identify type and extent of pollution in the basin	No. of doc	15	3	3	2	2	2	1	1	1	0	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, Urban Dev't Bureaus. HEI	All sub-basins
	Establish wastewater treatment plants at major towns	No. of plant	10	2	2	1	1	1	1	1	1	0			All sub-basins
	Establish wastewater treatment plants at higher education institutions (HEI)	No. of HEI	10	2	2	1	1	1	1	1	1	0			Higher education institutions in the basin
	Expand solid waste management infrastructure in large cities	No. of Cities	10	2	2	1	1	1	1	1	1	0			Large cities in the basin
	Establish administrative procedures for discharge permit /licensing system as per regulations	No. of doc	10	1	1	1	2	2	1	1	1	0			All sub-basins
	Provide awareness raising training on water pollution	No. of workshops	150	30	30	30	10	10	10	10	10	10			All sub-basins
2.6	**To conserve wetlands and hydropower reservoir shores**														
	Identify and rehabilitate wetlands	No. of wetland	20	3	3	2	3	3	2	2	1	1	MoWE, Regional and Zonal Water	MoWE, Regional and Zonal Water sectors, NGOs,	All sub-basins

	Investigate and demarcate reservoirs and rivers buffer zones	No. of buffer zone	90	10	10	10	10	10	10	10	10	10	sectors	EPA, Urban Dev't Bureaus, MoA, MoILD	All sub-basins
	Develop guidelines on buffer zone and wetland management	No of doc	6	2	2	2	0	0	0	0	0	0			All sub-basins
	Provide awareness raising training on buffer zone and wetland management	No of training	15	2	2	1	2	2	1	2	2	1			All sub-basins
	Estimate sediment transport/yield into the reservoirs	No of doc	20	3	3	2	2	2	2	2	2	2			All sub-basins
Goal 3	**Improve water resource potential and conservation, and community livelihoods through integrated watershed management**														
3.1	**To capacitate the stakeholders in integrated watershed management**														
	Strengthen institutional integration in integrated watershed management	No of platform	9	1	1	1	1	1	1	1	1	1	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, MoA	All sub-basins
	Conduct awareness creation training on integrated watershed management	No. of training	45	5	5	5	5	5	5	5	5	5			
	Undertake regular stakeholder consultations on integrated watershed management	No. of consultations	45	5	5	5	5	5	5	5	5	5			
3.2	**To rehabilitate severely degraded watersheds**														
	Produce effective land use policy and rules	No. of doc.	3	1	1	1	0	0	0	0	0	0			
	Establish and maintain nursery sites	No. of nursery site	1500	200	200	100	200	200	100	200	200	100	MoWE, Regional and Zonal	MoWE, Regional and Zonal Water	

	Conduct biological SWC measures	km^2	1000	150	150	100	100	100	100	100	100	100	Water sectors	sectors, NGOs, EPA, MoA,	All sub-basins
	Implement Physical SWC measures	km^2	30,000	4000	4000	1000	4000	4000	4000	4000	4000	1000			
	Prepare watershed management plan for each watershed	No. of water sheds	38	10	10	8	5	5	0	0	0	0			
	Constructing gully rehabilitation structures	km	6000	1000	1000	500	1000	1000	500	400	400	200			
	Promote participatory sustainable forest management	No. of training	45	5	5	5	5	5	5	5	5	5			
	Enhancing biodiversity conservation and management	No. of training	45	5	5	5	5	5	5	5	5	5			
	Ensuring proper national park management	No. of training	45	5	5	5	5	5	5	5	5	5			
	Monitoring and controlling the prevalence of invasive species	No. of Campign	45	5	5	5	5	5	5	5	5	5			
3.3	**To improve the livelihood of the community**														
	Enhance the farming system through modern technology	No. of HHs	6Mil	1Mil	1Mil	0.5Mil	1Mil	1Mil	0.5Mil	0.4Mil	0.4Mil	0.2Mil	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, MoA, MoI, MoTRC,MoT, MoILD	All sub-basins
	Introduce modern livestock breeding system	No. of HHs	0.4 Mil	0.1Mil	0.1Mil	0.1Mil	0.1M	0	0	0	0	0			
	Develop small and medium scale manufacturing industries	No of Industries	1600	250	250	150	200	200	150	150	150	100			
	Introducing agropastoral practices in lowland areas	No of people	1Mil	0.1mil	0.1mil	0.3mil	0.1mil	0.1mil	0.3mil	0	0	0			All sub-basins mainly Omo-Sharma and Lower Omo sub-basins
	Enhancing the ecotourism potential of the basin	No. of training	150	10	10	30	10	10	30	10	10	30			

	Enhancing the wildlife management system in national parks and protected areas	No. of training	15	1	2	2	1	2	2	1	2	2			
Goal 4	**Ensure active stakeholder participation to improve planning, implementation, monitoring and evaluation of IWRM projects**														
4.1	**To improve stakeholder awareness on water resources management and optimal use**														
	Asses awareness gap on water resources management and optimal use	No of Doc	15	2	2	1	2	2	1	2	2	1	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, Urban Dev't Bureaus, MoA, MoILD	All sub-basins
	Conduct capacity building trainings on Integrated Water Resources Management	No of train	15	2	2	1	2	2	1	2	2	1			All sub-basins
	Enhancing the gender parity in IWRM	No of train	15	2	2	1	2	2	1	2	2	1			All sub-basins
4.2	**To strengthen stakeholder's participation on watershed management**														
	Organize experience sharing programs on the best IWM practices	No of programs	15	2	2	1	2	2	1	2	2	1	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, Urban Dev't Bureaus, MoA, MoILD	All sub-basins
	Conduct capacity building trainings on Watershed Management at community level	No of trainings	100	15	15	10	10	10	10	10	10	10			All sub-basins
	Strengthening the institutional integration and coordination among stakeholders in integrated watershed management	No of trainings	60	8	8	4	8	8	4	8	8	4			All sub-basins
4.3.	**To implement legal framework through stakeholder participation**														
	Organize awareness creation workshops to engage stakeholders in legal enforcement	No. of workshops	60	8	8	4	8	8	4	8	8	4	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, Urban Dev't Bureaus, MoA, MoILD, Peace and	All sub-basins
	Establish stakeholder forum	No. of forum	15	2	2	1	2	2	1	2	2	1			All sub-basins

	Establish the Omo-Gibe River Basin Administration Office at Wolaita Sodo	No. of office	1	0	1	0	0	0	0	0	0	0		security sectors,	Omo-Sharma sub-basin mainly Wolaita Sodo City
Goal 5	**Reduce flood, drought and climate change risks to improve social, economic and environmental benefits in the basin**														
5.1	**To improve public awareness on early warning and disaster preparedness**														
	Identify and assess gaps on early warning and disaster preparedness	No. of doc	15	2	2	1	2	2	1	2	2	1	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, MoA, MoILD, Peace and security sectors, NMA NDPPC, HERI	All sub-basins mainly Omo-Sharma and Lower Omo sub-basins
	Conduct capacity building trainings on early warning and disaster preparedness	No. trainings	120	15	15	20	10	10	20	10	10	10			
5.2	**To enhance drought preparedness and climate change adaptation interventions**														
	Mainstream drought and flood risk reduction, climate change adaptation and social protection	No. of training	150	10	10	30	10	10	30	10	10	30	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, MoA, MoILD, Peace and security sectors, NMA NDPPC, HERI	All sub-basins mainly Omo-Sharma and Lower Omo sub-basins (Dasenech, Nyangatom, Salamago, Decha, Gibe Woreda, Hadaro, Kindo Koysha, Gessa Woreda, Loma Woreda, Abeshege Woreda, etc)
	Improve forest land cover and afforestation activity	km^2	400	40	40	70	30	40	80	20	30	50			
	Develop Early warning and response mechanism guideline	No. of doc	3	1	1	1	0	0	0	0	0	0			
	Improve community household asset and livelihood	No of HH	100, 000	5,000	10,000	25,000	5,000	10,000	25,000	5,000	5,000	10,000			
	Enhance Range land management system	km^2	2000	150	250	500	100	300	500	0	0	200			
5.3	**To Coordinate planning and design of drought preparedness, mitigation and emergency response activities**														
	Assessment and forecasting of drought hazards/events	No.of doc	10	1	2	2	1	2	2	0	0	0	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, MoA, MoILD, Peace and security sectors, NMA	All sub-basins mainly Omo-Sharma and Lower Omo sub-basins (Dasenech, Nyangatom, Salamago, Decha, Gibe Woreda,
	Prepare technical manual to control and monitor the drought management works	No of doc	3	1	1	1	0	0	0	0	0	0			
	Develop drought management plan	No of plan	3	1	1	1	0	0	0	0	0	0			

	Ensure effective monitoring, evaluation and reporting guidelines on drought actions	No of doc	3	1	1	1	0	0	0	0	0	0		NDPPC, HERI	Hadaro, Kindo Koysha, Gessa Woreda, Loma Woreda, Abeshege Woreda, etc)
5.4	**To develop flood protection infrastructures for efficient management and utilization of flood water**														
	Conduct investigation on the level and frequency of flood occurrence and mapping flood prone areas/hotspots	No of doc	6	1	1	1	0	0	0	1	1	1	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, MoA, MoILD, Peace and security sectors, NMA NDPPC, HERI	All sub-basins mainly Omo-Sharma and Lower Omo sub-basins (Dasenech, Nyangatom, Salamago, Decha, Gibe Woreda, Hadaro, Kindo Koysha, Gessa Woreda, Loma Woreda, Abeshege Woreda, etc)
	Conduct a study on socio-economic and environmental impacts of floods	No of doc	6	1	1	1	0	0	0	1	1	1			
	Rehabilitate and maintain river banks	km^2	1000	100	100	400	100	100	200	0	0	0			
	Design and construct flood protection and control structures (Dykes, etc.)	No of structure	20	2	4	4	1	2	2	1	2	2			
	Design and construct flood water harvesting structures (ponds, reservoirs)	No of structure	20	2	4	4	1	2	2	1	2	2			
	Improve consultation, participation and networking of stakeholders on flood management	No of Consult	80	10	15	20	5	10	20	0	0	0			
	Increase community resilience to flood risks	No of HH	100, 000	5,000	10,000	25,000	5,000	10,000	25,000	5,000	5,000	10,000			
5.5	**To Strengthen the Community in accessing, using and understanding of DRR and climate information**														
	Conduct awareness creation/skill gap filling training on DRR	No of training	60	4	6	10	4	6	10	4	6	10	MoWE, Regional and Zonal Water sectors	MoWE, Regional and Zonal Water sectors, NGOs, EPA, MoA, MoILD, Peace and security sectors, NMA NDPPC, HERI	All sub-basins mainly Omo-Sharma and Lower Omo sub-basins (Dasenech, Nyangatom, Salamago, Decha, Gibe Woreda, Hadaro, Kindo Koysha, Gessa Woreda, Loma Woreda, Abeshege Woreda, etc)
	Strengthen institutional networking for DRR	No. neworks	10	1	2	2	1	1	1	0	1	1			
	Conduct trainings on adaptive technologies on disaster risk management	No of training	30	3	6	6	2	3	3	1	3	3			
	Establish basin wide disaster risk reduction council/steering committee /	No of committee	8	2	2	2	0	1	1	0	0	0			
	Ensure effective Monitoring , Evaluation, and reporting on DRR actions	No MoE	45	5	5	5	5	5	5	5	5	5			

9.5.2. DETAILS OF FINANCIAL PLAN

Table 41: Details of Financial Plan for the Period of 15 years (2024-2038)

No	Description of Goals, Objectives and Major activities	Unit	Qty.	Estimated budget in mil. Birr											Responsible body	Partner
				Unit price	Total Price	2024-2028			2029-2033			2034-2038				
						Gibe Gojeb SB	Omo Sharma SB	Lower Omo SB	Gibe Gojeb SB	Omo Sharma SB	Lower Omo SB	Gibe Gojeb SB	Omo Sharma SB	Lower Omo SB		
Goal 1	**Enhance availability, sustainable management, proper allocation and optimum utilization of water resources in the basin for sustainable social, economic and environmental benefits**															
1.1	**To augment surfacewater resource availabilityin the basin**															
	Assessment of surface water availability in the basin	No. of Doc	18	10	180	20	20	20	20	20	20	20	20	20	MoWE	NGOs, HERI
	Assess water scarce areas and identify alternative sources in the basin	No. of Doc	18	10	180	10	20	30	10	20	30	10	20	30	MoWE	NGOs, HERI
	Developing manual of rainwater harvesting technology	No. of Doc	3	5	15	5	5	5	0	0	0	0	0	0	MoWE, MoA	NGOs, HERI
	Strengthen community water harvesting capacity	No of training	12	5	60	5	5	10	5	5	10	5	5	10	MoWE, MoA	NGOs, HERI
	Assess water use conflicts for identification of alternative sources	No. of Doc	6	10	60	10	10	20	0	0	0	0	10	10	MoWE	NGOs, HERI
	Develop and rehabilitate buffer zones along the dams reservoirs, rivers, wetlands in the basin	No. of buffer zone	16	10	160	20	20	20	20	20	20	10	10	20	MoWE, EPA, MoA	NGOs, HERI

	Undertake environmental and social impact assessment in areas related to water resources	No. of Doc	6	10	60	10	10	10	0	0	0	10	10	10	MoWE, EPA, MoA	NGOs, HERI
	Construct surface water enhancing structures and its use in water scarce areas	No. of structures	45	50	2250	200	250	300	150	250	350	150	200	400	MoWE	NGOs, HERI
1.2.	**To increase groundwater resource availabilityin the basin**															
	Develop the basin groundwater database (physical, chemical, electrical)	No. of Doc	3	50	150	50	50	50	0	0	0	0	0	0	MoWE	NGOs, HERI
	Quantify the existing amount of groundwater in the aquifers of the basin	No. of Doc	6	10	60	10	10	10	0	0	0	10	10	10	MoWE	NGOs, HERI
	Develop monitoring groundwater wells in selected areas in the basin	No. of wells	10	35	350	70	70	70	70	35	35	0	0	0	MoWE	NGOs, HERI
	Construct groundwater resource enhancing structures and its use in water scarce areas	No. of structures	10	50	500	100	100	100	100	50	50	0	0	0	MoWE	NGOs, HERI
	Develop standards for the GW development	No. of Doc	3	20	60	20	20	20	0	0	0	0	0	0	MoWE	NGOs, HERI
1.3.	**To improve irrigation water use efficiency in the basin**															
	Assess irrigation potential of the basin	No. of Doc	14	10	140	20	20	20	20	10	20	10	10	10	MoWE	NGOs, HERI
	Study irrigation efficiency of all existing schemes in the basin	No. of Doc	50	10	500	60	60	60	60	60	50	50	50	50	MoWE	NGOs, HERI

	Assess knowledge, attitude and practices on efficient irrigation technology	No. of Doc	45	10	450	50	50	50	50	50	50	50	50	50	MoWE	NGOs, HERI
	Build technical capacity of the water users to avoid the use conflict	No of training	120	20	2400	300	300	200	200	300	300	300	200	300	MoWE	NGOs, HERI
	Create model irrigation scheme for demonstration	No of model sites	10	20	200	20	20	20	20	20	20	20	20	40	MoWE	NGOs, HERI
	Assess the feasibility of groundwater for irrigation	No of doc	20	10	200	20	20	20	20	20	20	30	20	30	MoWE	NGOs, HERI
	Introduce drip irrigation techinology	No schemes	20	20	400	40	40	40	40	40	40	60	40	60		
	Introduce sprinkler irrigation techinolgy	No of schemes	10	20	200	20	20	20	20	20	20	20	20	40		
1.4	**To allocate water resources among different uses**															
	Assess seasonal and annual total water availability of the basin	No. of Doc	6	100	600	100	100	100	0	0	0	100	100	100	MoWE	NGOs, HERI
	Identify major water sources and assess their existing water supply and delivery efficiency	No of docs	10	20	200	20	20	20	20	20	20	20	20	40	MoWE	NGOs, HERI
	Provide training to build professional capacity to perform appropriate and effective decisions on water allocation and use	No of trainings	15	10	150	20	20	20	20	20	20	10	10	10	MoWE	NGOs, HERI
	Assess all type of water demands and demand management system	No. of Doc	15	10	150	20	20	20	20	20	20	10	10	10	MoWE	NGOs, HERI

	Entitle/Allocate water for all water demands	No. of Doc	15	20	300	40	40	40	40	40	40	20	20	20	MoWE	NGOs, HERI
	Permit water use license	No. of license	100	1	100	13	13	14	10	10	10	10	10	10	MoWE	NGOs, HERI
	Enhancing the payment for water use/opportunity cost through training	No. of training	200	2	400	52	52	56	40	40	40	40	40	40	MoWE	NGOs, HERI
1.5	**To improve public awareness on IWRM through capacity building training**															
	Conduct studies on the application of IWRM in the basin	No. of Doc	20	10	200	20	20	20	30	30	20	20	20	20	MoWE	NGOs, HERI
	Strengthening the policy implementation of IWRM	No. of training	15	10	150	20	20	20	20	20	20	10	10	10	MoWE	NGOs, HERI
	Establish IWRM demonstration sites for technologydissemination	No. of Sites	10	15	150	15	15	15	15	15	15	15	15	30	MoWE	NGOs, HERI
	Prepare capacity building trainings on the benefit of water user associations (WRUAs)	No of trainings	30	5	150	20	20	20	20	20	20	10	10	10	MoWE	NGOs, HERI
1.6	**To Improve the hydro-meteorological information system**															
	Conducting bathymetric survey at the ereservoirs	No. of study	10	10	100	10	20	10	10	10	10	10	10	10	MoWE, NMA	NGOs, HERI
	Upgrade all existing manual and automatic hydrological gauging stations	No of stations	20	25	500	75	75	50	75	75	25	50	50	25	MoWE, NMA	NGOs, HERI
	Establish new river gauging stations and	No of	20	20	400	60	60	80	40	60	100	0	0	0	MoWE, NMA	NGOs,

	improve its coverage and status in the basin	stations														HERI
	Upgrade existing meteorological station	No of station	20	20	400	60	60	40	60	60	20	40	40	20		
	Install new meteorological stations and improve its coverage and status in the basin.	No of stations	20	25	500	75	75	100	50	75	125	0	0	0	MoWE, NMA	NGOs, HERI
	Provide training in collecting, processing and disseminating of hydro meteorological data	No of trainings	15	10	150	20	20	20	20	20	20	10	10	10	MoWE, NMA	NGOs, HERI
	Establishing hydrological and meteorological database system for proper data registration and manageemnt at Wolaita Sodo, Jimma and Jinka Universities	No. of DBS	6	20	120	40	40	40	0	0	0	0	0	0	MoWE, NMA	NGOs, HERI
1.7	**To investigate the use of electric power from off grid electric energies and energy saving techinologies**															
	Study of solar energy potential	No of doc	100	2	200	20	40	40	20	40	40	20	40	40		
	Study of wind energy potential	No of doc	100	2	200	20	40	40	20	40	40	20	40	40		
	Study of biogas potential of the area	No of doc	400	0.5 mil	200	25	25	20	25	25	15	25	25	15		
	Sub-total 1				**13,895**											
Goal 2	**Ensure the availability of good water quality for sustainable social, economic and environmental benefits**															

2.1	**To reduce surface and groundwater salinity problem across in the basin**															
	Produce water quality map for rivers, swamps, reservoirs, and groundwater	No of Packages	24	200	4800	600	600	600	600	600	600	400	400	400	MoWE	NGOs, HERI
	Assess major pollutants contributing to water salinity	No of Doc	12	20	240	40	40	60	20	20	60	0	0	0	MoWE, EPA	NGOs, HERI
	Monitor salinity problems associated with irrigation projects in all sub-basins	No of Doc	6	10	60	10	10	10	0	0	0	10	10	10	MoWE, EPA, MoA	NGOs, HERI
	Equipping the sectorial offices with the knowledge and tools to control the salinity problem in the basin	No of training	15	20	300	40	40	60	40	40	60	0	0	20	MoWE, EPA, MoA	NGOs, HERI
2.2	**To ensure Environmental friendly Agricultural practices**															
	Implement Agro-chemical pollutant permit standards in large farms	No. of farms	30	10	300	20	20	60	20	20	60	10	10	80	MoWE, MoA, EPA	NGOs, HERI
	Increase public awareness on environmental pollution	no. of training	36	10	360	40	40	40	40	40	40	40	40	40	MoWE, MoA, EPA	NGOs, HERI
	Establishing drainage system in large farms like Ari and pastoral zones	No. of farms	30	20	600	40	40	120	40	40	120	20	20	160	MoWE, MoA	NGOs
2.3	**Develop and enforce regulatory instruments focusing on maintaining water quality standards and control pollution**															
	Inventory of water quality and pollution sources through establishing stations at permanent water quality monitoring sites	No. stations	12	50	600	50	50	50	100	100	50	100	50	50	MoWE, EPA	NGOs, HERI
	Review water quality standards for rural,	No of	3	30	90	30	30	30	0	0	0	0	0	0	MoWE, EPA	NGOs,

	municipal/urban and irrigation water supplies	doc														HERI
	Equipping the existing regional laboratories with facilities	No of Lab	5	100	500	100	100	100	100	100	0	0	0	0	MoWE	NGOs, HERI
	Improve urban sewerage management infrastructure for main towns	No of towns	20	100	2000	200	200	100	400	400	100	200	200	200	MoWE, EPA	NGOs, HERI
	Develop standards, guidelines and procedures on wastewater quality, solid wastes and discharge regulation	No of doc	9	10	90	10	10	10	10	10	10	10	10	10	MoWE, EPA	NGOs, HERI
2.4	**To establish water quality monitoring system in the basin**															
	Developing water quality monitoring network stations	No. of stations	6	100	600	100	100	100	0	0	0	200	100	0	MoWE	NGOs, HERI
	Develop water quality monitoring database	No. of DB	6	50	300	50	50	50	0	0	0	100	50	0	MoWE	NGOs, HERI
	Establish Grade B water quality laboratory at Jimma, Wolaita Sodo and Jinka Universities	No. of Lab	3	150	450	150	150	150	0	0	0	0	0	0	MoWE	NGOs, HERI
2.5	**To implement integrated waste management practices**															
	Identify type and extent of pollution in the basin	No. of doc	15	10	150	30	30	20	20	20	10	10	10	0	MoWE, EPA	NGOs, HERI
	Establish wastewater treatment plants at major towns	No. of plants	10	200	2000	400	400	200	200	200	200	200	200	0	MoWE, EPA	NGOs, HERI
	Establish wastewater treatment plants at higher education institutions	No. plants	10	200	2000	400	400	200	200	200	200	200	200	0	MoWE, EPA	NGOs, HERI

