Sidama National Regional State

Environmental, Forest and Climate Change Authority

The State of Environment Report

June, 2022

Hawassa, Sidama, Ethiopia

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Acronyms and Abbreviations

AR5	Fifth Assessment Report
CAF	Cancun Adaptation Framework
CBD	Convention on Biological Diversity
CMIP5	Coupled Inter-comparison Project No.5
COP	Conference of the Parties
COPD	Chronic Obstructive Pulmonary Disease
CR	Climate Resilience
CRGE	Climate Resilient Green Economy
CSA	Central Statistical Agency
CV	Coefficient of Variation
EFCCC	Environment, Forest, and Climate Change Commission
EPACC	Ethiopia's Program of Adaptation to Climate Change
ESDP	Education Sector Development Programme
FAO	Food and Agriculture Organization
FEWS NET	Famine Early Warning System Network
GDP	Gross Domestic Product
GE	Green Economy
GER	Gross Enrollment Ratio
GHG	Greenhouse Gases
GTP II	Growth and Transformation Plan
HCFs	Health Care Facilities
HWSD	Harmonized World Soil Database
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
JMP	Joint Monitoring Programme
LDCs	Least Developed Countries
MDG	Millennium Development Goals
MEFCC	Ministry of Environment, Forest and Climate Change
MO FED	Ministry of Finance and Economic Development
MOE	Ministry of Education
MoWIE	Ministry of Water Irrigation and Energy
MSW	Municipal Solid Waste
NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Programme of Action

NDCs	Nationally Determined Contributions
NER	Net Enrollment Ration
NFMS	National Forest Monitoring System
NMA	National Meteorological Agency
NTFP	Non-Timber Forest Products
PAs	Protected Areas
PCBs	Poly Chlorinated Biphenyls
PPP	Public-Private Partnerships
PSNP	Productive Safety Net Program
PSR	Pupil-Section Ratio
RCP	Representative Concentration Pathways
REDD+	Reduced Emissions from Deforestation and Forest Degradation
SAI	Standard Anomaly Index
SBOFED	Sidama Finance and Economic Development
SNRS	Sidama National Regional State
STD	Standard Deviation
SWC	Soil and Water Conservation
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Program
WHO	World Health Organization
WRI	World Resources Institute

Acknowledgements

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SECTION ONE

1. Overview of the Region

1.1. Geographical Location of Sidama National Regional State

Sidama National Region State is one of the regions in Ethiopia which is located in the northeast of Lake Abaya and southeast of Lake Hawassa. The region is geographically located between $6^{0}05'$ and $7^{0}10'$ north of latitude and 38^{0} 0' and $39^{0}10'$ east of Longitude. It is bordered on the north, east and on the south by the Oromia Region except for a short stretch in the middle where it shares a border with Gedeo zone. The west part of the region is bordered by the Bilate River, which separates it from Wolayita zone. The region is bounded between Tikur Wuha River in the north and Dilla town in the south, spread out in a cone-shaped area of the middle of southern Ethiopia. Sidama is generally a fertile area, varying from flat to highland.

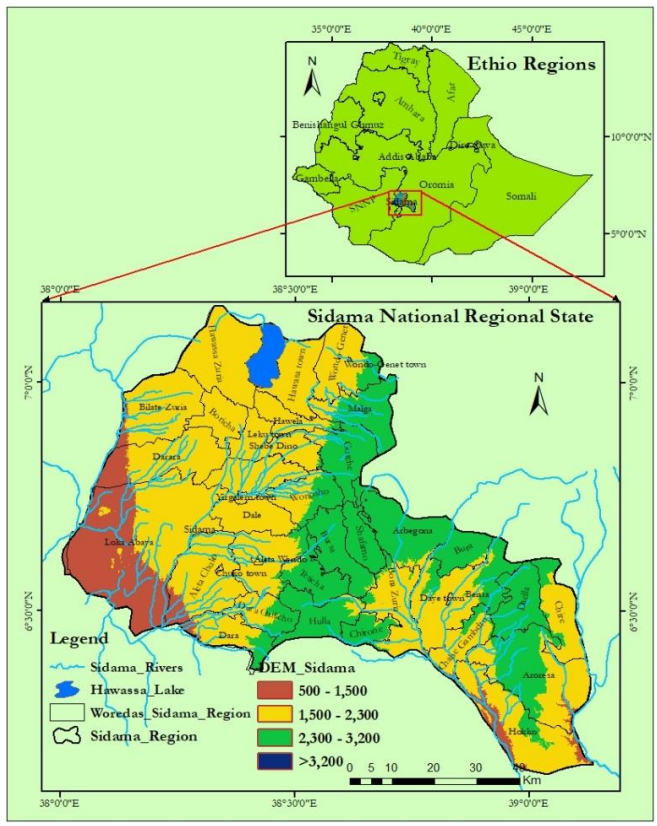

Figure 1 Sidama National Regional State

The Sidama National Regional State consists of 37 administrative divisions, of which 30 are woreda administrations, 6 are town administrations and one city administration which is divided in to 8 sub cities. Currently there are 668 kebeles both in urban and rural parts of the region. The Figure 2. shows the location of the region and the administrative woredas in the region.

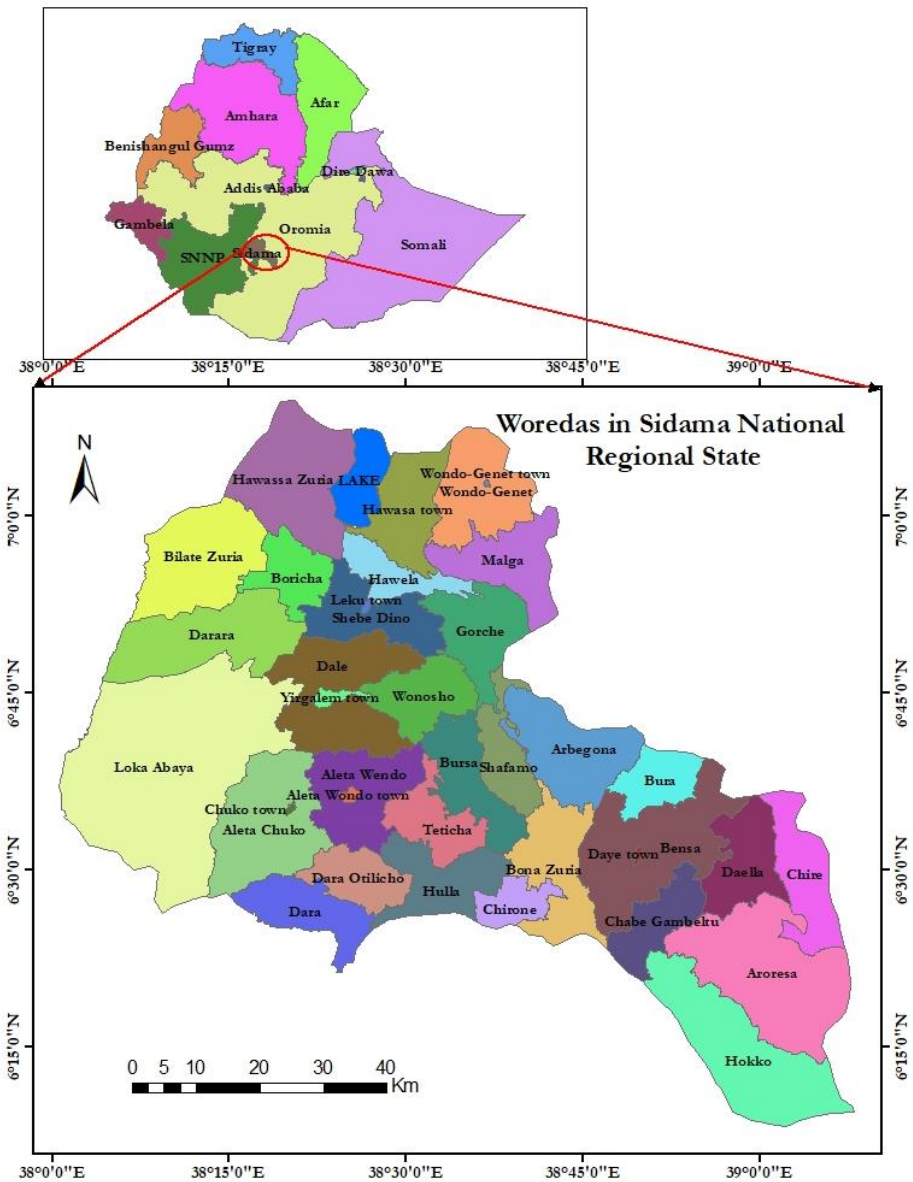

Figure 2 Woredas in Sidama Regional State

1.2. Agroclimatic Zone of Sidama Regional State

The agroclimatic zone of the Sidama Region is classified based on the traditional agroclamatic zone classification method adopted from Dejene, (2003). According to the classification more than 60% of land is in woyina dega climatic zone. The agroclimatic zone of the region is presented in Figure 3. and Table 1. below. The agroclimatic classifications have important implications for strategies in development of appropriate technologies for agricultural and rural development, natural resources management (NRM) and migration (Dejene, 2003).

Figure 3 Agroclimatic Zone of Sidama Regional State

Table 1 Agroclimatic Zone of Sidama Regional State

Altitude Range	Agroclimatic Zone (Amharic)	Agroclimatic Zone (Description)	Area (ha)	Percentage (%)
500-1500	Kola	Warm and Semi-Arid	70127.72	10.345
1500-2300	Woyna Dega	Cool and Sub-Humid	408536.76	60.266
2300-3200	Dega	Cool and Humid	199192.56	29.384
>3200	Wurch	Cold and Moist	33.12	0.005

1.3. Topography of the Sidama Region

The physical features of the region typically include natural formations such as mountains, rivers, lakes and valleys. The Sidama Region is the part of Great East African Rift-valley which was formed during the Cenozoic Era or Tertiary Period. The region is mainly found in South Eastern Highlands of Ethiopia. The elevation of region varies from 1104 m.a.s.l in Rift-valley around Lake Abaya in Loka Abaya woreda to 3311 m.a.s.l in Mount Garamba which is the highest peak of the region that is found in Arbegona woreda and located at 86 km distance in north east from Hawassa city and 361 km from Addis Ababa city (Figure 4.).

From the total area of the region about 30% of the area has relatively higher altitude ranging from 2300 - 3200 m.a.s.l while the middle land which is about 60 % of total area ranging from 1500-3200m above mean sea level. The remaining 10 % is categorized as low land with altitudes ranging from 500 - 1500 m.a.s.l. In other hand, the western part of Sidama Region is characterized by lower land topography in association of its location in Great East African Rift-Valley. This part of the region includes few part of Lake Abaya and whole part of Lake Hawassa on the floor of the Ethiopian Rift valley. These altitudinal variations made the region to have different land forms such as Mountains, Plateaus, Hills, Plains, Valleys and water bodies.

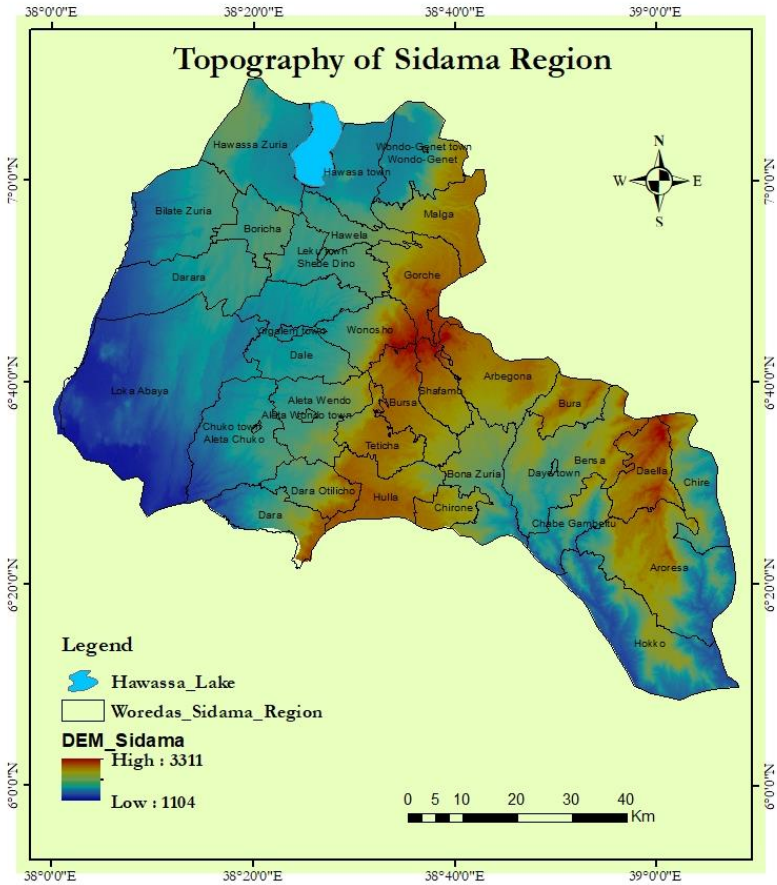

Figure 4 Topography of Sidama Region

1.4. Eco-tourism

Ecotourism is defined as "responsible travel to natural areas that conserves the environment and improves the well-being of local people. Conservation offering market-linked long-term solutions, ecotourism provides effective economic incentives for conserving and enhancing bio-cultural diversity and helps protect the natural and cultural heritage of our beautiful planet. Communities By increasing local capacity building and employment opportunities, ecotourism is an effective vehicle for empowering local communities around the world to fight against poverty and to achieve sustainable development. Interpretation of ecotourism in Sidama region is, with an emphasis on enriching personal experiences and environmental awareness through interpretation, ecotourism promotes greater understanding and appreciation for nature, local society, and culture.

1.5. Cultural Tourism

In Sidama region, Cultural tourism has a long history, and with its roots in the Grand Tour is arguably the original form of tourism. It is also one of the forms of tourism that most policy makers seem to be betting on for the future. The Sidama region tourism, for example, asserted that cultural tourism accounted for 47% of regional tourism, and forecast that it would grow at a rate of 15% per year. There are a number of cultural tourist attractions in region. In year 2013 more than ten thousand local and international tourists are visit cultural tourist sites in region around Yirgalem town, Wondogenet and Aletawondo Woreda. This underlines the growing importance of cultural tourism as a source of cultural consumption. The generalization of cultural consumption on holiday, however, points to one of the main problems of defining cultural tourism. Fichee-Camballala ceremony has been attracting a number of tourists as holiday traveler. Other cultural attraction was visited such as Sidama Cultural coffee ceremony, dish and food preparation, settling pattern so on by tourist's leisure travel. There is a general perception that cultural tourism is 'good' tourism that attracts high spending visitors and does little damage to the environment or local culture while contributing a great deal to the economy and support of culture.

Figure 5 Cultural Tourism

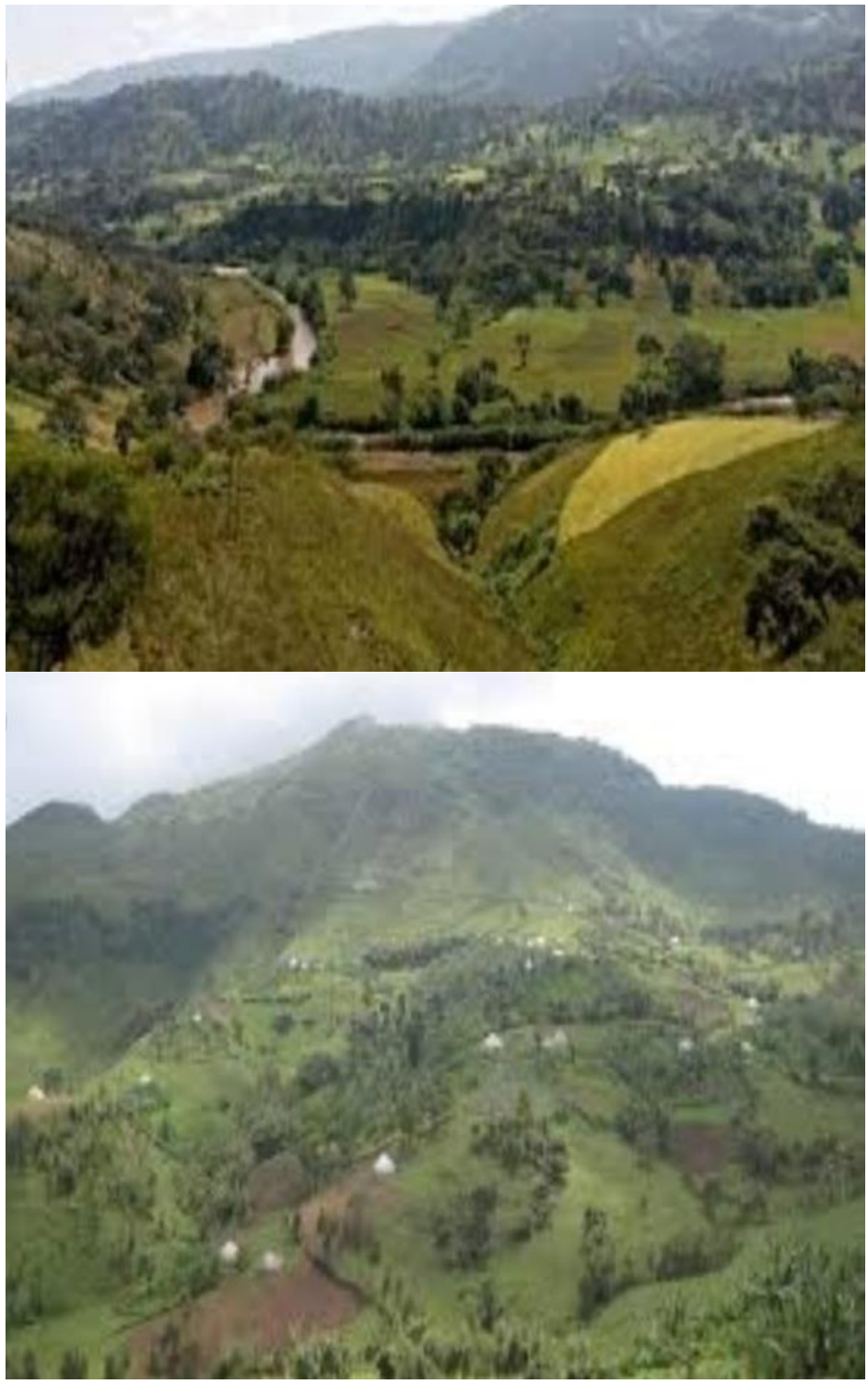

Figure 6 Ecotourism (Garamba Mountain Area)

Table 2 Major Tourist Attraction Sites in the Region

No	Name of Tourist Attraction Sites	Existence Area/Woreda	Major Attractions
1	Loka Abaya National Park	Loka Abaya	▪ Fascinating landscape with springs water ▪ Abundant Animal and plant species: ▪ Lion, Hyena , Wolves, Tiger
2	Garamba Community Conservation Area	Arbegona	▪ Fascinating landscape with springs water ▪ Abundant Animal and plant species: ▪ Lions, Hyena , Wolves, Tiger etc
3	Lake Hawassa	Hawassa City	▪ Different Animals and Birds: ▪ Hippopotamus ▪ Fishes ▪ Python ▪ Resorts and Star Hotels along the shore
4	Wondogenet/Wabe Shebele Hot Springs	Wondo Genete	▪ Natural scenery & hot spring water ▪ Swimming pools ▪ Cultural foods ▪ Bed Rooms ▪ Different Animal and Bird Species/Monkeys, Apes etc
5	Gidawo Hot Springs	Yirgalem City	▪ Hot spring water with beautiful nature water ▪ Abundant Birds and Plant Species ▪ Individual bath rooms
6	Logita Water Fall	Bona Zuria	▪ Spectacular fall with torrential sound ▪ Various endemic Birds and trees species ▪ Wild mammals
7	Bonora Water Fall	Bensa	▪ Cataract and blue winged birds ▪ Various endemic Birds and trees species/ coffee fields, ▪ Wild mammals ▪ Caves, impressive landscape
8	Hawassa Gudumale	Hawassa	▪ Ideal Place to visit cultural justice/ tribunal sits of Sidama

Source: Bureau of Culture and Tourism (2012 E.C)

SECTION TWO

2. State and Trends of the Social, Economic and Environment

2.1. Introduction to Social Environment

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.

Human social environments encompass the immediate physical surroundings, social relationships, and cultural milieus within which defined groups of people function and interact. Components of the social environment include built infrastructure; industrial and occupational structure; labor markets; social and economic processes; wealth; social, human, and health services; power relations; government; race relations; social inequality; cultural practices; the arts; religious institutions and practices; and beliefs about place and community. The social environment subsumes many aspects of the physical environment, given that contemporary landscapes, water resources, and other natural resources have been at least partially configured by human social processes. Embedded within contemporary social environments are historical social and power relations that have become institutionalized over time. Social environments can be experienced at multiple scales, often simultaneously, including households, kin networks, neighborhoods, towns and cities, and regions. Social environments are dynamic and change over time as the result of both internal and external forces (Robert C. Byrd 2001).

2.2. State and Trends of Social Environment

2.2.1. Population of Sidama Regional State

The SNRS is newly established region which was one of the zones in SNNPR. Based on the CSA report of 1999 E.C census, the projected population size of the region in 2012 E.C was 4,710,648, in which 2,384,086 were male and 2,326,562 were female. The population of the region is growing rapidly with an average annual growth rate of 2.9 %. The size of the population is always changing in response to fertility, mortality and migration. The actual size

of the population can be explained basis of the particular place and in a particular time. Regarding population distribution at Woredas/Towns/City Administration level, Hawassa city administration, Dale, Bensa, Aleta Wondo, Shebedino, Aleta Chuko and Hawassa Zuriya Woredas have the highest number of population, whereas Daela, Chirone, Burra and Shafamo Woredas have the lowest number of population. High numbers of people are living in Woyina Dega agroclimatic zone of the region and the population distribution of the region was not even.

