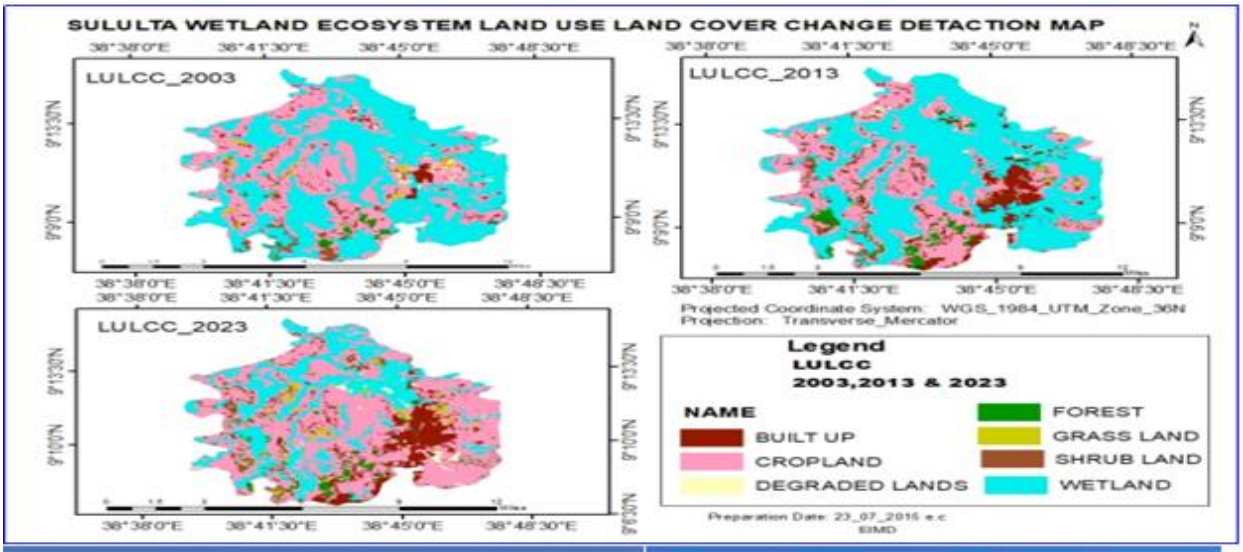
The Federal Democratic Republic of Ethiopia

Environmental Protection Authority

Fact Sheet of Sululta Wetland

In Oromia Region



Prepared By State of Environment Data Study and Report Preparation Desk

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Contents

List of figures

List of Tables

Acronym and Abbreviations

CSA- Central Statistical Agency

DPSIR-Driver Pressure State Impact Response

FAO- Food and Agricultural Organization

FDEMADRMFSEWRD- Federal Democratic of Ethiopia Ministry of Agriculture Disaster Risk Management and Food Security Sector Early Warning and Response Director

FDRE -Federal Democratic Republic of Ethiopia

FGD-Focus Group Discussion

GDP-Growth Domestic Product

GTP-Growth and Transformation Plan

IBC - Institute of Biodiversity Conservation

IPCC, F, A-R Intergovernmental Panel on Climate Change Fifth Assessment Report

IPCC, T, A –R Intergovernmental Panel on Climate Change Third Assessment Report

LSICLLCC – Land sat image of land use land cover change

LULC-Land Use Land Cover

M.a.s.l- Meter above sea level

Max. – Maximum

MEFCC-Ministry of Environment Forest and Climate Change

Min. – Minimum

MOFED-Ministry of finance and Economic Development

NMASDDB- National Metrology Agency

NSIDC_ National Snow and Ice Data Center

R.F – Rainfall

SDGs-Sustainable Development Goals

SLM -Sustainable Land Management

Temp. -Temperature

UNFCCC- United Nation Frame Work on Convention of Climate Change

1. General Back ground

1.1. Environment for Green Economy Development

Human societies of different interests and values, with the objective of using resources, have interacted with the environment throughout history and, in the process; they have altered it. Most African economies depend highly on natural resources, aim to achieve industrialization and economic diversification, and face challenges of poverty and unemployment.

Growing awareness on the failure of the traditional development thinking to satisfy the needs of the expanding global population, in turn, led to emergence of the idea of sustainable development**.** Sustainable development is development which meets the needs of the present generation without compromising the ability of future generations to meet their own needs. The concept of sustainable development takes into account the interlinking of the environment, economic and social issues. The idea of development, in this sense, is not based on a straight-line progression from traditional to modern mass-consumption society which results in social inequalities and negative environmental impacts. Instead, the kind of development aspired here is that remedies social inequities and environmental damage while maintaining a sound economic base.

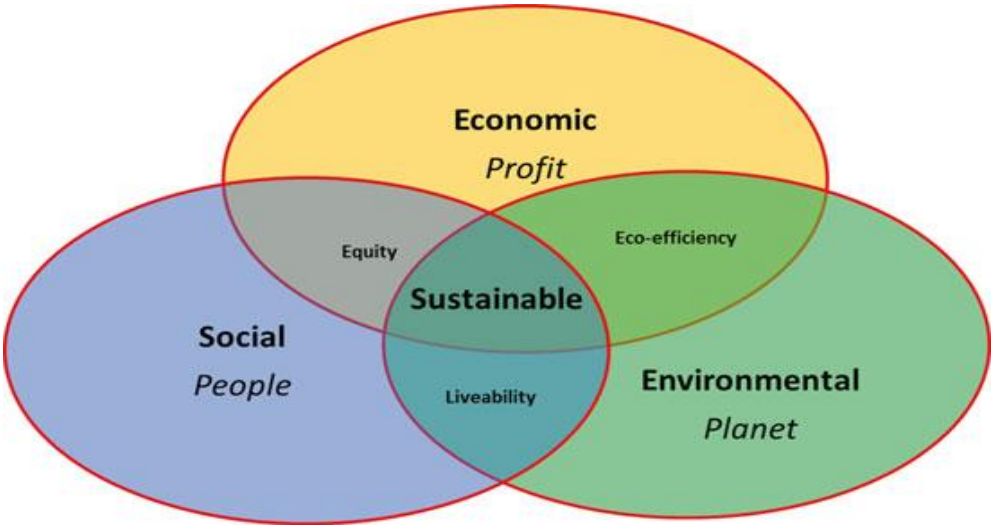


Figure 1: the Three Dimensions of Sustainability (Source: Green Growth, Green Economy And Sustainable Development: Terminological and Relational Discourse 2017)

The kind of economy developed in this case is green economy that results in improved human-wellbeing and social equity while significantly reducing environmental risks and ecological scarcities.

Green Economy*:* A green economy can be defined as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP, 2011).

In practical terms, in a green economy investing in ecological resources and services, such as a stable climate, bio-diversity and clean air and water, can be an opportunity for profit, employment and growth rather than cost and burden on economy.

The Government of the Federal Democratic Republic of Ethiopia is striving to fulfill their responsibilities to their citizens. The government strives to provide Social services and securities ensure adequate functioning of infrastructure, provide a climate Conducive employment and pay their debts. To be able to achieve the desired social and economic development, the government has already started to pursue its development endeavors following the green growth path.

Accordingly, the country's second 5 years Growth and Transformation Plan II (2015/2016-2019/2020) and the newly 10 year strategic action plan that aims at improving the livelihoods of its people is being implemented.

Furthermore the environmental sector plan is also mainstreamed into the GTP II and the newly 10 year strategic action plan of the country. One of the activities outlined within the environment sector plan of the GTP II is the preparation of Fact sheet of the country through undertaking assessment. To this end, The Environment protection authority of Ethiopia has conducted assessment of Sululeta wetland ecosystem in Oromia region in an integrated approach to study the status of the wetland.

2 Social and Economic Environment

2.1 Social Environments

The social environment refers to the immediate physical and social setting in which people live or in which something happens or develops. It includes the culture that the individual was educated or lives in, and the people and institutions with whom they interact.

Wetlands have played a noticeable role in the growth of human civilizations and cultural development. This is true globally, where major pre-historic civilizations, including those on the Nile, Euphrates and Tigris, have emerged and developed.

Ethiopia, with its different geological formations and climatic conditions, is endowed with considerable water resources and wetland ecosystems, including twelve river basins, eight major lakes, many swamps, floodplains and man-made reservoirs (Leykun Abunie, 2003)

With the exception of coastal and marine-related wetlands and extensive swamp-forest complexes, all forms of wetlands are represented in Ethiopia. These include alpine formations, riverine, lacustrine, palustrine and floodplain wetlands. Floodplains are found both in Ethiopia's highlands and lowlands, although they are most common in the North-Western and Western Highlands, Rift Valley and Eastern Highlands. Hillman and Abebe (1993) estimate that wetlands cover 1.14% of the total landmass of the country.

Sululta wetland is found in Sululeta sub city, one of the administrative city of Sheger city Administrator. It is about 23 km North of Addis Ababa; it is separated from Adis Abeba by Entoto plateau.

The area of sub city was isolated from oromya regional administration by new master plan incorporated to Sheger City administration at the end of 2022. Accordingly, the earlier Master plan of the town was prepared in **1999** E.C that includes about **10,424** hectares of a reserved total area which actually urbanized.

2.1.1 State and trends of Social and Economic Environment

Population

According to the projected data of the city Administration based on **2010** projection the total population of the city is estimated to be **129,843 (62,896** male & **66,947**female) in 2023. The

distribution of religion shows Orthotics **76%,** Muslim **9%, protestant 8%** and others **4%** according to the data gathered in 2010 E.C in our town**.** There are many nation and nationalities in the town. There are about **54%** Oromo, **25%** Amara, **7%** Gurage, **1%** Gamo, **5%** Tigre, and **8%** others (siltie, Walayita, etc). The job condition of the population includes, agriculture about **33.1%,**trade **36.8%,** government employee1.8%, Industry employee, **7.81%** others **20.49% (** non-government employee, daily laborers etc) (Solulta sub city,2023).

Education

Educational participation and Distribution

Availability of Kindergarten: in 2021 and 2022 the government & 37 non-governmental kindergarten in Sululta administrative town, having a student of population in 2021 who attended these schools was 3620 (1830male & 1790 female) and in 2022 was 6617 (3365male & 3252 female). There were also 7 male and 218 female teachers under the study years (Education Office of sululeta, 2023).

Table 1: Availability of government & non-governmental Kindergarten

S/N	**Study area**	**Availability of government & non-governmental Kindergarten**							
		Year	No of school	No of student			No of teachers		
				M	F	T	M	F	T
1	Sululeta tawon	2021	37	1830	1790	3620	7	218	225
		2022	37	3365	3252	6617	7	218	225

Source: Education Office of Sululeta, 2023.

The student numbers were annually incremented by 183%. There is unexpected increase of student enrolment from 2021 to 2022 is the case of covid-19 declined and many of schools are opened.

Table 2 **Student Enrolment Government and NGOs Schools by Grade**

Levels		***2021***			***2022***		
			None.	*Total*		*None.*	*Total*

	Sex	*Gov.t*	*Gov.t*		*Gov.t*	*Gov.t*	
1st Level (1-6)	*Male*	2449	1931	***4380***	2750	*2304*	***5054***
	Female	2617	*2018*	***4635***	*3117*	*2289*	***5406***
	Total	5066	*3949*	***9015***	5867	*4593*	***10460***
2nd Level (7-8)	*Male*	611	*273*	***884***	573	*250*	***823***
	Female	*794*	*299*	***1093***	*803*	*328*	***1131***
	Total	*1405*	*572*	***1977***	*1376*	*587*	***1954***
Primary (1-8)	*Male*	3060	2204	**5264**	*3323*	*2554*	***5877***
	Female	*3411*	*2317*	***5728***	*3920*	*2617*	***6537***
Total		*6471*	*4521*	***10992***	*7243*	*5171*	***12414***
Total secondary (9-12)	*Male*	*1257*		***1257***	*1573*		***1573***
	Female	*1485*		***1485***	*1968*		***1968***
Total		*2742*		***2742***	*3541*		***3541***
1-12	*Male*	*4317*	2204	**6521**	*4896*	*2554*	***7450***
	Fema	*4896*	*2317*	***7213***	*5888*	*2617*	***8505***
Total		*9213*	*4521*	**13734**	10784	*5171*	***15955***

Source; Education Office of Sululeta, 2023.

Sululeta town had 12 governmental schools, Out of these, 3 schools were grade 1-6 (1-4), 1schools were grade 7-8 (5-8) 3 high schools (9-12). The elementary schools enrolment of the town had 5,264 male and 5,728 female a total of 10,992 students in 2013 E.C. In the year 2014 E.C a total of 12,414 students with 5,877 males and 1,968 females were enrolled. Whereas, the senior secondary schools were 2,742 (1257 male and 1485 female) students were enrolled in 2013, while in 2014 this number increased by 29% and to reach 3,541 (1573 male and 1968 female) were enrolled.

On the other side number of teachers in the primary schools of the town had 388 teachers (male 195 and female193) in both sex in 2013 government and non-government and 421 teachers (male 211 and 209 females) in both sex in 2014 respectively. Out of this 3 (1 male and 2 female) in 2014 had TTI level of education .The rest 418 (211 male and 207 female) in 2014 had Diploma and above levels of educational back ground.

The senior Secondary schools of the town had 85 teachers (55 male and 30 female) in the academic year 2013. In 2014 this decreased to 80 teaching staff (48 male and 32 female). From these teachers 7 were degree holders in 2013 and 10 were degree and above holders in 2014 e.c.

Ratio of students to teachers, class, textbook and coverage

The national standard for the student-teacher ratio is 50:1 for primary and 40:1 for secondary schools. The lower the student-teacher ratio the higher the opportunity for contact between the teacher and students, however, the very low student-teacher ratio indicates the inefficiency of the education system or underutilization of the resources.

In the below table indicated that the student class and teacher-student ratios were progressed from year to year but a result isn't positive impact on environmental protection activities.

In the class student and teacher ratio was near normal which means only 6% of resource was useless in 2022.

Table 3: Ratio of students to teachers, class and textbook

S.N	**Year**	**Student class ratio from grad 1 to 12**		
		KG	**Grade 1-8**	**Grade 9-12**
1	2021	1:16	1:28	1:32
2	2022	1:29	1:29	1:44

Source: Sululeta Educational Office, 2022.

Health

Health is one of the most preeminent social sectors. It can be broadly defined as the state of being well physiologically and psychologically. It also has an overarching effect on sustainable socio-economic development. Health is a fundamental prerequisite for the success of any work is significant importance for the family, organization and the country in general.

Health institutions: - there are **2** health centre and **health** posts in both years under study. In the mentioned health institutions the number of medical personnel administered under health office was **124** health officers, **16** Nurses, **37** Pharmacy Technicians, **7** Lab Technicians and **6** Sanitarians under the study years. In addition to this there are **24** Community health extensions in the town.

In the study area top ten adult and children disease in the year 2022 were:

Table 4**: Sululeta health data (**Sululta city administration Health office, 2022)

S.N	**Top ten disease**			
	2022		**2023**	
1	Functional intestine disorders	1914	AURTI	5686
2	Dyspepsia	1433	Functional intestinal	3808
3	Acute upper respiratory infections	1427	Typhoid and parathyroid	3191
4	Cough	945	Acute tonsillitis	2447
5	Urinary system infections	783	Dyspepsia	2429
6	Pain	686	Disorder of urinary system	2421

7	Acute to anilities	655	superficial injury of unsperted body repion 1974	
8	Typhoid and parathyroid	595	bronchitis	1735
9	Pneumonia	499	cough	14425
10	Bacterial-intestinal infection	475	pneumonia	1329

The mentioned health institution was given services for the population of the town. There were different number of patients treated in the institutions for TB patients, Lab test and the like. Similarly , mother health services were Antenatal care,**1228,** Delivery services **634,**postnatal care **866,** Family planning services **3109** and, mother and children vaccination services **(BCG 1375,** Measles **1652, DPT$_1$ 1751 , DPT$_3$ 1636 PW-TT$_2$+ _1727** are types of Vaccination was given . In similar way medical health services (Out patients new **24,288,** repeatedly treated **5000,** Inpatients **154 and** lab test **2000** was given by government Health institutions.

Transport: - Road transport is the only mode of transport that exists in Sululta town. The total lengths of all types of roads giving traffic service are in the years **2014 E.C.** Out of these **19.5km** is asphalt, **157.56 km** is Gravel & **2.5** km is coble stone. The other road infrastructure that is important for the quality of road transport ditch that extends **235** kms & about 77culverts & **25** bridges constructed in the town.

In addition to this, there were town taxies that are being facilitated in coordination with AA city administration bajaj **560** bus station **2** Motor bycile**168** DNA cart(gaarii) **1300**, Damas **20**, dry cargo car **41**, pickup car **5** land cruser vehicles inspected &registered by type of services up to 2014 EC.

Communication:- In the town there were **2** telephone stations and Digital with -pay station, - employees, **18** subscribers in the year under study and mobile networks in available in the town and 1 postal service exists in town administration.

Water

Water is the vital role for health and wellbeing of individual, food security and with ultimately sustainable economic growth. Water resources have a significant role in the socio-economic development of a country or an area, particularly concerning food production, health, energy and the environment.

The major sources of drinking water supply for the Sululta town administration were spring, ponds etc, supplied through pipe lining water. In the town there were **1/one spring** and Borehole 8/eight development as well as distribution schemes (gravity system) giving services in the year of **2014 e.c.**

From the urban population of the town **_99024** urban populations were supplied with potable water where **73.2%** have an access of clean water supply.

Energy Supply: - Regarding the domestic supply of energy of the Sululta town administration were fire wood, cow dung, charcoal, kerosene and electric energy were consumed by the residents of the town according to their importance. In relation to this, from the total population of the town **%** (Abba warraa) population of town were supplied with electricity in **2014.** In the Sululta town administration surroundings had hydro-electric supplies.

Mining:- It is commonly known that minerals play a vital role in the economic and social development of any country. Minerals are non-renewable resources that need careful utilization for their sustainability to serve the future generation.

The major types of minerals that are found in Sululta town are Basalt and Ignimbrite. These minerals are used for buildings, masonry works and road construction activities of the town.

Industry

Sululta town administration has different types of industry. These include Jiandang Peng PP Bag Manufacturing, Damot Industrial and Commercial PLC, Elemtu, Nestle Water Ethiopia, Selam Spring Mineral Water Factory, to day, Abays Trading PLC, Allied chemical.

Waste Management;

FGD participants indicated that the waste management system in the study area was partially better by collection and separation in city area of sululeta but it was disposed in the wetland area including industrial waste.

Regarding economic activities,

The study area is characterized as an agricultural economy where by the main social, and economic aspects are expressed in terms of crop production and animal husbandry. The agricultural production system is mainly mixed farming, including crop and livestock productions.

Similarly, animal husbandry is another major source of livelihood in the area i.e. Such as cattle, sheep, goat, poultry, donkey**,** hours, and mule.

2.1.2. Drivers and Pressure of Social and Economic Environmental Change

- **Demographic pressure:**

The driver of environmental change is mainly the results of population growth. Due to;

(i) Lack of awareness on contraceptive methods contributes to high birth rates. Even though, currently, much attention is given to the provision of primary health care in households, the provision of family planning services is still low. As a result, there is much more delivery and an increase in the existing population.

(ii) As the study area near to Adiss abeba town, due to increased labor demand, the surrounding communities especially the youths migrate to the urban area for casual labor.

(iii) Expansion of settlement; according to land sat image of EPA, 2022, the settlement area increased and wetland affected.

- **Farmland expansion**

  The wetland area is surrounded by agricultural land and animal raring activities responsible for the scrambling of the wetlands.

- **GHG Increasing in the Atmosphere**

It's responsible for regional micro and macro climate change and global warming. In the year 2015 Global level of CO_2 crossed the symbolic and significant 400 parts per million benchmark (WMA, 2019).

2.1.3. Impacts of Social and Economic Environmental Change

The main pressure and driver of social and economic environmental change of the study area is a high rate of population growth, there is a very high demand over the available natural resources to satisfy the increasing demand by cultivating the forest land, using forest products and expanding settlement area in the forest, which intensified the condition of environmental degradation.

As a result, the area experiences water shortages when to the decline of underground water during February–May. Therefore people in the study area travel long distances it takes 40:00 minute every other day to fiche drink water. Such long-distance trekking undoubtedly hinders household heads or other family members from devoting enough time to other livelihoods and, therefore, incurring further economic losses and made sanitation problems and also responsible for water-borne diseases like typhoid, typhus and giardia, this indicated by FGD participants.

In turn, this being unhealthy can affect farming and other domestic and economic activities, reducing food security and economic well-being.

2.1.4. Responses to Change of Social and Economic Environment

In the study area the wetland polluted by industrial waste as a resulted averagely 5 animals loosed per household. Due to the government take action on the factory that had been converted in to other activates.

- There are many potential policy responses to the environmental implications of local population pressure. The population policy of Ethiopia aims at
  - ✓ Closing the gap between high population growth and low economic productivity through planned reduction of population growth;
  - ✓ Improving the carrying capacity of the environment by taking appropriate environmental protection measures; and
  - ✓ Improving the social and economic status of vulnerable groups (Women, Children and Elderly).
- In line with the policy document, Ethiopia set out a national population program with national priorities as stated below:
  - Expansion of population information, education and communication;
  - Provision of expanded family planning services;
  - Strengthening of training in population; and
  - Promotion of the status of women.
- Incorporating environmental education into the national curricula;
- Providing incentives for human activity that embraces ecological considerations;
- Enhancing stakeholder awareness through programs in the media, workshops, short courses,
- To reduce the problem and provide quality education at the primary school level, schools were constructed at the village level, teachers were trained and placed, and girls' participation was increased to some extent. In recent years as a part of the growth and transformation plan, health service coverage and school enrolment at primary school levels improved remarkably as human capital development also received significant attention from the Ethiopian government.
- The government by allocating budget for various sectors, such as agriculture, education, health, and water and road development has shown promising effort in eradicating poverty in the woreda. As a part of government health policy document health professionals in the

Worda are working on maternal and child care, immunization, control of basic infectious disease, epidemic and sexually transmitted diseases and malaria

- Regarding to a new plan has been coined and put into practice by different components of the government like Growth and Transformation Plan GTP II and ten year development plan. The planning year is between 2015/16 and 2019/20 and 2020/21 to 2029/30. GTP's vision in the economic sector is "to build an economy which has a modern and productive agricultural sector with enhanced technology and an industrial sector that plays a leading role in the economy; to sustain economic development and Secure social justice; and, increase per capita income of citizens so that it reaches at the level of those in middle-income countries." and 10 years road map.

2.1.5. Outlook for Socio-Economic Environment

The study area has a total population of about **129,843** with the annual average growth rate of **1.32%**. If everything continues as it is practiced at a present population growth within the study area of 1,23 % will continue. The baseline data in the year **129,843** people are living in the study area; it will be reached 3,895,290 in the year 2045. It indicates the subsistence mode of the economic situation that based on farming land expansion will pressurize the limited natural resources. Then, the natural environment could not be able to provide the environment service.

If the government will be given attention and dune to creating a favorable educational environment, make political stability and avoiding security problems and properly control spared of disease, the access and quality of human capital will be improved those are better options for saving the environment.

2.1.6. Recommendation

If different interventions are taken by governmental and non-governmental bodies to influence the imbalance of overpopulation to that of the natural resource base, such as demographic programs incorporating family planning, health and education services are properly implemented, the demographic trend would be stabilized.

Moreover, diversification of activities will generate income and minimize the impact on a given natural resource that is instead of depending on agriculture could be engaged in other activities such as poultry production.

3. Physical Environment of Sululta Wetland

3.1. Land

3.1.1 State and Trend of Land Use Land Cover Change (Lulcc) for Sululta Wetland Ecosystem

Land cover and land use assessment are important inputs for ecological studies. However, there is confusion in the use of the terms land use and land cover. Land use is defined as a term that describes how the land is utilized by people and is mainly related to a functional role for economic activities, whereas land cover (LC), which is the focus of this study, describes the physical characteristics of Earth's surface. Land cover change (LCC) is one of the major factors that affect biophysical systems from the local to the global scales. LCC has direct and indirect consequences on the status of the natural environment and human activities. Land productivity, land degradation, hydrological cycle, biodiversity, and quality of the environment are some of the natural processes that could be affected by LCC. The disruption of the natural systems' capacity to meet human needs by changing LC exposes more people and the environment to the harmful effects of climate change(Basin et al., 2022).

Generally in the world particularly in Ethiopia land is the major natural resource on which economic, social, infrastructure and other human activities are undertaken. Changes in land use have occurred at all times in the past, and present, and are likely to continue in the future (Lambin et al., 2003).

Change in land use land cover (LULC) is one of the constraints which can influence the development of sustainable agriculture in general in Ethiopia and particularly in Sululta woreda.

The change in LULC can negatively affect the possible use of land and completely lead to soil and wetland deterioration that influences productivity in the Sululta wetland ecosystem.

Wetlands have many socio-economic and ecological benefits. The values and services gained from wetlands can be categorized into functions, products, and attributes.

Despite the benefits gained from wetlands, they are under threat from the conversion of wetlands for intensive irrigation agriculture, the expansion of human settlements, industrial pollution, agricultural pollution by pesticides, use of fertilizers, water diversion for drainage, and the construction of dams.

Fogera floodplains including Welala and Shesher Wetlands are one of the 73 hot spots in Ethiopia which are identified as important bird areas. They provide shelter to the endemic, globally endangered, vulnerable, and near-threatened species of birds [4,5]. The local community gets benefits from Welala and Shesher Wetlands in the form of fishing, grazing for cattle, and small-scale irrigation. These valuable wetlands are under threat from overgrazing, drainage, water diversions for small irrigations, and conversion into farmlands. Although several studies were conducted on Fogera floodplains, an in-depth study with particular reference to Welala and Shesher Wetlands was lacking (Atnafu, Dejen, & Vijverberg, 2011).

SULULTA wetland is found in the Oromia region SULULTA districts, Sululta is one of the woredas in the Oromia Region of Ethiopia. It was part of the former Mulona Sululta woreda which was separated from Mulo and Sululta woredas. Part of the Oromia Special Zone Surrounding Finfinne, Sululta is bordered on the south by the city of Addis Ababa, on the west by the Mulo and Mirab Shewa Zone, on the north by Semien Shewa Zone, and the east by Bereh. Towns in Sululta include Chancho, Durba, Muger Sheleko, Rob Gebeya, Sululta and Segno Gebeya. Located at 9.16667, 38.75 (Lat. / Lng.), about 1 mile away.

This wetland is surrounded by the Sululta plain, which is a wide, shallow valley with an elevation of 2500 meters above sea level, almost surrounded by mountains with CROSS BY LONG Rivers which drain into the Muger. The WETLAND is swampy with some quite large areas of open water in the rainy season, but it reverts to grazing land during the dry months. The surrounding mountainsides were covered with forest dominated by *Juniperus procera*, and the lower slopes supported groves of Acacia, but now most of the hillsides are covered with

plantations of Eucalyptus with only the odd native tree remaining, except for the groves protected by the presence of a church.[3]

The wetland is changed

-Query;-pollution of the environment:-

Food, pollution ጉድጓዱን እንደ ምሽግ በመጠቀም ለሌባ ተጋልጠናል፣ጉድጓዱ ሰውና ከብት ላይ አዳጋ አእያስከተለ ነው። (We are exposed to thieves using the well as a fort, the well is causing danger to people and cattle).

The wetland is distributed and sold to many investors for different purposes hence the wetland served for grass to sell and crop with over-irrigation in this case the wetland is divided into two parts on the top part higher irrigation on the downside due to over leaching and deposited of water which resulted to siltation the land is already changed in to bare land.