	Expand solid waste management infrastructure and recycling in large cities	No. of cities	10	100	1000	200	200	100	100	100	100	100	100	0	MoWE, EPA	NGOs, HERI
	Establish administrative procedures for discharge permit /licensing system asper regulations	No. of doc	10	5	50	5	5	5	10	10	5	5	5	0	MoWE, EPA	NGOs, HERI
	Provide awareness raising training on water pollution	No. of work shops	15 0	5	750	150	150	150	50	50	50	50	50	50	MoWE, EPA	NGOs, HERI
2.6	**To conserve wetlands and hydropower reservoir shores**															
	Identify and rehabilitate wetlands	No. of wetl and	20	30	600	90	90	60	90	90	60	60	30	30	MoWE, EPA, MoA	NGOs, HERI
	Investigate and Demarcate reservoirs and rivers buffer zones	No. of buff zon	90	20	1800	200	200	200	200	200	200	200	200	200	MoWE, EPA, MoA	NGOs, HERI
	Develop legal and policy guidelines on buffer zones and wetland management	No of docs	6	30	180	60	60	60	0	0	0	0	0	0	MoWE, EPA, MoA	NGOs, HERI
	Provide awareness raising training on buffer zone and wetland management	No of train	15	10	150	20	20	10	20	20	10	20	20	10	MoWE, EPA, MoA	NGOs, HERI
	Estimate sediment transport/yield into the reservoirs	No of reser	20	10	200	30	30	20	20	20	20	20	20	20	MoWE, EPA, MoA	NGOs, HERI
Sub-total 2					**20,170**											
Goal 3	**Improve water resource potential and conservation, and community livelihoods through integrated watershed management**															
3.1	**To capacitate the stakeholders in integrated watershed management**															
	Strengthen institutional platform in integrated watershed management	No of train	9	10	90	10	10	10	10	10	10	10	10	10	MoWE	NGOs, HERI

	Conduct awareness creation training on integrated watershed management	No	45	10	450	50	50	50	50	50	50	50	50	50	MoWE, EPA, MoA	NGOs, HERI
	Undertake regular stakeholder consultations on integrated watershed management	No.	45	10	450	50	50	50	50	50	50	50	50	50	MoWE, EPA, MoA	NGOs, HERI
3.2	**To rehabilitate severely degraded watersheds**															
	Produce effective land use policy and rules	No. of docu	3	20	60	20	20	20	0	0	0	0	0	0	MoWE, EPA, MoA	NGOs, HERI
	Establish and maintain nursery sites	No. of nursery site	1500	5	7500	1000	1000	500	1000	1000	500	1000	1000	500	MoWE, EPA, MoA	NGOs, HERI
	Conduct biological SWC measures	Km2	1000	5	5000	750	750	500	500	500	500	500	500	500	MoWE, EPA, MoA	NGOs, HERI
	Implement Physical SWC measures	Km 2	30,000	6	180,000	24000	24000	6000	24000	24000	24000	24000	24000	6000	MoWE, EPA, MoA	NGOs, HERI
	Prepare watershed management plan for each watersheds of the basin	No watershe	38	10	380	100	100	800	50	50	0	0	0	0	MoWE, EPA, MoA	NGOs, HERI
	Constructing gully rehabilitation structures	km	6000	5	30000	5000	5000	2500	5000	5000	2500	2000	2000	1000	MoWE, EPA, MoA	NGOs, HERI
	Promote participatory sustainable forest management	No. of training	45	5	225	25	25	25	25	25	25	25	25	25	MoWE, EPA, MoA	NGOs, HERI
	Enhancing biodiversity conservation and management	No. of training	45	5	225	25	25	25	25	25	25	25	25	25	MoWE, EPA, MoA	NGOs, HERI

	Ensuring proper national park management	No. of training	45	5	225	25	25	25	25	25	25	25	25	25	MoWE, EPA, MoA	NGOs, HERI
	Monitoring and controlling the prevalence of invasive species	No camp	45	5	225	25	25	25	25	25	25	25	25	25		
3.3	**To improve the livelihood of the community**															
	Enhance the farming system through modern technology	No. of HHs	6mil	0.01	60,000	10,000	10,000	5000	10,000	10,000	5000	4000	4000	2000	MoA	NGOs, HERI
	Introduce modern livestock breeding system	No. of HHs	400,000	0.01	4000	1000	1000	1000	1000	0	0	0	0	0	MoA	NGOs, HERI
	Develop small and medium scale manufacturing industries	Number	1600	2	3200	500	500	300	400	400	300	300	300	200	MoI	NGOs, HERI
	Introducing agropastoral practices in lowland areas	No of people	1mil	0.15	150,000	15,000	15,000	45,000	15,000	15,000	45,000	0	0	0	MoA	NGOs, HERI
	Enhancing the ecotourism potential of the basin	No. of training	150	4	600	40	40	120	40	40	120	40	40	120	MoT, EPA, MoA	NGOs, HERI
	Enhancing the wildlife management system in national parks and protected areas	No. of training	15	5	75	5	10	10	5	10	10	5	10	10	MoT, EPA, MoA	NGOs, HERI
Sub-total 3					**442,705**											
Goal 4	**Ensure active stakeholder participation to improve planning, implementation, monitoring and evaluation of IWRM projects**															
4.1	**To improve stakeholder awarenesson water resources management and optimal use**															
	Asses awareness gap on water resources management and optimal use	No of Doc	15	10	150	20	20	10	20	20	10	20	20	10	MoWE, EPA, MoA	NGOs, HERI

	Conduct capacity building trainings on Integrated Water Resources Management	No of train	15	10	150	20	20	10	20	20	10	20	20	10	MoWE, EPA, MoA	NGOs, HERI
	Enhancing the gender parity in IWRM	No of train	15	10	150	20	20	10	20	20	10	20	20	10	MoWE, EPA, MoA	NGOs, HERI
4.2	**To strengthenstakeholder's participation on watershed management**															
	Organize experience sharing programs on best IWRM practices	No of programs	15	10	150	20	20	10	20	20	10	20	20	10	MoWE, EPA, MoA	NGOs, HERI
	Conduct capacity building trainings on Watershed Management at community level	No of trainings	100	5	500	75	75	50	50	50	50	50	50	50	MoWE, EPA, MoA	NGOs, HERI
	Strengthening the institutional integration and coordination among stakeholders in integrated watershed management	No of trainings	60	6	360	48	48	24	48	48	24	48	48	24	MoWE, EPA, MoA	NGOs, HERI
4.3.	**To implement legal framework through stakeholder participation**															
	Organize awareness creation workshops to engage stakeholders in legal enforcement	No. of workshops	60	5	300	40	40	20	40	40	20	40	40	20	MoWE	NGOs, HERI
	Establish stakeholder forum	No. of forums	15	6	90	12	12	6	12	12	6	12	12	6	MoWE	NGOs, HERI
	Establish Omo Gibe Basin Administration Office at Wolaita Sodo	No. of office	1	20	20	0	20	0	0	0	0	0	0	0	MoWE	NGOs, HERI
	Sub total 4				**1,870**											

Goal 5	**Reduce flood, drought and climate change risks to improve social, economic and environmental benefits in the basin**															
5.1	**To improve public awareness on early warning and disaster preparedness**															
	Identify and assess gaps on early warning and disaster preparedness	No. doc	15	10	150	20	20	10	20	20	10	20	20	10	MoWE, EPA, MoA, NMA,	NGOs, HERI
	Conduct capacity building trainings on early warning and disaster preparedness	No. trainings	120	2	240	30	30	40	20	20	40	20	20	20	MoWE, EPA, MoA, NMA,	NGOs, HERI
5.2	**To enhance drought preparedness and climate change adaptation interventions**															
	Mainstream drought and flood risk reduction, climate change adaptation and social protection	No. of training	150	3	450	30	30	90	30	30	90	30	30	90	MoWE, EPA, MoA, NMA,	NGOs, HERI
	Improve forest land cover and afforestation activity	Km2	400	10	4000	400	400	700	300	400	800	200	300	500	MoWE, EPA, MoA, NMA,	NGOs, HERI
	Develop Early warning and response mechanism guideline	No. of doc	3	10	30	10	10	10	0	0	0	0	0	0	MoWE, EPA, MoA, NMA,	NGOs, HERI
	Improve community household asset and livelihood	No of HH	100,000	0.01	1000	50	100	250	50	100	250	50	50	100	MoWE, EPA, MoA, NMA,	NGOs, HERI
	Enhance Range land management system	Km2	2000	10	20,000	1500	2500	5000	1000	3000	5000	0	0	2000	MoWE, EPA, MoA, NMA,	NGOs, HERI
5.3	**To Coordinate planning and design of drought preparedness, mitigation and emergency response activities**															
	Conduct assessment and forecasting drought hazards/events	No. of doc	10	10	100	10	20	20	10	20	20	0	0	0	MoWE, EPA, MoA, NMA,	NGOs, HERI
	Prepare technical Mannual to control and monitor the drought management works	No of doc	3	15	45	15	15	15	0	0	0	0	0	0	MoWE, EPA, MoA, NMA,	NGOs, HERI

	Develop drought management plan	No of plan	3	20	60	20	20	20	0	0	0	0	0	0	MoWE, EPA, MoA, NMA,	NGOs, HERI
	Ensure effective Monitoring, evaluation and reporting guidelines on drought actions	No doc	3	10	30	10	10	10	0	0	0	0	0	0	MoWE, EPA, MoA, NMA,	NGOs, HERI
5.4	**To develop flood protection infrastructures for efficient management and utilization of flood water**															
	Conduct investigation on the level and frequency of flood occurrence and mapping flood prone areas/hotspots	No of docu	6	15	90	15	15	15	0	0	0	15	15	15	MoWE, EPA, MoA	NGOs, HERI
	Conduct a study on socio-economic and environmental impacts of floods	No	6	20	120	20	20	20	0	0	0	20	20	20	MoWE, EPA, MoA	NGOs, HERI
	Rehabilitate and maintain river banks	Km2	1000	30	30,000	3000	3000	12,000	3000	3,000	6,000	0	0	0	MoWE, EPA, MoA	NGOs, HERI
	Design and construct flood protection and control structures (Dykes, etc.)	No of structure	20	100	2000	200	400	400	100	200	200	100	200	200	MoWE, EPA, MoA	NGOs, HERI
	Design and construct flood water harvesting structures (ponds, reservoirs)	No of structure	20	100	2000	200	400	400	100	200	200	100	200	200	MoWE, EPA, MoA	NGOs, HERI
	Improve consultation, participation and networking of stakeholders on flood management	No of Consult	80	5	400	50	75	100	25	50	100	0	0	0	MoWE, EPA, MoA	NGOs, HERI
	Increase communities resilience to flood risks	No HH	100,000	0.1	10,000	500	1000	2500	500	1000	2500	500	500	1000		
5.5	**To Strengthen the Community in accessing, using and understanding of DRR and climate information**															
	Conduct awareness creation/skill gap filling training on DRR	No of training	60	5	300	20	30	50	20	30	50	20	30	50	MoWE, EPA, MoA	NGOs, HERI

	Strengthen institutional networking for DRR	No. neworks	10	4	40	4	8	8	4	4	4	0	4	4	MoWE, EPA, MoA	NGOs, HERI
	Conduct trainings on adaptive technologies on disaster risk management	No of training	30	5	150	15	30	30	10	15	15	5	15	15	MoWE, EPA, MoA	NGOs, HERI
	Establish basin wide disaster risk reduction council/steering committee /	No of committee	8	10	80	20	20	20	10	10	0	0	0	0	MoWE, EPA, MoA	NGOs, HERI
	Ensure effective Monitoring Evaluation and reporting on DRR	No M&E	45	5	225	25	25	25	25	25	25	25	25	25	MoWE, EPA, MoA	NGOs, HERI
Sub-total 5					**71,510**											
Total					**550,150**											
Contingency (10%)					**55,015**											
Grand total					**605,165**											

10. IMPLEMENTATION STRATEGY

10.1. Establishment of the Institution and Partnership Strategy

The main implementation framework for the strategy will be provided by the Ministry of Water and Energy, which is in charge of carrying out most of the actions and action plan specified to assist water resource management and development in the Omo-Gibe river basin. All the plans and strategic activities can only be implemented with the support and the active participation of all other governmental organizations designated as implementing bodies and involved in the development and management of water resources in the basin. Therefore, the smooth execution of the plan and its success depend greatly on securing the commitment of all high-level stakeholders of the implementing agencies, ignoring ambiguities in the duties and responsibilities of institutions, and increasing the degree of decision-makers' understanding of the significance of WRM for the sustainable growth of the nation. Once the responsible authority has approved this strategic basin plan, these institutions, or the collaboration among the institutions, need to be strengthened in order to successfully carry out or coordinate the measures that are indicated in the plan. The major implementing agency for the plan, the Ministry of Water and Energy, will be in charge of carrying it out.

As part of the implementation strategy for managing water resources, responsible institutes should assess the priorities and split action plans into phases. They should also collaborate with the primary implementing organizations to ensure that the requirements and priorities of each body are reflected. For example, with the financing available, most action plans that improve the basin's knowledge of its water resources and provide an essential enabling environment can be prioritized and implemented immediately. The plan must be reviewed on a regular basis. This will ensure that it stays in line with the anticipated results of practical research on the development and management of water resources, as well as with the developed systems for monitoring, evaluating, and adaptive management. Every five years, a comprehensive review of the action plan is necessary to ensure that its actions are being implemented as intended and that longer-term projects are integrated into the national policy for the management and development of water resources.

Any person, group, agency, or academic institution involved in the creation of the Omo-Gibe River Basin plan and partaking in the activities, exertions, and benefits of a successful implementation is connected by a partnership. Building partnerships is essential to the planning process since they are developed by important stakeholders who are identified during the creation of the basin plan and added gradually. In order to mobilize resources and carry out the basin's strategic plan as outlined with justifiable adjustments, it is critical to establish relationships with stakeholders. As a result, there are networks and strategic linkages between relevant ministries, non-governmental organizations, traditional leaders and institutions, the commercial sector, public and private universities, research centers, and civil society.

UNEP, UN, UNDP, FAO, the World Bank, Africa Bank, Farm Africa, GIZ, CARE Ethiopia, water resources, environment, agriculture, planning and finance, local communities and institutions, agencies and institutes, universities, and research centers are the main organizations anticipated to form partnerships. As a result, based on activities and the budgetary plan, partnerships will be formed for thematic areas at the federal, regional, zone, and district levels. The parties will utilize a mostly signed Memorandum of Understanding as a legally binding contract. The Memorandum of Understanding specifically mentions a set timetable, cooperative activities, and a management cycle.

Encourage the stakeholders to assume responsibility for the plan's implementation process and results. It guarantees a network of governance to address intricate issues related to environmental and watershed management. This will be accomplished by encouraging resource sharing and learning across communities—two crucial components of a collaborative, participatory process that centers on local communities managing their own natural resources. Decentralizing management strategies to the community will enable them to take on greater stewardship roles.

10.2. Strategy for Funding and Resource Mobilization

The goal of resource utilization, a crucial official duty, is to make it possible for operational priorities and strategic objectives to be carried out in a logical, predictable, and justified way. An executing institution can plan how it will produce income to fund its operations in the short, medium, and/or long term by using a fund-raising strategy. Therefore, the timely and effective implementation of water resource management action plans depends on having a solid fund-raising strategy. Every facet of the institutional business cycle is impacted by funding strategy, including corporate planning and budgeting, program delivery, management, resource allocation, and governance and policy decision-making.

In order for the actions of this strategic plan to be implemented effectively, the funding strategy needs the following: i) to increase the regular budget resource base for core functions through ongoing high-level policy consultations; ii) to identify critical areas for resource organization based on a thorough budget analysis; iii) to adopt an institutional mechanism for finance utilization, planning, monitoring, and management; and iv) to identify major funding sources that support developmental projects at basin and sub-basin scales; v) Put in place a framework for recovering all direct program costs; vi) Create cooperative mechanisms to draw attention to budgeting and pinpoint the points of entry for the short and long-term priority action strategies into the national and regional planning processes; vii) Determine which development partners are actively engaged in water resource evaluation, development, or have a close relationship with them.

As you work to develop a connection between their projects and the execution of the key actions determined during this process, make use of their overarching purpose and vision statements. Generally speaking, the fund-raising plan that will be implemented by the responsible implementing and coordinating entities should ensure: efforts coordination, public participation and consultation, a discussion forum, partnership development, efficiency and transparency, government, community, and development partner commitment, action goals with clear benefits and a fundraising establishment.

10.3. Communication Strategy and Capacity Building

Using communication methods is essential to carrying out the Omo-Gibe River Basin strategic plan. IWRM based basin management involves a wide range of stakeholders. Public awareness campaigns and education initiatives within basins enlighten residents and employees about challenges within the basin and the management of the basin. Therefore, during the designated implementation period, the primary implementer will use meetings, emails, video conferences, newsletters, and other forms of communication to coordinate the implementation of the basin plan activities with the supporting agencies, including NGOs. Through meetings, forums, media, newsletters, and other channels, the project implementers should look for and communicate funding with relevant governmental agencies and non-governmental organizations. Using phone conversations, reports, meetings, or emails, the agencies that were granted or consented to carry out the activities would update the project owners on the state of the work according to the nature of the task. Supporting agencies will provide the project owner with a monthly update on the status of the activities via email, meetings, etc. Implementers will showcase the entire delivered work to stakeholders through annual meetings, video conferences, and report materials. To inform stakeholders who are inaccessible, the plan's implementation operations will include both public and private media.

The process of enhancing and bolstering people's potential to better themselves as individuals, groups, organizations, and communities is known as capacity building. Training, instruction, technical support, networking, and cooperation inside the company will all be used to achieve this. This capacity building lowers poverty, enhances problem-solving abilities, fosters community cohesiveness and collaboration, and raises standard of living.

11. MONITORING AND EVALUATION FRAMEWORK

Monitoring of Omo Gibe River basin plan is a collection and analysis of information to track progress against the objectives in the plans and check compliance to established standards. Thelogical framework is part of the integrated approach of monitoring the basin plan. The indicators are the main tool for monitoring progress towards achieving the objectives. Monitoring of all specific objectives will be done by stakeholder participation and validated through whole monitoring report by leading and collaborator institutions. Also evaluation of the basin plan follows a systematic and objective assessment of the design, implementation and outcome of an on-going or completed intervention of the basin plan.

A clear framework, agreed among the key stakeholders at the end of the planning stage, is essential in order to carry out monitoring and evaluation systematically. This framework serves as a plan for monitoring and evaluation, and should clarify: What is to be monitored and evaluated, The activities needed to monitor and evaluate, Who is responsible for monitoring and evaluation activities, When monitoring and evaluation activities are planned (timing) and How monitoring and evaluation are carried out (methods). Monitoring and evaluation is done by each one year and compiled into five year to understand the progress of the short term plan and enable to take appropriate measurement and modifications for the coming medium term planning as well as long term planning.

The planned list of activities, targets, technical designs, and reasons for selection, maps, and others are benchmarks used to compare achievements and their impact against baselines in participatory monitoring and evaluation processes. Recurrent activities will be prepared and reported monthly, quarterly, annually, and at the beginning, at the middle and at the end of each stage of the project. The report will be evaluated with field assessments, workshop and related techniques.

Mid-term and terminal evaluation will be organized, in close consultation with partners, communities and implementers. The mid-term evaluation will determine the progress being made towards the achievement of outcomes and will identify corrective action if necessary. This will enable review the effectiveness, efficiency and time lines of implementation. Terminal evaluation will review project impacts, analyze sustainability of result and whether the plan has achieved the outcomes and the socioeconomic development with protected environment.