Population is one of the important factors which help to balance the environment. If the population will be balanced, then all the needs and demand of the people can be easily fulfilled, which helps to preserve the environment of the region. Hence having information on population size and distribution are very crucial for planning, monitoring and evaluation of any development programs. The population map of the region is shown in Figure 7.

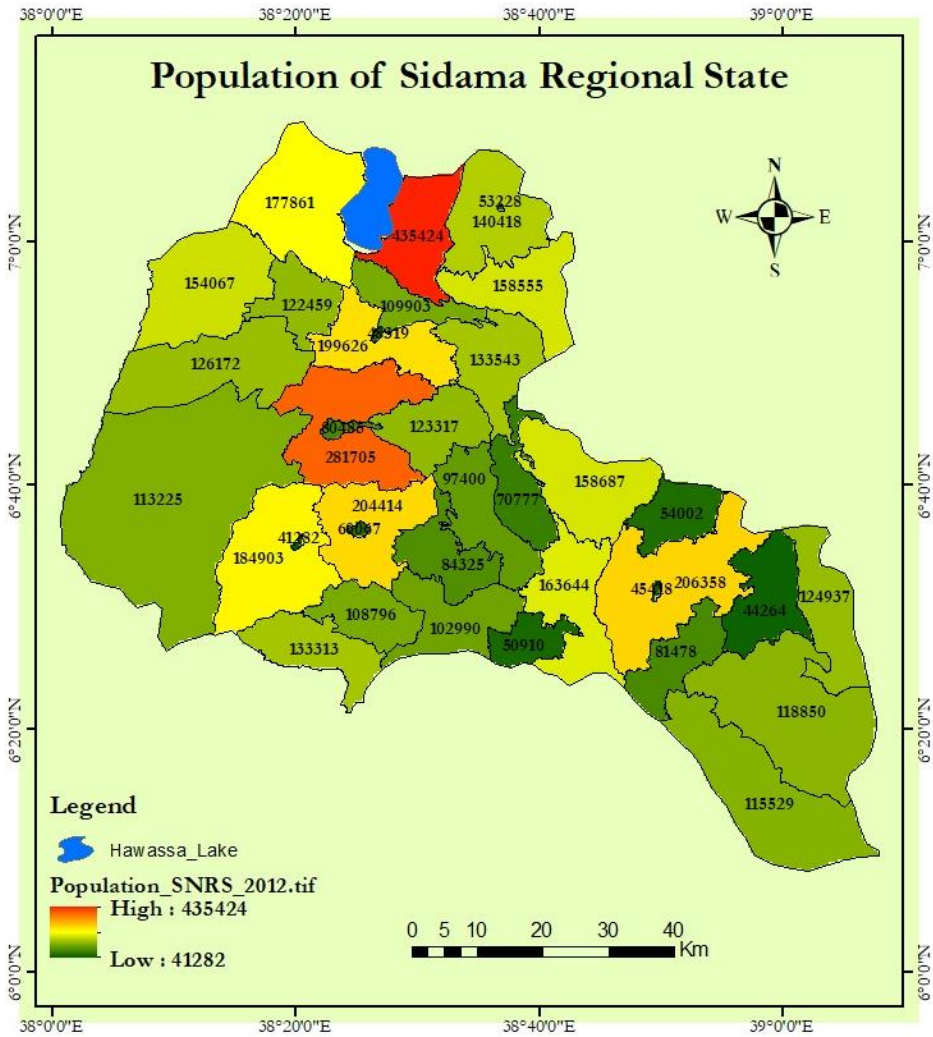

Figure 7 Population Map of Sidama Regional State

2.2.2. Population Density of Sidama Regional State

The population of Sidama is highly distributed in areas where there is fertile land, available water and pasture land. In some areas of the region such as Loka-Abaya, Bilate Zuriya, Daela, Aroresa and Hokko Woredas population distribution is partial sparse. The Sidama Region is one of the most densely populated regions of the country of which in average 674 persons are living in a square kilometre. Even within the region there is a great variation in population density from Woreda to Woreda. Dara, partial of Bona–Zuria and Wonsho woredas have been suffering by high population explosion (Figure 8). This rapid population growth has become one of the major challenges facing the Sidama society today. Unbalanced population

growth has created additional burden and brought about heavy pressure upon socio-economic development in the Region.

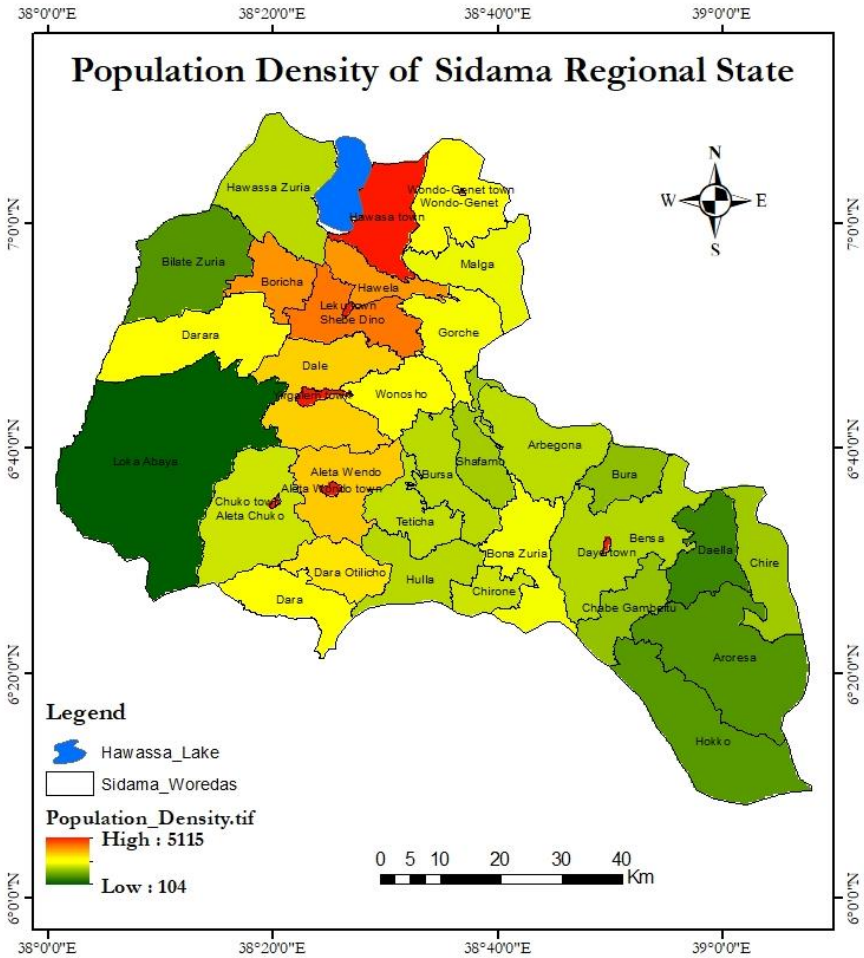

Figure 8 Population Density of Sidama Regional State

Table 3 Population and Population Density of Sidama Regional State (Woreda Level)

No.	Woreda/Towns	Population	Area (km2)	Density (p/km2)
1	Shebedino	199,626	148.60	1343
2	Leku Town	48,319	21.73	2223
3	Hawela	109,903	89.70	1225
4	Hawassa Zuriya	177,861	275.36	646
5	Arbegona	158,687	241.50	657
6	Shafoma	70,777	119.24	594
7	Aleta Wondo Town	60,067	21.33	2816
8	Aleta Wondo Woreda	204,414	191.95	1065

9	Dara	133,313	152.71	873
10	Dara Otilcho	108,796	112.93	963
11	Hulla	102,990	160.95	640
12	Teticha	84,325	125.69	671
13	Chirone	50,910	73.10	696
14	Bensa	206,358	325.84	633
15	Daye Town	45,418	25.46	1784
16	Bura	54,002	102.53	527
17	Chabe Gambeltu	81,478	150.70	541
18	Aroresa	118,850	318.49	373
19	Hokko	115,529	306.37	377
20	Yirgalem Town	80,485	38.70	2080
21	Dale	281,705	267.85	1052
22	Boricha	122,459	98.20	1247
23	Bilate Zuriya	154,067	421.40	366
24	Darara	126,172	150.84	836
25	Gorche	133,543	168.16	794
26	Malga	158,555	206.74	767
27	Wonsho	123,317	138.03	893
28	Loka Abaya	113,225	1086.70	104
29	Chire	124,937	215.13	581
30	Daela	44,264	154.68	286
31	Bursa	97,400	149.83	650
32	Chuko Town	41,282	25.49	1620
33	Aleta Chuko Woreda	184,903	267.32	692
34	Bona Zuriya	163,644	209.21	782
35	Wondo Genet Town	53,228	10.41	5115
36	Wondo Genet Woreda	140,418	169.54	828
37	Hawassa City	435,424	249.85	1743
Total		**4,710,651**	**6992.26**	**674**

2.2.3. Settlement Pattern of the Region

In Sidama culture, the settlement pattern has a definitive structural pattern of settlement. The culture of settlement pattern is the same in the high land and low land areas. The only difference is some variation around low land house and high land house on their interior partition, construction techniques and construction materials. In addition, the Sidama pattern

settlement culture has a definitive structural settlement. According to the settlement pattern, there are two land ownership systems known as *Utuwa* which owned individually and *Danawa* which are communally owned land. The most characteristic feature of Sidama landscape is the mosaic of cluster of homesteads. The midland contains a continuing chain of villages, while homesteads in the highlands are a little more scattered on the open savanna, in the lowlands homesteads are even more scattered. In between the homesteads are patches of farm fields and open land for grazing cattle. Homestead consist of round huts surrounded by lush garden of *weese*/ false banana/, tree of Coffee plant and a variety of fruit trees, including mangoes, avocados, peaches, and many others grow in abundance. The lush green garden gives Sidama land the appearance of a green and fertile. The best approach to describe this pattern is looking at bottom-up dimension. These are "*Qa`e", "Qacha", "Ollaa",* and "*Qammatte".*

"Qa'e": - is one of the settlement patterns in the area pertains to immediate family line. As a result of polygamy trend in the locality these sort of settlement pattern is patriarchal structure. The household establishes 2-5 "*Mines"*/houses or individual house for his wives and for his married male children. It is almost rather the place where extended families live. Also*, "Qa`e"* is characterized by unfenced open field in front of the "*Mines*" for common use/*Danawa* which the dwellers mutually share. However, the individual "*mine"* has his own "*Gate*" which is referred as to garden behind the "*Mine".* And the space mine and is fenced in order restrict the cattle pass to the "*Gate"*/garden.

Qacha: - is the second structure of the settlement pattern and it consists each of 3-7 *Qa`es*. The people wholive in each *Qa`es* of a given *Qacha* have kinship relation. The people share the same Grave yard in *Qacha.*

Ollaa: - is the set of 2 up to 5 *Qacha*. Each Qacha in the *Ollaa* consist *Qa'e*. The members of *Ollaa* have the institutions for emergency and saving and social activities such as *Jirte*, for funeral activities *Dee*, for farming and harvesting activities and *Cinaancho*, for house construction etc. The members of the *Ollaa* are also having land for common use/*Danawa* to share *Gudumale*, for cultural place for assembly and various ceremony and festivals, open field usually covered by old aged trees; Ancestors Burial area, known as "Soodda", traditional Market Place and other cultural and social values.

Qammatte: - is the set of the *Ollaa*; the number of *Ollaa* in the *Qammatte* is determined by the clan by the reason of Sidama settle with clan based settlement. Sidama- Hanaafa Cultural Tourist Village is the best place to visit Sidama people settlement pattern.

2.2.4. Education

Education is the most important factor that plays a leading role in Human development. It promotes a productive and informed citizenry and creates opportunities for the socially and economically under privileged section of the society. One of the primary goals of Ethiopia Ministry of Education is promoting primary education in every corner of the country, based on the motto "Education for all". In Ethiopia, basic education is called general education (a total of 12 years: primary 1st cycle (4 years) + primary 2nd cycle (4 years) +general secondary (2 years) + preparatory secondary (2 years)) (UNESCO, 2010). In this report, the term "general education" is used to refer to basic education.

The primary enrollment target set for the ESDP I was surpassed with enrollment reaching 13.5 million in 2005/06 from 8.1 million in 2000/01 (WB, 2008). Over this period, the GER increased from 61.6% to 91.3% and the NER from 52.2% to 77.5% (WB, 2008a). However, access to education opportunities continues to be an obstacle, especially for female and other "most vulnerable children" (rural children, orphans, children in remote locations, and dropouts, etc.), and poor children (GEQIP, 2009). Due to the lack of school facilities, the pupil-section ratio (PSR) has become greater in both primary and secondary education (WB, 2005). Especially, the rapid increase in enrollment in the lower primary education has enlarged the size of a section (WB, 2005). As the barriers of participation, lack of schools in rural areas (MOE, 2010) and financial burden on households paying education expenditures (WB, 2005) are pointed out.

In the Sidama region, the primary enrollment reaching 1.1 million in 2013/14 from 0.948 million in 2006/07 (SREB, 2022). The total number of primary schools were 1,232 among these the total number of primary government schools were (1,041 schools) and Non-government schools were (191 schools). In addition, the total number of secondary schools were 113 among these secondary schools (95 schools) were government and (18 schools) were Non- government schools. In the same way the primary school, the number of secondary schools increased by more than 20% compared to the previous year in 2006/07 and 2013/14. For example, 2006/07 The primary school number were 990 schools and in

2013/14 E.C year reaching 1232 schools .This means increased by more than 24% compared to the previous year in 2006/07 . In year, 2006/07 E.C secondary school number were 61 schools and in 2013/14 E.C reaching 113 secondary schools this means increased by more than 18% compared to the previous year in 2006/07(SREEB, Education Statistics Annual Abstract of each year).

Table 4 Enrollment Trends the government and non-government Primary and secondary school enrolment from 2005-2014 E.C

Primary Gov School Enrolment					
			M	F	T
Primary	Gov	2005	673073	637090	1310163
Primary	Gov	2006	460240	440139	900379
Primary	Gov	2007	520761	490375	1011136
Primary	Gov	2008	570575	531644	1102219
Primary	Gov	2009	558731	520257	1078988
Primary	Gov	2010	537857	516849	1054706
Primary	Gov	2011	506780	491267	998047
Primary	Gov	2012	553376	527419	1080795
Primary	Gov	2013	532272	514400	1046672
Primary	Gov	2014			

Government School Enrolment From 2005- 2014 E.C					
			M	F	T
Secondary	Gov	2005	40818	29996	70814
Secondary	Gov	2006	46682	38235	84917
Secondary	Gov	2007	51115	42038	93153
Secondary	Gov	2008	62788	48030	110818
Secondary	Gov	2009	67653	51376	119029
Secondary	Gov	2010	99200	71880	171080
Secondary	Gov	2011	61732	46316	108048
Secondary	Gov	2012	81040	63737	144777
Secondary	Gov	2013	106026	86589	192615
Secondary	Gov	2014			

Primary Non Gov School Enrolment					
			M	F	T
Primary	Non Gov	2005	10468	10246	20714
Primary	Non Gov	2006	25536	22939	48475
Primary	Non Gov	2007	27527	25171	52698
Primary	Non Gov	2008	26093	23912	50005
Primary	Non Gov	2009	31346	28353	59699
Primary	Non Gov	2010	37380	33578	70958
Primary	Non Gov	2011	30634	27172	57806
Primary	Non Gov	2012	31447	27504	58951
Primary	Non Gov	2013	28846	26302	55148
Primary	Non Gov	2014			0

Non Gov School Enrolment From 2005- 2014					
			M	F	T
Secondary	Non Gov	2005	3612	2920	6532
Secondary	Non Gov	2006	3916	3171	7087
Secondary	Non Gov	2007	4408	3553	7961
Secondary	Non Gov	2008	4556	3857	8413
Secondary	Non Gov	2009	4586	3745	8331
Secondary	Non Gov	2010	5446	4287	9733
Secondary	Non Gov	2011	4650	3795	8445
Secondary	Non Gov	2012	4581	3715	8296
Secondary	Non Gov	2013	4705	4038	8743
Secondary	Non Gov	2014			

Table 5 Ratio of students to teachers, class and textbook

Year		Year Teacher student ratio		Student class ratio		Student book ratio	
		1-8	9-12	1-8	9-12	1-8	9-12
2016	Government	57:1	32:1	65:1	60:1	1:1	-
	Non-government	29:1	30:1	33 :1	49:1	1:1	1:1
2017	Government	53:1	30:1	69 :1	68:1	1:1	1:1
	Non-government	33:1	28:1	39:1	47:1	1:1	1:1
2018	Government	47:1	42:1	67:1	107:1	1:1	1:1
	Non-government	34:1	34:1	45 :1	60:1	1:1	1:1
2019	Government	39:1	26:1	64:1	64:1	1:1	1:1
	Non-government	27:1	29:1	38 :1	46:1	1:1	1:1
2020	Government	40:1	32:1	62:1	78:1	1:1	1:1
	Non-government	27:1	26:1	40:1	51:1	1:2	1:1
2021	Government	31:1	32:1	46:1	48:1	1:3	1:1
	Non-government	26:1	26:1	29 :1	39:1	1:3	1:1

Source; sidama national state education bureau, 2022

Table 5 above indicated that ratio of students to teachers, sections and textbooks between 2016 and 2020 in the region. The national standard for student-teacher ratio is 50:1 for primary and 40:1 for secondary schools. The lower student-teacher ratio the higher the opportunity of contact between the teacher and students, however, very low student-teacher ratio indicates inefficiency of the education system or underutilization of the resources. As indicate above in table, which indicates a very low student-teacher ratio with compared to the standard. This shows underutilization of resources/teachers. And student-section ratio has similar standards with that of student-teacher ratio. Then, in the above table, which shows above the standard. Therefore, a higher student-section ratio indicates overcrowding of class and hence less interaction between students and teachers as well as among students themselves. With regarding to student- textbook ratio, it has 1:1 ratio, the previous years which improves the quality of education. But, in 2020 and 2021, it becomes 1:2 and 1:3 which affects the quality of education.

Textbook of primary education had been developed by experts at the regional level in accordance with the framework approved by the MOE, and textbooks of secondary education had been developed by experts at the federal level. Experts at the regional level added local context or made changes to the national framework, translate them to local languages. Domestic publishers printed and distributed them. Each region had authority of

the selection of publishers (interview with the Curriculum Development and Implementation Directorate of bureau).

2.3. Drivers and Pressures of Social Environment

Social driving forces fulfill human needs for social relations, equity, governance, and cultural identity. Social driving forces broadly capture the suite of social, community, and political characteristics that influence the structure and function of economic sectors, as well as act as key determinants of human health. For example, a lack of equity or repressive governance may influence the ability of economic sectors to function or constrain the ability of individuals to fulfill their basic human needs. Social driving forces include the day-to-day interactions and connections within a community include: religious affiliations, social groups, marriage, and family dynamics. Equity describes the fairness of opportunities in a community, including: access to education, access to health care, access to jobs.

Pressures are defined as human activities, derived from the functioning of social and economic driving forces that induce changes in the environment, or human behaviours that can influence human health. Pressures fall into two classes environmental pressures and human behaviour pressures. On the environmental side, identifying a particular activity as a Pressure implies a causal relationship between that activity and an environmental change. Environmental pressures may include discharges of chemical, physical, or biological agents, land use changes and direct contact uses. The intensity of Environmental Pressures depends on the technology and extent of source activities and can vary across geographic regions and spatial scales. Environmental pressures in the region include land use land cover changes resulting from alterations of the natural landscape, typically associated with population growth. Discharges of pollutants as may result from the operation of industries or vehicles, or the diffuse distribution of contaminants from agricultural lands, roads, or lawns through groundwater or stormwater runoff, including: applied chemicals, use of fertilizers, pesticides, insecticides, and herbicides. Atmospheric discharges which are vehicle and smokestack emissions including greenhouse gas emissions, sulphur and nitrogen oxide emissions, and volatile organic compound emissions. The old vehicles and industries in the region are the major source for the discharge of gases to the atmosphere. Waterborne discharges including

point and non-point source discharges are the wastewater discharges, contaminant discharges, and impervious surface runoff. The sources for waterborne discharges in the region are industries, hospitals, hotels, and different factories.

Human Behavior is an additional class of Pressures that can influence human health independent of environmental pressures, which influence the physical condition of the environment. We specifically define human behaviors, as with all pressures, as human activities that can increase the chances of developing a disease, disability, or syndrome. In some cases, the burden of chronic disease is preventable with modifications of these behaviors. However, social driving forces (e.g., social status, exposure to violence) and economic sectors (e.g., health services, government) can both motivate and constrain human actions (e.g., our ability to consume a healthy diet), and are often beyond, or perceived as beyond, personal control.

2.4. State and Trends of Economic Environment

2.4.1. Livelihood Zones of Sidama Region

Livelihood zone map of the region defines geographic areas of a country where people generally share similar options for obtaining food and income and similar access to markets. An understanding of the spatial livelihood systems is a key component of the region food security analysis. The maps are adapted from famine early warning system network (FEWS NET). The map is produced by considering agro-climatology, elevation, land-cover, market accessibility, sources of food, and major economic activities. A livelihood zone map is typically accompanied by a livelihood description which outlines the key characteristics of each zone. According to FEWS NET category the main crops of the region are Coffee, Chat, Enset, Maize, Wheat, Barley, Teff, Pepper, Pulses, & Sorghum. The livelihood zone names and major crop types of the region are presented in Figure 9 and Table 6.