-Uncultivated land was changed to cultivated land

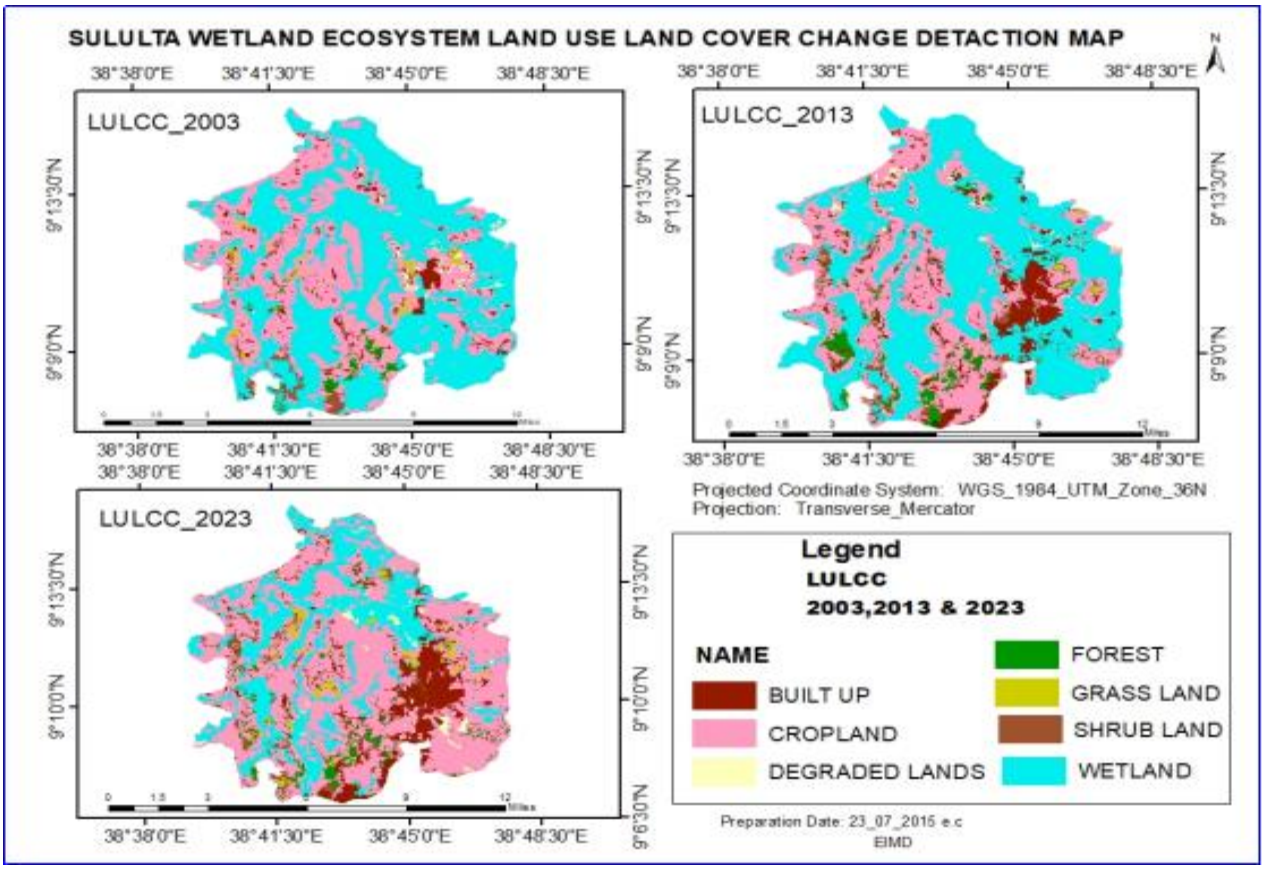


Figure 2 Sululta wetland ecosystem land use land cover change between 2003, 2013, and 2023

A total of Seven LULC feature class types were generated in the Sululta wetland ecosystem with different reference years, via, 2003, 2013, and 2023 G.c. As indicated in the classification scheme Built-up, Cropland, Degraded land, Forest, Grassland, and shrub land and Wetland are the major identified LULC classes for the study periods.

Table 5:- Land Use Land Covers Change (LULCC) for (2003, 2013, and 2023) in the Sululta wetland ecosystem**.**

Class name	**Years**				Rate of change (hectare/year)		
	2003 _ha	2013_ha	2023Area_ha	from 2003-2023 LCC in ha	2003_2013	2013_2023	2003-2023

Built-up	581.53	1314.95	1663.96	1082.43	73.34	34.9	54.12
Cropland	6443.41	5458.24	9388.05	2944.64	-98.52	392.981	147.23
Degraded land	201.94	182.4	234.06	32.12	-19.54	5.17	32.12
Forest	215.41	603.11	596.88	381.47	38.77	-0.623	38.147
Grassland	175.79	174.86	303.03	127.24	-0.09	12.82	6.36
Shrub land	304.56	387.42	586.88	282.32	8.29	19.95	14.12
Wetland	8932.35	8734	4082.11	-4850.2	-19.84	-465.19	-242.51
Total	16855	16855	16855				

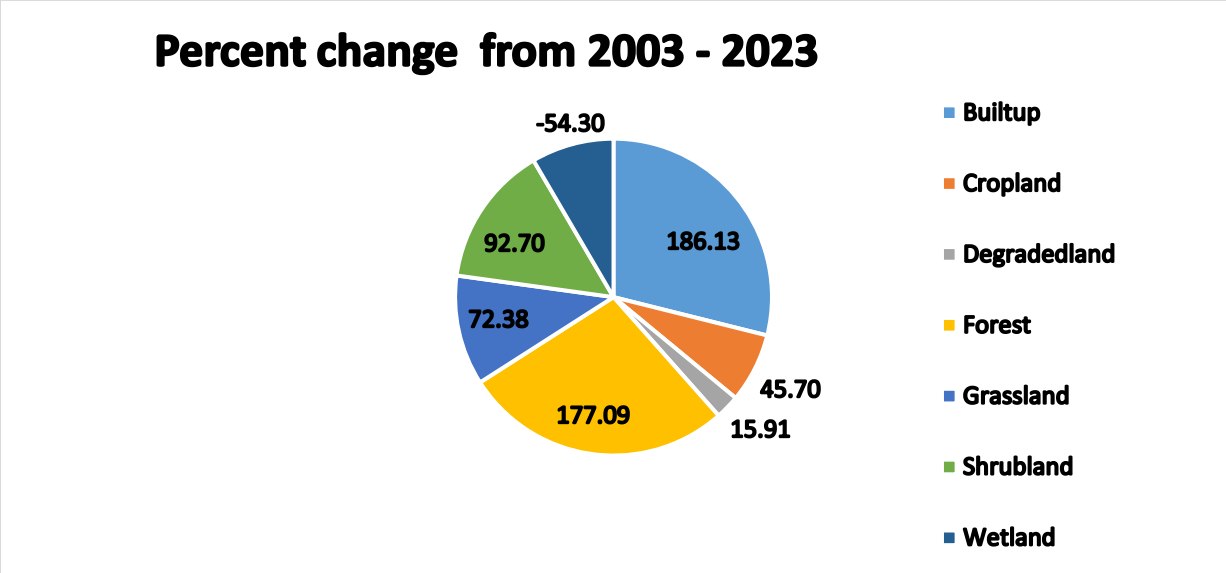
As shown in the table1:- within 3 decades (2003, up to 2023), Among the major identified land uses; Built-up, Cropland, Degraded land, Forest, Grassland, and shrub land and shows an increment in hectares of land cover change 1,082.43, 2,944.64, 32.12, 381.47, 127.24, and 282.32 respectively. But Wetland cover becomes dramatically declined by 4,850.24 Hectares.

In the years 2003, 2013, & 2023 urban built-up shrub land increased by 5181.53,1314.95, 1663.96, and 304.56, 387.42 586.88hactars respectively. Parallel to this investigation different studies also indicate dramatic urbanization increases at the expense of the Suluta wetland ecosystem. For example, the study of Bekele, (2021) from the year 2010 to 2019 indicated that urbanization in the Sululta wetland ecosystem increased from 33.44 to 45% respectively.

In this study from all land use land cover types only urban built areas and shrub land increased from the beginning of the study years to the end o the study years (2003-2023). The increase in shrub trees and stability of forests and grassland is because the Ethiopian government has consistently made global headlines with ambitious tree-planting targets, since launching its Green Legacy Initiative (GLI) in 2019 which seeks to plant 20 billion trees within four years until 2022(Getahun, 2022). Under this program, Ethiopia planned to plant more than 4 billion trees on 1.5 million hectares across the country (Takele, Lakew, & Kabite, 2022).

The results of the image analysis showed the magnitude of increment in the forest from the beginning of the first period of the study year (2003) to the second of the study year (2013) but at the end of the study year(2023), the forest slightly declined. The rate of change of forest to other LULC classes was 38.77 ha, -0.62ha, and 1.61 per year between 2003 to 2013, 2013 to 2023, and 2003 to 2023 respectively. The rate of change of grass to other classes was: -0.09, 12.82, and 6.36 per year between 2003 to 2013, 2013 and 2023, and 2003 and 2023 respectively. From this, we can understand that starting to the mid of the study years (2003-2013) grass cover showed negative trends, and then from the mid to the end of the study years this is because

With the same interval of years, the wetland decreased by 19.84 per year between 2003 to 2013 and 465.19ha after 10 years between 2013-2023, and finally from 2003_2023 decreased by 242.51 hectares per year. Concerning farmland, 147.23 ha was changed to other LULC classes between 2003-2023, which means a decrease of 98.52ha per year rate of change between the years 2003-2013, and 392.981ha per year rate of change from the year 2013-2023. Increased by 946.98ha. On account of the plantation campaigns, goggle earth images and the change matrix table depicted that many croplands were converted to forestlands/ planting trees.



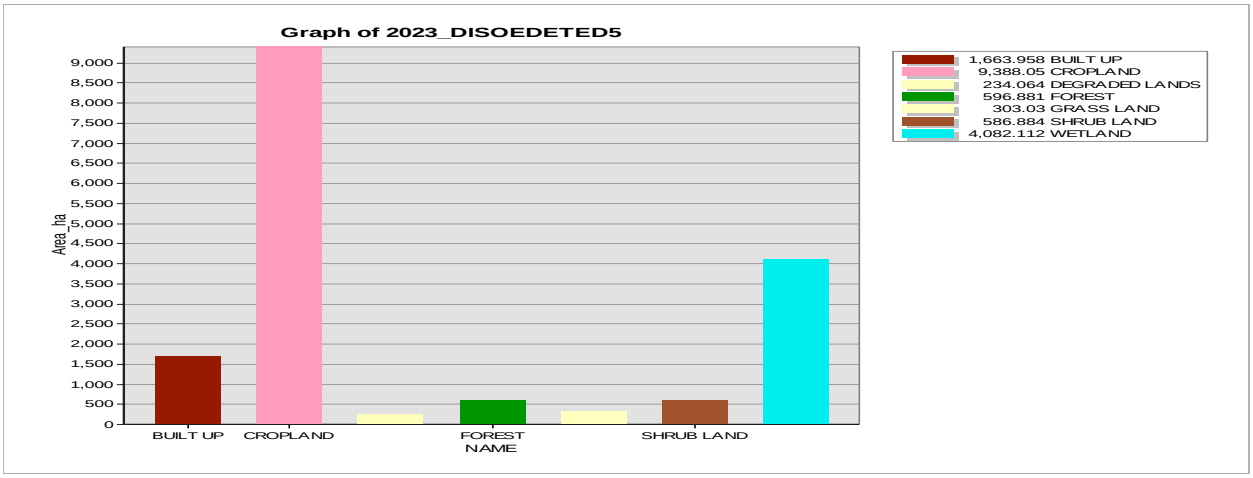
Fuger land use land cover percent change from 2003upto 2023

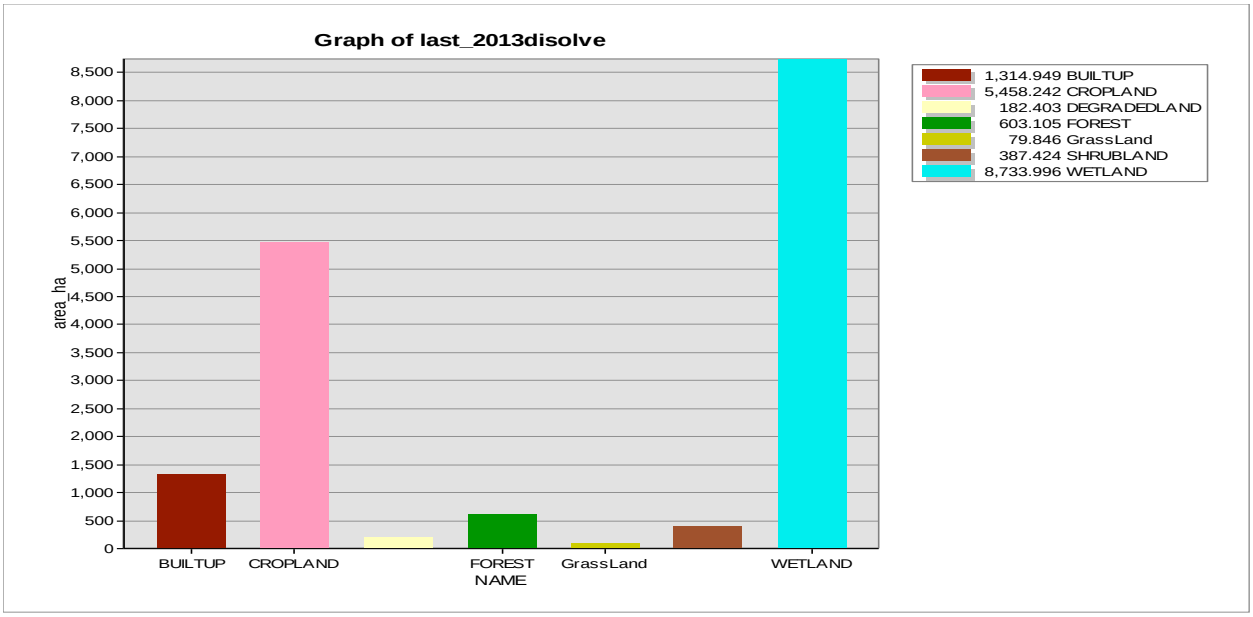
The analysis of the LC patterns in the study ecosystem revealed that over the past 2 decades (in 2003 and 2013) the dominant land cover was wetland but in 2023 cropland was the main dominant one. This is because the cultivated land and built-up areas have increased a lot at the

expense of wetland covers. Table 5 shows that starting from 2003, 2013, and 2023 built up and cropland increased by 581.53, 1314.95, 1,663.96, and 6443.41, 5458.24, and 9388.05 hectares respectively.

Similarly, the area coverage of built-up areas, shrub land, and increased over time (i.e., from 1986 to 2020). Built-up areas as a percentage of the overall study area were 0.03%, 0.76%, and 1.53% in 1986, 2003, and 2020, respectively. Vegetation cover increased by 27.25 percent the reason behind the increment of vegetation cover is land changed by the plantation forest campaign.

Land use land cover change detection is a comparative analysis of independently produced classifications and simultaneous analysis of multi-temporal data. Following image classification as part of the change detection process, accuracy needs to be assessed to evaluate the degree of acceptability of the classification process.





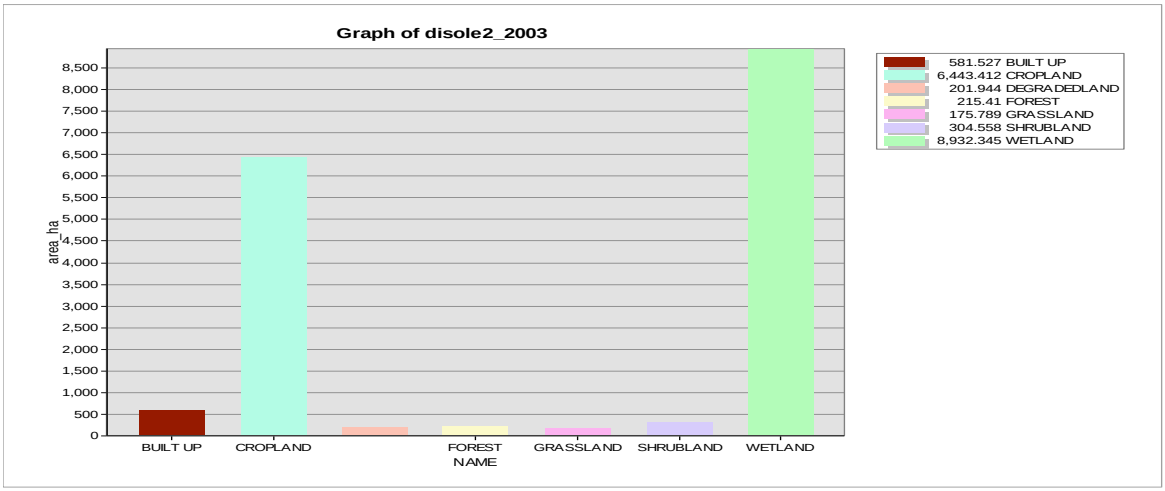


Table 6 Land Cover Class in 2003

Land Cover Feature Class	2003 LAND COVER CLASS									
	Built-Up	Cropland	Degraded land	Forest	Grassland	Shrubland	Wetland	Column Total	Class Change	Area unchanged
Built-up	399.	493.5	51.52	16.0	10.7	14.94	383.8	1369.	970.71	399.0

		04	3		9	5		7	75		4
	Cropland	92.54	3974.12	96.27	35.98	58.57	38.19	1184.18	5479.85	1505.73	3974.12
	Degraded land	7.09	126.35	10.31	0.01	0.00		42.73	186.50	176.19	10.31
	Forest	42.94	224.64	2.78	139.86	19.35	133.15	51.08	613.80	473.94	139.86
	Grassland	1.15	42.45	10.48	0.25	15.12	0.06	13.77	83.28	68.16	15.12 0.06
	Shrub land	20.96	127.90	1.76	19.52	41.56	102.55	75.17	389.43	286.88	102.55
	Wetland	18.88	1456.05	30.43	5.48	31.36	17.59	7179.08	8738.87	1559.79	7179.08
	Row Total	582.60	6445.04	203.56	217.19	176.71	306.49	8929.87			
	Class Change	183.56	2470.92	193.25	77.34	161.60	203.94	1750.80			

The LULC in the study area has undergone significant modifications and conversions in the course of the study years (Table 6). In the first period (2003_2013) after 10 years, from the year 2003_2013 cropland to wetland was the largest land cover conversion because during this year forest and shrub land show progress by 387.7ha and 82.86 ha net incensement hence northeast part of the study areas the wetland was increased but the reverse true in southern parts. this is because there was rapid urban expansion, especially in the southern part of Sululta towns which connected to the city of Addis Ababa, hence the society settled on wetlands through the drying of the marshland by mud, white clays, and sand. For this and other reasons, many wetlands areas were converted to other land cover classes for example 383.87 ha and 75 wetlands were converted to built-up, shrub land respectively. About 1184.18ha of wetland to cropland was the

next big land covers conversion. And the 3rd largest conversion was 383.87 ha of wetland converted to built-up/ settlement area.

Out of the 582.60 ha area of BUILT UP, 92.54ha, 7.09ha, 42.94ha, 1.15ha, 20.96ha, 18.88ha, 582.60ha, and 183.56ha were changed into cropland, degraded land, forest, grassland, shrub land, and wetland respectively (Table 6). Concerning Cropland, from the 6445.04 ha area of Cropland the highest proportion which was 1456.05 ha was changed into the wetland. The remaining 4.802ha were changed into shrubland (Table 6). Based on the total area of 2,858.630ha of shrub trees, 4,217.771ha were changed into farmland. The rest 1,896.929ha and 0.269ha were altered into grass and forest.

Regarding farmland, from 1, 9340.146ha area of farmland the large size which was 6,472.982ha was shifted into the grass, while the remaining 2,136.101ha and 295.150ha were changed into shrub and forest.

If, the change detection matrix is being considered from 1990 to 2014, then, there are some significant changes occurred table 12 these are mainly settlement, agriculture, and river/ water body. Vegetative area has a negative table 5 and its conversion has occurred mainly in settlement or built up/settlement areas table8 On the other hand, a considerable conversion has been occurred from agriculture and water body to settlement/ built up area. The conversion of agricultural land to barren land is also significant as 3.8 %. Conversion of agriculture to water body (9.09) and from water body to agriculture (10.23) is more or less same, so these are not so important. In some area agricultural land also converted into vegetation which are quantitatively 1.27 % with respect to total area.

The LULC change matrix of the study area showed that the forest of the study area changed in to other LULC classes in the last 20 years. However, the change or conversions of forest to other LULC classes were not consistent. Throughout the course of the study year much of the forest changed into other classes. The LULCC matrix between 2005 and 2015 depict about2357.115ha was changed into farmland and shrub trees. In the third phase of the study year (2000 to 2015) the matrix presented that 159.21ha, 444.54ha, and 1408.07ha of forest were converted into grass, shrub, and farmland. All these indicated that farmland expansion and related activities have damaged the forests. Farmland LULC of the area is the leading one to which forest was changed. Because image analysis showed that 5.7 of the forest area changed into farmland and shrub trees from 2005 to 2015.

Table 7 Land Cover Feature Class in 2003

Land Cover Feature Class		2003 Land Cover Class								
		Built Up	Cropland	Degraded land	Forest	Grassland	Shrubland	Wetland	Row Total	Class Change
2013 LAND COVER CLASS	BUILTUP	399.0427692	493.5308	51.51928	16.09185	10.74997	14.94479	383.8691	1369.749	970.7057
	CROPLAND	92.53689926	3974.118	96.26896	35.98406	58.56787	38.19113	1184.182	5479.848	1505.73
	DEGRADEDLAND	7.089600998	126.3539	10.30775	0.010816	0.004602		42.72986	186.4965	176.1888
	FOREST	42.93792882	224.6383	2.778725	139.8575	19.35053	133.1539	51.08206	613.7989	473.9414
	GrassLand	1.152497795	42.4512	10.48461	0.246471	15.11614	0.059596	13.76553	83.27604	68.15991
	SHRUBLAND	20.96445959	127.896	1.764468	19.51886	41.56445	102.5498	75.16925	389.4272	286.8775
	WETLAND	18.87699529	1456.051	30.43338	5.483776	31.35818	17.58609	7179.076	8738.866	1559.79
	COLUMENTOTAL	582.601151	6445.04	203.5572	217.1933	176.7117	306.4853	8929.874		
	CLASS CHANGE	183.5583818	2470.922	193.2494	77.33582	161.5956	203.9355	1750.797		

Table 8 Land Cover Feature Class in 2013

Land Cover Feature Class	2013								
	Built-	Cropl	Degra	Forest	Grass	Shrub	Wetla	Column	Row

		up	and	ded land		land	land	nd	Total	class change
2023	Built-Up	882.21	386.87	11.49	60.17	1.86	37.40	275.87	1655.87	773.66
	Cropland	254.35	4095.92	137.29	214.77	41.40	140.10	4499.18	9383.01	5287.09
	Degraded Lands	8.27	10.61	0.50	1.14	0.85	1.19	211.47	234.03	233.53
	Forest	65.72	187.07	2.37	227.95	2.27	55.04	59.47	599.89	371.94
	Grass Land	15.11	133.23	0.78	17.15	27.98	17.06	92.61	303.91	275.93
	Shrub Land	84.73	200.20	3.24	82.72	5.51	135.68	76.75	588.84	453.16
	Wetland	13.49	477.46	26.67	14.17		15.57	3531.27	4078.64	547.37
	ROW Total	1323.88	5491.36	182.34	618.06	79.88	402.05	8746.62	16844.19	
	Class Change	441.68	1395.44	181.84	390.11	51.90	266.37	5215.35	7942.68	

From the year (2013_2023) 4499.18 ha of wetland was largely converted into croplands this is the way the reason 2023 wetlands dramatically declined by 4,651.89 hectares from 2013 overages.

Table 9 Land Cover Feature Class in 2023

Land Cover Feature Class		2003land Cover Feature Class								
		BUILT UP	CROPLAND	DEGRADED LAND	FOREST	GRASSLAND	SHRUBLAND	WETLAND	Grand Total	CHANGE
2023 Land Cover Feature Class	BUILT UP	335.72	637.24	55.77	15.01	14.75	29.77	598.97	1687.23	1351.51
	CROPLAND	122.84	4662.14	109.42	44.00	61.91	69.75	4357.03	9427.09	4764.95
	DEGRADED LANDS	4.26	33.02	1.76		0.06	0.74	194.18	234.01	232.25
	FOREST	54.07	241.44	4.93	128.50	16.99	96.63	66.13	608.69	480.19
	GRASSLAND	7.40	187.86	7.58	2.03	35.34	11.73	54.24	306.17	270.83
	SHRUB LAND	61.62	224.85	5.48	34.92	47.41	104.04	116.55	594.87	490.83
	WETLAND	4.06	493.47	16.92	2.28	3.57	2.54	3560.10	4082.93	522.83
	Grand Total	589.97	6480.01	201.86	226.74	180.03	315.20	8947.19	16941.00	
	CHA	254.25	1817.87	200.10	98.24	144.69	211.16	5387.09		

Out of 1687.23 ha area of Built-Up, 637.24, 55.77, 15.01, 14.75, and 29.77 were changed into Cropland, Degraded land, Forest, Grassland, Shrub land, and Wetland respectively (Table 9). The change in the first period (1995-2005) was much more significant compared with the second (2005-2015). The land use land cover change matrix between 1995 and 2005 showed that during the indicated period there was a significant land use/land cover dynamics. From the total area of

grass 12,368.637ha, 9,646.235ha, 2,702.650ha, and 19.752ha were changed into farmland, shrub trees, and forest respectively. The general total net area (unchanged area) of shrub trees and farmland indicates decrement while grass showed an increment between 2005 and 2015 compared to between 1995 and 2005.

3.1.2. Drivers of LCC in the Sululta Wetland ecosystem

According to Girma et al., (2008) Assessing the driving forces behind LUCC is essential if previous patterns can explain and be utilized in forecasting future patterns. Land use and cover change can be caused by multiple driving forces that control some environmental, social and economic variables. These driving forces can contain any factor which influences human activities, including local culture, economic and financial matters, environmental circumstances (i.e. greenness, land quality, terrain situation, water availability, and accessibility to recreation), current land policy and development plans, and also interactions between these factors. Therefore, these drivers have to be found to pursue these controlling variables. The driving forces will be utilized to manage land change. Investigation of interrelations between the drivers of land change needs a strong knowledge about methods and effective variables, as well as land policy (Ellis and Pontius2006).

LCC is the result of a combination of different causative factors. The results of the FGDs, and field observations revealed that both anthropogenic and natural processes contributed to the observed LCC in the study area. However, anthropogenic activities are the more influential factors contributing to LCC, as compared to the natural processes. According to the results from the FGDs, the underlying causes of LCC in the study area are the complex socio-economic, institutional, biophysical, demographic, and technological factors (Table 9).

Land use/Land covers change between 2003 and 2013

The LULC in the study area has undergone significant modifications and conversions in the course of the study years (Table 8). In the first period (2003 and 2013) after 10 years, Out of 970.71ha area of Built-up, were changed to shrub trees, farm, and grass 493.53, 51.52, 16.09, 10.75, 14.94 & 383.87ha respectively (Table 8). Concerning grass, from 2,154.152ha area of grass the highest proportion which was 1,107.899 were changed into farmland area. The remaining 4.802ha were changed into shrubland (Table 8). Based on the total area of 2,858.630ha of shrub trees, 4,217.771ha were changed into farmland. The rest 1,896.929ha and

0.269ha were altered into grass and forest. Regarding farmland, from 1,9340.146ha area of farmland the large size which was 6,472.982ha was shifted into the grass, while the remaining 2,136.101ha and 295.150ha were changed into shrubs and forests.

Rapid population growth

High population growth was perceived as the major driver of the demographic factor causing LCC in the study areas. According to the 2007 and 2022 Population and Housing Census of Ethiopia, the total population of the districts increased from 129,000 to 190,597 respectively. The Population Density is 165.6/km² 2022 and also 2.6% Annual Population Change from 2007 to 2022 (Thomas Brinkhoff, 2022). According to the information from the FGDs, resettlement, immigration, and natural population growth were identified as the causes of the population increase in the Sululta wetland ecosystems.

Demand for agricultural land:- There are both interactions and trade-offs in the provision of Ecosystem Services in agriculture expansion (Bennett et al.,2009). In line with this, the increasing population in the Sululta wetland ecosystem increases the demand for land for farming and settlement, consequentially increasing degraded land cover, and bringing about the loss of wetland & ecosystem service, for example from the year 2003_2023 rate of change per year cropland, urban built area and degrade land 147.23ha, 54.12ha, and 32.12ha respectively.

Investment policy:- Due to high consideration for investment and not taking into account the benefits of wetlands to the environment and not using environmentally friendly, Ethiopia, wetland destruction, and alteration saw as an advanced development mode, even at the government level (Dixon & Wood, 2003). This indicates that wetlands and their value remain little understood (Gebresllassie et al., 2014). Convention on Biological Diversity of Ethiopia 4th report describe; Fogera marsh has been changed to the rice field, Sululta marsh is distributed to investors, ELFORA PLC has transformed the Chefa wetland in South Wello into farmland, and these are only a few examples of wetland degradation in Ethiopia. Lake Tana is loaded with silt and invasive water hyacinth because the wetland vegetation in the surrounding catchments was destroyed and used for agriculture. The wetlands used to stop silt and plant nutrition that is discharged to the lake have been converted to a rice paddy. The recent total drying up of Lake

Alemaya and the precarious existence of Lake Abijata are clear evidence of the looming danger to the wetland ecosystem in the country (Amsalu & Addisu, 2014)

Institutional transaction and new structure of the institution

Oromia region states established a new town surrounding Addis Ababa which was called Sheger Town and also all over the country new government employment structure were ongoing hence experts were not properly standardized or nominated resulting in obstacles to overall office works to manage the environment including wetland ecosystems.