11.1. INDICATORS OF MONITORING AND EVALUATION

Monitoring also measures the quality and effect of the IWRM Strategy. Further elaboration of the monitoring for evaluation of the IWRM Strategy should be undertaken as part of the roadmap and action/implementation plan. When evaluating the success of the measures within each challenge to reach the goals in each of the IWRM Strategy the evaluation procedure should be simple and similar to the scoring of the measures like saying low success = 1, medium = 2 and high success = 3 and so on. The criterion should also be weighted related to its relevance for each issues of the basin. Indicators can help to answer the questions where are we now, where do we want to go, are we taking the right path to get there, and are we there yet? Different level of indicators could be used to monitor and evaluate this IWRM plan implementation and results. The following are performance indicators which could be applied with in different stage of the plan: 1) Input indicators: Measure the quantity, quality, and timeliness of resources, human, financial and material, technological and information provided for an activity; 2) Process indicators: Measure the progress of activities; 3) Output indicators: Short-term results; 4) Outcome indicators: Medium-term results and 4) Impact indicators: Long-term results.

To monitor or evaluate these performances with indicators, baselines and target should be put in the plan. But, it is difficult to put all baselines and defined targets in developing countries integrated plan. These indicators can be categorized with in economic, social and environmental issues explained in the issue and challenges explained and each goal of the the plan: Socio-economic development indicators: includes social indicators such as access to safe water, water use efficiency, flood impacts, groundwater potential, clean water and sanitation coverage, population growth rate, poverty index, employment rate, access to safe energy source, enacted laws and regulations, participation of women and youths, malaria infestation, permanent loss of land and assets, etc. Economic indicators such as: Capital turn over, GDP, NPV, IRR, agricultural production or yield, Livestock production, Forage Development, Grazing land management, fish production, Tourism flow and revenue, revenue from hydropower, income from water transport, etc.

Environment indicators such as vegetation cover, biodiversity, conservation areas, cultural heritage areas and natural river flows, Soil loss in ton/ha/yr, wetland affected, Affected Fish protected habitat, Water Quality Index (WQI), Minimum Environmental Flow, change in occurrence of invasive species, etc.

Institutional integration indicators: organizational and institutional stability, harmonized policies, enacted laws and regulations, coordinated actions, capacitated institutions both human and financially, active participation in water related issues, well developed data base and information transfer and communication systems. These criteria are expressed as questions that ask to what extent the criteria have been met, not at all (=No), partially (=Partial), to large extent (=Yes).

Database management will be applied to modernize the M and E system of the plan. Integrated water resource management is a scientific approach of resource management and it needs a sophisticated and time series data. There should be developed information management system to facilitate basin wide data exchange between the implementer and the MoWE. During monitoring and evaluation, important data would be collected, analyzed and interpreted to make decision on implemented plan. To collect this data, we need the monitoring and evaluation tools such as periodic meeting, report, field visit, focus group discussion and interview.

11.2. RESPONSIBLE BODY FOR MONITORING AND EVALUATION

It is important to identify the participants and their responsibilities during monitoring and evaluation. Different committees should be organized with in different implementing sectors to coordinate the monitoring and evaluation activity in the implementation and result evaluation of the plan. The proposed committee will be technical and steering committee designated from the implementing sectors and coordinating agencies.

11.2.1. Steering Committee Organization

The steering committees are the decision makers from Region and Woreda water related sectors which is delegated by the head of each sector. The member institutes of the steering committee depend on recurrent institutional setup of the country and the region. The steering committee evaluates the performance of the implementing sectors with regard to the agreed plan.

11.2.2. Technical Committee

Technical committee which will be organized by professionals both at regional and Woreda level delegated from implementer sectors and stakeholders. Including water related sectors, research centers and university scholars.

Table 42. Monitoring and Evaluation Matrix

Goals	Objectives	Monitoring Parameters	Target in 15 years	Output	Indicator	Data source and verification way	Measument frequency	Reporting frequency	Responsible institutions
Enhance availability, sustainable management, proper allocation and optimum utilization of water resources in the basin for sustainable social, economic and environmental benefits	**To augment surface water resource availability in the basin**	**1)** Assessed surface water availability in the basin	18	Quantified water availability	Number of document developed	MoWE report	Annually	Annually	MoWE
		2) Assessed water scarce areas and identified alternative sources in the basin	18	Identied alternative sources	Number of document produced	MoWE report	Annually	Annually	MoWE
		3) Developed manual of rainwater harvesting technology	3	Developed guideline	Number of guideline developed	MoA report	Annually	Annually	MoA
		4) Strengthen community water harvesting capacity	12	Capacitated community	Number of training provided	MoA report	Annually	Annually	MoA
		5) Assess water use conflicts for identification of alternative sources	6	Assessed and identified conflicts	Number of documents developed	MoWE report	Annually	Annually	MoWE
		6) Develop and rehabilitate buffer zones along the dams reservoirs, rivers, wetlands in the basin	16	Developed and rehabilitated buffer zones	Number of buffer zones developed and rehabilitated	MoWE report	Annually	Annually	MoWE
		7) Undertake environmental and social impact assessment in areas related to water resources	6	Assessed social and environmental impact	Number of documents developed	MoWE report	Annually	Annually	MoWE
		8) Construct surface water enhancing structures and its use in water scarce areas	45	Constructed structures	Number of structures constructed	MoWE report	Annually	Annually	MoWE
	To increase groundwater resource availability in the basin	**9)** Develop the basin groundwater database (physical, chemical, electrical)	3	Developed groundwater database	Number of database documents produced	MoWE report	Annually	Annually	MoWE
		10) Quantify the existing amount of groundwater in the aquifers of the basin	6	Quantified groundwater	Number of document prepared	MoWE report	Annually	Annually	MoWE
		11) Develop monitoring groundwater wells in selected areas in the basin	10	Developed monitoing groundwater wells	Number of monitoring wells	MoWE report	Annually	Annually	MoWE
		12) Construct groundwater resource enhancing structures and its use in water scarce areas	10	Constructed groundwater structures	Number of constructed structures	MoWE report	Annually	Annually	MoWE

		13) Develop standards for the GW development	3	Developed standards for groundwater	Number of developed standards/guidelines	MoWE report	Annually	Annually	MoWE
	To improve irrigation water use efficiency in the basin	**14)** Assess irrigation potential of the basin	14	Assessed irrigation potentials	Number of documents for assessed irrigation potential	MoIL, MoA reports	Annually	Annually	MoIL, MoA
		15) Study irrigation efficiency of all existing schemes in the basin	50	Studied irrigation efficiency	Number of studied documents	MoIL, MoA reports	Annually	Annually	MoIL, MoA
		16) Assess knowledge, attitude and practices on efficient irrigation technology	45	Assessed knowledge, attitude and practices	Number of assessment documents	MoIL, MoA reports	Annually	Annually	MoIL, MoA
		17) Build technical capacity of the water users to avoid the use conflict	120	Capacitated water users/avoided conflict	Number of training given	MoIL, MoA reports	Annually	Annually	MoIL, MoA
		18) Create model irrigation scheme for demonstration	10	Created model irrigation scheme	Number of model irrigation o of model sites	MoIL, MoA reports	Annually	Annually	MoIL, MoA
		19) Assess the feasibility of groundwater for irrigation	20	Assessed feasibility of groundwater for irrigation	Number feasibility study documents	MoIL, MoA reports	Annually	Annually	MoIL, MoA
		20) Introduce drip irrigation technology	20	Introduced drip irrigation technology	Number of irrigation schemes	MoIL, MoA reports	Annually	Annually	MoIL, MoA
		21) Introduce sprinkler irrigation technology	10	Introduced sprinkler irrigation technology	Number of irrigation of schemes	MoIL, MoA reports	Annually	Annually	MoIL, MoA
	To allocate water resources among different uses	**22)** Assess seasonal and annual total water availability of the basin	6	Assessed seasonal and annual water availability	Number of study documents	MoWE report	Annually	Annually	MoWE
		23) Identify major water sources and assess their existing water supply and delivery efficiency	10	Identified water sources	Number of assessment documents	MoWE report	Annually	Annually	MoWE
		24) Provide training to build professional capacity to perform appropriate and effective decisions on water allocation and use	15	Capacitated professionals	Number of trainings provided	MoWE report	Annually	Annually	MoWE
		25) Assess all type of water demands and demand management system	15	Assessed water demands	Number of assessment documents	MoWE report	Annually	Annually	MoWE
		26) Entitle/Allocate water for all water demands	15	Allocated water for all water demands	Number of document for water allocation	MoWE report	Annually	Annually	MoWE

		27) Permit water use license	100	Developed water license permits	Number of license provided	MoWE report	Annually	Annually	MoWE
		28) Enhancing the payment for water use/opportunity cost through training	200	Enhanced payment for water use	Number of training given	MoWE report	Annually	Annually	MoWE
	To improve public awareness on IWRM through capacity building training	**29)** Conduct studies on the application of integrated water resource management in the basin	20	Conducted studies on IWRM	Number of Study documents	MoWE report	Annually	Annually	MoWE
		30) Strengthening the policy implementation of IWRM	15	Strengthened policy implementation of IWRM	Number of training provided	MoWE report	Annually	Annually	MoWE
		31) Establish IWRM demonstration sites for technology dissemination	10	Established IWRM demonstrationsites	Number of demonstration sites	MoWE report	Annually	Annually	MoWE
		32) Prepare capacity building trainings on the benefit of water user associations (WRUAs)	30	Capacitated WRUAs	Number of trainings provided	MoWE report	Annually	Annually	MoWE
	To Improve the hydro-meteorological information system	**33)** Conducting bathymetric survey of the reservoirs in the basin	10	Conducted bathymetric survey	Number of study documents	MoWE report	Annually	Annually	MoWE
		34) Upgrade existing manual and automatic hydrological gauging stations	20	Upgraded hydrological gauging stations	Number of stations upgraded	MoWE report	Annually	Annually	MoWE
		35) Establish new river gauging stations and improve its coverage and status in the basin	20	Established river gauging stations	Number of stations established	MoWE report	Annually	Annually	MoWE
		36) Upgrade the existing meteorological stations	20	Upgraded meteorological stations	Number of stations upgraded	MoWE report	Annually	Annually	MoWE
		37) Install new meteorological stations and improve its coverage and status in the basin.	20	Installed meteorological stations	Number of stations installed	MoWE report	Annually	Annually	MoWE
		38) Provide training in collecting, processing and disseminating of hydro meteorological data	15	Hydro-meteorological data improved	Number of trainings provided	MoWE report	Annually	Annually	MoWE
		39) Establishing hydrological and meteorological database system for proper data registration and manageemnt at Wolaita Sodo, Jimma and Jinka Universities	6	Established Hydro-meteorological database system	Number of database systems	MoWE report	Annually	Annually	MoWE

	To investigate the use of electric power from off grid electric energy and energy saving technologies	**40)** Study of solar energy potential	100	Studied solar energy potential	Number of study domuments	MoWE report	Annually	Annually	MoWE
		41) Study of wind energy potential	100	Studied wind energy potential	Number of study domuments	MoWE report	Annually	Annually	MoWE
		42) Study of biogas energy potential	400	Studied wind energy potential	Number of study domuments	MoWE report	Annually	Annually	MoWE
Ensure the availability of good water quality for sustainable social, economic and environmental benefits	**To reduce surface and groundwater salinity problem across in the basin**	**43)** Produce water quality map for rivers, swamps, reservoirs, and groundwater	24	Produced water quality maps	Number of produced maps	MoWE report	Annually	Annually	MoWE
		44) Assess major pollutants contributing to water salinity	12	Assessed water pollutants	Number of assessment document	MoWE, EPA report	Annually	Annually	MoWE, EPA
		45) Monitor salinity problems associated with irrigation projects	6	Monitored salinity problems	Number of douments	MoWE, EPA report	Annually	Annually	MoWE, EPA
		46) Equipping the sectorial offices with the knowledge and tools to control the salinity problem in the basin	15	Equiped sectoral offices	Number of training given	MoWE, EPA report	Annually	Annually	MoWE, EPA
	To ensure Environmental friendly Agricultural practices	**47)** Implement Agro-chemical pollutant permit standards in large farms	30	Implemented chemical pollutant permit standards	Number of large farms	MoWE, EPA report	Annually	Annually	MoWE, EPA
		48) Increase public awareness on environmental pollution	36	Increased public awareness	Number of training provided	MoWE, EPA report	Annually	Annually	MoWE, EPA
		49) Establishing drainage system in large farms	30	Established drainage system	Number of large farms	MoWE, EPA report	Annually	Annually	MoWE, EPA
	Develop and enforce regulatory instruments focusing on maintaining water quality standards and control pollution	**50)** Inventory of water quality and pollution sources through establishing stations at permanent water quality monitoring sites	12	Established water quality monitoring stations	Number of established stations	MoWE, EPA report	Annually	Annually	MoWE, EPA
		51) Review water quality standards for rural, municipal and irrigation water supplies	3	Reviewed water quality	Number of revewed documents	MoWE, EPA report	Annually	Annually	MoWE, EPA
		52) Equipping the existing regional laboratories with facilities	5	Equiped regional laboratories	Number of equipped laboratories	MoWE, EPA report	Annually	Annually	MoWE, EPA
		53) Improve urban sewerage management infrastructure for main towns	20	Improved sewerage infrastructure	Number of towns having infrastructures	MoWE, EPA report	Annually	Annually	MoWE, EPA
		54) Develop standards, guidelines and procedures on wastewater quality, solid wastes and discharge regulation	9	Developed standards, guidelines and procedures	Number of developed guidelines	MoWE, EPA report	Annually	Annually	MoWE, EPA

	To establish water quality monitoring system in the basin	**55)** Developing water quality monitoring network	6	Developed water quality monitoring network	Number of water quality monitoring stations	MoWE, EPA report	Annually	Annually	MoWE, EPA
		56) Develop water quality monitoring database	6	Developed database	Number of database	MoWE, EPA report	Annually	Annually	MoWE, EPA
		57) Establish Grade B water quality laboratory at Jimma, Wolaita Sodo and Jinka Universities	3	Established Grade B water quality laboratory	Number of Grade B water quality laboratory	MoWE, EPA report	Annually	Annually	MoWE, EPA
	To implement integrated waste management practices	**58)** Identify type and extent of pollution in the basin	15	Identified pollution extent	Number of study documents	MoWE, EPA report	Annually	Annually	MoWE, EPA
		59) Establish wastewater treatment plants at major towns	10	Established wastewater treatment plant at major towns	Number of treatment plants at major towns	MoWE, EPA report	Annually	Annually	MoWE, EPA
		60) Establish wastewater treatment plants at higher education institutions (HEI)	10	Established wastewater treatment plant HEI	Number of treatment plants at HEI	MoWE, EPA report	Annually	Annually	MoWE, EPA
		61) Expand solid waste management infrastructure in large cities	10	Expanded solid waste management infrastructures	Number of large cities	MoWE, EPA report	Annually	Annually	MoWE, EPA
		62) Establish administrative procedures for discharge permit /licensing system as per regulations	10	Established procedures	Number of license given	MoWE, EPA report	Annually	Annually	MoWE, EPA
		63) Provide awareness raising training on water pollution	150	Improved awareness	Number of training provided	MoWE, EPA report	Annually	Annually	MoWE, EPA
	To conserve wetlands and hydropower reservoir shores	**64)** Identify and rehabilitate wetlands	20		Number of wetlands	MoWE, EPA report	Annually	Annually	MoWE, EPA
		65) Investigate and demarcate reservoirs and rivers buffer zones	90	Demarcated buffer zones	Number of demarcated bufferzones	MoWE, EPA report	Annually	Annually	MoWE, EPA
		66) Develop guidelines on buffer zone and wetland management	6	Developed guidelined on buffer zone and wetland	Number of guidelines developed	MoWE, EPA report	Annually	Annually	MoWE, EPA
		67) Provide awareness raising training on buffer zone and wetland management	15	Raise awareness	Number of training provided	MoWE, EPA report	Annually	Annually	MoWE, EPA
		68) Estimate sediment transport/yield into the reservoirs	20	Estimated sediment yield	Number of studied reservoirs	MoWE, EEPCO report	Annually	Annually	MoWE, EEPCO
Improve water resource	**To capacitate the stakeholders in**	**69)** Strengthen institutional integration in integrated watershed management	9	Strengthened institutional integration	Number training provided	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA

potential and conservation, and community livelihoods through integrated watershed management	**integrated watershed management**	**70)** Conduct awareness creation training on integrated watershed management	45	Created awareness	Number of trainings given	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		71) Undertake regular stakeholder consultations on integrated watershed management	45	Conducted sateholder consultations	Number of sconsultations	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
	To rehabilitate severely degraded watersheds	**72)** Produce effective land usepolicy and rules	3	Developed land use policy	Number of policy documents	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		73) Establish and maintain nursery sites	1500	Established nursery sites	Number of nursery sites	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		74) Conduct biological SWC measures	1000	Implemented biological SWC measures	Area (Km^2) of land	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		75) Implement Physical SWC measures	30,000	Implemented physical SWC measures	Area(Km^2)	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		76) Prepare watershed management plan for each watershed	38	Prepared watershed plan	Number of watersheds	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		77) Constructing gully rehabilitation structures	6000	Constructed gully rehabilitation structures	Length (km)	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		78) Promote participatory sustainable forest management	45	Promoted participatory forest management	Number of training	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		79) Enhancing biodiversity conservation and management	45	Enhanced biodiversity conservation	Number of training	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		80) Ensuring proper national park management	45	Ensured national park management	Number of training	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
		81) Monitoring and controlling the prevalence of invasive species	45	Controlled invasive species	Number of campaign	MoWE, MoA, EPA report	Annually	Annually	MoWE, MoA, EPA
	To improve the livelihood of the community	**82)** Enhance the farming system through modern technology	6Mil	Enhanced farming system	Number of households	MoA report	Annually	Annually	MOA
		83) Introduce modern livestock breeding system	0.4 Mil	Introduced livestock breeding system	Number of households	MoA report	Annually	Annually	MOA

		84) Develop small and medium scale manufacturing industries	1600	Developed industries	Number of industries	MoWE, MoI report	Annually	Annually	MoWE, MoI
		85) Introducing agropastoral practices in lowland areas	1Mil	Introduced agropastoral practices	Number of households	MoA, MoIL report	Annually	Annually	MoA, MoIL
		86) Enhancing the ecotourism potential of the basin	150	Enhanced ecotourism	Number of training	Ministry of Tourism report	Annually	Annually	Ministry of Tourism
		87) Enhancing the wildlife management system in national parks and protected areas	15	Enhanced wildlife mnagement	Number of training	MoA, Ministry of Tourism report	Annually	Annually	Ministry of Tourism, MoA
Ensure active stakeholder participation to improve planning, implementation, monitoring and evaluation of IWRM projects	**To improve stakeholder awareness on water resources management and optimal use**	**88)** Assess awareness gap on water resources management and optimal use	15	Assessed awareness gap	Number of documents	MoWE report	Annually	Annually	MoWE
		89) Conduct capacity building trainings on Integrated Water Resources Management	15	Build capacity	Number of training	MoWE report	Annually	Annually	MoWE
		90) Enhancing the gender parity in IWRM	15	Enhanced gender parity	Number of training	MoWE report	Annually	Annually	MoWE
	To strengthen stakeholder's participation on watershed management	**91)** Organize experience sharing programs on the best IWM practices	15	Organized experience sharing programs	Number of programs	MoWE report	Annually	Annually	MoWE
		92) Conduct capacity building trainings on Watershed Management at community level	100	Capacitated community	Number of training	MoWE, MoA report	Annually	Annually	MoWE, MoA
		93) Strengthening the institutional integration and coordination among stakeholders in integrated watershed management	60	Strengthened institutional integration	Number of trainings	MoWE, MoA report	Annually	Annually	MoWE, MoA
	To implement legal framework through stakeholder participation	**94)** Organize awareness creation workshops to engage stakeholders in legal enforcement	60	Organized awareness creation workshops	Number of workshops	MoWE, MoA report	Annually	Annually	MoWE, MoA
		95) Establish stakeholder forum	15	Established stakeholder forum	Number of forum	MoWE report	Annually	Annually	MoWE
		96) Establish the Omo-Gibe River Basin Administration Office at Wolaita Sodo	1	Established basin administration office	Number of office	MoWE report	Annually	Annually	MoWE
Reduce flood, drought and climate change	**To improve public awareness on early warning**	**97)** Identify and assess gaps on early warning and disaster preparedness	15	Identified gaps on early warning	Number of documents	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA

risks to improve social, economic and environmental benefits in the basin	**and disaster preparedness**	**98)** Conduct capacity building trainings on early warning and disaster preparedness	120	Capacitated community	Number of trainings	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
	To enhance drought preparedness and climate change adaptation interventions	**99)** Mainstream drought and flood risk reduction, climate change adaptation and social protection	150	Mainstreamed drought and flood risk reduction	Number of training	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		100) Improve forest land cover and afforestation activity	400	Improved land cover	Area(km^2) of land	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		101) Develop Early warning and response mechanism guideline	3	Developed guideline	Number of guideline	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		102) Improve community household asset and livelihood	100,000	Improved asset and livelihood	Number of households	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		103) Enhance Range land management system	2000	Enhanced rangeland	Area (km^2) of rangeland	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
	To Coordinate planning and design of drought preparedness, mitigation and emergency response activities	**104)** Assessment and forecasting of drought hazards/events	10	Assessed drought hazards	Number of documents	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		105) Prepare technical manual to control and monitor the drought management works	3	Prepared technical manual	Number of manual	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		106) Develop drought management plan	3	Developed drought management plan	No of plan	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		107) Ensure effective monitoring, evaluation and reporting guidelines on drought actions	3	Developed guideline	Number of document	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
	To develop flood protection infrastructures for efficient management and utilization of flood water	**108)** Conduct investigation on the level and frequency of flood occurrence and mapping flood prone areas/hotspots	6	Investigated flood frequency	Number of document	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		109) Conduct a study on socio-economic and environmental impacts of floods	6	Assessed flood impacts	Number of documents	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		110) Rehabilitate and maintain river banks	1000	Rehabilitated river banks	Area (km^2) of river bank	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC,

									MoIL, MoA
		111) Design and construct flood protection and control structures (Dykes, etc.)	20	Constructed flood control structures	Number of structures	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		112) Design and construct flood water harvesting structures (ponds, reservoirs)	20	Constructed flood water harvesting structures	Number of structures	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		113) Improve consultation, participation and networking of stakeholders on flood management	80	Improved consultations on flood management	Number of consultations	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		114) Increase community resilience to flood risks	100,000	Increased community resielence	Number of households	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
	To Strengthen the Community in accessing, using and understanding of DRR and climate information	**115)** Conduct awareness creation/skill gap filling training on DRR	60	Filled skill gap	Number of training	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		116) Strengthen institutional networking for DRR	10	Strengthened network for disaster risk reduction	Number of neworks	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		117) Conduct trainings on adaptive technologies on disaster risk management	30	Adapted technologies on DRR	Number of training	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		118) Establish basin wide disaster risk reduction council/steering committee /	8	Established basin wide disaster risk reduction council	Number of council or committee	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA
		119) Ensure effective Monitoring , Evaluation, and reporting on DRR actions	45	Ensured monitoring and evaluation on DRR actions	Number of MoE	MoWE, NDPPC, MoIL report	Annually	Annually	MoWE, NDPPC, MoIL, MoA

12. RISKS, MITIGATION, AND CRITICAL SUCCESS FACTORS

12.1. REQUIREMENTS FOR EFFECTIVE IMPLEMENTATION OF THE BASIN PLAN

In order to ensure the effective implementation of the Omo Gibe River Basin Plan, the commitment of Basin Council is very crucial. Basin Council should insist the MoWE and its subordinate offices as a team to develop a schedule and structure to accomplish the strategic goals and specific objectives. Stakeholders and the community shall execute each activity according to the time and resources indicated in the plan. The execution process will be conducted in collaboration and team spirit. Though the responsibilities are equally shared among the different stakeholders, MoWE shall coordinate the activities mentioned under each specific objective. MoWE shall bring the stakeholders and the community on-board to take preventive measures for potential problems and corrective actions to manage unforeseen risks and uncertainties. If situations are beyond the stakeholders, attempts shall be made to resolve the problem through consultative meetings with MoWE.