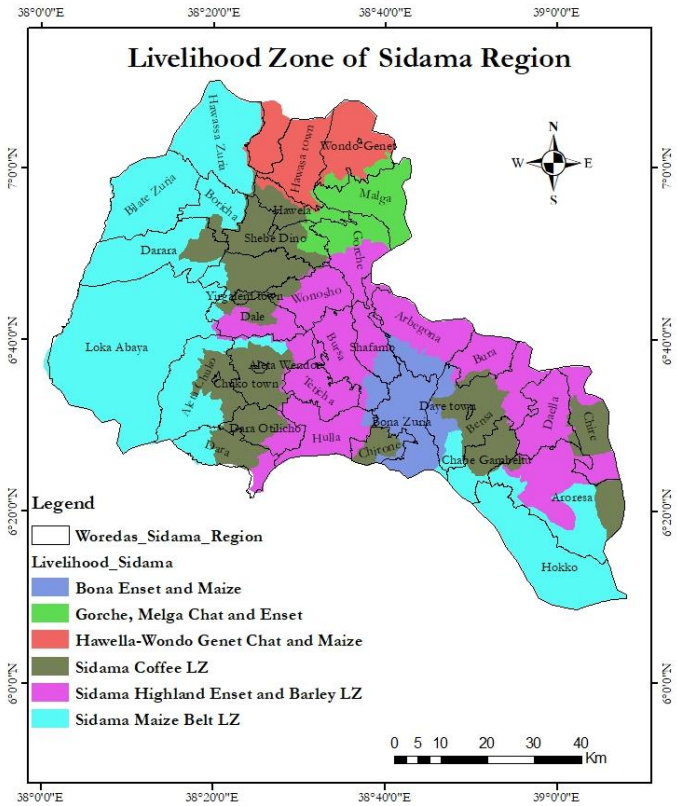

Figure 9 Livelihood of Sidama Regional State

Table 6 Livelihood Zone of Sidama Region

Livelihood Zone Name	**Livelihood zone Type**	**Main Crops**	**Main Livelihood stoke**	**Area (ha)**	**%**
Hawella-Wondo Genet chat and maize	Cropping - Meher Dominant	Chat and Maize	Cattle, Sheep and goats	44875.97	6.65
Sidama Maize Belt Livelihood Zone	Cropping - Belg Dominant	Maize, Teff, Pulses & Sorghum	Cattle, Sheep and goats	259372.97	38.42
Sidama Coffee Livelihood Zone	Cropping - Belg Dominant	Coffee, Enset & Maize	Cattle & Poultry	129648.6	19.2
Sidama Highland Enset and Barley Livelihood Zone	Cropping - Meher Dominant	Enset, Maize, Wheat & Pulses	Cattle, Sheep and goats	166700.6	24.69
Bona Enset and Maize	Cropping - Meher Dominant	Enset and Maize	Cattle, Sheep and goats	39911.99	5.91
Gorche Malga Chat and Enset	Cropping - Meher Dominant	Chat and Enset	Cattle, Sheep and goats	34717.41	5.14

2.4.2. Sidama Coffee Livelihood Zone

This zone covers the midland area of Sidama Region in Woyna Dega agroclimatic zone. This livelihood zone is densely populated part of the region. The land holdings of this zone are skewed heavily to the better-off and middle wealth groups: the better-off 20% of households hold up to eight or ten times as much land as the very poor 15 %, who have just one-quarter of a hectare to cultivate, from which they normally obtain one-quarter of their annual basic food needs. But wealthier households, with larger families, do not grow more than 60% of their food needs because in general people put half or more of their land under coffee. The rest goes to Enset as the main food crop, and small areas of maize, sorghum, fruits like avocados and pineapples. Sugarcane and eucalyptus are also grown for the market. The middle and better-off 60% of households own substantial livestock, including up to 8 cattle, whilst very poor households own no livestock at all, and the poor 25% of households perhaps one cow, exceptionally 2, and not more than one sheep or goat, haricot beans and root crops, and sometimes also fruits like avocados, pineapples. The very poor rely heavily on casual work, paid in cash and kind, to obtain the 75% of their food which they do not grow. Coffee harvesting and processing are labor-intensive, and migrant workers come into the zone seasonally from the highlands of the region. The poor grow somewhat less than half of their food but have a more varied portfolio of income activities, including not only casual labor but sale of coffee, petty trading, and about 20% from livestock and milk/butter, showing the value of even one or two carefully tended animals and their young. Overall, the population is food secure, despite huge income disparities. There was very little relief food aid even in a year such as 2003-4 when both coffee production and coffee prices were low, and maize prices were high due to drought in neighboring areas (Nations S., 2005). The main woredas included in this livelihood belt are Hawela, Shebedino, Dale, Aleta Wondo, Aleta Chuko, Dara, Chire, Bensa, Chirone, Dara Otilcho, and Partly Chabe Gambelito, Aroresa, Boricha, and Darara.

2.4.3. Sidama Maize Belt Livelihood Zone

This zone covers the lowest-lying areas of Sidama Region, with plains and undulating hills ranging between lowland and lower midland altitudes. Growing population pressure on the land, declining soil fertility, and erratic rainfall have made the zone food insecure to the extent that in the reference year the poor and very poor households (together 40% of the total)

covered only 35-45% of their annual basic food requirement with their own produce and have obtained some 21- 25% of their requirement from food aid except Hokko and Aroresa woredas in this belt. The main crop is maize, planted in the belg or spring rainy season; shorter-cycle crops, including sweet potatoes, haricot beans and teff are grown in the summer rainy season, and are particularly concentrated on when the maize crop is unpromising due to poor belg rains. The perennial Enset is a backstop but not at all as important as it is in the higher neighboring areas. Cattle and goats are important assets of the middle and better-off groups and proceeds from sales of animals and their products nearly rival the proceeds from maize and cash crop sales which make up the rest of these groups' income – mainly coffee, chat and chilli peppers. The main highway on the eastern border and internal all-weather link roads give good market access to the towns of the Sidama midland/highland and to Hawassa city. Animal and crop sales together give poor households around 60% of their annual earnings, but the very poor only 20%. Both groups make up the rest of their earnings through casual labor locally for wealthier farmers and through sales of firewood – leading to advancing deforestation along with the expansion of agriculture as the population increases.

2.4.4. Hawella-Wondogenet, Gorche Malga Chat, Enset and Maize Livelihood Zone

Ranging from low to high midlands, with both hilly and flat terrain, this is one of the most densely populated parts of the Region and therefore of all Ethiopia. The zone today lives more by cash crop and livestock sales than by food production, and is relatively wealthy. Better-off, middle and poor households normally purchase about 40%, 50% and 60% respectively of their annual staple food requirements which cannot be met by the stands of enset and plots of maize, haricot beans and Irish potatoes on the very small landholdings. As such it is a food secure zone, and the small amount of food aid is associated with development projects. Chat has overtaken coffee as the primary cash crop, although the latter still makes a significant contribution; eucalyptus poles are a secondary 'crop'. The chat industry is labor intensive in the daily picking, packaging, carrying, assembling and loading onto trucks of this perishable stimulant leaf. Thus it offers the poor substantial employment, whilst casual work and petty trade often associated with the nearby regional capital, Hawassa, bring further cash. This income in turn helps the poor to save enough to invest in some livestock, including one or two cows fed by hand from which they sell milk and butter which alone give them some 15% of annual cash income.

2.4.5. Dependence on Agriculture

The Ethiopian economy is highly dependent on agriculture. Agricultural production plays an important role in the economy. Agriculture accounts for 46.3 percent of the nation's Gross domestic Product (GDP), 83.9% of exports, and 80% of the labour force (FAO, 2004). Many other economic activities depend on agriculture, including marketing, processing, and export of agricultural products. Agriculture has been and will remain the main driver of Ethiopia's economic growth, accounting for almost 40% of GDP and more than 80% of the labor force, and contributing most of the foreign exchange earnings from export of goods regardless of a recent increase in the service and industry sector which contributes 45.8 and 14.2% respectively (FDRE, 2016). Ethiopia's rapid population growth is putting increasing pressure on land resources, expanding environmental degradation, and raising vulnerability to food shortages. It is also affected by climate- induced rainfall variability, low input such as fertilizer, improved seed, pesticide and herbicide use. Agriculture is also the source of livelihood to an overwhelming majority of the Sidama population as its employees more than 80% of the labor force. Nearly 90% of the Sidama live a life centered on agriculture.

The rural Sidama are mostly subsistence agro-pastoral (Asfaw and A˚ gren 2007; CSAE 2013; Hamer 1987). Important staple crops are Enset (the *wesse* plant) or 'they call it false banana' with a strong cultural tradition value for surrounding ownership; and maize and less commonly wheat (Triticum aestivum L.) and barley (Hordeum vulgare L.). Other crops are also grown and cattle are often raised. The major cultivated crops in the region include cereals, pulses, root and tuber crops, vegetables, spices and industrial crops. The major cereal crops include different species of maize, teff, barely, wheat, sorghum, haricot bean etc. Enset, which is the main and preferred food, provides more calories per unit of area than do most cereals (e.g., maize) and is drought resistant; these are important characteristics given increases in population density and the frequency of droughts (Asfaw and A˚ gren 2007). Cash crops include coffee (Coffea arabica L.) and ch'at (khat, Catha edulis Forssk. ex Endl.), a perennial bush chewed as a stimulant.

The total perenial and seasonal crops & cultivated land in agriculture between 2007-2014E.C were 476,911 ha/ . Among those type of Crops & average cultivated land Cane crop /Yeageda Sebil/ cultivated by rain and irrigation season were (67,487), Cereal crop

production (Yebirie Sebil) 43,942.3, Grain crop (Yetiratire Sebil) 54,103.2,Fruit crop (YefirafireSebil) 21,502.5, Horticultural land (rain and irrigation) 55,084.4, Enset land 93,517.4, Root tuber crop land33,162.5, Coffee cultivated land 149,915.7 and Spices cultivated land 6,025.91 as mentioned below in Table 7 (Sidama Region Agriculture and Natural Resource Bureau, 2022).

Table 7 Types of crops and cultivated land per hectare between 2007-2014 E.C year.

Type of Crops & cultivated per hectare	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**average cultivated land in ha**
Yeageda Sebil by rain and irrigation	64,946	65,049	68,232	69,597	62,145	62475	**71927.5**	**75524**	67,487
Cereal crop production (Yebirie Sebil)	42,643.6	43,070	43,501	43,936	44,375	44,819	44,375	44,819	43,942.3
Grain crop (Yetiratire Sebil)	52,710	53,290	53,876	53,876	54,469	55,068	54,469	55,068	54,103.2
Fruit crop (YefirafireSebil)	14,497.3	16,411	18,577	21,029	23,805	26,948	23,805	26,948	21,502.5
Horticultural land (rain and irrigation)	48,566.2	50,606	52,731	54,946	57,254	59,659	57,254	59,659	55,084.4
Enset land	93,237.8	93,331	93,424	93,517	93,611	93,704	93,611	93,704	93,517.4
Root tuber crop land	32964	33,030	33,096	33,162	33,229	33,295	33,229	33,295	33,162.5
Coffee cultivated land	122,684	130,536	138,890	147,779	157,237	167,300	167,400	167,500	149,915.7
Spices cultivated land	4,590.30	4,990	5,424	5,896	6,409	6,966	6,966	6,966	6,025.91
Total	**476839.17**	**476848.2**	**476857.2**	**476866.2**	**476875.2**	**476884.2**	**476893.2**	**476902.2**	**476,911**

Source: Sidama region agricultural bureau, 2022

Perhaps the most important source of income in Sidama national state is Coffee, and "Chat" or khat trees are also a major source of income. The Sidama area is a major contributor to coffee production, producing a high percentage of export coffee for the central government, second only to the Oromia region. Sidama region is the leading coffee producing region in Ethiopia, which contributes greatly to the foreign exchange of the federal government. The Central Statistical Agency (CSA, 2005) reported that 63,562 tons of coffees were produced in Sidama and Gedeo combined in the year ending in 2005, based on inspection records from the Ethiopian Coffee and Tea authority. This represents 63% of the SNNPR's output and 28% of Ethiopia's total output. Coffee productions supplied to central market such as washable coffee 1,9367.4 kuntal, jenfel kishir 2,450 kuntal, selective kishir 390.8 kuntal and tensafafi kishir 1,390 kuntal. Totally, coffee productions supplied to central market from the region was 23,598 kuntal. The Sidama farmers have been affected by hunger caused by declining world market prices for coffee, despite supplying the popular coffee chain Starbucks with the majority of their coffee products from the region (Sidama Region Agriculture and Natural Resource Bureau, 2021).

Ethiopia's livestock population is believed to be the largest in Africa, despite large population size contributed about 12-16% of national GDP, 30-35% of agricultural GDP, 15% of export earnings and 30% of agricultural employment (SNV 2008). Cattle play an important role in Sidama subsistence and risk-coping strategies (Caudell et al. 2015; Hamer 1987). Sidama raise zebu cattle, Bos indicus Linnaeus, primarily for dairy and fertilizer. Sidama also keep small stock and chickens (Gallus gallus domesticus Linnaeus) for consumption and sale (Asfaw and A˚ gren 2007). In general, Sidama favor using the profits from the sale of crops and wage-labor to purchase livestock and for livestock care (Yilma 2001). Beef consumption is rare and is limited to ceremonies (e.g., marriage, funeral) or the natural death of the animal. Sidama people recognize a symbiotic relationship between cattle and Enset. Enset provides fodder for cattle, especially in times of drought when other grasses and grains are not available, and, in turn, cattle provide fertilizer for the Enset. There is a high value attached to livestock by the Sidama, among whom a person without cattle is not regarded as a fully-grown social person, but as an outcast. Cattle numbers are good indicator of wealth, and gives chief popularity for the farmer who owns more cattle.

2.5. Drivers and Pressures of Economic Environment

Economic Driving Forces fulfill human needs for food and raw materials, water, culture, security, health, shelter, and infrastructure. Sidama Region is the region of which the industrial parks development corporation has started work first. The capital of the region is expanding rapidly due to the migration of people from the rural areas and other regions of the country. Residential housing, energy, water, hotels industries, educational sectors and health industries are the requirements for the residents of the city and these are the drivers for economic environment to be changed. In some cases, driving forces may fall into more than one sector (recreational fishing for food and culture). Ambivalent issues should be placed where they will be most relevant to a management issue. The drivers for economic Sectors are the factors which providing food and raw materials and they include: agriculture (croplands, rangelands) fishing (commercial fisheries, artisanal fishing, and recreational fishing) mining and quarrying (coal mining, mineral mining). The Sectors fulfilling human needs for water include: drinking water supply and irrigation. The human needs for Shelter include housing (home construction, real estate, single family and multi-unit housing). The Sectors for fulfilling human needs for health include medical care hospitals and pharmaceuticals. The Sectors fulfilling human needs for culture include: Tourism and recreation recreational fishing and hunting, beaches and natural lands. Education in the region includes primary and secondary education, colleges and universities. Social organizations such as churches, mosques, outreach groups, families are also economic driving forces. Infrastructure sectors provide the physical, organizational, and technical support for the economy to function and include: manufacturing and trade, road transportation, warehousing, construction and building construction.

SECTION THREE

3. ATMOSPHERE

3.1. Climate change

3.1.1. Introduction

Environmental challenges in Ethiopia includes, climate change, land degradation, overgrazing and deforestation, pollution of land, water and air pollution, loss of biodiversity and ecosystem services (Ekbom, 2013). Country's vulnerability to climate variability and climate change is high, due to its economy high dependence on climate sensitive sectors particularly agriculture, pastoralism and natural resources, and relatively low adaptive capacity to deal with these expected changes (Gebremichael, 2009; WBG, 2021). The country is experiencing climate change and its impacts on the environment and natural resources. Frequently experienced climatic extreme events like droughts and floods, in addition to rainfall variability and increasing temperature; disasters and environmental problems associated with climate namely landslide soil erosion and land degradation, deforestation, desertification, and loss of biodiversity and wildlife, pests (locusts) and diseases burdens which contribute to adverse impacts on health, socio-economic activities and environment with multifaceted effects (Edwards, 2010; WBG, 2021; Abrham Belay, 2021).

Climate change refers to a change in state of climate that persists for extended period. It may be due to variations in natural (change of solar cycle, volcanic eruptions) and/or anthropogenic external forcing (forced variability) anthropogenic changes in the composition of atmosphere and land use (IPCC, 2021). Evidence indicates that anthropogenic factors are the major contributors of the currently prevailing global climate change (Gebremichael, 2010; Gebeyehu, 2016). In recent years, our planet has experienced some of the warmest temperatures ever recorded, record-breaking weather extremes, powerful storms, increasing tragic flooding from rising sea levels and associated storm surge, huge wildfires, and continued melting of glaciers and polar sea ice (IPCC, 2021). According to IPCC Reports global warming of 1.5°C above pre-industrial levels and globally averaged precipitation over land increased since 1950, with a faster rate of increase since the 1980 was observed due to human influences which increases greenhouse gases (GHGs). Ethiopia is one of the largest

humanitarian aid beneficiaries in the world and experiences significant climate induced drought and water-related stresses on crop and livestock productivity ***(WFP, Ethiopia Overview, World Food Program, Rome, Italy, 2015).***

An Average temperature has increased by an average of 1°C since1960, at an average rate of 0.25°C per decade; and highly variable rainfall trends across country has been observed in the last three to four decades (WBG, 2021). These changes are recognized to have substantial impact on the environment, natural resource as and various socio-economic sectors, including agriculture, water, health and ecosystem biodiversity which is highly vulnerable to temperature and precipitation changes (IPCC, 2014; Gebeyehu, 2016).

Developing countries like Ethiopia, which has contributed no/little GHGs emissions as compared to developed countries, will be under severe pressure of increased incidences of catastrophic droughts, flooding and disease burdens from the impacts of climate change. They have limited adaptive capacity as compared to the developed countries because of their limited financial resources, high levels of poverty, skills and technologies. Continued climate change is expected to bring greater variability, and extreme weather events (e.g., droughts, floods) which will further drive degradation of the country's ecosystems. Therefore, understanding of the state of the climate (temperature and precipitation), its variability and how it is changing is very important climate information relevance to regions and sectors for adaptation, mitigation impact, and even for better planning and implementation of economic programs in a region.

3.1.2. Climatic Features of Sidama Region

Sidama National Regional State is found in Southern Ethiopia which has a high population density and above 80% of its population are dependent on small-scale, labor-intensive agriculture. It is one of the most climate-vulnerable hotspots underpinned with a very weak adaptive capacity (Bedeke et al., 2018). Sidama has a tropical humid climate modified by altitude with two rainy seasons, Belg and Kiremt local known as "*Hawado*" and" Badheessa", and dry season Bega or "*Arro*" season. The region has three agro-climatic zones; stable, wet and cool highlands **(Dega),** Midland **(Woina Dega)** moist to humid Climate, and low land **(Kolla)** highly variable and semi-arid climate. The amount, duration, and intensity of rainfall

in the region vary considerably, generally decreasing from highland to lowlands (Sidama Finance and Economic Development (SBOFED), 2021). As it has a tropical climate system of Ethiopia, which is dominated by convective rainfall, the states that weather and climate arise from the influence of tropical weather systems, like the Inter-Tropical Convergence Zone (ITCZ), the monsoon, easterly waves, etc., and the quasi- stationary subtropical anticyclones of both northern and southern hemispheres.

3.1.3. State and Trends of climate

Long term (30 years) rainfall, maximum and minimum temperatures were used to characterize the state of climate in Sidama. The details about the geographic location of the meteorological stations are shown in Table1. The analysis of basic climate statistics including mean, standard deviation (STD) Coefficient of Variation (CV%), Standard Anomaly Index (SAI) and trends of rainfall, maximum and minimum temperatures, as well as other space-time climate characteristics that are provided local climate knowledge including those essential for climate change adaptation and mitigation. These climate indices will serve as a source of information for all components of the project as well as the partners and stakeholders.

Table 8 Selected Meteorological Stations for Regional State of Environment.

Station	Lon	Lat	Data
Hawassa	38.48	7.06	1991-2021
Bilate	38.27	6.71	1991-2021
Hagerselam	38.52	6.49	1991-2021
Aleta Wondo	38.42	6.6	1991-2021
Bansa Daye	38.83	6.53	1991-2021
Yirgalem	38.43	6.8	1991-2021
Kebado	38.35	6.43	1991-2021
Arbegona	38.72	6.69	1991-2021

The climate of Sidama is determined by the north and south movement of the inter-Tropical Convergence Zone (ITCZ) and altitudinal variation in the region. The rainfall regimes are identified to be uni-modal pattern, and Kiremt and ***Belg*** rains considered as major contributor moisture (more than 80% of annual rainfall) for the most parts of region. Northern and eastern (the lowland) part region is the hotter and prone to drought.

