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**ADDIS ABABA UNIVERSITY  
ETHIOPIAN INSTITUTE OF ARCHITECTURE, BUILDING  
CONSTRUCTION AND CITY DEVELOPMENT (*EiABC*) CHAIR  
OF URBAN AND REGIONAL PLANNING**

**MONITORING URBAN WETLANDS FOR SUSTAINABLE URBAN  
PLANNING: THE CASE OF BAHIR-DAR CITY, ETHIOPIA**

**BY:**

**DAWIT MALEDE**

**MAY, 2024**

**ADDIS ABABA, ETHIOPIA**

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ETHIOPIAN INSTITUTE OF ARCHITECTURE, BUILDING  
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case of Bahir-Dar city, Ethiopia**

**By:**

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**A Thesis Submitted to the School of Graduate Studies of Addis Ababa University,  
Ethiopian Institute of Architecture, Building Construction and City Development, In  
Partial Fulfillment of the Requirements for the Award of Masters of Science Degree in  
Urban Planning**

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**May, 2024**

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## DECLARATION

I declare that this thesis prepared for the partial fulfillment of the requirements for the degree of Master Science (MSc.) in Urban planning entitled “*Monitoring Urban Wetlands For Sustainable Urban Planning: the Case of Bahir-Dar City, Ethiopia*” is my original research work prepared independently by my effort with the close advice and guidance of my adviser. All views and opinions expressed therein remain the sole responsibility of the author. I also declare that this thesis has not been presented in any university and all sources I have used or quoted have been indicated and acknowledged using complete references.

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## STATEMENT OF CERTIFICATION AND APPROVAL

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Dawit Malede

May 2024 G.C

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## ABSTRACT

*The urban wetland ecosystem is the most overlooked habitat, and its services and values have not been well appraised. There are many wetlands in Bahir Dar city, but it hasn't received adequate attention and acknowledgment. By observing the problem, this study has been conducted to assess urban wetland monitoring in Bahir Dar city for sustainable urban planning and management. In the study, an explanatory research approach was employed along with survey methods. Throughout the investigation, a lot of descriptive statistics and analysis were conducted, together with thorough contextual assessments. The wetland dynamics quantification, which is based on satellite imagery is utilized to assess the biophysical environment using ArcGIS and Envi-Met simulation modeling tools; residents, governmental and non-governmental organizations are also considered to assess the socioeconomic aspects. In the end, the study identified around 20 wetlands in the city, with 45% being perennial and 55% exhibiting seasonal variations. These wetlands have great ecological importance to the residents of the city. However, poor solid and liquid waste management, lack of awareness, lack of legal framework, and urbanization are the primary challenges wetlands face to function sustainably in the urban landscapes of the study area. The study concludes that the benefits of wetland landscapes are not adequately prioritized by urban planners and decision-makers, which impedes their potential benefits. Finally, the research recommends the improvement of waste management, raising stakeholder awareness, strengthening legal frameworks, and monitoring urbanization that can ensure the ecological importance of wetlands for dwellers.*

**Key terms:** urban wetlands, wetland ecosystem, sustainable urban planning, ecosystem functions, Bahir Dar

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## **ACRONYMS/ABBREVIATIONS**

MSWM =	municipal solid waste management
GIS =	Geographical information system
ESV =	Ecosystem service values
LULC =	Land use land cover change
EPA =	Environmental Protection Authority
WCP =	Wetland Conservation Plan
UHI =	Heat Island effect
USEPA =	United State Environmental Protection Agency
USNOAA =	U.S National Oceanic and Atmospheric Administration
EWCO =	Ethiopian Wildlife Conservation Organization
EWNHS =	Ethiopian Wildlife and Natural History Society
EWRP =	Ethiopian Wetlands Research Project
IBCR =	Institute for Biodiversity Conservation Research
CSA =	Population and Housing Census Commission Central Statistical Authority
EBI =	Ethiopian Biodiversity Institute

# CHAPTER ONE

## 1. INTRODUCTION

### 1.1 Background of the study

The United Nations estimates that 55% of the world's population presently resides in cities. By 2050, this percentage is anticipated to increase to 68% (UNDES, 2019). The natural infrastructure is being affected and its innate sustainability process is being disrupted by this expanding trend of urbanization, both in terms of area and density (Ampatzidis & Kershaw, 2020). Additionally, it hurts the biological processes and health of the urban environment, including biodiversity loss, water pollution, and vegetation deterioration (Liao et.al, 2020). Furthermore, relative to their surroundings, urban centers often have less vegetation and water, and the current green and blue infrastructure is frequently endangered by growing human density (Gunawardena, et al., 2017).

Wetlands are among the most important components of the green-blue infrastructure because of their wide range of uses. Wetlands can be found in a range of hydrologic, climatic, and geographical contexts and also size, shape, plant, soil, and hydrologic conditions are all different. Despite these variations, wetlands can still be divided into different categories based on their shared traits. There is no single definition of wetlands that is recognized worldwide due to the diversity of wetland varieties (Wu Q. , 2017). But generally, wetlands can be defined as ‘‘expanses of marsh, fen, bog, or water, whether organic or artificial, long-lasting or momentary, with still or moving, fresh, brackish, or salt water, including marine waters whose depth at low tide does not exceed six meters’’ (Ramsar Convention, 2012).

Urban and peri-urban wetlands offer numerous benefits to communities, including habitats, education, water storage, pollution reduction, natural disaster protection, aesthetic appeal, landscape diversity, and recreational opportunities. They also provide cooling effects in summer and moderately strong winds, supporting cultural heritage and daily life, and contributing to sustainable urban planning (AG, 2013).

Due to urbanization and human interference, 50% of the world's wetlands have vanished in the previous few years (Manob et.al, 2022). Since 1900, 64% of the world's wetlands have vanished,

and even more are lost in some areas, such as Asia and Africa because wetlands and their advantages are being lost, that's why urban wetlands are vanishing more quickly than coastal ones (WWTC, 2018). Because the majority of these valuations have been carried out in Europe, North America, and China, there is a knowledge vacuum regarding the valuation of urban wetlands in developing nations (Lida, et al., 2022). In the past, Panama City in Panama, New Orleans in the United States, and Haikou in China are some of the cities that have been at the forefront of making positive changes to protect their urban wetlands by integrating them with urban planning.

The significance of wetlands in urban settings has grown increasingly obvious, particularly in areas where development goals have included sustainability. It is essential to recognize and incorporate the broader benefits that wetlands offer if cities are to remain sustainable (WWTC, 2018), because wetland ecosystems are essential to sustainable city development and support human lifestyles (Lida, et al., 2022).

Sub-Saharan Africa's marine, coastal, inland, and man-made wetlands hold significant economic, cultural, and ecological value. However, the degradation and loss of these wetlands are primarily due to natural and man-made factors such as deforestation, dam construction, urbanization, and poor management. Balancing local communities' needs with the ecological integrity of remaining wetlands is a challenging national and regional issue. Despite comprehensive biodiversity conservation plans, wetlands are often poorly treated in sectoral policies, highlighting the need for better management and conservation efforts (Ajonina, 2016).

However, a wetlands strategy is soon to be developed, and mangrove/wetland conservation and sustainable use problems are being mainstreamed within it. This long-term mainstreaming task can be traced back to the signatories of international wetlands-related conventions, such as the Ramsar Convention of Wetlands, which were then translated into national action programs, including institutional development at the local, national, and regional levels focusing on issues of sustained livelihood and poverty alleviation and coming under various integrated approaches, such as integrated approach to urban and wetland planning (Ajonina, 2016).

Many wetlands in Ethiopia are recognized for their biodiversity even though Ethiopia has not ratified the Ramsar Convention on Wetlands of International Importance. However, the

abundance and distribution of wetlands in Ethiopia are still unknown, in part due to inconsistent methods used to identify and delineate them as well as issues with weak sustainable use (Alan, et al., 2021). According to Alan , Adrian, & Afework (2021), wetlands make up roughly 1% to 2% of the country's total land area. The nation has several significant wetland regions. Tekeze Valley (Tigray), Baro-Akobo (Gambella), Omo-Gibe (South), Awash Valley, and the wetlands of Fogera, Dembia, Beles, Borkena, and Bahir Dar Zuria in the Amhara region are a few examples (EBI, 2024). Among them, Bahr Dar city and its surroundings are an area where a large-scale accumulation of wetlands can be seen.

Scientific urban planning must be used to integrate wetlands into urban landscapes to encourage long-term growth. To create a thorough urban development plan that carefully considers the relationships between environmental resource-impact relationships, urban planners must work closely with and communicate with hydrologists, policymakers, developers, and the local community at large. Therefore, it is necessary to research how wetlands affect urban areas and the people that live there.

## **1.2 Statement of the problem**

Numerous environmental, sociocultural, and economic advantages are offered by wetlands, such as reduced soil erosion, water purification, groundwater replenishment and release, and habitat provision, especially for birds and other wildlife (Samsul et al., 2023) as well as potential sites for nature-based ecotourism and community gathering places for local communities (Chen et al., 2022). However, pasture and agricultural land expansion as well as unchecked urban expansion, particularly in the urban and periurban areas, are putting this resource in danger of going extinct (Zekarias et al., 2021).

Bahir Dar city is home to diverse hydrological constituents and urban wetlands. However, these wetlands are not adequately governed and planned in the city's structural plan, hindering their potential benefits. The occupancy of these wetlands has decreased, according to Workiyie et al., (2021) within 35 years, wetlands and water bodies in the city and its surroundings had decreased by 75.71% (or 1618 ha).

The characteristics of the wetland ecosystem and its potential benefits in the study region have been the subject of several studies to date (Assefa et al, 2021; Ayalew, 2018; Eneyew & Assefa,

2021; Kassa & Teshome, 2015). Most of these studies concentrated on wetland habitats from a watershed perspective; they did not take into account the viewpoints of urban landscapes. A study conducted by Assefa et al. (2021) examines the urban landscape of Bahir Dar city, with a particular focus on the impact of land cover dynamics on wetlands. However, these areas are not being exploited effectively in terms of their ecological value, for example, their role in improving the amount of liquid wastewater entering water bodies, monitoring climate change, as a source of income, and protecting cultural values has not been adequately studied. According to Mekonnen, (2012), there is no modern municipal wastewater collection and treatment infrastructure in Bahir Dar City, 64% of wastewater discharges into the streets and open fields and most of it enters the major Nile River water stream and Lake Tana both directly and indirectly. The average temperature change in Bahir Dar city is greater than the global average (0.08°C per decade), at roughly 0.4°C each decade (Amente, 2012).

The primary cause of this issue is a lack of awareness of the advantages these locations provide to residents in terms of the environment, economy, social life, and culture. The researcher saw these locations granting development licenses to investors for a variety of construction services at the urban and infrastructure department of Bahir Dar city administration since the local government did not pay enough attention to these locations. This study main objective is to quantify the ecosystem services that wetlands provide and look at the main challenges that these wetland landscapes encounter to deliver the expected benefits, which were overlooked in previous studies make a resource for decision-making and implementation, and set up them for future study and research.

### **1.3 Objective of the study**

#### **1.3.1 General objective**

The general objective of the study is to assess the urban wetland monitoring in Bahir Dar city for sustainable urban planning and management.

#### **1.3.2 Specific objective**

The specific objectives of the study are to:

- Identify the major wetland areas of Bahir-Dar city;

- Evaluate the regulatory, social-economic, and recreational function of wetlands in the study area;
- Explore the primary challenges wetlands face to function sustainably in urban landscapes of the study area.

#### **1.4 Research questions**

The research questions of the study are:

- What are the major wetland areas of Bahir-Dar city?
- What is the major regulatory, social-economic, and recreational function of wetlands in the study area?
- What are the primary challenges wetlands face to function sustainably in urban landscapes of the study area?

#### **1.5 Significance of the study**

The research has studied the major regulatory, social-economic, and recreational functions of wetlands and the challenges wetlands face to function sustainably in urban landscapes in a detailed manner to contribute to creating awareness of the benefits of wetlands for the community. So that, it enables land-based decision-makers to make responsible decisions about wetlands it can serve as a resource for the implementation of the future wetland-related development plan. Also, in this study, wetlands in the city are well identified; In addition to simplifying the work of urban planners and architects during urban design and building construction, it allows them to do work that suits these areas.

Furthermore, this study serves as an additional resource to the body of literature in related fields. By building new theories and findings, research can provide valuable insights that further advance these fields. The research will serve as a valuable resource for future studies and scholarly endeavors.

## **1.6 Scope of the study**

The main purpose of this research is to assess urban wetland monitoring for sustainable urban planning and management. Although Ethiopia is a site of many urban wetlands from the North to South part of the region, considering the limited potential of study time and budget the research is specifically focused on Bahir Dar, the capital of the Amhara Region and former capital of West Gojjam. Although there are large-scale water bodies in the administrative boundary of Bahir Dar city including Woramit, Addis Alem, Zenzelma, and Woreb Micheal, this study mainly focused on identifying the main wetland areas of the inner city boundary of Bahr Dar.

Wetlands have a wide range of ecological importance, but this study focuses only on their environmental, socio-economic, and recreational functions. Among their many environmental benefits, the research focuses on their contribution to climate control. The research also has studied the primary challenges wetlands face to function sustainably in the urban landscapes of the study area.

## **1.7 Limitations of the study**

The research encounters limitations and challenges during the study seasons. Some of these major difficulties are:

- Limitation of well-organized data on wetland sites influences the strength of the research.
- Regarding money, there was not a sufficient budget that was given by the institute to do an investigation on those sites, as the study mainly relies on visitation.
- Time-wise, the study topic is the current issue of the city as one part of the country and it makes it difficult to cover all issues related to the topic.

## **1.8 Organization of the Study**

The study is conducted and delivered in phases of an organized manner, it starts with chapter one introduction to wetlands with contents of the background of the study, motivation, statement of the problem, research questions, and the objective, scope of study, significance, and research limitation. After that, it conducts reviews of the literature on the definition and social, economic, and environmental benefits of urban wetlands, mapping and demarcation of wetland features,

and major environmental laws, regulations, and permits relating to urban wetlands. Chapter Three of Research Methodology presents the techniques and procedures by which the research was conducted. The chapter covers research design, identifies data sampling techniques, and also explains 'where' data is collected. A detailed analysis of wetlands and the communities associated with them is offered in the results and discussions section of chapter four. Under Chapter Five, the research is concluded with a conclusion and a set of crucial suggestions.

# CHAPTER TWO

## 2. LITERATURE REVIEW

### 2.1 Introduction

An extensive overview of urban wetlands and their regulatory and socioeconomic advantages is given in this chapter. The review and the thesis as a whole are based on the conviction that it is critical to recognize and assess the socioeconomic and regulatory advantages of wetlands in Ethiopia during this period of massive urbanization.

The chapter begins by outlining the fundamental ideas of urban wetlands, including defining and assessing their advantages. It then discusses the difficulties that wetlands encounter in operating sustainably in urban environments. It also examines how stakeholders may improve urban wetlands management and protection. The other topics in this analysis are best practices for defining and assessing the ecological benefits of urban wetlands. The chapter ends with a summary of the issues with the function of urban wetland ecosystems and the difficulties they encounter based on the studied literature.

The majority of research and academic work done in Ethiopia has overlooked the advantages of urban wetlands from the perspective of sustainable planning, even though this is an urgent issue. This is often the largest gap in the literature on the topic of monitoring urban wetlands for sustainable design. The studies have also been conducted with an interest in investigating the matter from the viewpoint of an urban planner.

### 2.2 Operational Definition of Terms

**Ecosystem:** An ecosystem is a region where the weather, natural scenery, and a variety of other organisms coexist to create a bubble of life (Stanley, 2024).

**Urban wetlands:** Wetlands are areas of land that occasionally or always experience flooding from water. Urban wetlands can be located within cities or in the suburbs around them. They comprise coastal variations including salt marshes, mangroves, and coral reefs, as well as rivers and their flood plains, lakes, and swamps (Ramsar Convention, 2012).

Sustainable urban planning: The process of creating and maintaining cities that are resilient in terms of the environment, society, and economy is known as sustainable urban planning. It seeks to improve urban residents' quality of life while lessening the detrimental effects of urbanization, such as inequality, pollution, traffic, and heightened susceptibility to disasters.

Ecosystem functions: The ability of natural processes and elements to directly or indirectly produce commodities and services that meet human needs (Groot, et al., 2002).

## **2.3 The Concept of Urban Wetlands**

Due to the diversity of wetland varieties, there is no single definition of wetlands that is recognized worldwide (Wu Q. , 2017). Wetlands can be found in a range of hydrologic, climatic, and geographical contexts. Size, shape, plant, soil, and hydrologic conditions are all different. Despite these variations, wetlands can still be divided into different categories based on their shared traits.

Wetlands are places where water is present at or near the soil's surface all year long or for various periods throughout the year, including the growing season (USEPA, 2022). There are two wetland definitions in most common use. In the U.S., the U.S. Army Corps of Engineers defines wetland as:

*“Areas that, under normal circumstances, do support a prevalence of flora generally adapted for life in saturated soil conditions, since they are frequently and persistently inundated or saturated by surface or groundwater. Generally speaking, wetlands consist of bogs, marshes, swamps, and similar places.”* (USACE, 2017).

The second commonly used definition was developed by the U.S. Fish and Wildlife Service (FWS). The FWS definition provides:

*“Wetlands are areas where the water table is typically at or near the surface or when the land is covered with shallow water. They are the areas where terrestrial and aquatic systems meet. Wetlands must have one or more of the following three characteristics to be classified. (1) The land supports mostly hydrophytes at least occasionally; (2) The substrate is mostly undrained hydric soil; and (3) The substrate is not soil and is wet or covered in shallow water at some point throughout each year's growing season.”* (DBHC & DMBM, 2022).

Wetlands are classified in a variety of ways depending on the source. Classification systems frequently employ the Cowardian system and Brinson's HGM (hydrogeomorphic) method of classifying wetlands. The five primary categories of wetlands that exist are riverine, marine, tidal, lacustrine, and palustrine, and they are categorized by the U.S. Fish and Wildlife Service using the Cowardin system (USEPA, 2022). Wetlands are classified under this classification based on hydrologic regime, vegetation cover, and landscape position. The HGM (hydrogeomorphic) classification of wetlands, which is based on their hydrologic regimes and landscape placements, divides wetlands into five basic categories: flat, fringe, riverine, depressional, and slope (Wright et al., 2006). As the name implies, wetlands fall into this group based on their hydrodynamics, hydromorphic environment, and primary water source (such as precipitation, groundwater, or surface water).

Inland (non-tidal) wetlands and coastal (tidal) wetlands are the two recognized broad categories of wetlands, according to the American Planning Association (APS, 2002). Most tidal or coastal wetlands are swamps that are periodically affected by the tides, like mudflats, mangroves (tropical maritime plants or shrubs), and coastal salt and brackish marshes (APS, 2002). They have a close connection to the salinity-varying environment that results from the interaction of fresh and saltwater (USEPA, 2022) and they are primarily found in middle and high latitudes across the world along protected beaches.



Figure 2.1: Tidal or coastal wetlands (Source: Georgia Department of Natural Resources, 2020)

Riparian wetlands are solitary depressions embraced by dry land (playas, basins, and "potholes"), along the edges of lakes and ponds, and other low-lying parts where precipitation sufficiently

saturates the soil or where underground water intercepts the soil surface (vernal pools and bogs), are the most prevalent types of inland/non-tidal wetlands (USEPA, 2022). Often emerging in shallow water near the margins of ponds, lakes, and rivers, as well as alongside streams in depressions with inadequate drainage, their high nutrient content makes them one of the planet's most productive ecosystems (Wright et al., 2006).



Figure 2.2: Inland or non-tidal wetlands (*Source: SCOTUS, 2022*)

**Table 2.1:** Types of Wetlands

No	Main Category	Sub-category	Functions
1	<p style="text-align: center;"><b><u>Marshes</u></b></p> <p>Marshes are normally permanently saturated and can be either saline or fresh water.</p>	<p style="text-align: center;"><b><u>Tidal marshes</u></b></p> <p>Tidal marshes are found along the coastlines and are affected by changing tides.</p> <p style="text-align: center;"><b><u>Non-tidal marshes</u></b></p> <p>These marshes occur along streams and are usually freshwater, but can also be brackish.</p>	<ul style="list-style-type: none"> <li>- Recharge groundwater.</li> <li>- Moderate streamflow (this is an especially important function during droughts).</li> <li>- The presence of marshes in watersheds slows and stores water helping in mitigating floods.</li> <li>- Filters water through the sedimentation of pollutants.</li> </ul>
2	<p style="text-align: center;"><b><u>Swamps</u></b></p> <p>Swamps are freshwater wetlands dominated by woody plants</p>	<p style="text-align: center;"><b><u>Forested swamps</u></b></p> <p>Forested swamps are often inundated by flood water (slow-moving or still water) from streams &amp; rivers.</p> <p style="text-align: center;"><b><u>Shrub swamps</u></b></p> <p>These swamps have often waterlogged soil and are dominated by shrubby vegetation.</p>	<ul style="list-style-type: none"> <li>- Flood protection.</li> <li>- High in productivity.</li> <li>- Support rich bio-diversity.</li> <li>- Rich deposits of alluvial soil from floods.</li> <li>- Timber from the swamps can be sustainably harvested for various purposes.</li> </ul>
3	<p style="text-align: center;"><b><u>Fens</u></b></p> <p>Fens are peat-forming wetlands that receive nutrients from sources other than precipitation</p>		<ul style="list-style-type: none"> <li>- Prevents &amp; reduces the risk of floods.</li> <li>- Improve water quality.</li> <li>- Less acidic &amp; higher nutrient values.</li> <li>- Support diverse flora &amp; fauna.</li> </ul>
4	<p style="text-align: center;"><b><u>Bogs</u></b></p> <p>Bogs are characterized by spongy peat deposits, acidic waters &amp; a thick layer of sphagnum moss.</p>	<p style="text-align: center;"><b><u>Bogs through territorialization</u></b></p> <p>Bogs can form as sphagnum moss growing over a lake or pond &amp; gradually filling it.</p> <p style="text-align: center;"><b><u>Bogs through planification</u></b></p> <p>Bogs can form as sphagnum moss layers dry land preventing water from leaving the surface.</p>	<ul style="list-style-type: none"> <li>- Prevent downstream flooding by absorbing precipitation.</li> <li>- Support rich bio-diversity</li> </ul>

(Source - PalArch's journals of the archaeology of Egypt, 2021)

### **2.3.1 Theoretical of urban landscape sustainability and wetlands functions**

Proper resource management and planning may help ensure the sustainability of cities as they become more urbanized. Sustainable cities are instances of sustainable development and contribute to economic progress and prosperity (McInnes R. J., 2014). Wetlands serve as natural resources in sustainable urban environments and offer a variety of ecosystem services, including boosting biodiversity, enhancing water quality, and reducing climate change (Odgaard et al., 2016). Moreover, by managing runoff in these places, wetlands help maintain human safety and create a suitable living environment by moderating the regional climate (Song, et al.,2019).

Urbanization, however, has put wetlands in danger by destroying and shifting the land use from GBI to residential or industrial structures in recent decades. As a result, one of the main cautions for protecting these priceless natural resources and promoting urban sustainability is the loss of natural wetlands (Davidson, 2014). As a consequence, adequate methods for assessing and analyzing the sustainable development of wetlands should be used (Song, et al.,2019).

Wetlands have a reputation for delivering ecosystem services, making them a great candidate for utilization as natural solutions to address a variety of environmental, social, and economic concerns (Thorslund , et al., 2017).

### **2.4 Ecosystem Service Value**

According to USNOAA, (1970) ecosystem service values are defined as:

WHY measure the value of ecosystem services?

People may be encouraged to preserve ecosystems and the services they offer by valuing non-market goods and services such as ecosystem services. Ecosystem services could be underestimated in the absence of measurement, making it challenging to determine how much money is required for the sustainable management of these resources.

WHAT ecosystem service values can we measure?

Measuring changes in ecosystem services and their effects on human well-being is significant and instructive for policymakers and managers, even though the entire worth of Earth's ecosystem may be incalculable. Scholars have devised methods for assessing the effects through

financial measures (like the cost of commercially significant fish species) and non-financial measures (like the decrease in water-borne illnesses resulting from high water quality or the preservation of life from flooding hazards).

Whose valuation of ecosystem services should we measure?

Different ecosystem services may vary as a result of a single policy or management choice, which may influence various social groups. It is necessary to take into account the parties who are impacted by the choice, both positively and negatively, in the political and ecological boundaries. Since these services typically benefit larger populations, it may occasionally be beneficial to include non-local and even future recipients, particularly for recreational and cultural appreciation purposes.

When do we measure ecosystem service values?

It is possible to compare various policy and management options, such as the advantages and disadvantages of green infrastructure, habitat restoration, or the use of green spaces, by measuring services using common metrics (dollars, lives saved, etc.). One can decide whether a non-monetary appraisal suffices or if it is worth the time, money, and knowledge needed to undertake a monetary value based on the policy and managerial settings.

How do we measure ecosystem service values?

Best practices in coastal management, as well as an overview of several approaches to valuing environmental services, are provided in the information that follows. Working with economists will be easier if you have a rudimentary understanding of these ideas, particularly when project scoping is involved. But all these techniques are predicated on certain fundamental beliefs. Economists and other specialists in biophysical science, social science, stakeholder involvement, and communication are typically required to carry out the actual work to ensure that the project is carried out effectively.

### **2.4.1 Methods Used for Ecosystem Services Valuation**

According to the governmental agency of USNOAA, (1970) there are five different methods of evaluating ecosystem service: -

**Input Valuation Method:** - evaluates the degree to which the value of the outputs that ecosystem services contribute to will be impacted by changes in those services. When valuing ecosystem services that are inputs to marketed goods, use this approach. Example: Fisheries production, landings, and revenue are impacted by changes in mangrove health.

**Revealed Preference Method:** - estimates the worth of non-market items by using market pricing related to customer decisions. When humans consume some components of the ecosystem services that are being valued, either directly or indirectly, apply this method. Examples: Property values are impacted by the presence of wetlands and beaches, and the quality of a beach influences how much visitors are willing to pay.

**Stated Preference Method:** - often known as contingent value or choice experiments, involves asking participants a series of questions to determine which option they prefer. When evaluating the willingness to pay for management alternatives or the presence or existence values of ecosystem services—which humans do not consume directly or indirectly—use this method. Examples: The values of preserving urban open space, creating renewable energy, rehabilitating damaged wetlands, and conserving species can all be estimated using people's preferences.

**Cost-Based Method:** - calculates the overall costs that would result from the loss of ecosystem services or their replacement by artificially created substitutes, not the prices that a particular person would be willing to pay. When administering a survey with limited time or resources, use this approach. Examples: In the absence of marshes, storm damage to communities will increase; if a healthy watershed is compromised, community water treatment costs will increase.

**Benefit Transfer Method:** - estimates values for an unstudied site using research findings from previous valuation studies conducted at one or more sites. When the unstudied site's characteristics (geographic location, habitat type, population makeup, etc.) are comparable to those of the studied locations, employ this strategy. An example of this would be the application

of the ecological production function in Southeast Florida studies, which connects fisheries and coral reefs in Caribbean regions.

## **2.5 The Values of Urban and Peri-urban Wetlands and Their Challenges**

Wetlands were once thought of as wastelands and regularly drained for farming and urban development. (Hopkinson, et al., 2013). In recent years, an increased understanding of the socio-ecological functions and values supplied by wetlands has emerged. Urban wetlands are particularly appreciated since they are situated in habitats where some of these functions are most needed.

The biological functions that wetlands perform in their natural state are vital to the country's economic and environmental health and cannot be replaced or would cost astronomically to do so. By lowering flood peaks and limiting the loss of life and property, wetlands offer a natural means of controlling flooding. They also enhance water quality by removing pollutants such as heavy metals, excess fertilizers, and waterborne sediments (Jamshaid, et al., 2018). By slowing down the erosive forces of flowing water, wetlands preserve the quality of surface waters (APS, 2002).

### **2.5.1 Urban Wetlands and Recreational and Cultural Values**

Wetlands provide numerous possibilities for recreation in the outdoors (Jingbo, et al., 2020). The case for protecting wetlands may be made based on the economic advantages of wetland leisure activities. The wetlands' numerous recreational activities include hiking, swimming, animal viewing, and fishing (Moeltner & Woodward, 2008). People who go to wetlands for recreational purposes notice and highly value these natural resources, especially because these activities cannot be easily replaced by other forms of relaxation (Alikhani, et al., 2021). Therefore, the advantages of leisure may serve as a stronger incentive for individuals to preserve wetland habitats (Ye, et al., 2016).

Large, biodiverse, or reasonably intact ecosystems are the focus of the majority of conservation activities across the world, with urban areas receiving less attention (Chiesura, 2004). Growing urbanization has been accompanied by an increase in the separation between city residents and the environment. This disconnection from nature is thought to be a factor in the mental disorders

that are currently the main cause of impairments in middle- and high-income nations (Keniger, et al., 2013).

The reliance on environmental interactions necessary for existence, such as hunting and fishing, has vanished as more people migrate into towns and cities. People deliberately seek out environmental connections as a substitute for entertainment and leisure (Dallimer, et al., 2012). Wetlands, for example, which offer possibilities for engaging with the natural environment are frequently highly desired because cities are stressful places (Bolund & Hunhammar, 1999). The benefits of this relationship for physical health, psychological wellness, cognitive capacity, and social cohesiveness make it essential for health and welfare (Dallimer, et al., 2012). Urban environments with green areas may enrich a city's visual and cultural characteristics. In addition, these places sometimes provide inhabitants with their sole chance to engage with nature (Bolund & Hunhammar, 1999).

Living adjacent to or around green areas is vital for urban residents because the presence of natural assets like wetlands, parks, forests, and green belts improves the quality of life (Chiesura, 2004). There is growing evidence that early exposure to nature may alter views towards it later in life and that spending time in outdoors with kids boosts their self-confidence and mental health (Keniger, et al., 2013).

Residents have access to green space in towns and cities thanks to urban wetlands. Urban wetlands frequently offer chances for hobbies like bird watching in addition to being aesthetically pleasant. They provide residents of the area the chance to witness 'wild' creatures that they may not otherwise see. Urban wetlands also give locals a place to engage in leisure activities like walking, jogging, and dog walking.