Absence of implementation and execution of laws/ procurers

Lack of awareness:- According to Betru, Tolera, Sahle, & Kassa, (2019) the lack of awareness of the value of wetland conservation and the subsequent low priority in the decision-making process has resulted in the destruction or heavy modification of many wetland areas, causing substantial social and environmental costs (Turner et al. 2000).

On the other ways, according to FDG who live in the Sululta wetland ecosystem, there is a large number of the population without good trends/awareness to full fill available or created jobs in the wetland ecosystem and surrounding areas.

Occurrence of corruption:- According to Kudumba, (2022) arresting rampant corruption within the government and the city's administrative structures, strengthening protections on wetland ecosystems through robust legislation, better management of inter-party contestations (ZANU-PF and MDC) hence wetlands in Sululta ecosystem will be utilized sustainably**.** Related to this idea we did not get service due to the suspension of the institution by corruption. However, some information, especially secondary-level information, is not available at all. For example, Land and land degradation data could not be obtained.

Even if corruption-combating actions were started in the Sululta town administration, it is true that the incidence of corruption has a big social and economic crisis specifically in the Sululta wetland ecosystem, generally in Ethiopia and as far as the in the world.

PRESSURE

Wetland degradation is becoming a severe problem generally in Ethiopia and particularly in Sululta woredas. Pressure on wetlands from both the poor and the rich sectors of society has increased since wetland services are public goods. This affects the environment and people's livelihoods. The main pressure of wetland degradation in Sululta wetland includes draining, misuse, and conversion to other uses like Wheat cultivation or urban sprawl. Hence the Sululta Wetland resources have been subjected to overexploitation and intensive resource use. And also Because the marshland is plowed in the summer, the flowing water is intercepted by machines for excessive irrigation, it is wasted or used to grow grass, excavation is conducted and frequent grazing is conducted; It has been confirmed that the fertile soil of the swamp is washed away with silt and floods due to being filled with water in winter.

The rapid growth of urbanization:- Throughout the world, urban areas have increased in size over recent decades. The United Nations report indicates that currently, more people in the world (55%) are residing in urban centers, a proportion that is expected to increase to 68% by 2050. This rapid population growth and urban expansion across the globe is followed by the degradation of local environments through air pollution, intensification of the heat island, depletion of urban green spaces, biodiversity, and ecosystem services. Overall, population growth and urban expansion place pressure on natural resources and threats to compromise the quality of life within the urban environment (Gelan & Girma, 2021).

According to Beka, (2016), Governments in developing countries likely invest domestic capital in the provision of infrastructure in the urban areas while a larger proportion of the population is found in the rural areas.

Developing countries like Ethiopia who's only about 19% of their population live in an urban area with good development facilities and 83% of their rural population with the worst development facility can be the best example. Such a situation will lead to the creation of a high standard of living in the urban areas by creating an enormous disparity between the urban and the rural areas. As a result, rural dwellers tend to migrate to urban areas to take advantage of favorable policies (Tettey 2005:24).

When we look at the nature of urban expansion in the study area, it is an outcome of different factors such as natural population growth, rural-urban migration, and expansion of industries. Thus, the self-generated theory which assumes rural-urban migration and industrialization as fundamental causes of urbanization is a relevant theory for urban expansion in the study area. In

line with this the result of land use land cover analysis shows that;- surrounding the Sululta wetland ecosystem the urban area grew rapidly from 2003,2013,and2023increase by 581.53ha, 1314.95ha, 1663.96ha respectively. according to the result of the change matrix table analysis the urban expansion was large at the expanse of wetland and cropland.

Figure 3 Rappid Urbanization in Sululta

Expansion industries:- The Sululta wetland ecosystem is facing a major social, cultural, and economic change as a result of urban expansion, industrialization, residential development, and other formal and informal businesses. Accordingly, local farmers' livelihoods, social relations, and cultural practices are at risk. Thus, local farmers consulted for this study had developed dissatisfied feelings towards the urban development in the area, and lost a sense of belongingness to the development program (Beka, 2016).

The results of the study show that industrial and urban expansion in Sululta is taking place at an accelerated rate and also at the expense of wetland & local farmers' livelihoods. It was found that there was a gap between policy contents and implementation, which resulted in negative consequences on the livelihood of the farming community.

According to a focus group discussion in the Sululta wetland ecosystem due to the fact that the sewage from the industry is directly released into the river, in addition to harming the biodiversity that lives in the water, it is also causing damage to us and our cattle.

Figure 4 Industry Expansion

Figure 5 polluted water

FDG further pointed out that, since there is a lack of clean water in our area, we mostly use the Sibilu River for various purposes, so the direct pollution from the industrial effluents will cause a serious crisis in the local ecosystem, including us.

Expansion mining (quarry) site:- Quarry and aggregate production is important because of its positive impact on the economic development of the country being a source of construction materials, revenue for the government through taxation and royalties, and employment especially of the rural population (Divya, 2012). The industry also provides employment opportunities for

both skilled and unskilled workers thereby supporting many urban and rural families as it contributes to their livelihood and socioeconomic well-being. Rock quarrying and stone crushing is a global phenomenon and has been one of the causes of concern everywhere in the world, including the developed countries (Lammeed and Ayodele, 2010). Quarrying of natural stone, including sand, gravel, and crushed rock, represents the main source of construction materials used throughout the world. At the global level, the production of natural stone products witnessed a substantial increase over the last decade, with an increasing number of countries involved in the production of natural stone. Worldwide the production of natural stone has increased by 30 percent in the last 10 years (World Bank Stone Report, 2006).

However, operations of quarrying whether small- or large-scale, are inherently disruptive to the environment (Makweba & Ndonde, 1996). Mining of stones frequently generates land use conflicts in populated areas due to its negative externalities including loss of vegetation, noise, dust, truck traffic, pollution, and visually unpleasant landscapes. It also causes a conflict with competing land uses such as farming, especially in areas where high-value farmland is scarce and where post-mining restoration may be infeasible (Willis and Garrod, 1999). According to Ross (2001), environmental problems are further aggravated by the lack of adequate mitigation measures by the respective quarry operators. This in turn affects ecological sustainability which is a threat to overall economic sustainability. With regards to the prevailing 2 environmental legislation and its enforcement, there is a total lack of efforts in monitoring, rehabilitation, restoration, or post-mining programs for minimization of adverse environmental impacts. Environmental impact is any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products, or services. Quarrying is a form of land use method concerned with the extraction of non-fuel and non-metal minerals from the rock. Sand, gravel, and limestone are obtained from the earth through quarrying for building houses and other civil construction is obtained from quarrying or rocks of the earth’s crust. However, several wastes are generated when rocks are extracted from the earth. Environmental disturbances as a result of mining and processing activities constitute a major threat to public health and environmental quality (Adepoju, 2002).

Environmental degradation by Quarrying of stone, including sand, gravel, and crushed rock accompanies mining operations and remains after they cease, with air pollution, scars on the

landscape, and threatened surface and underground waters. As FDG said with regret "*Due to these mining activities, we are more suffering from pollution of air, food and drinking water, especially through Madan drilling"*. We have also confirmed that, as a result of this quarrying waste generated alongside could constitute serious environmental problems either at the point of production, processing, or during extraction hence the local residents fail environmental hazards/ dangers.

Figure 6 expansion of quarrying site

Overgrazing

Ethiopia holds the largest livestock population in Africa estimated at 54 million heads of cattle, 25.5 million sheep, 24.06 million goats, 0.92 million camels, 4.5 million donkeys, 1.7 million horses, 0.33 million mules, 54 million chickens, and 4.9 million beehive. It's also among the 28

smaller countries (25 in Africa) where grazing land accounts for greater than 60% of the total land area. Despite these huge resources, the productivity of livestock in general is low and its contribution to the national economy is below expected. Among the major problems affecting livestock production and productivity in Ethiopia, feed shortage in terms of quantity and quality is the leading problem.

The major feed resources in Ethiopia are natural pasture (grasslands) and crop residues with varying proportions among the different zones of the country. Similar to the other parts of Ethiopia, the role of grazing lands as a major livestock feed resource is diminishing from time to time because of natural and human-induced factors (increased conversion of grazing lands to cropland) which created heavy grazing pressure on the remaining grazing lands although the extent of degradation varies from site to site (Ebro, Tegegne, Nemera, Abera, & Deribe, 2017) SOER (2022)

But due to many humans induce factors in the Sululta wetland ecosystem a little bit of wetland changed to dry grasslands. For example, land uses land cover change detection analysis shows that in the first phase of the study year cropland was converted to forest lands finally forest land was harvested and changed to dry grasslands. The other reason for the increase in the grass was around urban areas wetlands were forced to dry b/c of the presence of high human interventions the wetland changed to grasslands. And also the Change matrix table analysis shows that from (2003_2023) 54.24 hectares of wetland were changed to grasslands.

Figure 7 over Grazing

Over irrigation

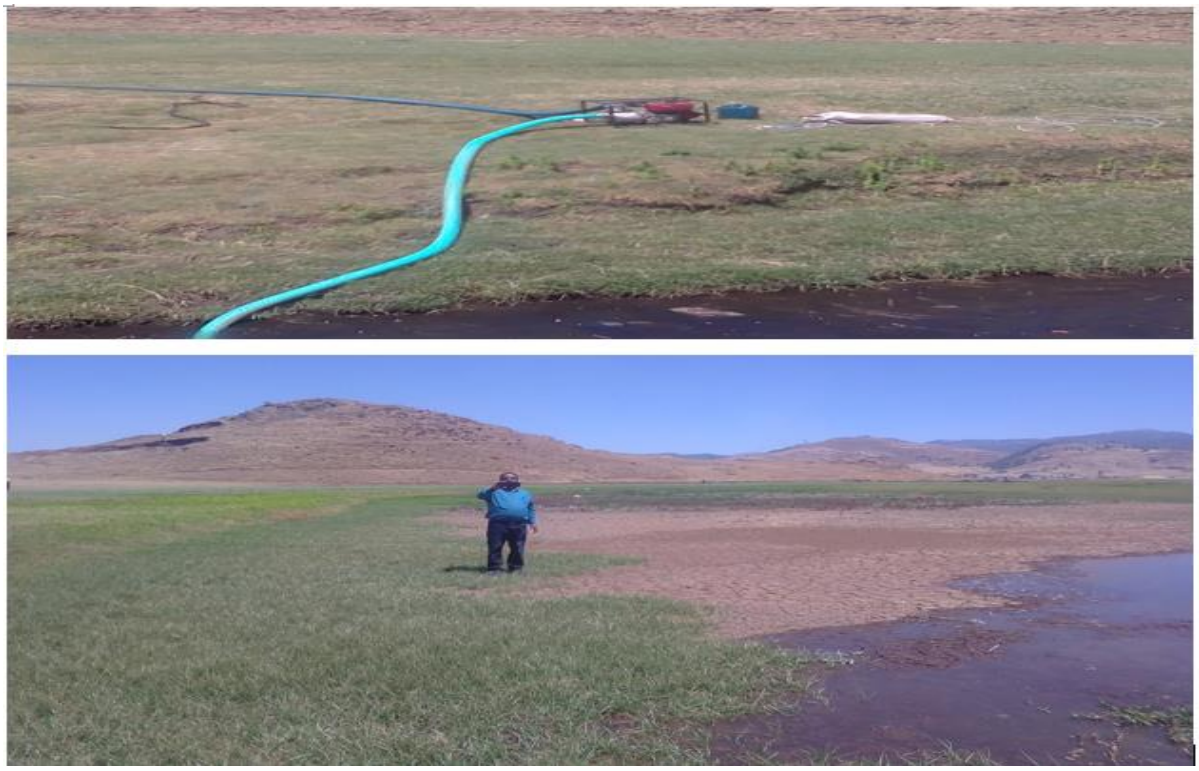


Figure 8: over Irrigation

Drying of wetland:- Applying white soil and sand to the wetland for about dry swamp land for Suitable the purpose they want.

The other method of drying the wetland was to drain the swamp

Figure 9: different activates for drying wetland

3.1.3. Impacts of Land/Use Land Cover Change and land degradation

The adverse impacts of LCC were associated with the underlying factors related to human activities. Some of the observed consequences of LCC in the Sululta wetland ecosystem included severe soil erosion and land degradation in the highlands and sedimentation in the lakes, rivers, and dams in the lowlands. Similar effects were observed in the highlands of Ethiopia.

Such effects happened because of the prevalence of unregulated agricultural expansion and settlements at the expense of the natural environment. A reduction in the cover of shrubland, forestland, and natural grassland plays a significant role in modifying the characteristics of the surface hydrology and soil erosion processes in the highlands and the sediment flow in the low-altitude landscapes. The LCC in this sub-basin has consequences for the larger Abay basin in which the Grand Ethiopian renaissance dam is located. The sediment load from this sub-basin will shorten the lifetime of this huge dam unless every part of the upper catchment area is properly managed. For instance, the expanding cultivated land on the steep slopes, implemented without using suitable land management techniques, may make the area more susceptible to erosion and sedimentation in the catchment's water bodies. A similar study also reported that LCC has a strong potential to lower the crop productivity of subsistence agriculture.

The decline of land productivity siltation and acidity of soils

Land degradation /decline of soil fertility

Due to the Pollution of water; - Damage to human and livestock

Climate change and Drought, due to drought occurrence with an annual frequency above 300 calf died annually, 25 years ago the wetland was covered by forest now due to deforestation we face to understand the daily and annual condition of the atmosphere.

The first victim of female disability

Malnutrition

Changing natural forest to manmade forest

Shortage of water for drinking and irrigation

Decline of ecotourism

Expansion of invasive alien specious

Decline of biodiversity

Flooding

3.1.4. Responses

Changing of skin industries to textile industries

Cultivation of plantation forest

Changing of livestock to productive specious

Water shade

3.1.5. Outlooks

The study recommended that, unless the urban expansion of the area is managed properly, the impact on local farmers' livelihood will be dangerous.

3.2. State and Trend of Forest in the Sululta Wetland

The forest resources of Ethiopia play critical roles in providing valuable ecological and economic resources for the country's overall development, and in particular rural population in forest regions which are heavily dependent on these resources for their livelihoods (MEFCC, 2018). Managing forests sustainably and equitably will be essential for maintaining the ecological integrity, maintaining or enhancing freshwater supplies, protecting biodiversity and improving rural livelihoods. Forests are important sources of livelihood for millions of people and contribute to the national economic development of many countries. In Ethiopia, the diverse forest resources available provide goods and services of significant values to the society, environment and economy (Moges et.ai, 2010). Afromontane vegetation, especially the dry Afromontane forests, provide a diverse range of ecosystem services including serving as habitat for wild animals, watershed protection, soil erosion prevention and control, provision of fodder for livestock, non-timber forest products, groundwater regulation, flood control and climate change mitigation .

Despite their crucial importance in livelihood and climate regulation, forest resources all over the globe are subjected to enormous pressure resulting in deforestation and degradation due to the increase in human and cattle population and widespread rural poverty (FAO, 2011). For instance,

since 1990 FAO,2015 has estimated that about 129 million hectares of forests have been lost internally, from agricultural expansion and unsustainable fuel wood collection, inadequacy of legal and regulatory frameworks coupled with their poor implementation, institutional instability of the forest sector and poor capacity. The depletion of forests has many ecological, social and economic consequences, including the extinction of biotic communities leading to reduction in biodiversity, soil erosion, global warming and loss of income to forest dwellers (Chakravarty et.al, 2012).

Ethiopia is a landlocked and predominantly agrarian country. Agriculture, including forestry, accounts for 54% of the Gross Domestic Product (GDP), employs 85% of the population, accounts for about 90% of the export and supplies over 90% of the raw materials for the agro-industries (MoFED 2006). Ethiopia owns diverse vegetation resources that include high forests, woodlands, bush lands, plantations, and trees outside forests. Each of these vegetation resources variously contributes to the production, protection and conservation functions, and play significant role in the national and local economy. There are six key economic roles that forest resources play in Ethiopia: (i) foreign currency earnings, mainly from export of non-wood forest products; (ii) import substitution for energy; (iii) contribution to the GDP; (iv) employment generation; v) livelihood support for millions of citizens, and vi) provision of environmental services that support other sectors, particularly agriculture, construction and energy. At local level forests and trees provide food, medicine, energy, fodder, farm implement and construction materials. Upon conversion forestlands have been offering fertile croplands to sustain crop production. When protected forests are used as rangelands, act as biological measures to conserve soil and water and provide watershed protection. Studies show that 90% of the energy used in Ethiopia originates from biomass, and nearly 80% of human and 90% of livestock populations in Ethiopia depend on traditional herbal medicine for primary health care (WHO 2002 and Yinger et al. 2007).The current area estimate for plantations is at 972,000 ha including commercial plantations, small holder eucalypt woodlots and community forests (MEFCC, 2015).

As part of this role, this report is compiled to present the state, trend, drivers and impacts of deforestation and forest degradation in sululta wetland ecosystem located in North showa zone.

Descriptions of words

Forest**:** According to Ethiopia's forest proclamation No. 1065/2018, forest is defined as "trees, plants and other bio-diversity accumulation at and in the surrounding of forest lands, roadsides, riverside, farm and grazing lands as well as residential areas or parks that grow naturally or developed in some other ways". This is the legal forest definition of Ethiopia.

According to MEFCC (2015) the technical forest definition of Ethiopia used for MRV purpose is Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 20 % or tree height of 2 m and an area of more than 0.5ha are included under forest, areas normally forming part of the forest area which are temporarily unstock as a result of human intervention or natural causes but which are expected to revert to forest.

Woodland: is an open stand, at least 10 meter tall with canopy cover of at least 40 percent and its field layer usually dominated by grasses.

Forest degradation is the decline of the capacity of a forest to produce healthy ecosystem products and services such as the provision of timber and other resources, support to biodiversity, carbon storage and as a result of environmental and anthropogenic changes. Forest degradation results owing to decrease in tree cover, the biodiversity in the forests or the changes to a lower state of the forest structure.

Deforestation is the complete removal of forest and conversion of its land use for other land uses other than forest.

Approaches to Conduct State of the Environment

The Driver, Pressure, State, Impact & Response (DPSIR) framework is a conceptual model, which can be used to define cause and effect relationships among the drivers (human needs), pressures (human activities), environmental state (negative trends), impacts (cascading social, environmental or economic changes), and responses (institutional policy and programs to improve conservation). The aim is to understand the real drivers which are sometimes unique to the local situation and then to identify and implement the most effective responses to remove or at least reduce the pressure.

Some benefits of this approach are 1) building a contextual understanding of cause and effect relationships, 2) identifying key gaps in understanding to prioritize research and monitoring, 3)

identifying the key pressures and drivers that "if addressed" would provide the greatest conservation benefit, and 4) enabling prioritization of limited financial and human resources to the most impactful issues.

The Driver-Pressure-State-Impact-Response (DPSIR) Framework provides a structure within which to present the indicators needed to enable feedback to policy makers on environmental quality and the resulting impact of the political choices made, or to be made in the future.

3.2.1. State and Trends of Sululta wetland forest Ecosystem

Forests are one of the most important natural resources with diverse economic, sociocultural and ecological uses. The livelihoods of hundreds of millions of people worldwide have been depending on forest products either directly or indirectly (Anonymous, 2008). Mostly, indigenous forest dwellers were the primary users of forest resources to a higher degree for domestic uses and income generation.

According to MEFCC (2017) there are four vegetation types in Ethiopia. These are Acacia Commiphora, Combretum Terminalia, Dry Afromonotrne and Moist Afromontra.

Though, Ethiopia is the centre for diverse flora and fauna, these resources are under immense pressure from deforestation and forest degradation, overexploitation, overgrazing, habitat loss, invasive species and pollution. The depletion of forests has many ecological, social and economic consequences, including the extinction of biotic communities leading to reduction in biodiversity, soil erosion, global warming and loss of income to forest dwellers (Friis et al. 2011).Continued degradation of the forests can destroy the entire forest cover and biodiversity, and it mainly occurs because of anthropogenic changes (Abraham, 2016). A growing influence of forest based livelihoods, illegal harvesting of forest products, expansion of farms(smallholder and commercial farms) ,overgrazing and other activities were identified as major causes of forest degradation (Fekadu, 2010 and Ministry of Environment and Forest, 2015). Due to similar reason, the remaining natural high forest species and woodlands (e.g. Aningeria adolfi-friederci, Yushania alpina, Albiza schimperiana, Prunus africana, Podocarpus flactus) of the southern and south-western parts of the country were found to be highly vulnerable (Kumlachew, 2003).

Ethiopia has close to 17.35 million ha (15.7% of the country area) of forest resources, including bamboo, dense woodland, natural forests, and planted forests. Plantation forest also comprises

public indus-trial plantations and private woodlots. Most of the natural forests exist in the south-western and south-eastern parts of the country

Table 10: Estimates of area cover of various forest resources in Ethiopia

Forest Types	Area (ha)
Bamboo	519,124
Dense Woodland	10,739,286
Natural Forest	5,266,419
Plantation	827,613
Total Forest types	17,352,443

Source: MEFCC, 2015

The study was conducted in Oromia Region Sululta city Administration Woserbi Woreda in Sululta Wetland ecosystem. During this study the data was collected from both primary and secondary data source. With regard to this the primary data was collected from FGD, key informants from kebele administrator, development agents and Landsat image. Field observation was also another primary source of data that support the analysis of the study. On the other hand, secondary data was used to conduct the study. This data was collected from published documents, region and woreda reports. During the desiccation in FGD and also woreda report, plantation forest around the study area was highly increased, but natural forests are degraded highly, due to various reasons, such as expansion of urban settlement, industrial expansion, fuel wood consumption, furniture product and charcoal.

Besides the open grassland and cultivated lands, the mainland-cover types are flower farm, plantation forest and woodland forests surrounding “Entoto” mountain. However, the trend is rapidly changing towards legal and illegal urban expansion. The area under settlements is expanding very rapidly on peri urban agricultural land due to residences, industry, social services, green area, urban Agriculture and transport and terminal. Looking all the existing nonagricultural use, residence is a visible major urban land use. The existing green area is unique, all the different types of greens like urban agriculture, grazing land and protective forest available in within the boundary of the study area.

Table 11 Land Use Land Cover of Sululta wetland

Class name	**Years**				Rate of change (hectare/year)		
	2003 _ha	2013_ha	2023Area_ha	from 2003-2023 LCC in ha	2003_2013	2013_2023	2003-2023
Built-up	581.53	1314.95	1663.96	1082.43	73.34	34.9	54.12
Cropland	6443.41	5458.24	9388.05	2944.64	-98.52	392.981	147.23
Degraded land	201.94	182.4	234.06	32.12	-19.54	5.17	32.12
Forest	215.41	603.11	596.88	381.47	38.77	-0.62	38.147
Grassland	175.79	174.86	303.03	127.24	-0.09	12.82	6.36
Shrub land	304.56	387.42	586.88	282.32	8.29	19.95	14.12
Wetland	8932.35	8734	4082.11	-4850.2	-19.84	-465.19	-242.51
Total	16855	16855	16855				

Source: GIS and remote sensing

According to land use land cover classification table above the plantation forest coverage of sululta town was 215.41ha in 2003, 603.11 ha in 2013 and 596.88 ha in 2023.In the year 2003 to 2013 the forest coverage was increased from 215.41 ha to 603.11 ha This indicates that the forest coverage of the area was increased by 38.147 ha in each year because in order to convert the wetland in to other land uses the local community plant eucalyptus tree. On the other hand the forest coverage was reduced from the year 2013 to 2023 by 0.62 ha because the plantation forest was degraded due to expansion of industry, Urbanization and agricultural expansion.

Table 12 2023 Land Change Matrix

	2003 land use change matrix									
	Land use change matrix	Built Up	Cropland	Degraded Land	Forest	Grassland	Shrubland	Wetland	Grand Total	Change
2023 Land change matrix	Built Up	335.72	637.24	55.77	15.01	14.75	29.77	598.97	1687.23	1351.51
	Cropland	122.84	4662.14	109.42	44.00	61.91	69.75	4357.03	9427.09	4764.95
	Degraded Lands	4.26	33.02	1.76		0.06	0.74	194.18	234.01	232.25
	Forest	54.07	241.44	4.93	128.50	16.99	96.63	66.13	608.69	480.19
	Grassland	7.40	187.86	7.58	2.03	35.34	11.73	54.24	306.17	270.83
	Shrub Land	61.62	224.85	5.48	34.92	47.41	104.04	116.55	594.87	490.83
	Wetland	4.06	493.47	16.92	2.28	3.57	2.54	3560.10	4082.93	522.83
	Grand Total	589.97	6480.01	201.86	226.74	180.03	315.20	8947.19	16941.00	
	Change	254.25	1817.87	200.10	98.24	144.69	211.16	5387.09		

The above Table shows that, LULC in the study area have undergone significant modifications and conversions in the course of the study years. From the total 226.74ha of forest coverage only 128.50 ha forest was unchanged but 98.24 ha were converted to other land uses i.e. 44 ha forest were shifted to crop land, 2.03ha of forest was converted to grass lands, 34.92ha of forest was converted to shrub land, 2.28ha altered to wetland.

Table 13: The most dominant tree species found in sululta wetland ecosystem.

No	Local Name	English name	Scientific Name
1	Woira	African Olive	Olea europaea *L.*
2	Girar	Acacia	Acacia senegal
3	Wanza	Large-leaved cordia	Cordia Africana

4	Yehabesha Tide	Cypress	Cupressus Lusitanica Mill
5	Grevila	Grevillea/Silk Oak	Grevilla robusta
6	Shola	Cape Fig	Ficus sur forssk
7	Girare	Acacia abyssinica	Acacia nilotica *(L.*
8	Agam	Carissa spinarum	Carissa spinarum *L*
9	Bisana	Croton macrostachyus	Croton zambesicus

Source:

3.2.2. Driver and pressures Sululta Wetland Forest Ecosystem

A drivers-pressures-state-impact-response (DPSIR) framework distinguishes between drivers and pressures. Drivers are the ultimate factors that cause change, and pressures are the more immediate factors that affect the environment.

According to the data collected focused group discussion and key informants the main cause for the deforestation of the natural vegetation's is the following!

- Population growth: According to the projected data of the city Administration based on **2010** projection the total population of the city is estimated to be **129,843 (62,896** male & **66,947** female).
- Urban expansion
- Industrial Expansion: Sululta town administration has different types of industry. These include Jiandang Peng PP Bag Manufacturing , Damot Industrial and Commercial PLC , Elemtu, Nestle Water Ethiopia, Selam Spring Mineral Water Factory , To day , Abays Trading PLC, Allieid chemical

Table 14 Number and Type of Industry

	Year	No. of Industry	Type of Industry
1	2013	14	Large
		33	Medium
		31	Small
2	2014	15	Large

		40	Medium
		63	Small
	Total	118	

Therefore, in Sululta town there are more than **118** investors having registered capital of **1,993,400,000 birr** who invested on land area of **169.5 ha**

- **Wood extraction for House construction, firewood and charcoal:** According to FGD and filed observation most part of the wetland was changed in to settlement due to this reason the forest resources was destructed for house construction purpose.

Extensive extraction of fuel wood for both commercial and subsistence purposes is a driver of degradation throughout Ethiopia. The demand for wood fuel in 2009 was 77 million m3 against 9.3 million m3 of sustainable supply (Beleke, 2011). More than 40% of the annual charcoal supply to Addis Ababa is from the Rift Valley areas (Alem et al., 2010 as cited by Benzin & Serk, 2013). The activity is aggravated by inefficient traditional charcoal production technologies. Fuel-wood extraction is most prominent in surrounding urban areas, as these areas have high demand for fuel-wood.

Figure 10 Forest Extraction for house construction

To resolve the current problem, taking appropriate measure and giving community awareness is better way to conserve and protect this life giving resource. Unless drastic measures have taken to reverse these dangerous trends of deforestation, it could lead to far-reaching problem.

- **Coal mining:** The participants in the FGD explained that coal mining is one of the major driver for the degradation of forest because in order to produce coal the investor construct nonstandard road by degrading the forest to make the suitable condition for coal mining, unfortunately the road is highly eroded during rainy season, due to this the forests around the road was highly degraded through massive erosion.