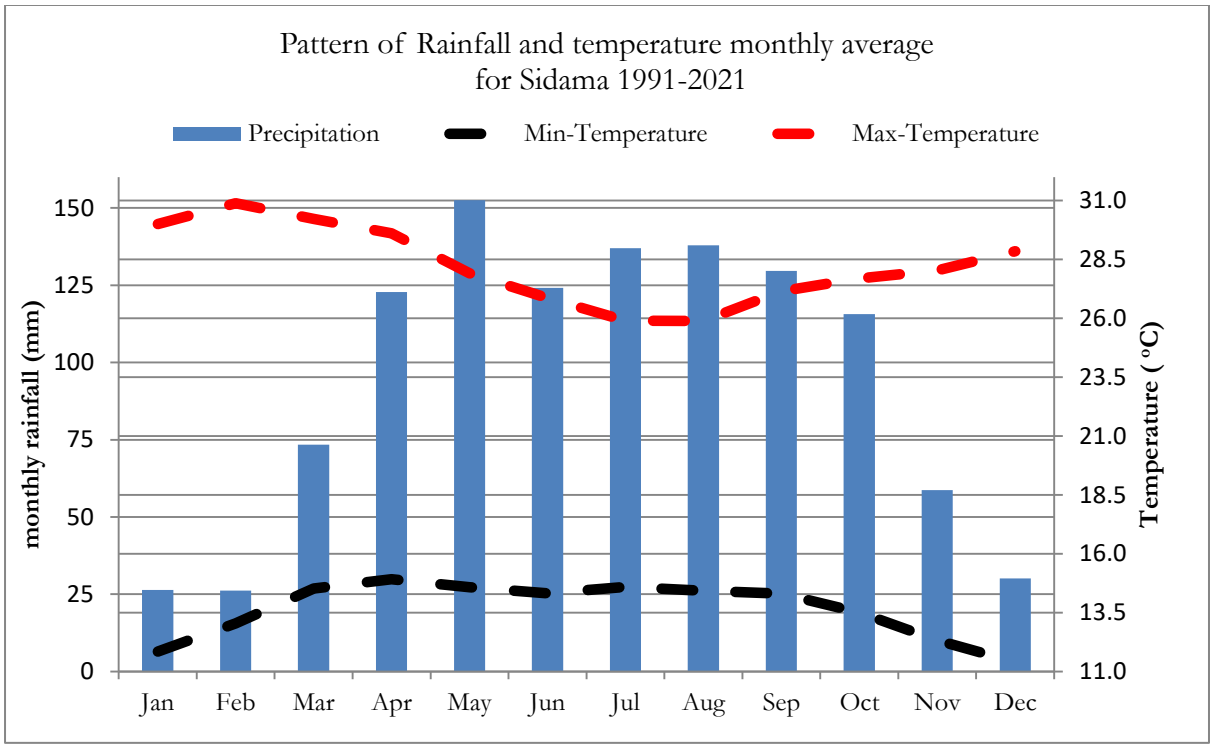

Figure 10 Pattern of Rainfall and temperature monthly average

It was observed that parts of the Sidama region receives mean annual rainfall between 600 to 1600mm/year (Figure 11). The mean annual rainfall is small across northern and western parts in the Sidama lowland areas which is the part of the Great Rift Valley, whereas high amount across the highland (figure 11). (Ethiopian meteorological Institute, SNNPR Meteorological Service Center, 2022).

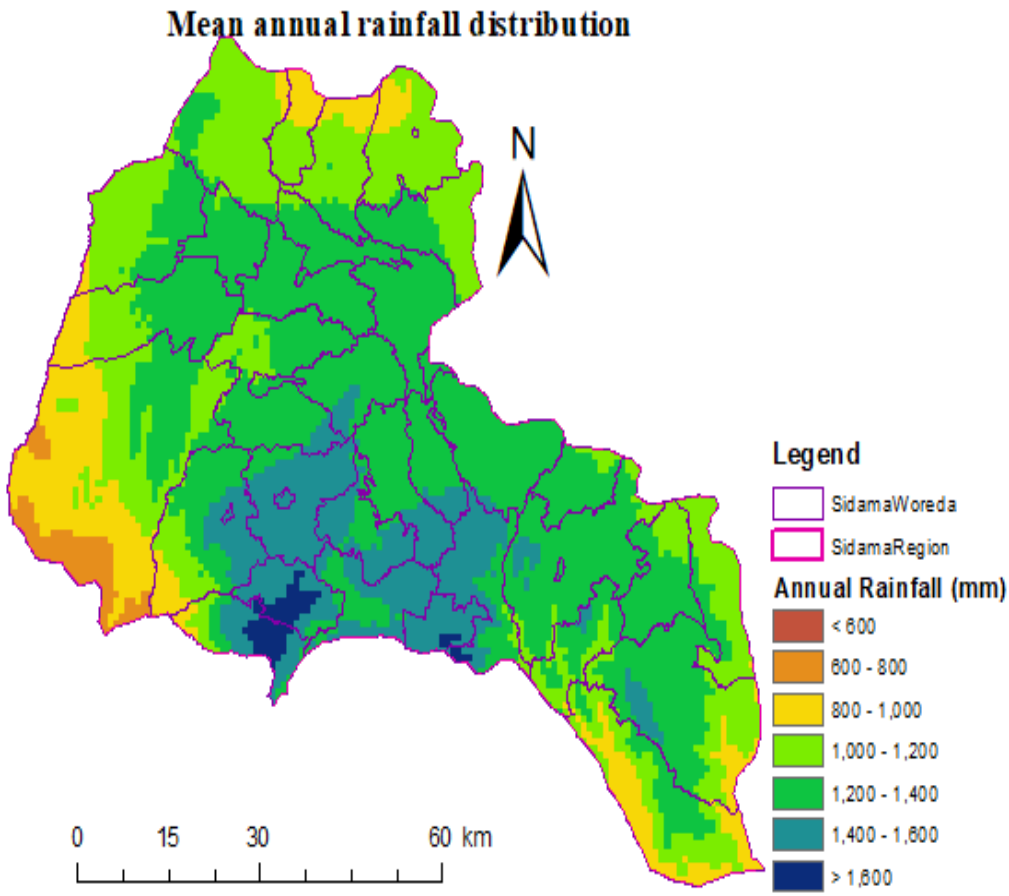

Figure 11 Mean Annual Rainfall Distribution

The data from 1991 to 2021 indicates that there was insignificant increasing, this might be due to variability in the area throughout the analysis period. The mean annual rainfall (1217.4mm/year), Standard deviation (183.4mm) and CV% (15.6%) value. The coefficient of variation showed that rainfall in the region has low inter-annual variability (Table 9). The inter-seasonal rainfall variability for the Belg and Kiremt season was relatively moderate (CV>20%), and moderately to high variable (20.3% < CV > 55.2%) for the Bega season across region. Comparing the seasonal variability, Bega rainfall is the highly variable than the seasonal and annual rainfall in the region.

Table 9 Descriptive statistics of annual and seasonal rainfall from 1991-2021

	Annual			Belg			Kiremt			Bega		
	Mean	STD	CV	Mean	STD	CV	mean	STD	CV	mean	STD	CV
Arbegona	1317.9	131.1	9.9	473.8	78.7	16.6	558.3	80.8	14.5	206.7	75.0	36.3
BensaDaye	1288.5	129.2	10.0	469.6	84.6	18.0	532.3	90.6	17.0	286.5	66.1	23.1
Hawassa	971.0	153.0	15.8	347.1	101.0	29.1	464.2	97.6	21.0	159.7	68.3	42.8
Yirgalem	1195.8	321.9	26.9	451.8	145.1	32.1	492.7	173.2	35.2	251.4	138.6	55.2
Hagerselam	1376.0	146.5	10.6	521.1	99.1	19.0	533.4	92.0	17.2	321.6	65.2	20.3
Kebado	1366.5	240.8	17.6	547.8	164.9	30.1	509.9	126.8	24.9	308.8	97.6	31.6
Bilate	822.8	191.2	23.2	315.3	118.3	37.5	318.4	91.0	28.7	189.1	70.2	37.1

The other climate element that is of significant influence in the areas is temperature. Temperatures are also very much modified by the varied topography. The mean temperatures of the region vary from 11.5^{o}C and 27.5^{o}C. The cooler mean temperature is observed over the highland of Sidama and the hotter occurs over eastern lowland, which is part of the Great Rift Valley (Figure 12).

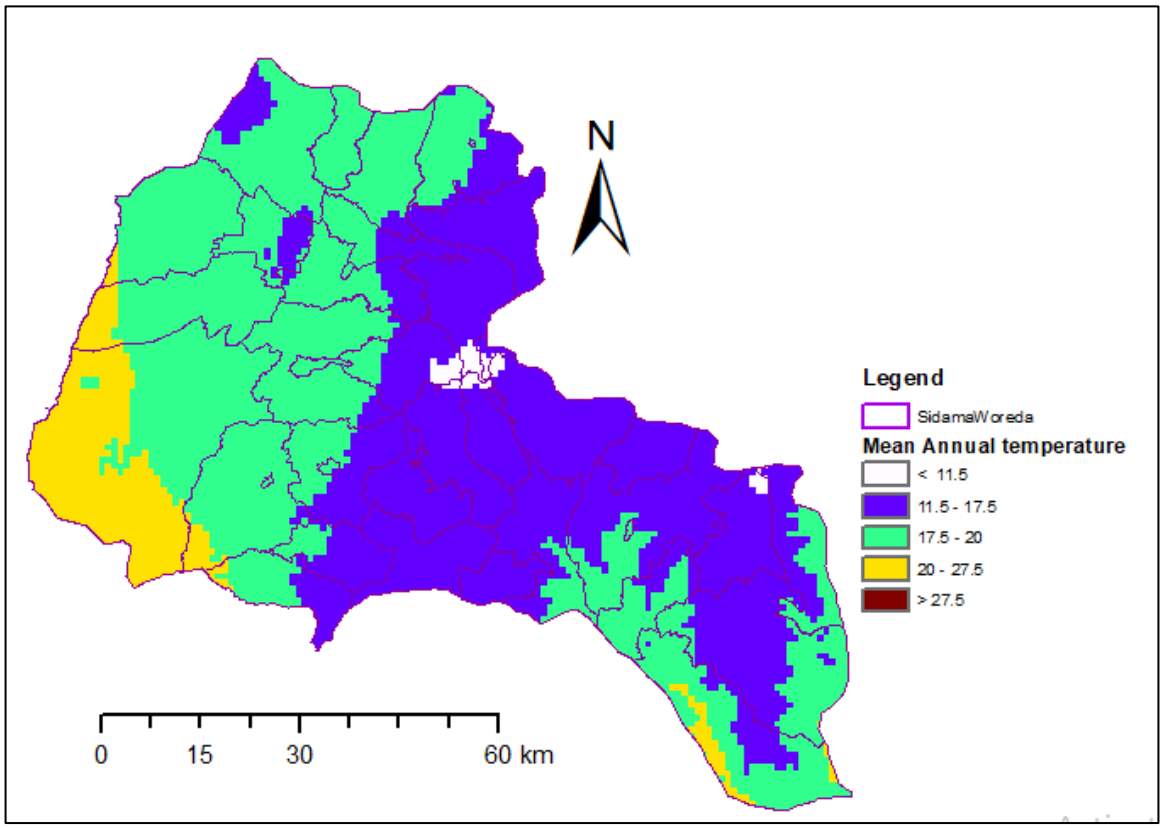

Figure 12 Spatial distribution of mean annual temperature

Observed rainfall anomaly over the past 30 years, Sidama experienced both dry and wet conditions. the frequency of negative anomaly or drought years were high over lowland and midland areas of the region. whereas, the highland area experienced more wet condition as by using rainfall anomaly index (Figures 13). The wet seasons (Belg and Kiremt) rainfall showed increase of positive anomaly for last decade from 1991 to 2021. It is clearly shown in figure that higher negative rainfall anomaly is observed especially after 1991 Elinino event and 2021, which is associated with the strong La Nina with IOD negative event recorded in the region.

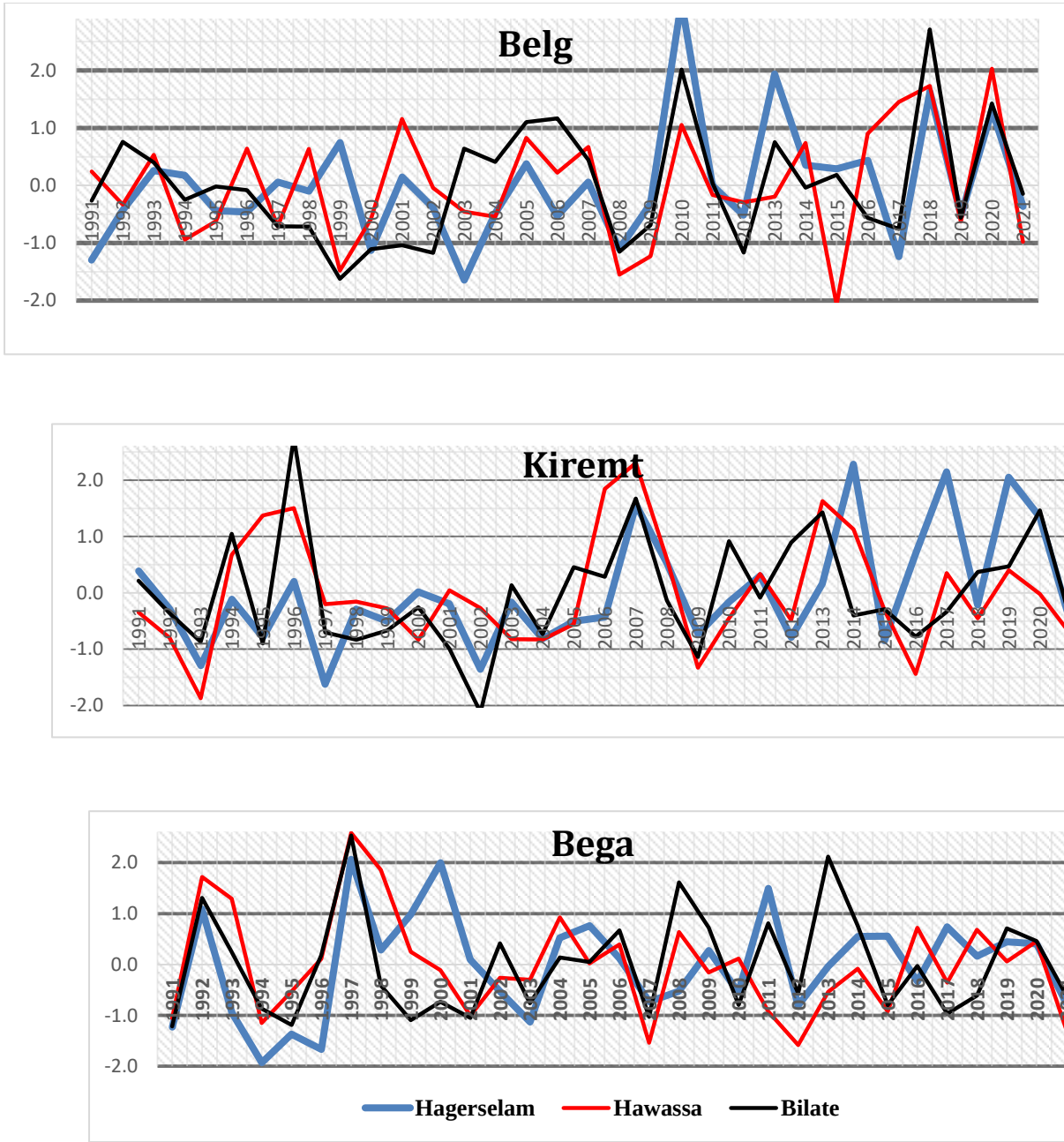

Figure 13 Standard Rainfall Anomaly index (RAI) for the period from 1991-2021.

3.1.4. Rainfall Trends

Strong variability makes long-term precipitation trends for Ethiopia difficult to determine, however an overall decline has been observed in the last three to four decades, with significant year-to-year volatility. While precipitation trends across Ethiopia are highly variable, some areas of the country are expected to experience a reduction in rainfall. For example, the south-central region of the country has experienced a 20% decrease in rainfall since 1960. While high degrees of inter-annual variability exist for precipitation trends across Ethiopia, the incidence of drought increased and the rains in central and northern areas occurring in February to May have become increasingly less predictable. The rise of sea surface temperatures in the Indian Ocean influences the migration of the ITCZ which can further increase variability in the timing and duration of rainfall seasons, altering traditional rainfall patterns and causing more frequent drought (USAID, 2012) . Ethiopia has three rainfall seasons: Bega, Belg, and Kiremt. The primary rainy season, Kiremt, occurs from mid-June to mid-September and accounts for 50–80% of annual rainfall. Sidama found Southern part of Ethiopia experience two distinct wet seasons, Belg, from March to May, and Extended Kiremt occur from June to October, Bega from November to February which has drier and colder climatic conditions over most part of the region. Mean annual rainfall distribution is approximately 1217.4 mm/year.

In case of Sidama the incidence of drought increased and the rains occur over the most areas in March to October have become increasingly less predictable. Rainfall amount has unstable over Sidama, with only a statistically non-significant slight increase. The lowlands, the midland and highlands areas exhibit fluctuating pattern with increasing trends in Belg, Kiremt seasonal and annual rainfall. The lowland areas of Sidama are characterized by a high variability in rainfall and decreasing of rainfall Bega season. In spite of year-to-year variability, statistical insignificant increasing trends were noticed in spatial and temporal scale.

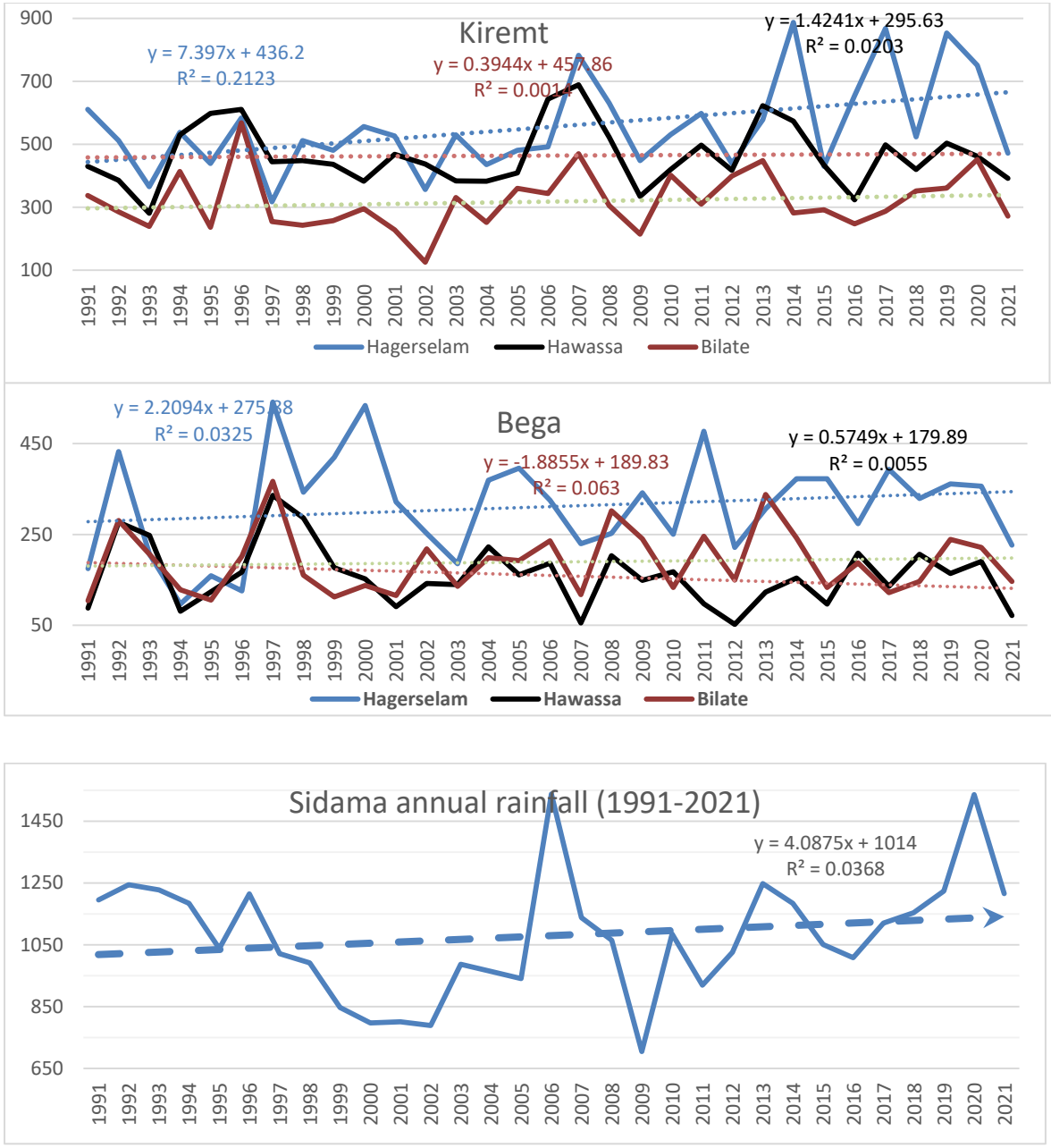

Figure 14 Rainfall trend in Sidama national region from 1991-2021

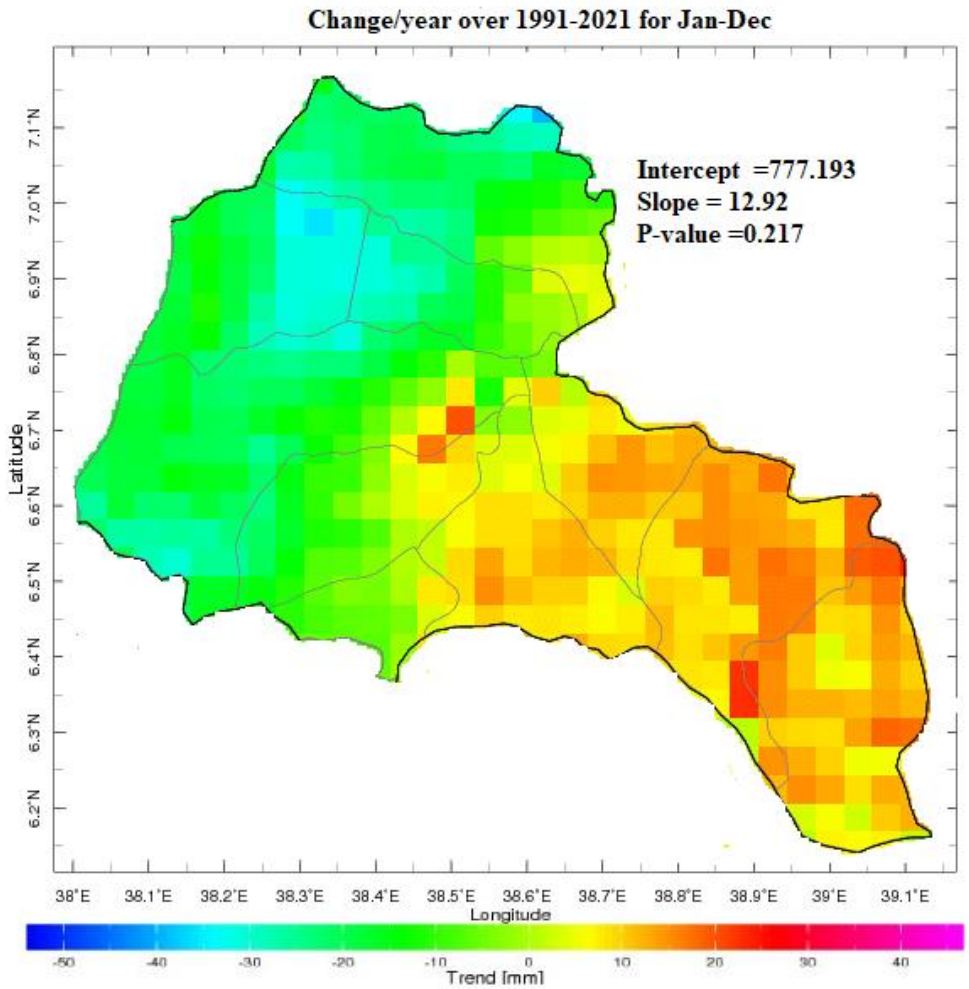

Figure 15 Spatial pattern of rain fall change in Sidama from 1991-2021

3.1.5. Temperature trends

Average temperatures in Ethiopia have increased by an average of 1°C since1960, at an average rate of 0.25°C per decade. Increases have been most noticeable from July through September. The average number of 'hot nights' (the hottest 10% of nights annually) increased by 37.5% between 1960 and 2003 and the average number of 'hot days' per year, increased by 20%; cold days have also decreased. Observed temperature increases have also lead to increased evapotranspiration and reduced soil moisture; higher rates of warming have been observed in the central regions and highland areas (Environment ,Forest and climate change , 2015)

The temperature trend in Sidama indicates an increase of 0.038°C per three decades since the 1991s. The observed temperature increase is proportionate with corresponding increases in the minimum, maximum and mean temperatures (Figures 16). According to NMA (2015) report which is prepared as Climate guideline is to support the decision-making process at farm level over the specified areas around Boricha and Shebedino pilot District and Ayele (2020) also found clearly rising temperature in the Sidama region.