### **2.5.2 Urban Wetland and Economic Value**

Aspects of ecosystems that are consumed or used to promote human well-being are called ecosystem services. To emphasize the non-market value of natural facilities, the idea of ecosystem services emerged from the study of ecological economics and was formalized around 20 years ago (Costanza, et al., 1998). In essence, the idea acknowledges the significance of natural ecosystems for human survival and aims to provide a set of instruments that will allow for the cautious and comprehensive management of natural resources.

Early research concluded that the value of ecosystem services for the entire global biosphere ranged from \$16 to 54 trillion USD per year, with an average of USD 33 trillion annually (in 1994 currency) (Costanza, et al.,1998). In 1994, the global GNP was around USD 18 trillion annually. Although there are still obstacles to implementation, there is growing interest in using ecosystem services analysis to promote improved development planning in Southeast Asia (Ro, et al., 2019).

There has been a lot of interest in measuring the many ecological services that wetlands provide (Georgiou, Turner, & Fisher, 2012).

### **2.5.3 Urban Wetlands and Urban Heat Islands**

Urbanization and the rise in human activity have altered land use, land cover, and hydrological cycles in recent decades. The metropolitan Heat Island (UHI) effect, which is the result of an increase in metropolitan temperature, hurts the microclimate of urban regions (Bidabadi, et al., 2019). One of the well-known consequences of the present climate change is this impact (Deilami, et al., 2017). When an urban region is much warmer than its surroundings, the UHI effect is evident (Bidabadi, et al., 2019). The change in the kind of land surface use is what causes the UHI impact (Li, et al., 2015). Natural landscapes are replaced by man-made surfaces, which may store more heat that is gradually released at night (Xue, et al., 2018).

UHIs have an impact on urban regions' energy use, environmental quality, and population health (Xue, et al., 2018). To coordinate development initiatives to improve people's well-being, urban planners and politicians have been increasingly interested in the connection between land use and urban climate (Gunawardena, et al., 2017). In this spirit, research communities, strategists, and urban planners have realized the natural and eco-friendly cooling impact of GBI as a solution (Wu, et al., 2018).

Nevertheless, even though water bodies, including urban wetlands, have a cooling impact, their research has lagged behind that of other green places like forests and parks (Gaoyuan, et al., 2020). Indeed, urban wetlands are regions within or next to cities that provide a range of advantages and ecosystem services, including the ability to significantly reduce UHI impacts on urban areas and provide a cooling effect (CE) to nearby areas (Xue Z. , et al., 2019).

## **2.5.4 Urban Wetlands and Biodiversity**

In addition to providing food and shelter, wetlands are essential habitats for fish and other species during the breeding, spawning, nesting, and wintering seasons. These include species that are important for trade and leisure, endangered species, and migratory birds. It is imperative to comprehend wetlands as an intricately linked element of the hydrologic system (APS, 2002). A community may need to spend more on drinking water treatment, storm water management, and flood control infrastructure if its wetland services are lost. Similar to this, when wetland services are reduced, residents may also experience higher flood insurance premiums, lower property values, and fewer recreational opportunities.

Different biological systems called wetlands improve water quality and store carbon (Mallick & Chakraborty, 2018). Wetlands are home to a wide range of creatures, including mammals and microorganisms, and are significant providers of biodiversity (Eppink, et al., 2004). These species include mammals like beavers and amphibians, birds, insects, reptiles and they are particularly well-suited to aquatic environments (Verones, et al., 2013). Indeed, wetlands contribute to increased biodiversity in urban environments by acting as networks of fragmented habitats that facilitate animal movement within their ecosystems (Hassall, 2014).

Wetlands as habitats have sadly been broken up by urbanization and the growth of urban areas. Indeed, the habitat is harmed by the fragmentation of wetlands, which has become a significant concern in urban settings (Hale, et al., 2019). Wetlands continue to be crucial and extremely useful for animal species, even though fragmentation is a danger to their continued survival (Mayer-Pinto, et al., 2017). Consequently, recognizing the value of wetlands, protecting them, and maybe improving their connectivity with one another will greatly aid in the conservation of biodiversity in urban areas (Soanes, et al., 2018).

When compared to the situation of having no wetlands at all or having fewer of them, conserving even wetlands that are deemed to be of inferior quality (in terms of reduced biodiversity) and polluted (in terms of water quality) offers several benefits (Goertzen & Suhling, 2013). This is because poor habitats can be crucial in maintaining connections between healthy areas when urban wetlands are fragmented. In this sense, a network of sub-optimal habitats can sustain more biodiversity at the landscape level (Hale, et al., 2019).

**Table 2.2:** Urban Wetland Ecosystem Services

No	Domain	Services
1	Water security	Wetlands control groundwater recharge and water quantity.
2	Flood & drought regulation	Wetlands work as a kind of natural sponge, soaking up extra water and reducing floods and the harmful effects of storms and droughts. This factor gradually lessens socio-economic harm to urban assets
3	Historical, scientific, recreational & cultural values	Wetlands have a significant role in the values connected to history, religion, archaeology, and human evolution in many different civilizations. They serve as leisure locations for a variety of interesting activities
4	Climate change adaptation	Wetland soil aids in the long-term carbon sequestration that facilitates climate change adaption
5	Biodiversity	Because of their special placement between water and land, freshwater and saltwater, wetlands are one of the most productive environments and shelter a broad variety of biodiversity
6	Fertile land	Wetlands are crucial food sources because they promote nutrient cycling and pest control (such as rice paddy systems and the related bio-diversity). Additionally, they enable the gathering of papyrus, reeds, and several fish species with substantial economic value
7	Pollution filters	Wetlands serve as filters for pollutants, enhancing the quality of the water
8	Resilience to storms	Wetlands prevent soil erosion and sediment movement, which increases storm resilience and aids in the development of new land

*(Source – PalArch’s journals of the archaeology of Egypt, 2021)*

## 2.6 Urban Wetland Challenges

Since 1900, 64% of the world's wetlands have vanished, and even more are lost in some areas, such as Asia and Africa because wetlands and their advantages are being lost, that's why urban wetlands are vanishing more quickly than coastal ones (WWTC, 2018). Urbanization, industry, transportation, forestry plantations, and agriculture have been the most significant global sources of wetland loss among the many harmful human activities (Xu, et al., 2019).

Wetlands are impacted by urbanization in a variety of direct and indirect ways. For instance, it has been observed that building affects wetlands by directly causing habitat loss, adding more

suspended particles, changing the hydrology, and altering the water quality (Darnell, 1976). Wetlands can be altered more through indirect effects, such as eutrophication, sedimentation, and changes in hydrology, than by direct effects, such as filling and drainage (Keddy, 1983). Wetlands may be impacted by urbanization on several different levels, including the landscape (loss of large areas), the wetland complex (drainage or modification of some of the units in a group of closely spaced wetlands), and the individual wetland (modification or fragmentation) (Weller, 1988).

Numerous factors, including biogeochemistry, ecology, and physical characteristics, can be impacted by climate change in wetlands. At some point, modifications to one or more of these elements may have an impact on the others. Johnson et al. (2005) estimated in research at Northern Prairie wetlands that these wetlands may dry up in the future as a result of global warming, which might diminish the habitat of the waterfowls that were an integrated part of this ecosystem. One of the anthropogenic factors that often threatens the survival of wetlands worldwide is land use change. Reclamation of wetlands for agricultural, urbanization, and other economic reasons, excessive use of wetland resources, disruption of biodiversity, and many other actions can all result in changes to land use (Bhowmik, 2020). According to Hemond & Benoit (1988), organic matter from surface runoff and external sewage effluent flow can alter BOD and COD levels in wetlands. This has the potential to significantly alter the wetland's biogeochemistry, which could have detrimental effects on the biotic communities that are there.

## **2.7 Mapping and Parameters of Delineating Wetlands**

Wetland mapping is the process of identifying wetlands on the ground by identifying the types of wetlands present as well as their boundaries, it is generated by combining secondary resources such as soil data, flood maps, types of plants that can live in wetlands, and surface water maps with remote Sensing Imagery (Kusler, 2011). Wetland mapping science now has access to more advanced GIS tools and remotely sensed imagery with ever-increasing spatial, temporal, and spectral resolution thanks to technical advancements in GIS and remote sensing (Wu Q. , 2017).

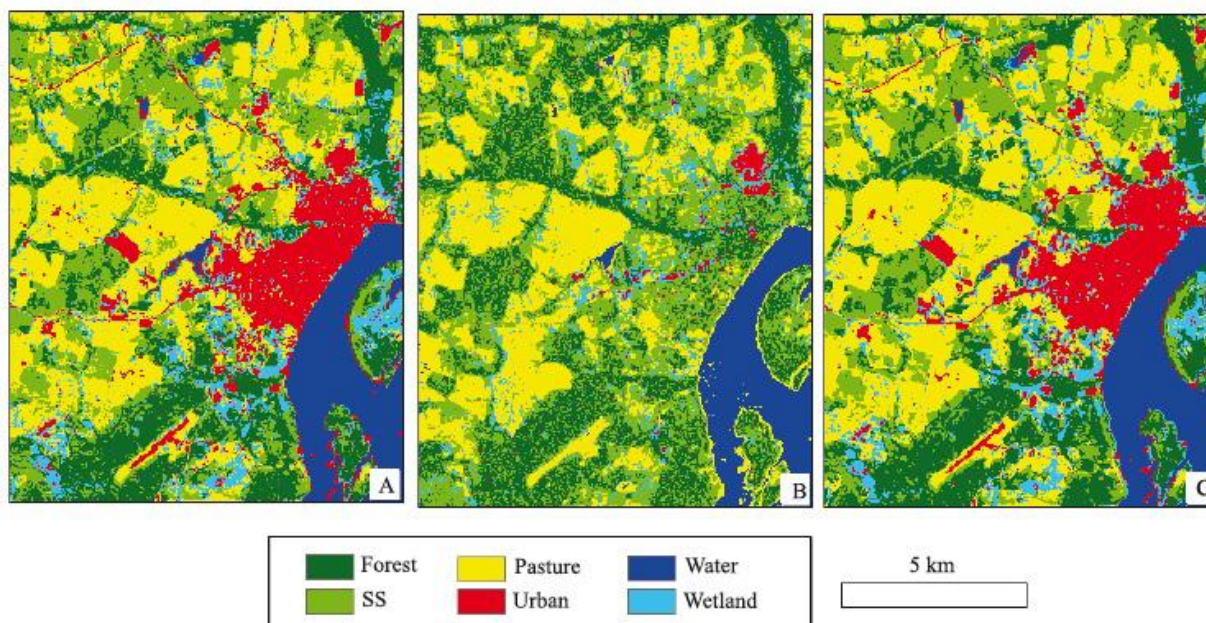


Figure 2.3 Remote Sensing Imagery (Source - Land use/cover classification in the Brazilian Amazon using satellite images, 2017)

Ethiopia's wetlands' abundance and distribution remain unknown due to variations in how they are classified or defined. Wetland indicators including hydrology, vegetation, soil types, and topographic position combined with GIS and remote sensing tools can make it easier to identify and map wetland boundaries.

**Table 2.3:** Characteristics of wetlands

Characteristics of wetlands			
No.	Wetland hydrology	Hydrological vegetation	Hydric soil
1	Waterlogged ground – saturation within 12 inches of surface	Specialized tissues (aerenchyma) that is spongy and transports air from the leaves and stems to the roots	Excessive moisture
2	Visible mud or dry mud cracks	Floating leaves	Gleied coloring below the surface or the major color of soil is dark and dull
3	Watermarks on trees or grasses	Adapted to anaerobic soils	A predominance of decomposed organic matter
4		Buttressed trunks	Rotten egg odor
5		Shallow root system	

(Source - Britney Webster, 2020)

Wetland mapping capabilities have increased because of the use of GIS and remote sensing, especially in developing nations like Ethiopia use this mechanism as a mapping tool for those types of futures. But large-scale wetland mapping and monitoring could be greatly improved by recent improvements in the quality and availability of high-resolution LiDAR, SAR, UAS, hyperspectral, and multispectral data, as well as the advent of multi-sensor and multi-scale data fusion approaches (Wu Q. , 2017).

## **2.8 The Main Legal Tools for Protecting Urban Wetlands**

Wetland resources are open to claims from a wide range of user groups. Competition between different people, sectoral interests or administrations, and across political boundaries emerge for ownership of or access to wetlands, their products, or the land on which wetlands are located. In contrast, the absence of clear policies may be demonstrated by poorly defined goals, disjointed actions, or a lack of awareness of wetland issues even among decision-makers. Institutional weaknesses, such as administrative overlaps or a gap in operations, might make this worse (Klemm, 1999).

The 1994 Ethiopian Constitution, which has a broad environmental scope and identifies the environmental values to be safeguarded and protected, was the first step in incorporating environmental concerns into the supreme law of the land. The rights of Ethiopian citizens to a clean and healthy environment are outlined in Articles 44 and 92. According to the Constitution, both the government and the people have a responsibility to conserve the environment, and projects and programs should not be created or carried out in a way that endangers the environment.

There are still some crucial environmental management and protection tools lacking. A strategic land use plan is one of them. The biggest danger to wetlands is frequent land use planning and legislation. As a result, there might be less available land, which would put pressure on wetlands as a potential source of additional land. There is currently no national explicit coordinated policy for wetlands in Ethiopia (no national Wetlands Policy), despite growing interest in them. Instead, wetlands have held a cross-sectoral position in the frequently incoherent policy of several government bodies (Bekele, 2011). For example, wetlands are mentioned only briefly in the Ethiopian Water Sector Strategy of the Ministry of Water Resources (later the Ministry of Water, Irrigation and Energy) in 2002 when it comes to "*carry out appropriate drainage*

*works on all wetlands" and "reclaim existing wetlands, and prevent the formation of the new ones." (MoWR, 2001)''.*

The Ethiopian National Conservation Strategy was developed by the Environmental Protection Authority, which was established in 1995. As part of this strategy, the EPA incorporated the need to protect and restore wetlands to preserve water resources and, when necessary, to carry out environmental impact assessments of development projects (EPA, 1997).

Ramsar, Iran, hosted the adoption of the Convention on Wetlands of International Importance, Particularly as Waterfowl Habitat on February 2, 1971. Almost thirty years after it was initially globally enforceable, it remains the only environmental agreement that specifically addresses the requirements of a particular kind of ecosystem (Klemm, 1999). On 11th Meeting of the Conference of the Parties to the Convention on Wetlands, Four policy proposals and five practical principles serve as key signals that all levels of government - from the national to the local - should take into account and put into practice when creating laws that address both urban planning and management and the sensible use of wetlands:

*Policy principle 1: The breadth of services that wetlands offer makes them vital components of the infrastructure that supports urban and peri-urban settlements.*

*Policy principle 2: Urban and peri-urban regions that are socially and environmentally sustainable benefit from the prudent use of wetlands.*

*Policy principle 3: Urban development and management practices should prevent future deterioration or loss of wetlands. If this is not feasible, impacts should be reduced and any remaining effects suitably countered by initiatives like wetland restoration.*

*Policy principle 4: Sustainable urban and peri-urban settlements depend on the full engagement of local and indigenous communities, municipalities, and government sectors in wetland management and urban and peri-urban spatial planning decision-making.*

*Policy principle 5: Government priorities and coordinated efforts to increase disaster resilience are necessary in light of the threat posed by both natural and man-made disasters, as well as the effects they have on wetlands and urban populations.*

*Practical Principle 1: Wetland conservation*

*i) Wetlands should be protected at all costs during urban development.*

*Practical principle 2: Wetland restoration and creation*

- i) Wetland formation and/or restoration should be included in urban infrastructure, particularly water management infrastructure, to preserve or enhance ecological character and optimize the provision of ecosystem services.*
- ii) It makes sense to give chances to restore wetlands precedence over those to build new ones. Wetlands shall only be established in conjunction with economic and social initiatives that include the benefits of ecosystems, and in compliance with the regulations of each Contracting Party, provided that no alternative course of action is feasible.*

*Practical principle 3: Understanding the value of wetland*

- i) Examining ways to reduce urban poverty by maximizing the benefits of sustainably utilized wetland ecosystem services in compliance with wise use principles is crucial.*
- ii) When considering livelihood possibilities and the distribution of economic advantages, trade-offs between the market and the state must be considered.*
- iii) Incentives such as payment for environmental services should be employed both inside and outside of urban environments to protect wetlands.*
- iv) To make wise decisions, urban planners must have a solid understanding of the advantages of wetlands. It is critical that the effects of wetland loss and degradation be specifically taken into account when planning urban areas.*

*Practical principle 4: Stakeholder engagement*

- i) Urban development and wetland management should be based on the principles of inclusivity, local population empowerment, and involvement.*
- ii) The governance of urban development and wetland management has to involve all pertinent stakeholders and be decentralized to the greatest extent feasible.*

*Practical principle 5: Integrated planning*

- i) A vital strategy for preserving wetlands and the ecological benefits they offer, both inside and outside of cities, is thematic planning.*
- ii) Wetland considerations must be appropriately included into other spatial planning elements (e.g., water resource management, transportation infrastructure development, fuel supply, agriculture production, and Integrated River Basin Management, as adopted under Resolution X.19).*
- iii) To prevent wetlands and other natural habitats from being lost or harmed, alternative areas for planned urban developments—both official and informal built development—must be found.*

## **2.9 Stakeholders' assessment in wetland protections**

According to (Eco-Tech, 2009) some of the potential stockholders which is involving in an approach to integrate urban wetlands into urban land use planning are: -

**Districts:** The districts carry out decentralized environmental protection and management operations on the recommendation of committees in charge of environmental protection. Wetland is a crucial resource for the districts, and the districts must participate in its management for conservation.

**Developers:** The project's developer is directly responsible for it and is required to give all pertinent information about it throughout the EIA process. At public hearings, developers consult with professionals who conduct EIA studies on their behalf and respond to inquiries regarding potential effects and suggested mitigation measures. The environmental management plan, which includes the mitigation measures recommended in the EIA report, must be implemented by developers, and they are also responsible for carrying out any necessary environmental monitoring and auditing.

**EIA Experts:** Professionals who have registered with REMA to conduct impact studies are EIA specialists. They support the developer in carrying out EIA, creating plans for environmental management and monitoring, and preparing EIA reports.

**Lead Agencies:** The management and protection of environmental resources, public health, and socioeconomic development are under the control of leading organizations such as government ministries or departments. The EIA of projects falling under their sectors is the responsibility of the lead authorities. They participate in the review process and offer essential technical information to EIA professionals during EIA studies. Government organizations such as MINELA, MINAGRI, MINALOC, etc. are important lead organizations in wetlands.

Developing a wise use wetlands management plan for Ethiopia might be spearheaded by a few institutions that have already been working on wetlands-related projects for some time. These are:

- Ethiopian Wildlife Conservation Organization (EWCO): wetland distribution, preliminary mapping, and gathering information, protected area management;

- Ethiopian Wildlife and Natural History Society (EWNHS): wetland birds, identification of wetland Important Bird Areas (IBAs), and promoting the research and management of threatened species;
- Ethiopian Wetlands Research Project (EWRP): Indigenous knowledge, sustainable management, socio-economic processes, equity/gender, and cultural values;
- Environmental Protection Authority (EPA): environmental policy, conservation strategies, and Environmental Impact Assessment (EIA) procedures;
- Institute for Biodiversity Conservation Research (IBCR): biodiversity conservation in Ethiopian Rift Valley Lakes;
- Addis Ababa University: amongst others, limnological studies, wetland biodiversity, and social studies.

The Public: Participation in the EIA process is a legal right for communities. A consensus may be reached on the nature and sufficiency of suggested mitigation measures and recommendations thanks to public participation, which also enables the identification of significant social and environmental issues. The public's involvement in the EIA process involves offering suggestions and information to the studies throughout the scoping and public hearing phases. The general public offers project developers and REMA suggestions on methods to prevent, reduce, or make up for negative environmental impacts.

International Funding Organizations: EIA is a requirement of all international funding agencies, especially for projects with potentially large implications.

Academic Institutions: EIA Technical Committees frequently co-opt members from academic institutions. Additionally, they incorporate environmental education throughout their curricula. Training institutions should include wetland management instruction in their curricula to help students build their capability and awareness for managing wetlands and other natural resources. Academic institutions working with REMA could create training modules for both wetland management and EIA as well as implement training programs.

## **2.10 The impact of urban land use change on wetlands**

Several studies assessed the value of ecosystem services lost as a result of changes in land use (Liu, et al., 2012). Some of this research calculated how LULC will affect the values of the services provided by forests (Balthazar, et al., 2015). Others calculated the reduction in several terrestrial ecosystem services brought on by LULC dynamics (Song, et al., 2015). It has also been shown that LULC has an impact on the ecological services that wetlands supply (Zhao, et al., 2004). Some of these research findings demonstrated how LULC modification has a detrimental impact on ecosystem services (Zhang, et al., 2015). Reports from a select few others demonstrated increased ecosystem service values as a result of LULC (Badamfirooz & Mousazadeh, 2019). Even though this research shed light on how the LULC altered the values of ecosystem services, the majority of them were carried out in certain geographical areas (South East and East Asia). In Africa, especially Ethiopia, the economic gains or losses of ecosystem services related to LULC are not well evaluated. Few research has determined how LULC would affect ecosystem services (Kindu, et al., 2016). However, the focus of these investigations was a micro-watershed in a rural environment or a forest ecosystem. There is insufficient discussion of how LULC as a result of urban growth affects ecological services.

For the past two or more decades, urban areas have significantly increased in size in Ethiopia (Terfa, et al., 2019). The growing urbanization has a significant impact on ecological services. It changes the hydrology, water quality, and connectivity of wetlands, which reduces biodiversity (Ehrenfeld, 2000). Few research has been conducted in the past about the growth of Bahir Dar City and its effects on LULC. (Admasu, et al., 2020). Performed research in Bahir Dar City on the ecological services provided by expropriated land. The three land-use types—cropland, agroforestry, and grassland—that are endangered by the growth of Bahir Dar City were the major focus of this study. In addition, they only relied on expert opinions and community perceptions to assess the ecological services of the expropriated land use categories. The value of ecosystem services was not defined, and the wetland ecosystem services that are endangered by city growth were not addressed. On the LULC of Bahir Dar City and the underlying variables for its LULC dynamics, two further investigations were also carried out (Haregeweyn, et al., 2012). However, the focus of this research was not on the effect of LULC on ecosystem services or the values of ecosystem services lost or gained as a result of LULC. Furthermore, they included

wetlands with other land cover groups including forests, rangelands, and water in their LULC categorization rather than treating wetlands individually. Research and development programs that pay scant attention to wetland ecosystem services that are given to urban areas contribute to their underestimation. The key to wetlands' sustainable use and management in urban and peri-urban areas is to educate users, planners, and decision-makers about their advantages (McInnes R. , 2013). Putting a value on wetland ecosystem services can assist decision-makers become more aware of their importance (Costanza, et al., 1997).

## 2.11 Summary of the Literature Review and Identified Research Gaps

A total 46 items; 28 from article journals, 4 books, 4 websites, and 10 reports have been reviewed for this review. All of the carefully reviewed resources are available in soft copies.

### 2.11.1 Summary of the Literature Review

**Table 2.4:** Summary of the literature reviews

<b>A. Summary on wetland delineation</b>	
<b>Author and date</b>	<b>Conclusions</b>
(Kusler, 2011)	Wetland mapping is the process of identifying wetlands on the ground by identifying the types of wetlands present as well as their boundaries
(Wu Q. , 2017)	Wetland mapping science now has access to more advanced GIS tools and remotely sensed imagery
<b>B. Summary on regulatory, social-economic, and recreational function of wetlands</b>	
(Odgaard, et al., 2016)	Wetlands serve as natural resources in sustainable urban environments and offer a variety of ecosystem services, including boosting biodiversity, enhancing water quality, and reducing climate change
(Gaoyuan, et al., 2020)	water bodies, including urban wetlands, have a cooling impact
(Moeltner & Woodward, 2008)	The wetlands' numerous recreational activities include hiking, swimming, animal viewing, and fishing
<b>C. Summary on challenges wetlands face to function sustainably in urban landscapes</b>	
(Davidson, 2014)	Urbanization, however, has put wetlands in danger by destroying and shifting the land use from GBI to residential or industrial structures
Johnson et al. (2005)	wetlands may dry up in the future as a result of global warming
(Bhowmik, 2020)	One of the anthropogenic factors that often threatens the survival of wetlands worldwide is land use change

(Source: Organized by the author, 2024)

### **2.11.2 Identified Research Gaps**

Most of the literature reviewed concluded that urban wetlands are threatened worldwide. Pollution, urbanization, climate change, lack of awareness, and land use land cover change are some of the reasons mentioned in the literature review for preventing these wetlands from providing proper services to the community. The majority of evaluated literature has employed mixed research methodologies, which is the most effective way to address these kinds of problems. In light of their increasing significance in the sector, particularly for the identification of wetlands, several literary works have also made use of technologies like satellite imagery and GIS.

Identification in coastal and surrounding wetlands has been experienced in many studies. However, a major gap found in the literature review was that the identification of wetlands was based only on coastal areas; That is, it does not include the small wetlands in the center of the city that are surrounded by dry land. By showing the social, environmental, and economic value of these places to the community with figures supported by numbers and studying the barriers that prevent them from providing appropriate services; filling the research gap in this area is the main objective of this study.

## **CHAPTER THREE**

### **3. RESEARCH METHODOLOGY**

#### **3.1 Introduction**

The methodology used for this study is explained in this chapter. This chapter covers every step in carrying out this research, including the geographical area, study design, description of the population and sample, and population and sample size. The chapter concludes with a detailed discussion of the form of analysis that are chosen and the procedure employed to acquire the data.

#### **3.2 Description of the study area**

##### **3.2.1 Location of the study area**

The study focuses mostly on the wetland areas of Bahir Dar City. Bahir Dar is the capital of Amhara National Regional State. The absolute location of Bahir Dar City is 11°30'26" N to 11°39'34" N latitude and 37° 16'36" E to 37° 29'17" E longitude. Regarding the relative location, Bahir Dar City is one of the largest cities in the northern part of the country, which is away 500 km from the capital of Addis Ababa. Its average elevation is 1830 meters above sea level and it is situated in the northwest highlands of Ethiopia.

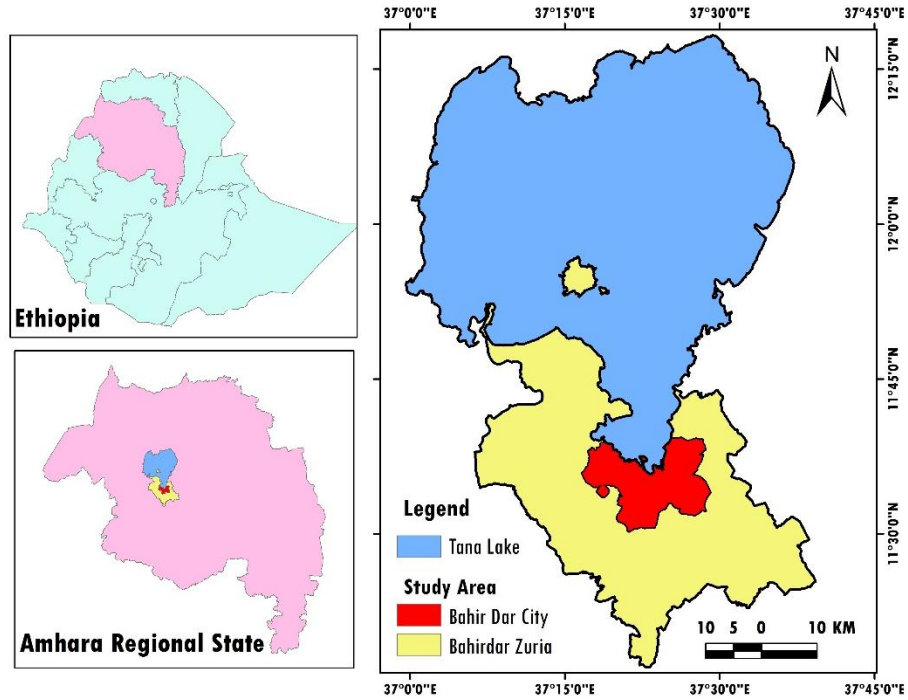


Figure 3.1: Map of the study area (Source: organized by the author, 2024)

### 3.2.2 Biophysical background of the study area

Apart from minor height rises in the eastern and western peripheries, the city's topography is flat, with hardly any slope gradient. Bahir Dar belongs to the Woina-Dega climatic condition according to the condensed traditional agro-climatic categorization system. ‘‘The city's average annual rainfall was 1445 mm, with 84–90% of the total falling between June and September. The average annual ambient temperature of the city is between 15 and 21°C’’ (Addisu, et al., 2015).

### 3.2.3 A Brief History

Around the fourteenth century, Saint Kidane Miheret Church was founded in the current location of St. Giorgis Church, serving as the historical center of Bahir Dar City (Seyoum, 2012). However, before the Italian invasion, it was a small community (Seyoum, 2012).

During the Italian occupation (1928–1933), the village was transformed into a contemporary township. During this time, the town was an important military base for expeditions operating in the region. Soon after the Italians left, in 1948, Bahir Dar was selected to be the capital of Awuraja. The town had a significant transformation in the 1960s and 1970s, and in 1987 it was designated as the West Gojjam Province capital. It swiftly expanded into four rural kebele

administrations adjacent to the main metropolitan region after being selected in 1993 as the administrative seat of the Amhara National Regional State (Adam, 2014). The CSA predicted that Bahir Dar City's total population would exceed 396,000 in 2017 (PHCCCSA, 2012).

The Amhara National Regional State's political and economic center is currently located in the city. Its natural attractions, like as the Blue Nile Falls, birds, and hippos, as well as its rich cultural heritage, which includes the Lake Tana Monasteries, make it one of the most popular travel destinations in the country. Since the city is located on the Lake Tana beach and riverbank of Abay, it has lacustrine and riverine wetlands within its peri-urban kebele administrations (Wondie, 2018). The city is also well known for its wide boulevards that are lined with palm trees and a variety of colorful flora. For addressing the issues brought on by increased urbanization, it was awarded the UNESCO Cities for Peace Prize in 2002 (UNESCO, 2022).