3.2.3 Impact of deforestation and forest degradation on the livelihood of local communities.

Forests play an important role in the environment like providing the basic necessities, providing habitat for the variety of wildlife species, contribute to the control and moderate climate, prevent soil erosion and flooding despite the benefits obtained from forest ecosystem goods and services, the clearing of forest and deforestation have contributed to the continued decline of forest resources in Ethiopia. The participants of FGD as well as woreda forest expert clarified that degradation of forest ecosystem bring various impact to the local community, some of them are:-

- **Declining the abundance of aquatic animals and plants**:
- **The variability in amount and distribution of rain fall:** FGD participants perceive that the distribution of rainfall was decreased from year to year. Due to this problem the growing season was changed and correspondingly the temperature was raised highly. FGD participants associate this problem with the impact of deforestation and change in forest ecosystem services.

3.2.4. Response of deforestation and forest degradation

Even if there were no responses taken from Regional, Zonal and Woreda level to solve those problems for the protection of deforestation and forest degradation from the local community

3.2.5. Outlook

Unless the stakeholders reverse forest coverage change of the area, the people will lose the total forest and shrub area for the next 50 years.

As the data obtained from GIS land use land cover detection, 2020 the forest coverage of the forest ecosystem from the year 2002 to 2022 was declined by 0.82 ha in each year and also the

total coverage of the forest will be declined by 41ha for the next 50 years. This will in turn contribute to livelihood food insecurity among people living in the forest-farm interface.

If deforestation and forest degradation in South west Ethiopia continues as the existing rate, the amount of rainfall infiltrating in to the soil as well as percolation of water into ground will be reduced. This leads to low water availability during dry seasons, affecting human and livestock access to water throughout the year.

3.2.6. Option for future action

Working to end deforestation and forest degradation while helping to restore forests lost is our best chance to solve the climate emergency, protect wildlife, and defend the rights of Indigenous Peoples and traditional local communities. That's why we are campaigning for more forests tomorrow than there are today. So in order to reduce and to end deforestation and forest degradation all stockholders should better to undertake the following actions:-

- Participatory forest management should be practiced in and near watersheds, as part of the national Sustainable Land Management Program (SLMP). This is contributing to greater resilience on the part of smallholder farmers, in the face of climate change.
- Appropriate soil and soil water conservation practice should be applied for better management of forest as well as to create sustainable and suitable environment.
- Reinforcing and expanding forest protected areas; and adopting agroforestry, afforestation and reforestation and sustainably managing existing planted forests to meet demand for wood, thereby reducing pressure on natural forests.
- Establishes forest nursery seedling site in the command area and produce sufficient amount of seedlings for plantation purpose
- Putting in place disincentives such as fines for forest clearing, laws and regulations to protect forest, and zoning for production and protection. They concerned body should give awareness for the community about the impact of deforestation and forest degradation on the local community as well as the environment.

Generally, the government as well as the local community should practice Environmental policy on the ground level.

3.3. State and Trend of Biodiversity

Biodiversity is 'the variability among living organisms from all sources including; terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystem' (CBD, 1992; Article 2).

Ethiopia is one of the world countries, which is rich in faunal, floral and microbial diversity. Ethiopia is considered as the fifth largest floral country in tropical Africa. The flora of Ethiopia is very diverse with an estimated number between 6,500 and 7,000 species of higher plants, of which about 15 percent or more are probably endemic. Ethiopia is also rich in faunal diversity with mammals (277 spp.), birds (861 spp.), reptiles (78 spp.), amphibians (54 spp.), and fishes (101 spp.) (Mishra et al,2012).

The diversity of ecosystems of Ethiopia has been described in a number of reports and publications (e.g. Tesfaye Awas et al., 2003; IBC, 2005; 2009). According to the recent reports, 10 distinct ecosystems are found in Ethiopia (Abebe Getahun and Eshete Dejen, 2012). From this Classification of ecosystems Oromia has nine ecosystems diversity is based on vegetation types, which describe dominant plant species composition of the respective ecosystems. These ecosystems are geographically located in different highlands, mid-altitudes and lowlands and harbour unique and diverse floral, faunal and microbial species composition. The variation in the species composition across the ecosystems might be attributed to variability in climatic, edaphic and other associated factors within the ecosystems.

3.3.1. Flora Diversity of Sululta Wetland Ecosystem

The floral resources of Sululta wetland ecosystem is plant species listed in the following table by their Local name and Scientific name.

Table 15 Identified plant species of Sululta Wetland Ecosystem.

English name	Scientific name
Large-leaved cordia	Cordia Africana
red hot poker tree	Erythrina brucei
Labill	Acc. Saligna
	Carissa edulis
	Acacia albida
	Juniperus procera
	Hagenia Abyssinia
	Moringa oleifera
	Podocarpus falcatus
	Olea Africana
	Acacia Nilotica
	Vicus vasta
	Acacia species

Source:- (Oromia Region EPA,2023 and FGD).

According to FGD, the plant species like Tsede, Tikur-enchet, Key-enchet, Shimel, are highly threatened, because those plant specious were used for different material preparation as a timber product.The other threatened tree species are over utilized for charcoal, fuel wood and as a construction material. Due to these reasons the forest is highly deforested from period to period.

3.3.2. Faunal Biodiversity of Sululta wetland

Sululta wetland ecosystem encompasses desirable habitat contributing for the occurrence of high faunal diversity. However, the information for this state of environment report is limited to mammals and birds.

Table 16 Identified Animal species in Sululta wetland ecosystem.

Local name	Scientific name
Jib	*Hyaenidaecarnivora*
Neber	*Pantheratigris*
Tota	*Hylobates lar*
Dikula	*Aepyceros melampus*
Zinjaro	*Papio hamadryas*
Midaqo	*Cephalophus harveyi*
Tenchele	*Brachylagus idahoensis*
Kerkero	
Gureza	

Source:- FGD.

In the past the forest was essential habitat for different mammal species. However, nowadays many species like Lion, Buffalo, Giraffe and Deer are totally disappeared from the study ecosystem due to their habitat destruction.

Bird species: - As part of wildlife resource, besides assessing the abundance and diversity of larger mammalian species, making an attempt to identify and record wild animal species including bird species of the relevant areas within the territory of the forest ecosystem is equally important. Hence, through efforts made to identify available bird species in the potential wildlife areas, a number of bird species have been identified. The identified bird species in the sululta wetland forest ecosystem are listed in table below.

Table 17 Identified bird species in Sululta wetland ecosystem.

Local name	Scientific name
Amora/Qura	*Corvus corone*
Jigra	*Alopochen aegyptiacus*
Regbe	*Columba livia*
Koke	
Dakeye	
Gera	
Kutu	
Chilat/chilfit	
Genda qorqur	
Jofe	
Amanya	
Gugut	
Boso	

Source: FGD.

3.3.3. Status of Invasive species

Plant invasion is a strong threat to the species diversity around the world during the 21st century after habitat loss. Large number species of IAP are introduced to native country in the world and few of these become problematic; they are introduced in to a country either through human or natural (e.g. winds, birds, animals, water). Thousands of plant species have been transported by humans to areas far from their natural habitats; accidentally or intentionally (e.g. agro-forestry, horticulture, forestry, and animal husbandry purposes). However, invasions by IAPS are one of the largest threats to the ecosystems of the earth, and the services (Sonya A, 2010).

Invasive species cause biodiversity loss by competing with native species for feed and habitat and altering the physical environment in ways that exclude native species. So far, close to 35 invasive weed species are identified in Oromia, and they are posing negative impacts on native biodiversity, agricultural lands, rangelands, national parks, water ways, lakes, rivers, power dams, road sides and urban green spaces with huge economic as well as social consequences. Among these species: mesquites (*Procopius juliflora*), parthenium weed (*Parthenium hysterophorus*), water hyacinth (*Eichhornia crassipes*), lantana weed (*Lantana camara), Acacia* sp., and other weeds such as *Orobanche* and *Cuscuta* sp. are identified as major plant invaders. Recent surveys found also emerging plant invaders such Cryptostegia grandiflora, Parkinsonia aculeata, Mimosa diplorotricha and Nicotiana glauca (Rezene Fessehaie et al., 2012).

Status of Invasive species and their distribution in Oromia region

No	Name of Zone	Type/name of Invasive Alien species with area of coverage by zone															
		P. hysterophorus	*P. juliflora*	*E crassipes*	Striga species	*L. camara*	Argemone ochroleuca(mexicana)	Senna didymobotrya/Ajee	Calitropis procera	Cryptostegia grandiflora	Cuscuta campestris	Orobanche	Mujjan	Amaranthus	Accacia Maliifera	Accacia nubica	Total
1	East Arsii	6199		584	4335.5	3294	9.333	64.24									14486.073
2	West Arsii	12580				4575	32,850	1725			1650						53380
3	Bale	10195				40	6598										16833
4	Guji	3709.65			50	500.3	108	751.46									5119.41
5	West Gujii	1000		2500								7500	1400	275	98868.8	148303	259847.14
6	Borana	494344.2	308965				185379.07										988688.39
7	East Harerge	10412	540		6832	200											17984
8	West Harerge	1658	2715	3	197.5	440	77.5										5091
9	East Shewa	5000	2500	3000		3000	30,000		1500	400							45400
10	West Shewa	83.375			18525	650	1603										20861.375
11	South west Shewa	388.25					13045										13433.25
12	North Shewa	192			350		3020										3562
13	Iluu Abba bora	27		0.125		65	120	172									384.125
14	Buno Bedele	1500			1800												3300
15	Oromia around Special Zone	60															60
16	East Welega	14.0125		15	27												56.0125
17	Horo guduru Welega	247883.2															247883.23
18	West Welega	142.33	0.05		129	28											299.38
19	Qelem Welega	509.375				0.01											509.385
20	Jimma	1119			53	0											1172
21	East Bale	62587			8715		14500	4627									90429
	Total	959603.4	314720	6102	41014	12792	287309.9	7339.7	1500	400	1650	7500	1400	275	98868.8	148303	1788778.8

Ecosystem Services of Sululta Wetland Ecosystem

Ecosystem services are the many and varied benefits to humans provided by the natural environment and healthy. These ecosystems, functioning in healthy relationships, offer such things as natural pollination of crops, clean air, extreme weather mitigation, and human mental and physical well-being. Collectively, these benefits are becoming known as ecosystem services,

and are often integral to the provision of food, the provisioning of clean of wastes, and the resilience and productivity of food ecosystems.

Ecosystem Services is the mechanism by which the ecosystem provides resources that we often take for granted, such as clean water, forest and wildlife habitat and native and agricultural field pollination. If we are in the town or rural areas, the environment in which people live offers products and services that are very familiar to us in this way. Here, the services an ecosystem can provide are designed to moderate extreme weather and its effects, disperse seeds, mitigate drought and floods, and protect people from the harmful ultraviolet rays of the sun. It was also help to cycle and move nutrients, protect streams and rivers against erosion, detoxify and decompose waste and control agricultural pests. It also creates and retains soils and renews fertility, contributes to climate stability, purifies the air and water, and pollinates crops and forest (Gizachew, 2019).

Four different types of ecosystem services have been distinguished by the scientific body: regulating services, provisioning services, cultural services and supporting services. An ecosystem does not necessarily offer all four types of services simultaneously; but given the intricate nature of any ecosystem, it is usually assumed that humans benefit from a combination of these services. The services offered by diverse types of ecosystems (forests, seas, coral reefs, mangroves, etc.) differ in nature and in consequence. In fact, some services directly affect the livelihood of neighboring human populations (such as fresh water, food or aesthetic value, etc.) while other services affect general environmental conditions by which humans are indirectly impacted.

3.3.4. Drivers and Pressures of Biodiversity Degradation on Sululta Wetland Ecosystem

Anthropogenic factors have major influences on ecosystem functioning and stability, which are often reflected in changes to biodiversity that includes wildlife. This is because abundance and diversity of the ecosystem community are changed.

The main drivers of biodiversity degradation in sululta wetland ecosystems are population growth, expansion of urbanization and Industrial expansion of agricultural land expansion.

Population Growth: According to the projected data of the city Administration based on **2010** projection the total population of the city is estimated to be **129,843 (62,896** male & **66,947**female).

Expansion of Industry: Sululta town administration has different types of industry .These include Jiandang Peng PP Bag Manufacturing, Damot Industrial and Commercial PLC, Elemtu, Nestle Water Ethiopia, Selam Spring Mineral Water Factory, to day, Abays Trading PLC and Allied chemical. Due to the expansion of industries the specious diversity was declined because those dangerous industrial chemical wastes were disposed in to the wetland and damaged different species that live in and around the wetland.

There are many investors in sululta town. Accordingly, the following table briefly shows investment profile of the town:-

Table 18 Investment profile

	Year	No. of Industry	Type of Industry
1	2013	14	Large
		33	Medium
		31	Small
2	2014	15	Large
		40	Medium
		63	Small
	Total	118	

No	**Types of Project**	**No.of Projects**	**Land area in m2**	**Capital registered**	Job Opportunities
1	Large	15		1,000,300,000	2861
2	Medium	40		694,000,000	2106
3	Small	63		299,100,000	210
	Total	118	169.5 hec	1,993,400,000	5700

Source: - From projected data of 2014 E.C

Figure 11 Industries in the wetland ecosystem

Settlement: According to field observation and focused group discussion there is great amount of settlement in and around the wetland area. Due to this reason the wetland ecosystem was changed in to settlement area and also the diversity of plant and animal species existed in the wetland ecosystem was disappeared.

Figure 12 New settlement in the wetland ecosystem

Expansion of Invasive weeds:- Invasive species spreads from one place to the other places by different mechanisms. The more common spreading mechanisms are wind, cattle's foot, car tiers, birds, water and others. In the study area there was invasive weeds that dominate the wetland.

According to FGD, in the study area there are different invasive weeds like አቀንፍራ/*stringa lermontica/*, Nug-anbase, Ged-zemede and Qontir are expanded from period to period. Due to this reason the indigenous plant species that give medicinal value was disappeared instead invasive weeds was expanded consecutively the wetland and life's in the wetland was totally disappeared.

Figure 13 Invasive weeds in the wetland

Accumulation of plastic and other wastes in the wetland: According to field observation and in the FGD plastic accumulation was one of the major drivers for the degradation of the wetland as well as different species in the wetland.

Figure 14 waste damping

3.3.5. Impact of Biodiversity Degradation

Biodiversity provides free of charge services that are crucial for the well-being of the citizens in the region. These services include clean water, pure air, soil formation, and protection, pollination, crop, pest control, and the provision of foods, fuel, fibres and drugs. As elsewhere, these services are not widely recognized, nor are properly valued in economic or even in social terms. Reduction in biodiversity affects these ecosystem services. The sustainability of ecosystems depends to a large extent on the buffering capacity provided by having a rich and healthy diversity of genes, species and habitats

Losing biodiversity is like losing the life support systems that the human beings, and other species, are desperately depend on Climate change will have significant impacts on biodiversity and will cause shifts in the distribution of species as they search for new, suitable habitat.

In the case of the protected areas, these shifts could be outside the boundaries of protected areas or it could cause new species to move into the protected area. According, the designated sites constitute valuable space for nature, possibly allowing other species to move in (Hole et al. 2009). Many observation and analysis have confirmed that changes in climate over the last few decades of the 20th century have already affected biodiversity (UNDP, 2008).

In Oromia region in general and at living areas of farming community in particular, where both human and livestock populations heavily concentrated, biodiversity loss become more serious during prolonged droughts and severe water stress During this time, pressure on surrounding ecosystems that are embodied with diverse biological resources will increase. Destruction of forests, removal of grasses, forest fire, soil erosion by winds, killing of wild animals for different purposes, extraction of water from scarce sources, and conflict over scarce resources in general will be more and more as local people will be forced to exploit and utilize scarce resources around in order to sustain their live and adapt themselves to increasing climate change shocks and risks.

Invasive weeds also affect the community by decreasing crop productivity and also decrease the availability of wetland ecosystem.

In general the local community affected socially, economically and ecologically due to the loss and degradation of wetland diversity. Ever more people produce ever more waste and pollution. As populations increase, the disposal of waste from households, agriculture and industry, becomes an increasingly serious issue.

Due to the wetlands are becoming choked with plastic waste which is killing millions of animals, from sea turtles to whales

3.3.6 Responses to Biodiversity Degradation on Sululta Wetland ecosystem

There was no response taken at all.

3.3.7 Outlook

If the practices Industrial expansion around the wetland, expansion of urbanization as well as land us change like covering the wetland in to eucalyptus tree continues as it is practiced as present, the wetland diversity of the ecosystem will totally destructed within the coming two decades.

Unless the Federal government and Oromia regional state government, concerned bodies and stakeholders deal and work together to protect and save the wetland ecosystem in common understanding, sululta wetland ecosystem is in great risk and it's difficult to control the future risk.

3.3.8 Recommendation

- Promote public training, education and community-based monitoring, where appropriate, as integral elements in conservation and management.
- Control illegal encroachment to wetland boundary and work in line with investment sectors of the region to conserve the biodiversity in common sense.
- Ensure legislations and guidelines to introduce a system of direct and indirect incentives to promote the conservation and sustainable use of biodiversity.
- Implementing the National biodiversity policies like; the policy provides for guidance towards effective conservation, rational development and sustainable utilization of the country's biodiversity, and contains comprehensive policy provisions for the conservation and sustainable utilization of biodiversity.
- Conducts ecological principles of conservation methods, such as
    - Biodiversity is supported by protection of any species and varieties
    - Habitat maintenance is fundamental to species conservation

3.4 Water Availability in Sululta Wetland Ecosystem

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities. Water abstraction for domestic use, agricultural production, mining industrial production, power generation, and forestry practices can lead to deterioration in water quality and quantity that impact not only the aquatic ecosystem (i.e., the assemblage of organisms living and interacting together within an aquatic environment), but also the availability of safe water for human also the availability of safe water for human that aquatic environments cannot be perceived simply as holding tanks that supply water for human activities. Rather, these environments are complex matrices that require careful use to ensure sustainable ecosystem functioning well into the future. Moreover, the management of aquatic environments requires an understanding of the important linkages between ecosystem properties and the way in which human activities can alter the interplay between the physical, chemical and biological processes that drive ecosystem functioning. Providing safe and secure water to people around the world, and promoting sustainable use of water resources are fundamental objectives of the Millennium Development goal. The international community has recognized the important links between ecosystem and human health and well-being ((GEMS), 2008).

Excess heat associated with the increase in global temperature during the last century is being absorbed and moved by the ocean. In addition, studies suggest that seawater is becoming fresher in high latitudes and tropical areas dominated by rain, while in sub-tropical high evaporation regions, waters are getting saltier (Feldman, 2017).

The intensification of extreme precipitation and flood events in overall climate regions increases as water availability seasonally increases from dry to wet regions. Similarly, there is an increase in the intensification of extreme precipitation and flooding with the seasonal cycle of water availability. The connection between extreme precipitation and flood intensity changes and spatial and seasonal water availability becomes stronger as events become less extreme (Tabari, 2020).

Water quality and the risk of water-associated diseases are serious public health concerns in many developing countries like Ethiopia. This is mainly due to a lack of proper testing and

monitoring system of water quality parameters for most of the towns in Ethiopia (Solomon. T, 2011).

Most of the population of Ethiopia in rural and urban areas does not have access to safe and reliable sanitation facilities. The majority of households do not have a sufficient understanding of hygienic practices regarding food, water, and personal hygiene. As a result, above 75 % of the health problems in Ethiopia are due to communicable diseases attributed to unsafe and inadequate water supply, and unhygienic waste management, particularly human excreta (Ministry of Health, F. 2011).

Consequently, pollution of surface and groundwater is one of the most serious problems affecting the health of the population of Addis Ababa, Ethiopia (*Dezuane J., 1996*). Likewise, the populations of Sululta town were obtaining their drinking water from groundwater which most of them found near to the residents and this, in turn, may affect the quality of drinking water. Due to the Scarcity of water supply in the town; people have been getting water by shift of 5-10 days (Sululta town water office, personal communication). Since the water was supplied by shift, certain water pipes were empty and dry while others were on supplying water to other areas. In this condition, microorganisms may grow up in the water line during water supply interruption due to a shift.

The water office of Sululta town checks their water quality standard once a year and when water-caused diseases rose only and chlorine was added randomly without a schedule (Sululta town water office worker interview, Mr. Diriba). The health sector of the town regularly reports that water-associated diseases are one of the top-ten diseases, and there are certain indicators that the population of the town is suffering from water-associated diseases, very probably due to poor drinking water quality (Sululta town health center quarter and annual report, 2010).

Diseases caused by contaminated water also exact a heavy economic load both on the public health care system for treatment and person affected for transport to the clinic, medicine, and lost productivity. Generally, the presence of contaminants in the water is leading to adverse health effects (JIMA, 2019).

Despite being a popular destination for both foreign and domestic investment, many residents in Sululta still do not have household access to clean drinking water. This caused mass protests to arise in Sululta in December 2015 and during the 2014–2016 Oromo protests

Chlorination is the only treatment method used in Sululta town. The drinking water supplied for the consumers was checked once a year and chlorine was randomly added to the storage tank. Sululta drinking water quality testing and monitoring system was assessed and drinking water quality parameters like pH, alkalinity, turbidity; EC, total hardness, residual of chlorine, total coliform, fecal coliform, etc. were analyzed by sampling from six boreholes, before and after treatment (chlorination) from three reservoirs, and water points. The results of these parameters were compared with the Ethiopian standard and WHO guideline values. Accordingly, in a sample from boreholes, the mean value of pH, TDS, turbidity, and E.C were 8.04, 171 mg/l, 0.32 NTU, and 64.17 μs/cm respectively fitted with Ethiopian standard and WHO guidelines. In addition, the mean value of total hardness 171.95 mg/l was accepted by Ethiopian standards but not accepted by WHO guidelines.

The laboratory test result of boreholes`, reservoirs`, and water points` mean value of free chlorine residue was zero (0) mg/l which is out of the range of Ethiopian standard and WHO guide lines , 0.2 mg/l-0.5 mg/l. Biological quality of the reservoirs water did not agree with the maximum limit of Ethiopian standard and WHO guide line. The mean values of the total coliform of reservoirs were 27.5 TCC/100ml, 1.5 TCC/100ml and 19.75TCC/100 ml for *kajima, Shufune* and *10 kilo* reservoirs respectively which are not in the range. The physicochemical parameters samples result from water points were agreed with the Ethiopian standard and WHO guide line except free chlorine residue. Free chlorine residue was below the range. The mean value of Total Coliform and Fecal coliform were 22.00TCC/100ml and 5.33 FCC/100ml respectively which were beyond Ethiopian standard and WHO guide line. Generally in dry season microorganism was found in *Sululta* town drinking water which was above the maximum limit and needs disinfection to safe the community from drinking water health problem.

Ethiopia has abundant water resources and contains the headwaters of numerous Tran's boundary rivers, including the Nile. Key water stress metrics suggest Ethiopia is water stressed. Total annual renewable water resources per person are 1,162 m3, which is below the Falkenmark Water Stress Indexi threshold for water stress and just above the water scarcity threshold. The ratio of water withdrawals to supply is 32 percent, which exceeds the SDG 6.4.2 threshold for water stress. Water stress is most evident at the sub-national level and seasonally in some locations.

In line with this according to the focus group discussion (FDG) on the Sululta wetland ecosystem" because of the investment policy encouragements *Sululta wetland ecosystem has been distributed to investors for different purposes, like agriculture, industrial activities, grazing grasses so on. Hence after serving different activities in the summer season, and turn to saturated waters in the winter season".* In line with this, Actions going on in the Sululta wetland ecosystem were not considered/ performed environmentally friendly, hereafter the wetland manifested to the surface and underground washed away in the winter season at the time of water saturation.

The expansion of cultivated land in place of natural vegetation has a substantial influence on the hydrologic characteristics of a watershed The LULC change also has a significant effect on changing hydrological processes such as runoff volumes, groundwater recharge, and infiltration in Ethiopian river basins . The Sibilu River basin is one of the largest river basins and is found in the Sululta wetland ecosystem.. Understanding Hydrological Processes under Land Use Land Cover Change in the Upper Genale River Basin, Ethiopia is crucial. The following map shows water occurrence change intensity.

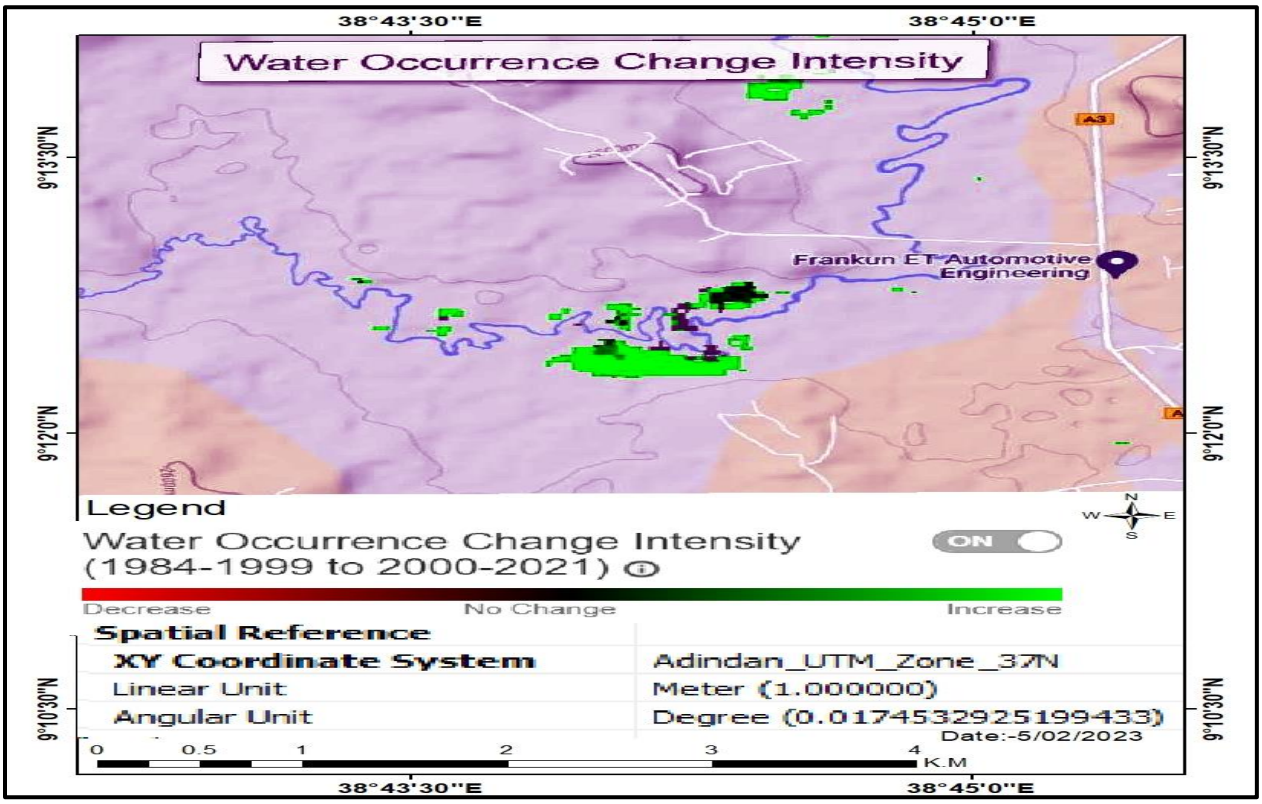


Figure 15 Water Occurrence Change Intensity

The map displays that, increases in water occurrence are shown in green, and decreases are shown in red. Black areas are those areas where there is no significant change in the water occurrence during the 1984-2021 period. The intensity of the color represents the degree of change (as a percentage). For example, bright red areas show greater loss of water than light red areas. Some areas appear grey on the maps, these are locations where there is insufficient data to compute meaningful change statistics (Jean-Francois Pekel, Andrew Cottam, Noel Gorelick, 2021).