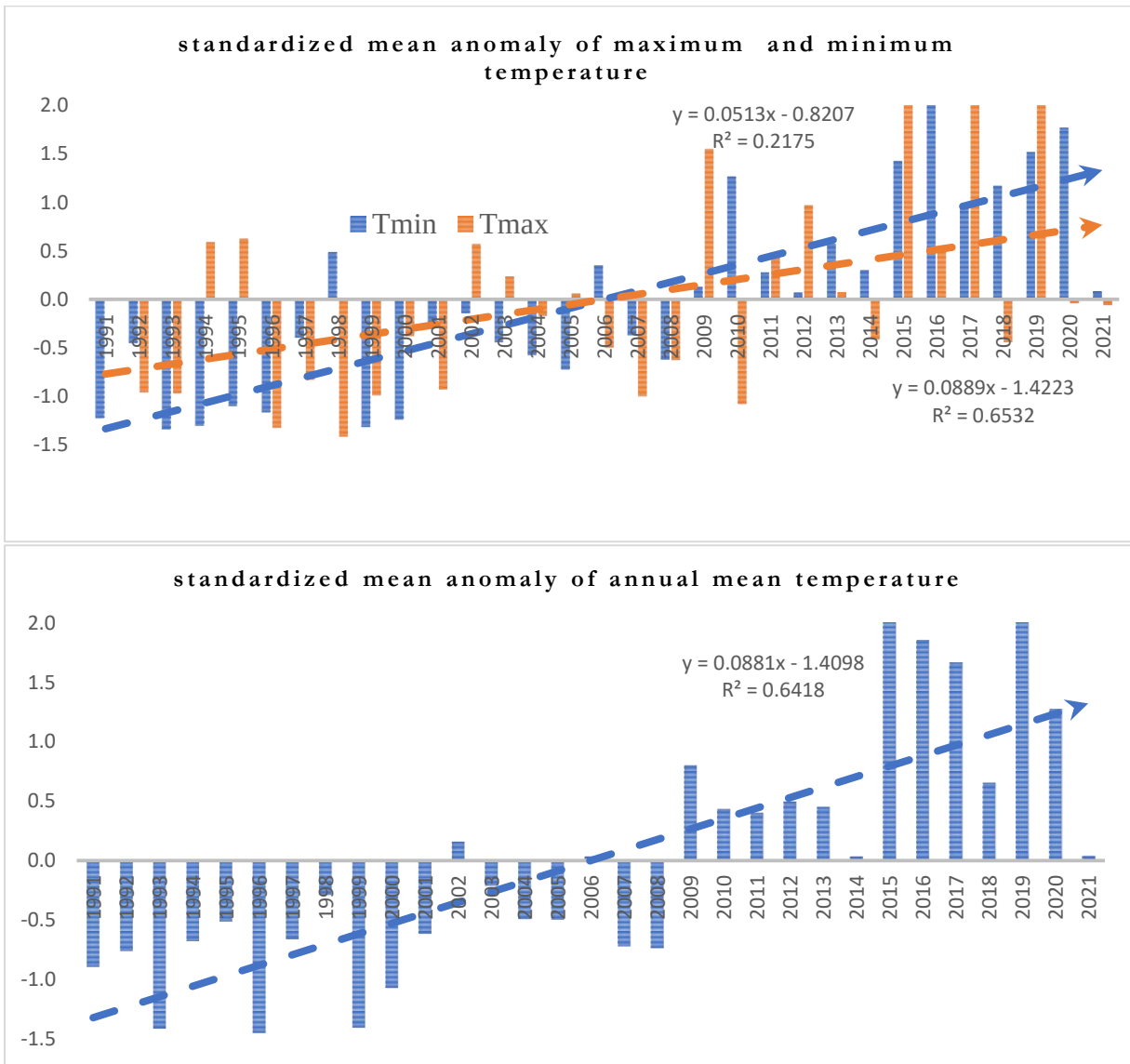

Figure 16 standardized mean anomaly of maximum and minimum temperature

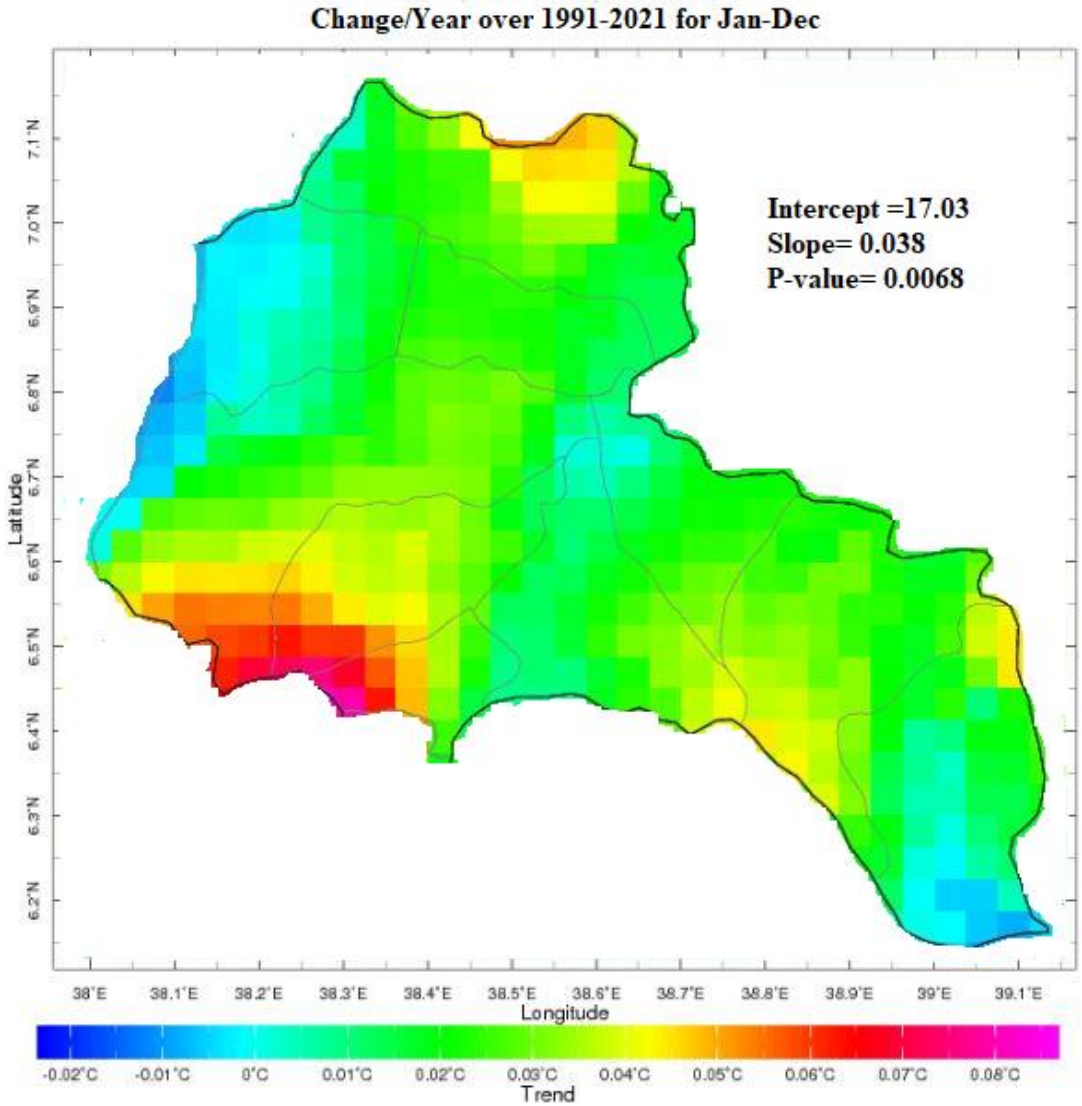

Figure 17 Spatial pattern of temperature change in Sidama from 1991-2021

The analysis of mean temperature over the period of 1973-2021 (Figure 18) showed the shifted towards the warmer ends mean (shifting the bell curve to the right) in the previous consecutive climatological periods (1973-2002, 1981-2010 and 1991-2021) and emergence of category of hot extremes outlier, but a change in the mean doesn't show any change. This shift (change) in normal distribution show consistent warming trends that have impacted livelihood.

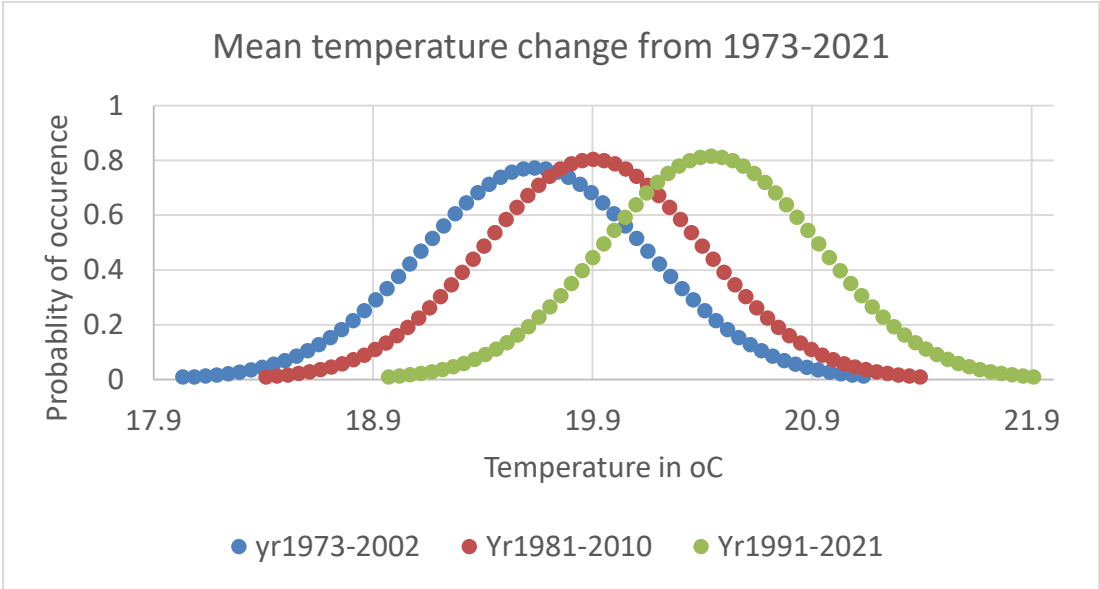

Figure 18 Probability of occurrence (y-axis) of local temperature (Bell curve) anomalies are relative to 1973-2002 1981-2010 and 1991-2021 climatology and standard deviations.

Projected Change in Annual Temperature and Rainfall

The CMIP5 (Coupled Inter-comparison Project No.5) data ensemble, which builds for the Global climate change projections presented in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) is presented at a 1.0º x 1.0º resolution. Four Representative Concentration Pathways (i.e., RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2039. The RCP2.6 represents a very strong mitigation scenario or a low to the RCP8.5 assumes emission scenario. Figure 19 presents the multi-model mean showing the projected changes in annual precipitation and temperature for the periods 2020–2039 Sidama region (6.05-7.10N, 38.0-39.10E) with respect to base time 1986-2005 AR5 CMIP5 subset.

Annual average precipitation is relatively low, but is expected to slightly increase by the end of the century, under a high emissions scenario of RCP8.5. An increased temperatures are expected for Sidama, with mean annual temperature changes expected to increase by 0.8 to 1.3°C by the 2039s under a low to high-emission scenario. Temperature increases are also expected to result in more intense heat, the frequency of 'hot' days and nights and higher rates of evapotranspiration, which expected to increase the frequency and intensity of extreme

droughts and floods, the region is likely to experience negative impacts on agriculture, health, water resources, ecosystems and livelihoods of communities in Sidama region.

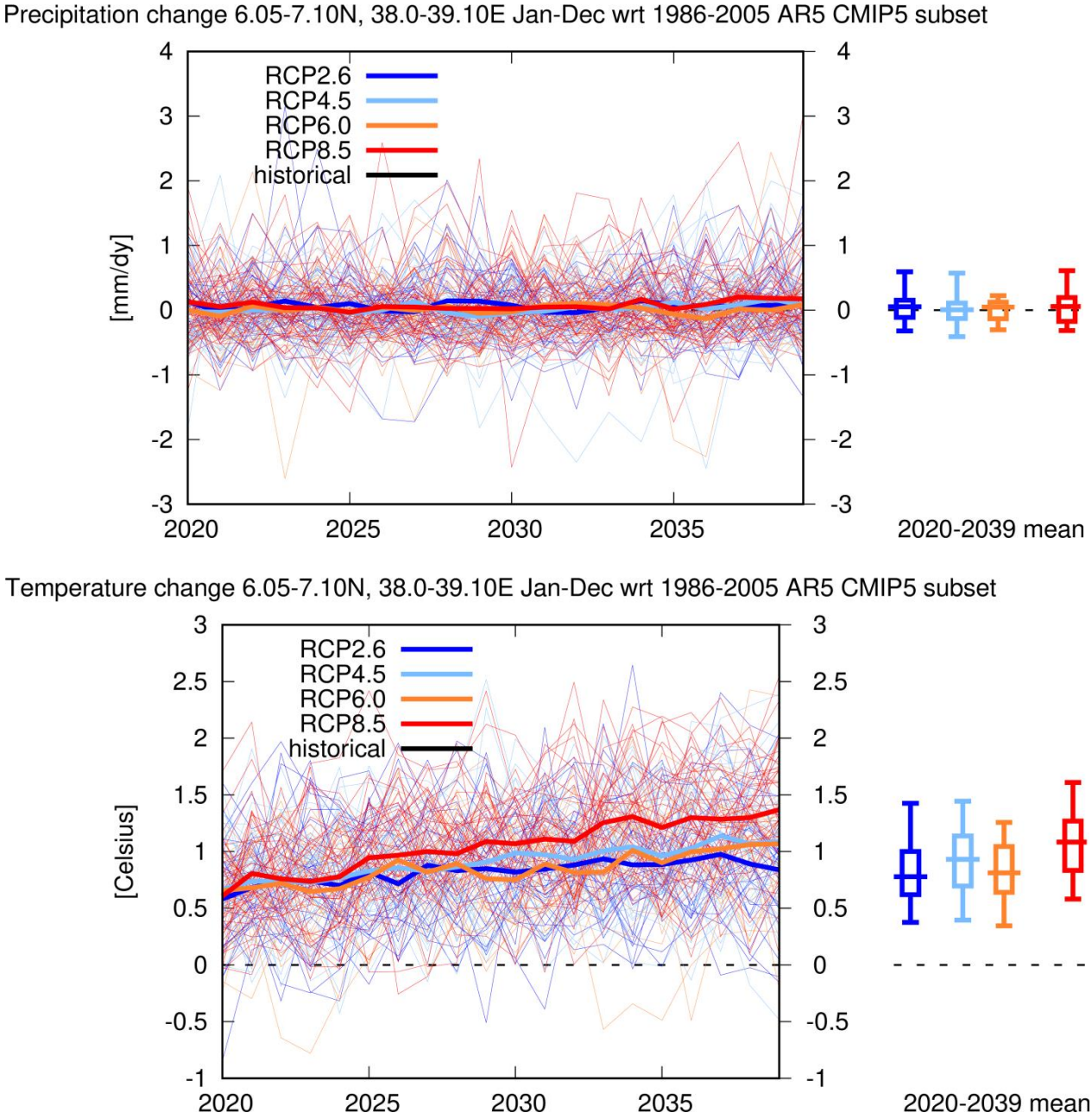

Figure 19 presents the multi-model Mean for Sidama (6.05-7.10N, 38.0-39.) 10E Annual (Jan-Dec) wrt 1986-2005 AR5 CMIP5 subset showing the projected changes in annual precipitation and temperature for the periods 2020–2039

On the left, for each scenario one line per model is shown plus the multi-model mean, on the right percentiles of the whole dataset: the box extends from 25% to 75%, the whiskers from 5% to 95% and the horizontal line denotes the median (50%).

3.1.6. Driving Forces and Pressure

The planet's climate has constantly been changing over geological time, with significant fluctuations of global average temperatures. Climate change involves not only rising temperatures, but also extreme weather events, rising sea levels, shifting wildlife populations and habitats, and a range of other impacts. The unprecedented acceleration of climate change over the last 50 years and the increasing confidence in global climate models add to the compelling evidence that climate is being affected by greenhouse gas (GHG) emissions from human activities (Center for Sustainable Systems, 2021). Social, demographic and economic developments exert pressure on the environment. The issues of development and sustainable livelihoods have been identified as the most important basis of many pressures on the environment creating an un-sustainable state of the environment. The most environmental problems in Ethiopia include, climate change, land degradation, overgrazing and deforestation, indoor air pollution and water pollution. Other, important environmental problems include loss of biodiversity and ecosystem services, spread of invasive alien species, urban outdoor air pollution (mainly in Addis Ababa), and toxic household wastes (Ekbom, 2013). According to assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007), it is clear that global warming is mostly due to man-made emissions of greenhouse gases (mostly CO2). The main drivers of climate change include high population growth, high urbanization rate, and overexploitation of land resources including forests, as well as an economic growth that is largely driven by needs for agricultural production, infrastructure expansion and increasing energy demand.

In general, it is known that greenhouse gases, aerosol emissions and land use affect climate. Overall, human activity is warming the planet. Climate change can affect earth's climate system in lots of different ways: Changes in the hydrological cycle, Warmer land, air, Warming oceans, Melting sea ice and glaciers, Rising sea levels, Ocean acidification, Global greening, Changes in ocean currents, More extreme weather, these and other indicators of climate change.

Climate change will have wide-ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. Changes in rainfall pattern, failure of rains or occurrence of successive dry spells in rainy season and rising temperatures will cause shifts in crop growing seasons which affects food security and water scarcity, Increases the risk of natural disasters (floods and droughts), and changes in the distribution of disease vectors putting more people at risk from diseases such as malaria will be exacerbated by low adaptive capacity to both climate variability and climate change and developmental challenges.

Climate change is already causing loss of life, damaging property and affecting livelihoods in Sidama region, in drought reason in 13 woredas like (lokka abbaya፣ Aleta Chuko፣ Wondo genet፣ Shebedino፣ Tula sub city፣ Hawela፣ Hoko፣ Hara፣ Chabe ganbeltu፣ Dale፣ Bilate zuriya and Hawassa zuriya Woredas) in188 kebeles 23,456 hectares of crops of maize and haricot bean were damaged and 70,477 (male,62,417 and female 8,060) people were affected by the cause of drought. In the region 153,159 people supported by productive seft net program (targeted clients number according to caseload allocation PSNP-5) in 2014 in 20 woredas due to food insecurity cause. Those woredas are (Aletawondo, Aleta chuko, Aroresa, Bensa, Bilate zurya, Bona zurya, Boricha, Chebe gab, Chirone, Dale, Dara, Dara Otilcho, Derara, Hawela, Hawassa zurya, Hoko, Hulla, Loka Abaya, Shebedino and Tulla S/city and and it is expected to continue to do so in the future (Sidama Agricultural office 2014 E.C data).