### **3.2.4 Socio-economic background of the respondents**

Bahir Dar has a population of 455,901 in 2022, with a population density of 2,136 people per km<sup>2</sup> (ESS, 2023). The city's main economic sectors include agriculture, agro-industrial processing, urban agriculture, manufacturing, and service businesses (Ayehu, 2015). The city is known for its tourist attractions, such as Lake Tana and the Blue Nile River. Bahir Dar has a large weekly market and a few music venues, and the city council maintains a sense of separation of powers and checks and balance (FDRE, 2023). The city is divided into nine sub-towns, each with wetland areas. The study focuses on the way to caste, the smaller groups living in the city, as they are closer to wetlands in their daily activities.



Figure 3.2: Woyto tribe (Source: [www.hornofafrica.org](http://www.hornofafrica.org), 2010)

A caste known as the weyto lives in northern Ethiopia's Amhara area near Lake Tana (Appelhans, 2016 ). They today reside in Bahir Dar, Abirgha, Dembia, and Alefa and worship the Nile River (Sköld, 2011). The Waytos relied heavily on Lake Tana for their subsistence; they used to fish and kill hippopotamuses and they were independently structured and distributed their catch evenly (Freeman, 2003). The religion of the Waytos was centered on water, and "Abinas" was the God of the Blue Nile who supplied wealth and well-being. In exchange, the populace offered Abinas animal sacrifices. The Wayto have adopted Islam while maintaining their devotion to the Nile (Sköld, 2011). Most of them live at a low economic level and it is believed by the community that they have a significant role in the development of the city and the preservation of the local culture.

### **3.3 Research Approach and Research Design**

Assessing urban wetland monitoring for sustainable urban planning is the use of data to evaluate or appraise wetlands to support decision-making and planning processes by systematic observation and recording of current and changing conditions. The study has been undertaken in an explanatory approach where assess urban wetland monitoring for sustainable urban planning has been explained in a detailed manner.

This research also uses mix of quantitative and qualitative approaches, so that it involves the generation of quantitative data and undertakes quantitative analysis of them. The quantitative approach is equally important to identify wetlands and explore the function of wetlands that serve for the community. The qualitative approach also has been used to find out the primary challenges that wetlands face in the town. This approach helps to make the study complete in assisting in gaining the desired output of explaining the conditions.

Study design, in general, refers to a framework for organizing and carrying out specific research. The research's most significant component is its design, which incorporates all four major factors: the strategy, the conceptual framework, deciding who and what to study, and the methods and tools to be used for data collection and analysis (Punch, 1998).

In general, there are various sorts of research designs, such as qualitative research and quantitative research. (Holmes, 2005). The researcher combined both qualitative and quantitative research methods in this study.

The researcher used qualitative data sources interviews, observations, media and communication, and documents. To examine social and cultural phenomena, researchers can use the qualitative research method, which entails observing people's feelings, thoughts, behaviors, and worldviews (Babu, 2008). Case study research, grounded theory, and action research are a few examples of qualitative techniques. Observation and participation observation are examples of qualitative data sources (fieldwork), as are interviews and surveys, documents and texts, as well as the researcher's feelings and impressions (Babu, 2008).

This research also followed a quantitative approach. Quantitative research is a rigorous, impartial procedure that looks at cause-and-effect linkages and other interactions between variables (Burns & Grove, 2005). Descriptive, explanatory, and exploratory research can all be conducted using surveys. The researcher employed a descriptive survey design and used quantitative data sources of land use/cover data used in GIS analysis and spatial modeling.

The survey questionnaires were prepared and conducted for two main viewpoints, the first one is to explain the extent of wetland functions for the community which is located on the boundary of Woyto tribe. The second one is to find out the level of stakeholder engagement in the sustainable use of wetlands. Both open-ended and close-ended questionnaires are used in the research. The morphological and environmental aspects of the research have been studied using detailed site observation and satellite imagery processing. After data collection was completed, data encoding and processing took place using Envi-Met simulation and Arc GIS. Then, the data were analyzed using descriptive statistical methods supported by graphs and maps. Generally, the research has been undertaken in an orderly and sequential manner starting from the problem statement to the conclusion and recommendations according to the following diagram.

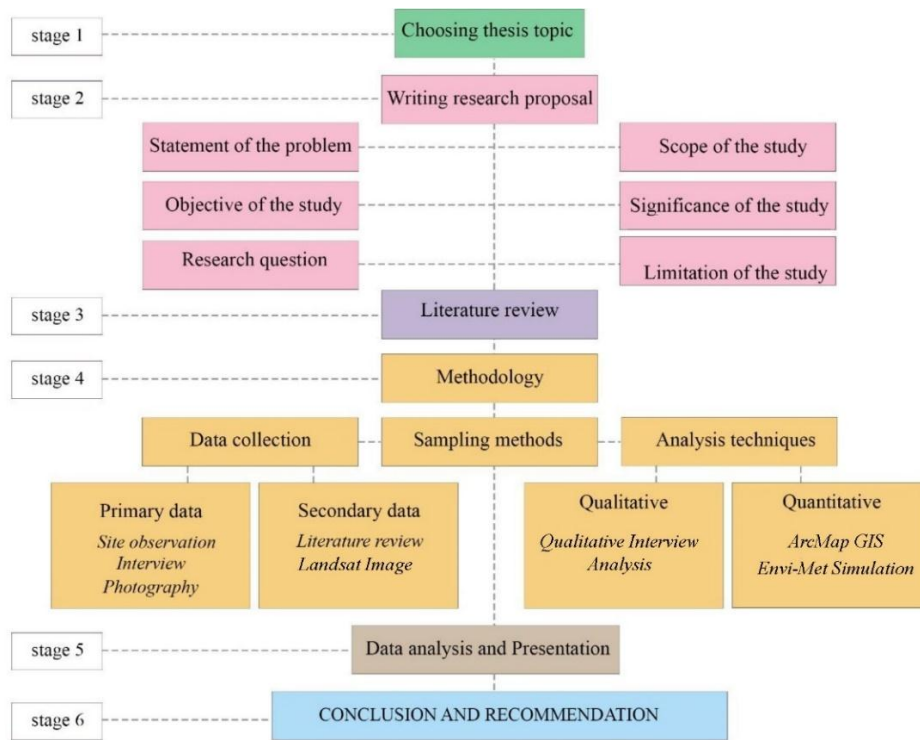


Figure 3.3: Diagram of research design (Source: organized by the author, 2014)

### 3.4 Research Methods

The approach used to conduct research is known as research methods. It includes resources and methods for carrying out specific investigations or making discoveries. The term "research method" refers to a variety of instruments used for various sorts of inquiries. (Walliman, 2017). Therefore, it is crucial to use a precise approach that is appropriate for the research's goal.

Some research techniques for gathering data include experiments, focus groups, interviews, observation, and archive research. However, a survey would be more appropriate for this thesis to locate and define wetlands as well as to gauge the extent of the community's benefit from them. The primary survey instruments used in this study were questionnaires and interviews. In addition to the self-administered closed-ended questions, a small number of open-ended questions were included in the questionnaires to elicit other unlisted concerns.

Stakeholder interviews were frequently used to determine the challenges that the city's wetlands must overcome to continue providing benefits to the local population. Descriptive analysis has been used to detect wetland areas using land satellite imagery and GIS. Also, a qualitative

description was employed to examine the difficulties. Lastly, contextual analyses of the active legal documents were conducted.

### **3.5 Justification for the Research Methods**

Mixed-method research has the potential to yield more thorough insights into research questions and enhance the validity and dependability of research findings through the utilization of complementary strengths, triangulation, flexibility, increased response rates, and a wider reach (Kuhn, 2023). A few different mixed research approaches have been used in this study, all of which have their roots in these arguments. Survey research has involved gathering a lot of data from a population. This kind of survey research's main objective was to swiftly and efficiently gather data characterizing a big sample of people of interest. (Ponto, 2015).

Finally, detailed descriptive statistics with the help of contextual review have been employed to identify and evaluate wetland functions. A strategy used to find out specifics about why something happens is called explanatory research. It can act as a springboard for more in-depth research. Understanding this kind of research can help you identify the underlying reason for a certain circumstance and fill in any knowledge gaps (Indeed , 2023).

### **3.6 Data Types and Sources**

In this study, primary and secondary data were also employed. The study's primary data are an essential component. Respondents who are Woyto tribe members are the primary data sources. Other sources of primary data include the working databases, which include base maps. Official websites such as Google Earth and USGS are also the source of primary data, such as satellite maps.

Secondary data are just as significant. For example, reports about urban wetlands that have been gathered from the Bahir Dar city urban and infrastructure office and other stakeholders who are close to wetlands include proclamations, policies, strategies, regulations, and manuals.

### 3.7 Data Collection Methods

Different data types and collecting techniques are employed by the researcher based on the research objectives. As previously stated, the researcher employed both qualitative and quantitative research techniques, and thus the research used a mixed approach.

To achieve the first research goal of this study, which is to identify the principal wetland areas of Bahir-Dar and its environs using primary data from Landsat imagery. This data analysis was very useful for depicting the magnitude and particular location of wetlands. Furthermore, physical observations were used to collect and validate data in connection to soil type, vegetation cover, and hydrological content in the surrounding area.

The second research objective of this study is to evaluate the regulatory, socio-economic, and recreational functions of the wetlands in the area, in this case, the study quantitative data of remote sensing data from Landsat images to demonstrate the relationship of urban wetlands with the local climate and qualitative data of secondary source of data from sub-cities to find out how many citizens are economically benefited in their district using wetland features an interview and questionnaire, especially with people who were commonly known as “Woyto” community to determine the impact and function of urban wetlands on recreational, economic and urban cultural preservation are gathered. To collect the sociocultural benefits of the wetlands the research takes into consideration a survey questionnaire with the Weyto community. Although the study covers the whole area and the surrounding communities of Bahir Dar city, the Weyto community are the smaller groups in the city that live together and are closer to wetlands and their day-to-day activity and livelihood is highly dependent on these wetland resources. Because of this, the questionnaires of the study are focused on these community classes. In total, 678 household settled on 4.8 hectares of land in the community of Woyto. To compute the economic, environmental, and recreational values of the wetlands the research obtained the main data from the wetland cover maps showing the temporal dynamics of the resource, concerned government and nongovernmental organization reports, and expertise interviews, observation, and key informants interview.

The third research objective of this study is to identify the primary challenges wetlands face to function sustainably in the urban landscapes of Bahir-Dar city. In this part, the main data is

obtained from the wetland maps generated from geospatial image processing. Besides, an interview and questionnaire survey are carried out to find out the views of closely related governmental and non-governmental institutions and stakeholders on the factors that affect wetlands to provide sustainable benefits to the city inhabitants. As secondary data sources, documents and proclamations related to urban wetlands specially to identify the gap related to legal frameworks.

In addition, to determine the wetlands' ecological/ environmental, and recreational significance as well as the main obstacles they face in the Bahir-Dar City landscape, some of the quantitative data are gathered from governmental and non-governmental organizations and other stakeholders that are closely related to the issue, including; -

- Bahir Dar city urban plan preparation and management bureau
- Urban Planning Institute
- Nile Basin Authority
- Bahir Dar City and Infrastructure Department
- Lake Tana and other water bodies protection and development agency
- Bahir Dar City Water and Sewer Office
- Bahir Dar city administration cleaning and beauty office
- Bahir Dar City Administration Culture, Tourism, and Sports Department
- Amhara Region Environment and Forest Protection Bureau
- Ethiopian Biodiversity Institute

### **3.8 Population of the Study and Sample Size**

The population of the research was communities that lived in Woyto tribes. To select the sample from the total population, the number of the population in the compound was collected from the Tana sub-city administration office. Based on this, the total samples from the total population have been decided.

#### **3.8.1 Sample Size and Techniques**

According to the data of Bahr Dar City Administration, Tana sub-city, there are 520 large families settled on 4.8 hectares of land in the community of Woyto. Of these, 43 families live

together with three households, 97 families live together with two households, and the remaining 380 families have one household. There are a total of 678 households in 520 large families. According to the sub-city information, there are about 3127 estimated residents in these 678 households. It is believed that 60% of this total population is of working age and engaged in direct employment. As the study aims to identify the environmental, social, and economic value of wetlands to the community; Based on this information, the researcher focused on 60% (working age and directly engaged) or 1900 members of the community and conducted the study.

Because it is impossible to survey every member of the population due to money or time, the study was able to look at the needs and conditions of the community by taking a statistical sample. The researcher used Slovin's Formula to determine a sample size.

$n = N / (1 + N (e)^2)$  ... Equation (1): Slovin's Formula (Simplified formula of proportion equation)

Where n is sample size, N is number of population size and e is the level of precision.

The sample size was computed as follows;

$$n = 1900 / (1 + 1900 (0.05)^2) = 330$$

After the sample size of the population was identified, Stratified sampling was undertaken to select each respondent to precise conclusions by ensuring that every subgroup was properly represented in the sample by dividing the respondents into gender subgroups (strata). Accordingly, 50% of the study participants are women and the remaining 50% are men. Additionally, formal and informal interviews and questionnaires were conducted with 50 respondents from ten different institutions on the factors that prevent wetlands from providing sustainable benefits to the city and their importance.

### **3.9 Data Analysis Methods**

The study makes use of both quantitative and qualitative data analyses. To analyze the quantitative data, geospatial modeling and statistical tools are used. For qualitative data analysis, narration, description, and discussions of the data obtained from interviews, document review, and observations are used.

For the first objective of the study, Remote sensing data from Landsat images to delineate wetland features of the area are analyzed using a Geographical information system (GIS) environment; that helps to identify and map the wetland areas in the study area and to measure the area covers. Then, the study uses descriptions and photographs to visualize the compassions of the ecosystem and to confirm wetland regions that were outlined using a GIS tool showing their typical soil, plant, and hydrological volume.

For the second objective, the study selected two wetlands representing all others in terms of the size of the area feasible to assess the ecosystem functions. Thus, the selected wetlands are taken as a case study area to calculate the ecosystem value. The specific place taken here is Kebele 8, locally known as the Gambi area. The two selected case study wetlands are Sent Merry and the old radio station neighborhood area. The wetland's ecological, socioeconomic, and recreational values are computed.

To compute the ecological or environmental value, in this work, the ecosystem service values (ESVs) of various LULC modifications were estimated using the benefit transfer approach. If site-specific valuation data is unavailable, the benefit transfer approach involves estimating the equivalent site values (ESVs) of other comparable places based on information already available from the original study site (Haregeweyn, et al., 2012). Using data provided by (Kindu, et al., 2016), the researcher adjusted tropical area coefficients on regional estimates of ESVs to determine the ESVs of the LULC types in the Mariam Sefer Wetland area, who used cautious estimations of ESV coefficients, based on values from studies conducted in places close to the geographical context of our study area, to conduct a study on LULC and ESVs in Ethiopia.

The three primary ESs—supply, regulation/monitoring, and provision—are included in these ESVs (Kindu, et al., 2016) and using the most recent global coefficients as well provided by (Costanza, et al., 1997). Therefore, the following Equation was used to determine the ESVs for all LULC types for each period (Costanza, et al., 1997).

$$ESV = \sum_{k=0}^n Ak(Vck)$$

Where ESV is the estimated ecosystem service value,  $A_k$  is the area (ha) of LULC type  $k$ , and  $V_{Ck}$  is the value coefficient (Appendix V) in US\$  $ha^{-1} year^{-1}$  for LULC type  $k$ .

The study estimated the ESVs on the current study based on the coefficients used in various studies in the tropical regions because all ESV estimations are based on studies from the study area itself or locations from the same biome, but not necessarily from the same topographic settings.

Then to measure the cultural socioeconomic value of the wetlands questionnaire survey data collected from different stakeholders and the community group is evaluated with some descriptive statistics and frequency distribution tables. And secondary source of data from sub-cities is to find out how many citizens are economically benefited in their district using wetland features and to identify wetlands' recreational and cultural value.

For the third objective of the study, discourse analysis is conducted from data obtained from stockholders in the form of interviews and questionnaire surveys, which could be analyzed with description statistics and frequency tables. And thorough description, narration, and discussions of the results obtained from documents and proclamations to identify the primary challenges wetlands face to function sustainably in urban and peri-urban landscapes of Bahir Dar city.

### 3.9.1. Descriptive Statistics Analysis

In general, descriptive statistics are particular techniques that are employed to efficiently, logically, and meaningfully compute, characterize, and summarize research data that has been gathered. In the manuscript text, tables, and/or figures, descriptive data are presented quantitatively or graphically (Vetter, 2017).

The gathered data for this study have been enumerated, arranged, and visually displayed using the percentage coverage. The investigation that was done produced conclusions about the ecological roles of wetland habitats. To identify and define wetland regions and assess their ecological function, this research predominantly uses descriptive statistical analysis.

### **3.9.2. Qualitative data analysis**

The process of organizing, evaluating, and interpreting non-numeric, conceptual data, and user feedback to identify themes and patterns and respond to research questions.

Comprehensive contextual assessments of the crucial urban wetland documents have been conducted using the qualitative approach. Proclamations regarding wetlands were among the papers examined. In addition to this, a qualitative statement was made through in-depth discussions with the stakeholders to identify the reasons that hinder them from providing the ecological services that wetlands should provide.

### **3.10 Method of data presentation**

The process of employing different graphical forms to visually express the relationship between two or more data sets so that an informed choice may be made based on them is known as data presentation (Vedantu Blog, 2020). The fundamental information in data is typically captured in a raw manner, making it challenging to analyze. Thus, it is necessary to summarize, process, and evaluate raw data. No matter how skillfully managed, the data-derived material must still be presented engagingly in order to be useful to both authors and readers.

To simplify and clarify the research findings, the researcher employed tables and graphs (pictorial presentations of data). Because there are many different ways to show data in a tabular or pictorial format, from computer printouts to intricate pictographs. However, the goal of any table or graph is to simplify and communicate the significance of the data. Although the researcher employed several predefined forms for data presentation in tables or graphs to improve presentational efficiency. In this study, visual representations such as bar charts, pie charts, curve diagrams, pictograms, and others are employed.

### 3.11 Summary of the Research Methodology

**Table 3.1:** Summary of research methodology

Research Questions	Data and variables needed to be answered in the research question	Methods of analysis used to answer the question	Purpose of findings
What are the major wetland areas of Bahir-Dar city?	Remote sensing data from Landsat images and site observation	ArcMap GIS and Envi-Met simulation analysis	Identify the major wetland areas of Bahir-Dar city and the surrounding
What are the major regulatory and recreational functions of wetlands in the urban and peri-urban landscape?	Remote sensing data from Landsat images and interviews with stockholders	Descriptive analysis and qualitative description	Quantify the major regulatory and recreational function of wetlands in the urban landscape
What are the primary challenges wetlands face to function sustainably in urban and peri-urban landscapes of the study area?	Interview with stockholders	Descriptive analysis and qualitative description	Identify the primary challenges wetlands face to function sustainably in urban landscapes of the study area

(Source – organized by the author, 2024)

# CHAPTER FOUR

## 4. RESULT AND DISCUSSION

### 4.1 Introduction

This chapter is presented with research findings and discussions following the methods described above. Accordingly, the location and size of wetlands in the city have been carefully examined. The section also presented the environmental, social, and economic benefits of the urban wetlands provided to the community, and the major challenges the wetlands faced. In this regard, the next four subsections provide the results and the discussions that go along with them.

### 4.2. Description of the Respondents

#### 4.2.1. Socioeconomic Characteristics of the Respondents

Survey questions were used to gather and explain data on age, gender, occupation, monthly income per household, and family size to assess and explain the socioeconomic position of the study's primary respondents. Participants in this study range in age from those over 18 to those under 50 (those who are actively working). As a result, 42% of them are between the ages of 18 to 27; 35% are between the ages of 28 to 37; and 23% are between the ages of 38 to 50. The following graph shows the data that were gathered.

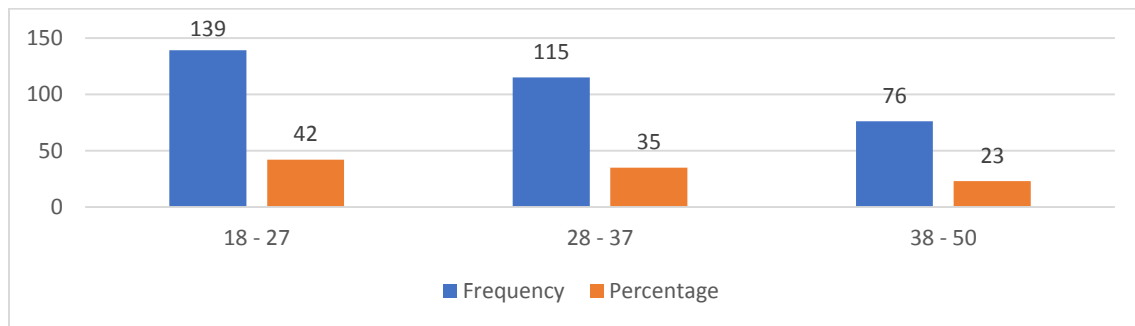


Figure 4.1: Graph of age group ratio of the participants (Sources: Organized by the author, 2024)  
Out of the 330 participants in the research, 50% of them are male and 50% of them are female, according to the survey results.

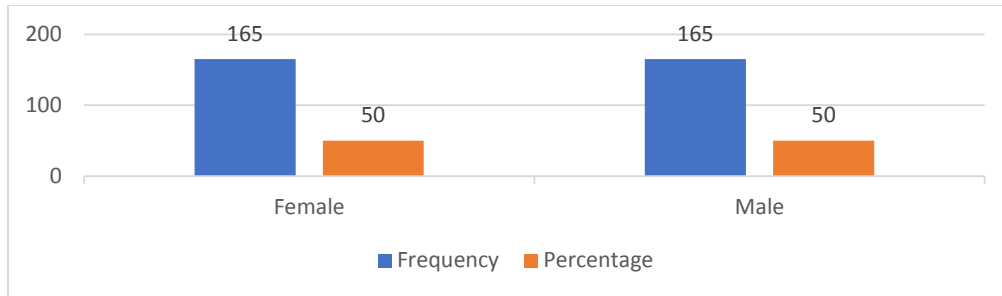


Figure 4.2: Graph of the gender ratio of the participants (Sources: Organized by the author, 2024)

The participants' jobs and sources of income make up the other socioeconomic variable; 53% of participants' sources of income are related to urban wetlands; 24% of the sample are private workers; government employees account for 6% whereas 17% of them are unemployed or students.

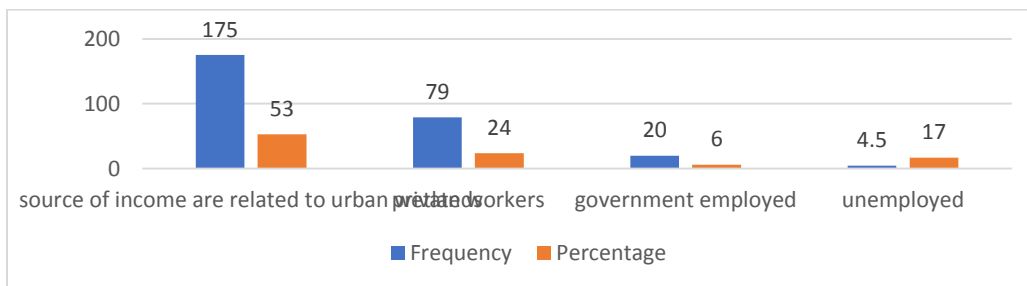


Figure 4.3: Graph of sources of income (Sources: Organized by the author, 2024)

According to the collected data, 18% of the participants are categorized under poor economic status by earning less than 2000 Ethiopian birr/month. Whereas, 72% are labeled as low income by earning 2,000-4,000 birr/month. The middle-income earners account for 6% by earning 4,000-6,000 birr monthly. The upper middle income and the high incomers that earn more than 6,000 birr monthly accounts for only 4% according to the category of CSA, (2007).

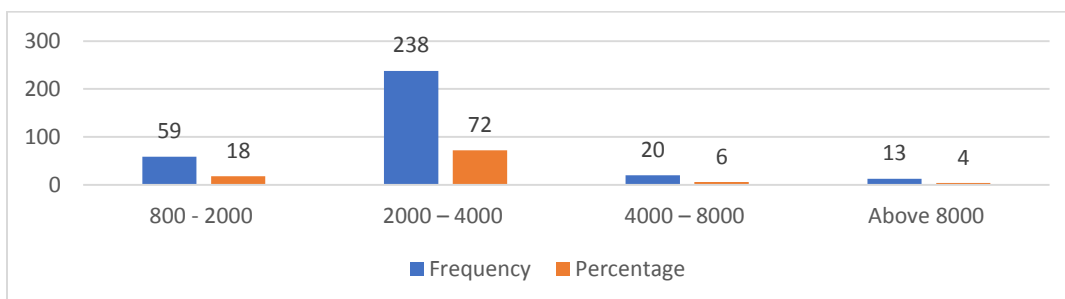


Figure 4.4: Graph of the monthly income of the participants (Sources: Organized by the author, 2024)

The family size of the participants in the research ranges from two individuals to households with more than 6 individuals and the average family size of the households is 4. Households with

a family size of 2 accounts for 6% of the participants; households with a family size of 3 accounts for 10% of the participants; households with a family size of 4 accounts for 24% of the participants; households with a family size of 5 accounts for 34% of the participants and participants with 6 members and more than it also covers 26%.

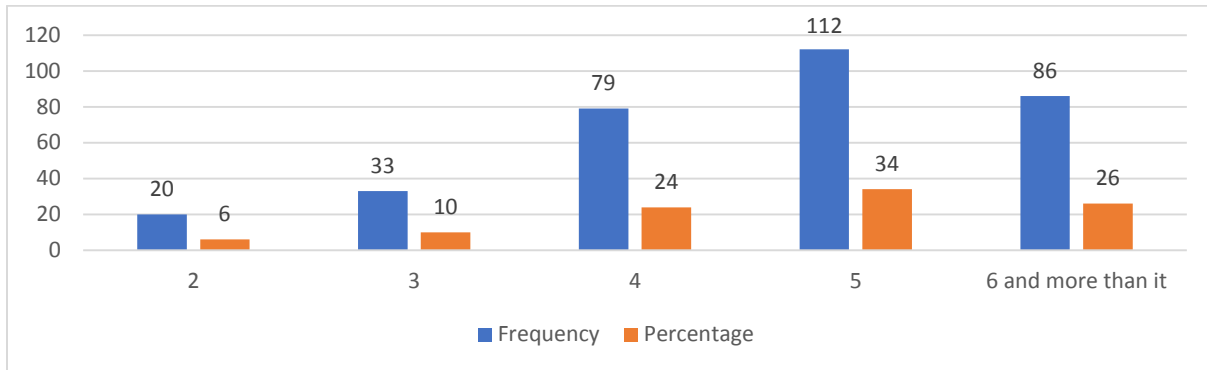


Figure 4.5: Graph of Family Size (Sources: Organized by the author, 2024)

#### 4.2.2. Qualitative Data

Open-ended questions are included in the survey's second section to collect respondents' opinions about the advantages of the wetlands that support them. To ensure the accuracy of the data gathered and the study, the open-ended question section also attempts to identify the challenges that wetland faces.

#### 4.3 Mapping the Major Wetlands and their status

Compared to the county's urban centers, the study area is widely known for having a substantial amount of wetland resources. According to the findings of the GIS-based analysis, about 20 wetlands are identified in the city and each of these wetlands has a different size. Among them, the smallest wetland area is 3.3 hectares of land, which is located a bit far away from Lake Tana and Abay River. The largest one is found on the coast of Abay, which occupies 198.2 hectares of land. These wetlands in the city cover a total area of 1016.3 hectares, and 45% of them are located on the coastal area of the Tana or Nile River, and the remaining 55% of them are surrounded by dry lands in the city center. The wetlands that exist in the coastal part of Tana and Abay are perennial, while the wetlands surrounded by dry lands fluctuate seasonally. They shrink in size during the dry season they become relatively wider in the wet season. The map of the wetland environment of the Bahir Dar city is presented is visualized in figure 4.6.

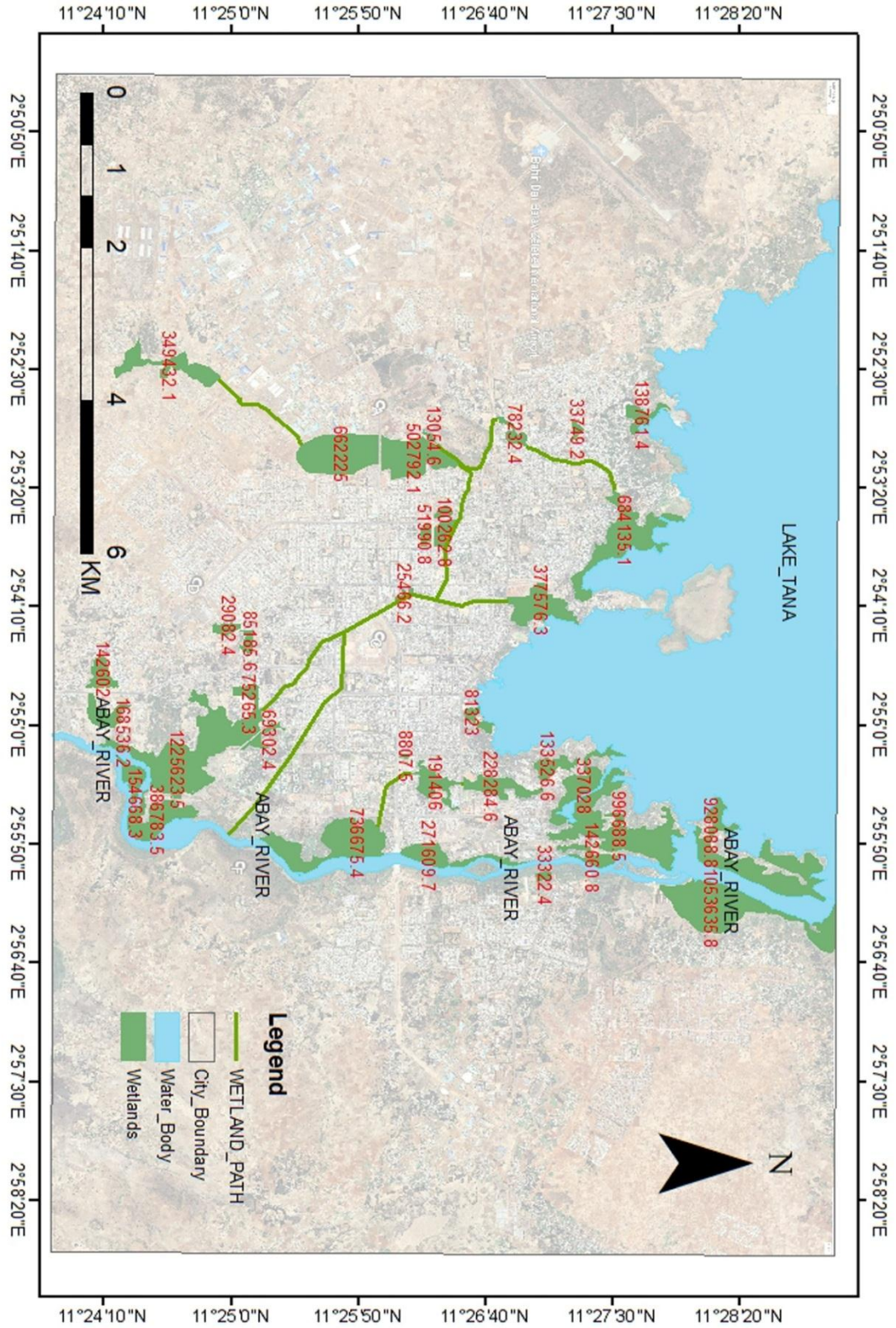


Figure 4.6: The wetlands configurations identified in the study area (source: organized by the author, 2024)

### 4.3.1 Features of the particular wetlands and their surrounding environments each

To see the specific characteristics of the wetlands and their surroundings, the study expands to include individual wetlands. The characteristics of each unique wetland area are evaluated using figures depicting the surrounding areas' environmental components. The following sub-section describes these particular wetlands.