12.2. RISKS, UNCERTAINTIES AND MITIGATION OPTIONS

MoWE shall take different intervention mechanisms to manage the challenges and unpredictable problems. This could involve two aspects. One is to anticipate potential problems ahead and design different preventive options and strategies. The second is to effectively manage any unpredicted risk. This could be effectively managed through strong team spirits among the stakeholders. Handling the challenges with potential stakeholders and seeking a means towards a common advantage based on the intended objective(s) is another option that the MoWE shall standby with. In this Basin plan, expected risks and uncertainties shall be managed by discussing the issues with an existing system of MoWE, regional and zonal offices. The basin implementation body, specifically, shall share experiences from experienced IWRM based strategic plan executing basins nationally and internationally and use the lessons obtained as a useful inputs.

The basin implementation body shall also prepare progress reports for project activities they have been assigned for, that can be related to specific project members or based on assignment. Though the responsibilities are equally shared among the basin implementation body, MoWE shall coordinate the project activities in each goal and manage the possible risks.

12.3. CRITICAL SUCCESS FACTORS (CSFS)

Critical to the success of this basin plan is finding a way to provide the basin governments and communities with the necessary confidence that enhance environmental outcomes nominated in the Basin Plan can be achieved in ways that have a neutral or positive socio-economic impact on Basin communities. The following five elements mentioned in the figure below can be considered as critical success factors to implement the basin plan.

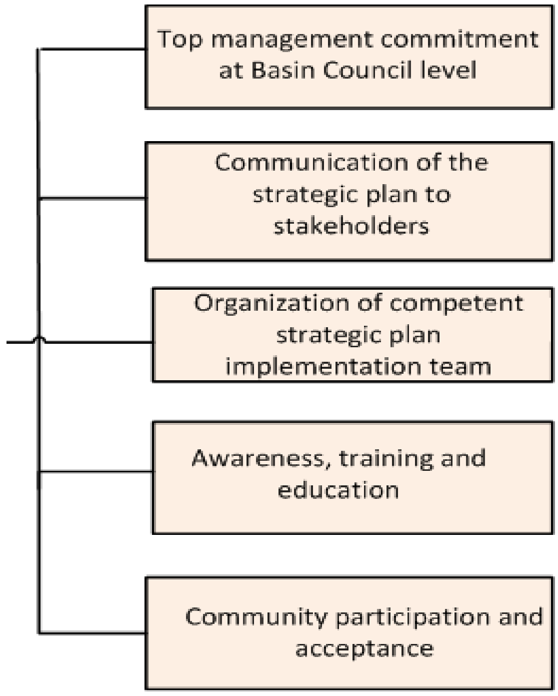


Figure 53 Critical Success Factors (CSFs) to implement the basin plan

REFERENCES

Abreham, Aneseyee, Teshome, Gudina, 2020. Land use/land cover change effect on soil erosion and sediment delivery in the Winike watershed, Omo Gibe Basin, Ethiopia.

Alistair Rieu-Clarke, Susan Baggett, Dale Campbell, K. J. Joy and Suhas Paranjape (2010), The Science–Policy–Stakeholder Interface and Stakeholder Participation. In: Science, policy, and stakeholders in water management: an integrated approach to river basin management. Geoffrey D. Gooch and Per Stålnacke (Eds).

Aneseyee, A. B., Soromessa, T., & Elias, E. (2020). The effect of land use/land cover changes on ecosystem services valuation of Winike watershed, Omo Gibe basin, Ethiopia. Human and Ecological Risk Assessment: An International Journal, 26(10), 2608–2627. https://doi.org/10.1080/10807039.2019.1675139

Armaw, A., & Molla, M. B. (2022). Assessing the trend and magnitude of land cover dynamics and its major driving forces in Omo National Park, Southern Ethiopia. Cogent Social Sciences, 8(1), 2042055.

Arowolo O, Deng X, Olatunji A, Obayelu E (2018) Assessing changes in the value of ecosystem services in response to land-use/land-cover dynamics in Nigeria. Sci Total Environ 636:597–609

Australia. 10th International River Symposium and International Environmental Flows Conference, 3-6 September 2007.

Avery, S. (2012). Development in Ethiopia's Omo Basin and its the effects on Kenya's Lake Turkana.

Awulachew, S. B., Yilma, A. D., Loulseged, M., Loiskandl, W., Ayana, M., & Alamirew, T. (2007). Water resources and irrigation development in Ethiopia (Vol. 123). IWMI.

Ayalew DW (2018). Theoretical and Empirical Review of Ethiopian Water Resource Potentials, Challenges and Future Development Opportunities. International Journal of Waste Resources 8:4 DOI: 10.4172/2252-5211.1000353Solomon S.H. (1998) Hydropower of Ethiopia: status, potential and prospects, EA CE Bulletin Vol 1, No 1, 1998, Addis Ababa, Ethiopia.

Ayalew, M. M., & Zeleke, S. A. (2018). Modeling the impact of entrepreneurial attitude on self-employment intention among engineering students in Ethiopia. Journal of Innovation and Entrepreneurship, 7, 1-27.

Badamfirooz J, Mousazadeh R (2019) Quantitative assessment of land use/land cover changes on the value of ecosystem services in the coastal landscape of Anzali International Wetland. Environ Monit Assess 191(11):694. https://doi. org/10.1007/s10661-019-7802-8

Bai, Junhong., Baoshan Cui, Huicong Cao, Ainong Li, Baiyu Zhang, "Wetland Degradation and Ecological Restoration", The Scientific World Journal, vol. 2013, Article ID 523632, 2 pages, 2013. https://doi.org/10.1155/2013/523632

Bannayan, Sanjani, Alizadeh, Lotfabadi. and Mohamadian, 2010. Association between climate indices, aridity index and rain-fed crop yield in northeast of Iran. *Field Crops Research*, 118, 105–114.

Berhanu, B., Seleshi, Y. and Melese, A.M. (2014) Surface Water and Groundwater Resources of Ethiopia: Potentials and Challenges of Water Resources Development. Springer International Publishing. Doi: 10.1007/978-3-319-02720-3_6.

Beshir K, Awdenegest M (2015) Identification of soil erosion hotspots in Jimma Zone, Ethiopia, using GIS based approach. ET J Environ Stud Manage 8(Suppl. 2):926–938. https://doi.org/10.4314/ejesm.v8i2.7S.

Bezabih, B., and Mosissa, T. (2017). Review on distribution, importance, threats and consequences of wetland degradation in Ethiopia. *International Journal of Water Resources Environmental Engineering*, 9:64–71.

Bezabih, M., Duncan, A.J., Adie, A., Mekonnen, K., Khan, N.A., Thorne, P., 2016. The role of irrigated fodder production to supplement the diet of fattening sheep by smallholders in southern Ethiopia. Tropical and Subtropical Agroecosystems 19, 263–275.

Chaemiso, S. E., Abebe, A., & Pingale, S. M. (2016). Assessment of the impact of climate change on surface hydrological processes using SWAT: a case study of Omo-Gibe river basin, Ethiopia. Modeling Earth Systems and Environment, 2(4), 1–15. doi:10.1007/s40808-016-0257-9.

Chaemiso, S. E., Kartha, S. A., & Pingale, S. M. (2021). Effect of land use/land cover changes on surface water availability in the Omo-Gibe Basin, Ethiopia. Hydrological Sciences Journal. doi:10.1080/02626667.2021.1963442.

Dagne, H., Assefa, E., & Teferi, E. (2024). Mapping and Quantifying Land Degradation in the Omo-Gibe River Basin, South-Western Ethiopia. African Geographical Review, 43(3), 452–466. https://doi.org/10.1080/19376812.2022.2164023.

Daily, G. C., ed. (1997). Nature’s services: societal dependence on natural ecosystems. Island Press, Washington, DC.

Daily, G. C., Matson, P. A., and Vitousek, P. M. (1997). Ecosystem services supplied by soil. In G. C. Daily, ed. Nature Services: Societal dependence on natural ecosystems, pp. 113–132. Island Press, Washington, DC.

Dereje Adeba, M. L. Kansal and Sumit Sen: 2015. Assessment of water scarcity and its impacts on sustainable development in Awash basin, Ethiopia

Dixon, A., Wood, A. & Hailu A. (2021). Wetlands in Ethiopia: Lessons From 20 years of Research, Policy and Practice: Wetlands in the Developing World. *Wetlands*, 41: 20. https://doi.org/10.1007/s13157-021-01420-x.

Endalamaw, Tenaw, 2015. Assessment of Existing and Future Situations of Flood-based Farming (Case Study of Lower OmoGhibe Sub-basin). Unpublished MSc Thesis, ArbaMinchi University, Ethiopia.

EWNHS (2018). A first directory of Ethiopian wetlands: descriptions, ecosystem services, causes of degradation and recommendations for restoration and sustainability. Ethiopian Wildlife and Natural History Society, Addis Ababa, Ethiopia.

FAO, 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). [Online] Avaliable at: http://www.fao.org/nr/water/aquastat/countries_regions/ETH/ [Revised 2016-04- 20]

Federal Democratic Republic of Ethiopia Ministry of Water and Energy: 2012. Scaling-Up Renewable Energy Program Ethiopia Investment Plan (Draft Final)

Federal Democratic Republic of Ethiopia Ministry of Water and Energy PART III Urban Water Supply Universal Access Plan (UWSPUAP) 2011-2015 December 2011

Ferrara, A., Kosmas, C., Salvati, L., Padula, A., Mancino, G., & Nole, A. (2020). Updating the MEDALUS-ESA Framework for Worldwide Land Degradation and Desertification Assessment. Land Degradation and Development, 31(12), 1593–1607. https://doi.org/10.1002/ldr.3559

Fikru Abiko Anose, Kassahun Ture Beketie, Tadesse Terefe Zeleke, Desalegn Yayeh Ayal and Gudina Legese Feyisa: 2021. Spatio-temporal hydro-climate variability in Omo-Gibe river Basin, Ethiopia

Fikru Abiko Anose, Kassahun Ture Beketie, Tadesse Terefe Zeleke, Desalegn Yayeh Ayal, Guddina Legese Feysa and Bereket Tesfaye Haile. 2022. Spatio-temporal analysis of droughts characteristics and drivers in the Omo-Gibe River basin, Ethiopia. *Environmental Systems Research.* https://doi.org/10.1186/s40068-022-00246-8

Flotemersch, J. E.; Leibowitz, S. G.; Hill, R. A.; Stoddard, J. L.; Thoms, M. C.; Tharme, R. E.(2016). A Watershed Integrity Definition and Assessment Approach to Support Strategic Management of Watersheds. River Research and Applications, 32(7), 1654–1671. doi:10.1002/rra.2978.

FOA, 1996. Agro-Ecological Zoning, Guidelines. FAO Soils Bulletin 73, FAO Land and Water Development Division, Rome, Italy.

FOA, 1996. Agro-Ecological Zoning, Guidelines. FAO Soils Bulletin 73, FAO Land and Water Development Division, Rome, Italy.

G. Pegram, Y. Li, T. Le. Quesne, R. Speed, J. Li, and F. Shen. 2013. River basin planning: Principles, procedures and approaches for strategic basin planning. Paris, UNESCO.

Gao, J., Li, F., Gao, H., Zhou, C., Zhang, X., 2017. The impact of land-use change on waterrelated ecosystem services: a study of the Guishui River basin, Beijing, China. J. Clean. Prod. 163, S148–S155.

Gashaw T, Tulu T, Argaw M, Worqlul W, Tolessa T, Kindu M (2018) Estimating the impacts of land use/land cover changes on ecosystem service values: the case of the Andassa watershed in the Upper Blue Nile basin of Ethiopia. Ecosyst Serv 31:219–228. https://doi.org/10.1016/j.ecoser.2018.05.001

Gebremeskel, G., Gebremicael, T. G., & Girmay, A. (2018). Economic and environmental rehabilitation through soil and water conservation, the case of Tigray in northern Ethiopia. Journal of Arid Environments, 151, 113-124. https://doi.org/10.1016/j.jaridenv.2017.12.002.

Gebreselassie, S., Kirui, O. K., & Mirzabaev, A. (2016). Economics of Land Degradation and Improvement in Ethiopia BT-Economics of Land Degradation and Improvement – a Global Assessment for Sustainable Development In (E. Nkonya, A. Mirzabaev, & J. von Braun, Eds., pp. 401–430). Springer International Publishing. https://doi.org/10.1007/978-3-319-19168-3_14.

Gebresllassie, Hagos., Temesgen Gashaw and Abraham Mehari (2014) Wetland Degradation in Ethiopia: Causes, Consequences and Remedies. Journal of Environment and Earth Science, 4: 11.

Gebretsadik, Z. M. (2014). Watershed degradation and the growing risk of erosion in Hawassa-Zuria District, Southern Ethiopia: watershed degradation and erosion in Hawassa-Zuria District. Journal of Flood Risk Management, 7(2), 118–127. https://doi.org/10.1111/jfr3.12033.

Girma, R., Gebre, E. (2020) Spatial modeling of erosion hotspots using GIS-RUSLE interface in Omo-Gibe river basin, Southern Ethiopia: implication for soil and water conservation planning. Environ Syst Res 9, 19. https://doi.org/10.1186/s40068-020-00180-7

Gizaw T, Degifie T (2018) Soil erosion modeling using GIS based RUSEL model in Gilgel Gibe-1 catchment, South West Ethiopia. Int J Environ Sci Nat Res 15(5):555923. https://doi.org/10.19080/IJESNR.2018.15.555923.

Goldman-Benner L, Benitez S, Boucher T, Calvache A, Daily G, Kareiva P et al (2012). Water funds and payments for ecosystem services: practice learns from theory and theory can learn from practice. Oryx 46:55–63. https://doi.org/10.1017/S0030605311001050.

Hailu A, Mammo S, Kidane M (2020) Dynamics of land use, land cover change trend and its drivers in Jimma Geneti District, Western Ethiopia. *Land Use Policy*, 99:105011. https://doi.org/10.1016/j.landusepol.2020.105011

Hailu Gisha, Abrham W/Mariam and Brook Abate; 2016. Assessment of Water Supply and Demand of Boditi Town. Civil and Environmental Research. www.iiste.org ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) Vol.8, No.11, 2016

Haregeweyn, N., Tsunekawa, A., Nyssen, J., Poesen, J., Tsubo, M., Tsegaye Meshesha, D., Schütt, B., Adgo, E., & Tegegne, F. (2015). Soil erosion and conservation in Ethiopia: a review. Progress in Physical Geography: Earth and Environment, 39(6), 750–774. https://doi.org/10.1177/0309133315598725.

Hargrove, W.L.; Heyman, J.M. A Comprehensive Process for Stakeholder Identification and Engagement in Addressing Wicked Water Resources Problems. *Land* 2020, *9*, 119. https://doi.org/10.3390/land9040119.

Harwood, A., Johnson, S., Richter, B., Locke, A., Yu, Z., Tickner, D., 2017. 'Listen to the river: Lessons from a global review of environmental flow success stories'. WWF-UK, Woking, UK.

Hatvany, M. G. (2009). Wetlands and Reclamation. *International Encyclopedia of Human Geography*, 241–246. doi:10.1016/b978-008044910-4.00589-7

Hirji, R., Davis, R., 2009. 'Environmental Flows in Water Resources Policies, Plans, and Projects: Finding and Recommendations. Environment and Development.

Huang Q, Zhao X, He C, Yin D, Meng S (2019) Impacts of urban expansion on wetland ecosystem services in the context of hosting the Winter Olympics: a scenario simulation in the Guanting Reservoir Basin, China. *Reg Environ Chang,* 19(8):2365–2379. https://doi.org/10.1007/s10113-019-01552-1

Hurni H (1985) Erosion-Productivity-Conservation systems in Ethiopia. Proceedings of 4th international conference on soil conservation, Maracay Venezuela, 3-9 November. pp. 654–674.

Hurni, K., Zeleke, G., Kassie, M., Tegegne, B., Kassawmar, T., Teferi, E., Moges, A., Tadesse, D., Ahmed, M., Degu, Y., Kebebew, Z., Hodel, E., Amdihun, A., Mekuriaw, A., Debele, B., Deichert, G., & Hurni, H. (2015). The Economics of Land Degradation. Ethiopia Case Study. Soil Degradation and Sustainable Land Management in the Rainfed Agricultural Areas of Ethiopia: An Assessment of the Economic Implications soil Degradation and Sustainable Land Management in the Rainfed Agricultural Areas of Ethiopia: An Assessment of the Economic Implications Report for the Economics of Land Degradation Initiative, 94.

Hydropower of Ethiopia: status, potential and prospects, EA CE Bulletin Vol 1, No 1, 1998, Addis Ababa, Ethiopia.

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

ITAB-CONSULT PLC, 2001. Implementation Strategy for River Basin Integrated Development Master Plan. Final Report. Basin Development Studies Department, Ministry of Water Resources, MoWR.

Jaweso, A., Bauwe, & Lennartz. (2019). Hydro-Meteorological Trends in the Upper Omo-Ghibe River Basin, Ethiopia. Water, 11(9), 1951. doi:10.3390/w11091951.

Jos, T.A., Boudewijn, B., Dennis, F.W. and Roland, B., 2006. Wetlands and Natural Resource Management: Wetland Functioning in a Changing World Implications for Natural Resources Management, *Springer-Verlag Berlin Heidelberg, Ecological Studies*, 190: 80-85.

Kindu M, Schneider T, Teketay D, Knoke T (2016) Changes of ecosystem service values in response to land use/land cover dynamics in Munessa-Shashemene landscape of the Ethiopian highlands. Sci Total Environ 547:137–147. https://doi.org/10.1016/j.scitotenv.2015.12.127

Kleinschroth, F., Mekuria, W., Schwatke, C., & McCartney, M. (2021). Ecosystem services in changing social-ecological systems. In The Omo-Turkana Basin (pp. 78-101). Routledge.

Knüppe, K., & Meissner, R. (2016). Drivers and barriers towards sustainable water and land management in the Olifants-Doorn Water Management Area, South Africa. Environment and Development, 20, 3–14. https://doi.org/10.1016/j.envdev.2016.09.002.

Leh D, Matlock D, Cummings C, Nalley L (2013) Quantifying and mapping multiple ecosystem services change in West Africa. Agric Ecosyst Environ 165:6–18

Liu Y, Hou X, Li X, Song B, Wang C (2020). Assessing and predicting changes in ecosystem service values based on land use/cover change in the Bohai Rim coastal zone. Ecol Indic 111:106004. https://doi.org/10.1016/j.ecolind.2019.106004.

Lukas, P.; Melesse, A.M.; Kenea, T.T. (2023). Prediction of Future Land Use/Land Cover Changes Using a Coupled CA-ANN Model in the Upper Omo-Gibe River Basin, Ethiopia. *Remote Sens.*, *15*, 1148. https://doi.org/10.3390/rs15041148.