3.4.1. State and Trend of Water in Sululta wetland

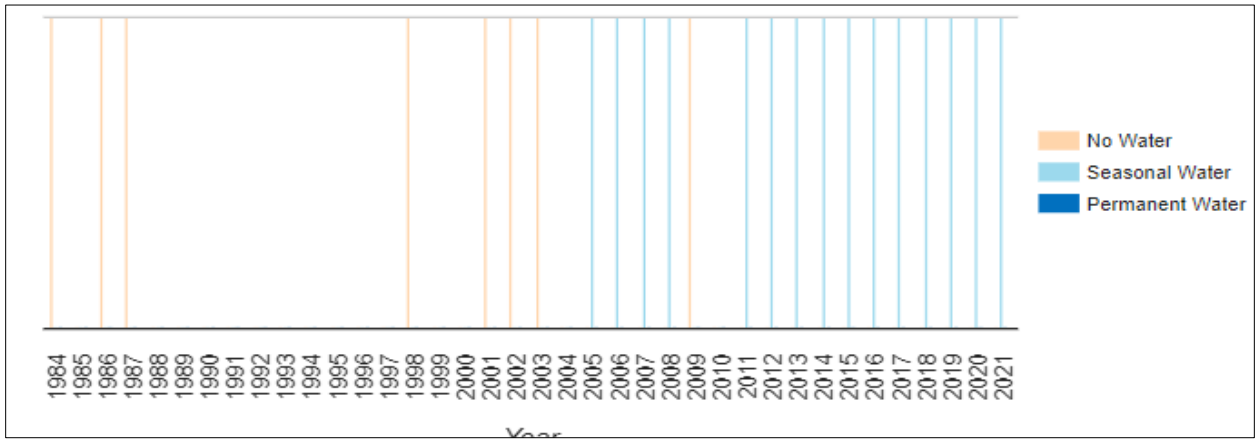


Figure 16 Water history

Pixel Coordinates: Lat: 9.206967, Long: 38.736311

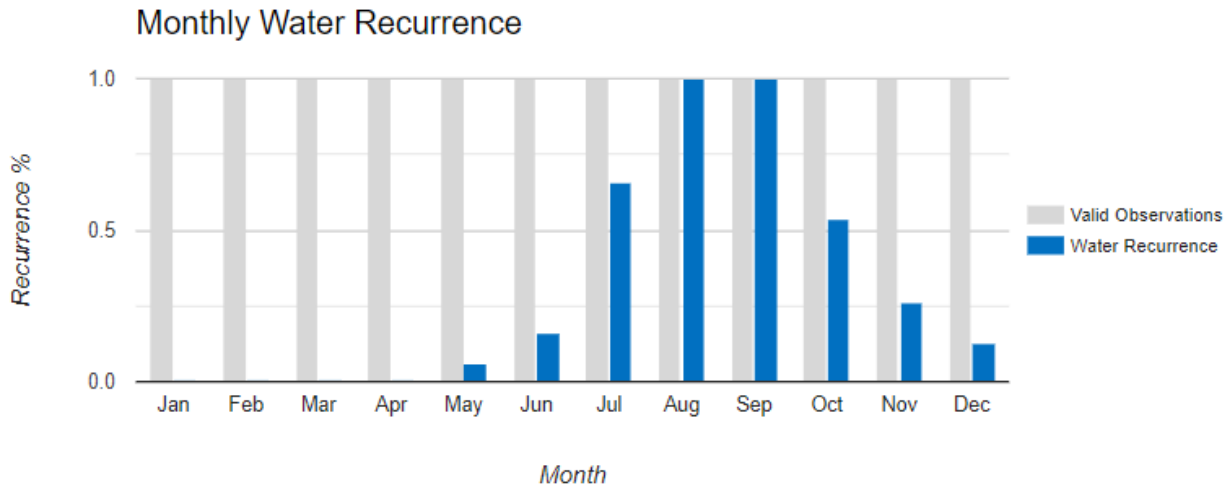


Figure 17 Monthly Water Recurrence

Source:-(Jean-Francois Pekel, Andrew Cottam, Noel Gorelick, 2021)

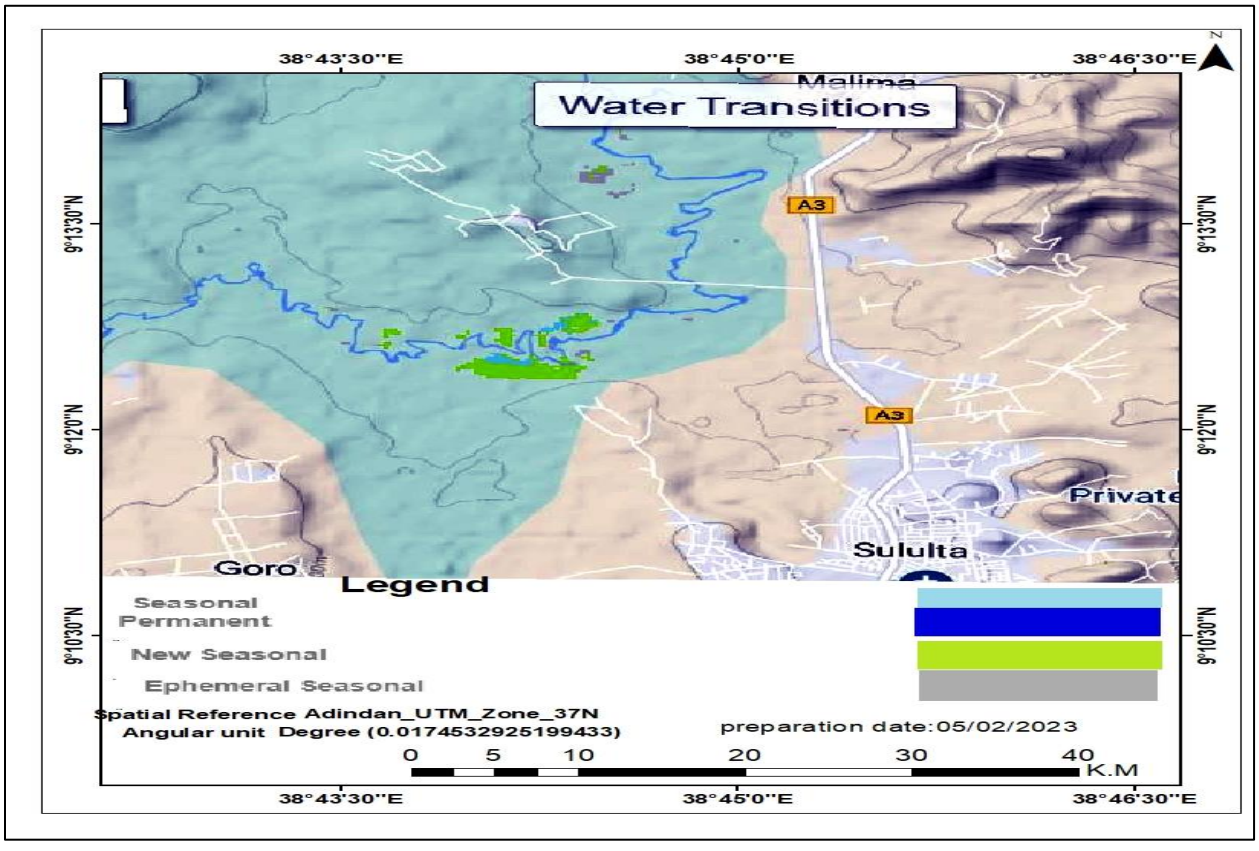


Figure 18 Water transition

1. New seasonal water surfaces (i.e. conversion of a no-water place into a seasonal water place)
2. Ephemeral seasonal water (i.e. no water places replaced by seasonal water that subsequently disappeared within the observation period)
3. Temporal profiles recording the full history of each pixel are provided. These allow us to define every month the water's presence or absence (and also the absence of observation) throughout the archive. Using the profiles it is possible to identify specific months/years in which conditions changed, e.g. the date of filing of a new dam, or the month/year in which a lake disappeared. In addition, profiles documenting the seasonality (and possible transition of seasonality) are provided. These profiles allow us to discriminate between occurrence changes resulting from intra and inter-annual variability or resulting from the appearance or disappearance of seasonal or permanent water surfaces. An example of this transition map is shown below (Jean-Francois Pekel, Andrew Cottam, Noel Gorelick, 2021).

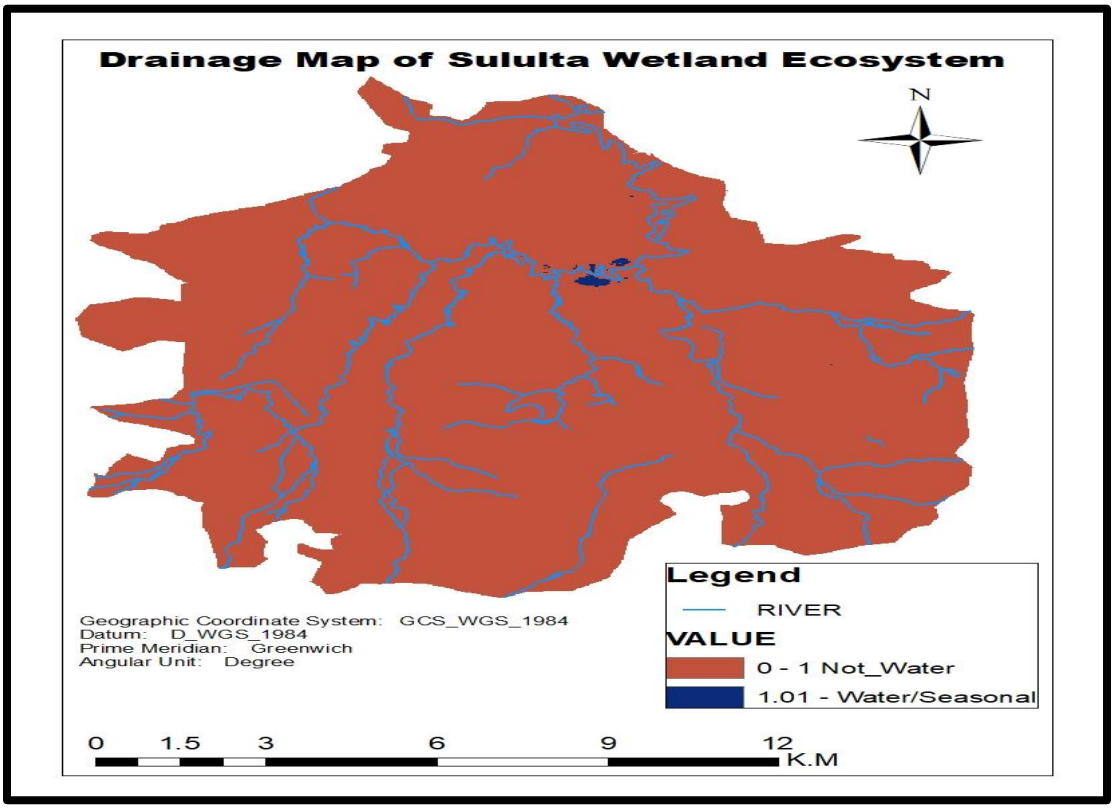


Figure 19 Drainage Map of Sululta Wetland Ecosystem

In the study area, Siblu and Deneba are two main rivers across the center of the Sululta wetland ecosystem. The shape of the catchment is almost circular showing a fast response to rainfall input whose surface runoff will be abundant for any conservation scheme.

Table 19: The mean monthly run-off

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Siblu	0.53	*0.35*	*0.41*	*0.52*	*0.59*	*1.61*	*35.54*	*92.02*	*39.27*	*5.10*	*1.39*	*0.80*	*178.15*
Deneba	0.14	0.06	0.05	0.07	0.15	0.41	11.13	32.11	12.52	3.25	1.74	0.24	62.37
Mughe	0.6	0.5	0.7	0.8	0.8	2.1	51.8	119.8	53.9	7.6	2.1	1.0	246.65

Source:- Derba & Project, (1986)

The monthly discharge of the Sibilu River ranges from 0.35 million m^3 in February to 92.02 million m^3 in August. The monthly discharge of the Deneba River ranges from 0.05 million m^3 in March to 32.11 million m3 in Augustthe monthly discharge of the Mugher River ranges from 0.58 million m3 in February to 119.85 million m3 in August (Derba & Project, 1986).

There are about 3 more rivers because the name of the river varies depending on the destination or its surroundings. They are:

1. Bilewo Shet
2. Rogogo Shet
3. kola Shet

Water Quality in Sululta Wetland Ecosystem

According to GEMS (2008), the quality of any body of surface or groundwater is a function of either or both natural influences and human activities. Without human influences, water quality would be determined by the weathering of bedrock minerals, the atmospheric processes of evapotranspiration and the deposition of dust and salt by wind, the natural leaching of organic matter and nutrients from the soil, by hydrological factors that lead to runoff, and by biological processes within the aquatic environment that can alter the physical and chemical composition of water. As a result, water in the natural environment contains many dissolved substances and non-

dissolved particulate matter. Dissolved salts and minerals are necessary components of good quality water as they help maintain the health and vitality of the organisms that rely on this ecosystem service (Stark et al., 2000).

The world's water ecosystem is at high risk due to its changing biological, chemical, and physical properties. Groundwater, which is the primary source of drinking, is deteriorating due to the increasing population growth, urbanization, land use/land cover changes, water demand, and climate change. The combined effects of these changes and nature activities such as droughts and water resources, particularly freshwater, are becoming inadequate and polluted. The human population also suffers from water diseases such as methemoglobinemia (blue-baby syndrome) and thyroid effects in bottle-fed infants (less than 6 months old) caused by nitrate-polluted portable water. This rapid increase in population also transforms the natural environment into an anthropogenic environment, which means that anthropogenic activities would take place at a massive scale, such as industrialization and massive food production activities to meet the food and fiber demand of the exponential population growth (Ahmad et al., 2021). In Sululta at the dawn of the industrial residents, humans' life span had been disturbed due to the consumption of polluted water discharged from industries and mixed with clean water. The quality and quantity of ground and surface water resources in Sululta are affected by land use/landcover (LULC) dynamics, particularly the increasing urbanization coupled with high household wastewater discharge and decreasing open lands.

Amount of nitrate concentration

Investigations in developing countries on safe drinking water are mainly focused on the incidence of acute infectious diarrhea because it is a cause of death among young children. In addition, chemical agents have been associated with adverse health effects. One of these chemicals of concern is nitrate. Risks to human health associated with high levels of nitrate in drinking water include thyroid gland dysfunction, gastric cancer, and a decrease in the capacity of blood to transport oxygen (known as methemoglobinemia) in infants below six months old. In addition, it poses health problems for pregnant women. Finally, excessive nitrates can cause health problems in ruminant animals and once released into the environment, can cause dead zones in the oceans near major rivers (Atnafu, Dejen, & Vijverberg, 2011).

According to studies in both developed and developing countries, nitrate levels in groundwater have been increasing (Hu et al., 2005), and can present serious problems (Spalding & Exner, 1993).

In line with this, the societies who live surrounding Sululta wet Groundwater and spring water is preferred as a source of potable water because it is available throughout the year and is less contaminated than surface water.

Furthermore, according to Jima, (2019), aggregated data for fluoride, nitrate, iron, and conductivity, subdivided by supply type and regional state, is shown for the period from 1995 to 2004. Of 769 samples analyzed for fluoride, overall compliance was approximately 83%, with maximum concentrations up to 26.5 mg/l in Oromia. The lowest levels of compliance were in Afar (52%), Oromia (71%), and Somali (73%). Although overall compliance for nitrate was high in Ethiopia (Ca. 97%), in Dire Dawa the figure was only 67%, with nitrate concentrations of up

Amount of PH

The importance of pH in distributed water is normally related to the corrosive or scale-forming properties of water and the efficiency of chlorine disinfection. In raw water, pH can impact coagulation performance. Water treatment processes such as lime soda softening and high alum dosage coagulation can alter the pH. Groundwater usually has a stable pH.

Unless pH has an impact on or is altered by treatment processes in use, it is not an important control measurement. Meters and less accurate color comparators are available for on-site pH measurements. On-site monitoring should be carried out on water entering the distribution system. Monitoring of pH may have to be done at various frequencies depending on the size of the facility and supply source. Off-site monitoring is not required.

Sulphide (as H2S)

In groundwater, sulphide can be generated biologically or may originate from a gaseous environment in the aquifer. Sulphide may also be produced in household hot-water heaters. In addition to its distinctive odor, sulphide gas can be corrosive and hazardous in confined spaces.

Any measurement of sulphide as hydrogen sulphide gas dissolved in the water should be done on-site. The need for such analyses will be determined on a site-specific basis.

General Chemical (Major Ions)

The composition and concentration of general chemicals identify the water‟s chemical composition. This will vary among supply sources. A groundwater supply generally will have less variability than a surface water supply, which tends to vary at least on a seasonal basis. In general, samples should be collected from treated water at the water treatment site as outlined in the below Table.

Table 20: General Chemical Monitoring Guidelines

Population	**Groundwater Source**
0-5000	1 per 2 years
5001-100000	1 per 6 months
>100000	1 per 6 months

Source: CAWST, 2013

General Chemicals are classified as the following parameters: Alkalinity (as CaCO3), Bicarbonate, Calcium, Carbonate, Chloride, Conductivity, Fluoride (for non-fluoridating communities), Hardness (as CaCO3), Magnesium, Nitrate, Sodium, Sulphate, and Total Dissolved Solids. Source: CAWST, 2013

Health and Toxicity

Iron, manganese, copper, and zinc are usually in the general chemical classification. Samples for monitoring the health and toxicity parameter grouping should be collected from treated water at the water treatment plant. Regular on-site iron and manganese measurements are important for process control in facilities intending to remove these constituents (Ashbolt, N.J. 2004).

The Health and Toxicity grouping also includes aluminum, arsenic, barium, boron, cadmium, chromium, lead, selenium, and uranium.

Lead may warrant special attention for problematic sites. Lead is a special situation as it may be introduced into the water via leaching from lead pipe services or plumbing systems (Saskatchewan Ministry of Environment, 2012)

Table 21: Health and Toxicity Monitoring Guidelines

Population	Groundwater Source
0-5000	1 per 2 years
5001-25000	Annually

>25000	1 per 6 months
Health and Toxicity are classified as the following parameters: Aluminum, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Selenium, Uranium, and Zinc	

Cyanide

Monitoring requirements for cyanide are shown in the Table below. Cyanide can exist in many forms. Free cyanide is a concern concerning human toxicity. Cyanide concentrations in groundwater and surface water are typically very low. Significant cyanide concentrations are most often a result of a site-specific pollutant source.

Table 22: Cyanide Monitoring Guidelines

Population	Groundwater Source.
<5000	Nil
5001-25000	Annually
>25000	1 per 6 months

Source: CAWST, 2013

Mercury

Mercury enters water supplies naturally and via man-made sources. Mercury concentrations in groundwater tend to be very low. Adherence of mercury onto sediments typically results in higher concentrations in bottom sediments (Downie, A.J, 2005). Monitoring guidelines are shown in the Table below.

Table 23: Mercury Monitoring Guidelines.

Population	Groundwater Source
<5000	Nil
5001-25000	Annually
>25000	1 per 6 months

Source: CAWST, 2013

Fluoride

Fluoride is often added to drinking water for the prevention of dental decay. Excessive fluoride concentrations may cause mottling (brown spots) on teeth. Split samples should be periodically

obtained to compare off-site and on-site measurements. Off-site fluoride monitoring guidelines are shown in the Table below.

Table 24 Off-Site Fluoride Monitoring Guidelines

Population	Groundwater Source
0-500	1 per month
501-100,000	1 per week
>100,000	1 per week

Source: CAWST, 2013

Note: For communities not fluoridating refer to the monitoring under the General Chemical section. This monitoring schedule is for communities artificially adding fluoride to drinking water or where fluoride levels consistently exceed the maximum acceptable concentration

On-site testing at the water treatment plant for all communities artificially adding fluoride is required daily regardless of population size (Jima, 2019).

Benzene, Toluene, Ethyl benzene and Xylenes (BTEX)

Due to the volatile nature of these chemicals, concentrations in surface water are generally very low. Detectable values in groundwater are normally associated with site-specific pollution sources particularly the petroleum industry (Amon M, Mhosisi M, Christopher H.D. Magadza, Richard. O, Tamuka. N, Maxwell. B and Hodson.M, 2014). BTEX monitoring frequencies are outlined in the Table below.

Table 25 Benzene, Toluene, Ethylbenzene and Xylene Monitoring Guidelines

Population	Groundwater Source
0-5000	Nil
5001-100000	1 every 3 years
>100000	Annually

Source: CAWST, 2013

BTEX involves the parameters: Benzene, Toluene, Ethylbenzene, and Xylenes which are all volatile organic chemicals

Amount of total Coli form

The fact that a water supply has been used for a long time without any adverse effects is no guarantee of its safety. Residents of a community may develop a tolerance for certain bacteria to which they are regularly exposed, but strangers often become ill from drinking the same water. For this reason, drinking water must be tested regularly for bacteriological quality (Boe-Hansen, R. 2002).

The standard bacteriological method for judging the suitability of water for domestic use is the coliform test. This method of analysis detects the presence of coliform bacteria, which are found in the natural environment (soils and plants) and the intestines of humans and other warm-blooded animals. They are discharged in the bowel movement; hence, any food or water sample in which this group of bacteria is found is to be suspected of having come into contact with domestic sewage, animal manure, or with soil or plant materials. It follows that such a water supply may contain pathogenic bacteria and viruses which cause such serious human illnesses as typhoid fever, dysentery, hepatitis, etc. (Boe-Hansen, R. 2002).

The present regulations require water systems to take a minimum number of microbiological samples each month based on the number of persons being served. The larger the population served, the more microbiological samples are required per month. The two standard methods for determining the number of coliform bacteria in a water sample are the multiple-tube fermentation technique and the membrane filter technique (CAWST, 2013).

In the multiple-tube fermentation technique, a series of fermentation tubes containing special nutrients are inoculated with appropriate quantities of water to be tested and incubated. After 24 hours, the presence or absence of gas formation in the tubes is noted. This is considered a presumptive test for the presence of coliform organisms. A confirming test performed for drinking water samples involves a similar technique using the culture from the positive presumptive test in a different nutrient medium.

In the membrane filter technique, which is less time-consuming, an appropriate quantity of water to be tested is filtered through a specially designed membrane filter that traps bacteria. The filter is removed and placed in a special dish with nutrients and incubated for 24 hours. The typical coliform colony has a metallic surface sheen. The results are usually expressed as the number of coliform colonies per 100 ml of water sample.

Sululta Town water quality testing and monitoring system

According to mentioned in following Table 2.10 the Sululta town drinking water quality testing system that one sample was taken and tested in the laboratory to characterize the yearly consuming water. From the world trend drinking water quality testing and monitoring was dependent on the number of consumers and water sources. Accordingly, the Sululta town water source was borehole and monitored as the following.

1. Three boreholes of water directly joined to the main distributor pipe without blending into the reservoir where chlorine was added.

2. Chlorination was conducted randomly on the reservoir.

3. Chlorine dosage was not properly known. They used 1 kg of chlorine powder (Ca (Cl O) 2) for 5000 m3 water and randomly reduce less than 1kg of chlorine powder for less than 5000 m3 reservoirs.

4. Chlorine solution concentration was not known but able to form a solution

Table 26: Comparison of drinking water quality testing and monitoring system of Sululta Town and world trend

s/no	Parameters	World trend	Sululta town
1	For biological test	-Depend on the	Not depend on the
2	For the Physico-chemical test sample tested	2 times a year	1 time a year
3	Chlorination	Scheduled	Not scheduled

(Source: Sululta town water bureau, questionnaire and discussion results)

Drinking Water Quality Testing Options

Historically, conventional laboratories were mainly used to carry out water quality testing. Now there is a wide variety of good kits and products available in the commercial market that allows you to do testing on your own. The five different water quality testing methods are available:

- ✓ Observation
- ✓ Using portable test kits
- ✓ Using a mobile laboratory

- ✓ Sending samples to a commercial laboratory
- ✓ Setting up your project laboratory

Observation

Water quality testing tells you about the quality at the time of sampling, but it cannot give you information on either the causes of pollution or possible future trends. Simple observation is a very useful tool to identify potential risks that could affect the current and future quality of drinking water. If contamination is suspected through observing the local environment, then testing is the next step to confirm the water quality.

Poor water quality may be indicated by observing the water source, the immediate household surroundings, containers used to carry water from the source, storage containers, and personal hygiene and sanitation practices. Water quality can also be assessed by making qualitative observations of its physical characteristics such as turbidity, color, odor, and taste. The general health, well-being or energy levels of the local population can also provide some insight into the quality of the drinking water (CRAUN GF, 1986).

Sanitary inspection is a useful observational technique. It needs no special equipment and it is quick and cheap. Some training may be required, but it does not require highly trained staff. Local conditions can also be taken into consideration during a sanitary inspection.

Using Portable Test Kits

Water quality testing can be a challenge where resources are limited. The lack of testing available in developing countries highlighted the need for rapid, simple, and inexpensive test methods. This need is especially great for rural and small communities and household water supplies that are located far away and cannot afford commercial laboratory testing. On-site testing using portable kits with simplified test methods has allowed water quality testing to be a possibility in developing countries.

National Drinking-Water Standards

A national standard for drinking water, ES 261:2001 Drinking-water – specifications was established in 2001 by the Quality and Standards Authority of Ethiopia, the organization responsible for setting standards in Ethiopia. The 2001 standard supersedes the first edition of 1990 (ES 261:1990), which was limited to piped drinking water supplies and supplies that served more than 10,000 people. The ES 261:2001 standard specified maximum permissible levels, as well as methods for testing, for18 physicochemical parameters that affect the palatability of

drinking water; 24 toxic (including 11 pesticides); total viable organisms; fecal streptococci; coliform organisms; and E. coli type 1 strain (thermo tolerant).

Table 27 Characteristics that affect the palatability of drinking water

Substance (parameters)	permissible limit	Test method
Total hardness (as CaCO3)mg/l	300	ES607
Total dissolved solid mg/l. max	1000	ES609
Total iron(as Fe) mg/l. max	0.3	ESISO6332
Manganese (as Mn) mg/l, max	0.5	ESISO 6333
Ammonia(NH3+,NH4+)mg/l. max	1.5	ESISO7150-2
Residual, free chlorine mg/l. max	0.5	ESISO7393

Drinking Water Quality Parameter

Alkalinity is defined as a measure of the buffering capacity of water to neutralize strong acids. This capacity is attributed to bases that are present in natural waters including OH-, HCO3-, and CO32-. More alkalinity in your water sample means more buffering capacity of your water sample.

Turbidity is a measure of the cloudiness of the water. We measure turbidity because it is a good indicator of the effectiveness of the water treatment system. Turbidity in water is caused by suspended matter, such as clay, silts, finely divided organic and inorganic matter, soluble colored organic matter, and plankton and other microscopic organisms. It can arise in drinking water if the water is inadequately treated or if sediment is re-suspended. Turbidity can also come from biofilm or corrosion products in the distribution system. High levels of turbidity can protect microorganisms from the effects of disinfection and can stimulate bacterial growth. Low turbidity minimizes both the amount of chlorine required for the disinfection of water and the potential for transmitting infectious diseases.

Conductivity is a proxy indicator of total dissolved solids, and therefore an indicator of the taste or salinity of the water. Although this parameter does not provide information about specific chemicals in water, it acts as a good indicator of water-quality problems, particularly when it changes with time. There is little direct health risk associated with this parameter, but high values are associated with poor taste, customer dissatisfaction, and complaints (WHO, 2004). High-conductivity water, for example, can cause excessive scaling in water pipes, heaters, boilers, and household appliances. The conductivity of water varies considerably by geological region, owing to differences in the mineral and chemical properties of the water body. However, changes in conductivity over time, and high conductivity values, indicate the water is contaminated, which can cause corrosion in rising mains and pipes (FMOWR 2001)

Table 28: Categoried of hardness based on range concentration

No	Range of concentration (mg/l)	Categorized of hardness
1	0-50	Soft water
2	50-150	Moderately hard water
3	150-300	Hard water
4	More than 300	Very hard water

(Source: Dezuane, 1996)

Water treatment

Water treatment is any process that makes water more acceptable for specific end-use. The end use may be drinking, industrial water supply, irrigation river flow maintenance, water recreation, or many other uses, including being safely returned to the environment. Water treatment removes contaminants and undesirable components (reducing their concentration) so that the water becomes fit for its desired end use (www.webcrawler.com).

Groundwater: Water that fills the spaces between rocks and soil making an aquifer. Groundwater depth and quality varies from place to place. As water moves through the water cycle, it naturally picks up many things along its path. Water quality will naturally change from place to place, with the seasons, and with the kinds of rocks and soil which it moves through.