#### Wetland area I

It is one of the identified coastal wetlands in Bahir Dar City and it is located in the area of a unique local name called *Gedro*. In general, there are two large wetlands in the area, one of which surrounds *Debremariam* Church, and these adjacent wetland areas cover a total of 198.2 hectares. This wetland is not temporary and it is attractive and is known for being green year after year.

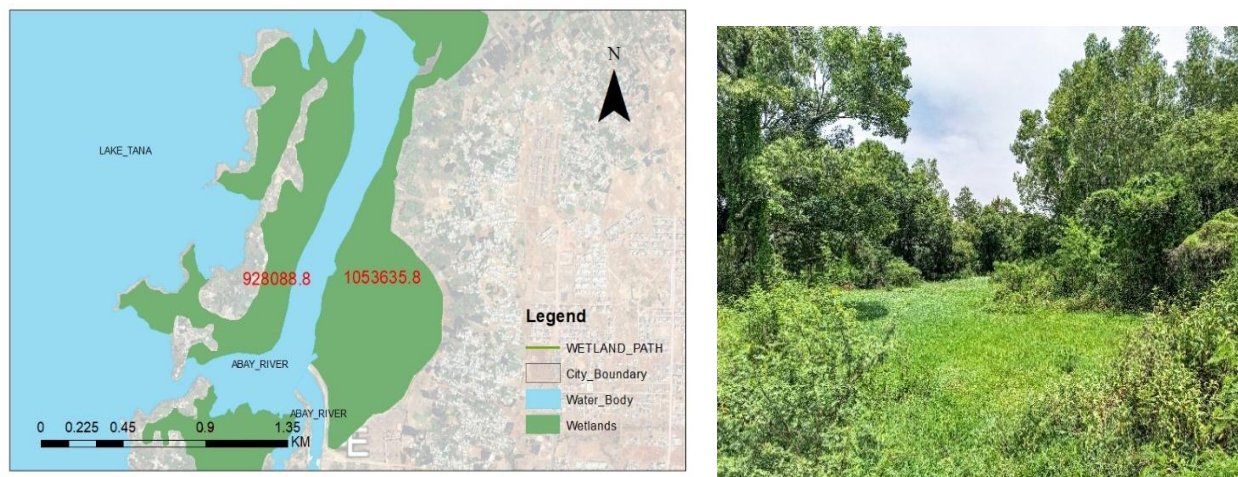


Figure 4.7: Map of Wetland Area I and current appearance (source: organized by the author, 2024)

#### Wetland area II

One of the famous wetlands in Bahr Dar city is located in an area called Abo Kebele 10. This coastal wetland, located between Abo Church and Tana Hotel, covers a total of 13.35 hectares of land. This wetland is non-temporary and visually attractive and is known for its greenness year after year.



Figure 4.8: Map of Wetland Area II and current appearance (source: organized by the author, 2024)

### Wetland area III

One of the wetlands in Bahir Dar city that is used as a summer sports venue is the field commonly known as Borborit. This wetland is located behind the headquarters of Amara Media Corporation in Keblee 13. Surrounded by dry land, this wetland covers a total area of 7.8 hectares. This wetland is seasonal and dries up in the summer, and since there are many residential areas in the area, it plays an important role in reducing the risk of flooding by holding water, especially in the winter.



Figure 4.9: Map of Wetland Area III and current appearance (source: organized by the author, 2024)

### Wetland area IV

One of the largest wetlands in Bahir Dar City is located in the area of the Nile River Bridge and covers 147.6 hectares. In addition to being a large area, as it is close to the Nile River Bridge and

the city center, it is possible to develop the area beyond its current use and make it a major tourist destination.



Figure 4.10: Map of Wetland Area IV and current appearance (source: organized by the author, 2024)

#### Wetland area V

One of the main wetlands in Bahir Dar city is located behind what is commonly known as Faki Sefer, between Abo and Bata Church, this coastal wetland covers a total area of 68.4 hectares. This wetland is located near Lake Tana and is a scenic spot.

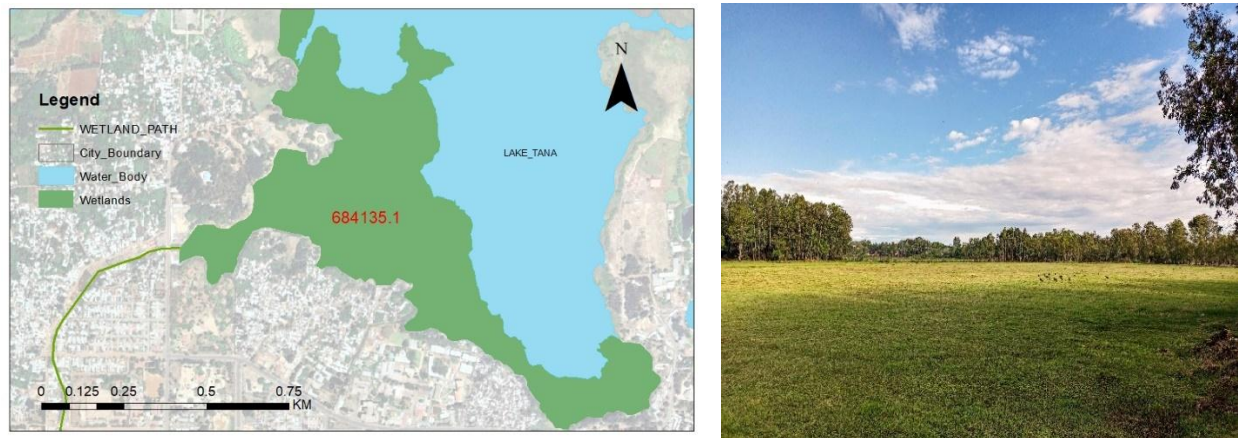


Figure 4.11: Map of Wetland area V and current appearance (source: organized by the author, 2024)

#### Wetland area VI

This wetland is located in the center of the city and is also known as Artikota (አርጢቆጣ). It is located between Giorgis Church and Lakeshore Hotel and covers a total of 8.1 hectares. Although it is located on the side of Lake Tana and is a very attractive place to see, it is filled with stones and used for various construction works.



Figure 4.12: Map of Wetland Area VI and current appearance (source: organized by the author, 2024)

### Wetland area VII

This wetland is located south of the city on the road leading to Addis Ababa and is also known as Gaja field (ጋጃ መስክ). It is located around Gordema Gabriel and covers a total of 11.4 hectares of land. The area is surrounded by dry land and is a seasonal wetland, making it a favorite sports venue for the local community during the summer months.



Figure 4.13: Map of Wetland Area VII and current appearance (source: organized by the author, 2024)

### Wetland area VIII

This wetland is located on the west side of the city on the road leading to Debre Markos and is also known as Gudo Bahar (ጉድ ባህር) or Garbas (ጋርባስ). It is located around Mount Dbanke (ደባንቄ ተራራ) and covers a total of 109.6 hectares of land. The area is surrounded by dry land and

seasonal wetlands, so it serves as a preferred sports venue and driver's training ground for the local community during the summer months.



Figure 4.14: Map of Wetland Area VIII and current appearance (source: organized by the author, 2024)

#### Wetland area IX

This wetland is located in an area commonly known as Nok, kebele 16. It is located around Kebele 16 mosques and covers a total of 2.5 hectares of land. The area is surrounded by dry land and is a seasonal wetland, so it serves as a preferred sports venue for the local community during the summer months.



Figure 4.15: Wetland area IX and current appearance (source: organized by the author, 2024)

#### Wetland area X

This wetland is located in an area commonly known as Gambi, Kebele 08 from the city center. It is located between the Selam Argiew Maryam and Gambi Hospital and covers a total of 19.1

hectares of land. Although the place is surrounded by dry land, it is not seasonal and is a swampy place from year to year, which makes it visually attractive and green.



Figure 4.16: Map of Wetland area X and current appearance (source: organized by the author, 2024)

#### Wetland area XI

It would not be an exaggeration to say that there are no more beautiful green spaces in the city. This wetland is located on the banks of the Nile River, next to the newly constructed Nile River Bridge. Covering a total of 73.6 hectares, this place has the same view year after year and its social and economic benefits are significant.

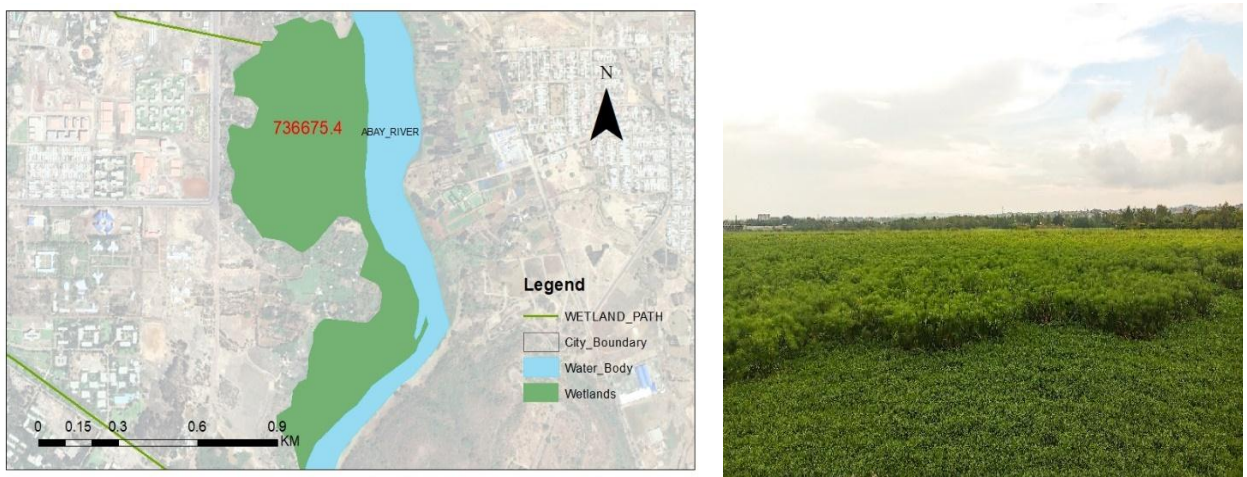


Figure 4.17: Map of Wetland area XI and current appearance (source: organized by the author, 2024)

#### Wetland area XII

One of the major wetlands in Bahir Dar city is located in an area known as Depo Keble 13. Located in the area of the old Ethiopian Defense Forces fuel depot, this coastal wetland covers a total of 37.7 hectares of land. This wetland is ephemeral and visually appealing and is known for its greenness year after year, but recently it has been filled with stones and is being used especially for the feast of Epiphany.

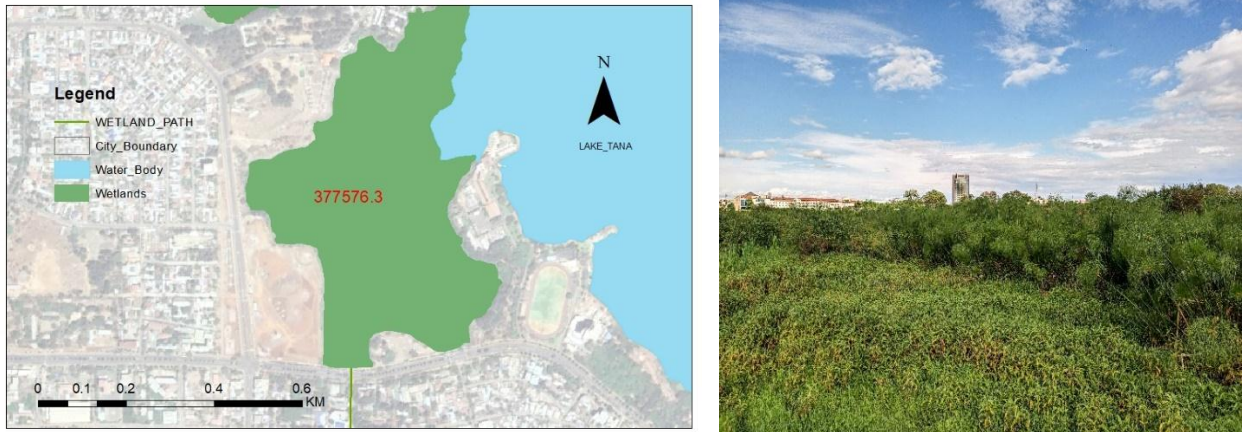


Figure 4.18: Map of Wetland Area XII and current appearance (source: organized by the author, 2024)

#### Wetland area XIII

One of the largest wetlands in the city of Bahr Dar is located in an area called Peda, located behind the Peda campus of Bahr Dar University, this coastal wetland covers a total of 191.1 hectares. This wetland is non-temporary and visually appealing and is located in five interconnected areas of varying widths.

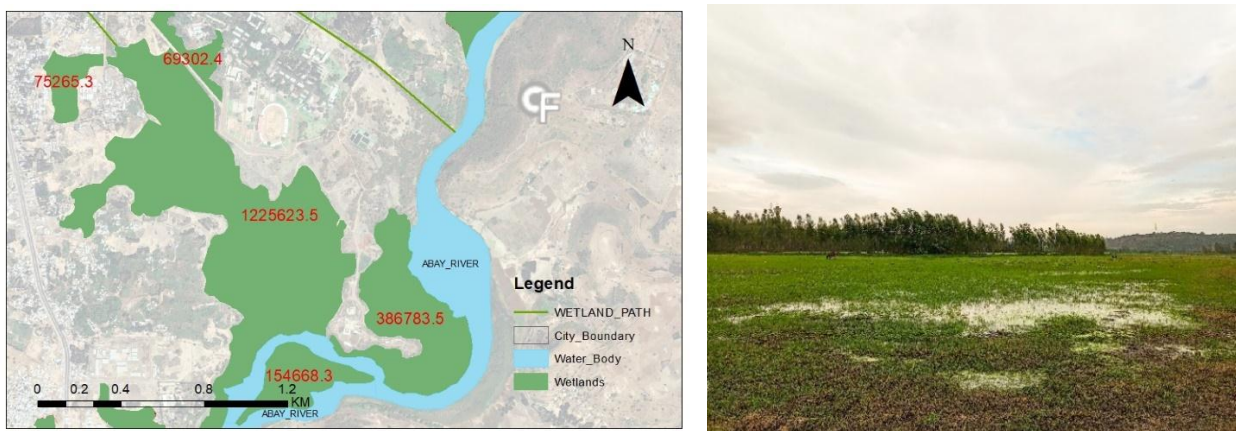


Figure 4.19: Map of Wetland Area XIII and current appearance (source: organized by the author, 2024)

#### Wetland area XIV

One of the wetlands known to most of the university students in Bahr Dar city is located in an area known as Poly. Located in the Poly campus of Bahr Dar University, this wetland is surrounded by dry land and covers a total area of 22.8 hectares. This wetland is not seasonal, it is attractive to look at and it is a green place year after year, but it is a place that is in danger especially due to the expansion of construction by the university.



Figure 4.20: Map of Wetland Area XIV and current appearance (source: organized by the author, 2024)

#### Wetland area XV

One of the wetlands in the Bahir Dar city is the summer sports grounds commonly known as the Old Radio Station. This wetland is located on the side of Tana Sub-district, Keble 16. Surrounded by dry land, this wetland covers a total of 18.6 hectares. This wetland is seasonal and dries up in summer, and as there are many residential areas in the area, it plays an important role in reducing the risk of flooding by holding water, especially in winter. It used to be one big wetland, but recently it has been divided into three due to the construction of a road.



Figure 4.21: Map of Wetland area XV and current appearance (source: organized by the author, 2024)

#### Wetland area XVI

One of the main wetlands identified in the study in Bahr Dar city is located in an area called Debre Tsge Qusquam Maryam Church, which is located on the road from Bahr Dar to Sebatamit City. This wetland surrounded by dry land covers a total area of 31.1 hectares. This wetland is seasonal and used for various sports during the summer.



Figure 4.22: Map of Wetland area XVI and current appearance (source: organized by the author, 2024)

#### Wetland area XVII

One of the main wetlands identified in the study in Bahir Dar city is located around Keble 13, behind the Catholic school, this wetland surrounded by dry land is the smallest of the ones identified in the study and covers a total of 3.3 hectares. This wetland is seasonal and is used as a

commercial area during the summer; This area, which is said to be large in area, has been reduced in size due to the informal settlements in the area.



Figure 4.23: Map of Wetland area XVII and current appearance (source: organized by the author, 2024)

#### Wetland area XVIII

This wetland is located on the west side of the city around Kebele 14. It is located in the industrial zone area and covers a total of 34.9 hectares of land. As the area is surrounded by dry land and is a seasonal wetland, it serves as a preferred sports ground for the local community in the summer months and is also used as a loose grazing land for livestock.

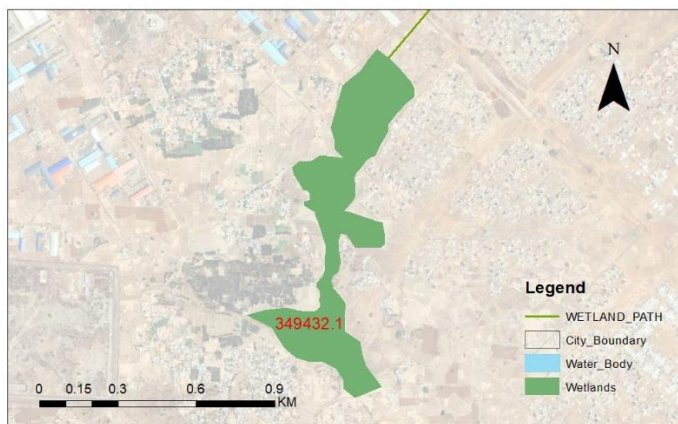


Figure 4.24: Map of Wetland area XVIII and current appearance (source: organized by the author, 2024)

## Wetland area XIX

This wetland is located outside the city center in an area commonly known as Woramit. It is located behind Woramit Impact Real Estate and covers a total of 13.8 hectares. The place is located on the coast of Lake Tana and is a marshy place year-round, making it visually attractive and green.

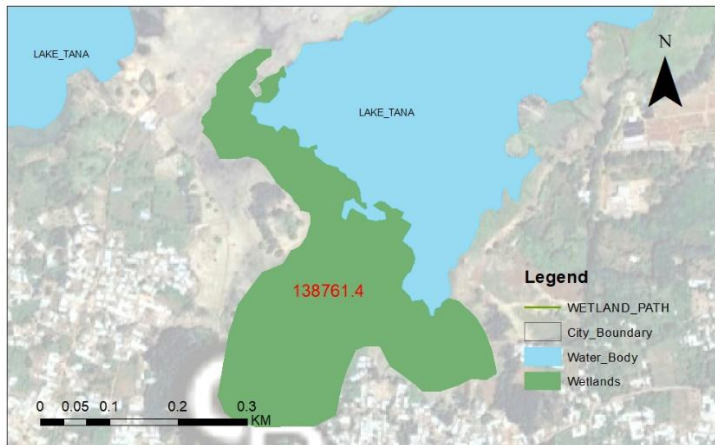


Figure 4.25: Map of Wetland area XIX and current appearance (source: organized by the author, 2024)

## Wetland area XX

One of the wetlands located in the city and identified in the study is located in the area called Keble 11 Semahtat Memorial. Located between the Semahtat Memorial and the current Abay Bridge, this wetland, surrounded by dry land but close to the coast, covers a total of 3.3 hectares of land. This wetland is relatively small, non-seasonal, and visually appealing, known for its year-round greenery.



Figure 4.26: Wetland area XX current appearance (source: organized by the author, 2024)

### 4.3.2 The size and seasonal characteristics of the wetlands

As indicated in detail above, there are about 20 wetlands in total, and the size, condition, and type of land they occupy are shown in the table below.

**Table 4.1:** Size, condition, and type of wetlands

No.	Name	Type	size (hectare)	Condition	
				Seasonal	Non-seasonal
1	Wetland area I	Costal	198.2		✓
2	Wetland area II	Costal	13.35		✓
3	Wetland area III	Non-coastal	7.8	✓	
4	Wetland area IV	Costal	147.6		✓
5	Wetland area V	Costal	68.4		✓
6	Wetland area VI	Costal	8.1		✓
7	Wetland area VII	Non-coastal	11.4	✓	
8	Wetland area VIII	Non-coastal	109.6	✓	
9	Wetland area IX	Non-coastal	2.5	✓	
10	Wetland area X	Non-coastal	19.1		✓
11	Wetland area XI	Costal	73.6		✓
12	Wetland area XII	Costal	37.7		✓
13	Wetland area XIII	Costal	191.1		✓
14	Wetland area XIV	Non-coastal	22.8		✓
15	Wetland area XV	Non-coastal	18.6	✓	
16	Wetland area XVI	Non-coastal	31.1	✓	
17	Wetland area XVII	Non-coastal	3.3	✓	
18	Wetland area XVIII	Non-coastal	34.9	✓	
19	Wetland area XIX	Costal	13.8		✓
20	Wetland area XX	Non-coastal	3.3		✓

(Source: organized by the author, 2024)

Interestingly, as shown in figure 4.27, most of these wetlands that are identified in this study are connected to each other by thin marshy canals with flowing water. If these canals can be systematically protected and developed; besides adding to the attractiveness of the area, they can be alternative waterways for transportation. In addition to this, it is known that Bahr Dar city is among the cities that are affected by floods in winter. According to NDRMC, (2020), Dega Damot and Bahir Dar Zuria districts from the West Gojjam Zone of the Amhara National Regional State were designated as flood risk zones during rainy seasons. If these wetlands can be

protected, they will play an important role in reducing the risk of flooding.



Figure 4.27: wetland locations in the city (source: organized by the author, 2024)

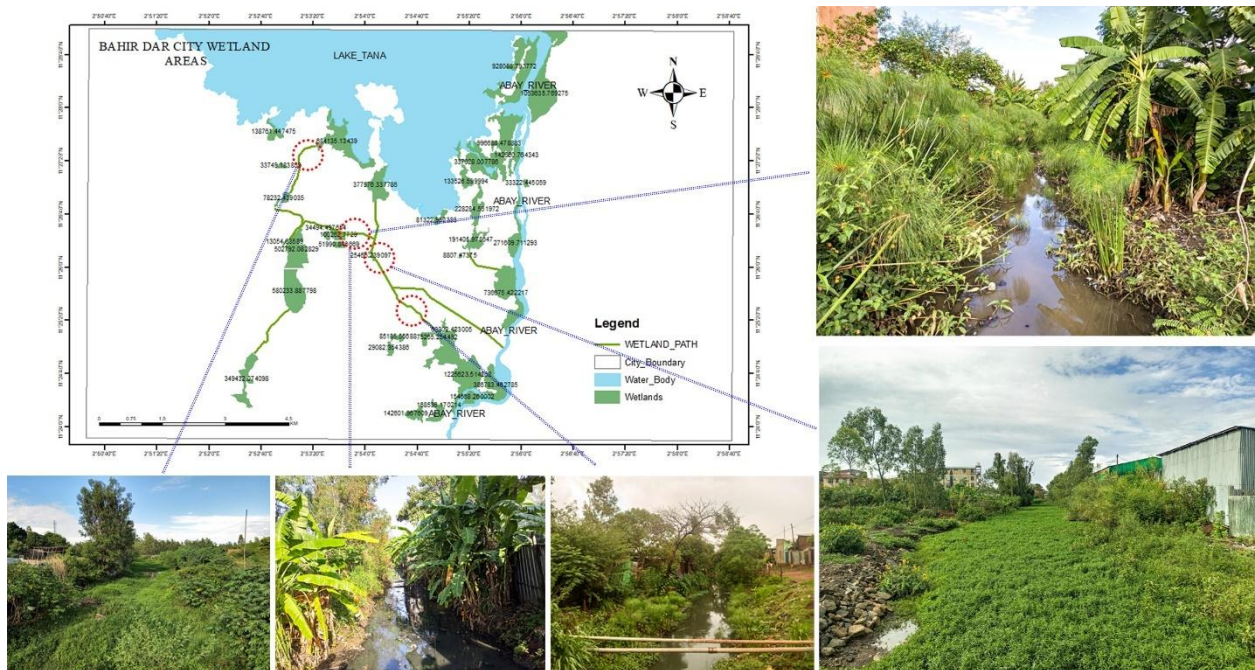


Figure 4.28: Marshy canals (source: organized by the author, 2024)

## 4.4 Functions of Wetland in the urban landscapes

Based on the questionnaires that the researcher conducted with the community regarding the environmental, cultural, and economic importance of wetlands, the researcher found the information below.

### 4.4.1 Ecosystem service value in terms of money

As it is stated in the methods section, to measure the main ecosystem services, the study takes into consider only the selected wetlands as a case study area. The wetland that is used for calculating the ecosystem value is the specific place locally known as Gambi, which is found in Kebele 8 when it is evaluated in its change through time, it covered 28.75 hectares of land in 2005, but in the same month of 2023, its area has decreased to 20.02 hectares. If this scenario is continued the future trend will lead to loss of this precious resource. Based on this assessment just after 18 years, about 8.73 hectares of wetlands will be lost. Unless some intervention mechanisms are introduced the ecosystem will be totally lost in less than 50 years.

The ESVs in the current study decreased to 19759.74 US\$ ha<sup>-1</sup> year<sup>-1</sup> in 2023 from 28376.25 US\$ ha<sup>-1</sup> year<sup>-1</sup> in 2005. According to the research, ESVs in the 8.73ha study region had decreased by 8,616.51 US\$ ha<sup>-1</sup> year<sup>-1</sup> over the previous 18 years.

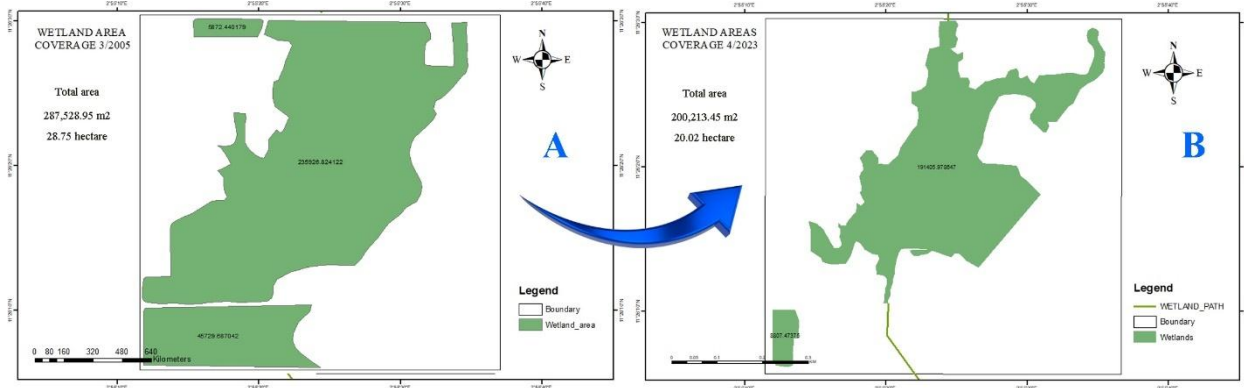


Figure 4.29: LULC of Gambi, Kebele 8 wetland area (source: organized by the author, 2024)

### 4.4.2 Environmental Significance

According to the researcher survey about the environmental importance of wetlands, 93% of the respondents believed that wetlands have environmental importance by giving the benefits like; creating a suitable and comfortable local air condition in their site, facilitating plant growth, and making the sceneries attractive to inhabitants.

In response to overwhelming positive feedback from the community, the researcher has scientifically proven the importance of wetlands to the atmosphere. Taking two large and small wetlands in the city and using Envi-met simulation software, the researcher tried to show what kind of local climate change would result if it is protected and destroyed.

**Case Area I - *Maryam sefer* (Sint Merry Neighborhood) wetland area**

This is *Maryam Sefer* (Sint Merry Neighborhood) wetland area which is located on Kebele 08 behind Gambi Medical College and covering 20.02 hectares of land. Figure 4.26, shows the simulation result of the potential air temperature and flow pattern that estimates how much local climate change will occur if it is preserved and destroyed.