Matthew Heberger, Kristina Dennelly,Heather Cooley, (2016). A community Guide for Evaluating Future Urban Water Demand, Pacific Institute.

MEA (Millennium Ecosystem Assessment) (2005) Ecosystems and human wellbeing: synthesis. Island Press, Washington, DC.

Mengistu, F., & Assefa, E. (2019). Farmers' decision to adopt watershed management practices in Gibe basin, southwest Ethiopia. International Soil and Water Conservation Research, 7(4), 376–387. https://doi.org/10.1016/j.iswcr.2019.08.006.

Misganaw C, Aramde F, 2019. Impacts of land use/land cover change on stream flow and sediment yield of Gojeb watershed, OmoGibe basin, Ethiopia.

Moges D.M., Bhat H.G. (2020), Watershed degradation and management practices in north-western highland Ethiopia. Environ Monit Assess. 192(10):664. doi: 10.1007/s10661-020-08628-0. PMID: 32995923.

Montanarella, L., Pennock, D.J., McKenzie, N., Badraoui, M., Chude, V., Baptista, I., Mamo, T., Yemefack, M., Singh Aulakh, M., Yagi, K., 2016. World's soils are under threat. Soil 2, 79–82.

MoWE (2013). Ministry of water and energy, FDRE. http://www.mowr.gov.et/index.php. Accessed 4 January 2021.

MoWR (Ministry of Water Resources). 1996. Integrated Development of Omo-Ghibe River Basin Master Plan Study, Vol. XI F1, F2, F3, Addis Ababa: Ethiopia.

MoWR, 2001: Ethiopian Water Sector Strategy

Mpelasoka, F., Hennessy, K., Jones, R. and Bates, B., 2008. Comparison of suitable drought indices for climate change impacts assessment over Australia towards resource management. International Journal of Climatology, 28, 1283–1292. doi:10.1002/joc.1649

Muluneh, A., Stroosnijder, L., Keesstra, S., & Biazin, B. (2017). Adapting to climate change for food security in the Rift Valley dry lands of Ethiopia: Supplemental irrigation, plant density and sowing date. The Journal of Agricultural Science, 155(5), 703–724. https://doi.org/10.1017/S0021859616000897

Murray, B.R., Zeppel, M.J.B., Hose, G.C., Eamus, D., 2003. Groundwater dependent ecosystems in Australia: It's more than just water for rivers. Ecological Management & Restoration, Vol 4, No 2, August 2003.

Nelson E, Mendoza G, Regetz J, Polasky S, Tallis H, Cameron R et al (2009). Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. Front Ecol Environ 7:4–11. https://doi.org/10.1890/080023.

Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padgham, J., & U, P. (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability Part B: Regional Aspects Pauline Dube, Dube, Neil, Leary. In Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on January (Cambridge University Press,Cambridge, United Kingdom and New York, NY, USA) pp. 1199–1265. Africa.

Nkonya, E., Mirzabaev, A., & von Braun, J. (2015). Economics of land degradation and improvement - a global assessment for sustainable development. Economics of Land Degradation and Improvement - A Global Assessment for Sustainable Development, 1–686. https://doi.org/10.1007/978-3-319-19168-3.

Omo Gibe River Basin Development Master Plan Study; 1995. Survey and Analysis Report

Omuto, C. T., Balint, Z., & Alim, M. S. (2014). A Framework for national assessment of land degradation in the drylands: A case study of somalia. Land Degradation and Development, 25(2), 105–119. https://doi.org/10.1002/ldr.1151

Pumo, D., Arnone, E., Francipane, A., Caracciolo, D., & Noto, L. V. (2017). Potential implications of climate change and urbanization on watershed hydrology. Journal of Hydrology, 554, 80–99. https://doi.org/10.1016/j.jhydrol.2017.09.002.

Ramsar Convention Secretariat (2013). The Ramsar Convention Manual: a guide to the Convention on Wetlands (Ramsar, Iran, 1971), 6th ed. Ramsar Convention Secretariat, Gland.

Scholes J, Montanarella L, Brainich E, Barger N, Ten Brink B, Cantele M et al (2018) IPBES: summary for policymakers of the assessment report on land degradation and restoration of the intergovernmental science-policy platform on biodiversity and ecosystem services. IPBES Secretariat, Bonn

Sheffield, J., Andreadis, K.M., Wood, E.F. and Lettenmaier, D.P., 2009. Global and continental drought in the second half of the twentieth century: severity–area duration analysis and temporal variability of large-scale events. Journal of Climate, 22, 1962–1980. doi:10.1175/ 2008JCLI2722.1

Shiferaw E. Chaemiso, Suresh A. Kartha & Santosh M. Pingale (2021). Effect of land use/land cover changes on surface water availability in the Omo-Gibe Basin, Ethiopia, Hydrological Sciences Journal, DOI: 10.1080/02626667.2021.1963442.

Shiferaw, H., Alamirew, T., Kassawmar, T., & Zeleke, G. (2021). Evaluating ecosystems services values due to land use transformation in the Gojeb watershed, Southwest Ethiopia. Environmental Systems Research, 10, 1-12.

Shroder, J. F. (2014). Afghanistan environmental degradation. In Natural resources in Afghanistan (pp. 466–491). Elsevier. https://doi.org/10.1016/B978-0-12-800135-6.00017-9

Sun, W., Shao, Q., Liu, J., Zhai, J., 2014. Assessing the effects of land use and topography on soil erosion on the Loess Plateau in China. Catena 121, 151–163.

Sutton P, Anderson S, Costanza R, Kubiszewski I (2016) The ecological economics of land degradation: impacts on ecosystem service values. Ecol Econ 129:182–192

Tarfasa, S., Balana, B. B., Tefera, T., Woldeamanuel, T., Moges, A., Dinato, M., & Black, H. (2018). Modeling smallholder farmers' preferences for soil management measures: a case study fromSouth Ethiopia. Ecological Economics, 145, 410–419. https://doi.org/10.1016/j.ecolecon.2017.11.027.

Tesfaye HE, Bogale G (2019) Bogale G (2019) Modeling-impact of Land Use/Cover Change on Sediment Yield (Case Study on Omo-gibe Basin, Gilgel Gibe III Watershed, Ethiopia). Am J Mod Energy 5(6):84–93. https://doi.org/10.11648/j.ajme.20190506.11.

Tesfaye, T. W., Dhanya C. T., Gosain, A. K. (2020). Modeling the impact of climate change on the environmental flow indicators over Omo-Gibe basin, Ethiopia. *Modeling Earth Systems and Environment* https://doi.org/10.1007/s40808-020-00813-x.

Tesfaye, T. W., Dhanya C. T., Gosain, A. K. (2020). Modeling the impact of climate change on the environmental flow indicators over Omo-Gibe basin, Ethiopia. *Modeling Earth Systems and Environment* https://doi.org/10.1007/s40808-020-00813-x.

Teshome Seyum and Manfred Koch, 2013. Swat-hydrological modelling and simulation of inflow to cascade reservoir of semi-ungaged Omo-Gibe River basin, Ethiopia: *PH.D. dissertation Kassel University ICWRER 2013.*

The World Bank. Brisbane Declaration, 2007. Environmental flows are essential for freshwater ecosystem health and human well-being. Brisbane,

Thoms MC, Parsons ME, Foster JM. 2007. The use of multivariate statistics to elucidate patterns of floodplain sedimentation at different spatial scales. Earth Surface Processes and Landforms 32: 672–686. DOI:10.1002/esp.1440.

Thoms MC, Parsons ME, Foster JM. 2007. The use of multivariate statistics to elucidate patterns of floodplain sedimentation at different spatial scales. Earth Surface Processes and Landforms 32: 672–686. DOI:10.1002/esp.1440.

Tolessa T, Senbeta F, Abebe T (2017) Land use/land cover analysis and ecosystem services valuation in the central highlands of Ethiopia. For Trees Livelihoods 26:111–123. https://doi.org/10.1080/14728028.2016.1221780

Tolessa, T., Senbeta, F., & Abebe, T. (2016). Land use/land cover analysis and ecosystem services valuation in the central highlands of Ethiopia. Forests, Trees and Livelihoods, 26(2), 111–123. doi:10.1080/14728028.2016.1221780

Tolessa, T., Senbeta, F., & Abebe, T. (2016). Land use/land cover analysis and ecosystem services valuation in the central highlands of Ethiopia. Forests, Trees and Livelihoods, 26(2), 111–123. doi:10.1080/14728028.2016.1221780

Tolessa, T., Senbeta, F., & Kidane, M. (2017). The impact of land use/land cover change on ecosystem services in the central highlands of Ethiopia. Ecosystem services, 23, 47-54.

Velpuri, N.M. Senay, G.B (2012). Assessing the potential hydrological impact of the Gibe III Dam on Lake Turkana water level using multisource satellite data. Hydrology and Earth System Sciences 16:3561-3578.

Viste E, Korecha D, Sorteberg A (2013) Recent drought and precipitation tendencies in Ethiopia. Theor Appl Climatol 112:535–551.

Wang, J., & Dong, K. (2019). What drives environmental degradation? Evidence from 14 Sub-Saharan African countries. Science of the Total Environment, 656, 165–173. https://doi.org/10.1016/j.scitotenv.2018.11.354.

WAPCOS (Water & Power Consultancy Services (I) Ltd.). 1995. The National Water Resources Master Plan, Addis Ababa: Ethiopia

Wola AW. (2023). Land Use/Land Cover Change and its Driving Forces in Mago National Park, Southern Ethiopia. J Biomed Res Environ Sci.10; 4(4): 693-705. doi: 10.37871/jbres1726, Article ID: JBRES1726.

World Bank, (2006). Ethiopia: Managing Water Resources to Maximize Sustainable Growth a World Bank Water Resources Assistance Strategy for Ethiopia. Agriculture and Rural Development Department, Washington, DC.

Yericho Berhanu Meshesha and Mulugeta Bekele Abdi: 2019. Challenges and opportunities for implementation of Integrated Water Resource Management in Omo-Gibe Basin, Ethiopia; Journal of Ecology and The Natural Environment; Vol 11(7), ISSN 2006-9847

Yimer M., Asnake Y., 2021. Analysis of meteorological droughts in the Lake's Region of Ethiopian Rift Valley using reconnaissance drought index (RDI)

Yirsaw E, Wu W, Shi X, Temesgen H, Bekele B (2017). Land use/land cover change modeling and the prediction of subsequent changes in ecosystem service values in a coastal area of China, the Su-Xi-Chang Region. Sustainability 9(7):1204. https://doi.org/10.3390/su9071204

APPENDICES

Appendix 1: Population Size of Gibe-Gojeb Sub-Basin

Z_NAME	W_NAME	Area	2020	2025	2030	2035	2040	2045
Gurage	Abeshege	559.047	79901	90536	102586	116240	131712	149243
South West Shewa	Ameya	897.309	174866	198141	224513	254396	288256	326623
West Shewa	Bako Tibe	625.235	187456	212406	240678	272712	309010	350139
East Wellega	Boneya Bushe	437.522	68789	77945	88319	100075	113394	128487
Gurage	Cheha	573.151	44479	50399	57107	64708	73321	83080
West Shewa	Chelia	631.834	234814	266068	301481	341609	387077	438597
Kefa	Chena	233.131	222310	251899	285427	323418	366465	415241
Jimma	Chora Boter	1628.31	128952	146116	165563	187600	212570	240863
West Shewa	Dano	659.923	140056	158697	179820	203754	230874	261603
Jimma	Dedo	1515.89	407175	461370	522778	592360	671203	760540
Gurage	Enemor Ener	915.019	227373	257636	291928	330783	374811	424698
Gurage	Enidguagn	151.156	65024	73679	83485	94597	107188	121455
Gurage	Ezha	331.565	115608	130995	148431	168187	190573	215938
Dawuro	Gena Bosa	633.563	114558	129806	147083	166660	188842	213977
Jimma	Gera	1056.82	160339	181680	205862	233262	264309	299489
Kefa	Gesha	130.682	6715	7609	8621	9769	11069	12543
Gurage	Geta	193.907	90347	102372	115998	131437	148932	168754
Kefa	Gewata	825.282	96270	109084	123603	140054	158695	179818
Hadiya	Gibe	447.833	149118	168966	191455	216938	245812	278530
Kefa	Gimbo	392.723	130328	147675	167330	189602	214838	243433
East Wellega	Gobu Seyo	263.844	60556	68616	77749	88097	99823	113109
Jimma	Gomma	128.528	88133	99864	113155	128216	145282	164619
South West Shewa	Goro	372.913	66104	74902	84872	96168	108968	123472
East Wellega	Gudeyabila	241.219	80484	91196	103335	117089	132673	150332
Gurage	Gumer	181.901	108369	122793	139137	157656	178640	202417
Hadiya	Hosaena	38.0122	179761	203687	230798	261517	296325	335766
West Shewa	Jibat	505.14	103408	117172	132767	150438	170462	193150
Jimma Spe Town	Jimma Town	50.5209	250909	284305	322146	365024	413608	468660
Jimma	Kerisa	957.355	234886	266149	301574	341713	387195	438731
Gurage	Kokir Gedebano	547.758	124073	140587	159299	180502	204527	231749
Konta	Konta Special	344.558	129665	146923	166479	188637	213745	242194
Jimma	Limu Kosa	969.89	235584	266940	302470	342729	388346	440035
Jimma	Limu Seka	922.904	268370	304090	344564	390426	442392	501274
Dawuro	Mareka	211.149	190009	215299	243956	276426	313218	354908
Kefa	Menjwo	862.606	144128	163311	185048	209678	237586	269209

Gurage	Muhur NA Aklil	466.973	115149	130475	147842	167519	189816	215081
West Shewa	Nono	695.66	120166	136160	154283	174818	198086	224452
Jimma	Omonada	1619.09	355217	402496	456069	516771	585554	663491
South West Shewa	Seden Sodo	242.703	98756	111900	126794	143671	162793	184461
Jimma	Seka Chekorsa	822.314	295677	335032	379624	430152	487406	552279
Jimma	Sekoru	1004.77	199182	225693	255733	289771	328339	372041
Jimma	Shebe Senbo	765.589	160229	181555	205721	233102	264128	299283
Hadiya	Soro	704.966	269031	304839	345413	391388	443481	502509
Kembata Timbaro	Tibaro	298.45	147876	167558	189860	215131	243765	276210
Jimma	Tiro Afeta	927.146	187490	212445	240721	272761	309066	350203
Dawuro	Tocha	467.029	142959	161987	183547	207977	235659	267025
South West Shewa	Weliso	646.238	202219	229134	259632	294189	333346	377714
South West Shewa	Wonchi	440.617	132178	149771	169705	192293	217887	246888
YEM	Yem Sp	647.898	116044	131489	148991	168821	191291	216752
		29,187.64	**7,651,090.00**	**8,669,447.00**	**9,823,352.00**	**11,130,841.00**	**12,612,358.00**	**14,291,065.00**

Appendix 2: Major cultural and heritage sites in Oromia Region of the Gibe-Gojeb Sub Basin

S/N	Name	Zone	Woreda
1.	Wara cave	Jimma	Gera
2.	Fincadeda the1st water fall	Jimma	Gera
3.	Fincadeda the2nd water fall	Jimma	Gera
4.	Amushe water fall	Jimma	Gera
5.	Miniral hot sprin/kecho	Jimma	Sokorruu
6.	Beletgera forest	Jimma	Seka chekorsa
7.	Mesera A/Magal	Jimma	Gera
8.	Kubasaiyed Hasen	Jimma	Gera
9.	Golu hot spring	Jimma	Cohor Boter
10.	Gojob cave	East Wollega	Boneya Boshe
11.	Konchi Mountain and forest	East Wollega	Boneya Boshe
12.	Laga Jarti Waterfall	East Wollega	Boneya Boshe
13.	Gibe River and Dhaga bora	East Wollega	Boneya Boshe
14.	Gimbi Rabbi	East Wollega	Gobu Seyo
15.	Habri mineral water	East Wollega	Gobu Seyo
16.	Arsa Abba Tune	East Wollega	Gobu Seyo
17.	Laga Ongobo waterfalls	East Wollega	Gobu Seyo
18.	Bosok cave	East Wollega	Gobu Seyo

Source: Annual Socio-economic Data, 2020

Appendix 3: Population Size of Omo-Sharma Sub Basin

Z_NAME	W_NAME	2020	2025	2030	2035	2040	2045
Basketo	Basketo	80983	91762	103975	117814	133496	151264
Wolayita	Boloso Bonbe	115883	131307	148784	168587	191026	216452
Wolayita	Boloso Sore	301147	341230	386647	438110	496423	562496
Kefa	Chana	222310	251899	285427	323418	366465	415241
Kefa	Cheta	44479	50399	57107	64708	73321	83080
Wolayita	Damot Sore	139440	157999	179029	202858	229858	260453
Kefa	Decha	175261	198588	225020	254971	288907	327361
Gamo Gofa	Denba Gofa	105580	119633	135556	153598	174042	197207
Gamo Gofa	Deramalo	109842	124462	141028	159799	181068	205168
Gamo Gofa	Dita	113404	128498	145601	164981	186940	211821
Hadiya	Duna	166826	189031	214191	242699	275003	311605
Dawuro	Esara	90093	102084	115672	131068	148513	168280
South Omo	Gelila	6052	6858	7770	8804	9976	11304
Dawuro	Gena Bosa	114558	129806	147083	166660	188842	213977
Gamo Gofa	Geze Gofa	97282	110230	124902	141526	160363	181708
Kefa	Gimbo	130328	147675	167330	189602	214838	243433
Kembata Timbaro	Hadaro Tunto	160666	182051	206282	233738	264848	300099
Kembata Timbaro	Kacha Bira	169895	192508	218131	247164	280062	317338
Wolayita	Kindo Didaye	128892	146048	165486	187513	212471	240750
Wolayita	Kindo Koyisha	145165	164486	186380	211187	239296	271146
Konta	Konta Special	129665	146923	166479	188637	213745	242194
Gamo Gofa	Kucha	201296	228088	258447	292846	331824	375990
Dawuro	Loma	147556	167196	189449	214665	243237	275612
Gamo Gofa	Malekoza	161164	182615	206921	234462	265669	301030
Dawuro	Mareka	190009	215299	243956	276426	313218	354908
Bench Maji	Meinit Goldiya	47168	53446	60560	68620	77754	88103
Bench Maji	Meinit Shasha	60197	68209	77288	87575	99231	112439
Kefa	Menjwo	144128	163311	185048	209678	237586	269209
Hadiya	Merab Badawacho	36698	41583	47117	53388	60494	68546
Wolayita	Ofa	142636	161621	183133	207508	235127	266422

Gamo Gofa	Sawula Town	58303	66063	74856	84819	96109	108901
South Omo	Selamago	37954	43006	48730	55216	62565	70892
Bench Maji	Semen Bench	4540	5144	5829	6605	7484	8480
Bench Maji	Shay Bench	47168	53446	60560	68620	77754	88103
Wolayita	Sodo Town	194977	220928	250334	283653	321408	364187
Wolayita	Sodo Zuriya	211629	239797	271714	307879	348858	395291
Hadiya	Soro	269031	304839	345413	391388	443481	502509
Kembata Timbaro	Tanbaro	147876	167558	189860	215131	243765	276210
Dawuro	Tocha	142959	161987	183547	207977	235659	267025
Kefa	Tulo	87160	98761	111906	126801	143678	162802
Gamo Gofa	Zala	99690	112959	127994	145029	164333	186206
		5,179,890	5,869,333	6,650,542	7,535,728	8,538,737	9,675,242

Appendix 4: Farming Systems in the Omo-Sharma Sub basin

Farming system	**Cultivation**	**Cropping**	**Crops**
Coffee based	oxen	single	coffee, maize, teff, sorghum, enset
Cereal dominant	oxen	single	maize, teff, wheat, sorghum, noug, berbere
Cereal dominant	oxen	double	maize, teff, wheat, Faba, haricot, enset, barley, pea, taro
Mixed	oxen	double	cereals, enset, Irish and sweet potato, yam, taro, haricot, Faba, spices,
Mixed	oxen	single	maize, sorghum, teff, sweet potato, cassava haricot, groundnut, cotton
Perennials	hoe	double	enset, chat, coffee, Faba, maize, wheat
Enset	hoe	double	enset, barley, Faba, maize, Ethiopian kale
Upland shifting cult.	hoe	double	sorghum, maize, teff, haricot, Faba
Lowland shifting cult.	oxen	single	sorghum, millet, haricot, cow pea,
Agro-pastoral	hoe	single	sorghum, millet, tobacco, cow pea, squashes
Plantation	mech.	perennial	coffee, tea, fruits, spices
Commercial	mech.	annual	maize, haricot, chillies, vegetables, spices

Appendix 5: Water supply access condition at Omo-Sharma Sub Basin.