In developing countries, 75% of all industrial waste and up to 95% of sewage is discharged into surface waters without any treatment (EPA, 2001). Even though Water **25** may be clear, it does

not necessarily mean that it is safe for us to drink. It is important to judge the safety of water by considering the following three types of parameters:

A. Microbiological- bacteria, viruses, protozoa, and helminths (worms)

B. Chemical- minerals, metals, chemicals, and pH

C. Physical- temperature, color, smell, taste, and turbidity

Safe drinking water should have the following microbiological, chemical, and physical parameters:

 Free of pathogens (A pathogen is any living organism that causes disease. Pathogens commonly found in drinking water include bacteria, viruses, protozoa, and helminths)

 Low in concentrations of toxic chemicals

 Clear

 Tasteless, odorless, and colorless (for aesthetic purposes)

Microbiological quality is usually the main concern since infectious diseases caused by pathogenic bacteria, viruses, protozoa, and helminths are the most widespread health risk associated with drinking water. Only a few chemicals have caused widespread health effects from people drinking water with excessive quantities of those chemicals. These include fluoride, arsenic, and nitrate (Gurmessa Oljira, 2015).

Multi-barrier Approach to Safe Drinking Water

The best way to reduce the risk of drinking unsafe water is to use the multi-barrier approach.

The five steps of the multi-barrier approach to safe drinking water are:

1. Protect the source of water
2. Sedimentation of water
3. Filtration of water
4. Disinfection of water Keep the source

Sediment

Filter

Store Safely

Disinfect

5. Store water safely

Each step in the process, from source protection to water treatment and safe storage, helps reduce health risks.

Water can be treated at a central location, in large volumes, and then supplied to households through a network of pipes. This is often called centralized or community water treatment.

Smaller volumes of water can also be treated at the point of use, such as in institutions (e.g., schools, clinics, religious institutions), and in the home. This is also commonly called household water treatment and safe storage since the family members gather the water, and then treat and store it in their home (J.Brown and M.R.Perez, 2016).

Both conventional (community) and household systems follow the same basic water treatment process, which is the middle three steps of the multi-barrier approach: sedimentation, filtration, and disinfection. The main difference between conventional and household systems is the scale of the technologies used (EPA, 2011).

Figure 2.3 The basic water treatment process diagram.

- Sediment- water removes larger particles and often more than 50% of pathogens
- Filtering- water removes smaller particles and often more than 90% of pathogens
- Disinfecting water deactivates or kills any remaining pathogens

Most water requires some type of treatment before use, even water from deep wells or springs. The extent of treatment depends on the sources of water. Appropriate technology options in water treatment include both community-scale and household-scale boiling. Other techniques such as filtration, chemical disinfection, and exposure to ultraviolet radiation (including solar UV) have been demonstrated in an array of randomized control trials to significantly reduce the level of waterborne disease among users in low-income countries. Another type of water treatment is **27**called desalination and is used in dry areas with access to large bodies of saltwater (WHO, 2004).

Table 29: Sululta town boreholes biological test results at different times.

No.	Parameter	Unit	Value	WHO maxim. Limit
1	Turbidity	NTU	0.52	5
2	Total dissolved solids @105ºC	mg/l	206.0	100
3	pH	Log10	8.11	6.5-8.5
4	Conductivity	µs/cm	412.0	400
5	Ammonia	mg/l	0.08	-
6	Sodium	mg/l	2.3	200
7	Potassium	mg/l	4.6	-
8	Magnesium	mg/l	9.0	150
9	Manganese	mg/l	0.13	0.1
10	Fluoride	mg/l	0.77	1.5
11	Chloride	mg/l	13	250
12	Nitrite	mg/l	Nil	0.2
13	Nitrate	mg/l	0.32	10
14	Alkalinity	mg/l CaCO3	195	200
15	Carbonate	mg/l CO3	Trace	-
16	Bicarbonate	mg/l HCO3	237.9	-
17	Sulphate	mg/l	4.0	400
18	Total hardness	mg/l CaCO3	75.0	100
19	Total iron	mg/l	0.06	0.3
20	Phosphate	mg/l	0.33	-
21	Calcium	mg/l	29.0	200

Source: Source: Sululta town water bureau; borehole drilling manual, 2017

Sululta town drinking water and related health effects

The sources of drinking water for Sululta town are boreholes and spring which were treated in reservoirs. These boreholes were located at different land top graphical and some of them were very close to the residential area as seen following.

a) Borehole of Wale b) Borehole of Kera around

Figure 20 Boreholes and their topographical location.

Source:- Segni Jima, (2019)

Borehole a) was constructed by a wire fence in a proper way that any animals cannot reach inside and contaminate. Others like Kera, near to the market, and Asir kilo were not as better as. Their fence was made of wood and also damaged so that many things can reach easily. Cattle, sheep, donkeys, and horses were grazing daily near and inside the fence.

According to the Sululta health office quarter and annual report of different times, most of the top ten diseases were waterborne diseases. These diseases are typhoid, giardia, diarrhea with blood, and non-blood.

Table 30:Waterborne from top ten disease causes of morbidity for under 5 years category (2009 E.C) of Sululta town health center quarter 2

Disease	Number of people affected	Percentage %
Diarrhea with blood	12	2.43

Diarrhea without blood	89	18.05
Other diseases	392	79.52

Source: Sululta town health center report of quarter 2 of 2009 E.C

Table 31:Ten top causes of morbidity for Sululta town health center quarter 3 the year 2009 E.C.

Disease	Number of people affected	Percentage %
Diarrhea without blood	205	11.61
Other diseases	1560	88.39

Source: a report of ten top causes of morbidity of Sululta town health center quarter 3, the year 2009 E.C.

Table 32: Ten Top causes of morbidity for Sululta special zone zonal health department (quarter 1 the year 2010).

Disease	Number of people affected	Percentage %
Typhoid fever	1044	7.62
Diarrhea without blood	2182	15.92
Other diseases	10477	76.46

Drinking water quality testing and monitoring system

According to Segni Jima, (2019) the thesis result analysis shows that the cleaning of tankers treatment was done per half a year. This situation indicated weak testing and monitoring system of the Sululta town water bureau was not seen as creating a problem. The rate of drinking water quality of Sululta town was completed in the following table.

Table 33: Rate status of drinking water quality at Sululta Town

Drinking water quality variables	Rate of quality of drinking water			Total percent %
Good in %	Acceptable in %			Poor in %
Clarity	80	20	0	100
Color	80	20	0	100
Taste	60	40	0	100
Smell	80	20	0	100

Source: own calculation and questionnaire (2019)

As the above Table result, the drinking water quality rating was done by writing as good, acceptable, and poor rank. Clarity, color, and smell had good responses 80 %, and 60 % for taste. Clarity, color, and smell had 20% and taste had 40%. According to Segni Jima 2019 three things were list out the reason why the Sululta water bureau quality testing and monitoring system is weak. These were „no laboratory and treatment schedule, no willing of active surveillance, and assumed that well water has no harm on consumer" which were selected by 80% sample population. The lack of professional workers was 20 %.

All healthcare center workers have selected the "no" option" which is 100 % of the population size. This indicated that they doubt the water quality supplied for Sululta town. This could be assured by amounts of patients with the water-borne disease who came to the health center.

Sululta town drinking water main parameters were tested in different ways physicochemical and biologically. In *Sululta* town the water quality testing and monitoring system were not considered as significant things because the body was sensible about water quality as seen in laboratory sample results and data assessed; even *Sululta town* water bureau gave focused on quantity due to that they focused to address water quantity demand. By this situation, the town water quality testing and monitoring is in question that still in suspension.

Physico-chemical properties of Sululta town drinking water

Water sample sources

. *Boreholes*

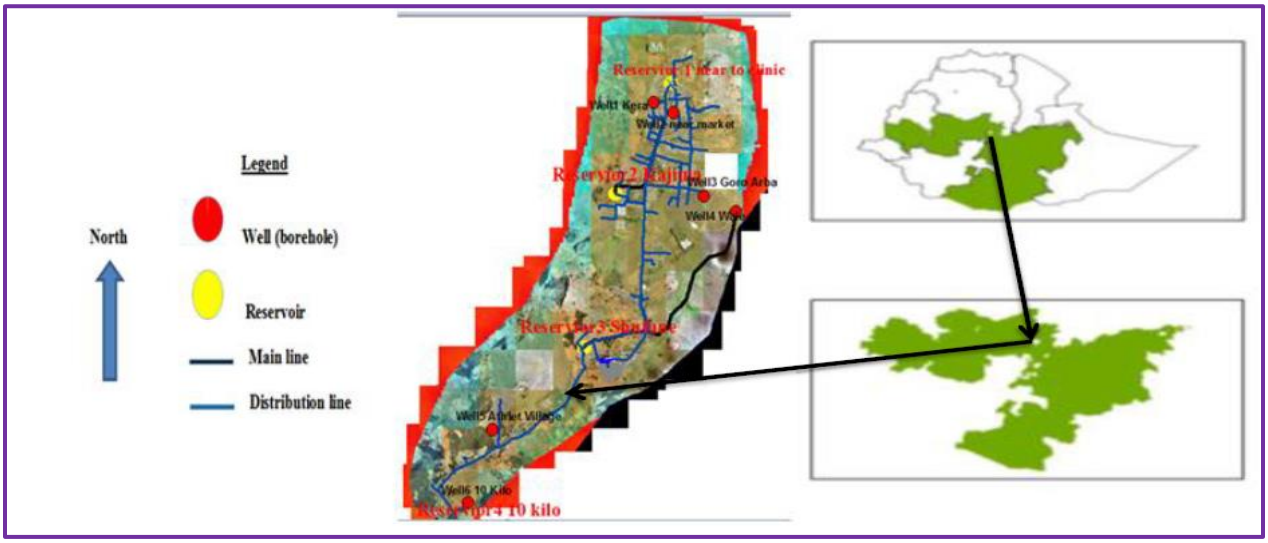


Figure 21:Sululta town geographical map

Source:- Segni Jima 2019

There are six boreholes taken for this research. These boreholes were tested for physical-chemical parameters like pH, TDS, turbidity, electrical conductivity, alkalinity, total hardness, temperature, and free chlorine residue.

PH -It was tested on-site boreholes for all boreholes. As shown in Table 4.7 below, the pH values for the boreholes varied from 6.5 up to 8.5; the range of pH value for drinking water (WHO, 2004). According to Ethiopian Standard, the recommended pH value for drinking water is 6.5- 8.5 (ES, 2001). Therefore, the values of pH for the source met the recommended pH value set by WHO guidelines and Ethiopian standards.

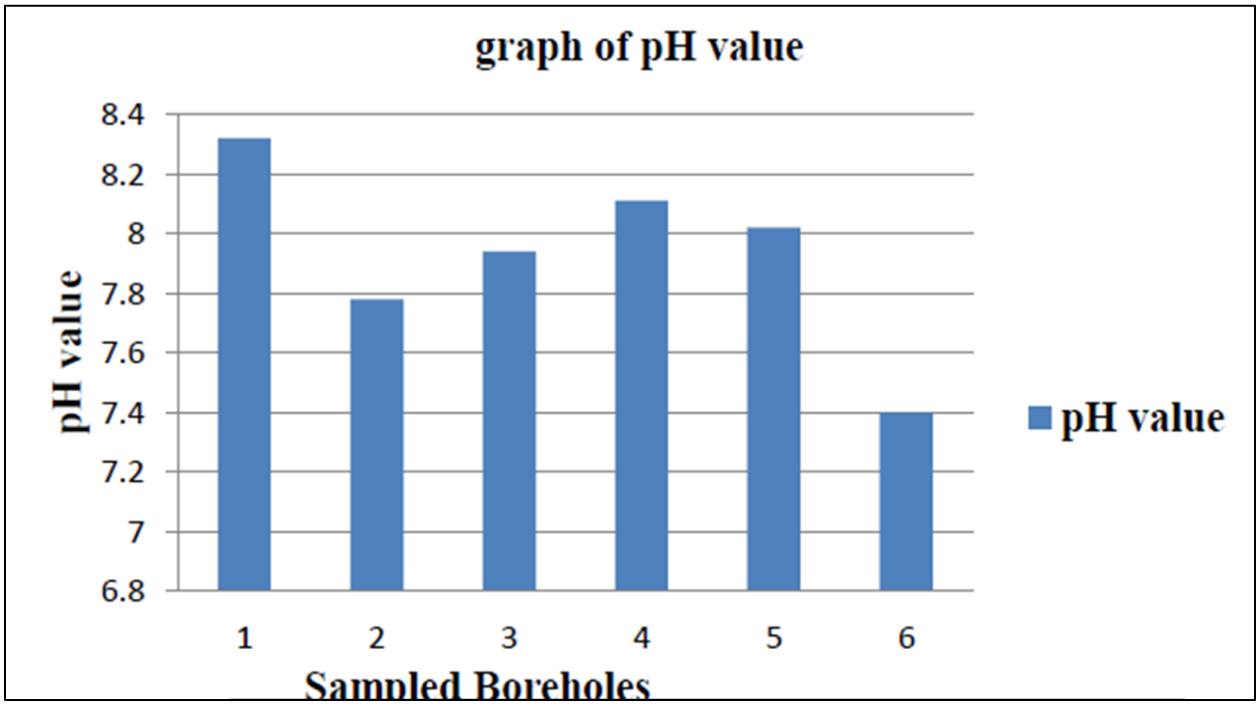


Figure 22; Graph of pH values of sampled boreholes

Source:- Segni Jima 2019

Table 34: Mean values of physicochemical parameters sample tested for Sululta town boreholes

pH value parameters	unit	The mean value of boreholes` result	Ethiopian standard permissible limit	WHO guideline permissible limit
pH	Log10	7.93	6.5-8.5	6.5-8.5

TDS	mg/l	171	1000	500
Turbidity	NTU	0.32	<5	<1.5
Electrical Conductivity	µS/cm	342	1200	400
Alkalinity (as CaCO3)	mg/l	76.83	200	150
Total Hardness	mg/l	139.00	300	100
Temperature	ºC	17.94	_	_
Chlorine Residue	mg/l	0.00	0.20-0.50	0.20-0.50

Source: literature review and own calculated mean values of parameters

Total dissolved solids (TDS) - In drinking water, total dissolved solids are primarily made up of inorganic salts with small concentrations of organic matter. Contributory ions are mainly carbonate, bicarbonate, chloride, Sulphate, nitrate, potassium, calcium, and magnesium. The major contribution to total dissolved solids in water is due to the natural contact with rocks and soil. A minor contribution to TDS is pollution including urban runoff. The TDS tests are considered to determine the general quality of water.

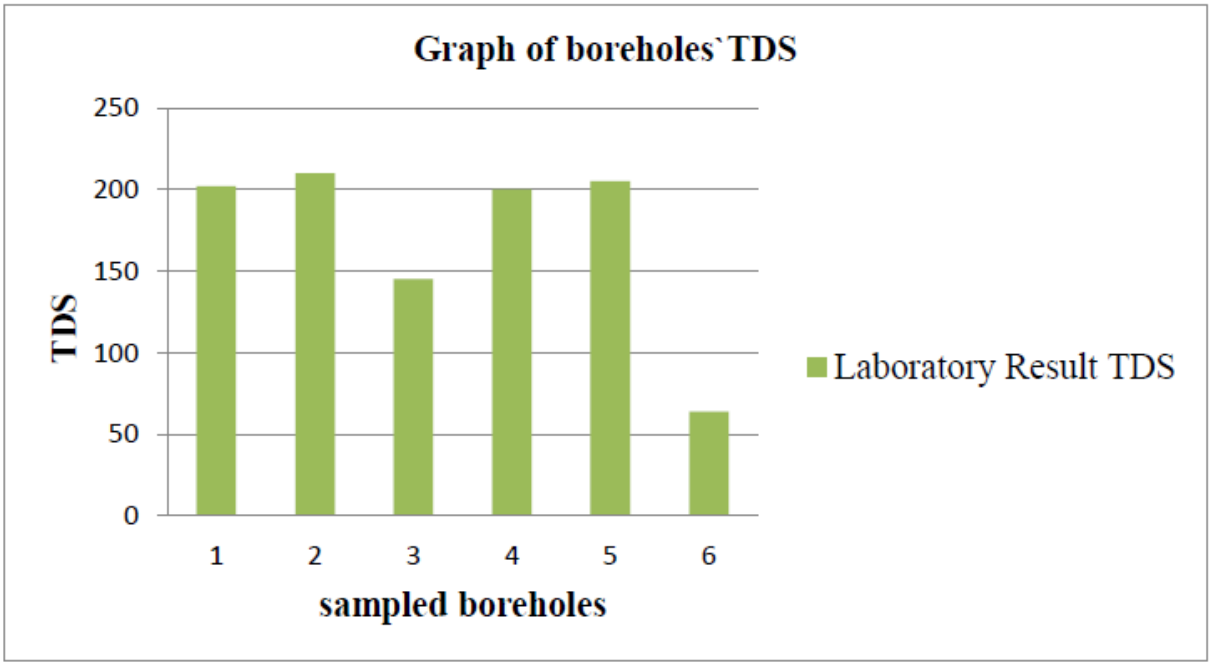


Figure 23: graph of TDS of sampled boreholes

Source:- Segni Jima 2019

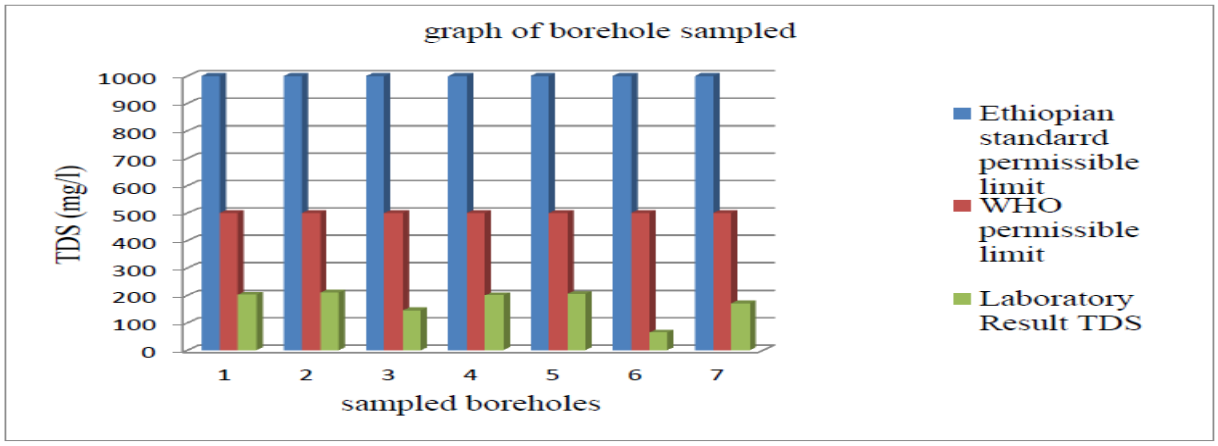


Figure 24: Graph of TDS maximum permissible limit and mean of test result comparison Source:- Segni Jima 2019

The mean value of TDS of boreholes as Table 4.7 was 171 mg/l and the maximum limit recommended by the Ethiopian standard was 1000 mg/l and that of the WHO guideline was 500 mg/l. This mean value of TDS was much less than both the Ethiopian standard and WHO guidelines' maximum limit and accepted. This means the value is comfortable for consumers.

Turbidity: - Turbidity is the unit of measurement for quantifying the degree to which light traveling through a water column is scattered by the suspended organic (including algae) and inorganic particles. The scattering of light increases as the presence of suspended load increases and turbidity is commonly measured in Nephelometric Turbidity Units (NTU).

Turbidity may be classified as both physical and microbiological parameters. It is classified as the physical parameter, because it can raise aesthetic and psychological objections by the consumer, and as a microbiological parameter, because it may harbor pathogens and obstruct the effectiveness of disinfection. Direct health effects depend on the precise composition of the turbidity-causing materials, but there is other implication. As turbidity can be caused by sewage matter in water there is a risk that pathogenic organisms could be shielded by the turbidity particles and hence escape the action of the disinfectant. According to the WHO (2012) standard for turbidity, the maximum allowable permissible limit value must always be low, preferably lower than 1 NTU. It is recommended that for water to be disinfected, the turbidity should be reliably less than 5 NTU and preferably have a median value of less than 1 NTU.

Figure 4.4 shows the results of the turbidity of Sululta town borehole water. The results show that it was under the range of Ethiopian standards and WHO guidelines.

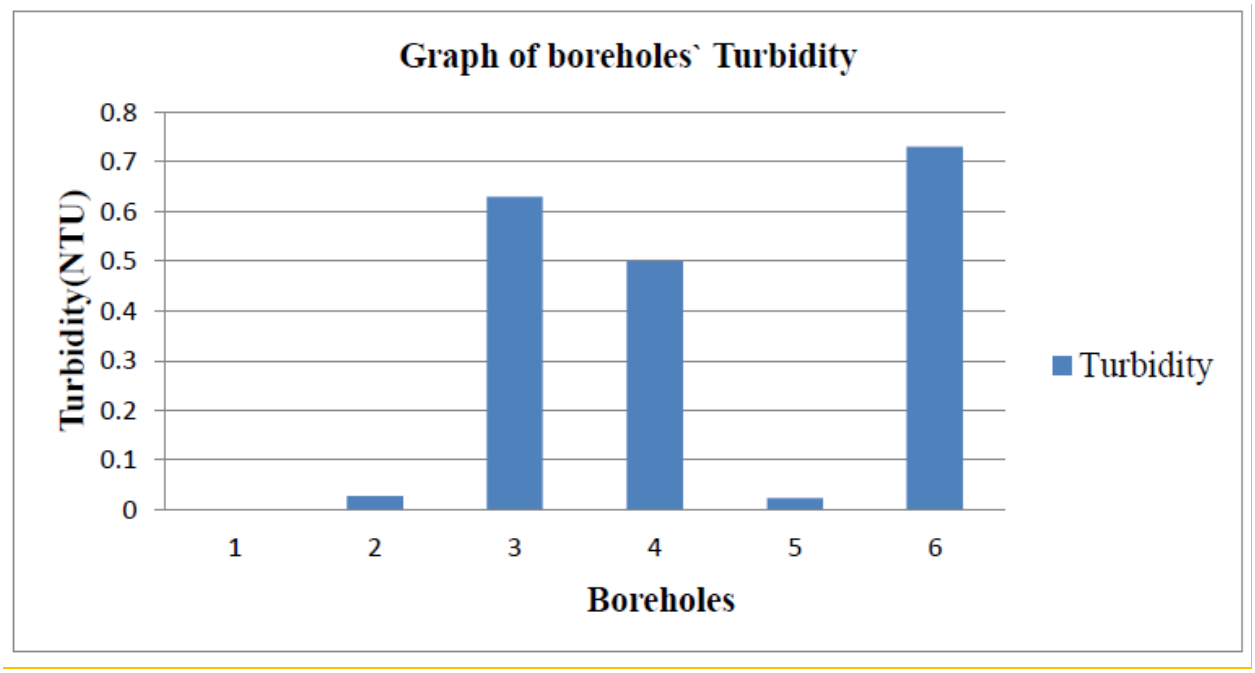


Figure 25: Graph of turbidity of sampled boreholes.

Source:- Segni Jima 2019

Total coliform

As shown in Table 4.8 the total coliform and fecal coliform mean values of all reservoirs were beyond the Ethiopian standard and WHO guidelines. The mean value of total coliform of kajima, Shufune, and 10-kilo reservoirs were 27.25, 1.5, and 19.75 respectively. These values are not recommended by both Ethiopian standards and WHO guidelines.

Fecal coliform

The mean values of fecal coliform as shown in Table 4.8 were 0.25FCC/100 ml, 0.00 FCC/100 ml, and 0.50FCC/100 ml for kajima, Shufune, and 10 reservoirs respectively. From these reservoirs, the Shufune reservoir was zero value of fecal coliform. This zero value may be due to the location of the borehole which is found very far from the residential area and the area is protected by the wire fence. Shufune reservoirs get water from this borehole (wale borehole). Other reservoir results were not accepted by Ethiopian standards and WHO guide values except the Shufune reservoir. Both reservoirs were polluted by fecal coliform and needed disinfection.

. *Water points*

Table 35: mean values of three water points

Tested parameters	mean values of three water points
pH (log10)	8.01
TDS (mg/l)	185.33
Turbidity (NTU)	1.22
Electrical Conductivity(µs/cm)	370.00
Total Hardness (mg/l)	86.67
Temperature (ºC)	16.58
Free Chlorine Residue (mg/l)	0.00
Total Coliform(per100ml)	22.00
Fecal Coliform (per 100ml)	5.33

Source:- Segni Jima 2019

These three selected sample sites were tested for these selected parameters which have a high contribution to water quality. Electrical Conductivity was under the maximum limit of Ethiopian standards and WHO guidelines. As shown in Table 4.9 only pH, total hardness, TDS, EC, and turbidity were matched with Ethiopian standards and WHO guidelines. Free chlorine residue was not found on sample points just like other sample points and it is indicated under the standard. All biological parameters were above the standard of Ethiopia and WHO guidelines this was due to the absence of chlorine at all points of water source and distribution.

Effectiveness of existing schedule of chlorination in Sululta town drinking water

The chlorination time of Sululta town drinking water treatment was not orderly scheduled. Within this research time, four months of chlorine was not added to any water sources in the town. The results of free chlorine residue of all water sources (boreholes, reservoirs, and water points) were under the standard. Since there was no regular schedule of chlorination the treatment bodies did not know when they should add the chlorine. So the existing schedule was disturbing the treatment system and the water was polluted with microorganisms. The absence of a proper schedule of chlorination program brought absence and lack of standard concentration of chlorine in drinking water. In absence of disinfectant in water caused the appearance and growth of the pathogen. Therefore people were consuming no chlorinated water at the time this research sample was taken.

3.4.2. Driver of Sululta Wetland Ecosystem Water Quality and Availability Deterioration

In conjunction with the growing population, urban and industrial expansion in our country as well as in the Sulutta circuit is growing rapidly. Sululta is a fast-growing urban and peri-urban area to the north of Addis Ababa that is expected to continue to rapidly increase in population over the coming decades. There are significant challenges to meeting the present and future WASH needs for the general population and the administrative, industrial, commercial, educational, and recreational sectors in a sustainable manner (Project & Wilson, 2018).

According to the analysis of land cover changes, the city of Sululta is one of the most developed urban areas in Ethiopia, for example, urbanization grows 581.53 hectares, 1314.95 hectares, and 1663.96 hectares in 2003, 2013, and 2023 respectively. Likewise, the population of Sululta district grew from the year 2007 and 2022 to 129,000 and 190,597 respectively.

Focus group discussion (FDG) in the Sululta wetland ecosystem also asserted that “due *to rapid urban and industrial developments the wetland becomes shrinking and destroyed as a result we face the challenge of drinking water scarcity and pollution of water*"

As most rivers including Sibilu within the watershed punctuated from the wetlands, their existence was determined based on the hydrological function. Now the Sululta wetland ecosystem degradation become serious, this occurred mainly due to rapid Urbanization at the expense of wetlands, agricultural changes, and also climate change the mentioned one. Climate change will increase the frequency and severity of flooding and drought risks. The Ogaden, Wabi- Shebele, Awash, Afar-Denakil, Mereb, and Aysha Basins are already vulnerable to drought, which has caused widespread loss of livestock and crops, increased poverty and malnutrition, and several major famines (USAID/Sustainable Water Partnership (SWP), 2021).

RATE OF INDUSTRIALIZATION

According to Assefa, (2016) Based on MoFED‟s (2011) estimation, the average growth of manufacturing production (at a constant price) was 9.5 percent for the period 2005/06–2009/10. Even though the sector‟s share of GDP has not changed and albeit it‟ small contribution to employment generation, the sector is doing well and is increasing at least at the pace of the rate of economic growth and has maintained its share. Furthermore, the number of firms is growing at a rapid pace except for the year 2009/10. (GetnetAlemu andMehrabMalek, 2010). According

to CSA‟s annual survey of medium and large manufacturing industries and employment growth rate has increased from an average of 2.06 percent for the period 2000/01– 2004/05 to 11.4 percent for the period 2005/06–2009/10. Although this growth is encouraging, the total number of employees in medium and large manufacturing industries is still very small.

ETHIOPIA'S LEATHER AND LEATHER PRODUCTS INDUSTRY (LLPI)

According to a recent CSA publication on livestock resources, Ethiopia has 53.4 million cattle, 25.5 million sheep, and 22.7 million goats (CSA, 2011). This puts the country as one of the richly endowed countries in livestock resources. It is estimated that the country can collect 3.7 million cattle hides, 8.4 million sheep skin, and 7.7 million goat skin. The sheep skins are well known for their quality. The goat skins in particular are known for their quality and international acceptance. Both goat and sheep skins are preferred for leather garments and glove manufacturing in addition to being used for shoe uppers. The resource endowment of the country illustrates the considerable potential of the country in the leather industry.

The tanning sector

According to Gebremichael, (2016) Currently, 30 tanneries and 18 enterprises manufacturing leather products operate in the country producing products ranging from various forms of leather articles such as shoe uppers, leather garments, stitched upholstery, school bags, handbags, industrial gloves, and finished leather.