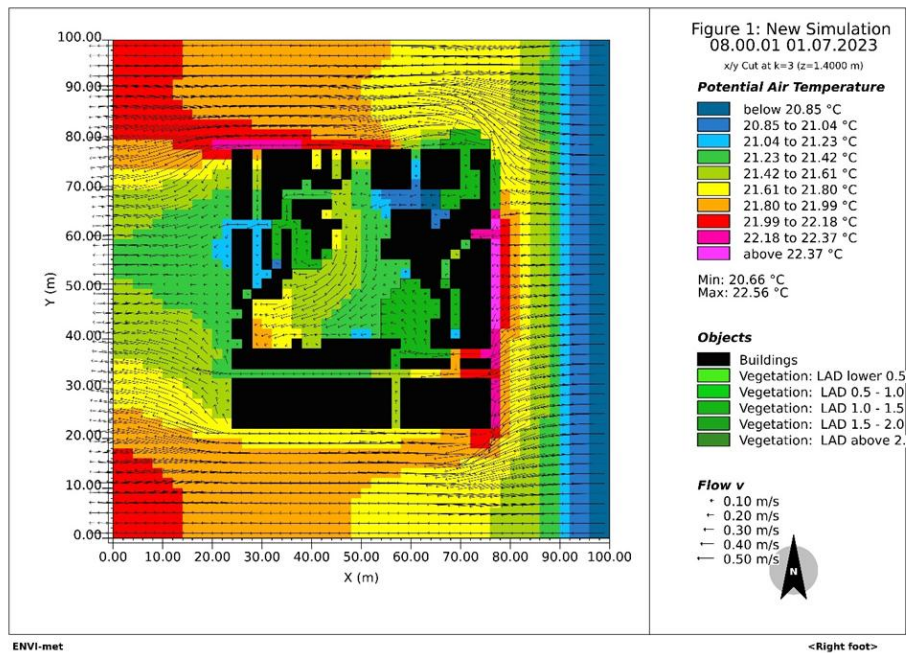


Figure 4.30: Simulated potential Air Temperature result of *Sint Merry* Neighborhood wetland area

(Source: organized by the author, 2024)

As shown in figure 4.30, if the wetland area can be protected, the local climate was between 20.66 and 22.56 degrees Celsius on average, and it indicates that there was comparatively good air condition in the area compared with the second scenario.

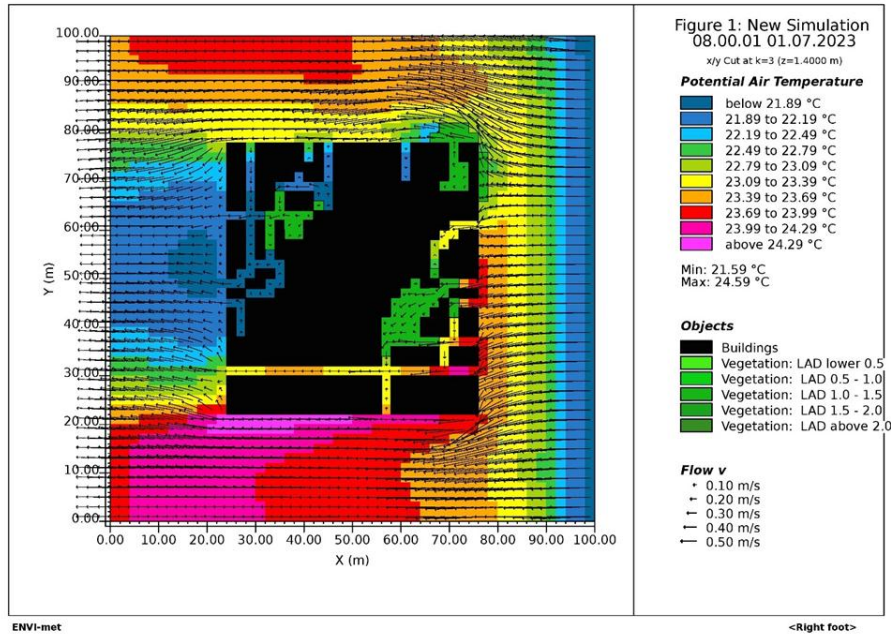


Figure 4.31: Simulated potential Air Temperature result of *Sint Merry* Neighborhood wetland area

(Source: organized by the author, 2024)

As shown in the figure 4.31, if the wetland in the area is destroyed, the local climate would be change between 21.59 and 24.59 degrees Celsius, and there wouldn't be good climate circulation in the area. If the wetlands in the area are lost, the local climate would increase from 20.66 to 21.59 degrees Celsius, and the maximum would rise from 22.56 to 24.59 degrees Celsius. If the wetlands disappear, rapid air pressure and circulation will be reduced and disrupted.

### Case Area II - Old Radio Station wetland area

This is an old radio station wetland area which is located on the side of Tana Sub-district, Keble 16, and covers a total of 18.6 hectares of land. Figures 4.32& 4.33 show that the simulation result of potential air temperature and flow pattern estimates how much local climate change will occur if it is preserved and destroyed.

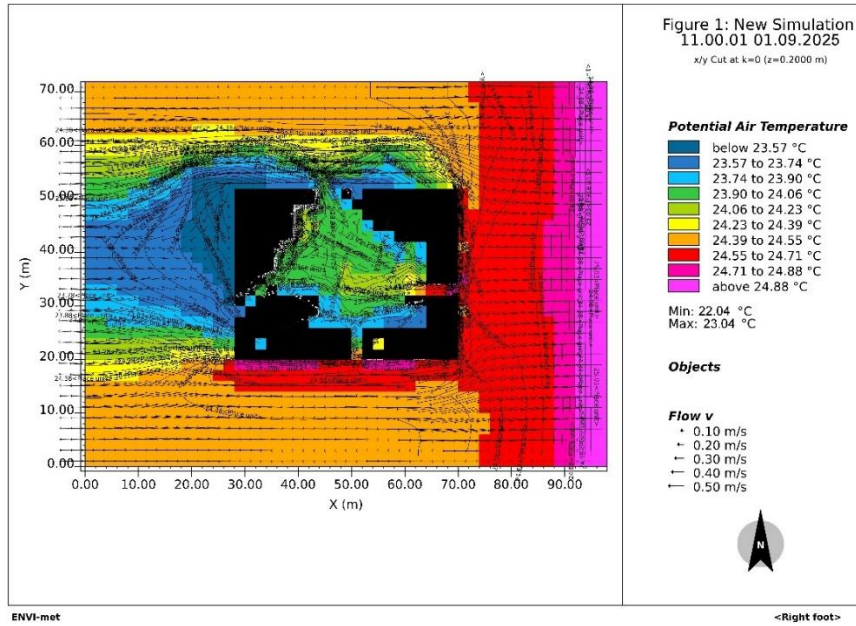


Figure 4.32: Simulated potential Air Temperature result of *old radio station* wetland area (Source: organized by the author, 2024)

As shown in figure 4.32, if the wetland area can be protected, the local climate is between 22.04 and 23.04 degrees Celsius on average, and it indicates that there is good air circulation in the area.

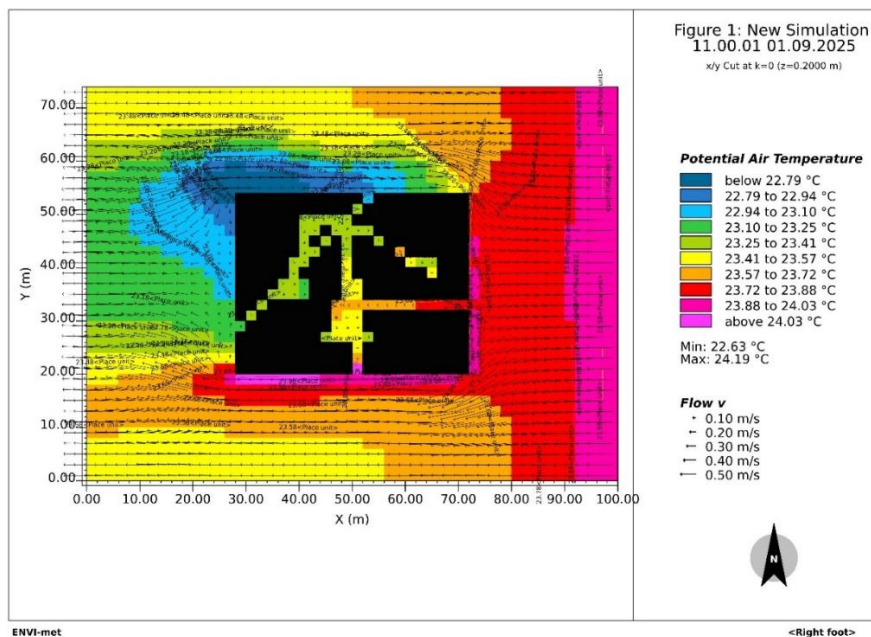


Figure 4.33: Simulated potential Air Temperature result of *old radio station* wetland area (Source: organized by the author, 2024)

As shown in figure, 4.33 if the wetland in the area is destroyed, the local climate will be between 22.63 and 24.19 degrees Celsius, and there will be no good climate circulation in the area. If the wetlands in the area are lost, the local climate will increase from 22.04 to 22.63 degrees Celsius, and the maximum will rise from 23.04 to 24.19 degrees Celsius. If the wetlands disappear, rapid air pressure and circulation will be reduced and disrupted.

In general, the above two cases prove that the existence of wetlands is of great importance for the existence of good ambient air.

#### 4.4.3 Cultural and Economic significance of the wetlands in the study area

According to the information we obtained about the cultural importance of wetlands from the selected households of the Woyto community, 86 % of the respondents believe that wetlands have cultural importance, and among the reasons they mentioned, the *che'fe* used for traditional ceremonies is found in this place, and the papyrus plant used for making *mosab*, *sefed*, *jebena sitter*, and *dawja*, used for traditional crafts is found in these places



Figure 4.34: che'fe and traditional crafts (Source: Photo by the author, 2024)

However, 14 % of respondents believed that wetlands have no cultural significance, although they did not give a reason why.

In Bahir Dar city, there is a traditional festival called "January in Bahir Dar" which is organized every year by the Bahir Dar City Administration Culture, Tourism and Sports Department. The canoe is a traditional form of water transportation and is an indigenous resource used for fishing. Abraham Asefa, who is the head of the culture, tourism, and sports department of Bahir Dar city administration, told us during the interview that this is a big economic base in addition to preserving culture.

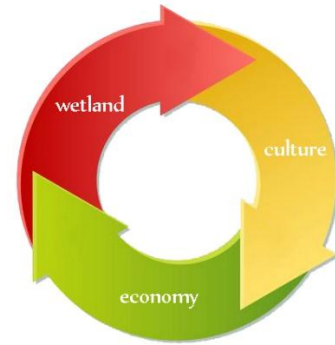


Figure 4.35: Traditional festival by Canoe (Source: organized by the author, 2024)  
 The participants' jobs and sources of income make up the other socioeconomic variable; 53% of participants' source of income are related to urban wetlands.

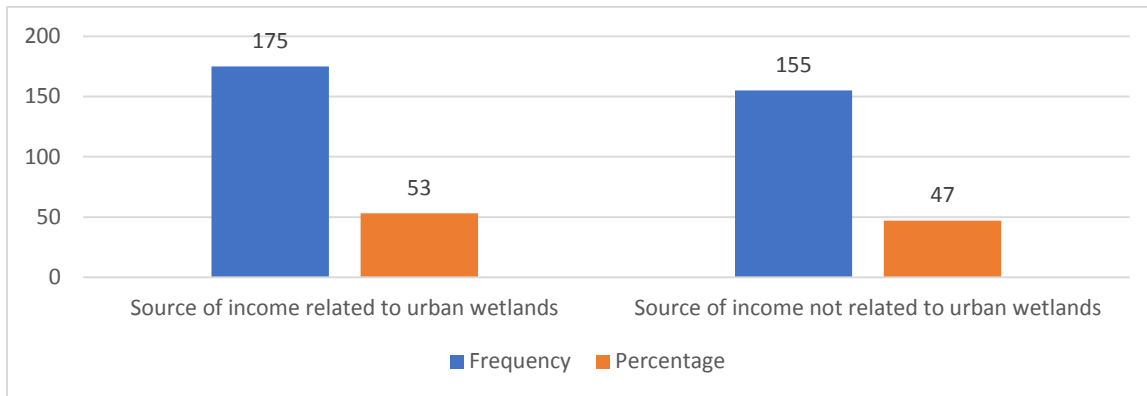


Figure 4.36: Graph of sources of income (Sources: Organized by the author, 2024)  
 175 of the participants whom the source of income is linked with urban wetlands; most them work in traditional crafts 57%; 23% of them work on selling Nile grass (ch'efe): 17% of them work fishing by making canoes and the remaining 3% work on urban farming on wetland peripheral area.

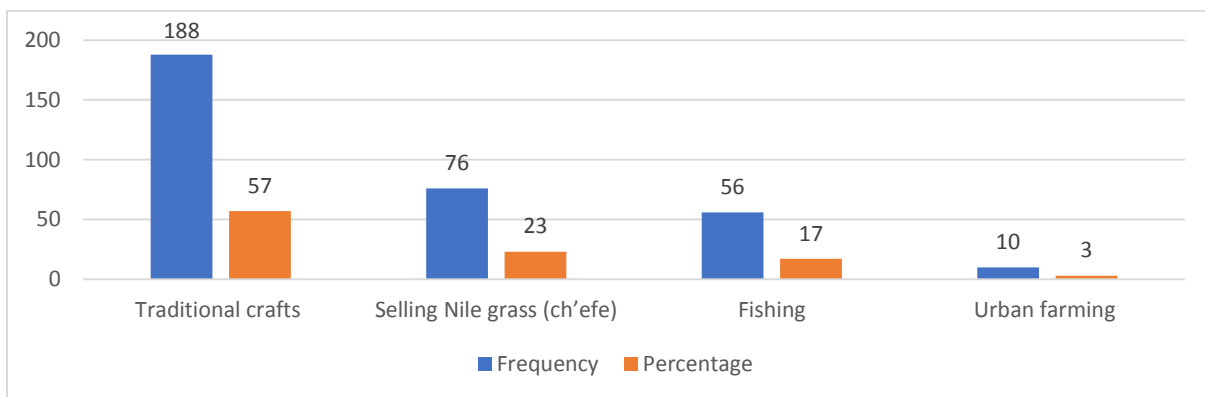


Figure 4.37: Graph of Types of Work (Sources: Organized by the author, 2024)

Traditional handicrafts, urban farming, fishing by making canoes, and selling Nile grass (ch'efe) are the types of jobs created by the communities in these urban wetlands, but traditional handicrafts are more important sources of income than other types of work.



Figure 4.38: Fishing by making canoes (Source: Photo by the author, 2024)

#### 4.4.4 Recreational significance

Based on the information we obtained about the recreational value of wetlands, 73% of respondents believe that wetlands have environmental value because they are a place to listen to oneself. After all, they are visually appealing and attractive, and because of the favorable climate in the area. This participant used this place for different types of recreational activities; of them, 7% of them used it for hiking; 18% of them used it for fishing; 32% of them used it for bird watching and setting and 43% of them used the place for photography purposes.

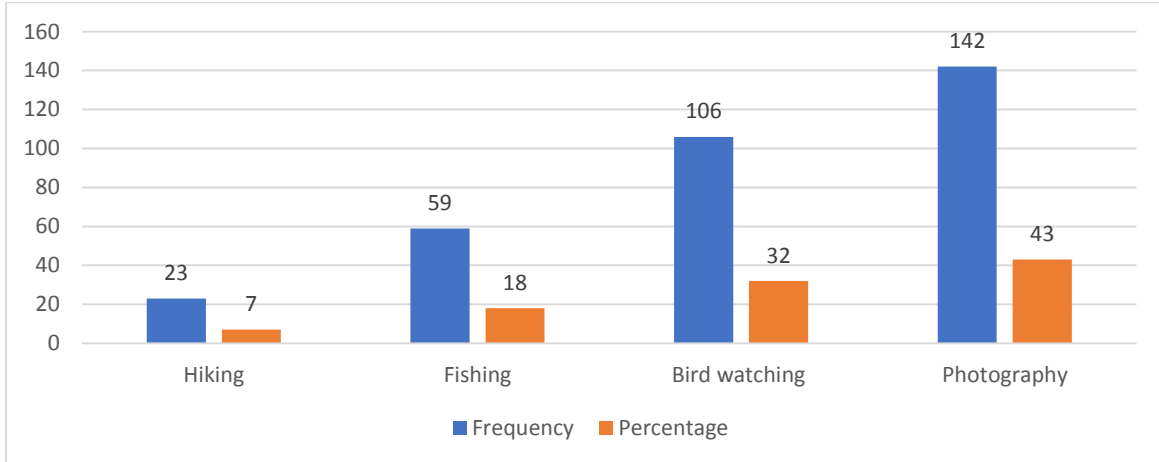


Figure 4.39: Graph of Recreational Activity rate (Sources: Organized by the author, 2024)



Figure 4.40: Wetland as a recreational area (Source: Photo by the author, 2024)

## **4.5 The major Challenges wetland landscapes face**

Wetland ecosystems are extremely delicate and susceptible to harm from even little alterations in their surroundings. The wetlands within and around the urban system are experiencing an increasing amount of trouble. Offices located in the city and considered by the researcher to have a direct relationship with the study, such as Nile Basin Authority, Bahir Dar city urban plan preparation and Management Bureau, Urban Planning Institute, Bahir Dar City and Infrastructure Department, Lake Tana and other water bodies protection and development agency, Bahir Dar City Water and Sewer Office has interviewed about the importance of wetlands in the city and the obstacles or challenges to their proper use. Based on the information obtained by the researcher, the following are mentioned as challenges; Weakness of municipal solid waste management (MSWM) and failure to update the liquid waste disposal system, Lack of awareness of stakeholders, Lack of legal framework, and Urbanization.

### **4.5.1 Weakness of municipal solid waste management and liquid waste disposal system**

Since solid waste disposal is a multi-faceted and challenging issue, it is well known that developing countries, beyond Bahr Dar city administration, are faced with high waste production and ineffective handling.

Based on the information we received from the Municipal Solid Waste Management Office of Bahir City Administration, the main issues of the solid waste disposal system were identified and a survey was conducted to provide statistical guidelines for effective management of solid waste. The municipality generates 421.215M3 solid waste per day makes the city the second largest after Laga Tafo about their population with a SW generation rate of 0.44 kg/c/d and the results show that solid waste collection and sorting system was weak, waste composting and recycling efficiency was very low, waste transportation and disposal management were not standardized and environmentally sound. As a result, according to the data of the Bahr Dar City Administration's Cleanliness and Beauty Office, the wetlands in the city are being used as solid waste dumps, and the researcher was able to realize this when he looked around the city.



Figure 4.41: solid waste disposal in wetland areas (Source: Photo by the author, 2024)  
Human waste from industry and residential use pollutes the environment. There is no standard municipal wastewater collection and treatment system in Bahir Dar Town. Due to inadequate sanitation facilities, people were forced to urinate outside and discharge raw wastewater in unsuitable locations, which contaminated wetlands.

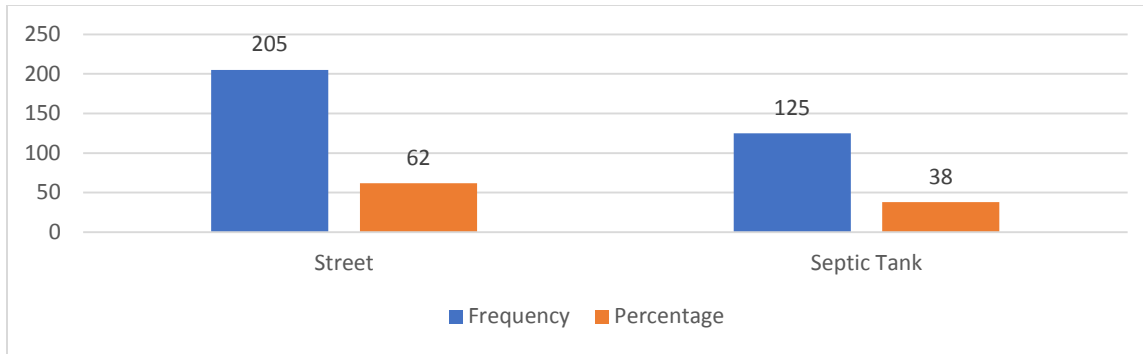


Figure 4.42: Respondents wastewater disposal system ratio (Source: organized by the author, 2024)

According to the researcher's interview with 170 residents of 17 sub-districts in the city, 62 percent of the respondents discharge their wastewater into the streets and fields.

#### 4.5.2 Lack of stakeholder awareness and failure to fulfill responsibility

The findings of this study indicate that the lack of understanding of the stakeholders that wetlands are a challenge to prevent them from providing environmental, social, and economic value to the community or reduce their contribution to sustainable development. Interviews with stakeholders responsible for wetlands indicate that most sector offices are making efforts but have not done direct work in these areas. According to the survey done by the researcher, only 18% of the institutions are doing direct activities from the stakeholders in the city; of these Lake Tana and other water body protection and development agencies and the Urban Planning Institute are mentioned.

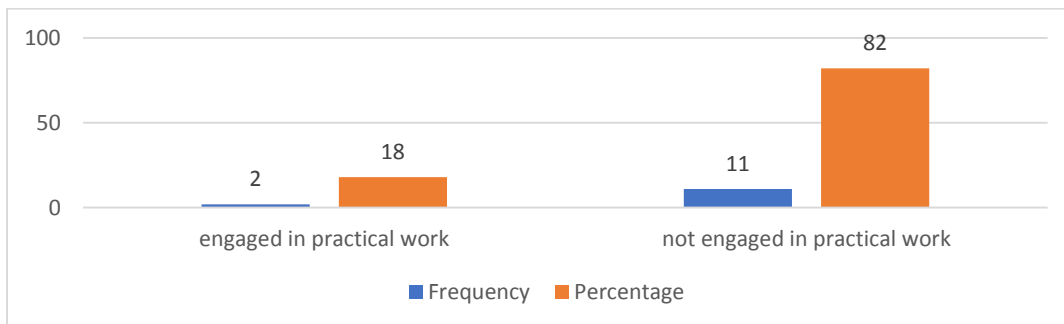


Figure 4.43: Practical activity rate of stakeholders (Source: organized by the author, 2024)

### **4.5.3 Lack of legal framework**

Through deep reading of literature by the researcher on wetlands, it was confirmed that there is no direct legal framework for wetlands at the city or national level.

The 1994 Ethiopian Constitution, which has a broad environmental scope and identifies the environmental values to be safeguarded and protected, was the first step in incorporating environmental concerns into the supreme law of the land. The rights of Ethiopian citizens to a clean and healthy environment are outlined in Articles 44 and 92. According to the Constitution, both the government and the people have a responsibility to conserve the environment, and projects and programs should not be created or carried out in a way that endangers the environment.

The Ethiopian National Conservation Strategy was developed by the Environmental Protection Authority (EPA), which was established in 1995. As part of this strategy, the EPA incorporated the need to protect and restore wetlands to preserve water resources and, when necessary, to carry out environmental impact assessments of development projects.

There is currently no national explicit coordinated policy for wetlands in Ethiopia (no national Wetlands Policy), despite growing interest in them. Instead, wetlands have held a cross-sectoral position in the frequently incoherent policy of several government bodies. However, for urban wetlands to be used for sustainable urban planning and management, we need to develop a consistent national policy and sign wetland-based agreements such as the Ramsar Convention. Due to the social, economic, and environmental importance of wetlands, they should be studied as an independent thematic area in urban planning.

### **4.5.4 Urbanization**

Planning and laws related to land use are often the largest threats to wetlands. This might mean that there would be less land available, which would put pressure on wetlands as a possible source of new land. CSA (1994, 2007) reports that the total number of housing units in Bahir Dar City grew from 19,808 in 1994 to 45,501 in 2007. A total of 63,820 residential units were constructed between 2007 and 2019, of which roughly 25,000 were built unlawfully, according to data from the city's municipal administration office. The city's explosive population increase is responsible for the built-up area's expansion. According to housing and population censuses

(CSA 1984, 1994, 2007), the city's total population increased from 54,800 in 1984 to 472,063 in 2020 as a result of people moving from rural to urban regions. Put another way, this means that the city's population has increased by 11,591 people yearly.

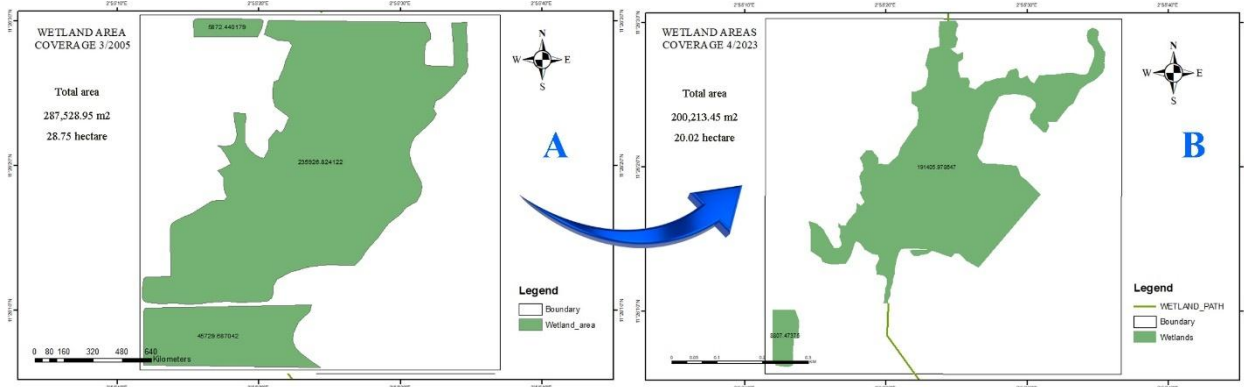


Figure 4.44: Urbanization influence on wetlands (Source: organized by the author, 2024)  
 The wetland shown in Figure 4.44 is one of the wetlands identified in the study. According to the European calendar, it covered 28.75 hectares of land in 2005, but in the same month of 2023, its area decreased to 20.02 hectares. This means that in just 18 years, 8.73 ha or about 87300 square meters of wetlands have been lost. If it continues at this rate, we could lose this wetland in less than 50 years.



Figure 4.45: Wetlands as a construction area (Source: organized by the author, 2024)  
 As shown in the picture above, it can be observed that the wetland areas in the city are filled and used for various types of construction.

#### **4.6 Wetland conservation planning and management approaches**

The study has demonstrated the importance of monitoring urban wetlands for sustainable urban management and planning. It is inappropriate to employ just the restriction of human activity for nature protection since wetland conservation has been used for production. For the Wetland Conservation Plan (WCP), thus, the ecosystem-oriented and awareness-oriented techniques should be used.

The primary techniques used for WCP are as follows: a) recognizing the city's biodiversity; b) protecting and conserving the wetland vegetation; c) enhancing the role of wetlands; d) encouraging ecotourism as a means of protecting the environment; and e) concentrating on environmental education and public awareness.

During the research survey, the researcher realized that ecologically based approaches are effective in protecting and managing wetlands. These approaches consist of 5 main procedures, which are 1) Identification of wetlands 2) Knowing the environmental, social, and economic importance of wetlands and understanding the problems caused by their disappearance 3) Establishing a legal basis supported by policy 4) Creating a coordinated system of stakeholders 5) Doing community awareness work.

To conserve wetlands and use them for sustainable development, it is necessary to carefully identify the areas where they are located. To do this, using high-quality satellite images and conducting physical observation will allow us to identify places more. Continuing from that, it is necessary to know the environmental, social, and economic importance of these places, and to understand the problems they will cause if they disappear. If possible, it is also necessary to know their political influence because at one point in the history of Ethiopia, Emperor Tewodros II wanted to make his capital Bahir Dar a city, but at that time, the city was the location of many swamps, so he went to Gondar for fear of a malaria epidemic (Blanc, 2016). But now, studies are proving that wetlands are the basis of economic and urban sustainable development if they are properly managed. To show this, developed and developing countries are working on artificial wetlands. For example, environmentally friendly constructed wetlands in China are a case in point (Dong Liu, 2009).

Thirdly, to protect and easily manage wetlands, it is necessary to establish a legal basis supported by national policy in addition to implementing international policies by identifying these areas

and knowing their benefits. In this policy, who are the stakeholders and their role should be clearly defined. However, accepting international policies or approving national policies alone does not ensure the security of these areas; instead, creating a coordinated system of stakeholders and raising awareness for the community will allow for sustainable protection and management of these threats.

## **4.7 Discussion of the Results**

### **4.7.1 Consistence of the Sample Characteristics**

GIS tools and remotely sensed imagery with the help of observation were conducted to identify and delineate wetland areas. To clarify the primary concerns regarding the socioeconomic level of 330 participants in the study, 42% of them are between the ages of 18 to 27; 35% are between the ages of 28 to 37; and 23% are between the ages of 38 to 50. Concerning to gender ratio of the participants, 50% of them are male and 50% of them are female. Coming to the income source of the participants, 53% of participants' source of income are related to urban wetlands with work type of traditional crafts with 57%; 23% of them work on selling Nile grass (ch'efe); 17% of them work on fishing by making canoe and the remaining 3% work on urban farming on wetland peripheral area.

The economic status of the participants is that 72% are labeled as low income; middle-income earners account for 6%; upper middle income and the high incomer's account for only 4% according to the category of CSA, (2007). Concerning the family size of the participants Households with a family size of 2 account for 6% of the participants; a family size of 3 accounts for 10%; a family size of 4 accounts for 24%; family size of 5 accounts for 34% and participants with 6 members and more than it also covers 26%. According to the collected data and analysis, most of the community participants are directly or indirectly beneficiary from these wetlands. In addition to this, in-depth discussions and interviews were conducted with the stakeholders to identify the challenges that the wetlands face.

### **4.7.2 Major wetland areas of Bahir-Dar city and the surrounding**

The results of the GIS-based investigation show that the city has approximately 20 distinct wetlands, with the smallest being a 3.3 ha wetland near the Abay River and Lake Tana. The largest, covering 198.2 ha, is near the coast of Abay. The total area of these wetlands is 1016.3 hectares, with 45% along the Tana River's coast and 55% encircled by dry ground in the city

center. The wetlands along Tana's and Abay's shores are perennial, with smaller wetlands during the dry season and wider ones during the wet season.

Major wetland areas of the same study area were also reported by different authors (Assefa, et al., 2021, Zawdie, et al., 2002, Balew & Korme, 2020), surprisingly, the data presented in all the studies cited are very different. According to Assefa, et al., (2021), wetlands covered 2760 hectares in 2019, but according to Balew & Korme, (2020), these wetlands covered only 1705 hectares in 2017. These two studies which are based the land use and land cover changes were done in the same administrative area by included the surrounding small kebeles, such as Waramit, Addis Alem, Zenzelmana, and Werbe Michael, but this study was done based on the inner city boundary of Bahir Dar only.