N.o	Zone Name	Population Numbers (2010E.C)			Drinking Water Supply Beneficiary		
		Urban	Rural	Total	Urban	Rural	Total
1	Kenbata Tebaro	137,398	815109	952,507	79836	430137	509973
2	Dawuro	120,654	553,908	674,562	72108	223561	295669
3	Debub Omo	33,944	756851	790795	18395	308477	326872
4	Konta	11,180	105354	116534	11000	52142	63142
5	Hadiya	287700	1519873	1807573	195572	667364	862936
6	Keffa	34,934	1171071	1,206,005	19454	651120	670574
7	Wolayta	277780	1814162	2,091,942	225016	947386	1172402
8	Gurage	126409	1631864	1,758,273	104216	774400	878616
9	Yem	13,317	98500	111817	12707	70948	83655
10	Basketo		76729	76729		26315	26315
11	Gofa	91,808	578615	670423	30730	242559	273289
12	Merab Omo	28,513	254,620	283,133	18,170	87,266	105,436

Source: SNNPR Annual Socio-economic Data, 2020

Appendix 6: Natural, Pale anthropological, cultural and social attraction sites in Omo-Sharma sub basin

SN	Tourist Site Name	Zone	Woreda	Fauna, Flora, Scenic environments and Anthropogenic Assets
1	Mago National Park	Debub Omo	Selamago, Debub Ari, Hammer and Benatsemay	Spectacular landscape; Elephants, Buffalos, Lion, Leopards, Cheetah, Giraffes, Greater & Lesser Kudu, Gerenuk, Wild dogs, Water Bucks, Lelwel Hartebeest, Tiang, etc; Birds including Secretary bird, Abyssinian ground Hornbill, Butlers, Eagles etc; Enormous plant species
2	Omo National Park	Bench Maji & Debube Omo	Maji, Surma, Menite,	Fascinating landscape with spring water
			Salamago & Dasseneche	Herds of Elands, Buffalo, Topi, and Oryx, Lelwel Hartebeest, De Brazza's Monkey, Giraffe, Lion, Hyena , Wolves, Cheetahs etc; Abundant plant species
3	Maze National Park	Gamo Gofa	Kucha, Zala, Gofa, Daramalo, and kameba	A large number of Swayne's Hartebeest, Buffalo, Lesser Kudu, Waterbuck, Grant's Gazelle
4	Chebera Churchura National Park	Dawro & Konta S. W.	Esera, Tucha & Konta S.W	Fascinating western highland forest with different tree species ; Elephants, Buffalo, Giant Forest Hog, Hippos, lion, Leopard, etc
5	Gibe sheleko nationalpark	Gurage zone	Abeshegy,enemorena enere,cheha	Fascinating landscape with spring water Enormous plant species; Hippos, Monkey, Oryx, Hyena , Cheetahs etc; Fascinating landscape with spring water; Abundant plant species
6	Tama Wildlife Reserve	Debube Omo	Salamago	Burchell's Zebra, Lelwel Hartebeest, Buffalo, Patas Monkey, Lion, Reed Buck, Water buck,
7	Chew Bahir Wildlife Reserve	Debub Omo & Borna Zone /Oromiya R.S/	Hammer & Teltele	Grevy's Zebra, Oryx, Topi, Ostrich, Lion
8	Murulle Controlled Hunting Area	Debube Omo	Dassenech, Hammer Kuraz	Topi, G. Gazelle, L. Kudu, G. Kudu, Buffalo

Appendix 7: Population Data of Lower Omo Sub Basin

Z_NAME	W_NAME	2020	2025	2030	2035	2040	2045
South Omo	Selamago	37954	43006	48730	55216	62565	70892
South Omo	Gelila	6052	6858	7770	8804	9976	11304
South Omo	Hamer	81926	92830	105186	119186	135050	153025
South Omo	Bena Tsemay	71850	81413	92249	104528	118440	134205
South Omo	Dasenech	71846	81409	92244	104522	118434	134197
South Omo	Gnangatom	22946	26000	29461	33382	37825	42860
Gamo Gofa	Melekoza	161164	182615	206921	234462	265669	301030
Bench Maji	Meinit Shasha	60197	68209	77288	87575	99231	112439
Bench Maji	Maji	47168	53446	60560	68620	77754	88103
Bench Maji	Surma	4540	5144	5829	6605	7484	8480
Basketo	Basketo	90989	103100	116822	132371	149990	169953
South Omo	North Ari	90989	103100	116822	132371	149990	169953
South Omo	Tolta town	4779	5415	6136	6953	7878	8926
South Omo	South Ari	90989	103100	116822	132371	149990	169953
South Omo	Wub Hammer town	13431	15219	17244	19539	22140	25087
South Omo	Gazer town	9298	10536	11938	13527	15327	17367
South Omo	Jinka town	51954	58869	66705	75583	85643	97042
South Omo	South Ari	90989	103100	116822	132371	149990	169953
South Omo	Gelita town	6052	6858	7770	8804	9976	11304
South Omo	Dimeka town	5177	5866	6647	7532	8534	9670
South Omo	Turmi town	3051	3457	3917	4439	5029	5699
South Omo	Hamer	81926	92830	105186	119186	135050	153025
South Omo	Key afer	5492	6223	7051	7990	9053	10258
South Omo	Omorate	6069	6877	7792	8829	10004	11336
Bench Maji	Maji town	4540	5144	5829	6605	7484	8480
		1,121,368	1,270,624	1,439,741	1,631,371	1,848,506	2,094,541

Appendix 8: Borehole/ water well data of Omo Gibe basin

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
Amecho watto # 2	KT, doyogena	371477	822577	2186	202	110.9	4.77
Wagbeta	KT, doyogena	363483	813176	2305	144	38.4	18
wonjela	KT, Angacha	370232	825456	2153	167	87.88	4.88
Bala	Dawro	283860	760880	2170	116	38.5	7.6
Boyna	Dawro,Esara	287595	759440	1596	86	20.65	4.7
Gesa Chere	Dawro	310063	775377	2119	60	3	2.72
Areka ARC	Wolaita	355143	780262	1787	151	60	4.7
Woybo	Wolaita	354246	776963	1807	150	44	2.5
christ hosp.	Wolaita	362998	757550	2040	123		3
catholic ko1	Wolaita	362455	757565	1960	121		2.5
catholic ko2	Wolaita	362625	757524	1940	103	32	1.5
catholic ko3	Wolaita	364520	757000	1960	143	40	2
china kon 1	Wolaita	360250	758540	1910	162	19	8
china kon 4	Wolaita	360060	758272	1883	85	17	11
china kon2	Wolaita	361162	757983	1925	130	33	0.5
Waraza 1	Wolaita	359100	755650	1842	180	34	12.2
waraza 2	Wolaita	359460	756647	1867	176	47	5
waraza 3	Wolaita	358840	755708	1848	182	35	14
waraza4	Wolaita	358847	756053	1849	176	41.22	16
waraza5	Wolaita	358750	755513	1848	180	37.24	16
waraza6	Wolaita	358448	755232	1834	148	27.7	16
Ansome1	Wolaita	361657	751538	1833	145	40.22	19
ansome2	Wolaita	361503	751012	1831	152	36.4	18
Aroge/Geneme	Wolaita	362263	759694	2057	250	127	6.4
WSU 1	Wolaita	361868	755320		136.8	51	2.6
WSU 2	Wolaita	361575	754559	1855	136	33.2	7.6
Wola sodo u 3	w/sodo	361426	753207		152	46	15
Wola sod uv 4	w/sodo	361080	752872		158	44.6	15
Agri Tvet	Wolaita	363609	755752	1868	180	13.5	5.3
ws office	Wolaita	362895	757971	2039	205	102.2	7.2
shola kodo	Wolaita	354774	756550	1914	150	78	5
Catholic ko3	Wolaita	362625	758540	2060	78	40	0.5
04P Gerera	Wolaita	354300	751500	1850	112	55	1.5
Sorphela1	Wolaita	354800	764400	1995	65	42	2
Sorphela2	Wolaita	357495	764850	1970	60	30	1
Humbo larena	Wolaita	359600	747900	1820	81	48	3
13P Tome	Wolaita	352100	748510	1800	87	51	
Boditi town1	Wolaita	374308	770495	1943	97.5	33.25	5.5
Boditi town2	Wolaita	373500	769600	2000	143.5	59	5
Ade Damot	Wolaita	$38^0$23'19.8"	777230	1840	135	80.05	4
dola	Wolaita	359968	775158	1816	134	39.3	8
dangara salata	Wolaita	362093	774064	1864	182	69.1	6
gurumo koy	Wolaita	360947	770598	1932	150	48.1	6
Dengera	Wolaita	361088	774707	1845	134	62	5.6
Areka	Wolaita	357337	780293	1726	160	12.7	3

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
Admancho	Wolaita	366299	777862	1869	136	65.2	1.4
AREC sheep	Wolaita	386969	771172	1771	170	16	
Areka Arc w2	Wolaita	355143	780262	1787	151	60	4.77
garagodo	Wolaita	364215	782651	1809	185	42.8	10
yukera	Wolaita	358000	776161	1773	218	57.8	10.2
shanto	Wolaita	372373	776546	1934	188.7	69.8	7.5
Abota ulto	Wolaita	378492	777496	1915	163.5	40.04	7
warbira suke	Wolaita	370908	774636	1969	126	83.6	
Bibiso olola	Wolaita	371067	772743	1979	169	100.3	
Gununo	Wolaita	351405	764815	2022	102	34	5.8
gununo2	Wolaita	352813	765074	2001	180	23	12
Galcha	Wolaita	358510	735300	1746	139	47	6
bele town	Wolaita				138	38.6	4.9
busha	Wolaita	346850	743659	1681	201	39	5.5
Shalte	Wolaita	355955	744450	1770	83	43	3
koysha wan.	Wolaita	359922	744250	1850	138	62	5.2
Hana Pastoral	South Omo	171251	690858	516	193	50.6	1
Agri villagewell	Souuh omo	170679	683956	475	179	12.4	8.5
Sugar co (Orom #2)	Souuh omo	177895	653436	526	171	21.75	4
Hana / Gura villagr	Souuh omo	178625	670205	518	182	19.5	1.5
Kako town	Souuh omo	239667	626547		55	3.47	1.5
Pastoral well 3	Souuh omo	170862	685986	508	187	25	3,2
Hana/ Main town	Souuh omo	168184	674177	584	203	13.1	2
Hosana NE Hosp	Hadiya	371223	835707	2222	316	104.44	24.4
Buska Lodge	Souuh omo	224511	550129	913	82	14.6	0.2
Kichen	Silte/Alicho	406948,	883233	2879	175	96.1	9
F3 kuraz deep	Bench Maji	820730	674646	476	168	12.1	8
WSU-Tercha 1	Dawro	296000	791310	1261	250	49.68	2
WSU-Tercha 2	Dawro	291130	791209	1297	153	28.96	19.8
WCU #1	Hadiya	378737	832414	2097	220	21.5	60
Agata /Geta	Guraghe	385679	878377	2726	171		
Boloso Bo	Farawo aTajura Sp	346195	790490	1525			2.8
Boloso Bo	Ambe Chando	340912	786974	1229			2.6
Damot G	Gacheno	380956	777581	1877	160		2.6
Damot G	Shakisho shon	374459	756950	1885	260		3
Damot G	Obojage	366651	770132	2056	162		4
Damot p	Ade Damot	342797	777230		135	80.05	4
Damot p	Limal	372704	757987		180		2.5
Damot p	Bibiso	371061	772739		169		3.2
Damot p	Pulassa Bakala	369239	780948	1902	188	56.7	4
Damot p	W/Suke	370907	774639	1954	150		4
Damot p	Lera	376409	784057	1922	158		2.5
Damot p	Abota	378066	776448	1915	160		3.5
Damot p	Game	372483	783710	1902	103		2.4
Damot G	Buge	382167	783515	1882	112		2.5
Humbo	SH/Ose	360307	747340	1796	130	60	0.4
Humbo	K/Wangala	359904	744269	1863	138	61.58	5.2

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
Humbo	Galcha Kora	353494	735514	1749	108		2.5
Humbo	SH/Gola	357130	745060	1765			
Boloso Sore	Dangara Salata-	362090	774066	1866	182	69.1	4.4
Boloso Sore	Gara Godo	364215	782651		185	39	10
Boloso Sore	Yukara	358000	776161		218	57.8	10
Boloso Sore	Hembecho	349963	791523				3.2
Boloso Sore	Gurumo Koysha	360951	770598		136	48.12	6
Damot S	Gu 1 Wogsha minno	351499	765020		180		4.5
Damot S	Gu -2 Takacha	352813	765074		180	18.8	3.5
Damot S	Gu 3 - Newl WSu						
Damot S	Mere	353992	763690		SP		6
Damot S	Demba Zam Boko-	350895	772050		120		1.5
Sodo zuria	Bulkama Fakaka	348292	752853	1840	120	178	6
Sodo zuria	Haba Gerera-Spring	3743969	652778		176	47	5
Sodo zuria	Shola Kodo-	354491	736184		150	78.8	5
Offa	Busha	346850	743659		200	39	5.5
Kindo Koyisha	Bele 01	352813	765074		147	40.8	3
Kindo Koyisha	Bele 02	337312	765037	1241	145	80	1.2
Kindo Koyisha	Bele -03 WSU						
Boreda	Zefine Menuka	326642	646959	1557	144		6.9
Ubba Dere Tse	Gelada & Zeko	264275	664050	986	80	12.02	5
Zalla	Ottolo	293416	677567	1370	70		2.5
Zalla	Shakaro	284016	660433	958	96		1.5
Bonke	Darse Hanka	290854	720817	1123	80	2.18	3
Kemba	Tsala Tsamba	262402	693455	1400	110	31.4	1
kucha Town	2	323665	715360	1347	140	20	2
Kullo-	Tihgalle	329466	713652	1426	88	20	
Kucha	Bedena/Wazete	331861	718648	1357	120	36	
Kucha	Mesha Chaba	314650	711067	1228	98	20	
Kucha	Mesha Morka	312973	710129	1216	160	21	1.7
Kucha	Deha	339927	724841	1286	150	36	
Asheker	Asheker	648160	230111	1054	65	10	7.4
Male	Doyso	646236	278774	830.7	68	21	9
Male	Boriya	219175	554655	972	50	25	1
Male	Argude	221509	569511	1130	24	8	1.5
Hammer	Catholic Camp	228776	572484	1109	10	2.5	2
Hammer	Dimaka1	228665	572622		42	2.5	2.5
Hammer	Dimaka2	228665	572622		48	2.5	0.8
Hammer	Dimeka3	228665	572622	solar	90	2.5	2
Hammer	Neartok	228569	572416	1096	41	2.5	2.5
Agude(Turmi)	Keyna	222623	545747		30	2	2
Turmi	Kayna	222617	545756	883	12	1	3
Ache Algore	Shaba	243775	578320	1311	70	5	2.6
Ache Mussa	Mussa	239323	582231	1312	75		2
Gelila	2	240794	683547	2012	158	24	7
Dasenech	Kayssa	236233	633888	1414	55	11.5	5.5
Dasenech	Saka	661222	225914	1501	111		
Dasenech	Tolta	660319	227806		116	49.2	10.2
Semen Ari	Metser	661757	231204	1670	130	22	2.1
Semen Ari	Berka	225245	655950		150		5

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
Debub Ari	Gergo	283860	760880	2165	116	38.5	7.6
Debub Ari	Sharinge	283964	761092	2165	106		7.5
Debub Ari	Boyna	287654	759714	1992	86	20.65	4.7
Esara Mare	Mari Guta	289040	777007	2277	100	52.9	5
Esara Waka	Wuny	298289	779122	2163	150	8.2	10
Dega kedida	Haro	381626	805419	2055	270		7
Dega kedida	Boname	381158	804859	2086	235		2.36
Kedida	Abonsa	381193	796541	2016	260	159.6	5
Fulasa	Weta	380038	803214	2099	278	130	6
Hangeda	Babiso	356327	822296	2113			3
Gebeba Lange	Umaro	339835	830031	1787	135	42.3	6
Shano	Hubayicho	344723	830832	1901	132	20	5.5
Kosha	Shokbora	363714	819186	2667	202	120	3
Tambaro	Bukako	359121	828665	2042	114	91	4.5
Soro Bandali	Market area	379430	844538	2376	251		4
Soro Misha	Hogocho	351434	833786		137		10
Soro wera	Shango	352479	829994		140		6
Soro wabo	Danemuma	348283	829112		130		13
Gombora	Agotalsa	381014	831845		187		4.8
Gombora	Masibira	373930	842123	2325	91.9	41.1	6
Gombora	Shutime	377319	845372	2355	160	110	5
Gombora	Hayse	375409	826829	2108	150		
Lemo	Lesana	381052	831880	2165	157		
Lemo	Lasaba	373773	832720	2195	215	119.3	3
Jawe	Hamasbecho	365507	839986	2121	146	68.8	2.5
Ashekubega	Lolo	365782	831502	2121	134	118	3.5
Kalesha	Balena	375421	836099	2266	189	130.8	8.7
Lasena Kassa	Gudas	378293	826004	2081	141	67	2.6
Awosa	Bokuna	311960	855707	1870	130		3
Were Boya	Got 2 Gerero	376554	796471	1985	140	100	3
2nd Keshora	Bokicheba	369876	786850	1964	120	90	2.7
2nd Koto	Mathecha	370937	791764		135		3
2nd Kotto	Ashengo	369603	792166	1986	180	140	2.9
Yabkuna	Belete Minche	369492	784740	1857			16
Tikare Anbesa	Wuha limat	393499	792192	1727	208		3
Woldaya	Godegora	394233	786161	1676	181		3.8
Abuka	Shemogole	391770	788490	1736	270		4
Langano	2nd Toke	394073	787126	1697	216		3.1
Ajeba Borare	Borare	380210	795207	2018	199		2.2
Wera Boshera	Dawe wonze	382101	792950	1973	235		5
Jarso Hadena	Oda	378471	786550	1919	108		1.8
Wera Lalo	Botele	384060	791559	1983	138		1.5
Kenchera	Banchemo	385956	790273	1950			2.1
Wer Bonkoya	Belete	397539	778956	1547			4.9
Otaolo	Gordanacho	348661	813813	2628			5
Hudad 5	Hudad 5	342753	927431		114		3
Misha	Hudad 6	341121	930220		120		2.5
Misha	Tuba telilo	358801	920899		149		2.6
Misha	Garbaja	381512	915481		135		3.5
Abeshke	katbare	376293	916286		150	90	2.22

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
Abeshke	cherite	392453	917914		97		2.5
Abeshke	ferezguira	397903	910760		137		3
Muhur Akli	Goto bale	441924	879932		242		4
Muhur Akli	slase	386437	873774		160		4.5
Geta	Tach yezebezir	402682	890863		103	67	5
Geta	Yefanja wonize	395594	881983		215	160	3
Geta	Guragazer	396722	876823		230	130	3
Geta	Deweshe	396565	886589		153	70	5
Gumer	Udadishi	190237	771213	2210	115	35	6
Gumer	beha	193177	793291	1861	80	27	7
Gumer	Awurada 03	189737	788410	2014	138	34	4
Decha	Wodeyo	184986	827864	1664	87	4	3
Decha	Doma	821577	836066	1605	140	7	4
Decha	Konda	168978	840353	1589	160	12	2.5
Decha	Medado	173235	838894		70		
Gewata	Wareta	828992	806932	1782	174	41.5	3
Gewata	Agelglot	811991	791382	2137		4	0.5
Gewata	Jibbank	810719	791785	2100			
Gewata	Abech	818538	803207	1889		13	2
Gewata	Dimbira	829071	807143	1771		41.5	2.5
Chena	Benja	807896	789692	2216			
Chena	yadota	811982	866068	2295	150	27	3
Chena	Deka	804778	839658	2181	117	20	12
Chena	Meshami	793952	837943	2239	128		14.5
Chena	Meshami	794020	838153	2235	128		14.5
Sylem	Bitagenet	808515	804905	1813	100	20	4.3
Gesha	Odda	800128	800117	1467	111		
Gesha	shama	201267	772696	1731	110	20	4
Bita	Uufa	194547	818916	1712	132	108	4
Bita	Wushwush	184683	806684		118		6
Bita	Wushwush	184683	806684	1914	90	75	4.5
Cheta	Gojeb				147		2.7
Cheta	Geshidari	209935	820419	1295	100	85	4.5
Gimbo	Berhan Ber	768689	784579	1212	76		6
Gimbo	Selale	777829	779986	1656			
Gimbo	Police Station	786164	682671		126	27	3
Misha town	Tulkit Road	604223	3526698		110	8	4
Sheko Anjo	Kibish	770736	672051	983	123	6.84	2
Maji Jemmu	Jonkach	805341	735155	1492			3
SurmaGebre Mihiret	Brhan Ber	768689	784579	1212	76		6
SurmaM /Sheko	Selale/Husen Area	777829	779986	1656			
Menit Shasha	Jongach	805341	735155	1492			3
Sheko	Doboka	259110	793268	1397	154	6	9
Sheko	Fulasa	257176	792621	1533	7.5		
Sheko	ungafa	251325	786235	2227	3.5		
Meinit Shasha	Gurguta	245712	785816	1976	6		
Meinit Shasha	Bocha Yafa	241596	788175	2065	2.3		
Meinit Shasha	Zupha	234206	756823	1400	2		
Konta	Angila	229871	693831	985	120		