Figure 20 Disaster Risk Management report of Hoko woreda in Sidama region in 2013/14 E.C

Table 10 Crop production, production loss in quintal and food insecured peoples by the cause of drought in 2013/14 data of Sidama Agricultural office

S.no	woredas	Affected kebeles	Crops and cultivated land in ha			Production per kuntal			Affected land per hectare				Production loss /kuntal			Participant/affected people		
			maize	Haricot bean	total	maize	Haricot bean	total	maize	Haricot bean	total	%	maize	Haricot bean	total	male	female	total
1	lokka	21	4,318	1,986	6,304	200,787	29,794	230,581	2,865	1,331	4,197	67	133,246	19,965	153,211	7,586	2,206	9,792
2	cabbe	6	1,620	1,160	2,708	75,330	17,400	92,730	1,475	1,130	2,605	96	68,588	16,950	85,538	8,341	1,010	9,351
3	hoko	13	4,608	120	4,728	214,272	1,800	216,072	3,527	118	3,645	77	164,022	1,766	165,788	5,555	293	5,848
4	A/cu	24	2,418	917	3,335	112,414	13,755	126,169	1,620	881	3,174	70	75,330	13,217	88,547	15,230	1,004	16,234
5	Hazuriya	15	6,812	54	6,866	316,758	810	317,568	974	58	933	14	45,268	870	46,138	2,578	239	2,817
6	dararа	14	2,714	489	3,203	102,649	5,715	108,364	1,386	255	1,304	41	51,104	3,068	54,171	373	51	424
7	dara	13	904	78	982	45,663	1,092	46,755	673	70	743	76	31,295	980	32,275	1,637	222	1,859
8	H/zuriya	12	3,743	321	4,064	174,050	4,494	178,544	1,239	235	1,473	36	57,590	3,283	60,873	4,019	499	4,518
9	bensa	10	1,306	212	1,518	60,729	2,968	63,697	971	192	1,163	77	45,152	2,688	47,840	4,351	334	4,685
10	B/zuriya	16	2,076	1,974	4,050	96,534	27,636	124,170	1,447	845	2,291	65	67,274	11,823	79,079	6,039	1,339	7,378
11	dale	19	1,031	836	1,866	47,941	11,704	59,645	385	636	1,021	55	17,910	8,903	26,813	3,786	221	4,007
12	boricha	13	2,400	371	2,771	111,600	5,194	116,794	328	142	469	17	15,243	1,981	17,224	1,364	180	1,544
13	tula	12	1853	0	1,853	86,164.5	0	86,164.5	311	0	311	16	14,461	0	14,461	**1558**	**462**	**2018**
	total	188	35,803	8,518	44,248	1,359,141	374,860	1,734,001	17,563	5,893	23,456	53	816,679	82,502	899,181	**62,417**	**8,060**	**70,477**

However, the impact will be higher on low-income countries, such as Ethiopia, which have limited capacity to cope with the effects of a changing climate impacts on human health, the environment, agriculture, water supply, sanitation and socio-economic activities. Within the same framework, Sidama region have been experiencing climate change. In the last decade, average temperature of the SNNPR region had risen by 0.4 0c (NREPA, 2012) above the national 0.37 0c (NMA, 2007). This shows the seriousness of the problem in the region. (NREPA, 2012).

3.1.7. Impacts of climate change

Climate change is altering temperature, precipitation, and sea levels, and will adversely impact human and natural systems, including water resources, agriculture and food security, human settlements and health, ecosystems, and biodiversity (Center for Sustainable Systems, 2021). It is considered one of the biggest challenges of the 21st century, globally impacting people's lives (Bedeke, 2018). Its' severity is high in Africa, whose main economic activities largely depend on climate-sensitive sectors. Climate change impacts all economic sectors, with agriculture being one of the most sensitive and intrinsically vulnerable (Pagabeleguem et al, 2016). In Ethiopia, the impact of climate change on the socio-economic fabric of society is tremendous (Auci et.al , 2018).

The southern parts of Ethiopia are most vulnerable, with significant rainfall variability and change resulting in prolonged drought and flood occurrences (Belay et al., 2021). Sidama's rural livelihoods are at risk due to several factors, an important one being adverse impacts of the ongoing climate change. By most measures, exposure and sensitivity are high and adaptive capacity is low in region. The most severely affected areas in the region are, semi-arid lowland areas, where known as maize and Coffee belt livelihood zones such as Boricha, Loka Abaya, Bilate zuria, Belela, Hawassa Zuria districts (Hameso S. Y., 2015). These areas experiencing higher temperature, frequent dry spell, late onset and receive less Belg rainfall in amount causing decreases in agricultural production leads to chronic food insecurity problems worsen by low resilient capacity of communities (SNRS, 2021).

The same areas have been subject to several interventions including the PSNP or Safety Net programs whose results have yet to be proven from sustainable development point of view. Rural residents account for over 94% of the population. Recent research involving 1094 households from highland and midland ecological zones, showed that about 75% respondents reported to be moderately and severely food insecure (Regassa and Stucker, 2011). The region is also prone flood, particularly during the Belg (in April and May) and during kiremt rainy season (in August – October), due to heavy rain causes flash flooding, rainfall-triggered landslides surface flooding (Chire), surface flooding due to poor drainage systems (Hawassaa),

Riverine floods due to overflow and expansion of lakes (Hawassa and Abaya/Loka Abaya). In April 2013, heavy rainfall in the midland and highland areas caused localized flooding in Lokka Abaya as the Bilaate River overflowed. This has affected more than 3,500 people leading to livestock deaths, damaged houses and infrastructure, as well as damage to over 600 hectares of crops in Sidama and its surrounding areas (WFP, 2013).

In general, rainfall variability, drought, flood, landslides, food insecurity and scarcity water availability, and the spread of malaria and other diseases related to climate are the major climate related hazards in region. Recurrent drought events in the past resulted in displacement of large populations, loss of lives and damages to property. Floods are also recurrent in parts of the country and cause loss of lives and property; For example

- In 2006 G.C, 19,087.35 ha of cultivated land affected by drought
- In 2013 G.C, 5,822 hectare of land affected by flood and landslides
- In 2019 G.C, 6,589 number of people were affected and 172 died by COVID-19
- In 2022 G.C, 23,456 ha of land and 70,477 people affected by drought

The social, economic, and environmental costs of droughts and floods as the extreme climate events have always been immense. The major areas of concern for region are human health, agriculture, food security, water resources and infrastructure.

Impact on Human health

Climate change has a wide range of impacts on human health, direct and indirect. The existing evidence on the impacts of climate change on health in terms of direct impact; mortality, injury and displacement (from natural hazards floods and droughts), and indirectly mediated through the environment via increases the incidence of vector and waterborne infectious diseases (for instance, occurrence of malaria cholera, diarrhea), reduced food and water availability translating into malnutrition and increases in severity of infectious diseases among vulnerable groups. It is worth noting that climate sensitive diseases like malaria, onchocerciasis and schistosomiasis, are already common in the region, a situation expected to worsen with climate change.

SNRS RDRMC EPRP report 2020 shows that By cause of climate change **Cholera** causes Potential Humanitarian Consequences are Life loss, Increased disease burden, decreased productive labor force and productivity, School dropout e.g. Dara, Loka Abaya, Wendo Genet, Hawassa city and Boricha and **Measles cause** Life loss, increased disease burden, decreased productive labor force and productivity and School dropout in Boricha, Loka Abaya and Hawassa city (RDRMC), 2020).

Table 11 The number of woreda attacked by different type of disease in each year within the last 5- 10 years

Situations requiring Extraordinary action	Geographical location	Potential Humanitarian Consequences
Measles	**10 woredas:** Dara, Loka Abaya, Wendo Genet, Hawassa city,darara,bilate zuriya,hawassa zuriya,chuko woreda, Hoko and Boricha	Life loss, increased disease burden, Decreased productive labor force and productivity, School dropout.
Cholera	**6 woredas** : Dara, Loka Abaya, Wendo Genet, darara, bilate zuriya, hawassa zuriya, Hoko and Boricha	Life loss, Increased disease burden, Decreased productive labour force and productivity, School dropout
Malaria	**8woredas:** Dara, Loka Abaya, Wendo Genet, Hawassa city,darara, bilate zuriya, hawassa zuriya,, Hoko, Bensa, Bona and Boricha	Life loss increased burden, decreased productive labor force and productivity, School dropout
Livestock Disease (vector borne diseases mainly trypanosomosis)	**7 woredas:** Dara, Loka Abaya, darara, bilate zuriya, hawassa zuriya, Hoko and Boricha	Lower livestock production and productivity, mortality, reduced food and income sources, malnutrition, Displacement of people, School dropout
Crop pest & Disease	**10 woredas:** Dara, Loka Abaya, Wendo Genet, Hawassa city, darara, bilate zuriya, hawassa zuriya, chuko woreda, Hoko and Boricha	Lower crop production and productivity, Shortage of food at household level, reduced food and income sources, malnutrition, School dropout
Corona Virus/COVID19	**All woredas of the región**	Mortality, morbidity, socio economic crisis

SNRS Disaster Risk Management Commission (RDRMC),2022

Impact on Agriculture and Food Security

Ethiopia's agriculture is heavily dependent on natural rainfall and is dominated by small-scale subsistence farmers, with irrigation agriculture accounting for less than 1 % of the total cultivated land it is the most vulnerable sector to the impacts of climate change ((WBG), 2021). Climate change may affect agricultural productivity, and consequently, nutrition and health. Rising temperatures, shifting and shortening of crop growing/Belg season, increased intensity and frequency of extremes (drought and flood) can affect food security through direct impacts on agricultural productions (e.g., causes widespread crop failure and changes in the quantity and quality of livestock feed and forage), and through indirect impacts on livelihoods and income that in turn have consequences for food insecurity) (IFPRI, 2019) .

Increased heavy rainfall as a result of climate change can cause soil erosion, crop damage and waterlogging, which makes the land difficult or impossible to cultivate for agriculture. Climate-related diseases such as malaria and tsetse flies highly impact both human and animal well-being (Parham et al. 2015. Thus, temperature, the amount and temporal distribution of rainfall and other climatic factors during the growing season are key determinants to the crop yields and, in turn, food shortages, malnutrition and famine including Sidama region due to the impacts of climate change (MoFED, 2006). Agriculture is the source of livelihood to an overwhelming majority of the Sidama population as its employees more than 80% of the labor force. These include, shortened growing period, increased water stress, increased loss of soils and plant nutrients, increased scarcity of livestock feed and water, increased 'heat load' on livestock, and flood damages on crops, grazing resources in some areas. Hence the poor, and vulnerable, especially women and children will be severely affected.

In addition to the direct effects on agricultural production and supply, climate change will also affect the demand side. With local production declining, income opportunities and purchasing power will decrease. At the same time, decrease in production and increased demand will lead to price increases for the most important food crops like cereals, negatively affecting food and nutrition security of the poor. Climate-related disasters (eg: flood and drought) have the potential to destroy crops, critical infrastructure, and key community assets therefore deteriorating livelihoods and exacerbating poverty in Boricha, Hawassa Zuriya, Bilate Zuriya,

Lokka Abaya, Darara, Shebedino, Alata Chuko, Dara, Aroreesa and Hoko Girja. According Sidama Region Agriculture And Natural Resource Management Bureau report (SRADBR, 2021), insect pest and weed infestation occur due to climate change particularly drought and they reflect that before this time the temperature was normal but now a day temperature increase from time to time and become cause for insect pest and weed infestation which leads to degradation of productivity (Table 12).

Table 12 Seasonal crops and affected land by climate change in the region per hectare between 2006/07-2014 E.C.

Types of seasonal crops & affected land	**Year/ha**							
	2006/07	2008	2009	2010	2011	2012	2013	2014
Maize, Harcoit Bean, Teff & Potato	19,087.3	5,822	--	13,210	13,200.7	4,269.5	23,456	23,456

Figure 21 Sidama Region Agriculture and Natural Resource Management Bureau Report,2021

Impact on Ecosystems, Land use and Land cover change

Climate change is likely to cause significant adverse impacts in all five of the major ecosystems in the region; i.e. (i) forest, (ii) dry lands, (ii) wetlands and (iv) agro-biodiversity ecosystems. The experienced and projected impacts shift in geographical ranges of some native plants and animals, change of crop growing period, changes in timing of life cycle events of some plants and animals, spread of invasive species, pest and diseases, and declines in species, populations and genetic resources as well as extinction or loss of biodiversity resources. According to Plan and Development Bureau of the Region, from the total area, forest covered 11%, and 17.5% in 2007 and 2013, respectively. The proportion of the total area of the region was covered by grazing land (7.4%) and 6.5% in 2007 and 2013 respectively and uncultivated land (1.6%) and (1.2%) in 2007 and 2013, respectively while woodland and shrub land 3% and 2.6% in 2007 and 2013, respectively and annual cropland took the largest share of the total land in 2013. of the total area of the region.

Annual cropland accounted for 25.1% and 27.6% of the total area in 2007 and 2013, respectively. However, it showed a significant increment to 2.5% of the total area of the region in the year 2013. The area coverage of perennial cropland has shown an increasing between 2007 and 2013. It covered 43.6% in 2007, and 47.4% in 2013. This shows that the percentage shares of uncultivated land declined from 1.6% in 2007 to 1.2% in 2013. On the contrary, a decrease of unproductive land from 1% in 2007 to 0.9% in 2013 was observed. The area covered by cropland was increased by 17411.3 hectares between 2007 and 2013. Climate and land use/cover change have strong interconnection and the concurrent mutual influence on each other. Research findings indicate that Land use/cover changes are mainly caused by human activities such as overgrazing, expansion of built-up, deforestation and conversion of land use/cover to agriculture is a crucial driver of climate change.

The cumulative effect of these multidimensional impacts of climate change is loss of ecosystem services and functions, which are vitally important for human wellbeing. According to Plan and Development Bureau of the Region, from the total area, forest covered 11%, and 17.5% in 2007 and 2013, respectively. The proportion of the total area of the region was covered by grazing land (7.4%) and 6.5% in 2007 and 2013 respectively and

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The cumulative effect of these multidimensional impacts of climate change is loss of ecosystem services and functions, which are vitally important for human wellbeing.

Figure 22 Land degradation in Boricha (Hameso, 2012).

Impact on Infrastructure

Extreme events such as floods and heavy rains that are becoming more frequent can cause destruction of infrastructure such as water supply lines, and roads and bridges. This will have an extra burden in terms of additional infrastructure maintenance costs. An example is the floods of 2020 in Hawassa Lake and Abaya Lake (around Loka Abaya) destroyed roads and home, and the displaced many caused loss of residential property.

Social dimensions of climate change impacts

Climate change affects different economic, social and age groups differently. The poor, women, children, and older people are particularly vulnerable. The poor in both rural and urban areas of Sidama national region possess fewer resources, including information and decision-making authority, to cope with climate change shocks and stresses. Women are

disproportionately vulnerable to climate change compared to men, because of existing gender inequalities. Gender inequalities mean that women and men have differing roles, resources, rights, knowledge, and time with which to cope with climate change.

Women's status is generally low and women are at a disproportionate at risk from environmental degradation, conflicts, and natural disasters, due to gender roles, and historic, cultural and socio-economic reasons. Despite legislation to protect their land rights women often have insecure access to land and their land ownership is secondary (through their relationships to men). Traditionally, land is transferred to men, but land certification in both women's and men's names have increased which has given women a somewhat better negotiating status within the households.

Children constitute another large group who are most vulnerable to climate change impacts in region. Children face multiple threats from climate change, including direct impacts from increasingly frequent and intense climate related disasters, increased incidence of water borne diseases, poor sanitation, declining nutrition, increasingly fragile livelihoods, and additional burdens on their families. Through such multiple impacts, climate change could affect children's mental capacity, learning, and growth. Violence against children, as well as women, including sexual abuse, trafficking and early marriage generally increase when families are under economic pressure, hence a likely indirect impact of climate change on children, girls and women. There is very little research evidence on climate change impacts on the elderly in region. However, it is obvious that older people will be more affected than youth by climate change impacts because of their greater physical weakness and associated decline in incomes that can be common in old age. Reduced mobility, changes in physiology, and more limited access to resources all undermine the adaptive capacity of elderly, including greater susceptibility to climate-sensitive diseases that may increase in incidence and range.

Impacts on poverty

Many are poor but according to the MDG progress report of 2010, Ethiopia is on its way to achieve the targets of halving poverty by 2015. Around 29% of the population live in extreme poverty However, even though the MDG1 target would be reached 2015, still over 20% of the Ethiopian population, almost 20 million people will live in poverty and hunger.

Furthermore, despite the progress of reducing poverty in Ethiopia during the last years, poverty is still widespread and inequality remains high. Income inequality has risen in both rural and urban areas but is more evident in urban areas.

In Sidama region drought impacts Potential Humanitarian Consequences like Poor harvest, shortage of food, higher level of malnutrition, Higher staple food prices, Morbidity and mortality, School dropout, outward migration and other negative coping mechanisms, Poor livestock body condition & productivity, livestock death of livestock and loss of income from Agriculture labor are serious challenges for five woredas such as Hawassa Zuriya, bilate zuriya , darara, Boricha, and Loka Abaya. In addition to this **Flood and land slide causes Displacement**, Loss of life and properties, Disease outbreak including livestock disease, Damage to natural resources, Shortage of food and increased level of malnutrition, Interruption of schooling, damage to infrastructures and basic Services, Absence of safe water and basic sanitation. E.G Loka Abaya, Hawassa Zuriya, Bilate Zuriya and Chire woredas ((RDRMC), 2020)

3.1.8. Responses to Climate Change

Ethiopia became part of the international community to respond to climate change by ratifying the United Nations Framework Convention on Climate Change (UNFCCC) in 1994 and the Kyoto Protocol in 2005. A provision in the Convention is for all Parties to the Convention 'to develop, periodically update, publish, and make available national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs). Ethiopia submitted the First/ Initial National Communication to the UNFCCC Secretariat in 2001 and the Second National Communication in 2016.

Similarly, Ethiopia prepared and submitted a National Adaptation Programme of Action (NAPA) in 2007 as recommended at the seventh session of the Conference of the Parties (COP 7) to the UNFCCC for the Least Developed Countries (LDCs) to identify and submit their most urgent and immediate adaptation needs. NAPA was updated and replaced by Ethiopia's Program of Adaptation to Climate Change (EPACC) in 2010.

The country has also submitted a Nationally Appropriate Mitigation Action (NAMA) plan to the UNFCCC in 2010 to comply with the requirements of the Copenhagen Accord, which is an outcome of COP 15 in Copenhagen, with the Intended Nationally Determined Contributions (INDCs) in 2015 in accordance with the decisions at COP 20. The INDCs have become NDCs (Nationally Determined Contributions) as Ethiopia has signed the Paris Agreement in 2016. Most recently, Ethiopia has completed preparation of a National Adaptation Plans (NAPs) (in 2017) in compliance with the Cancun Adaptation Framework (CAF) of the UNFCCC that invites all developing country Parties to formulate and implement medium- and long-term adaptation plans.

As it is clear from the foregoing, Ethiopia has been an active member of the international community through the UNFCCC process. Learning from this and taking into account the national development-planning context, Ethiopia developed an overarching framework and strategy, which is the Climate Resilient Green Economy (CRGE) strategy, which was launched in 2011.

The CRGE strategy

The vision of the CRGE is to achieve middle-income status by 2025 in a climate resilient green growth path that will be carbon neutral by 2030. It has three complementary objectives of fostering economic development and growth; ensuring abatement and avoidance of future emissions, i.e., transition to a green economy; and improving resilience to climate change. The CRGE has two building blocks: Climate Resilience (CR) and Green Economy (GE) components.

The objective of the GE component is to lead to the target of zero net emissions by 2030. It has four pillars: improving crop and livestock production for higher food security and farmer income while reducing emissions; protecting and re-establishing forests for their economic and ecosystem services; expanding electricity generation from renewable sources of energy; and leapfrogging to modern and energy-efficient technologies in transport, industries, and buildings. The GE strategy is completed and currently being implemented on power, buildings, forestry, soil, livestock, transport, and industry.

The CR component aims at building a climate resilient economy, by enhancing capacities to cope with and manage climate-change related shocks and stresses. CR strategies have been prepared and implementation is underway for agriculture and forestry, and water and energy sectors. Health and transport sectors CR strategies are under development. Even though sectoral CR strategies are yet to be developed for some sectors, the CRGE strategy has been under implementation mainstreamed into the second five-year Growth and Transformation Plans (GTP I, 2010-2015 and GTP II, 2015-2020). In the current Plan (GTP II), building climate resilient green economy is one of the nine pillar strategies.

The Environment, Forest, and Climate Change Commission (EFCCC) coordinates implementation of the CRGE strategy across sectors, and carries out capacity-building activities for sectoral and regional bodies. The Sectoral Reduction Mechanism (SRM), which was issued in 2014, facilitates actions on priorities identified in the CRGE and guides various sectors to reduce GHG emissions and vulnerability to climate change, and compiles a web-based CRGE Registry to monitor progress towards the strategic objectives. The function of resource mobilization, allocation, and management for CRGE implementation is provided by the CRGE Facility, which was established in 2012. The responsibility of the financial management aspect of the CRGE Facility is given to the Ministry of Finance and Economic Development (MO FED), while EFCCC is responsible for managing its technical aspects.

Productive safety net program

For over 30 years, responses to food insecurity in Ethiopia were dominated by emergency food aid. While this saved lives, it often failed to protect livelihoods, and this became a growing concern. In response, the Ethiopian government revised its emergency food aid system in 2005 and launched the Productive Safety Net Program (PSNP), a more productive approach to providing a safety net to vulnerable populations. Furthermore, between 2010 and 2014, the Ethiopian government stepped up its efforts to address both relief and development, with harmonized donor support. Through this enhanced developmental approach, the PSNP provides a safety net for households that are both chronically food insecure and poor, and often affected by shocks. With an objective to assure food consumption, and simultaneously to protect and develop assets along with services, PSNP operates across widespread geographies and rural communities to determine eligibility to

receive payments based on specific criteria. Such payments are made to households that can contribute to public works (labor); or, if labor is limited or impossible, unconditional support is provided. Through this infrastructure, PSNP contributes to a local enabling environment for community development.