RATE OF URBANIZATION

The urbanization in Sululta towns grows dramatically with big positive changes, for example, it grows 581.53 ha,1314.95 ha, and 1663.96 ha in the years 2003, 2013, and 2023 respectively, and also the 54.12 ha growth rate of urbanization in Sululta wetland ecosystem from the year (2003-2023), This big change of urbanization drives wetland degradation and water pollution.

Urban planning is not keeping pace with population growth. Planning, budgets, and infrastructure are failing to serve most urban residents in the developing world with water and sanitation, contributing to poor health conditions and heavy pollution loads in wastewater.

Unplanned 'slum' areas pose a wider health risk. Unsanitary conditions in neighborhoods without water and sanitation services create a constant threat of a disease outbreak, such as cholera, that can devastate poor communities and spread through the city and beyond.

Un served urban communities are vulnerable to shocks. The poorest neighborhoods are often in areas more exposed to natural hazards such as flooding, sea level rise, forest fires, landslides, volcanic eruptions, and tsunamis. A lack of resilient water and sanitation systems and hygiene facilities means that the community's ability to stay healthy during environmental shocks is severely compromised.

RATE OF AGRICULTURAL EXPANSION

Agricultural land expansion for the production of both food and cash crops, such as maize, and rice, has been at the expense of natural habitats, often intact or disturbed forests, and grasslands. Across the different SSA countries, proximate drivers, such as soil fertility decline, climate change, variability, access to services, and demand for food and fuel, constitute important drivers of agricultural expansion. Underlying drivers such as population dynamic and human resettlement, demand for agricultural land, government policies, accessibility/distance to market, increase in prices of agricultural products, increased income, and land tenure operating at both micro and macro levels are likely to indirectly cause agricultural expansion. In addition, certain factors such as effective law enforcement, endemic pests, and diseases, conflict and insecurity, productivity uncertainty, culture, cost of land clearing, and agricultural inputs subsidies availability can place restraints on agricultural expansion (Jellason, 2010).

Agriculture Expansion in the Sululta wetland ecosystem was the main driver of ground and spring water pollution in Sululta wetland ecosystems.

Cropland Rate of change (hectare/year) 2003-2013 was (-98.52), and 2013-2023 (392.981) and from 2003_2023 (147.23). B/n the years 2003 and 2013, the Rate of change showed a dramatic decline this is because the wetland ecosystem converted to a plantation forest as a result of this shortage of cropland has happened in the study area. That is why from the year 2013-2023 the Rate of change (hectare/year) cropland increased to (392.981).

WATER USE FOR VARIOUS PURPOSES

In general, water can be used for direct and indirect purposes. Direct purposes in the society in the Sululta wetland ecosystem include bathing, drinking, and cooking, while examples of indirect purposes are the use of water in industrial processing. The majority of the Sululta people's water use is for agriculture and household consumption.

Figure 26 water use for different purpose

WATER HARVESTING SCHEME

Business in the Sululta district of Ethiopia's Oromia region is growing. So why, despite abundant rainfall, does half the population have no access to fresh water?

In Sululta wetland ecosystem the residents of the Sululta town and surrounding area trudge along the road with empty yellow jerrycans that they will fill from muddy wells and water points.

Figure 27:People in Sululta queue for tap water.

Photograph. source:-: William Davison 9 Mar 2017

The local government has failed to provide water for most households in the area

Investing in water infrastructure is challenging for a poor country, funding is not the problem in relatively wealthy Sululta, according to Messay. Instead, he believes corrupt management of the land rush, a lack of demand on investors to protect the environment, and the government's inadequate planning and data collection have contributed to the crisis.

"When the public burned the investments down, it was not that they wanted to damage them. It was our problem in managing them," says Messay (International, Guardian, & Guardian, 2023).

The national government, which likes to describe Ethiopia as the "water tower of Africa", is investing heavily in hydropower, including the continent's largest dam, in the Nile basin. However, past failures to tap water resources in the rain-deprived east of the country contributed to a fifth of the population needing aid during a drought that began in 2015, killing livestock and causing crops to wither (International, Guardian, & Guardian, 2023).

In Suluta, there has been investment in boreholes and pumps, but mostly by the private sector. Abyssinia Springs, in which Nestlé Waters bought a majority stake last year, pumps 50,000 litres an hour, which means its capacity is more than half that of the local government.

“There’s water everywhere. The only problem is the government’s willingness,” says a manager at another company, Classy Water, who did not give his name.Many non-water businesses have dug their own wells (International, Guardian, & Guardian, 2023).

According to Getachew Teklemariam, a former government economic planner, there has been a lack of water infrastructure planning that takes into account demographic and economic changes across Ethiopia. Instead, development has been piecemeal and household water supply numbers are sometimes inflated by officials for political gain. “With a lack of insight into the reality on the ground, most efforts at improving infrastructure have been uncoordinated and wasteful,” he says. Today, locals in Sululta travel on public transport to queue for water at a tap built by the Sudanese-owned Nile Petroleum, or pay others to do so. At the end of the town, which mostly lies along one main road, residents collect water from a faucet provided by China-Africa Overseas Leather Products. But the tannery has been accused of polluting water supplies, and in January 2016 protesters invaded the premises. Last month, it was a base for about 50 Ethiopian soldiers monitoring the security situation. “There’s water everywhere. The only problem is the government’s willingness,” says a manager at another company, Classy Water, who did not give his name. Many non-water businesses have dug their own wells. Messay, a mechanical engineer who has worked in the public water sector for a decade, says the government has erred by placing only minimal demands on investors in its eagerness to create jobs: “They [the leather company] drop their waste downstream. It is killing the farmers’ cattle, it’s making the fertility of the soil deplete.” Managers from the firm did not respond to requests for comment. Turkish contractors are digging a borehole to increase the water supply, which Messay believes might be meeting half the demand.Nestlé Waters says it wants to help and is funding Addis Ababa University experts to study the environmental and socio-economic situation of the area. The study might feed into another “integrated” plan and possibly an effort to turn Sululta into an “eco city”. But Messay is sceptical as to whether the corporation’s public interest is genuine, noting that there were similar noises from Abyssinia Springs when the water plant was built about seven years agov (International, Guardian, & Guardian, 2023).

PRESSURE

GENERATION OF URBAN WASTEWATER (TOTAL)

In Sululta wetland ecosystem focus group discussion (FDG), pointed out that, "Sululta wetland ecosystem is an area where there is an urban expansion resulting in the exploitation of key natural resources and land degradation including encroachment of wetlands, inappropriate solid and liquid waste management systems, and uncoordinated scrambling competition over land."

Currently in Sululta town, solid waste generation is calculated based on Ethiopia's average per capita solid waste generation rate, which is between between0.3-0.5kg/day (EMUDC, 2012). The amount of solid waste generated by the existing population which is estimated to be 52,126 of the town is about 15,637 kg/day to its minimum rate. Table 3.2 shows the amount and projected solid waste generated per capita at 0.3kg/day rate to the population of Sululta town. The total household solid waste generation rate in the town by weight and volume was estimated by using the average per capita waste generation rates of the country. Hence the estimated daily and yearly solid waste generated was 15,637kg and 5,707,505 kg or 5,707.5 tons respectively (Kenate, 2017).

GENERATION OF INDUSTRIAL WASTE

Discharging industrial waste into water bodies without any treatment is the main source of water pollution. Sampling and preserving waste water was based on the American Public Health Association (APHA, Standard Methods for the Examination of Water and Waste water, American Public Health Association, Washington, D.C, 1999). A composite sampling method was employed to collect industry wastewater samples and thereby determine the concentration of pH, electric conductivity, chemical oxygen demand Total nitrogen, total phosphorus, and water temperature using an ultraviolent atomic spectrophotometer, pH meter, and conductivity meter. The results revealed values of all sampling points were significantly different. The sampling points of Sululta of site 2 and site 5, Gelan of site2 and site 5, and Burayu of site4 were not within the pH ranges of the United States Environment Protection Agency (United States environmental protection agency, USEPA (2009). National primary drinking water regulation) depicting the water not safe drinking and irrigation purposes. The low mean pH value at Sabata sampling site of 3 was found. The results of nutrients showed all study sites and sampling points were seriously polluted by Total nitrogen and Total Phosphorus.

Therefore, the industrial effluents in the Sululta wetland ecosystem affected water quality, human, and aquatic health, and environmental pollution and thereby need mitigation measures of sustainable monitoring and supervision of untreated release of industrial waste into the environment, phytoremediation of affected streams and rivers, awareness creation for community and advising firm owners to install industry waste treatment plants (Jagemma, M., Worku, H., Gemeda, 2023)**.**

Figure 28 industrial *effluents in the Sululta wetland ecosystem*

Source:- 2023 filed observation

Photo shows gold sun industries waste generate to the river and the society fish polluted water for household consumption**.**

AGRO-CHEMICAL USE

Agricultural intensification is achieved in several ways including increased application of agrochemicals and the use of artificial pest-control systems. However, agricultural intensification is often considered negative in terms of its effect on biodiversity and the overall ecosystem (Tscharntke *et al*.,2005). "agrochemicals" refers to any kind of fertilizer or pesticide used in an agricultural system that is not organic but rather has inorganic chemical properties. Among the common fertilisers that farmers use are methomyl, dimethoate, oxamyl, cymoxanil, pyrimethanil, potassium, and nitrate (Oller *et al.*, 2007). Some of the common pesticides are DDT, fluvalinate, coumaphos, chlorothalonil and chloropyrifos (Zhu *et al*.,2014). All of these chemicals impact the environment and living beings in different ways (Uddin, 2018). In line with this farmers in sululta wet land ecosystem applied many **agro-chemical to the farmland ,** According to FDG for one hactares ½ fertilizer and chemicals, applied to produce different crops while for አረም for one hectare farm land ½ litter chemichals was used and also 1 litter chemicals for one hectar farm land for about rust.

GENERATION OF HOUSEHOLD WASTE

In terms of volume the estimated daily and yearly waste generation rates were 30m3 and14, 268.76 m3 respectively in the sululta wetland ecosystem.

Table 36 Projected per capita solid waste generation with population (OUPI, 2016)

Year	***Population***	***Weight***			***Volume***	
		Kg)/ Day	***Kg/year***	***Ton/year***	***M3 /day***	***M3 /year***
2016	52,126	15,637	5,707,505	5,707.5	30	14,268.76
2026	260,776	78,233	28,555,045	28,555.05	195.58	71,387.6125

Source:- OUPI (2016) and Kenate, (2017)

The projected population data was obtained from OUPI (2016) which helped the researcher as a spring board to project the amount of solid waste generated.(Kenate, 2017)

Figure 29: waste damping

Around and in sululta wet land ecosystem, the solid and liquid waste generation was random and mismanaged. According to FGD due to siltation, soil erosion which worsened by quarry and investments, and climate change are the main driver of the polluted water and soil aggravated reason.

TOTAL WATER DEMAND

Access to fresh drinking water is a daily challenge for many people in Sululta. Sululta is a fast growing urban and peri-urban area to the north of Addis Ababa that is expected to continue to rapidly increase in population over the coming decades. There are significant challenges to meeting the present and future WASH needs for the general population and the administrative, industrial, commercial, educational and recreational sectors in a sustainable manner. As result, in order to align with Government of Ethiopia's ambitious policies and strategies, as well as to meet the aspirations and expectations of Sululta residents, an innovative approach will be required in the subsectors of water supply, sanitation and solid wastes management. In addition, in order to

meet environmental and health targets, the approach needs to take into account integrated water resources management, including urban planning, agriculture, industry and commerce (Project & Wilson, 2018).

According to focus group discussion we have one spring but know days which decline in quantity. If it continuous with reduction and drying like these there will not be an option of water access in our surrounding.

3.4.3. IMPACT

No people affected by water-borne diseases

Water borne illnesses, such as cholera or diarrhea, are the leading cause of death in children under five years old in Ethiopia.

In addition to illness, many Ethiopian children, especially girls, face problems with school. Statistically only 45% of kids attend primary school. The others are put to work collecting water each morning and helping their families earn money.

Ethiopia is located in Africa's Horn where drought and politics are two leading causes of water shortage. In a study conducted by Water.org they found that "42% of the population has access to a clean water supply" and only "11% of that number has access to adequate sanitation services". In rural areas of the country, these figures drop even lower, resulting in health problems in the villagers as well as their animals.

In the past twenty years, droughts have affected several areas of the country, leading to ponds, wells, streams and lakes drying up or becoming extremely shallow. Many people living outside of the cities collect water from these shallow water sources, which are often contaminated with human and animal waste, worms, or disease. During months and sometimes years of drought, disease runs rampant through small villages and towns. Frequently there is not enough water for people to bathe, leading to infections and sickness in children. Waterborne illnesses, such as cholera or diarrhea, are the leading cause of death in children under five years old in Ethiopia(Shore, 2023).

Face difficulty of water shortage:- amount of yield (farm) productivity reduction, ecotourism decline and malnutrition were the main impacts on society who live in sululta wetland ecosystem.

3.1.% of aquatic life lost

No livestock affected by waterborne disease we are victim with our livestock's due to water pollutions

According to the Sululta health office quarter and annual report of different times, most of the top ten diseases were waterborne diseases. These diseases are typhoid, giardia, diarrhea with blood, and non-blood (Segi Jima, 2019).

Table 37: Waterborne from top ten disease causes of morbidity for under 5 years category (2009 E.C) of Sululta town health center quarter 2

Disease	Number of people affected	Percentage %
Diarrhea with blood	12	2.43
Diarrhea without blood	89	18.05
Other diseases	392	79.52

Source: Sululta town health center report of quarter 2 of 2009 E.C

Table 38:Ten top causes of morbidity for Sululta town health center quarter 3 the year 2009 E.C.

Disease	Number of people affected	Percentage %
Diarrhea without blood	205	11.61
Other diseases	1560	88.39

Source: a report of ten top causes of morbidity of Sululta town health center quarter 3, the year 2009 E.C.

Table 39: Ten Top causes of morbidity for Sululta special zone zonal health department (quarter 1 the year 2010).

Disease	Number of people affected	Percentage %
Typhoid fever	1044	7.62
Diarrhea without blood	2182	15.92
Other diseases	10477	76.46

Source:- Segi Jima, (2019)

Total abandoned land due to salinity

Soil salinization and acidification are common processes that particularly characterize drylands. These processes can be attributed either to natural conditions or anthropogenic activities. While

natural causes include factors such as climate, lithology, topography, and pedology, human causes are mostly related to agricultural land-use, and specifically, to irrigate agriculture.

Time spent to fiche water

According to Neggessa Damise Mangasha, (2020)**,** Women and girls can pass many hours a day collecting water from distant sources and thus the time saved by taking a safe water source closer to the household can be very significant. The time saved is used for much needed leisure or, possibly (but not necessarily) activities relating to improved child care, or economic production. Less time spent fetching water is one less possible excuse for not allowing girls to attend school or in some extreme cases, even to marry. Energy saved: - women who walk long distances to collect water can burn as much as 600 calories of energy or more per day, which may be one third of their nutritional intake. Closer sources of water can thus recover the nutritional status of women and children (and hence health and wellbeing) (UNICEF, 1999). Prevention of injuries: - When girls are forced to carry heavy loads of water over large distances, there is a danger of lasting spinal column and pelvis injury and deformations. Closer water sources minimize this (UNICEF, 1999). But unimproved water and sanitation services have many negative impacts on people livelihood, among of which health and socio-economic are the major one. FDG also asserted that to fetch water minimum we travel 1:30 up to 2:00 hours

No dry waters

3.4.4. Response

Changing the function of industries:- with the collaboration of the regional government the local administrator in the Sululta wetland ecosystem changing of textile industries to tannery industries.

Water policy: - Ethiopia is committed to Integrated Water Resources Management (IWRM). Policies, strategies, and programs are being revised to reflect the government's decision to centralize the water sector. Greater emphasis is needed on improving sector financing; increasing staffing and technical capacity; strengthening water quality monitoring, water use and pollution permitting and enforcement; and establishing Basins Development Agency (BDA) branch offices.

Water Resource Management Policy The overall goal of the Ethiopian Federal Water Resource Management Policy of 1998 addresses the need “to enhance and promote all national efforts towards efficient and optimum utilization of water resources of the country for socio-economic development on sustainable bases”. The policy indicates environmental conservation and protection as an integral part of water resources planning and project development. One of the five general policy objectives of the policy also stated as “conserving, protecting and enhancing water resources and the overall aquatic environment on a sustainable basis”(Avenue, 2021).

Number of water treatment plans in Sululta wetland ecosystem in Oromia Ethiopia

The performance of tannery wastewater treatment plants in the vicinity of Addis Ababa, Ethiopia was evaluated through a case study of a selected industry called China Africa Tannery located in Sululta town of the Oromia regional state. The treatment performance of tannery wastewater treatment plants in the Addis Ababa Area, Ethiopia was evaluated through a case study of a selected industry. Accordingly, the actual treatment plant is well-functional, reasonably efficient, and attained the national tannery effluent discharge standard for major parameters such as BOD5, COD, sulfide, chromium, and total phosphorous. No seasonal (except for the combined primary-secondary treatment in removing NH3-N and TSS) and day-to-day treatment efficiency variations were observed though further research is essential in this regard. Actual plant design and international benchmark treatment efficiencies were also well achieved for some parameters (Tsegaye & Kaba, 2017).

3.4.5. Outlook

Sululta town water quality testing and monitoring system was not familiar with water quality monitoring criteria. The water qualities follow up the system from sampling frequency; sampling time and number of samples needed were not considered.

From the laboratory result of samples from the boreholes, the mean value of pH, TDS, turbidity, and E.C. was fitted with Ethiopian standards and WHO guidelines. In addition, total hardness was accepted by Ethiopian standards but not accepted by WHO guidelines because it fell into hard water. The free chlorine residue was not accepted by both the Ethiopian standard and WHO guidelines because it was a zero (under the standard) result.

The laboratory test results of free chlorine residue of reservoir water become under the Ethiopian drinking water standard. The recommended value of FCR by Ethiopian standard and WHO guidelines are 0.2 mg/l-0.5 mg/l. The mean FCR value of Sululta town was 0 mg/l which is out of the detectable range. It indicated that the water in the reservoir was not treated at the time of sampling.

The biological quality of the reservoir's water did not agree with the limit of Ethiopian standards and WHO guidelines. Ethiopian standard and WHO guidelines limit were not to be detectable and absent respectively. But the mean values of the total coliform of reservoirs were 27.5TCC/100ml, 1.5 TCC/100 ml, and 19.75TCC/100ml for kajima, Shufune, and 10-kilo reservoirs respectively which are not in the range; even that of kajima and 10 kilos were excess number related to Shufune reservoir.

The physicochemical parameters samples result from water points agreed with the Ethiopian standard and WHO guidelines except for free chlorine residue. Free chlorine residue was under the standard. The Sululta water bureau had no proper and written chlorination schedule as considered from the situation seen by this research activity. Also, they stated that they add when the consumer complains about the quality of the water.

3.4.6. Recommendation

Improve water quality testing and monitoring system.

The town should have a laboratory with professional employees.

It should have an effective schedule of chlorination for both boreholes and reservoirs.

It has to determine the amount of chlorine (dosage) added to water based on water volume and consumption rate.

It is better to install the determined chlorine dosage sensor mixer (machine) to mainline per time to distribute chlorine equally by constant time intervals through the water.

Check timely the status of drinking water quality for the physicochemical and biological parameters.

In addition to the determination and checking of the status of indicator organisms, monitoring other microbial water quality such as Giardia, Cryptosporidium, and Amoebae.

Further studies should be conducted during the rainy season.

Distribution of pathogen-free water for human consumption is, in this respect to increase the quantity of water supply to the community. There is a need of selecting appropriate treatments

depending on the water quality stage and use a multi-barrier approach such as protection and delineation of water sources from sources of contamination, to educate the sanitation and hygiene awareness promotion of the community.

Additionally, the water quality at the household level should be analyzed, and storage sites should be maintained free from contaminates. And the other biological and physicochemical parameters have to be determined through other investigations.

3.5 Atmosphere of Sheger-City Administrator in Sululita- Sub City Wetland

The Weather and climate of Ethiopia depends on altitude and geographic location (precipitation varies with latitude, decreasing from south to north). The landscapes of Ethiopia are wildly varied from the Afar Depression (~125 m below sea level) in the east to the spectacular world heritage Mountains of Ras Dashen (4,533 m above sea level) in the north (IBC, 2005). Elevation is the most important determinant of the average annual temperature of the country with a reduction of 0.5–0.7°C per 100 m increase in altitude (Liljequist, 1986), and given its geographic location close to the equator and the Indian Ocean.

According to Bekele F. (1997) stated that, the Weather and climate of Ethiopia arise from the influence of tropical weather systems, like the Inter-Tropical Convergence Zone (ITCZ), the South Indian Ocean anticyclone (Mascarin High), the low-level jet (LLJ), the South Atlantic anticyclone. It is mainly controlled by ITCZ and associated atmospheric circulations as well as by the complex topography of the country.

Climate is the "average weather" or more specifically the statistical aspects of the atmosphere-hydrosphere-land surface system that varies over time ranging from months to millions of years. Climate also describes long-term statistical averages and measures of variability associated with daily weather (Peter T. et al., 2015).

Climate change is inevitably resulting in changes in climate variability and the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events (IPCC, 2012).

A different source indicates that Ethiopia has less contribution to climate change, for instance in 2018 Ethiopia's contributed 368.8 Mt CO_2e, removing 108.4 Mt CO_2e, leaving a net emission of 260.4 Mt CO_2e GHG emissions, which is accounted for only 0.5% of global emissions for the

year (EPA, 2022) but highly exposed to its impact. Climate change increased the number of 'hot' days in Ethiopia by 20% from 1960 to 2003, and a 37.5% increase in the number of 'hot' nights over the same period (Alex Evans, 2012).

Climate Variability is defined as variations in the mean state and other statistics of the climate on all temporal and spatial scales, beyond individual weather events. The term "Climate Variability" is often used to denote deviations of climatic statistics over a given period (e.g. a month, season, or year) when compared to long-term statistics for the same calendar period. Climate variability is measured by these deviations, which are usually termed anomalies. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external factors (external variability) (WMO, 2019).

Drought: An extreme climatic event (drought) is shortening (Gutierrez et al., 2014).

Flood: An overflow of water onto normally dry land. The inundation of a normally dry area is caused by rising water in an existing waterway, such as a river, stream, or drainage ditch. Flooding is a longer-term event than flash flooding: it may last days or weeks (NWSWFS, 2021). Specific topics, with climate change and its implications becoming the most investigated theme in the last decade.

Our study focuses mainly on climate change and/ variability of the SCA of Sululta Sub City wetland in Oromia region; it's located at 38^{0} 30'07''to 38^{0} 33'25''(update at compiled part) E longitude, and, N latitude and 06°58'09'' to 07°54'30'' – 07°54' 30'' N latitude with an altitude of Sululta Between 2,600 to 3230 m.a.s.l. Its agro-ecology is categorized under''Dega'' climate.

The field data collection process took place in February 2023 with trained data collectors supervised by the General Director. More data were gathered through focus group discussions (FGD) which were carried out across around SCA of Sululta Sub City across four directions which are East, West, North, and South of the wetland ecosystem.

Structured questionnaires and field observation employ together the necessary data. The study also used Meteorological data collected from the National Meteorological Agency of Ethiopia for the period 1993–2022 other relevant data and official unpublished documents from governmental organization were employed.

Sululta sub-city is one of the city administrations of Sheger is including the study area; it's located around **23** Kms far from the capital City Addis Ababa on the Addis Ababa Gojam road.

3.5.1. State and Trend of Climate Variability and/or Change of Sululta City Administration

Rainfall

The climate of the region characterized by Bimodal /rain gets twice a year/ rainfall distribution which occurs in the summer and spring seasons. As it is indicate in fig.1 high rain fall recorded in the Automn "Belg" season, it includes March to May, peeks in May with a mean of 3819.9mm, by the influence of south western winds, coming from the Congo basin, that can bring relatively abundant R.F (M. Fazzini et al.2015). Whereas the other seasons were getting a heavy amount of rainfall in the summer "Kiremt" season, these include July, August, and September with Maximum of 3775.6mm. Due to the influence of Guinean monsoon, equatorial warm and humid winds, which are also substantially influenced by the orographic diversity (M. Fazzini et al.2015). The study area has a high RF variability due to the seasonal progression of the inter-tropical convergence zone (ITCZ), an atmospheric circulation feature often modified by the El Niño–Southern Oscillation (ENSO) (Tafesse M. 2019).

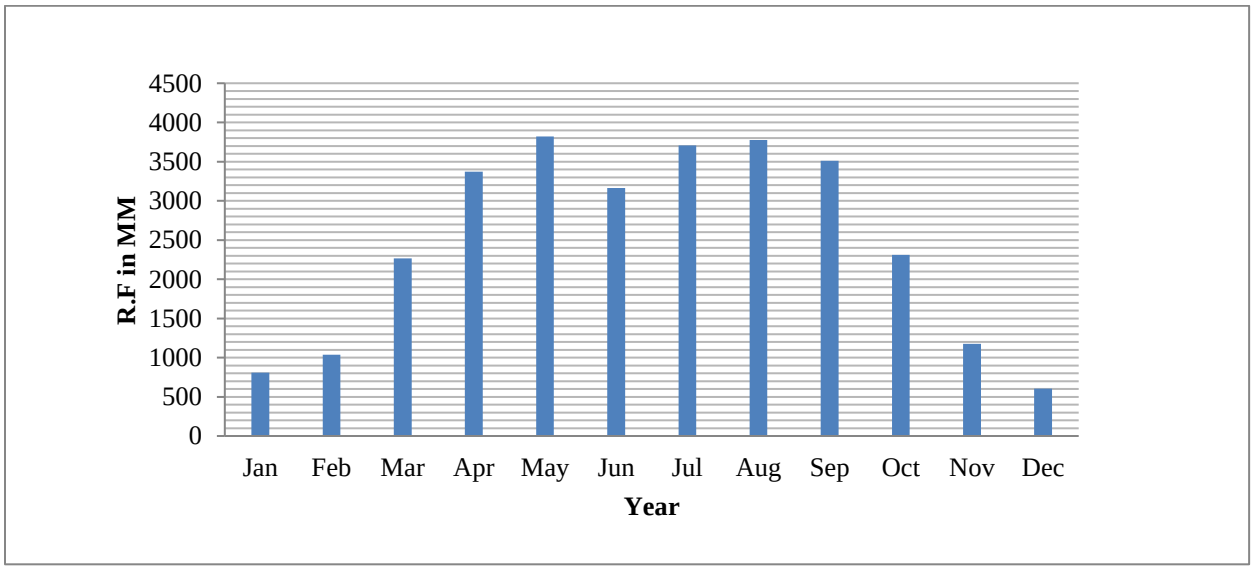


Figure 30: Monthly Average rainfall of HTSC from the year2091 to 2020 in mm.

The amount of rainfall differ from year to year because of climate change and/or variability, as figure 2 indicated total **average** annual rainfall of Hwella Tulla Sub-City was **985.04.8mm** with the **highest** of **1277.5mm** in the year 2019 while, the **lowest** of **670.9mm** in the year 2015.

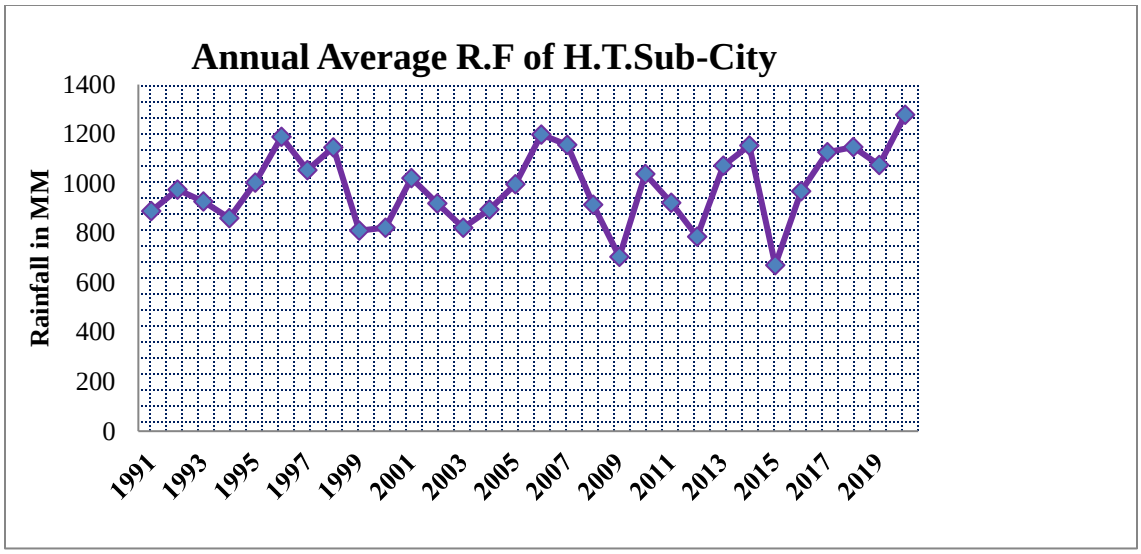


Figure 31: HTSC Annual Average Rainfall in mm from the year 2091-2020.