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
Konta	Angila	230171	695421	995	61.4		
Konta	Golewa/Fofa	336907	868380	2557	54		2.9
Konta	Gemegehero	337987	869284	2622	129.1	18	
Konta	Kambo	332203	856020		2		
Basketo	Asrr Center	331567	875178				1.68
Yem Saja	zabe	328445	882599	3475	138		7.4
yem Fofa T	Wishi Gasoni	336282	867790	2551	153		3.8
	Wonjela	370232	825456		167	87.88	4.88
	Kako Bena	239667	626547		55	3.5	1.5
	Adidamot	442797	777230		134.4	80.05	4
	Basketo	224806	699188		55.5	9	3
	Basketo	224621	699329		46.5	10.4	2.5
Birale Farm	Bena Tsemay	278277	592788		83	30.7	4
Shakaro # 2 Kemba	Kemba	289663	660224		94	50	2.5
Wolyta	Areka # 2	355143	780262		151	60	4.77
Kembata	Amecho Watto2	371477	822577		202	110.9	4.77
Wolkite town	wolkite	365444	923342	1965	200	34.55	2.5
Konda	Gewatta	830902	84066.6		157.8	10.5	7
Wolaita Univ. BH-2	W/Sodo	361575	754559		136	33.11	15
Doguda Gayrio	Sodo	460335	900046	*1934*	318	244	3
Adeb/Aselech	Guraghe	498006	892978	3130	104	9.9	20
Aroge arada	Woliyta	362236	759694		250	127	6.4
laska	basketo	235764	697868		60	22.25	7.85
Fofa # 1	yem	336899	868385	-	54	8.7	2.5
Fofa # 2	yem	337955	869251		129	18	6.2
Gelila	S/omo	240704	683349		158	12.6	2
pastoral st 3	Salamago	170862	685986		187	25	3.2
Main town 1	Salamago	168184	674177		203	13.12	2
Habicho/gomb	Gombor	352235	836144		70	0	24
Esera	esera	361080	752872		116	38.5	7.6
Mari	Mareka	361080	752872		100	52.9	7
Serera	Doyo gena	368736	808334	2470	280	163.75	7.6
Pastoral st 1	Salamago	683956	170679		193	50.6	1
Agri vilage 1	Salamago	683956	170679		179	12.4	8.5
Dalacho	Jimma-Gomma	231368	862724	1866	190	50.64	9
Goga Kamise	Jimma-Gomma	238912	884289	1411	185	4.17	9
Ilike Sufa	Jimma-seka	235922	843451		150	0	5.5
Somodo	Jimma- Mnna	260195	856100	1974	189	84.31	5
Benja 2	Nano Benja	289393	964039	1716	223	5.01	2.5
Geriru	Jimma-Mencho	285099	827228	1811	220	30.06	8.5
Wayu	Jimma-Botor Tolay	316423	919318	1619	180	0	15
Baso	Jimma- Sokoru	321306	853772	1859	192	5.07	2.5
Benja 3	Jimma- Nano Benc	289395	964041	1716	150	13.85	1.5
Ilike Toli	Jimma- menna	262853	856715	2017	150	0	10
Toba	Jimma- Gumay	225212	881062	1800	140	0	21
Benja 3	Jimma- Nano Benc	292409	966095	1586	132	2.6	10
Nono Konja	Jimma- Nano Benc	293009	948530		84	9.93	20

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
	Galiye Rogida	358290	926080	1699	459	82.0	
	Goro	375734	926348	1787	360	8.9	
	Gindo	357700	944225	1822	360	25	
	Meti Walga	383826	947387	2058	265	0	
Sodo Gerba	Gedo Kistana /	408282	939498	2311	360	22	
woliso	Woliso Prison	386183	943986	2023	108	0	
woliso	Woliso#2TWS	387549	945858	2067	93	0.0	
woliso	Negash Lodge	387835	943260	2037	297	5	
woliso	Negash Lodge	387802	943130	2034	300	5	
woliso	Woliso-02	386986	945147	2050	133	0	
Goru-	Goru-Gurura	381713	933854	1896	100	7.46	
Chaha	kassa(Atnafu)	351822	949233	1906	60	18	
Goru-		373172	928362	1782	66	17	
Goru-	Kereyu	352087	943847	1816	57	12.5	
Goru-	Chitu	381267	951278	2093	53		
Goru-	Darian	378626	961413	2572	173		
Goru-	South-west Shoa	377000	942000	1952	174	14.7	
Goru-	Yesuf & Ya,a Gadi	363500	939000	1779	53	15	
Goru-	Muka arba	363500	939000	1783	56	15	
Goru-	Ameya Gar-Konno	356500	937500	1721	56	16	
Goru-	Wenchi, Haro	378500	945500	2156	56	21	
Goru-	Goro	368377	924410	1761	93	47.38	
Goru-	Wondimitu	385518	959705	2363	133.4	12.47	
Goru-	Kile	395680	935828	2108	100.5	5.05	
Goru-	Woliso	387657	946375	2063	132.5	0	
Goru-	Ameya	350776	948648	1901	135	29.8	
Goru-	Ameya	354182	939439	1734	150		
	omo rate town	172424	531184	399	18	12.5	
	Wiswish	184552	808085	1944	11	10	
	Bonga	195544	803344	1768	0.12	7.3	
	Chira	196038	857507	2033	12.96	6.66	
	Diri	200624	815886	1759	10	9.4	
	Maki ilage	210934	652553	607	3	0.78	
	turmi town	224426	550369	895	6.7	4	
	Shebe	226949	831469	1868	7	6.25	
	Yetnebersh Village	228608	647279	1475			
	dimeka town	228731	572264	1079	7	4	6
	Jinka	230487	640737	1547	16.5	12.5	
	Gazer town	231901	654118	1747	12.2	10	
	alduba village	235217	599988	1295	5	2	
	Donke Village	235935	696385	1763	5.38	4.48	
	Sombo	238173	836477	2037	10.5	8.05	
	Belta Vilage	238722	707343	2082	10.57	10.4	
	Seka	249668	841364	1818	17.1	16.1	
	Chida	256890	862252	1544	3.3	2.55	
	Bulki	257516	695276	2357	4.1	3.4	
	Jima town	260651	848497	1697	11.3	11	
	Dedo	265405	830283	2222	15.6	15.28	
	Serbo	276948	852443	1693	6	5.4	
	Bako town	286980	1008967	1602	3	0.3	

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
	Mala Village	288490	707013	1195	8.1	5.4	
	Sheboke town	292948	1005556	1633	9.5	7.5	
	Waka	297895	780953	2418	11.3	10.9	
	Asendabo	304496	858342	1582	11.5	9.4	
	Omo Nada	307408	843461	1859	9	8.42	
	ljaji	315768	993801	1678	17	15	
	Gedo town	329463	996413	2536	14.6	14	
	Kumbi town	334211	898466	1953	17	13.5	
	Ablti	342710	903933	1592	4.5	3.9	
	Doge Mashiod	348325	762382	2193	16.8	16.6	
	Tunto	349010	979056	1590	15.3	10.6	
	Wachiga	351073	746189	1747	9.55	9.2	
	Bokota village	351131	914224	1592	5	3	
	Hadaro Town	352931	795355	1775	14.7	14.45	
	Shamba	353921	765745	2059	5.1	5	
	Areka	357094	781123	1718	14.7	14.45	
	Woirre village	362403	878191	2058	10.75	10.4	
	Shinshicho	365420	796733	1803	17.8	16.7	
	lera	377932	856372	2677	12.2	11.9	
	Durame Town	378189	800263	2078	9.4	9.1	
	Gurura Gura Villa	381322	933296	1933	16	14	
	Agena	391269	899457	2263	5.78	4.9	
	Kile Village	395610	935900	1966			
	areke	396998	803844	2780	18	17.5	
	Kotke Village	398971	934633	2177	21.5	17.7	
	Getbo Village	405616	938733	2415	7	6.6	
	Bejebar	412902	896922	3172	27		
	Daba	339,956	724,874	1400	117	66.7	0.7
	Areka Town No1	358,340	780,290		157	13.2	3
	Bonga	195070	806175	1547	58	5	6.3
	Waching Esho No1	348,455	743,400		63	14.3	5.2
	Wachiga	350,792	744,408		100	30.54	4
	wachigasho	348,455	743,401	1661			
	Seresho	344,061	742,338	1586			
	Hossaina	371,843	836,672	2270	150	120	10
	Wotkite town	365,060	916,329	1861	108	36.25	5
	serbo	276,950	852,445		42	7	
	Kumbi town	333537	898284	1920	62	23.3	
	workite town	365,060	916,330	1900	102	26.7	4
	Omo rate town	172,420	531,180		53	30	
	Omo rate town	172,420	531,180		72	40	
	Omo rate town	172,420	531,180		65.7	13	
	Omo rate town	191,079	490,562		40	25.4	
	Omo nada	307192	843093	1835	50	17	
	Darge Village	335,896	931,664	1488			
	Hossaina	372,824	836,485	2283	210	180	5
	Seka	249,319	839,091	1864			
	Asendabo	303942	857852	1679	46	26	
	Seka	248,981	839,062	1822			
	Shebe	226,949	831,469	1868			

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
	Serbo	276857	852720	1752	50	4.18	
	Nairi	328,204	888,843	1985			
	Asendabo	339,430	857,850		109	9.78	
	China	197,013	856,517	2064	45	1	
	Wishiwish	185,107	808,420	1867			
	Sekoru town	324,875	874,755		100	43	2.8
	Deneta	320,618	867,247	1784	70	6.24	
	Abili	341,517	904,306	1772			
	Sekoru town	324,874	874,756	1774			
	Limu genet	274,604	893,380	1584			
	Gerra institute	216306	862513	2003	65	5.6	
	Umu genet	275615	893437	1732	50	17	
	EWWCA off	262181	847875	1823			
	jimma sta	261232	848318	1705	60	2.2	
	Jimma Airport	259850	847764	1634	58	13	
	Waja K.chur	359648	760907	1880			
	Areka	357337	780293	1726	160	12.7	3
	Sodo Town	360225	758510	1804	124.1	93.6	
	Abonsa	380913	797738	2055			
	Morka town	312934	710091	1246			
	Morka town	313456	709936	1178	90	28	3.7
	Baso	328403	714128	1511			
	Selamber	329667	715352	1420	61	6.35	4
	Dana no-1	339956	724874	1288	117.5		
	Dana no-2	341793	733469	1252	92	57.6	1.52
	Gesube	340655	743331	1515	84	63	4
	Otolo Village	293426	677565	1417			
	Kersa	272700	701790	1305		0.53	2
	Sawfa	265268	696166	1298			
	Mela Village	288306	707168	1196	57	10.9	3
	Kako Village	240029	625289	1301			
	Keyafer	248718	611366	1654			
	Mukeche Village	244589	618450	1303			
	Jinka town	229526	638762	1446	67	7.26	
	Amechowato	369565	821598	2267			
	Mugo	388035	866512	3074	33		
	Kabul	392884	870585	2757	17	9	
	Rembat	366848	890340	1869			
	Gubre town	367290	905112	1844			
	Adele kuili 2 Villa	340305	924368	1545	68		
	odo Village	344758	920697	1460	52	35	
	Wollote Town	365886	916326	1929	97.5	62.36	
	Gro town	375405	928338	1894	12	50	
	Dilata Town	395535	954911	2341		16	
selamago	selamago	178440	670017	520	106	9.05	2.07
selamago	Hana camp	178625	670205	518	182	19.5	2.75
selamago	aound hana	181995	688646	590	102	20.3	10
Male	Limo gento	255975	653718	1035	130	2.45	12
Selamago	Around sugar fac	831984	674403	450	170	20.02	6.5
Selamago	sugar	177566	654395	538	63	10.13	6.4

Location	Zone/woreda/kebele	UTME	UTMN	Alt	Dep(m)	SWL(m)	Q(l/s)
Kefa	Bonga town	194789	802831	1585	152	3.5	10
keffa	Bonga town	194547	803388	1578	150	3.8	44
keffa	Bonga town	194620	803089	1594	132	5	48
keffa	Bonga town	194780	802827	1590	117	3.3	9.3
Keffa	Bonga town	194430	803704	1601	150	4.4	19.6
Jima	sokoru town	210317	943422	1874	128	33.1	

Appendix 9: Groundwater recharge estimation of Omo Gibe Basin

Sub-Basin	Area (km^2)	PPT (mm/yr)	PET (mm/yr)	RO (mm/yr)	Recharge (MCM/yr)
1. Gibe Amara	1097	1181	1165	141	(-)137
2. Amara	353	1160	1165	248	(-)89
3. Alenga	342	1249	1165	203	(-)41
4. Fato	810	1346	1033	520	(-)168
5. Tunjo	2640	1683	1165	489	(+)77
6. Gibe-Tunjo	1309	1346	1165	321	(-)183
7. Werabesa	372	1248	1059	561	(-)138
8.Gibe-Werabesa	1010	1485	1165	265	(+)56
9. Walga	2941	1234	1059	289	(-)335
10 Gilgel Gibe	5152	1276	1033	323	(-)412
11 Gibe Wabe	374	1610	1154	52	(+)151
12 Wabe	1943	1151	1059	453	(-)701
13 Gorombo	1221	1197	1068	460	(-)404
14 Gibe-Fofa	2456	1255	1068	251	(-)157
15 Gojeb	6932	1598	1154	439	(+)35
16 Gibe-Gojeb	3002	1412	1033	121	(+)775
17 Soke	910	1588	1154	114	(+)291
18 Waybo	600	1191	1148	176	(-)80
19 Deme	1940	1160	1148	76	(-)124
20 Omo-Deme	1971	1338	1148	199	(-)18
21 Zage	2527	1274	962	86	(+)571
22 Irgene	1287	1375	1305	243	(-)223
23 Mansa	1053	1606	1154	334	(+)124
24 Omo-Mansa	558	1315	1305	45	(-)20
25 Zinga	1232	1574	1305	304	(-)43
26 Denchiya	3563	1738	1016	304	(+)1489
27Omo-Denchiya	1624	1622	1012	186	(+)689
28 Sherma	4166	1649	1012	377	(+)1083
29 Omo-Sherma	922	1670	1012	84	(+)529
30 Aku	1125	1670	1012	364	(+)331
31 Muwi	1224	1670	1171	230	(+)329
32 Omo-Muwi	1382	1299	1171	44	(+)116
33 Meki	4532	1255	1012	110	(+)603
34 Kako	1087	936	1171	45	(-)304
35 Omo-Kako	2599	1299	1171	18	(+)286
36 HamerKoke	1662	581	1308	67	(-)1320
37 Omo-Turkana	5718	628	1171	55	(-)3419
38 Kibbish	5068	1670	1126	41	(+)2549

Note: PPT = precipitation, PET = potential evapotranspiration, RO = run-off.

Appendix 10: Priority sites for hydropower development in Omo Gibe Basin (Daniel A., 2015)

River	Site Reference	Location Northing (Deg, Min, Sec)	Location Easting	River Bed Level	Normal Water Level	Dam Crest length (m)	Average flow (m^3/s)	Head (m)	Power (MW)
Gilgel	OM1*	07-52-20	37-24-00	1390	1438	200	64.6	138	87.4
Gibe	OM2	8-11-30	37-25-00	1200	1300	500	68.8	100	87.4
Gibe	OM 3	08-35-00	37-16-00	1500	1600	500	80.7	400	316.3
	OM 4*	8-15-00	37-30-00	1130	1200	400	205.7	100	501.6
	OM 5	8-1-00	37-35-45	1000	1100	300	230.9	100	225.7
	OM 6	07-56-00	37-30-00	900	1000	600	352.8	100	345.7
Wabe	OM 7	8-21-30	38-05-40	1900	2000	500	8.2	100	8
	OM 8	8-20-00	38-01-30	1800	1900	750	11.7	100	1.5
	OM 9	8-16-20	37-52-25	1700	1800	500	16.5	100	16.2
	OM 10	8-14-00	37-44-00	1600	1700	1000	23.4	500	114.7
Omo	OM 11	7-12-30	37-27-00	800	900	400	376.4	100	269.1
	OM12*	07-55-20	37-25-40	690	800	750	452.8	100	443.7
	OM 13*	06-37-45	37-04-00	600	700	600	507.8	100	497.6
	OM 14	6-27-30	36-25-00	500	600	700	558.8	100	547.6
	OM 15*	6-22-00	36-04-20	470	500	500	617.6	50	302.6
	OM 16	6-02-40	35-59-00	440	450	500	617.6	25	151.3
	OM 21	07-19-00	37-25	810	910	-	-	100	0
Gojeb	OM 17	07-33-50	36-07-30	1510	1550	300	16.3	250	39.9
	OM 18*	7-23-50	36-33-20	1200	1300	550	48.9	200	75
	OM 19*	7-13-50	36-53-30	1000	1100	500	68.1	100	66.7
	OM20*	7-16-25	37-12-00	915	1000	400	84.4	100	82.9
	Total								**4180.9**

Appendix 11: List of Existing Irrigation Projects in Gibe-Gojeb Sub-Basin

No	Scheme Name	Zone	District	P.A	Command Area	Actual Area	Beneficiary	Cons, by	Remark
1	Gulufa	Jimma	Shabe Sombo	S/Daruu	40	32	50	Gov	SF
2	Kishe	Jimma	‘’	Kishe	46	38	80	GRS	SF
3	Diko	Jimma	‘’	Angacca	150	150	271	Gov	F
4	Cililoo	Jimma	Sokoru	Unkuree	73	53	150	Gov	F
5	Qarsaa	Jimma	Kersa	T.Qarsu	70	70	150	ESRD	SF
6	Birbirsa a	Jimma	Kersa	Girma	70	70	308	Gov	SF
7	N.Gudd a	Jimma	O.Neda	D.Yaya	120	75	155	AGP	F
8	T.Beya m	Jimma	O.Neda	T.Beyam	85	55	160	LWF	F
9	Nadhii 2	Jimma	T/Afeta	Busa	85	74	177	FCE	SF
10	Nadhi 1	Jimma	T/Afeta	Ako	80	80	185	LWF	SF
11	Nadhi	jimma	T/Afeta	Tiyo & Gibe Koticha	45	45	90	Gov	F
12	Qawa	Jimma	Macho	G.Qadida	150	88	270	GOV	SF
13	w.wades a	Jimma	Botor Tolay	w.wadesa	75	51	100	LWF	SF
14	Wanja	Jimma	Mana	G.Bosoqa	102	75	396	ADB	SF
15	Tamsa	Jimma	Goma	Dalacho	72	72	211	AGP	F
16	Naaso	Jimma	Gera	T.Xeso	100	100	180	AGP	F
17	Melka hida	Jimma	Goma	C.Cago	150	62	115	AGP	F
18	Gicho	Jimma	Gera	S.Loya	80	80	120	AGP	F
19	Melka hola	Jimma	Goma	O.Baqo	40	40	80	AGP	F
20	Bosonte	Jimma	L.Saqaa	B.Raya	35	35	70	AGP	F
21	Aranga ma	Jimma	L.Saqaa	Santo	31	26	62	AGP	F
22	C.Alga	Jimma	L.Saqaa	C.Alga	73	54	146	AGP	NF
23	Ata	Jimma	Gera	M.Chira	15	15	30	AGP	SF
24	Sisaay	Jimma	Gera	G/ chala	15	15	32	AGP	SF
25	Cuqulis	Jimma	Limu Seka	Mirkuz	20	18	25	AGP	F
26	Coqorso	Jimma	Limu Seka	Saqaa	46	41	98	AGP	F
27	Murii	Jimma	Goma	B/Dinsara	15	12	51	AGP	SF
28	Kokka	Jimma	Gera	G.Chala	15	15	28	AGP	F
29	Biila	Jimma	Gera	K.Badey	15	11	25	AGP	F
30	Chami	Jimma	Goma	qadamssa	32	18	65	AGP	F
31	Sunde	Jimma	Goma	Bulbulo	15	10	45	AGP	F
32	Wadesa	Jimma	Goma	Bashasha	15	10	51	AGP	SF

33	Bildima	Jimma	Gomma	Diinuu	15	15	30	AGP	F
34	keyama	jimma	Sokoru	heretoo	20	20	65	WV	F
35	Aboobe	jimma	L/kossaa	Techo	45	45	72	Gov	SF
37	Aleltu	Jimma	C/Boter	Baggee	78	70	145	Gove	F
39	waro Gibe	Jimma	Dedo	Waro Kolobo	313	300	475	AGP	SF
40	Gibe Qacama	Jimma	Seka Cokorsa	Dabo Yaya	200	150	600	SSD	F
41	Warqee	Jimma	Limu Seka		23	23	25	AGP	F
42	Badoo	Jimma	Gera		25		47	AGP	F
43	Affallii	Jimma	Dedo		26	26	39	AGP	SF
44	Ofole Dawe	Jimma	Dedo		38	38	120	AGP	SF
45	Korjo	Jimma	Dedo		25	25	50		F
46	O/Gubu u	Jimma	Goma		20		50	AGP	F
47	Konchee	Jimma	Goma		23	23	123	AGP	F
48	Doogga aja	Jimma	Goma		22	22	33	AGP	F
49	Jalo Roba	Jimma	O/Nadda		35	35	129	AGP	F
50	Nada Qala	Jimma	O/Nadda		25	25	32	AGP	F
51	Malacho	Jimma	O/Nadda		30	30	37	AGP	F
52	kolobo ofolee	Jimma	Dedo		55	40	76	AGP	F
53	Colle Lalo	Jimma	O/Nadda		300	300	377	AGP	F
54	makulo	Jimma	O/Nadda		35	35	31	AGP	F
	Total				**3,328.00**	**2,812.00**	**6,532.00**		