According to Assefa, et al., (2021), data indicates that 493 hectares of wetlands were lost in Bahir Dar city administration between 2004 and 2019, while according to Balew & Korme, (2020) data, only 65 hectares were lost from 2002 to 2017. Zawdie, et al., (2002) data shows that in 2002, wetlands covered only 300 hectares in the city administration; there is also a difference of 1470 hectares compared to Balew & Korme, (2020) study done in the same year. Studies on the extent of land occupied by wetlands are inconsistent; this gap originates from the inconsistent interpretation of wetlands, but generally from a lack of thorough study of each wetland.

Although all studies are inconsistent; the findings of this study are in stark contrast to the findings of Balew & Korme, (2020) and Zawdie, et al., (2002). The finding of the Assefa, et al., (2021) study is related to the finding of this study; because if this study included small kebeles in the city administration, such as Waramit, Addis Alem, Zenzelmana, and Werbe Michael, it would be close to the data mentioned by Assefa, et al., (2021). But, overall this study differs from similar studies mentioned above in that it details the location of each wetland.

Generally, the above analysis indicates that a large-scale study involving all stakeholders should be conducted about wetlands. This should start with giving a consistent definition for wetlands which is environmentally oriented.

### **4.7.3 Major regulatory, social-economic, and recreational functions of wetlands in the study area**

#### **Ecosystem service value (ESV)**

All ecosystem components are valued in various studies. In this study, taking a single wetland as a case by identifying its possession in different seasons; the researcher tries to demonstrate the value of its ecosystem service. The wetland that is used for calculating the ecosystem value is the specific place locally known as Gambi, The ESVs in the current study decreased to 19759.74 US\$ ha<sup>-1</sup> year<sup>-1</sup> in 2023 from 28376.25 US\$ ha<sup>-1</sup> year<sup>-1</sup> in 2005; that means it lost 30.4% of its service value over 18 years.

ESV with the same study area was also addressed by Assefa, et al., (2021). According to Assefa, et al., (2021), In 1984, the research area's total ESV was USD  $29.73 \times 10^6$ . The total ESV dropped to  $20.84 \times 10^6$  in 2019. According to this, a total of USD  $8.9 \times 10^6$  ESV was lost over 35 years, or 29.9% of its ESV. Over the study periods, the loss of wetlands and other water bodies contributed primarily to the overall ESV decline; of the overall ESV lost in the study area, 63.9% has come from wetland ESV loss.

The research finding of Assefa, et al., (2021) is closely related to this research finding. Although Assefa, et al., (2021) Ecosystem Service Value study does not only refer directly to wetlands; 63.9% share of lost ESV is accounted by wetlands. Therefore, the study of Assefa, et al., (2021), which is conducted in a nearby area reinforces the findings of this study, but in general, the research findings indicate that the Ecosystem Service Value of wetlands is decreasing and needs attention.

#### **Environmental significance**

Another important benefit of wetlands is their ability to regulate microclimate. Taking one of the identified wetlands as an example in this study, it was possible to show how to modify the local microclimate. For example, the minimum potential air temperature in the wetland area of Maryam Sefer on 01/07/23 was 20.66 0c and the maximum was 21.59 0c. But on the same day and time, if the wetland had lost its land cover, the simulated potential air temperature would have increased to a minimum of 22.56 0c and a maximum of 24.59 0c.

Similar potential temperature simulation experiments have not been conducted in the area of this study, but many studies and reports reinforce this finding. Among them, Zawdie, et al., (2002), explains that Ethiopia's wetland resources are not fully documented and that they play a significant role in controlling the local climate in many parts of the country. The Ethiopian Biodiversity Institute also points out that wetlands play a significant role in local climate regulation (EBI, 2004). In general, the above cases prove that the existence of wetlands is of great importance for the existence of good ambient air.

### **Cultural and Economic Significance**

Of 330 direct participants in this study, 53% of the participant's source of income is related to urban wetlands. 175 of the participants whom the source of income is linked to urban wetlands; most of them work in traditional crafts with 57%; 23% of them work on selling Nile grass (ch'efe): 17% of them work fishing by making canoes and the remaining 3% work on urban farming on wetland peripheral area. Although no research on the cultural and economic value of wetlands focuses only on the Wayto community in Bahr Dar city, various studies can be mentioned that study the economic value of wetlands to the community. According to Amsalu & Addisu (2014), wetlands offer a wide range of products and services related to social, economic, and cultural activities, tourism, agricultural production, and biodiversity conservation.

Numerous wetlands in India are popular tourist destinations. Some examples of popular wetland-based tourist destinations include Small Run of Kutch, the backwaters of Kerala, and Chilka Lake in Odisha; in these areas, tourism is one of the main sources of revenue for the general public (Bassi, et al., 2014). Through resource production, the facilitation of leisure activities, and other advantages like pollution control and flood protection, wetlands support both the local and national economies (EPA, 2006). And also According to Greenway (2005), wetlands can efficiently extract nutrients from the water, which can then be used for irrigation in a variety of settings, including golf courses and agriculture.

Wetlands can also boost the economy in other ways, such as preserving biodiversity, lowering medical costs due to pollution, lowering soil fertility through recurrent flooding, and maintaining the equilibrium of the groundwater table (Ferreira, et al., 2023).

## **Recreational significance**

Out of 330 participants in the study, 241, or 73% used wetlands for recreation. These participants used this place for different types of recreational activities; of them, 7% of them used it for hiking; 18% of them used it for fishing; 32% of them used it for bird watching and setting and 43% of them used the place for photography purpose.

Wetlands are frequently charming locations for well-liked outdoor pursuits like hiking, fishing, bird watching, photography, and hunting. In 2001, over 82 million Americans engaged in these activities, spending over \$108 billion on them (EPA, 2006). According to (Ramsar Convention Secretariat, 2010) the economy of the Netherlands Antilles' Bonaire National Marine Park receives US\$30 million annually from recreational diving on its coral reefs; the Great Barrier Reef Marine Park welcomes 1.6 million visitors annually, who spend more than AU\$1 billion there; French water gardens that served as the inspiration for Monet's series of water flower paintings welcome half a million visitors annually; tourism to the Moremi Game Reserve in the Okavango Delta (Botswana) brought in US\$16 million in 2003; In the UK, The Broads Ramsar Site generates enough revenue from tourism to sustain 3,000 full-time jobs.

All the above-mentioned studies strengthen the findings of this study; as wetlands have become a source of income for many countries beyond their recreation service.

### **4.7.4 Primary challenges wetlands face to function sustainably in urban landscapes of the study area**

#### **Poor waste disposal system**

Poor municipal solid waste management and liquid waste disposal systems are cited as the primary challenges facing wetlands. 62% of the 330 individuals who participated in the study threw their waste water in the streets and fields. Other studies agree that this problem prevents wetlands from providing the services they should provide to society. For example, According to Mekonnen, (2012), there is no modern municipal wastewater collection and treatment infrastructure in Bahir Dar City, 64% of wastewater discharges into the streets and open fields and most of it enters the major Nile River water stream and Lake Tana both directly and indirectly.

The main sources of pollution for wetlands include untreated sewage, trash dumping, industrial wastewater, runoff from fields of agriculture, highways, excessive use of synthetic chemicals in homes and businesses, etc. According to Hemond & Benoit (1988), Surface runoff of organic matter and external sewage effluent flow can alter BOD and COD levels in wetlands; this might significantly alter the wetland's biogeochemistry, which would be detrimental to the biotic organisms that are there and flourishing. The wetlands' and its biotic communities' ability to supply ecosystem services may be reduced as a result.

In a study by Kumar et al. (2011) the concentration of Mn in the muscles of fish raised in the eastern Kolkata wetlands was found to be significantly higher than the FAO/WHO acceptable limits. Even yet, various species' concentrations of As, Hg (II), Ni, Cd, and other elements varied within the allowed ranges. These heavy metals most likely come from nearby agricultural areas, tannery wastewater, road runoff, and urban sewage systems.

These studies demonstrate that pollutants can originate from a variety of sources, impact wetlands in various ways, and have detrimental effects on several animals. Humans may also be susceptible to contaminations such as heavy metal pollution. As a result, it is necessary to determine the origins and implement appropriate mitigating actions.

### **Lack of stakeholder's awareness and failure to fulfill responsibility**

According to the survey done by the researcher, only 18% of the institutions are doing direct activities from the stakeholders in the city; of these Lake Tana and other water body protection and development agencies and the Urban Planning Institute are mentioned. All stakeholders with the exceptional of the community try to use and manage wetlands in their way. However, identification of wetlands during the structural planning of the city, management of designated wetlands, development of wetlands, prevention of liquid and solid waste, allocating a budget for the development and protection of wetlands, and making a policy are some of the responsibilities that the stakeholder's failed to fulfill in the study area.

The problem identified is not just the lack of awareness among stakeholders, but also the deficiency of technical and experienced personnel. According to Raburu et al. (2024) to carry out specialized conservation and management programs, such as research, monitoring, integrated coastal zone planning, EIA/EA, and extension activities to monitor and manage the current

wetlands and their resources, there are insufficient technical and skilled people resources. However, according to Musasa et al. (2023) indicated that stakeholders have a vital and important role in the use and protection of wetlands if it is to be sustainable, and the study indicated that the government should invest in programs that involve various stakeholders in policy formulation and implementation.

As indicated in this study, all stakeholders try to control and manage wetlands for their convenience, but the community has not played any role in protecting and managing wetlands and the government is primarily responsible for the problem of not coordinating the community. According to Kadoma (2023), diverse interests and motivations drive the involvement of different stakeholders in wetland conservation and restoration initiatives; also it was discovered that when it comes to organizing and carrying out wetland conservation and restoration projects, community stakeholders are the least involved.

Therefore, all stakeholders, including the community, should play their role in protecting and managing urban wetlands.

### **Lack of legal framework (policy)**

According to Finlayson & Royal (2018), the legal guidelines created by governments about actions that impact wetlands are referred to as "wetland law and policy"; when applied broadly, refers to a variety of tools. Through deep reading of literature by the researcher on wetlands, it was confirmed that there is currently no national explicit coordinated policy for wetlands in Ethiopia. But, this is not only for Ethiopia, According to (Kang, 2013) there are no explicit regulations designed with the preservation and protection of lakes and wetlands in mind; depending on the national legislative and institutional framework, different levels of conservation acts provide indirect protection for the water bodies.

According to Ramsar Convention Secretariat (2010), a distinct wetland strategy offers a clear way to identify wetlands as ecosystems that need to be managed and conserved differently, without being hidden below other sectoral management goals. For urban wetlands to be used for sustainable urban planning and management, we need to develop a consistent national policy and sign wetland-based agreements such as the Ramsar Convention. Due to the social, economic, and environmental importance of wetlands, they should be studied as an independent thematic area in

urban planning. According to Amsalu & Addisu (2014) creating a national policy or wetland development strategy aimed at improving the ecological and socioeconomic functions of wetlands for the nation's present and future generations.

However, some developed countries have adopted national policies to protect wetlands and enable them to provide services. According to Rubec & Lynch-Stewart (1998) in Canada, wetland policies have been adopted by the federal government, two resource-based businesses, and four Canadian provinces; have made important advancements in this area that are acknowledged internationally and might serve as role models for other countries.

Ethiopia is an example of the conservation of the environment and has given careful thought to the management and protection of natural resources nowadays, including wetlands. The National Water Resources Management Policy, the Federal Environmental Policy, the Biodiversity Policy, the Agricultural and Natural Resources Development Policy, the Land Administration and Use Policy, and the National Conservation Strategy of Ethiopia are just a few of the policies and legal frameworks that refer to wetlands indirectly, even though the nation hasn't adopted a clear national policy on their conservation and management. Even if these policy frameworks have the potential to improve the way wetlands are maintained in the nation, the truth is that wetlands are currently being mismanaged, with some even in danger of going extinct.

### **Urbanization**

Land use planning and laws pose significant threats to wetlands. CSA (1994, 2007) reports that Bahir Dar City experienced a significant increase in housing units from 19,808 in 1994 to 45,501 in 2007, and according to the city's municipal administration office with 63,820 residential units constructed between 2007 and 2019, with 25,000 being unlawfully built. According to housing and population censuses (CSA 1984, 1994, 2007), the city's population surged from 54,800 in 1984 to 472,063 in 2020, driven by people moving from rural to urban areas, resulting in an annual population increase of 11,591 people; which would put pressure on wetlands as a potential source of additional land. This is evidenced by the fact that 8.73 ha of wetlands have been lost in 18 years in a survey conducted in one of the 20 wetlands located in the Maryam Sefer area.

Therefore, urbanization is one of the biggest threats for wetland to prevent them from giving ecological function in the study area. Although there is no documented information on how many wetlands we have lost due to urbanization in Ethiopia; according to Li et al. (2022), 58% of wetlands in the United States, 55% of wetlands in the Netherlands, 90% of wetlands in New Zealand since 1850, and 60% of wetlands in Spain have disappeared as a result of urbanization since 1950.

Wetland habitat fragmentation induced by urbanization can adversely affect native flora and fauna, leading to changes in species richness and distribution, population composition, and ecosystem function (Amsalu & Addisu, 2014). And also, according to Nuwagaba (2023) increased flood frequency, destabilization of eco-systems, and overexploitation of wetlands and their resources are all directly related to urbanization.

Therefore, it is imperative to pay attention to wetlands in urban development. According to WWW Consulting (2018), one of the most effective ways to retrofit wetlands into the urban environment is through the implementation of green infrastructure in new urban development.

# CHAPTER FIVE

## 5. CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

The ultimate motive of the study was to identify wetlands in the city and evaluate their regulatory, socio-economic, and recreational benefits they provide to the community to enable the preparation of a sustainable urban plan that considers wetlands. To do this, analyses were made using technologies such as Arc Map GIS software and Envi-Met simulation and it was important to find and interview the community members and stakeholders in the city who are especially close to these places. In particular, the section of the community called Wayto has special proximity to wetlands, so the analysis is based on them, and about 11 government offices that are responsible for these areas are also included in the analysis.

The analysis indicates that there is about 20 wetlands have been identified in the city and each of those sizes is different. Among them, the smallest wetland area is 3.3 hectares of land and is located away from the coast, and the largest area of wetland, which is 198.2 hectares located on the coast. These wetlands in the city cover a total area of 1016.3 hectares. Interestingly, most of these wetlands were identified in this study; they are connected to each other by thin marshy canals with flowing water. This is an indication of how much of a new look these places will bring to the city if they are developed.

According to the findings of the study, wetlands are important in terms of creating a suitable environment for the community, for example, they are a suitable place to plant plants and make the environment comfortable and attractive. In addition to this, the findings of the study indicate that they have a great potential and role in adjusting the local micro-climate.

Wetlands are of cultural importance, and one of the reasons is that the grass used for traditional ceremonies is found here, and the papyrus (Dengel) plant, which is used to make other traditional crafts, is also found here. Among the handicrafts made from this plant. According to the findings of this study, 53% of the community in the Woyto tribe has an average of 4 people per family, the source of income is related to urban wetlands, and 90% of family members earn between 1000 and 4000 Ethiopian Birr per month. The remaining 10% earn more than 5000 Ethiopian

Birr per month. This indicates that wetlands are providing significant cultural and economic value to the community and if they are protected and developed, they ensure sustainable urban planning and development.

Apart from environmental, cultural, and economic importance, the findings of the study indicate that wetlands are also preferred places for recreation. However, there are several barriers to these wetlands becoming part of sustainable urban planning. Among these, weak municipal solid waste management (MSWM) and non-modernization of the liquid waste disposal system, lack of stakeholder awareness, lack of legal framework, and urbanization are the challenges identified in the study.

Sustainable urban planning and development may be accomplished by recognizing the value of wetlands to the community in terms of the environment, culture, and economy and by easing the difficulties they confront.

## **5.2 Recommendation**

Research findings from all over the world make it clear that wetlands are one of the key ecosystems with several ecological and economic advantages. Wetland biodiversity must therefore be preserved with proper treatment, regulations, and public awareness.

Almost all of the major challenges which are identified in the study that the wetland face; including lack of legal frameworks (policy), poor waste disposal system, urbanization, and lack of stakeholder awareness and responsibility originated from weak urban planning management. Therefore, wetland management plans need to be formulated, developed, and integrated into urban planning.

### **5.2.1 General Recommendations for Integrated Urban and Wetland Planning**

#### **Inclusive participatory approach:**

NGOs and government agencies that are involved in wetlands should be included in the planning process. Additionally, an institution or its representatives should perform coordinated communication to expand their engagement in urban wetlands regions. Community-based activities provide another foundation for a participatory approach; during the period of spatial

planning and management, a varied representation of community members with particular proximity to wetlands should have collaboratively shaped discussions and outcomes, each sharing their knowledge, priorities, and desires. To achieve this, every member of the community affected by a (socio-economic and/or environmental) program or issue must be actively engaged. To interact with the communities, stakeholders should also run public awareness and education campaigns.

**Incentive systems:**

Just as public utilities pay for electricity and water, fees for public land services to protect wetlands should be encouraged in urban areas; this increases the sense of responsibility to the community in those areas. In addition, the government should enact tax exemptions for works related to wetlands to encourage redevelopment and conservation measures.

**Comprehensive approach:**

Wetland planning and management procedures need to be strategic, taking into account the demands, difficulties, and local context while keeping to the mandates and functions of all governmental levels to facilitate action. Regional and local governments, along with national ministries and departments carrying out their specialized sectoral or theme tasks, must collaborate to coordinate plans, communications, and procedures for group activities.

**5.2.2 Specific recommendations for stakeholders**

**Urban planners or Urban Planning Institute** – at the planning stage, the plan should take into account the following;

- The values of the urban wetlands should be clearly stated to help in decision-making
- Prepare management plans specifically for urban wetlands by identifying and charting each element of the wetland
- Map, schedule, and carry out baseline surveys to examine the primary ecological features of urban wetlands
- Start with integrated planning by combining many aspects of urban spatial planning (such as stormwater management, wastewater treatment, and water resources) to support urban wetlands as organic green infrastructure for preserving the environment
- Plan in coordination with the relevant public and private agencies

- Provide suitable frameworks for participatory methodologies that will empower and include stakeholders and local communities throughout the whole planning process
- To reduce urban pollution and sedimentation, especially to enhance sanitation without seriously impairing the ecosystem's capacity to provide other services, designate specific urban wetlands as natural wastewater treatment systems
- Create detailed strategies to modify planned urban developments to fit the ecological, physical, sociocultural, and economic characteristics already present

**Policymakers – should;**

- Provide comprehensive policies for urban planning that integrate development frameworks and spatial planning to safeguard urban wetland ecosystems and the services they provide (i.e., protection from urban flooding, management of temperature, provision of green infrastructure, etc.)
- Use management planning that addresses the needs of urban wetlands at different and suitable scales
- Create a framework of laws and regulations to conserve urban wetlands proactively
- Encourage collaboration between public and private entities in urban wetland planning and design by establishing regulatory charters
- Encourage a participatory approach by involving stakeholders and local communities in all phases of the planning and management process
- Encourage economic activity (enterprises, leisure travel, aquaculture, etc.) by paying for ecosystem services and providing subsidies

**Developers – should;**

- Encourage the repair and rehabilitation of urban wetlands that have deteriorated by requesting financial support from the local government
- Encourage the numerous advantages that come from including wetlands in development, such as improved community well-being, water safety, reduced risk of flooding, recreational opportunities, and temperature regulation
- Encourage the use of urban wetlands as a natural green infrastructure for stormwater management, water resource management, and other urban development activities
- Encourage community members to participate actively in all phases of planning and administration

**Bahir Dar City Planning and Management Office** – should monitor and control the identified wetlands based on the structural plan approved by the city administration.

**Bahr Dar City and Infrastructure Department** – it's the responsibility of this office to ensure that wetlands are taken into account in infrastructure development in the city, both by investors and by the government.

**Bahir Dar city administration cleaning and beauty office** – until community awareness is raised and the government pays proper attention to wetlands, these wetlands will not stop being garbage dumps, so this institution should clean these areas as soon as possible to prevent waste and make them look good.

**Water and Sewerage Office** – One of the main challenges for wetlands to provide proper services is waste pollution; Therefore, this institution should improve its operation by developing a modern and standardized waste disposal system.

**Bahir Dar University** – In addition to participating in the preparation of the plan, the institute should prepare and support a community awareness program by allocating a budget to community service.

**The community** - should;

- The responsibility of the community is high in terms of managing wetlands and ensuring sustainable development; because the users of these areas are part of the society.
- Directly involved in the development of plans, laws, or implementations related to these areas.
- Protect the wetlands in the area from pollution and illegal encroachment.

In addition to this, other stakeholders who have a direct relationship with wetlands, such as the Nile Basin Authority, Bahir Dar City Urban Plan Preparation and management Bureau, Lake Tana and other water body's protection and development agency, Bahir Dar City Administration Culture, Tourism and Sports Department, Amhara Region Environment and Forest Protection Bureau and Ethiopian Biodiversity Institute have to fulfill their respective responsibilities from planning to monitoring stage.

**Best practices for increasing community awareness and involvement in wetland conservation efforts**

A higher level of community involvement will empower and improve local conservation initiatives while also used to build capacity. According to Shrestha (2013) to improve the ability

for sustainable resource management and consumption, community participation is essential. Although it takes a long time to educate people and raise environmental awareness, the results are successful in terms of protecting and conserving wetlands; For this demonstration, according to Ghaderi et al. (2022) the community in Touran National Park is now actively involved in protecting the park's natural and cultural assets, thanks to a notable growth in conservation awareness.

According to Golmarvi et al. (2018) experiences in Japan show that the fastest and most efficient ways to increase public understanding of the environment are through participatory programs, which also have the potential to increase awareness throughout the years. Table 5.1 shown below is an example of environmental education programs in a municipality in Japan to increase community awareness on wetlands.

**Table 5.1:** Environmental Education Programs in a Municipality in Japan

No	Kind of Program	Name of Program	Explanation
1	Seminar	Lectures in Schools and Communities	To send waste management experts to speak in communities and schools
2	Video	Video on Recycling “Reduction, Separation, Recycling - What can be done by us”	distributing the video cassettes to elementary and junior high educational institutions
3	Paper Media	Handbook for Waste Reduction and Recycling	This handbook was distributed to all residents. The contents are 1) how to separate and 2) information on Waste reduction and recycling.
4	Paper Media	Educational booklet: “Let’s think together - Waste and Us”, “Let’s start from what you can do”	The booklets target primary school children.
5	Internet	Web Site on Waste	The website explains how to discharge and separate Wastes.
6	Event	Flea Market	To promote flea markets produced by private entities and to have a festival on the environment once a Year.
7	Promotion by Products	“Setagaya Roll”, “Setagaya Tissue”	To produce toilet paper and tissue paper from recycled paper
8	Seminar	Lecture on organic waste recycling	Lecture on organic waste reduction/recycling such as composting and eco-cooking
9	Direct Instruction	Direct instruction by collection crew	Direct instruction by the collection crew on how to discharge wastes
10	Facility	Education Center	Education center for waste reduction and recycling. Also used goods can be bought.

(Source: Golmarvi et al. (2018))

## **Best practices for waste Disposal Systems in wetland conservation efforts**

It's critical to preserve the environment, public health, and standard of living. When it comes to wetlands, effective waste management enhances public health by preserving wetlands and expanding their functions.

Implementation of community-based, policy-supported, and cost-effective strategies can improve sustainable waste management. According to Patel (2024), Muscad (2022), and Golmarvi et al. (2018) all support the sustainable waste management best practices listed below.

- i. Waste prevention
- ii. Waste reduction
- iii. Recycling and reuse
- iv. Incineration
- v. Landfill disposal
- vi. Composting
- vii. Anaerobic waste digestion
- viii. Waste collection

This figure you see below is the plan that the researcher made as a recommendation if the wetlands were to be developed in this way in the future.



Figure 5.1: Recommended development design of wetland areas (source: design by the author, 2024)



Figure 5.2: Recommended development design of wetland areas (source: design by the author, 2024)



Figure 5.3: Recommended development design of wetland areas (source: design by the author, 2024)



Figure 5.4: Recommended development design of wetland areas (source: design by the author, 2024)



Figure 5.5: Recommended development design of wetland areas (source: design by the author, 2024)

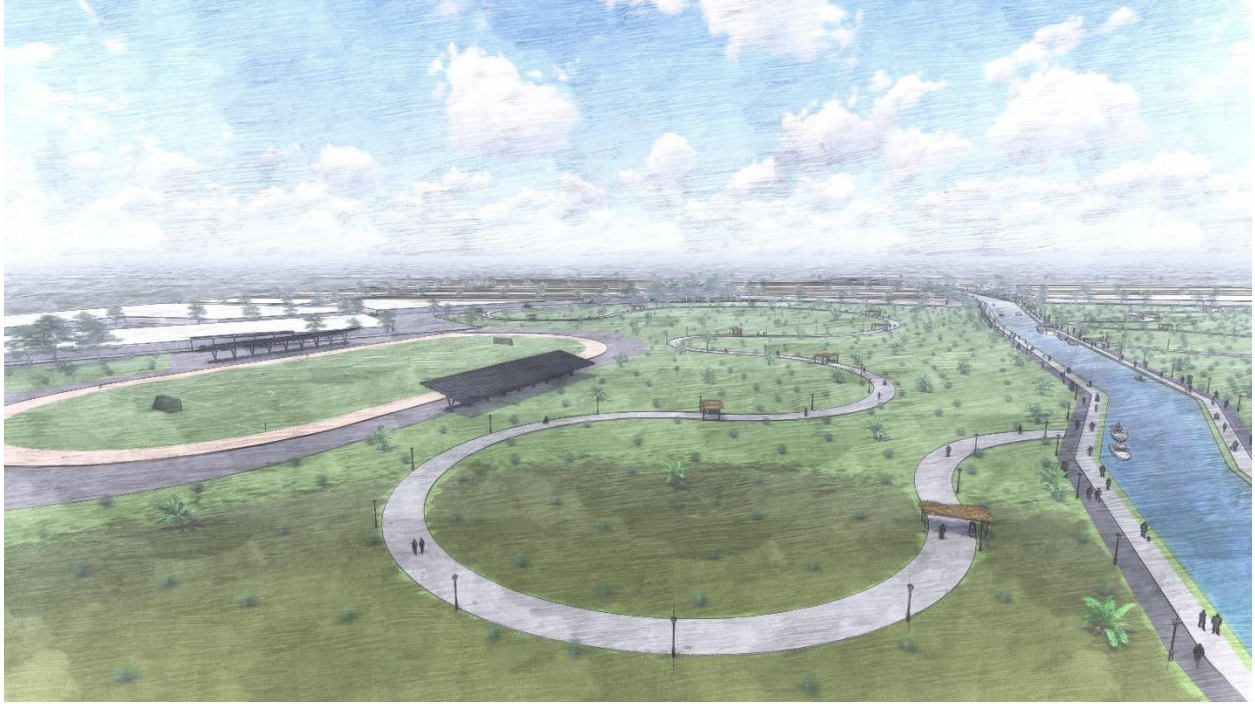


Figure 5.6: Recommended development design of wetland areas (source: design by the author, 2024)



Figure 5.7: Recommended development design of wetland areas (source: design by the author, 2024)

## **End Notes**

Even though it's hard to delineate and evaluate each wetland area around Bahir Dar city, I think I have fulfilled my research goal and objectives as I programmed. But for the future in my advanced research papers, I want to study it and by including more wetlands near the city, I will try to help in the effort to create a sustainable and comfortable city by showing and highlighting their environmental, economic, and social benefits.

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## **Annex I: Publishable Manuscript**

### ***Monitoring Urban Wetlands for Sustainable Urban Planning: The Case of Bahir-Dar City, Ethiopia***

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## ABSTRACT

**Background:** The urban wetland ecosystem is the most overlooked habitat, and its services and values have not been well appraised. There are many wetlands in Bahir Dar city, but it hasn't received adequate attention and acknowledgment. By observing the problem, this study has been conducted to assess urban wetland monitoring in Bahir Dar city for sustainable urban planning and management.

**Methods:** In the study, an explanatory research approach was employed along with survey methods. Throughout the investigation, a lot of descriptive statistics and analysis were conducted, together with thorough contextual assessments. The wetland dynamics quantification, which is based on satellite imagery is utilized to assess the biophysical environment using ArcGIS and Envi-Met simulation modeling tools; residents, governmental and non-governmental organizations are also considered to assess the socioeconomic aspects.

**Results:** In the end, the study identified around 20 wetlands in the city, with 45% being perennial and 55% exhibiting seasonal variations. These wetlands have great ecological importance to the residents of the city. However, poor solid and liquid waste management, lack of awareness, lack of legal framework, and urbanization are the primary challenges wetlands face to function sustainably in the urban landscapes of the study area.

**Conclusion:** The study concludes that the benefits of wetland landscapes are not adequately prioritized by urban planners and decision-makers, which impedes their potential benefits. Finally, the research recommends the improvement of waste management, raising stakeholder awareness, strengthening legal frameworks, and monitoring urbanization that can ensure the ecological importance of wetlands for dwellers.

**Keywords:** urban wetlands, wetland ecosystem, sustainable urban planning, ecosystem functions, Bahir Dar

## INRODUCTION

The United Nations estimates that 55% of the world's population presently resides in cities. By 2050, this percentage is anticipated to increase to 68% [1]. The natural infrastructure is being affected and its innate sustainability process is being disrupted by this expanding trend of urbanization, both in terms of area and density [2]. Additionally, it has a negative impact on the biological processes and health of the urban environment, including biodiversity loss, water pollution, and vegetation deterioration [3]. Furthermore, relative to their surroundings, urban centers often have less vegetation and water, and the current green and blue infrastructure is frequently endangered by growing human density [4].

One of the best natural resources in urban settings is said to be wetlands. With their extensive range of functions, wetlands are one of the most significant green-blue infrastructure elements. However, there is no single definition of wetlands that is recognized worldwide due to the diversity of wetland varieties [5]. Wetlands can be found in a range of hydrologic, climatic, and geographical contexts and also size, shape, plant, soil, and hydrologic conditions are all different. Despite these variations, wetlands can still be divided into different categories based on their shared traits. But generally, wetlands can be defined as “expanses of marsh, fen, bog, or water, whether organic or artificial, long-lasting or momentary, with still or moving, fresh, brackish, or salt water, including marine waters whose depth at low tide does not exceed six meters” [6].