Rainfall Anomaly (Drought) Index

According to WMO 2012, put the range of standard precipitation value **of agricultural**, metrological and hydrological drought from extremely wet to dry between 2 up to negative 2 respectively, as shown as below table.

*Table 40: **Standard Precipitation Value** (SPV)*

SN	Range of standard precipitation value	Category of precipitation
1	2.0+	Extremely wet
2	1.5 to 1.99	Very wet
3	1.0 to 1.49	Moderately wet
4	-99 to 99	Near normal
5	-1.0 to 1.49	Moderately dry
6	-1.5n to -1.99	Severely dry
7	-2 and less	Extremely dry

Source: WMO, 2012 Standardized Precipitation Index User Guide 2012.

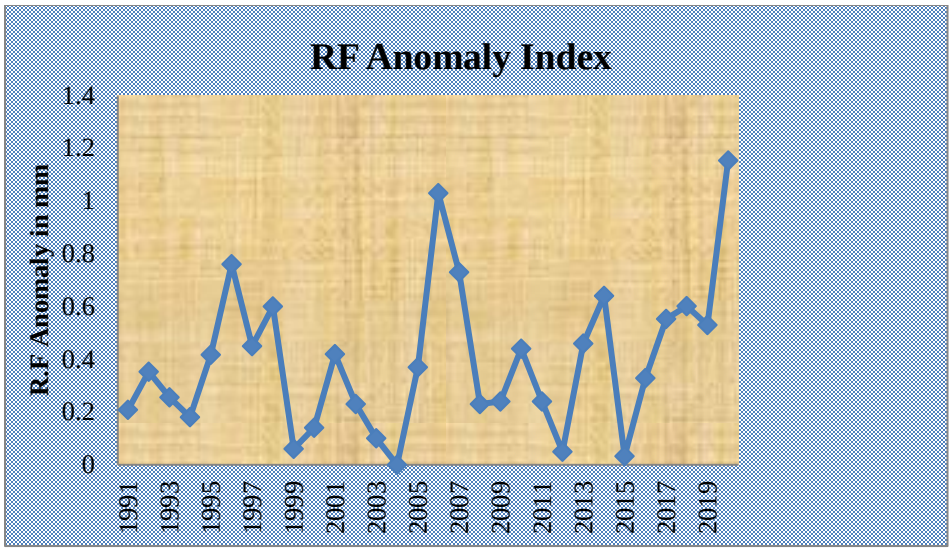


Figure 32: Rainfall Anomaly Index of HTSC (1991-2020)

Depends on **standard precipitation value**s (SPV) rainfall anomaly index of HTSC was shows that **moderately wet** precipitation and also it shows variability and trend line were increased as a result the frequency of flood increased than drought.

State and Trend of Temperature for HTSC

The atmospheric concentration of CO2 increased from year to year (F. Joos et al., 2013). The temperature has risen by about 0.3-0.6^{o}C since the late 19th century. The fourth assessment report (AR4) by the (IPCC, 2007) stated that the best estimates of likely increases in the mean global surface air temperature by the end of the 21st century are between 1.1°C and 2.9°C for the "low scenario" and 2.4°C and 6.4°C for the "high scenario,". Our study area is similarly exposed to Climate variability and Climate change.

The metrological data analyses of Hawella Tulla Sub-City in figure 33 indicated that average annual temperature **variability and trend** was highly increasing from the year 1991 to 2020. The variation of average temperature between lowest was 19.73^{O}C in the year 1996 and highest was 21.44^{O}C in 2015 whereas; average temperature and range were 20.42^{O}C and 1.7^{O}C

respectively. The rate of change or slope is 0.044^{O}C.

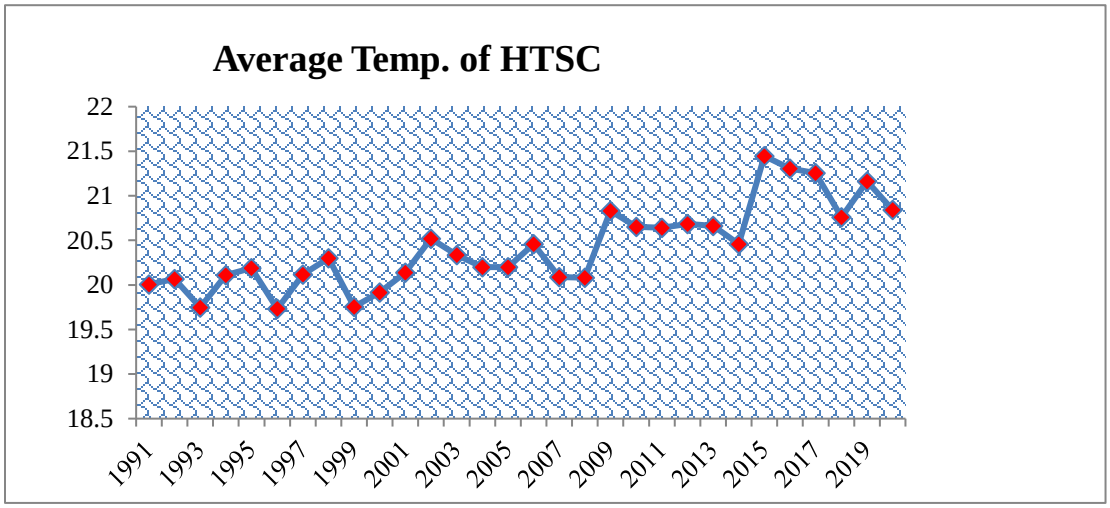


Figure 33: Average Annual Temperature of HTSC from the year 2091-2020.

Blow figure illustrates that **the Monthly average** temperature of the study area was **27.5°c** whereas; **the highest and lowest in February (31.18) and July (24.7)** respectively. Additionally the figure shows that the short dry season extending from January to March this is resulted in the difference between the thermal anticyclone of western Asia and Egypt and the equatorial low pressures determines the presence of trade winds blowing from northeast to southwest. These winds relatively cool but rather dry, control the dry period (Bega) (M. Fazzini et al.2015).

Generally, the meteorology data was indicated that the trend of the average temperature of HTSC was raised from year to year within **30** years.

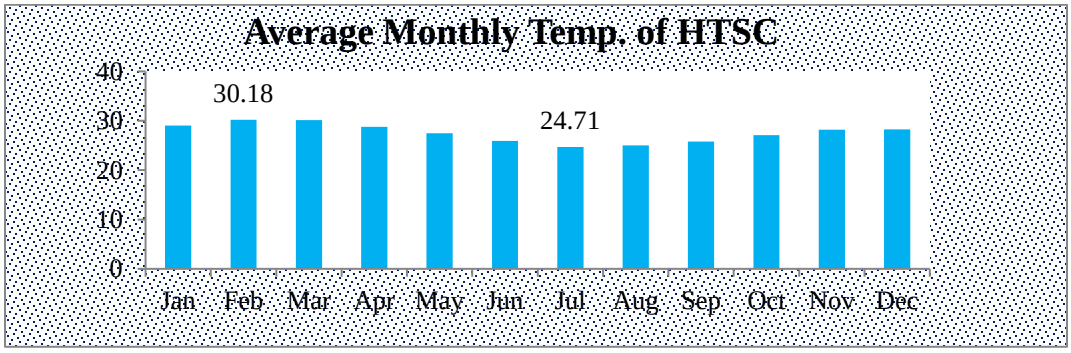


Figure 34: Average Monthly Temperature of HTSC from the Year of 2091-2020.

Temperature Anomaly

A positive anomaly means that the temperature was warmer than normal whereas a negative anomaly indicates that the temperature was cooler than normal.

Depends on the blow figure 53.4% of the year was recorded negative temperature anomaly from 1991-2008 except 2002 and 2006 with lowest cool temperature of -0.69°C and the remaining 46.6% was positive anomaly from 2009 to 2020 with peak of 1.02°C was recorded in 2015.

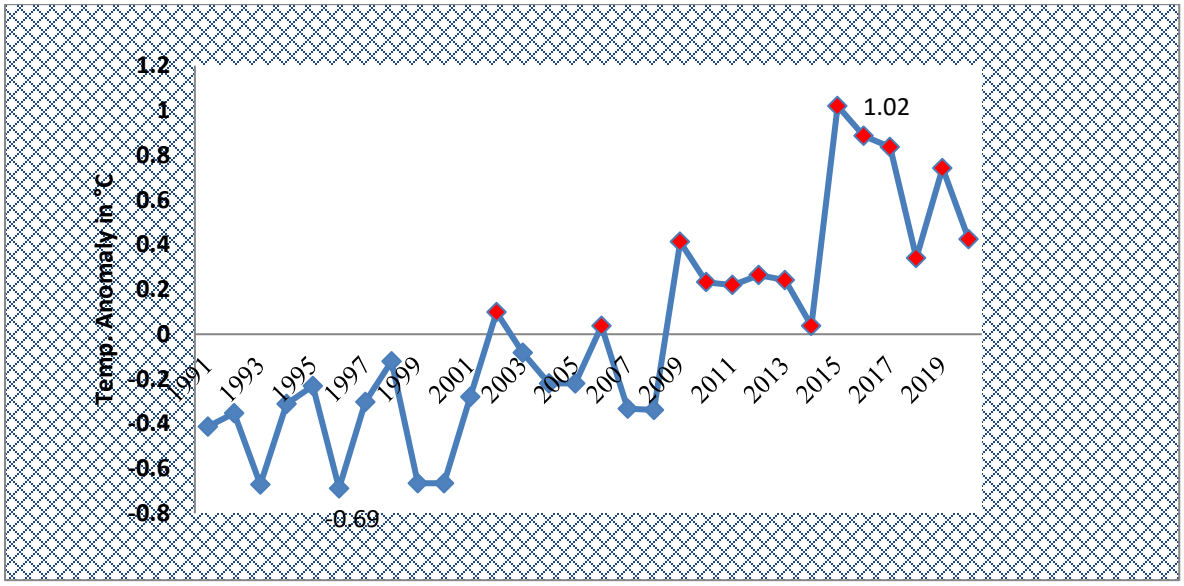


Figure 6: Average Annual Temp. Anomaly (calculating with WMO, 2017)

3.5.2. The driver and pressure of Climate Variability and/or Change to Sululta city Administration

Expansion of Industry:

It was a factor for increased frequency and magnitude of environmental degradation in the ecosystem as a great Deriver. According to socio economic data of sululta indicated that due to the location near to capital city of addis Abeba and also the urbanization of the Sheger City Administration of the Wetland of Sululta have 78 industries in 2021 and 118 large, medium and small functional factories planted until the end of 2022 and other 10 new factories establishing in 2023. These include Jiandang Peng PP Bag Manufakcharing , Damot Industrial and Commercial PLC , Elemtu, Nestle Water Ethiopia, Selam Spring Mineral Water Factory , To day , Abays Trading PLC, Allieid chemical, Gypsum factories, Textile industries, etc. However, rapid industrialization has positive impact on economic development of the countries but its case for

different types of waste like solid, liquid and gasses (outputs from factory chimneys to the environment) were release to the environment, due to this micro -climate change and variability was occurred in the wetland area, it has nationally contributed 1% for GHG emission

Urbanization

Ethiopia is among the least urbanized, but most rapidly urbanizing, nations in the world (UNDESA/PD, 2018). FGD participants were stated that the Sululta city was established in 1998, its land policy and the undergoing urban development endeavors are shaping new settlements in the end 2022. Therefore, 75% former rural settlements and private farm lands have been transformed into urban districts, industrial area and waste disposal. Additionally, waste disposal of sululta city is located at the wetland area, due to this in the rainy seasons it drains into all over the wetland and polluted the environment. Generally, raped urbanization has created major impacts on the environment with pollution and waste disposal. Due to this the Solid, liquid and gaseous wastes materials increase and polluted the environment. A waste material has nationally covers (3%) for GHG emission

GHG increasing in the atmosphere

It is responsible for regional micro and macro climate change and global warming. In the year 2015 Global level of CO_2 crossed the symbolic and significant 400 parts per million bench mark (WMA, 2019) and in 2021 CO_2 reaches at 415.7 parts per million (PPM), methane at 1908 parts per billion (ppb) and nitrous oxide at 334.5 ppb. These values compare with pre- industrial levels increased by 149%, 262% and 124% respectively (WMO, 2022).

And also the Sululta city location along the East African rift valley, due to this the toxic gases may become surrounded in the valley under conditions of atmospheric stagnation, compounding existing poor environmental conditions (DDEPA, 2013).

In the context of the study area, increasing the expansion of industry is the main driving factor for GHG increasing in the atmosphere.

Figure 35: Burning of fossil fuel from industrial area of sululeta (field survey).

LULCC

3.1 Rapid population growth:- FGD participants indicated that for different purposes like economic improvement and other cause the number of peoples displaced from rural area of Oromia and other regions were moved to the sululta town which leads wetland area changed in to settlement, industrial, agricultural and Grazing area. These activities are occupied over 75% of land compere before 25 years.

Figure 36: Settlements and Graves in the interior of the wetland.

Agriculture

Agriculture is limited (0.03%) impact on global climate variability and/or change but Ethiopia greatly contributed which is 61% of Green House Gases (GHG) emission (USAID, 2015).

1, Greasing of Animal

The economic activities of the people around Sululeta wetland ecosystem are mainly dependent on Agriculture; therefore the farmer mostly raring of animal and use their products. Not only that the farmers harvest the grass and seal it as cash crop from 100,000 to 7 million per year. Sometimes, they could be limitedly planting Eucalyptus tree around the wetland then the result

of this and over grazing, under and above groundwater was reduced and shrink the wetland. It is make favorable condition for the occupation of the wetland and It is responsible for microclimate change and /or Variability around the area.


Figure: over grazing and preparing grass for seal.

2, Crop Cultivation

Currently, the central government of Ethiopia emphasized on the covering the food gap of the people so put the direction for cultivating the wetland area in the dray season. As a result, 10 ha land of the wetland area covered wheat crop by the owner of sululeta city agricultural office.

Figure 37: Agricultural activities in the center of the wetland

Agriculture contribution to climate change is great in the study area;

1. Crop production (N_2O emission from organic and mineral N imputes. Burning of crop

residues, N_2O and CH_4 from manure handling (storage, etc.) and

2. Cattle farming (CH_4 from enteric fermentation), being the major source. (Frank Brentup Year GambH and Co.KG May 2008).

Crop production (N_2O emissions from organic and mineral N inputs, burning of crop residues, N_2O and CH_4 from manure handling (storage etc.)

Managed soils or all agricultural soils are directly and indirectly emits nitrous oxide that is usually estimated from data on nitrogen supplied to soils, including nitrogen fertilizer usage or sales, crops residue management, organic amendments, cultivation of organic soils (i.e. drainage of peat lands in agricultural land) and land-use conversions that enhance mineralization of nitrogen in soil organic matter (Rome, 2014).

The application of mineral fertilizer is a significant material for agricultural products and productivity improvement. In the climate change context, the fertilizer industry is a consumer of energy and an emitter of CO_2 and other greenhouse gases (GHG). Crop cultivation in Ethiopia emitted nitrous oxide total of 12 Mt CO_2e, which cover 9% of the total emission. (https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Ethiopia%20First/INDC-Ethiopia-100615.pdf

And the production of N fertilizer (in IPCC assigned to "Industry") releases another 410 Mt CO_2-equivalents (CO_2eq) per year, which is equivalent to 0.8% of the global GHG emissions. Our study area use fertilizer as followed and contributed to GHG emission.

Table 41: Use and Emission factors of mineral fertilizers in the HTSC

Years	Dap in Kg	Emission factors of DAP		Urea in Kg	Emission factors of urea
		N2O in ton	**CO2** in ton		**CO2 in ton**
2017	195,800	35.244	90.068	264,000	52.8
2018	185,250	32.715	85.215	277, 870	55.574
2019	181750	32.715	83.605	272,625	54.525
Total	562, 800	101.304	258.888	814,495	162.899

Average annual emission	**187,600**	**33.768**	**86.29**	**271, 498.3**	**54.29**

Source; HTSCANRO data with calculated by MRV given value (202)

Methane (CH4) emissions from enteric fermentation (cattle farming);

Animal population: FGD participants in 2023 indicated that the wetland was highly dominated by **well grass cover** which is better option to the raise of cattle population.

Figure 38: Cattle grazing in the Sululeta wetland.

Source; field observation, (2023)

Livestock is a significant source of global methane (CH_4) emission, among Ethiopian livestock species, 83 % of CH_4 emission from cattle. The amount of methane emittion is driven primarily

by the number of animals, the type of digestive system, and the type and amount of feed consumed IPCC (2006).

Table 42: Methane (CH_4) emission from Cattle population of Sululeta Sub-City

S.N	Year	Cattle population	Emissions Factor kg/head/yr	Total Emission of HTSC in k.g	CH4 emission from livestock enteric fermentation (cattle) (Gg CH4 yr-1)	In tCO_2
1	**2017**	**55,980**	**31**	**1,735,380**	**1.73538**	**43.3845**
2	**2018**	**77,140**	**31**	**2,391,340**	**2.39134**	**59.7835**
Average yearly	**yearly**	**66, 560**	**31**	**2, 063, 360**	**2.06336**	**51.584**
Increment	**2017 and 2018**	**21,140**	**31**	**655340**	**0.65534**	**16.3835**

Source: IPCC (2006 with author calculation)

Livestock manure is primarily composed of organic material and water. Under anaerobic conditions, the organic material is decomposed by anaerobic bacteria. The end products of anaerobic decomposition are **methane, carbon dioxide,** and **stabilized organic material.**

The **methane production** potential of manure depends on the manure's specific composition, which in turn depends on the **composition and digestibility** of the **animal diet** (Francesco N. et al. 2014).

In Ethiopia livestock emitted **methane** and **nitrous oxide** total of **65 Mt CO2e**, which cover 42% of the total. In the context of the study area, the livestock population was increased by 21,140 from the year 2009 – 2010, which contributed to the rising of methane (CH4) and nitrous oxide (N2O) emissions.

3.5.3. Impact of climate change and/or variability on the Sululta Wetland

The amount of greenhouse gases increases in the atmosphere case for increasing surface temperature. These conditions largely affected developing countries such as Ethiopia, which have limited capacity to cope with the effect of a changing climate (Gebeyehu, 2016).

In the FGD the participants explained that however, the wetland is located in the highland area but surrounded by highland and they were chosen based on their higher potential risk of exposure to siltation. It was accelerated evapotranspiration and dry up underground water in the wetland area, its sometimes increase vulnerability to droughts. It is also responsible for the loss of agricultural productivity and the expansion of insects, pests, and human diseases were known problems in the study area.

Drought

Drought exists when seasonal rainfall drops below normal by almost 30 to 50 % (Getachew Alem, 2018). It was occurred in the year 1988 and affected in average 10 cattle per household. The major effect of climate variability and/or changing was changed crop cultivation period which is rain comes after the beginning of the normal cropping season, and occasionally heavy amount of rain and high temperature occurred, for the fact that negatively affected at early or late vegetative stages of crop and also unexpected rain devastated the crop product at harvesting time. Seasonal change was occurred before 28 years; permanent cropping seasons was twice a year but currently, shifted to once a year or in June which was responsible for the loss of Belg product. However the agricultural products with fertilizer averagely increased by 19.2% but now without fertilizer the product is near zero.

Table 43:Rate of change in Agricultural product and Productivity comparisons Before 2002 to 2022

S/N	Types of crop	Productivity before 20 years in kg without fertilizer	Productivity in 2022 in kg with fertilizer
1	Barley	7	28
2	wheat	7	28
3	pea	6	18
4	Been	6	18
5	potato	35	65

Source; Sululeta FGD, (2022)

Health Impact

As the climate is changing, the existing diseases will aggravate and new diseases will emerge. Diseases such as cardiovascular mortality, respiratory illnesses, water-related contagious diseases, and malnutrition are directly or indirectly associated with climate change (Tafesse, 2019).

The Health-related impact in Sululeta wetland

S/N	Types of diseases	Years	
		2021	2022
1	Typhoid and Para typhoid	595	3191
2	Acute upper respiratory infections	1427	
3	Bronchitis		1735
4	Cough	945	14425
5	Pneumonia	499	1329

In the FGD (2023) implies that the wetland is surrounded by different industries. These industries have been releasing toxic waste to the wet land. As a result of this those cattle grazing on the wetland exposed to diseases result was death of animals (FGD 2023).

Figure 39: Before 30 years the wetland used for truest attraction with different bird spacious,

(Field Survey, 2023)

The expansion of industry and urbanization in the surrounding of the Sululeta wetland is a case to the declining of outdoor air quality which is lead to the emission of toxic gases such as SO_2, NO_2, and CO in addition to increasing concentrations of CO_2 and VOCs (Volatile organic compounds). The result especially NO_2 levels, may decrease lung function and increase the risk of respiratory symptoms, such as acute bronchitis and cough and phlegm, particularly in children, and. Also S_2O affects the human lung (Oluwasinaayomi et al., 2018). Top ten human diseases in the wetland were Acute upper respiratory infections, typhoid, Para typhoid, Cough, Pneumonia and, Bronchitis (ARHCAAO, 2020) are directly or indirectly associated with climate change (Tafesse, 2019).

At national level air pollution impact in Ethiopia

Globally 19,000 people dying every day from breathing polluted air (Oasis Earth, April 2021)

Based on the FGD data indicated that however the industry owner constricted drinking water from underground water and accessed to the people but the area experiences decline underground and river water during the December–February. Therefore during the dry season, the people in the study area travel long distances every other day to drinking water. Such long-distance trekking undoubtedly hinders household heads or other family members from devoting enough time to other livelihoods and, therefore, incurring further economic losses and made sanitation problem and also responsible for water-borne diseases like Para typhoid and typhoid. Globally billions living in water-stressed regions (Oasis, 2021)

Figure 40: People move to long-distance accessing drinking water

Source: Field Survey (2023).

Ecosystem Impact

FGD participants and field observation (2023) implies that the wetland is serve the society for different purpose like a recreational service (different Specious of birds found here in addition to visit hunt and seal to tourists), grass for grazing animal, traditional house cover, etc. But currently the service was highly declined, due to this the society loss social and economic value.

Figure 41: The remaining specious of birds found in the wetland area

Source: Field visit (2023).

3.5.4. Response to Climate Change and/or Variability in Sululeta wetland

Government Response at the Sululeta sub city

From 2003 - 2009 same factories responsible for polluted wetland water and area when the government takes action which is closed the Jiandang-pengPP bag manufacture factories and replaced by treatment plant implemented factories.

Figure 42 : The factories' which is replaced by closed factories'.

Source: Field Survey, 2023.

Government Response at National Level

The Government of Ethiopia has made various policies, legislative and institutional measures. In 2013, the Ministry of Environment, Forest Development, and Climate Change was established. The policies that have been put in place before 2007 to direct sustainable forest development and management with wider implications for improved environmental management, and reducing the effects of climate change include the following:

- ✓ **The Ethiopian Constitution (1995)** provides the rights to a clean and healthy environment as fundamental rights of citizens (articles 43 and 44).
- ✓ **Environmental Policy of Ethiopia (1997)** is the overarching policy for managing the environment and natural resources.
- ✓ **National Action Program** for the equitable sharing of the costs and benefits, arising from them and contribute to the well-being and security of the nation.
- ✓ **Climate change subject will integrate as a curriculum for the coming few years**

The above-mentioned point indicates the government of Ethiopia gives attention to make environmental protection policy, but weak implementation at the ground level

International Response

- ✓ Ethiopia intends to limit its net greenhouse gas (GHG) emissions in 2030 to 145 Mt CO2e or lower. This would constitute a 255 MtCO2e reduction from the projected 'business-as-usual' (BAU) emissions in 2030 or a 64% reduction from the BAU scenario in 2030. Ethiopia also intends to undertake adaptation initiatives to reduce the

vulnerability of its population, environment, and economy to the **Combat Desertification (NAP, 1998)** the GoE ratified the UN Convention to Combat Desertification (UNCCD) in 1997 and subsequently undertook the formulation of a NAP.

- ✓ **National Biodiversity Strategy and Action Plan (NBSAP, 2005)** the GoE developed the NBSAP to ensure the conservation and sustainable use of biodiversity, and to provide

adverse effects of climate change, based on its Climate Resilient Green Economy Strategy (CRGE). The CRGE is Ethiopia's strategy for addressing both climate change adaptation and mitigation objectives. The implementation of the CRGE would ensure a resilient economic development pathway while decreasing per capita emissions by 64% or more. The CRGE is also integrated into the Second Growth and Transformation Plan (the national development plan). In the long term, Ethiopia intends to achieve its vision of becoming carbon-neutral, with the mid-term goal of attaining middle-income status.

The full implementation of Ethiopia's INDC is contingent upon an ambitious multilateral agreement being reached among Parties that enables Ethiopia to get international support and that stimulates investments. The INDC will be updated periodically, as appropriate.

Overall, the EINDC marks an important next step on the path towards sustainable development, consistent with the Principle of Common but Differentiated Responsibilities and Respective Capabilities. In this context, Ethiopia reaffirms its continued commitment to building a climate-resilient green economy. This EINDC contributes to the global effort to mitigate climate change while ensuring the realization of an equitable and resilient green economic growth nationally.

3.5.5. Outlook for Climate Change and/or Variability

2011 baseline scenario of MEFCC, 2015 has been estimated that climate change could reduce the country's GDP by up to 10% by 2045.

If the rate of climate change and /or variability increased just like as trend line and industrial liquid waste material release to wetland will continue without implemented the recommended points and other additional research over the next three-decade,

- The situation continues as baseness as usual (BAU) the wetland should be completely lose, not only that but also rever should be highly decline or dry up due to this the city loss recreational service from the wetland.
- According to baseline data of 2014 - 2020 kiremt and belg product was declined by 19.36%, similarly in the next 30 years it should be declined by 82.97%.
- The average temp. will be reached at 1.32°**C** in the future 30 years.
- The average temp. will be reached at 1.32°C in the future 30 years.
- The average temp. will be reached at 1.32°**C** in the future 30 years.
- The frequency of drought will be increased significantly.
- CO_2 emission from livestock and fertilizer will be reached at 9,608 tones.
- N_2O emission from fertilizer (N_2O) will be reached at 1,688.4 tones.
- CO_2 emission from forest will be reached at 1,616,500 tones.
- Lose potential health benefits like increased malaria will rise to the epidemic level and also will increase the death due to malaria and water-borne disease (Typhoid, conjunctivitis, etc), malnutrition cause and other new diseases will be emerging.
- Scarcity of water will be increased significantly.

3.5.6. Recommendations

According to the study area profile, FGD, Field visit, and NMASSNNPR data indicated that the rate of atmospheric temperature increasing from year to year.

Therefore the following problem reduction method should be needed.

- Industrial waste material should be **recycled** and **corporate social responsibility** will be financially supporting the community to soil and water conservation activities.
- Environmental compliance directorate should be taken toxic chemicals sample from the wetland river and it should be tasted in the laboratory.

- Health center should be cerise attention on family planning.
- Adaptation options should focus on reforestation, area closure, implement zero grazing and cultivate the short growing crop and drought resistance crop should be possible.
- In order to reduce the emission of methane and niters oxide from the atmosphere, it is better to reduce the number of animals and also increase their quality.
- Develop research on the new productivity technology on the crop and animal.
- Improve the integration and coordination between policies across many sectors.
- SCASSC municipal and Health office should be organized to improve waste management system.
- Water mineral and energy office purify water source and improve water coverage.
- Government should be effectively implementing international agreement to reduce CO_2 emission.
- Identify wetland protection for sanctuaries.
- SCASSC will intensify the use of **solar , wind energy and other cooking stove** Climate change subject will integrate as a curriculum for the coming few years.

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Writers

- Mr. Gedamu Yewnesew
- Mrs. Banchaymolu Terefe
- Mrs. Yewbdar Alemu

Facilitator

- Mr. Tilahun Alemu
- M.r. Antene Teshome

Compiled by

- Mrs. Kidist Yewalashet