Planned Irrigation Projects in Gibe Gojeb Sub-Basin

S/N	Project name	Lat. (N)	Long. (E)	Alt.	Design Q	C.Area (ha)	Woreda
1	Ambelta	260048.4 m	1002092 m	1809m	77.06 m^3/s		Sire/East Wollega
2	Jarti	$8^o52'26"$	$37^000'$		30.32 l/s		Boneya Boshe (E.W)
3	Nedhi				432.32l/s	85	Tiro Afate, Jimma
4	Waro Kolobo						Dedo
	Keyama	882918	339244				Sokoru, Jimma
	Fecha	298122.5	1013115.8	1861			SE of Bako, West Shewa

	Jima	289436.2	1015265.8	1755			SE of Bako, West Shewa
	Robi	287755	1006896	1602		45	SE of Bako, West Shewa
	Teji	298122.5	1013115.8	1681			SE of Bako, West Shewa
	Bilbila			1850		80ha	Dano, West Shewa

Appendix 12: Irrigation Potential of Omo-Sharma sub basin

Medium Scale Scheme	Zone	Woreda	Water Source	Scheme type	Area Potential	Area Actual
Kete	KT	Hedero	river	Diversion weir	231	40
Sana	KT	Hadero	river	Diversion weir	250	30
Shata	Dawuro	Mareka	river	Diversion weir	250	189
Lefi	Wolaita	K/koysha	river	dam	560	0
Busha	Wolaita	Offa	river	Diversion weir	200	5
Dekeya	Wolaita	Offa	river	Diversion weir	200	30
Darge	Gurage	Abeshige	River	diversion weir	300	0
Ameka	Hadiya	Gambora	River	diversion weir	300	150.00
					2,291.00	**444**
Small Scale Scheme Name	**Zone**	**Woreda**	**Water Source**	**Scheme type**	**Area Potential**	**Area Actual**
Lamo	KT	Tembaro	River	Diversion Wier	120	89
Jeleka	KT	Tembaro	River	Diversion Wier	30	19
Bejo	KT	Tembaro	River	Diversion Wier	25	20
Kololo	KT	Tembaro	River	Divesion wier	45	40
Setame	KT	Tembaro	River	Divesion wier	89	81
Shapamo	KT	Tembaro	River	Divesion wier	80	60

Muileta	KT	Tembaro	River	Divesion wier	40	45
Kololancho	KT	Tembaro	River	Divesion wier	60	50
Chore	KT	Tembaro	Spring	Divesion wier	40	45
Gemesha	KT	Kacha Bira	river	Diversion weir	75	48
Ufute	KT	Kacha Bira	river	Diversion weir	40	40
Ufute	KT	Kacha Bira	river	Diversion weir	50	45
Soda	KT	Kacha Bira	river	Diversion weir	40	25.5
Bekera	KT	Kacha Bira	river	Diversion weir	18	7
Hinichine	KT	Kacha Bira	Spr ing	Diversion weir	30	21
Abaya	KT	Kacha Bira	Spring	Diversion weir	15	16
Yosha	KT	Hedero	river	Diversion weir	12	8
Doje	KT	Hedero	river	Diversion weir	136	25
Gingta	KT	Hedero	river	Diversion weir	70	13.6
Busha	KT	Hedero	river	Diversion weir	39	15
Gememo	KT	Kacha Bira	river	Diversion weir	75	48
Domba	G/Gofa	Kucha	River	Intake	95	45
Toni	Dawuro	Mareka	river	Diversion weir	96	77
Bachire	Dawuro	Gena bosa	river	Diversion weir	50	52
Yarda	Dawuro	Tocha	river	Diversion weir	90	79.24
Wosine	Dawuro	Gena bosa	river	Diversion weir	30	37
Zigna	Dawuro	Tocha	river	Diversion weir	120	55
Ongoto	Wolaita	K/koysha	river	Diversion weir	70	50
Baliya	Wolaita	K/koysha	river	Diversion weir	100	42.5
Woyo	Wolaita	Offa	river	Diversion weir	150	50
Magera	Wolaita	B/Bombe	river	Diversion weir	150	14

Takacha	Wolaita	S/zuriya	river	Diversion weir	150	
Bittete	Wolaita	D/Sore	Spring	Diversion weir	62	206
Ethana	Sodo Zuriya	B/Sore	river	Diversion weir	60	50
Woybo	Wolaita	B/bome	river	Diversion weir	190	106
Soke	Wolaita	B/Sore	river	Diversion weir	90	273
Lintalicho	Hadiya	Gibe	River	diversion weir	130	30
Bobicho	Hadiya	Gibe	River	diversion weir	140	80
Belete	Hadiya	MirabBadawacho	Spring	Pumping	34	
Gonjo	Hadiya	Soro	River	diversion weir	116.00	46.00
Hombancho	Hadiya	Soro	River	diversion weir	120	45
Gidachamo	Hadiya	Soro	River	diversion weir	100	80
Awishona	Hadiya	Soro	River	diversion weir	72	
Horuwa	Hadiya	Gambora	River	diversion weir	140	40
HAO	Hadiya	Gibi	River	diversion weir	100	60.00
Gochi	Hadiya	mirab Badawacho	River	diversion weir	120	87
Lintala	Hadiya	Soro	River	weir	104	65
Kecha Gemuna	Hadiya	Soro	River	pump	20	
Konta		Cheta Kechkacha	diversion weir		50	

Appendix 13: The soils of Gibe-Gojeb River Sub Basin

S.No.	Soil types	Area_km^2	Area_ha	Area_Percent
1	Calcaric flubisols	22.72	2272.00	0.07
2	Calcic fluvisols	250.40	25040.02	0.81
3	Calcic xerosols	155.68	15568.16	0.50
4	Chromic cambisols	85.44	8544.01	0.27
5	Chromic luvisols	1047.30	104730.37	3.37
6	Chromic vertisols	1363.83	136383.01	4.38
7	Dytric cambisols	2991.67	299166.75	9.62
8	Dystric fluvisols	2246.92	224691.58	7.22
9	Dystric gleysols	277.09	27708.59	0.89
10	Dystric nitisols	9137.44	913744.10	29.38
11	Eutric fluvisols	1274.19	127418.54	4.10
12	Eutric nitisols	618.62	61861.74	1.99
13	Gypsic yermosols	111.44	11144.01	0.36
14	Leptosols	482.35	48235.48	1.55
15	Orthic acrisols	2335.27	233527.17	7.51
16	Orthic luvisols	1014.85	101485.10	3.26
17	Orthic solonchaks	217.16	21716.31	0.70
18	Pellic vertisols	7473.13	747313.26	24.03

Appendix 14: Soils of Omo-Sharma Sub Basin

S.No.	SOIL_TYPE	Area_km^2	Area_ha	Area_Percent
1	Dystric nitisols	20329.84	2032983.91	25.44
2	Dytric cambisols	8009.04	800903.61	10.02
3	Chromic luvisols	1593.74	159373.50	1.99
4	Eutric nitisols	703.55	70354.93	0.88
5	Eutric fluvisols	10604.44	1060443.98	13.27
6	Chromic vertisols	6170.52	617051.95	7.72
7	Pellic vertisols	7969.52	796951.68	9.97
8	Dystric gleysols	493.79	49378.76	0.62
9	Dystric fluvisols	3292.74	329273.70	4.12
10	Orthic acrisols	7233.10	723309.80	9.05
11	Leptosols	2255.30	225530.30	2.82
12	Calcic xerosols	603.46	60345.55	0.76
13	Orthic solonchaks	1758.62	175862.23	2.20
14	Phaeozems	39.40	3940.01	0.05
15	Vertic luvisols	122.52	12252.07	0.15
16	Dystric cambisols	288.93	28892.65	0.36

Appendix !5: Soils of Lower Omo Sub Basin

S.No.	**Soil_Type**	**Area_Km^2**	**Area_ha**	**Area_percent**
1	Dystric nitisols	1609.03	160902.60	6.07
2	Dystric cambisols	1187.35	118735.22	4.48
3	Chromic luvisols	31.04	3104.42	0.12
4	Eutric fluvisols	8889.71	888971.29	33.55
5	Chromic vertisols	3626.80	362679.55	13.69
6	Orthic luvisols	109.12	10912.13	0.41
7	Dystric fluvisols	300.19	30019.47	1.13
8	Orthic acrisols	842.87	84287.10	3.18
9	Leptosols	1185.71	118570.70	4.48
10	Chromic cambisols	5337.91	533791.34	20.15
11	Calcic xerosols	383.79	38379.42	1.45
12	Orthic solonchaks	1250.00	125000.39	4.72
13	Vertic luvisols	121.24	12124.04	0.46
14	Dystric cambisols	107.74	10773.92	0.41
15	Haplic xerosols	1512.95	151295.29	5.71

Appendix 16: Participants of Startup Stakeholder Consultative Meeting

Presented by	Comments/Questions	Photo
1. Dr Mesfin Bibiso (WSU, former VPRCS)	• Launching the Project and Making the project known to the Stakeholders • The vice president assured that Wolaita sodo university will own and support the Omo Gibe basin plan project in all aspects it needs until its completion through University-Industry linkage platforms	
2. Mr.Getachew Gizaw (Former Deputy Director, BDA)	• Addressing the Opening Keynote Speech on the startup workshop, • While delivering the opening, he said that all stakeholders in the Omo Gibe River Basin should own the project and participate actively from its initial phase to its intervention stage as the basin development requires integration of experts and resources.	
3. Mr. Belayneh Yirdaw, (IWRM , head)	• Presented the Guideline for Basin Plan Preparation	
4. Dr. Abrham Asha (project leader)	• Presented "Scope and Roadmap of Omo Gibe River Basin Strategic Plan"	
5. Participants of startup Workshop	• The startup workshop participants discussed on the issues and forwarded as follows: 1. The plan should be a long term plan 15yrs 2. Basin plan golden rules should be followed 3. The project should be institutionalized 4. Roadmap should accept the dynamic nature of the basin 5. Stakeholders interaction should be a smooth 6. All stakeholders should be addressed	 

Appendix 17: Participants of the First Stakeholder Consultative Meeting Workshop

Presented / Raised by	Comments/Questions	Photo
1. Dr Adanech Yared (Former BDA, Director)	• Dr Adanech Yared , opened the stakeholder meeting • Groundwater potential of the basin should be quantified well with references based on the estimated result from master plan and various studies • Check the variation on rainfall and be accurate • Be consistent on the data you have 122bcm etc • How is the sedimentation problem in Gibe 1,2,3,4 and how long will it be a problem? • How can the sedimentation problem be solved? Mention the method with the project, and in which sub basin a problem is rising? How to minimize the sedimentation problem? Try to make a project and put a strategy • How to fill the data gap? How to address the data gap on river flow in lower parts of the basin? • Establishing of the river gauges and rain gauges in selected areas of the basin being consulted by the line sector	  
2. Mr.Asmamaw Kume (Advisor, State minister of IWRM)	• Develop trend of experience sharing and involvement of universities and skilled experts • Did you clearly understand the basin? Wrt to watersheds, basin and its inside and outside the country? Can you address the basin sub-watersheds? • Are all watersheds clearly mapped and characterized, wrt to watershed part of the content? For example wabe, walga, Woybo, Deme, etc? • Water allocation and demand issues ; Its hydropower, irrigation, parks, Agroprocesses, drinking, paxtoralists, Ethio Kenyan border issues, addressing in a way	

Presented / Raised by	Comments/Questions	Photo
	not creating conflict? • Do not copy from the master plan and try to know and write your title	
3. Mr. Getu / soci-oeconomist)	• Watershed land capability and suitability situation assessment • Life scenarios of people in the basin /socio-economics • Land degradation problem identification and solution making project proposal initiation	
4. Mr. Dejene /watershed MoA	• What makes the basin unique wrt to other Ethiopian basins? Make comparative analysis in watershed, socio economy, geo/hydrogeology, hydrology, etc • Watershed aspect siltation analysis , Dam siltation situation analysis/ in upper and lower dams, lower lands • Make socio-economy to be figurative, and map each component in the basin	
5. AsegidA (MoWE, basin planning expert	• The work should be finalized in scheduled time • Try to collect the temporal data on the water quality /ground and surface water quality • Sediment load data at temporal scale with in time range of the project • Select the river gauging stations along the lower reaches of the basin • Emerging issues in the lower part of the basin, middle and upper portions, Such as drought, flood, sedimentation, siltation, earth quake , etc • How to minimize the land degradation problems and indicate areas of land degradation, sedimentation etc • Stakeholder engagement and participation should be noted and ideas should be dealt with • The data should be timely • How is the current deforestation situation, erosion, land degradation, and what is the amount lost in soil content in each aspects? • Make land degradation, erosion, deforestation as thematic areas	

Presented / Raised by	Comments/Questions	Photo
6. Mr Dereje A./Sugar corporation	• Your data should be updated, Correct the conflicting data and try to use the right data • The cover of sugarcane by now is 18,000 hectares • There is weather station in the areas of sugar project • In these stations there is 875mm of rainfall consider it • What are the ecosystem services in the basin	
7. Biruk Lerebo/ Former BDA	• The no of kebeles, livestock in the basin • The no of industry and water utilization condition • Dams, the amount of water storage, measure impacts of the dam on the socio economic activity • What is the surface water amount and no of tributaries and map them correctly • Map the groundwater potential • Identify hot spot watersheds parts and map them, • Get the wetland works in the basin and map them	
8. Mezgebu/Agricultu re	• Why agriculture is not sub theme for the project? • What is the impact of land use in the watershed and water itself? • Watershed vs agricultural land scenarios • How the climate is is changing? what is the mitigation measure including carbon trading in the area should be made as a project in association with the dams • Emerging good works such as GebetaLehager and try to associate it with other good task ideas • Climate change model of the Omo-Gibe areas	
9. Nibret /GIS	• The role of geology in identification of minerals, water resources and etc • Groundwater data should be mapped and its potential areas should identified	
10. Diriba Muleta/ National meteorology	• Impact assessment of climate variability on rainfall anomally and seasonality, and impact reduction mechanisms	

Presented / Raised by	Comments/Questions	Photo
11. Dr Yared / Oromia Environmental protection	• The basin is diversified based on its use including: Hydropoer, Sugar , irrigation , wild life , tourist, • Up to dated data is necessary • For the planning and management , intervention projects are needful based on the indicators such as {physical, biological and policy issue} and try to develop them from this time of beginning • Make sure that you involve selected students to synergize the research ,community service, and technology transfer part along with this project • Make sure that you managed all your stakeholders • Emerging issues involvement on the basin such as carbon trade, new employment opportunities	
12. Mr.BelaynehYirdaw / Former BDA BDA	• What can we do as pilot project? Select areas including database, watershed, water resources, stakeholders issues, training provision, model watershed makings , intervention project as in sedimentation, selection of areas to breed improved ferriage and • Disaster risk management related to River overflow in identified areas • Integrate {water quantity and quality, watershed} monitoring to start at small scale integrated projects, for various purposes. Small scale watersheds that could be managed by the community itself • Make a project on community managed watersheds for integrated water resources management	

Appendix 18: Participants of the Second Stakeholder Consultative Workshop

Presented / Raised by	Comments/Questions	Photo
Jima stakeholder meeting at Jima university Agriculture college hall		
		
1. Jima zone Agri	• Request Oromia irrigation works for the data • Carbon trade in Omo Gibe basin should be tried • RF pattern vs climate change for climate model • What is the opportunities and the threats of Dams in the omo Gibe basin? Put them in separate with the questionnaires • Why do not you try to describe the Omo-Gibe basin based on three agro-climatic zones?	
2. Gezahegn from Dawro Zone	• Coal deposit mapping in Dawro and other mineral resources	
3. Kambata Tambaro zone	• It will be good if the characterization is based on major • Existing irrigation schemes in the basin should be mapped • Institutional analysis of the irrigation river catchments in the basin	

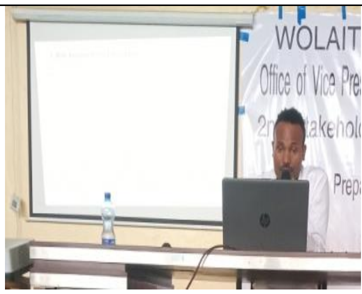
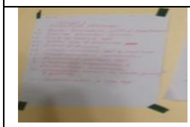
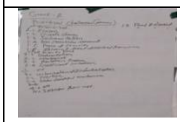
Presented / Raised by	Comments/Questions	Photo
4. Terefech /kefa zone	• Arrange the watersheds on micro watershed basis and try them to be owned by the community- use citizen science thesis for this case	
5. Haile yesus /Guraghe	• Try to institutionalize the watershed issue at community scale • How to sustain the management of thewatersheds- strategize • Basin scale mapping of wetland and the ecosystem service level	

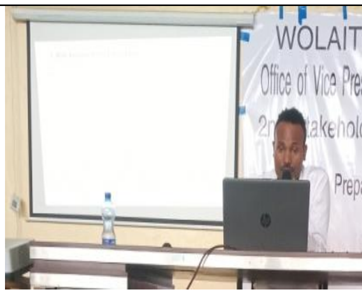
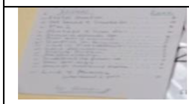
Appendix 19: Participants of the Third Stakeholder Consultative Workshop

Presented/Raised by	Comments/Questions	Photo
Participants of the stakeholder meeting		
Mr Getnet Bekalu Representative of the MoWE, making the opening speech		

Presented/Raised by	Comments/Questions	Photo
Dr Abrham Asha Making presentation on the issues related to the lowland part of the Omo Gibe basin		
Ato Bahiru Alemu SNNPRS irrigation	• Do you know the level of water balance in basin? • It is better to explain the existing water supply use for domestic, irrigation, e.t.c. • Re-check the irrigation potential around the basin	
2 Ermias South Omo Environment	• Give focus on flooding at lower basin especially around Dassenach Woreda and others • Please give consideration for flood return period	
3 Mr Kasaye / Agronomist South Omo	• Give focus on fodder and other plantation which is important for soil and water conservation • Pleases make detail analysis on soil type across the basin • Please consider the climate variability effect at lower basin	
4.	• What is the gap on master plan? • Livelihoods and poverty map should be included based on GIS • Geological map should be included • Climate projection should be conducted	

Appendix 20: Participants of the Fourth Stakeholder Consultative Workshop

Presented	Presentation made by	Photo
Dr Abrham Asha Fourth stakeholder meeting opening		
Mr Ermias Mekonnen Presenting the prioritization criteria		
 **Issues in Lower Omo sub-basin** **Group 1** 1. Girma 2. Asegid 3. Melesech 4. Teshome		
 **Issues in Middle Omo sub-basin** **Group2** 1. Mr Ermias 2. Dr Melku 3. Ms Tinebeb		

Presented	**Presentation made by**	**Photo**
Dr Abrham Asha Fourth stakeholder meeting opening		
Mr Ermias Mekonnen Presenting the prioritization criteria		
 **Issues in Upper Omo sub-basin** **Group 3** 1 Ergude 2. Fekadu Beye 3. Habtamu M 4.Israel Bereket		

Appendix 21: Participants of the Fifth Stakeholders Meeting

Presented	Presentation
Project prioritization workshop in pastoralist areas of Omo Gibe basin 1. Mr Teketel Matewos (MoWE) Opening the meeting for the discussion in selection of titles for future implementation 2. Dr Zablon Adane (WRI) 3. Ms Daisy Kosgei , international Alert, project officer	
Visit in Lower Omo at Omo Bridge 1. Mr Teketel Matewos, MoWE 2. Dr Abrham Asha, WSU 3. Mr Ermias Mekonnen, WDU 4. Mr Asegid , MoWE 5. Mr Getnet Bekalu, MoWE	

Appendix 22: Livestock composition in the Omo Gibe basin

Region	Zone	Livestock composition						
		Cattle	**Sheep**	**Goat**	**Poultry**	**Donkey**	**Horse**	**Mule**
SNNPR	Gurage	1,000,600	308,849	113,947	473,360	122,201	46,222	2,988
	Hadiya	950,388	206,732	218,039	724,972	171,007	25,241	4,605
	KTimbaro	399,307	56,441	71,433	243,969	54,961	4,587	495
	Wolayita	896,032	186,805	202,686	573,468	47,540	484	2,334
	South Omo	1,932,979	1,092,104	2,127,432	347,078	21,910	9,961	2,591
	Kefa	1,008,165	572,188	208,430	817,397	8,645	70,625	11,066
	Gamo Gofa	1,403,050	502,720	460,207	727,024	53,180	45,709	11,773
	Bench Maji	355,831	190,148	112,380	361,868	1,935	9,148	2,698
	Yem specia	78,228	17,284	43,314	52,069	5,357	372	196
	Dawuro	334,971	61,029	69,716	183,555	4,870	2,823	4,155
	Basketo sp	53,387	18,239	11,708	37,335	1,065	139	335
	Konta spec	114,682	18,712	27,395	85,110	801	930	860
OROMIA	East Wellega	1,008,968	274,629	189,644	770,250	121,636	4,437	4,030
	Jimma	2,369,307	750,487	515,513	1,868,113	179,228	63,567	22,291
	West Shewa	2,202,544	1,048,490	313,569	1,273,221	237,825	264,969	7,143
	South West Shewa	1,113,433	261,186	281,224	715,839	171,433	65,339	4,845
	Horo Gudru Wellega	681,928	162,022	172,992	442,035	101,067	26,508	2,896

Source: Report on livestock and livestock characteristics in the year 2012 E.C. (CSA, 2019/2020)