Table 13 PSNP-5 Targeted Clients Number According Tso Caseload Allocation as mentioned In Sidama Region 2014 E.C

R/N	Woreda	No. of kebeles	Total number of PDS plus PW						PDS in %	Av. no of PDS	Av. no of PW	Av. No. Of Total ben. Per Total HHH
			HHH			HHS						
			MHHH	FHHH	TOTAL	Male	Female	Total				
1	Aletawondo	13	1,606	1,398	3,004	5,618	5,396	11,011	10%	2.62	3.84	**3.67**
2	Aleta chuko	24	1850	1730	3580	7209	6126	13,335	10%	2.89	3.85	**3.72**
3	Aroresa	4	455	934	1,389	2,560	2,969	5,529	12%	3.00	4.16	**3.98**
4	Bensa	9	929	1,262	2,191	4,139	4,288	8,427	10%	3.26	3.92	**3.85**
5	Bilate zurya	17	1,162	807	1,969	4,386	3,799	8,185	15%	4.13	4.16	**4.16**
6	Bona zurya	11	1,186	1,076	2,262	4,190	4,182	8,372	10%	2.62	3.84	**3.70**
7	Boricha	13	1,051	840	1,891	4,097	3,838	7,935	12%	3.74	4.27	**4.20**
8	Chebe gab.	6	531	695	1,226	2,599	2,452	5,051	10%	3.55	4.11	**4.12**
9	Chirone	4	469	309	778	1,473	1,418	2,891	11%	3.86	3.70	**3.72**
10	Dale	16	1,247	1,220	2,467	3,569	4,041	7,610	13%	2.03	3.35	**3.08**
11	Dara	12	1,213	1,400	2,613	4,478	4,858	9,336	18%	2.56	3.98	**3.57**

12	Dara Otilcho	6	413	525	938	1,840	2,024	3,864	10%	2.51	4.43	**4.12**
13	Derara	14	1,181	733	1,914	4,175	3,331	7,506	16%	3.74	3.96	**3.92**
14	Hawela	6	619	711	1,330	2,223	2,150	4,373	12%	2.64	3.41	**3.29**
15	Hawassa zurya	20	1,055	1,081	2,136	4,862	4,310	9,172	13%	3.03	4.48	**4.29**
16	Hoko	7	514	973	1,487	2,486	3,630	6,116	9%	3.75	4.16	**4.11**
17	Hulla	4	411	273	684	1,531	1,360	2,891	9%	3.00	4.41	**4.23**
18	Loka Abaya	21	2,429	2,226	4,655	5,975	6,095	12,070	12%	1.98	2.71	**2.59**
19	Shebedino	**17**	1,072	1,148	2,220	3,782	3,911	7,693	11%	2.87	3.56	**3.47**
20	Tulla S/city	7	1,200	1,845	3,045	4,386	7,406	11,792	13%	3.68	3.90	**3.87**
	Total	**231**	20,593	21,186	41,779	75,578	77,584	153,159	12%	2.90	3.80	**3.67**

Number of permanent direct support = 12% Number of public work participant =88% Average no. of PDS participant =2.9

3.1.9. Outlook/Recommendations

Without effective adaptation, climate change could lead to decreased agricultural production, yield potential, and even land area not suitability for agriculture and indoor air pollution causes for a health risk in the near future.

The effective solution to the problem of indoor air pollution is the provision of clean energy alternatives such as electricity to households. However, the heavy dependence on biomass for household energy production will continue into the near future given the slow pace of electrification, or even the adoption of biomass-based fuel-efficient stoves in the country. Even when electricity availed, the rural households will most likely use it for lighting purposes and continue to rely on biomass for cooking and heating purposes. Indoor air pollution will therefore remain an environmental problem and a health risk in the near future. Improving access, including affordability, to clean energy sources is the lasting solution to the problem of indoor air pollution.

There are even fewer studies on ambient air quality in the country. The available information is for the city of Addis Ababa and the National Meteorological Agency has recently started air quality monitoring in Addis Ababa, Adama and Hawassa. The available evidence for Addis Ababa shows that particulate matter, ozone and carbon monoxide concentrations are higher than WHO standards. The major sources of these pollutants are emissions from vehicles and industries.

The fast rate of urbanization, the rapidly growing number of vehicles most of which are old in age and hence fuel-inefficient, and the weak institutional capacity to enforce air quality standards suggest that ambient air pollution is very likely to grow in Ethiopia in the coming years. The available observational data are too few to make any conclusion, but it is a useful initiative that should be strengthened and scaled up to cover the major towns.

Climate change – which is driven by the change in the global atmospheric quality – is a major development challenge to region. Natural climate variability is already a heavy economic burden to the country, and anthropogenic climate change constitutes an added problem layer. Drought and flood, which are the major climate related hazards in the country, are recurrent

phenomena in the historical climate. However, there is some evidence that the incidence and intensity of droughts and floods have increased over the past years. Model-based projections also suggest that climate change is likely to increase the frequency, severity and spatial coverage of drought and flood risks in the future. Economy-wide, climate change is projected to cause reduction in the national GDP by between 0.5 and 10% from what could be achieved in the 2040-49 decade without climate change impacts.

Recognizing the scale of the climate change challenge, Sidama has mainstreamed adaptation and mitigation actions into relevant sectorial policies and strategies and the implementation of the five- year development plans. The CRGE strategy provides the overarching policy direction and vision for the national adaptation and mitigation actions. Implementation of the CRGE and associated strategies the green economy strategy, the sectorial resilience strategies and the adaptation plan will certainly ease the economic, social and environmental costs of the ongoing climate change

In other words, as implementation of the CRGE progresses as it is planned, impacts of climate change will be mitigated as a result. But its full-scale implementation is beset with limited financial capacity to execute multiple and large-scale projects and programs, limited technological capacity to fully embrace green growth options, inadequate institutional capacity at all levels including institutions for research and development in climate change issues, and absence of effective coordination mechanisms at both the federal and regional levels. In addition to dedicating national resources, Sidama therefore needs to solicit support from bilateral and international sources of finance for program implementation as well as for technology transfer and institutional capacity enhancement including for coordination mechanisms at all levels. The fact that Sidama is a frontrunner in the international arena in contributing towards the mitigation of the global climate change should be used as an opportunity to leverage the much-needed international assistance.

In addition, based on regional context the following recommendation forwarded: -

- Ensure the integration of National Environmental Strategy goals are developed within sectorial and regional plans,

- Implement cross-sectorial climate-smart solutions at national and subnational levels,
- Integrate climate change concerns into relevant policies and planning processes at the s national and regional levels,
- Gain a better understanding of the timing and magnitude of incidence of several important indicators of climate change in the future, as well as the key vulnerabilities, development impacts, and possible adaptation responses,
- Widen the participation of the public, scientific institutions, women and local communities in planning and management, accounting for approaches and methods of gender equity
- Strengthen environmental monitoring capabilities for strengthened and more effective environmental management,
- Enhance regional adaptive capacity through continuing investment in weather stations and expanding the regional hydro-meteorological monitoring system and improved networking for the measurement of climate parameter,
- Strengthen the of technical capacity to integrate climate-smart agriculture and climate change risk management into farmer's and the wider agricultural sector,
- Improve the accuracy of the design parameters in predicting sedimentation and runoff for changing Ethiopian landscape, land use change, and precipitation patterns and
- Support understanding of sustainable land management practices and the impact of soil erosion on watersheds.
- Drought induces slow onset emergency and hence seasonal multiagency need assessments and standard nutritional surveys should be conducted based on early warning information to respond the affected population.
- Rapid assessment is required with the involvement of multi-agency team that include, BoANR, BoLF, DRMC, UN agencies, FAO, NMA, & NGOs to assess the impact of desert locust on crop and livestock feed production.
- Flooding onsets suddenly and thus flood induced emergency impacts a given community rapidly. Accordingly, rapid assessment is the type of assessment recommended to assess the needs of affected communities.

3.1.10. Outlook/future scenarios

- There should be projected changes in annual precipitation and temperature for the periods 2020–2039 . On the left, for each scenario one line per model is shown plus the multi-model mean, on the right percentiles of the whole dataset: the box extends from 25% to 75%, the whiskers from 5% to 95% and the horizontal line denotes the median (50%).
- Drought is recurrently happening in the region. The impact of the drought in 2013,2019 and 2022 was very high and thus huge number of populations in drought prone woredas was affected. According to the regional DRM 5,822, 6,589 and 70,477 people were identified to be relief food beneficiary in 2013 , 2019 and 2022 respectively. But, there were no drought occurrences in 2020. According to SNNP Meteorological Service Centre, Even there were normal to above normal rain Climate prediction over the south west of Sidama region, there is below normal rainfall probability over eastern portion of the region. In this condition for the next 10 year, 100,500 people should be expected to be affected by drought.
- It is expected that the swarming of young locust will exponentially increase in the coming few weeks so that low crop & Livestock production and productivity, Shortage of food at household level, reduced food and income sources, malnutrition, School dropout & migration are some of the consequences resulted from the locust infestation.
- Taking into consideration, the effect of desert locust on pasture, vegetation & crop land, in this condition for the next 5 year a total of 100,500 household will be in need of emergency seed & feed in the coming belg and meher crop seasons.
- Taking above climate related impacts into account, the key food security indicators and favoring climate in 2019 and 2022 drought reason high amount of people affected by food shortge problem. Thus, 100,000 people are planned to be in need of food/cash assistance in Sidama region.
- Based on above given the metrology forecast of rain from normal to above normal rain in the coming belg and meher rain in 2023, flood induced damage is expected to be high and is anticipated to be over and above last three years in the region. Accordingly, the

planning figure is calculated to be 100,000 population for the coming flood season in Sidama region.

3.2. AIR POLLUTION

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution. Air pollution is a global environmental health threat contributing to an estimated three million deaths per year worldwide (Lelieveld et al., 2015). The Global Burden of Disease project (World Bank & IHME, 2016) estimates a figure for premature deaths closer to 5.5 million (one in every ten and the fourth highest factor for causing early death). The most extreme estimates are presented by the World Health Organization (WHO, 2014), reporting that in 2012 over seven million people died (one in eight of total global deaths) as a result of air pollution exposure.

The effects of air pollution on human health are well documented in a range of epidemiological studies; exposure increases the risk of lung cancer, heart disease, bronchitis and other cardiorespiratory conditions (Kelly & Fussell, 2015). The economic cost of this health loss is also significant, the World Bank estimates that globally in 2013 air pollution led to $5.11 trillion in welfare losses, and $225 billion in lost labour income (World Bank & IHME, 2016).

Air pollution problems from the transport sector in AA are characterized by high-sulfur fuels, lack of emission standards, ineffective and unenforceable emission inspections, an aging vehicle fleet, and increasing emissions. Ethiopia currently imports 500ppm sulfur diesel and 10ppm sulfur gasoline, allowing for operation of Euro 3/III vehicles. Emission inspection, while mandatory, detects smoke and carbon monoxide only without setting any threshold. Therefore, it neither influences the pass/fail decision for the inspection nor enforces any emission reduction requirements. Most registered vehicles are over 10 years old, including buses, passenger cars and light duty vehicles, many of which are not subject to emission control under current practice.

Major air pollutants in AA are, comparable to other cities, PM2.5, NOx, and SO2, as well as CO2 as a leading greenhouse gas. The emission inventory developed by the World Bank ASA estimated the transport sector contributed 29% of PM2.5 emissions and more than 90% of NOx and CO2, respectively.

In Ethiopia, air pollution and its effects are not well documented. Until recent years, they were considered generally low and inconsequential. Recent studies, however, revealed that air pollution is increasingly becoming a health concern due to high concentrations of indoor as well as traffic-related and other ambient air pollutants ((FDRE, 2002; Graham, 2011; WHO, 2006).

3.2.1. Extent and trends in pollution levels

Indoor air pollution

There are a few case studies conducted on assessing indoor air pollution (IAP) in Ethiopia. The objectives of those studies were to assess the effects of indoor air pollution on human health using cross- sectional data. As there is no direct measurement of pollutant concentrations that cover the country, findings from case studies conducted in Tigray, west welega, Kebribeyah, and Butajira were considered and summarized in this report (Usinger, 2008; Dyjack et al., 2005).

Indoor particulate matter (PM), nitrogen dioxide (NO_2), carbon monoxide (CO)

Review of the few available studies across the country showed that the average concentrations of PM2.5 reached as high as 280 μg/m3 for 24-hour mean measurements (Tefera et al., 2016). A study conducted in 59 slum neighborhood houses of Addis Ababa in 2012 showed that the mean PM2.5 concentrations was 818 μg/m3 with a standard deviation of 3.61. Solid fuel, Kerosene and clean fuel are the major sources of pollutants in the study (Sanbata, 2012). Another study in Addis Ababa also reported that the 24-h mean PM2.5 from kitchens reached 1, 580 μg/m3 which exceeded the WHO standards (WHO, 2006). Based on TSP assessment in rural Tigray, it is reported that the average indoor TSP concentration was 20mg/m3 (Range 83–175 mg/m3) (Usinger, 2008).

A study in Gimbie, west Wollega, Oromia Region noted that the concentration of respiratory suspended particulate (RSP) in biomass-fuel-using-homes was 130 times higher than the air quality standards (Dyjack et al., 2005). In Arsi-Negele, indoor concentrations of CO and PM2.5 from biomass fuels in the 8-hr average period were 1.22 μg/m3 and 50 ppm, respectively (Desalegn et al., 2011).

Very few studies considered indoor concentration of Nitrogen dioxide (NO2) in Ethiopia. One study conducted in rural area of Ethiopia reported high average levels of NO2 (97 ppb) in a large longitudinal study. This is twice as high as the WHO standard for a mean 24-hr concentration (Kumie et al., 2009).

Regarding indoor carbon monoxide (CO), higher concentrations were found among households using traditional stoves and solid biomass fuels; the CO concentrations being higher than regulatory limits used in the United States. A study in Addis Ababa homes reported the 8 hr average CO concentration as 16 ppm (Range: 0.66 – 69 ppm). This exceeds the US EPA's 8 hr average CO limit of 9 ppm in 48% of the households (WHO, 2006). Burning dung was the major cause of higher CO concentration and sometimes it exceeded 4000 ppm due to low energy efficiency (Usinger, 2008).

3.2.2. **State and Trend**

In Ethiopia, air pollution and its effects are not well documented. National GHG inventory have been conducted under the condition to meet national reporting requirement of the UNFCCC. According to this assessment, the cumulative CO2, CH4 and N2O emissions across the energy, industry, transport, commercial and residential sectors for the year 1994 resulted a total of about 48,003 Gg. CO2-equivalents excluding CO2 emissions/removals from the LUCF sector. For the same year, the per capital emission is estimated to be 0.8976 tonnes of CO2-equivalents per year. The emission from agriculture sector contributes 80% of the total CO2- equivalent emissions, and out of this, 80% of the total CO2- equivalent emission is contributed by CH4.

There is a general increasing trend of GHG emissions in Ethiopia in the period 1990-1995. The relative comparison of GHG emissions for the years 1990 and 1995 shows that total

(gross) CO2 emissions (i.e. emissions from the Energy and Industrial Process sectors) have increased by about 24% while emissions of CH4 and NOX increased by 1% and 119% respectively. Aggregate emissions of GHGs in terms of CO2 –equivalents have increased by 12%. The sink capacity of Ethiopia in the Land Use and Land Use Change and Forestry (LUCF) sector is also decreasing rapidly. It is noted that the rate of growth in GHG emissions varies across sectors and sub-sectors.

In the case of Sidama, data that obtained from Hawassa Air pollution measuring Station, the concentration of all pollutants Such as PM10, PM2.5, SO2, NO, NOx, CO and O3 have showed increment from October month from 2017 to 2019 except the concentration of NO_2. This result implies that when we compare Ethiopia ambient standard with the data measured pollutant concentration in Hawassa air pollution measuring station it shows increment concentration of pollutants by causing expansion of industrialization, urbanization and transport increment.

Table 14 Pollutants and Its concentration for October 2017 and October 2019 in Hawassa Air pollution measuring Station, 2022.

Pollutants and Its concentration								
	PM10	PM2.5	SO_2	NO	NO_2	NO_x	CO	O_3
	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	mg/m3	ug/m3
2017								
Mean	26.6	60.5	4.2	21.9	0.8	22.7	6.1	-0.3
STD	27.7	63.4	0.4	113.4	1.8	111.7	0.3	1.9
2019								
Mean	1054.5	1169.4	29.9	2.5	7.6	9.3	35162.3	16.0
STD	558.5	620.2	10.0	10.3	17.5	10.9	9677.7	14.1

3.2.3. Drivers and Pressure of air pollution

Green House Gases (GHGs) are gasses that trap long-wave radiation in the upper atmosphere, raise atmospheric temperatures and produce other changes in the climate system. In particular, three GHGs had increased in the atmosphere, namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). From around 1750 to 2011, CO_2 increased by 40% from 278 part per million (ppm) to 390.5 ppm while methane increased by 150% from 722 ppb to 1803 ppb and nitrous oxide by 20% from 271 ppb to 324.2 ppb (IPCC, 2013, p.467). And this increase

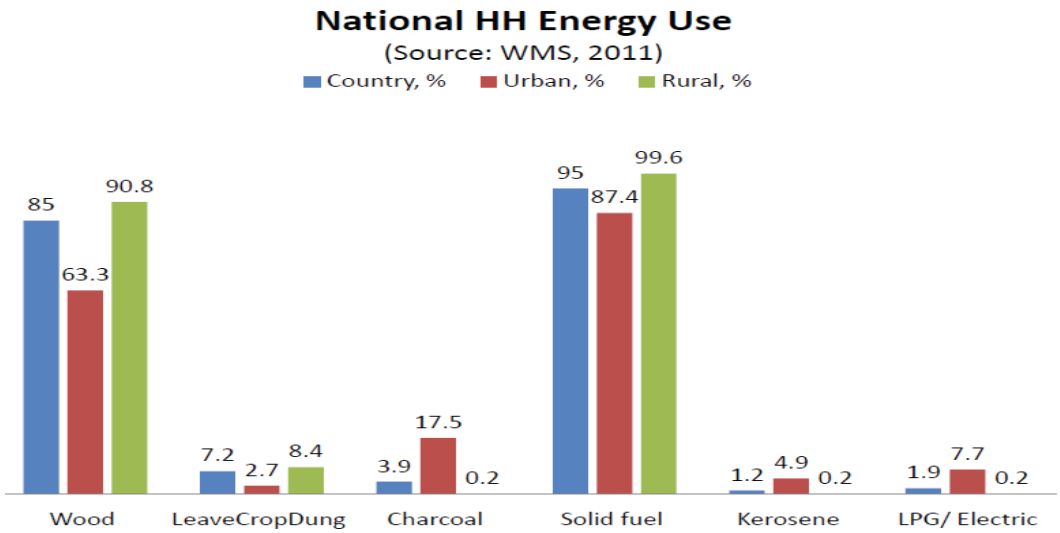
is the main driving cause of climate change. When ranked by their direct input to greenhouse effect, the most significant gasses are CO_2 accounting for 77%, methane for 14% and nitrous oxide for 8% of GHGs.

The production of these gasses varies with the type of economic activity. For example, energy supply is reported to account for 26%, industry for 19%, land use, land-use change and forestry for 17%, agriculture for 14%, transportation for 13% and waste and wastewater for 3% (IPCC, 2007a). Thus, agriculture causes approximately one-third of global GHGs when direct energy use, emissions from livestock, the production of fertilizer, pesticides, machinery and equipment as well as soil degradation and land-use change for feed production are taken into account (FAO, 2011, Hameso, 2013).

Causes of indoor air pollution

The major cause of indoor air pollution in Ethiopia is biomass fuel. According to a 2011 Welfare Monitoring Survey (CSA, 2011), 95% of Ethiopian households use biomass fuel with the majority using firewood for cooking (Figure 2). Firewood is the primary source of energy in both rural (90%) and urban (54%) areas.

Next to firewood, charcoal is used in urban areas (18%) for cooking compared to its negligible use in rural areas (0.2%). Use of cleaner fuels such as kerosene and electricity for cooking in rural areas is almost non-existent, but kerosene is widely used for lighting (88%) (CSA, 2011). These data are quite old and we believe that use of electric stove and biogas use have likely increased since these data were collected, but there is no actual data to support this claim.



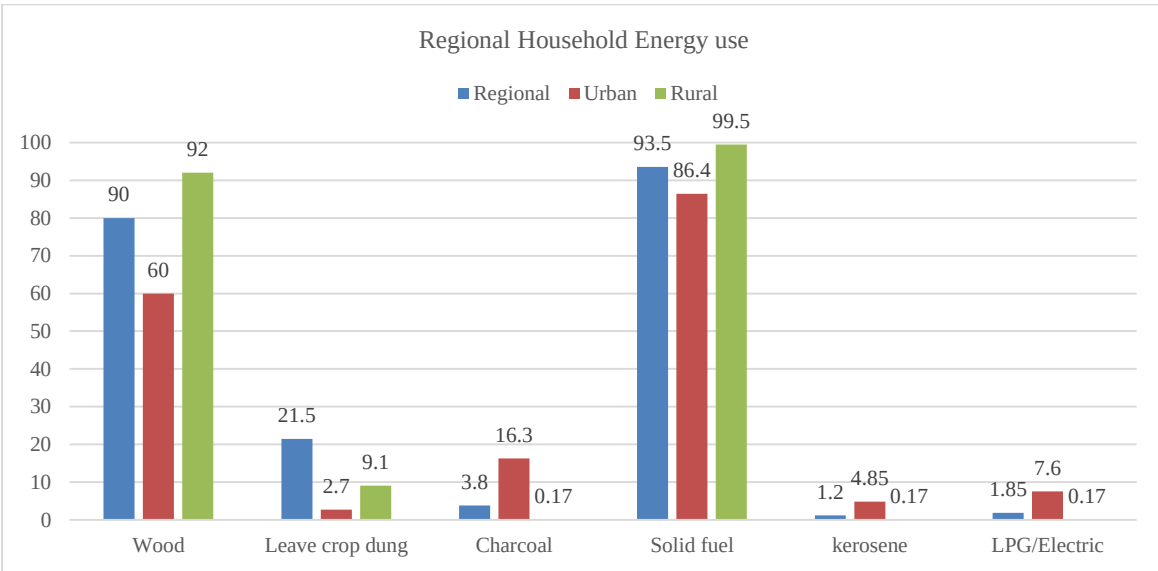


Figure 23 State of Environment 2017 Analysis Framework

Outdoor air pollution

Ambient air pollution is one of the least studied in Ethiopia. Monitoring of pollutants, which are related to traffic and industries, is a very recent phenomenon in some major cities like Hawassa, and Yirgalem. The sections below present analysis of available information on pollutants in Hawassa.