Urban and peri-urban wetlands are providing a variety of benefits and services to the community and sustainable urban planning. Wetlands not only offer habitat for plants and animals and simple access to educational opportunities for learning about the environment, but they also store water, enhance water quality, lower pollution, and offer protection from natural disasters by delaying flooding, lowering the danger of fire, and preventing erosion of river banks and beaches [7]. In addition to acting as urban green spaces that offer aesthetic appeal, landscape diversity, and recreational opportunities, wetlands and associated vegetation can provide a cooling effect to surrounding areas in the summer and moderate strong winds [7]. They can also contribute to the wellbeing of the community by supporting cultural heritage, spiritual values, and daily life of people [7].

Due to urbanization and human interference, 50% of the world's wetland has vanished in the previous few years [8]. Since 1900, 64% of the world's wetlands have vanished, even more is lost in some areas, such as Asia and Africa because of wetlands and their advantages are being lost, that's way urban wetlands are vanishing more quickly than coastal ones [9]. Due to the fact that the majority of these valuations have been carried out in Europe, North America, and China, there is a knowledge vacuum regarding the valuation of urban wetlands in developing nations [10]. In the past, Panama City in Panama, New Orleans in United

States, Haikou in China are some of cities that have been at the forefront of making positive changes to protecting their urban wetlands by integrating them with urban planning.

Marine/coastal, inland, and man-made wetlands are the several types of wetlands found in sub-Saharan Africa. They constitute rich and diversified sanctuaries for biodiversity conservation, eco-filters, climate regulation and flood-water retention. Their values are of considerable economic, cultural and ecological relevance to numerous stakeholders at local communities, national and global levels. The primary concerns that contribute to the degradation/loss of wetlands in Africa include both natural reasons (e.g., from climatic conditions such as drought) and manmade factors (e.g., deforestation, dams' construction, urbanization and bad management) caused by population expansion and economic development [11].

However, a wetlands strategy is soon to be developed, and mangrove/wetland conservation and sustainable use problems are being mainstreamed within it. This long-term mainstreaming task can be traced back to the signatories of international wetlands-related conventions, such as the Ramsar Convention of Wetlands, which were then translated into national action programmes, including institutional development at the local, national, and regional levels focusing on issues of sustained livelihood and poverty alleviation and coming under various integrated approaches, such as integrated approach to urban and wetland planning [11].

Many wetlands in Ethiopia are recognized for their biodiversity even though Ethiopia has not ratified the Ramsar Convention on Wetlands of International Importance. However, the abundance and distribution of wetlands in Ethiopia are still unknown, in part due to inconsistent methods used to identify and delineate them as well as issues with weak sustainable use [12]. According to estimates, wetlands make roughly 1% to 2% of the country's total land area [12]. They mainly take the form of lowland floodplains like those in Bahir-Dar city, upper Blue Nile basin, Northwestern Ethiopia, highland riverine swamps throughout the central plateau, and lakes in the Rift Valley.

Scientific urban planning must be used to integrate wetlands into urban landscapes in order to encourage long-term growth. In order to create a thorough urban development plan that carefully considers the relationships between environmental resource-impact relationships, urban planners must work closely with and communicate with hydrologists, policy makers, developers, and the local community at large. Therefore, it is necessary to research how wetlands affect urban areas and the people that live there.

## METHODS AND MATERIALS

### The study area

The study focused on the wetland areas of Bahir Dar City. Bahir Dar is the capital of Amhara National Regional State's. The absolute location of Bahir Dar City is 11°30'26" N to 11°39'34" N latitude and 37° 16'36" E to 37° 29'17" E longitude. Regarding the relative location, Bahir Dar City is one of the largest cities in the northern part of the country, which is away 500 km from the capital of Addis Ababa. Its average elevation is 1830 meters above sea level and it is situated in the northwest highlands of Ethiopia.

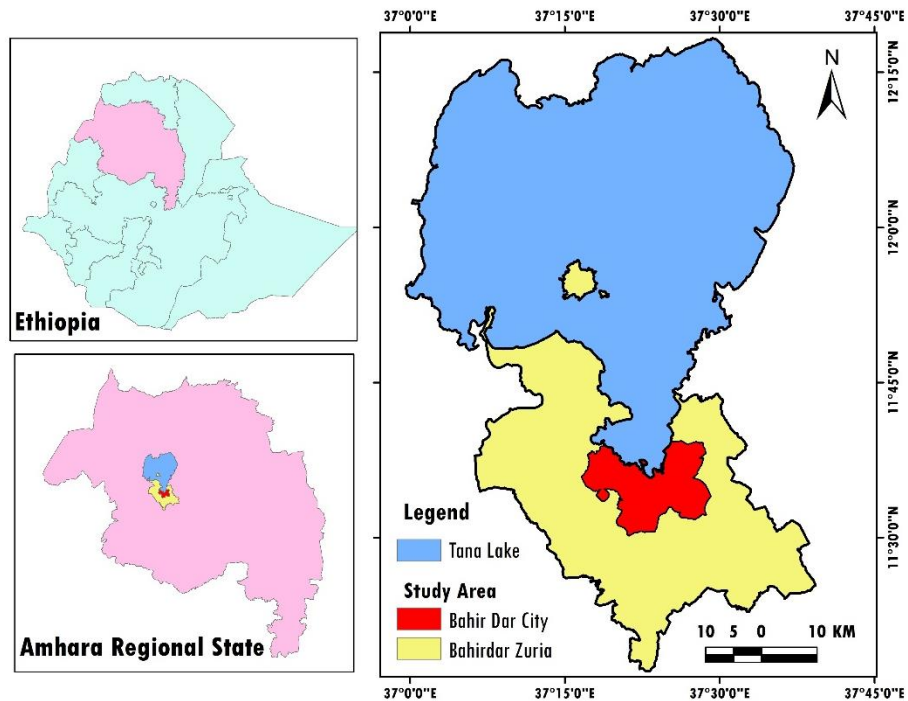


Figure 1: Map of study area (Source: organized by the author, 2024)

### Data collection Instruments

Different data collecting techniques are employed by the researcher based on the research objectives. The researcher employed both qualitative and quantitative research techniques and thus the research used mixed approach.

### Source of Data to achieve the first research goal of this study

#### *Landsat imagery and observations*

To achieve the first research goal of this study, which is to identify the principal wetland areas of Bahir-Dar and its environs using Landsat imagery. This data analysis is very useful for depicting the magnitude and

particular location of wetlands. Furthermore, the quality of ecosystem physical observations was used to collect and validate data in connection to soil type, vegetation cover, and hydrological content in the surrounding area.

### **Source of Data to achieve the second research goal of this study**

#### ***Landsat imagery, interview and questionnaire***

The second research objective of this study is to evaluate the major landscape functions of the wetlands in the area, in this case the study quantitative data of remote sensing data from Landsat images to demonstrate the relationship of urban wetlands with the local climate and qualitative data of secondary source of data from sub-cities to find out how many citizens are economically benefited in their district using wetland features and interview and questionnaire specially with people who were commonly known as “woyto” community to determine the impact and function of urban wetlands on recreational, economic and urban cultural preservation is gathered. To collect the sociocultural benefits of the wetlands the research takes in to consider survey questionnaire with weyto community. Although the study covers the whole area and the surrounding communities of Bahir Dar city, the weyto community are the smaller groups in the city that live together and are closer to wetlands and their day-to-day activity and livelihood is highly dependent on these wetland resources. Because of this, the questionnaires of the study are focused on these community classes.

#### ***Sampling techniques***

In total, 678 households settled in 4.8 hectares of land in the community of Woyto, and because of time and budget limitation only 330 samples households are used for the study and each household unit is selected randomly. To compute the economic, environmental and recreational values of the wetlands the research obtained the main data from the wetland covers maps showing the temporal dynamics of the resource, concerned government and nongovernmental organization reports and expertise interview, observation and key informant’s interview.

### **Source of Data to achieve the third research goal of this study**

#### ***Geospatial image, interview and questionnaire***

The third research objective of this study is to identify the primary challenges wetlands face in order to function sustainably in urban landscapes of Bahir-Dar city. In this part, the main data is obtained from the wetland maps generated from geospatial image processing. Besides, interview and questionnaire survey is carried out to find out the views of closely related governmental and non-governmental institutions and stakeholders on the factors that affect wetlands to provide sustainable benefits to the city inhabitants. As a

secondary data sources, documents and proclamations related with urban wetlands specially to identify to the gap related to legal frameworks.

In addition, in order to determine the wetlands' ecological/ environmental, and recreational significance as well as the main obstacles they face in Bahir-Dar City landscape, some of the quantitative data are gathered from governmental and non-governmental organizations and other stakeholders that are closely related to the issue, including; -

- Nile Basin Authority
- Bahir Dar city urban plan preparation and management Bureau
- Urban Planning Institute
- Bahir Dar City and Infrastructure Department
- Lake Tana and other water bodies protection and development agency
- Bahir Dar City Water and Sewer Office
- Bahir Dar city administration cleaning and beauty office
- Bahir Dar City Administration Culture, Tourism and Sports Department
- Amhara Region Environment and Forest Protection Bureau
- Ethiopian Biodiversity Institute ... on the factors that hinder wetlands from providing sustainable benefits to the city. Five questionnaires for each institution. 10 institutions with 50 questionnaires

### **Method of data analysis**

The study makes use of both quantitative and qualitative data analyses. To analyze the quantitative data, the geospatial modelling and statistical tools are used. For qualitative data analysis, narration, description and discussions of the data obtained from interviews, document review and observations.

***For the first objective of the study***, Remote sensing data from Landsat images to delineate wetland features of the area are analyzed using Geographical information system (GIS) environment, that helps to identify and map the wetland areas in the study area and to measure the area covers. Then, the study uses descriptions and photographs to visualize the compassions of the ecosystem and to confirm wetland regions that were outlined using a GIS tool showing their typical soil, plant, and hydrological volume.

***For the second objective***, the study selected two wetlands representing all others in terms of size of the area feasible to assess the ecosystems functions. Thus, the selected wetlands taken as a case study area to calculate the ecosystem value. the specific place taken here is Kebele 8, locally known as Gambi area. The two selected case study wetlands are Sent Merry and old radio station neighborhood area. The wetlands ecological, socioeconomic and recreational values are computed.

To compute the ecological or environmental value, in this work, the ecosystem service values (ESVs) of various LULC modifications were estimated using the benefit transfer approach. In the event that site-specific valuation data is unavailable, the benefit transfer approach involves estimating the equivalent site values (ESVs) of other comparable places based on information already available from the original study site [13]. Using data provided by [14], the researcher adjusted tropical area coefficients on regional estimates of ESVs to determine the ESVs of the LULC types in the Mariam Sefer Wetland area, who used cautious estimations of ESV coefficients, based on values from studies conducted in places close to the geographical context of our study area, to conduct a study on LULC and ESVs in Ethiopia.

The three primary ESs—supply, regulation/monitoring, and provision—are included in these ESVs [14] and using the most recent global coefficients as well provided by [15]. Therefore, the following Equation was used to determine the ESVs for all LULC types for each period [15]

$$ESV = \sum_{k=0}^n Ak(VCK)$$

where, ESV is estimated ecosystem service value, Ak is the area (ha) of LULC type k, and VCK is the value coefficient in US\$ ha<sup>-1</sup> year<sup>-1</sup> for LULC type k.

Then to measure the cultural socioeconomic value of the wetlands questionnaire survey data collected from different stakeholders and the community group is evaluated with some descriptive statistics and frequency distribution tables. and secondary source of data from sub-cities to find out how many citizens are economically benefited in their district using wetland features and to identify wetlands recreational and cultural value.

***For the third objective of the study***, discourse analysis is conducted from data obtained from stockholders in the form of interview and questionnaire survey, which could be analyzed with description statistics and frequency tables. and thorough description, narration and discussions of the results obtained from documents and proclamations to identify primary challenges of wetlands face to function sustainably in urban and peri-urban landscapes of Bahir Dar city.

## RESULTS

### Mapping the Major Wetlands and their status

In fact, compared to the county's urban centers, the study area is widely known for having a substantial amount of wetland resources. According to the findings of the GIS-based analysis, about 20 wetlands are identified in the city and each of these wetlands have different size. Among them, the smallest wetland area is 3.3 hectares of land, which is located a bit far away from Lake Tana and Abay River. The largest one is

found at the coast of Abay, which occupied 198.2 hectares of land. These wetlands in the city cover a total area of 1016.3 hectares, and 45% of them are located on the coastal area of the Tana or Nile River, and the remaining 55% of them are surrounded by dry lands in the city center. The wetlands that are existed in coastal part of Tana and Abay are perennial, while the wetlands surrounded by dry lands are fluctuating seasonally. They shrink in size during the dry season they become relatively wider in the wet season. The map of the wetland environment of the Bahir Dar city is presented is visualized in figure 3.

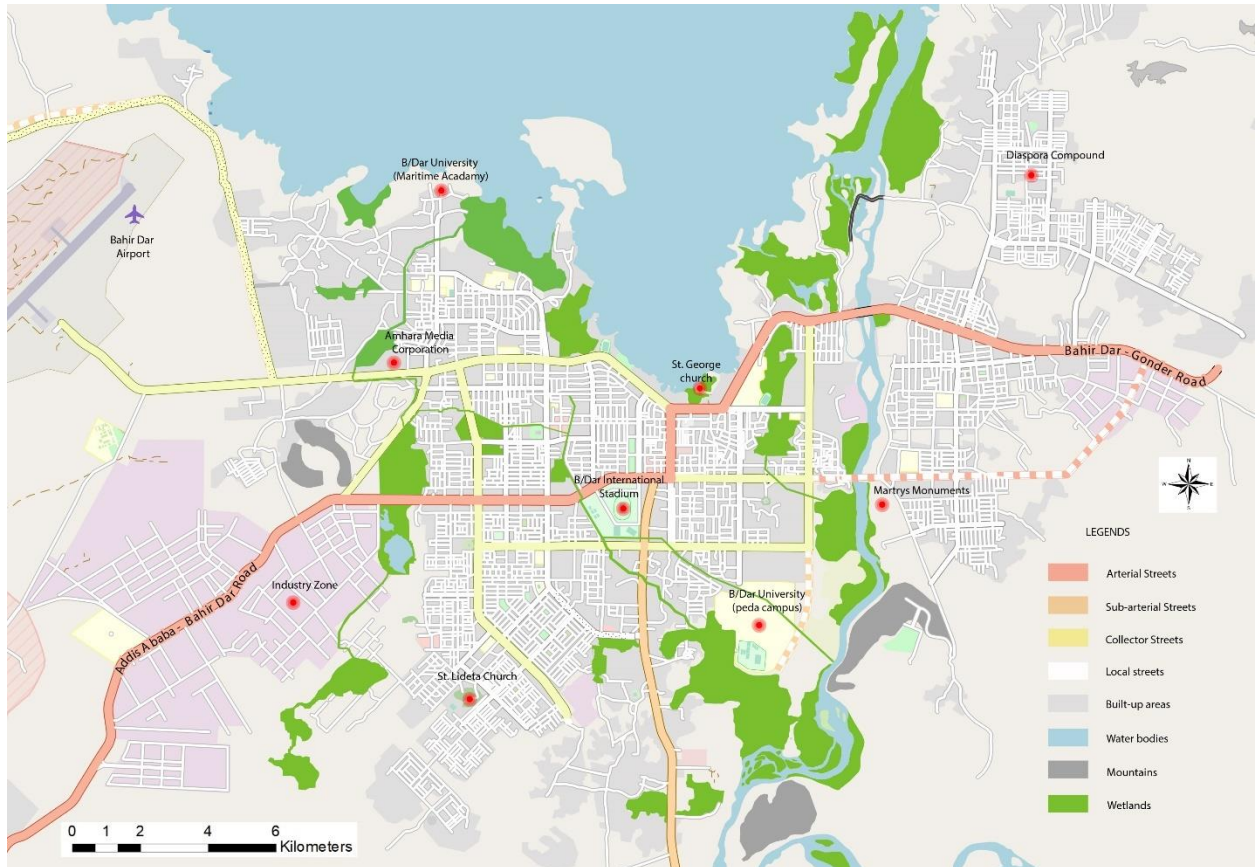


Figure 2: The wetlands configurations identified in the study area (Source: organized by the author, 2024)

### The size and seasonal characteristics of the wetlands

As indicated in detail above, there are about 20 wetlands in total, and the size, condition and type of land they occupy are shown in the table below.

**Table 1:** size, condition and type of wetlands

No.	Name	Type	size (hectare)	Condition	
				Seasonal	Non-seasonal
1	Wetland area I	Costal	198.2		✓
2	Wetland area II	Costal	13.35		✓

3	Wetland area III	Non-coastal	7.8	✓	
4	Wetland area IV	Costal	147.6		✓
5	Wetland area V	Costal	68.4		✓
6	Wetland area VI	Costal	8.1		✓
7	Wetland area VII	Non-coastal	11.4	✓	
8	Wetland area VIII	Non-coastal	109.6	✓	
9	Wetland area IX	Non-coastal	2.5	✓	
10	Wetland area X	Non-coastal	19.1		✓
11	Wetland area XI	Costal	73.6		✓
12	Wetland area XII	Costal	37.7		✓
13	Wetland area XIII	Costal	191.1		✓
14	Wetland area XIV	Non-coastal	22.8		✓
15	Wetland area XV	Non-coastal	18.6	✓	
16	Wetland area XVI	Non-coastal	31.1	✓	
17	Wetland area XVII	Non-coastal	3.3	✓	
18	Wetland area XVIII	Non-coastal	34.9	✓	
19	Wetland area XIX	Costal	13.8		✓
20	Wetland area XX	Non-coastal	3.3		✓

(Source: organized by the author, 2024)

Interestingly, as we see in figure 3, most of these wetlands that are identified in this study are connected to each other by thin marshy canals with flowing water. If these canals can be systematically protected and developed; Besides adding to the attractiveness of the area, they can be alternative waterways for transportation. In addition to this, it is known that Bahr Dar city is among the cities that are affected by floods in winter. Dega Damot and Bahir Dar Zuria districts from the West Gojjam Zone of the Amhara National Regional State were designated as flood risk zones by the Ethiopian National Disaster Risk Management Commission during rainy seasons [16]. If these wetlands can be protected, they have an important role in reducing the risk of flooding.

### **Functions of Wetland in the urban landscapes**

Based on the questionnaires that the researcher conducted with the community regarding the environmental, cultural and economic importance of wetlands, the researcher found the information below.

### **Ecosystem service value in terms of money**

As it is stated in the methods section, in order to measure the main ecosystem services, the study take into consider only the selected wetlands as a case study area. The wetland that is used for calculating the ecosystem value is the specific place locally known as Gambi, which is found in Kebele 8 when it is evaluated in its change through time, it covered 28.75 hectares of land in 2005, but in the same month of 2023, its area has decreased to 20.02 hectares. The study estimated the ESVs on the current study based on

the coefficients used in various studies in the tropical regions because all ESV estimations are based on studies from the study area itself or locations from the same biome, but not necessarily from the same topographic settings. The ESVs in the current study decreased to 19759.74 US\$ ha<sup>-1</sup> year<sup>-1</sup> in 2023 from 28376.25 US\$ ha<sup>-1</sup> year<sup>-1</sup> in 2005. According to the research, ESVs in the 8.73ha study region had decreased by 8,616.51 US\$ ha<sup>-1</sup> year<sup>-1</sup> over the previous 18 years.

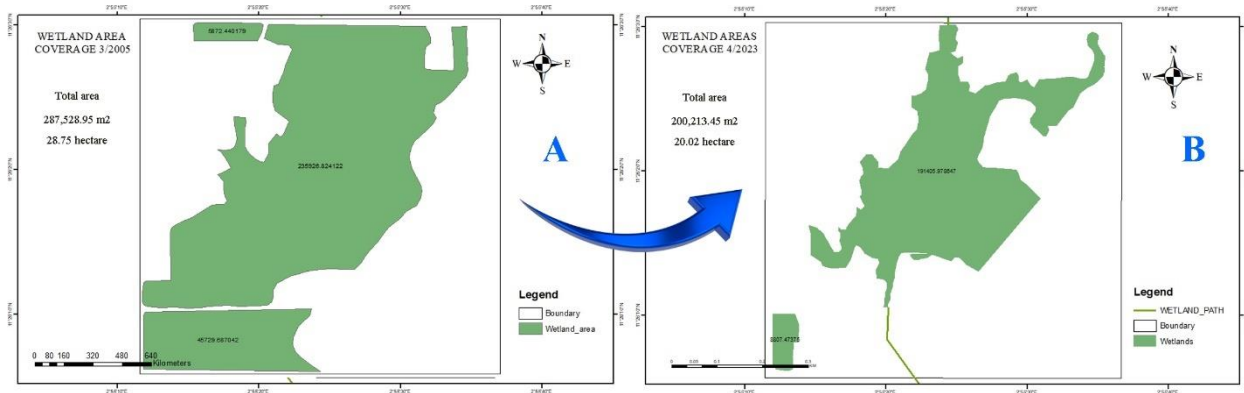


Figure 3: LULC of Gambi, Kebele 8 wetland area (source: organized by the author, 2024)

### Environmental significance

According to the information we got about the environmental importance of wetlands, 93% of the respondents believed that wetlands have environmental importance by giving the benefits like; creating a suitable and comfortable local air condition in their site, facilitating plants growth, and making the sceneries attractive to inhabitants. However, 7 %of respondents believe that wetlands have a negative environmental impact, citing mosquito breeding as one of the reasons.

In response to overwhelming positive feedback from the community, the researcher has scientifically proven the importance of wetlands to the atmosphere. Taking one wetland in the city and using Envi-met simulation software, the researcher tried to show what kind of local climate change would result if it is protected and destroyed.

### *Case Area I – Maryam sefer (Sint Merry Neighborhood) wetland area*

This is *Maryam sefer* (Sint Merry Neighborhood) wetland area which is located on Kebele 08 behind Gambi Medical college and covering 20.02 hectare of land. Figure 34 shows that the simulation result of potential air temperature and flow pattern that estimates how much local climate change will occur if it is preserved and destroyed.

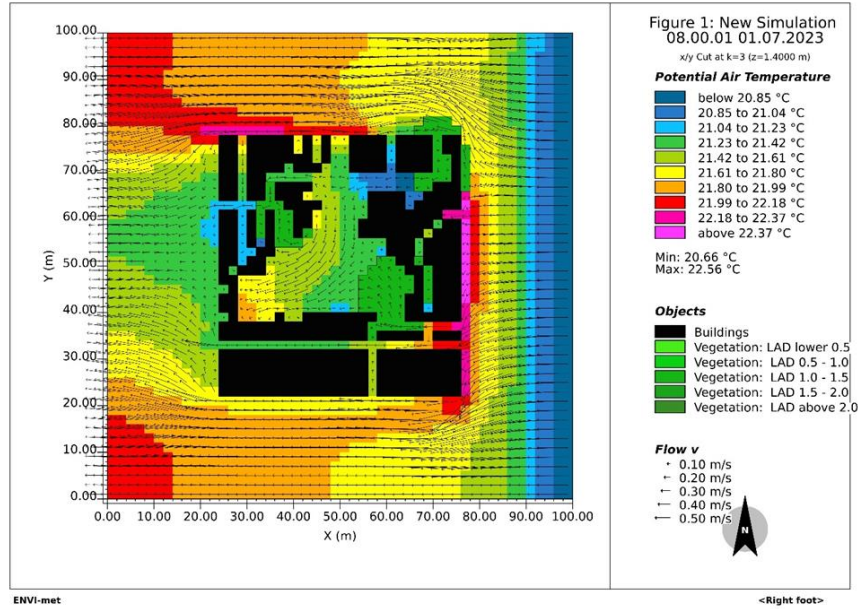


Figure 4: Simulated potential Air Temperature result of Sint Merry Neighborhood wetland area  
(Source: organized by the author, 2024)

As shown in figure 4, if the wetland area can be protected, the local climate was between 20.66 and 22.5 degrees Celsius on average, and it indicates that there was comparatively good air condition in the area compared with the second scenario.

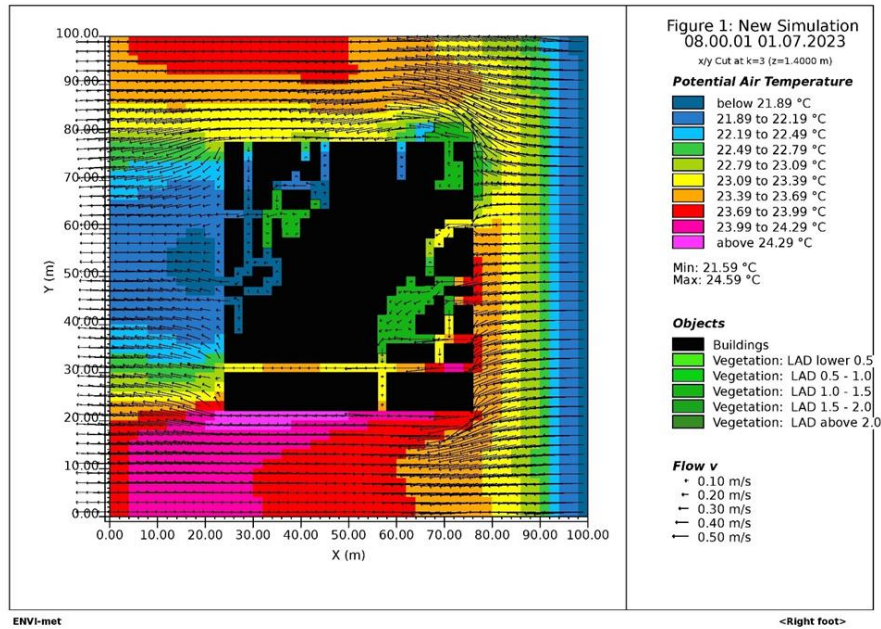


Figure 5: Simulated potential Air Temperature result of Sint Merry Neighborhood wetland area

(Source: organized by the author, 2024)

As shown in the figure 4.31, if the wetland in the area is destroyed, the local climate would be change between 21.59 and 24.59 degrees Celsius, and there wouldn't be good climate circulation in the area. If the wetlands in the area are lost, the local climate would increase from 20.66 to 21.59 degrees Celsius, and the maximum would rise from 22.56 to 24.59 degrees Celsius. If the wetlands disappear, rapid air pressure and circulation will be reduced and disrupted.

### Cultural and Economic significance of the wetlands in the study area

According to the information we obtained about the cultural importance of wetlands from the selected households of Woyto community, 53% of participants' source of income are related to urban wetlands.

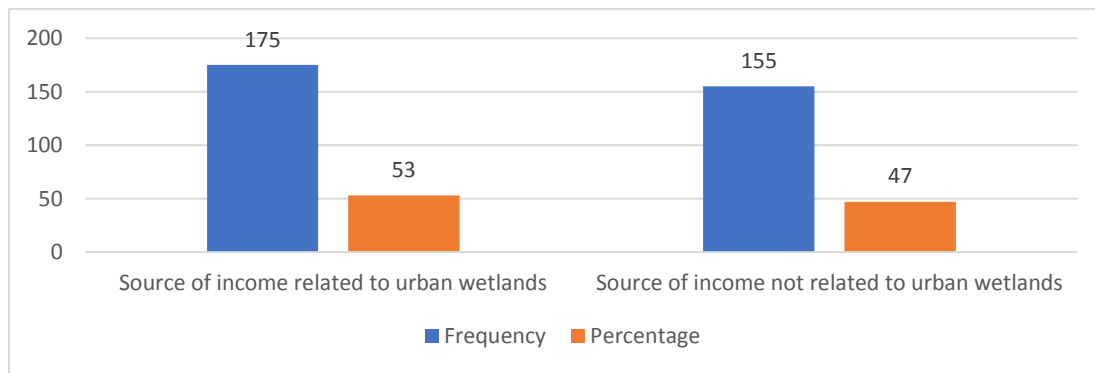


Figure 6: Graph of sources of income (Sources: Organized by the author, 2024)

175 of the participants whom the source of income is linked with urban wetlands; most them work in traditional crafts 57%; 23% of them work on selling Nile grass (ch'efe): 17% of them work fishing by making canoes and the remaining 3% work on urban farming on wetland peripheral area.

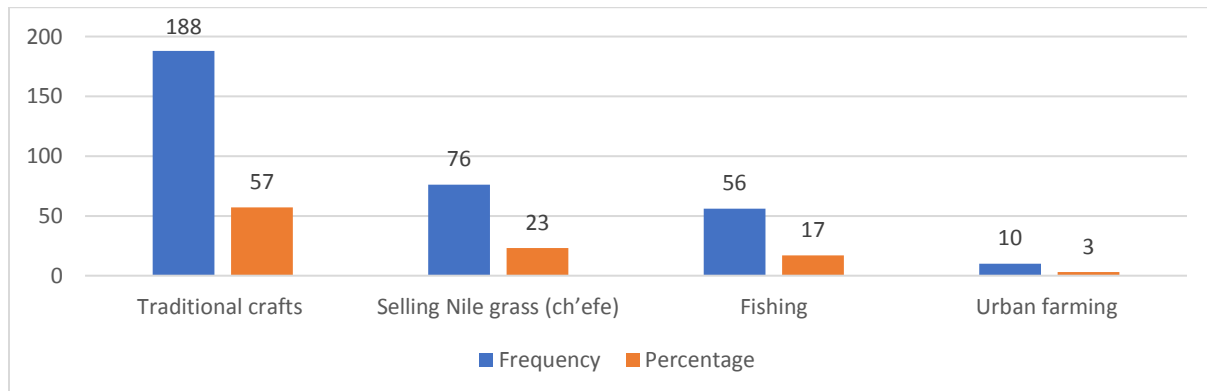


Figure 7: Graph of Types of Work (Sources: Organized by the author, 2024)

In Bahir Dar city, there is a traditional festival called “January in Bahir Dar” which is organized every year by the Bahir Dar City Administration Culture, Tourism and Sports Department. Canoe is a traditional form of water transportation and is an indigenous resource used for fishing. Abraham Asefa, who is the head of the culture, tourism and sports department of Bahir Dar city administration, told us during the interview that this is a big economic base in addition to preserving culture.

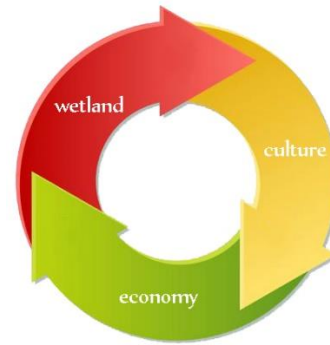


Figure 8: Traditional festival by Canoe (Source: organized by the author, 2024)

According to the research conducted by the researcher in the community of Wyoto, 53% of the total 678 household have a direct relationship with the wetlands as their source of income and 53% of the community in woyto tribe; With an average of 4 people per family, the source of income is linked to urban wetlands, and 90% of family members earn between 1000 and 4000 Ethiopian Birr per month; The remaining 10% earn more than 5000 Ethiopian Birr per month.

Traditional handicrafts, urban farming, fishing by making canoes, and selling Nile grass (ch’efe) are the types of jobs created by the communities in these urban wetlands, but traditional handicrafts are more important sources of income than other types of work.

### **Recreational significance**

Based on the information on the recreational value of wetlands, 73% of respondents believe that wetlands have environmental value because they are a place to listen to oneself. After all, they are visually appealing and attractive, and because of the favorable climate in the area. This participant used this place for different types of recreational activities; of them, 7% of them used it for hiking; 18% of them used it for fishing; 32% of them used it for bird watching and setting and 43% of them used the place for photography purposes.

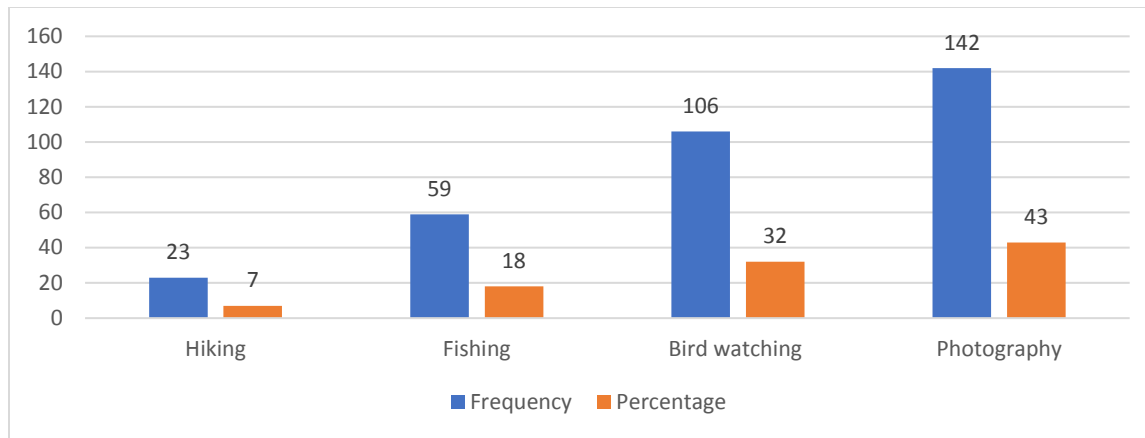


Figure 9: Graph of Recreational Activity rate (Sources: Organized by the author, 2024)

### **The major Challenges wetland landscapes face**

Wetland ecosystems are extremely delicate and susceptible to harm from even little alterations in their surroundings. The wetlands within and around the urban system are experiencing an increasing amount of trouble. Offices located in the city and considered by the researcher to have a direct relationship with the study, such as Nile Basin Authority, Bahir Dar city urban plan preparation and management Bureau, Urban Planning Institute, Bahir Dar City and Infrastructure Department, Lake Tana and other water bodies protection and development agency, Bahir Dar City Water and Sewer Office has interviewed about the importance of wetlands in the city and the obstacles or challenges to their proper use. Based on the information obtained by the researcher, the following are mentioned as challenges; Weakness of municipal solid waste management (MSWM) and failure to update the liquid waste disposal system, Lack of awareness of stakeholders, Lack of legal framework, Urbanization.

#### ***Weakness of municipal solid waste management and liquid waste disposal system***

Since solid waste disposal is a multi-faceted and challenging issue, it is well known that developing countries, beyond Bahr Dar city administration, are faced with high waste production and ineffective handling. Based on the information received from the Municipal Solid Waste Management Office of Bahir City Administration, the main issues of the solid waste disposal system were identified and a survey was conducted to provide statistical guidelines for effective management of solid waste. The municipality generates 421.215M3 solid waste per day that makes the city the second largest after Laga Tafo in relation to their population with SW generation rate of 0.44 kg/c/d and the results show that solid waste collection and sorting system was weak, waste composting and recycling efficiency was very low, waste transportation and disposal management were not standardized and environmentally sound. As a result, according to the

data of the Bahr Dar City Administration’s Cleanliness and Beauty Office, the wetlands in the city are being used as solid waste dumps, and the researcher was able to realize this when he looked around the city.

Human waste from industry and residential use pollutes the environment. There is no standard municipal waste water collection and treatment system in Bahir Dar Town. Due to inadequate sanitation facilities, people were forced to urinate outside and discharge raw waste water in unsuitable locations, which contaminated wetlands. According to the researcher’s finding, 62 percent of the respondents discharge their waste water into the streets and fields.

As we see from the above figure, the liquid waste dumped on the roads combined with the city’s topography, seeps into the wetlands during the rainy season, resulting in these areas being polluted. In this regard, environmentalists can study the level of pollution of the wetlands caused by this problem and also, because the wetlands’ liquid waste filtration process has been scientifically proven, researchers can study how much they can reduce the amount of liquid waste entering Lake Tana.

### ***Lack of awareness of stakeholders***

The findings of this study indicate that the lack of understanding of the stakeholders that wetlands are a challenge to prevent them from providing environmental, social, and economic value to the community or reduce their contribution to sustainable development. Interviews with stakeholders responsible for wetlands indicate that most sector offices are making efforts but have not done direct work in these areas. According to the survey done by the researcher, only 18% of the institutions are doing direct activities from the stakeholders in the city; of these Lake Tana and other water body protection and development agencies and the Urban Planning Institute are mentioned.

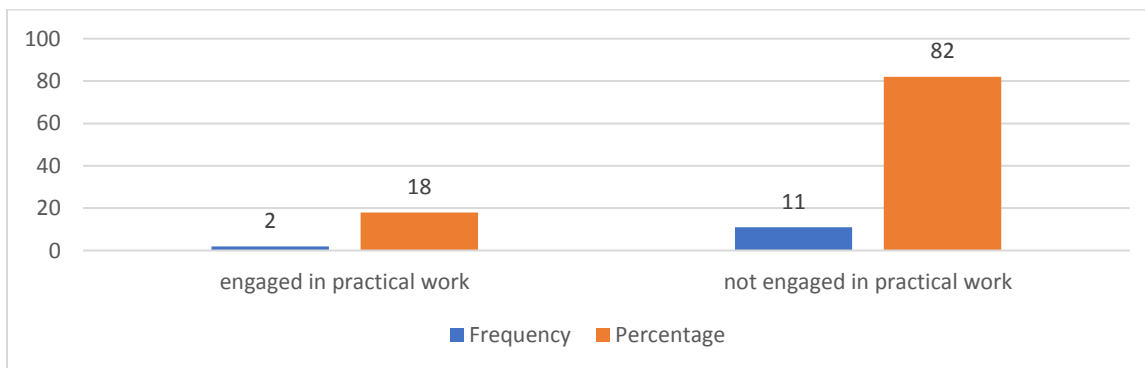


Figure 10: Practical activity rate of stakeholders (Source: organized by the author, 2024)

### ***Lack of legal framework***

Through interviews conducted by the researcher with stakeholders close to wetlands, it was confirmed that there is no direct legal framework for wetlands at the city or national level.

The 1994 Ethiopian Constitution, which has a broad environmental scope and identifies the environmental values to be safeguarded and protected, was the first step in incorporating environmental concerns into the supreme law of the land. The rights of Ethiopian citizens to a clean and healthy environment are outlined in Articles 44 and 92. According to the Constitution, both the government and the people have a responsibility to conserve the environment, and projects and programs should not be created or carried out in a way that endangers the environment.

The Ethiopian National Conservation Strategy was developed by the Environmental Protection Authority (EPA), which was established in 1995. As part of this strategy, the EPA incorporated the need to protect and restore wetlands in order to preserve water resources and, when necessary, to carry out environmental impact assessments of development projects.

There is currently no national explicit coordinated policy for wetlands in Ethiopia (no national Wetlands Policy), despite growing interest in them. Instead, wetlands have held a cross-sectoral position in the frequently incoherent policy of several government bodies. However, if urban wetlands are to be used for sustainable urban planning and management, we need to develop a consistent national policy and sign wetland-based agreements such as the Ramsar Convention. Due to the social, economic and environmental importance of wetlands, they should be studied as an independent thematic area in urban planning.

### ***Urbanization***

The biggest danger to wetlands is frequently land use planning and legislation. As a result, there might be less available land, which would put pressure on wetlands as a potential source of additional land.

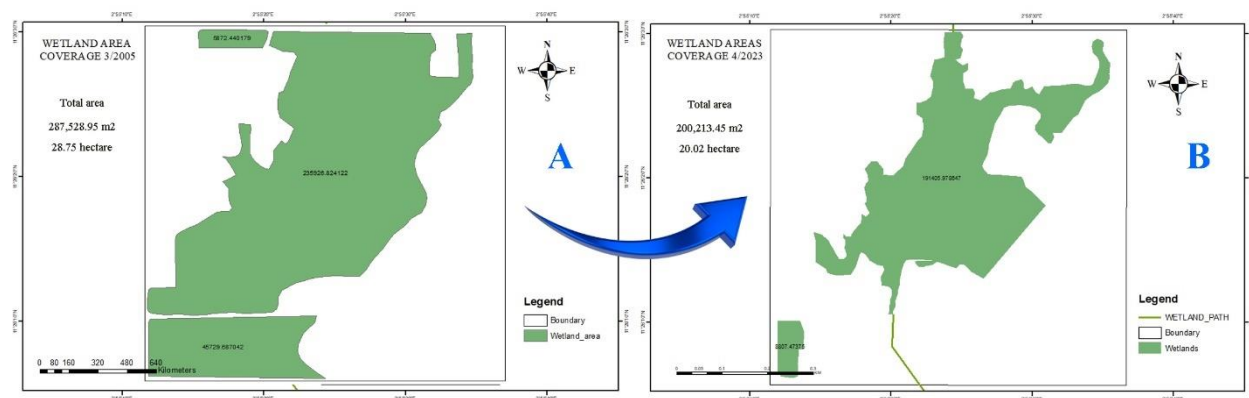


Figure 11: Urbanization influence on wetlands (Source: organized by the author, 2024)

The wetland we are referring to above is one of the wetlands identified in the study. According to the European calendar, it covered 28.75 hectares of land in 2005, but in the same month of 2023, its area has decreased to 20.02 hectares. This means that in just 18 years, 8.73 hectares or about 87300 square meters of wetlands have been lost. If it continues at this rate, we could lose this wetland in less than 50 years. Therefore, we need a big change, policy and implementation in our urban land use.

If this scenario is continued the future trend will lead to destined to loss this precious resource. Based on this assessment just after 18 years, about 8.73 hectares of wetlands will be lost. Unless, some intervention mechanisms introduced the ecosystem will totally be lost with less than 50 years.



Figure 12: Wetlands as a construction area (source: photo by the author, 2024)

As we can see in the picture above, it can be observed that the wetland areas in the city are filled with soil and used for various types of construction.

### **Wetland conservation planning and management approaches**

The study has demonstrated the importance of monitoring urban wetlands for sustainable urban management and planning. It is inappropriate to employ just the restriction of human activity for nature protection, since wetland conservation has been used for production. For the Wetland Conservation Plan (WCP), thus, the ecosystem-oriented and awareness-oriented techniques should be used.

The primary techniques used for WCP are as follows: a) recognizing the city's biodiversity; b) protecting and conserving the wetland vegetation; c) enhancing the role of wetlands; d) encouraging ecotourism as a means of protecting the environment; and e) concentrating on environmental education and public awareness.

During the I survey, the researcher realized that ecologically based approaches are effective in protecting and managing wetlands. These approaches consist of 5 main procedures, which are 1) Identification of

wetlands 2) To know the environmental, social and economic importance of wetlands and understand the problems caused by their disappearance 3) Establishing a legal basis supported by policy 4) Creating a coordinated system of stakeholders 5) Doing community awareness work.

In order to conserve wetlands and use them for sustainable development, it is necessary to carefully identify the areas where they are located. To do this, using high quality satellite image and conducting physical observation will allow us to identify places more. Continuing from that, it is necessary to know the environmental, social and economic importance of these places, and to understand the problems they will cause if they disappear. If possible, it is also necessary to know their political influence because at one point in the history of Ethiopia, Emperor Tewodros II wanted to make his capital Bahir Dar a city, but at that time, the city was the location of many swamps, so he went to Gondar for fear of a malaria epidemic [17]. But now, studies are proving that wetlands are the basis of economic and urban sustainable development if they are properly managed. To show this, developed and developing countries are working on artificial wetlands. For example, environmentally friendly constructed wetlands in China are a case in point [18].

Thirdly, in order to protect and easily manage wetlands, it is necessary to establish a legal basis supported by national policy in addition to implementing international policies by identifying these areas and knowing their benefits. In this policy, who are the stakeholders and their role should be clearly defined. But, accepting international policies or approving national policies alone does not ensure the security of these areas; Instead, creating a coordinated system of stakeholders and raising awareness for the community will allow for sustainable protection and management of these threats.

## **CONCLUSION**

The ultimate motive of the study was to identify wetlands in the city and identify the environmental, social, and economic benefits they provide to the community to enable the preparation of a sustainable urban plan that takes wetlands into consideration. To do this, analyzes were made using technologies such as Arc Map GIS software and Envi-Met simulation and it was important to find and ask the community members and stakeholders in the city who are especially close to these places. In particular, the section of the community called Wayto has a special proximity to wetlands, so the analysis is based on them, and about six government offices that are responsible for these areas are also included in the analysis.

The analysis indicates that, there is about 20 wetlands have been identified in the city and each of those sizes are different. Among them, the smallest wetland area is 3.3 hectares of land and is located away from the coast, and the largest area of wetland, which is 198.2 hectares located on the coast. These wetlands in the city cover a total area of 1016.3 hectares. Interestingly, most of these wetlands were identified in this

study; they are connected to each other by thin marshy canals with flowing water. This is an indication of how much of a new look these places will bring to the city if they are developed.

According to the findings of the study, wetlands are important in terms of creating a suitable environment for the community, for example, they are a suitable place to plant plants and make the environment comfortable and attractive. In addition to this, the findings of the study indicate that they have a great potential and role in adjusting the local micro-climate.

Wetlands are of cultural importance, and one of the reasons is that the grass used for traditional ceremonies is found here, and the papyrus (dengel) plant, which is used to make other traditional crafts, is also found here. Among the handicrafts made from this plant. According to the findings of this study, 53% of the community in Woyto tribe; An average of 4.5 people per family, the source of income is related to urban wetlands, and 90% of family members earn between 1000 and 4000 Ethiopian Birr per month. The remaining 10% earn more than 5000 Ethiopian Birr per month. This indicates that wetlands are providing significant cultural and economic value to the community and moreover, if they are protected and developed, they ensure sustainable urban planning and development.

Apart from environmental, cultural and economic importance, the findings of the study indicate that wetlands are also preferred places for recreation. However, there are several barriers to these wetlands becoming part of sustainable urban planning. Among these, weak municipal solid waste management (MSWM) and non-modernization of the liquid waste disposal system, lack of stakeholder awareness, lack of legal framework and urbanization are the challenges identified in the study.

Sustainable urban planning and development may be accomplished by recognizing the value of wetlands to the community in terms of the environment, culture, and economy and by easing the difficulties they confront. Finally, the research recommends the improvement of waste management, raising stakeholder awareness, strengthening legal frameworks, and monitoring urbanization that can ensure the ecological importance of wetlands for dwellers.

**Limitation of study:** The research encounter limitations and challenges during the study seasons. Some of this major difficulty's may be: Limitation of well-organized data on wetland sites influence the strength of the research, regarding money, there is no sufficient budget that was given by the institute to do investigation on those sites, as the study mainly relies on visitation. Time wise, the study topic is the current issue of the city as one part of the country and it make difficult to cover all issues related with the topic.

**List Abbreviations:** MSWM = municipal solid waste management, GIS = Geographical information system, ESV = Ecosystem service values, LULC = Land use land cover change, EPA =Environmental

Protection Authority, WCP = Wetland Conservation Plan, UHI = Heat Island effect, USEPA = United State Environmental Protection Agency, USNOAA = U.S National Oceanic and Atmospheric Administration, EWCO = Ethiopian Wildlife Conservation Organization, EWNHS = Ethiopian Wildlife and Natural History Society, EWRP = Ethiopian Wetlands Research Project , IBCR = Institute for Biodiversity Conservation Research, CSA = Population and Housing Census Commission Central Statistical Authority, EBI = Ethiopian Biodiversity Institute

## DECLARATION SECTION

**Authors' contribution:** Dawit Malede contributed in proposal development, data collection, data analysis and writing the manuscript. Asfaw Mohamed (Dr.) participated in data analysis, writing the manuscript and edited the manuscript based on his rich experience in publication.

**Competing interests:** Authors declared that there was no conflict of interest between authors and between authors and institutions.

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## Annex II: Questionnaires

### Questionnaires 1 - for community

በባህር ዳር ከተማ ውስጥ የከተማ እና የከተማ ዳርቻዎች የእርጥበት መሬት ክትትል ለዘላቂ የከተማ ፕላን እና አስተዳደር በሚል ርዕስ በአ/አ ዩኒቨርሲቲ በከተማ ንድፍ ት/ክፍል ስር ለሚዘጋጀው ጥናታዊ ጽሁፍ ግብዓት የሚሆን መጠይቅ

ዳዊት ማለደ

በአ/አ ዩኒቨርሲቲ በከተማ ንድፍ ት/ክፍል ውስጥ የሁለተኛ ዲግሪ ተማሪ

ግንቦት 2015 ዓ/ም

ይህን ቃለ መጠይቅ ለመመለስ ፍቃደኛ በመሆንዎ በቅድሚያ አመሰግናለሁ!

### ክፍል አንድ

ይህ ቃለ መጠይቅ የተዘጋጀበት ዋናው ዓላማ የጥናቱን ግኝት ለሌላ አካላት ሪፖርት ለማድረግ ሳይሆን በቀጥታ የጥናቱ ግብዓት በማድረግ የጥናቱን ዓላማ ማሳካት እንዲችል ታስቦ የተዘጋጀ ነው።

### አጠቃላይ መረጃ

እድሜ: .....

ፆታ: .....

የቤተሰብ ብዛት: .....

### ክፍል ሁለት

1. እርጥበት አዘል መሬቶች አካባቢያዊ ጠቃሚነት አላቸው ብለው ያስባሉ?

አወ አላቸው  አይ የላቸውም

አወ አላቸው ብለው ከመለሱ ፤ በምን መልኩ?

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2. እርጥበት አዘል መሬቶች ባህልን ከማስጠበቅ አንፃር ጠቃሜታ አላቸው ብለው ያስባሉ?

አወ አላቸው  አይ ያላቸውም

አወ አላቸው ብለው ከመለሱ ፤ በምን መልኩ?

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3. እርጥበት አዘል መሬቶች ለእርሶ ለመዝናኛነት ተመራጭ ስፍራዎች ናቸው?

አወ ናቸው  አይ አይደሉም

አወ ናቸው ብለው ከመለሱ ፤ በምን መልኩ?

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4. እርጥበት አዘል መሬቶች ኢኮኖሚያዊ ጠቃሜታ አላቸው ብለው ያስባሉ?

አወ አላቸው  አይ ያላቸውም

አወ አላቸው ብለው ከመለሱ ፤ በምን መልኩ?

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5. የእርስዎ ዋነኛ መተዳደሪያ ገቢ ከእርጥበት አዘል መሬቶች ጋር ቀጥተኛ ግንኙነት አለው?

አወ አለው  አይ ያለውም

አለው ብለው ከመለሱ ፤ ከታች የሚገኘውን ሰንጠረዥ ይሙሉ

ስም	የስራዎን አይነት	የገቢ መጠን	የቤተሰብ ብዛት

6. አጠቃላይ ከተማው ውስጥ ስለሚገኙ ከእርጥበት አዘል መሬቶች ያለዎት ምልክታ እና ዘላቂ ልማትን ከማስጠበቅ አንፃር ያጋጠሞቸው ተግዳሮቶች ምንድን ናቸው?

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ይህን ቃለ መጠይቅ ፍቃደኛ ሆነው በትግስት ስለመለሱልን አናመሰግናለን!

Questionaries 2 - for stockholders

በባህር ዳር ከተማ ውስጥ የከተማ እና የከተማ ዳርቻዎች የእርጥበት መሬት ክትትል ለዘላቂ የከተማ ፕላን እና አስተዳደር በሚል ርዕስ በአ/አ ዩኒቨርሲቲ በከተማ ንድፍ ት/ክፍል ስር ለሚዘጋጀው ጥናታዊ ጽሁፍ ግብዓት የሚሆን መጠይቅ

ዳዊት ማለደ

በአ/አ ዩኒቨርሲቲ በከተማ ንድፍ ት/ክፍል ውስጥ የሁለተኛ ዲግሪ ተማሪ

ግንቦት 2015 ዓ/ም

ይህን ቃለ መጠይቅ ለመመለስ ፍቃደኛ በመሆንዎ በቅድሚያ አመሰግናለሁ!

**ክፍል አንድ**

ይህ ቃለ መጠይቅ የተዘጋጀበት ዋናው ዓላማ የጥናቱን ግኝት ለሌላ አካላት ሪፖርት ለማድረግ ሳይሆን በቀጥታ የጥናቱ ግብዓት በማድረግ የጥናቱን ዓላማ ማሳካት እንዲችል ታስቦ የተዘጋጀ ነው።

**አጠቃላይ መረጃ**

ፆታ: .....

የስራ ቦት: .....

የስራ ድርሻ: .....

**ክፍል ሁለት**

1. የከተማዎ እርጥበት አዘል መሬቶች (wetlands) ለማህበረሰቡ አካባቢያዊ፣ማህበራዊ/ባህላዊ እና ኢኮኖሚያዊ ጠቀሜታቸው ምን ሊሆን ይችላል?

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2. እርጥበት አዘል መሬቶች (wetlands) በተገቢው ሁኔታ ለማህበረሰቡ መስጠት ባለባቸውን ጠቀሜታዎች ደረጃ ስራ ላይ ውለዋል ብለው ያስባሉ?

አወ አስባለሁ  አይ አላስብም

አወ አስባለሁ ከሆን መልስዎ፤በምን መልኩ?

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3. እርጥበት አዘል መሬቶች (wetlands) በተገቢው ሁኔታ ስራ ላይ እንዳይውሉ ማንቆ (ተግዳሮት) ናቸው ብለው የሚጠቅሷቸው ነገሮች?

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4. እርጥበት አዘል መሬቶች (wetlands) በተገቢው ሁኔታ ስራ ላይ እንዲውሉ በቂ ህጋዊ መሰረት እና አደረጃጀት አላቸው ብለው ያስባሉ?

አወ አስባለሁ  አይ አላስብም

5. እርስዎ የሚሰሩበት መስሪያ ቤት ፤ እርጥበት አዘል መሬቶች ለዘላቂያዊ ልማት እንዲውሉ ምን አስተዋጽኦ አለው?

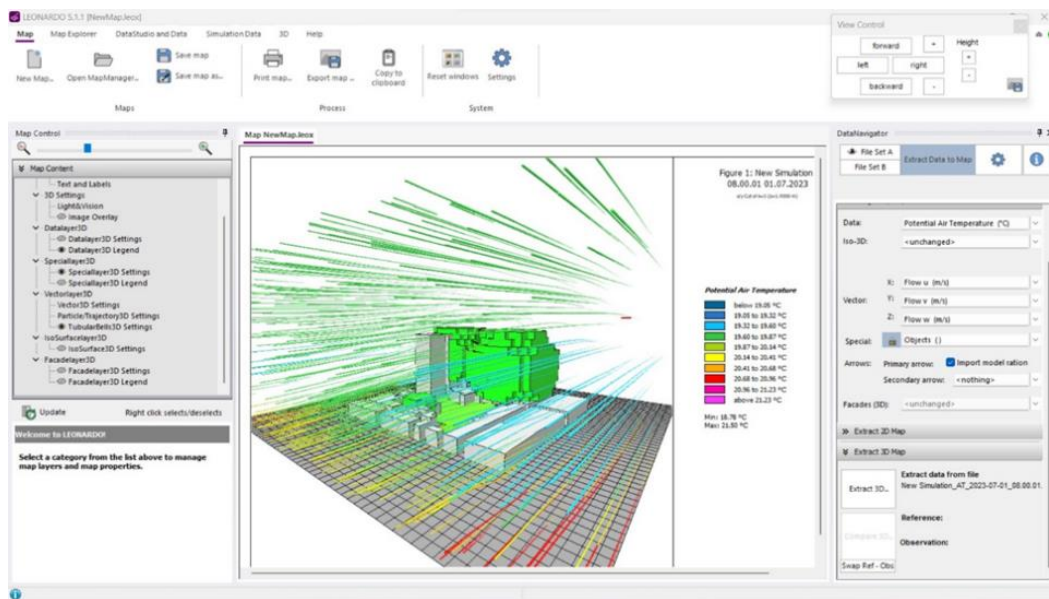
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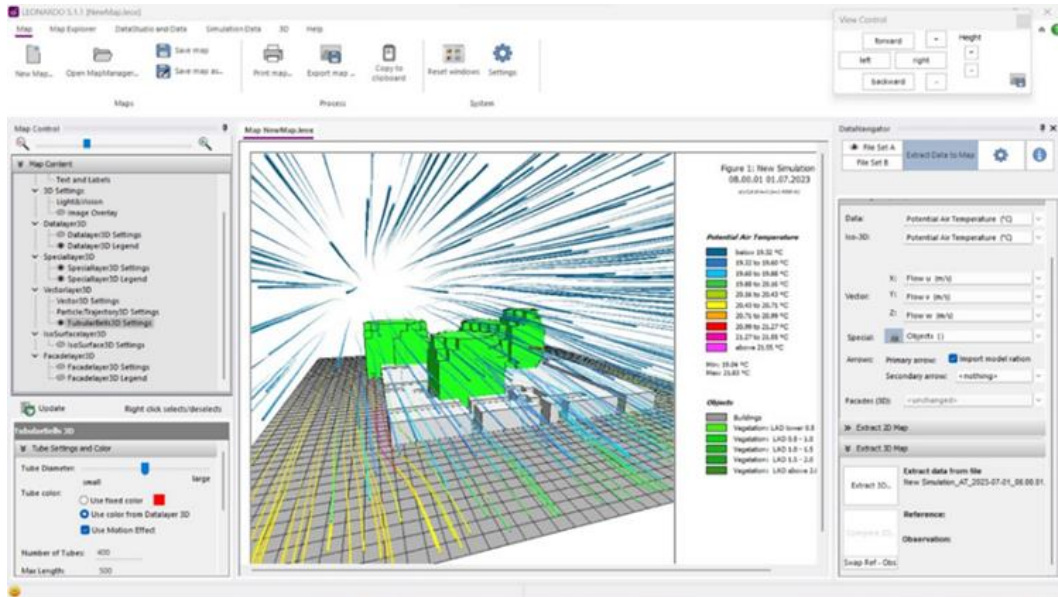
6. የትኞቹ ባለድርሻ አካላት የእርጥበት አዘል መሬቶች ልማት ላይ ቀጥተኛ አስተዋጽኦ ይኖራቸዋል ብለው ያስባሉ?

ይህን ቃለ መጠይቅ ፍቃደኛ ሆነው በትግስት ስለመለሱልን አናመሰግናለን!

### Annex III: Existing micro-climate and demolish micro-climate



Existing micro-climate



Demolish micro-climate

Annex IV: Equivalence meaning

Nile Basin Authority (የአባይ ተፋሰስ ባለስልጣን)

Bahir Dar city urban plan preparation and management Bureau (ባህር ዳር ከተማ አስተዳደር ከተማ ፕላን ዝግጅትና አፈፃፀም)

Urban Planning Institute (ከተሞች ፕላን ኢንስቲትዩት)

Bahir Dar City and Infrastructure Department (ባህር ዳር ከተማና መሰረተ ልማት መምሪያ)

Lake Tana and other water bodies protection and development agency (የጣና ሃይቅ እና ሌሎች ውሃ አካላት ጥበቃና ልማት ኤጀንሲ)

Bahir Dar City Water and Sewer Office (የባህር ዳር ከተማ ውሃና ፍሰሽ ጽ/ቤት)

Bahir Dar city administration cleaning and beauty office (የባህር ዳር ከተማ አስተዳደር ጽዳትና ውበት ጽ/ቤት)

Bahir Dar City Administration Culture, Tourism and Sports Department (የባህር ዳር ከተማ አስተዳደር ባህል ቱሪዝምና ስፖርት መምሪያ)

Amhara Region Environment and Forest Protection Bureau (የአማራ ክልል አካባቢና ደን ጥበቃ ቢሮ)

Amhara Bureau of Agriculture (የአማራ ግብርና ቢሮ)

Annex V: Biome equivalent of LULC types identified in this study and corresponding ESV coefficients based on global estimates. ESV coefficients are given in US\$ ha<sup>-1</sup> y<sup>-1</sup>

Biome equivalent LULC Type	ESV coefficients (US\$ ha <sup>-1</sup> y <sup>-1</sup> )	Sources
Bare-land	-	Costanza et al. (2014), Kindu et al. (2016)
Cropland	5567	Kindu et al. (2016), Costanza et al. (2014)
Grassland	4166	Kindu et al. (2016), Shiferaw et al. (2019)
Natural forest	5382	Costanza et al. (2014), Kindu et al. (2016)
Plantation	987	Shiferaw et al. (2019)
Settlement	6661	Costanza et al. (2014)
Shrub/bush	987	van der Ploeg and de Groot (2010), Kindu et al. (2016)
Waterbodies(rivers)	12,512	Costanza et al. (2014), Tolessa et al. (2017)
Woodland	987	Kindu et al. (2016), Shiferaw et al. (2019)