Particulate matter (PM), ozone (O3) and carbon monoxide (CO)

WHO studies in 2007 and 2008, PM10 mass concentrations measured in the city of Addis Ababa were in the range of 17 to 285 µg/m3 (WHO), 2007/08). This is higher than those in sub-urban areas, which was 40µg/m3. This is below the WHO standard value (Etyemezian et al., 2005) as well as Ethiopia's EPA (EPA, 2003). The mean TSP concentration of 195µg/m3 exceeded the WHO safe standard value (120 µg/m3). With regard to carbon monoxide, the mean concentration of all on-road collected samples was 5.4 ppm. This concentration is more than half of the 8-hour WHO standard value.

Figure 3a shows summary of three years' data collected from National Meteorological agency (NMA) Tikur Anbesa air pollution monitoring station in Addis Ababa for NO, NO2, O3 and CO gases. It can be seen that the 24 hour mean concentrations of NO2, NO and O3 were up to 50 µg/ m3, 21 µg/m3, 25µg/m3, respectively, during 2014 to 2017.

In the same period, the highest CO was 20 mg/m3. Among the pollutants, NO2 concentration was the highest and the major sources of this pollutant is vehicles. Vehicles are major contributors of nitrogen oxides, carbon monoxide, and other pollutants. Figure 3b shows PM2.5 concentrations, which was made available by US Embassy in Addis Ababa. The 24 hours mean PM2.5 concentration ranges from 0 to 60 µg/m3 with an average value close to 25 µg/m3. This is below the Ethiopian EPA's standard for daily PM2.5 concentrations.

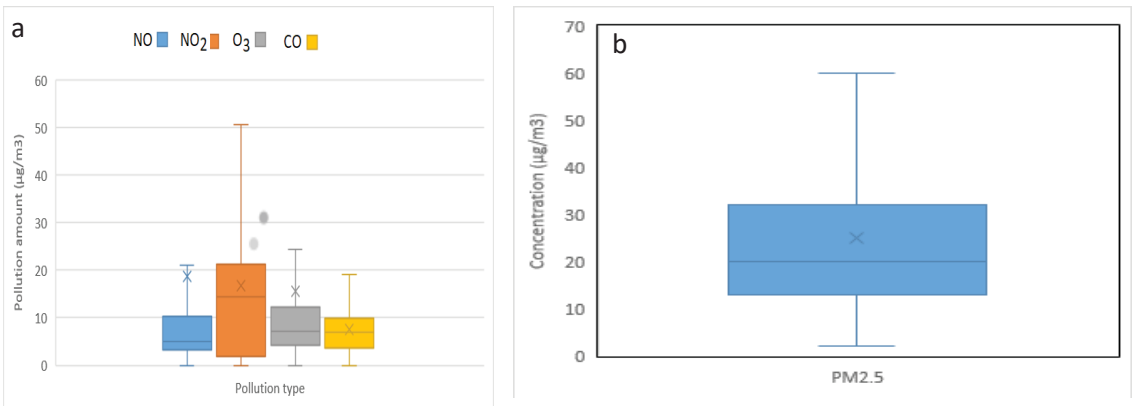


Figure 24 Air pollutants concentration measured at Hawassa Station, NMA, and Hawassa (a) Hourly mean PM2.5 concentrations

Causes of ambient air pollution

The major cause of ambient air pollution in Ethiopia is related with traffic. This is easily seen from the coincidence of peak concentration of pollutants with high traffic congestion segments of the day. It was observed that daily maxima of CO concentration in Addis Ababa were in the early mornings at rush hour time and late afternoons. The peak hour for PM10 and CO levels was 7:00 am. Secondary peaks follow this in the late afternoons and early evenings. High vehicle traffic and cooking/heating activities are expected to be the causes of such peak hours for PM10 and CO levels. Temperature inversion could also be a cause for higher concentration in the early evenings (Etyemezian et al., 2005). Other than the traffic, geological materials, probably from unpaved roads and road shoulders are also possible sources for PM10. According to Kumie et al. (2010), up to two-thirds, i.e., 34 to 66% of the total mass of PM10 reconstructed chemical composition was derived from geological materials.

Figure 25 shows the growth of vehicles in the country, which implies that the transport sector will continue to be the major cause of ambient air pollution in Ethiopia. The vehicles fuel consumption is anticipated to increase by 285 % between 2015 and 2035, with most of that increase coming from diesel (Danyo et al. 2017).

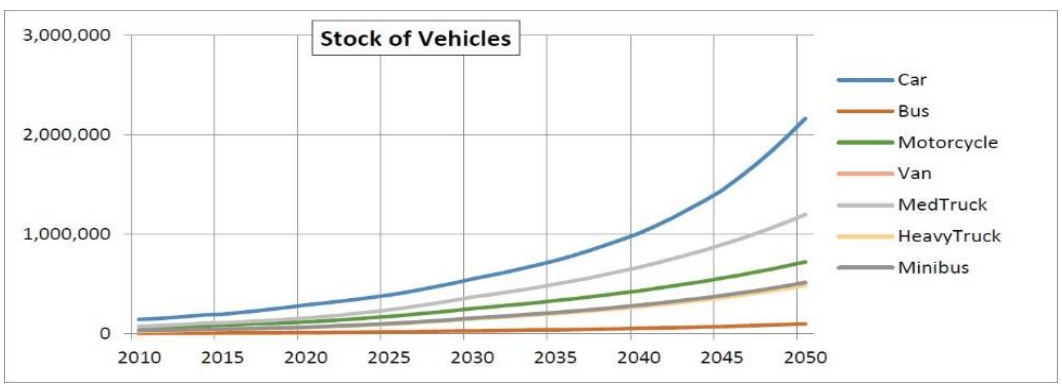
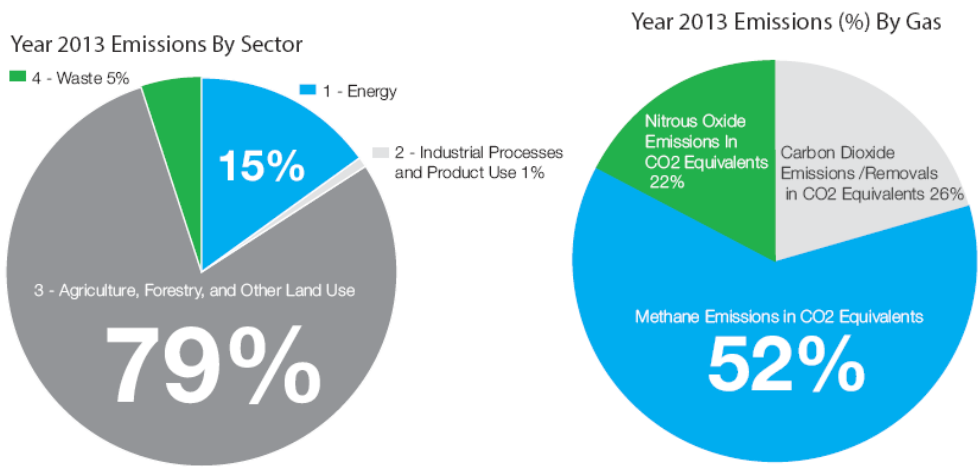


Figure 25 Projection of stock of vehicles (Source: Danyo et. al (2017)

GHGs emissions

Emission assessment in 2013 indicated that emissions from Agriculture, forestry and other land use accounted for 79% while the energy and industrial processes and product use (IPPU) sectors contributed 15% and 1% respectively and the waste sector only 5%. In terms of emission by gas, methane and carbon dioxide accounted respectively for about 52 and 26% of all greenhouse gas emissions from human activities in Ethiopia.

Based on the same source (the 2013 estimate), the total emissions were about 146,160.43 Gg of carbon equivalent. Out of this carbon equivalent, Carbon dioxide accounted 40,357.15 Gg; methane accounted 72,793.82 Gg and Nitrous Oxide accounted 30418.03 Gg. There was a decrease of emission by 24.11% in total estimated emissions compared with 2010.



Source: MEFCC (2015)

3.2.4. Impacts of air pollution

Hawassa has disproportionately high pedestrian fatalities for the Sidama region and also for Ethiopia. In addition to the exacerbation of road fatalities, rapid motorization also worsens traffic congestion, increases greenhouse gas (GHG) emissions, deteriorates local air quality, and results in health impacts and economic costs.

There are a few studies on health impacts of air pollution in Ethiopia. It is reported that air pollution is becoming the main cause of diseases such as acute lower respiratory infection and chronic obstructive pulmonary diseases (WHO, 2007; IHME, 2014). Ethiopia reported that 1,262,908 cases (5% of total) of acute upper respiratory infections and 5% of pneumonia cases this accounts for 7% of hospital admissions might have been linked to air pollution (MoH, 2011). For the same year, 2% of hospital admissions were due to tuberculosis. Pneumonia is the leading cause of hospital admissions and the second cause of morbidity in the country.

Another study reported 42% of 1,565 deaths that occurred in Hawassa in the years 2006–2009 were due to communicable diseases. Tuberculosis and respiratory tract infections caused 12% and 3% of the deaths, respectively. Non-communicable diseases accounted for 51% of the deaths, with asthma being the primary cause. Tuberculosis, respiratory tract infections, and asthma collectively accounted for about 17% of all deaths in Addis Ababa (Misganaw et al., 2012a). All are diseases that may have links with indoor or outdoor air quality situation. Another study found that tuberculosis and respiratory infections as the second (11%) and third (8%) causes of the deaths that occurred in public and private hospitals in Addis Ababa for the period 2006–2009 (Misganaw et al., 2012b).

Acute lower respiratory infection is also linked with high level of fine particulate matter in the air. The problem is especially observed among children (CSA, 2012). According to CSA's countrywide report, national prevalence of acute respiratory infection was 7% (CSA, 2012). Similar results were also found that focused in Addis Ababa and in the rural area of Shebedino district, southern Ethiopia (Sanbata, 2012; Biruck, 2011).

Recent study by Tarekegn MM and Gulilat TY in 2018 indicates that air pollution related diseases like acute upper respiratory infections, acute bronchitis, asthma, chronic obstructive pulmonary disease (COPD), pneumonia, have been increasing in the last five (Figure 26).

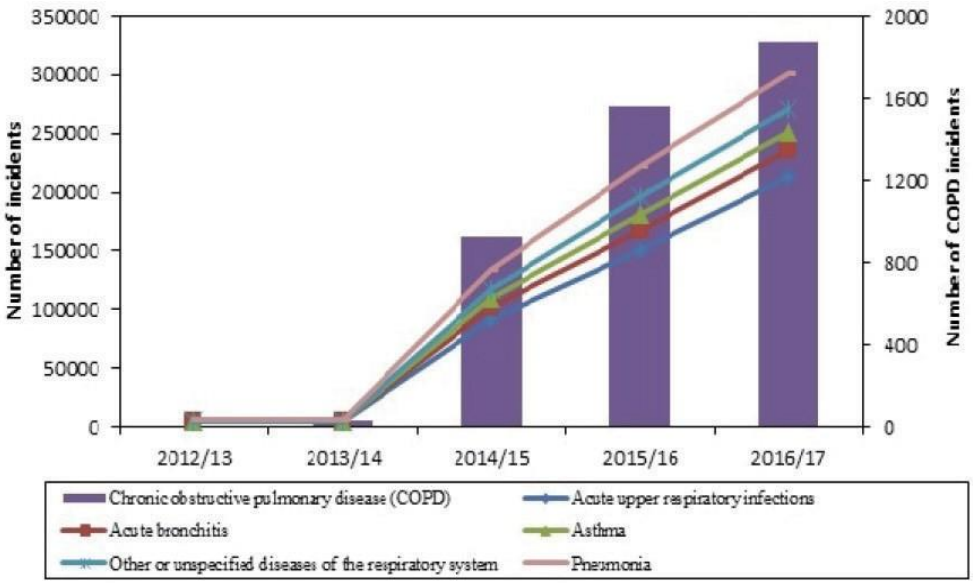


Figure 26 Air Pollution related respiratory Disease in Addis Ababa (Tarekegn MM, Gulilat TY (2018)).

3.2.5. Responses to air pollution

Sidama National Regional State has taken different response measures to ensure the right of citizens to live a healthy life in a healthy environment. The responses include developments of policy and legal frameworks and building institutions and capacity for air quality monitoring, surveillance and regulation.

Legal and policy frameworks

The Constitution of the Federal Democratic Republic of Ethiopia provides for a favourable policy environment for air quality (Article 44/1). The Constitution grants fundamental rights to have clean and healthy environment (FDRE, 1994). The 1993 Health Policy emphasizes about air pollution that the provisions cover environmental policy on ambient air quality standards and on the need for regulatory limits for both stationary and mobile air pollution sources (FDRE, 2003).

The policy priority for clean energy sources as part of the green growth strategy of the country will also have air quality benefits. For instance, in the transport sector the recently introduced light trains and railway is expected to effectively replace half of the country's need for fuel-based transportation and the emissions problems associated with it (Tefera, et al. 2016). Though it is not yet introduced, electric buses are also in the transport development plan of Hawasa city. Similarly, in the energy sector, clean energy production from hydropower, wind, geothermal, and solar sources are steadily increasing. With regard to decreasing indoor pollution, more than 11 million improved cooking stoves were planned to be distributed during the current Growth and Transformation Plan (GTP II) These all have air quality benefits, and hence can be considered as responses to the emerging problem of ambient air pollution. Especially, the renewable energy resources, wind power and solar radiation, are very huge (Figure 27a) and very recently, the government has given much attention to these resources though the current exploitation is less than 1 % from the potential.

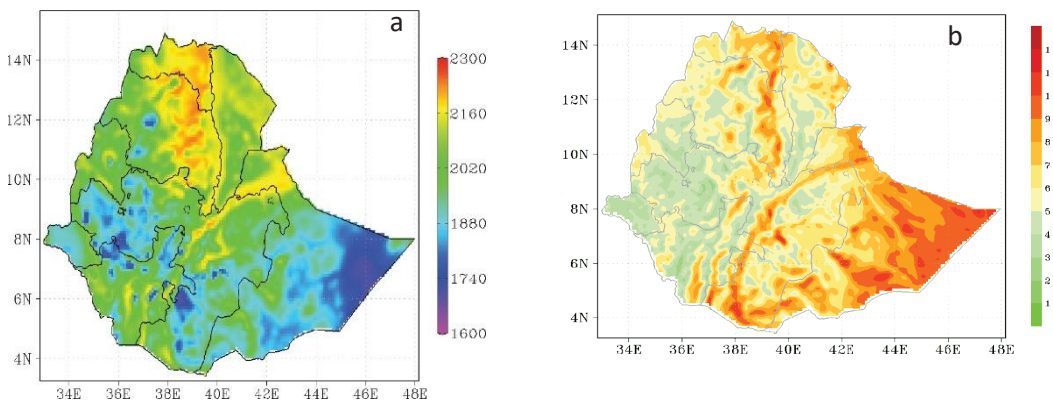


Figure 27 Distribution of average annual solar radiation in kWh/m2/yr (1980-2009) (a), and distribution of average wind speed, m/s (height: 50m, 1980-2009) (b). Source: MEF (2015)

Ambient air quality monitoring and regulating capacity

The then Ministry of Environment and Forest (now MEFCC) has set air quality standards, i.e., the Ambient Environmental Quality Standards aimed at controlling emissions by point sources. However, this has not been implemented. Very recently, efforts are underway to measure pollutant gases at Hawassa cities under the National Meteorological Agency. The monitoring and enforcing of the standards on ambient air pollution is under SNRS EPA.

Table 15 Air quality guidelines: Ethiopia and WHO

Pollutant	Guideline value (micrograms per cubic meter)	WHO air quality guidelines (micrograms per cubic meter)
Sulphur dioxide (10 minutes)	500	500
Sulphur dioxide (daily)	125	20
Sulphur dioxide (annual)	50	-
Nitrogen dioxide (1 hour)	200	200
Nitrogen dioxide (annual))	40	40
Carbon monoxide (15 minutes)	100000	-
Carbon monoxide (30 minutes)	60000	-
Carbon monoxide (8 hours)	10000	-
Ozone (8 hours)	120	100
Ozone (1 hour)		180
Particulate matter less than 10 microns (annual)	50	20
Particulate matter less than 10 microns(daily)	150	50
Particulate matter less than 2.5 microns(annual)	15	10
Particulate matter less than 2.5 microns(daily)	65	25
Lead (annual)	0.5	-

Source: Guidelines Ambient Environment Standards for Ethiopia 2003. The Environmental Protection Agency and The United Nations Industrial Development Organization prepared under the Ecologically Sustainable Industrial Development (ESID) Project, August, Addis Ababa

3.2.6. Recommendations

The recommended priorities further screened for implementation timeframe using magnitude and rapidity of impacts. Short term measures are expected to have an impact within 1-2 years after

implementation; medium-term with an impact within 3-5 years; and long term with a significant impact within more than 5 years. Various policy analysis and feasibility studies would be needed to implement the short- and mid-term measures. For example, in the case of deploying e-mobility, electric buses require the backing of a charging network and upgrading substations. The WRI study categorized Hawassa as a "stage zero" country with no policy, target, or implementation of electric buses, therefore an e mobility strategy that assesses power demand, battery disposal and specific infrastructural needs and the design of a demonstration project have been identified as key next steps. In 2023, the Ministry of Transport established a national e-mobility steering committee, a strategic step forward toward promoting e-mobility.

A set of high-priority measures are recommended. These measures, as framed under SSATP's urban transport policy approach of Enable, Avoid, Shift and Improve, represent all three categories of mitigation options covering fuels, vehicles, public transport and non-motorized transport, and reflect the government's priorities and ongoing investments. They are: (i) introducing 50ppm diesel fuel, combined with Euro 4/IV vehicle emission standards or equivalent, which is a high priority for the government; (ii) fostering public transport and NMT measures, if possible, combined with transport demand measures and transit-oriented development. Establishing maximum in-use vehicle emission levels and measurement procedures and strengthening the integration of emission testing in road-worthiness tests with quality control and enforcement measures.

These measures are being developed by the Federal Transport Authority; and (iv) introducing a ban on import of all diesel vehicles with less than 3.5t gross vehicle weight (GVW), including new and second-hand vehicles. Heavy duty diesel vehicles such as trucks or buses with more than 3.5t GVW are still permitted. At present, 36% of registered vehicles in Ethiopia are diesel. Even with the best available diesel technologies, the real-world performance of diesel engines results in high PM and NO2 emissions. It is important to note that these four priority recommendations are mutually supportive; therefore a coordinated implementation across these four priorities will maximize the effect of air quality reduction from the transport sector.

Medium-priority measures recommended: (i) promoting hybrid and electric vehicles with fiscally neutral instruments and other policies; (ii) integrating emission inspection including data access and sharing in vehicle roadworthiness test centers; and (iii) limiting the age of in-use fossil buses used for public transport in urban areas as a measure to speed up renovation of the public transport fleet and

to incentivize a switch to electric units. While Ethiopia as a country has adequate power generation resources, Hawassa's power infrastructure is facing severe capacity constraints. The deployment of e-mobility, especially electric buses, requires the backing of supporting power infrastructure.

A recent World Resources Institute (WRI) study recommended Hawassa conduct research on electric buses around power demand, battery disposal and specific infrastructural needs; this study recommended a multi-sector e-mobility strategy development involving the energy sector and feasibility design for pilot deployments in the short term. Other measures are considered low priority and not recommended at this stage.

Some non-recommended options are: (i) fuel efficiency standards, due to high complexity and potential dieselization of the vehicle fleet and a subsequent increase in air pollution; (ii) vehicle scrapping programs, due to their highly negative cost-benefit; (iii) vehicle retrofit programs with diesel particle filters, due to their considerable technical complexity and highly negative cost-benefit ratio; and (iv) age limitations for the import of new or second-hand vehicles, due to them not being an adequate proxy for vehicle performance. The correlation between vehicle age and vehicle emissions only exists in countries with advanced vehicle emission regulations. In Ethiopia, used as well as new vehicles arrive from different parts of the world. Second-hand vehicles made in Europe since 2006 comply with Euro 4/IV and with Euro 6/VI for vehicles since 2015, while new heavy-duty vehicles assembled locally in Ethiopia may only meet emission standards of Euro 0. Therefore, introducing an age limitation for importing vehicles may not be effective in Ethiopia at this time.

3.2.7. Outlook /Future forecast

Hawassa has disproportionately high pedestrian fatalities for the Sidama region and also for Ethiopia. In addition to the exacerbation of road fatalities, rapid motorization also worsens traffic congestion, increases greenhouse gas (GHG) emissions, deteriorates local air quality, and results in health impacts and economic costs. In addition, the study reported that 42% of 1,565 deaths that occurred in Hawassa in the years 2006–2009 were due to communicable diseases. This continues in this condition for the next 10 year 2,609 deaths will occurred due to communicable diseases.in general this continues in this condition for the next 10 year in overall Sidama region 13,045 deaths will be occurred due to communicable diseases.

SECTION FOUR

4. LAND

4.1. Introduction

Land degradation is a complex and detrimental problem, affecting many critical aspects of human life, which cannot be eliminated easily by implementing specific technical or technological measures. The fight against degradation rather requires holistic measures, which will then simultaneously enable to reduce poverty.

Land degradation in Ethiopia is a severe problem that affects agricultural productivity and food insecurity (Muluneh et al. 2017, FDRE 2011). Specifically, soil erosion by water is the most common form of land degradation in Ethiopia and has accelerated over recent decades due to unsustainable land use practices (Gebreselassie et al. 2016). Land degradation induced by soil erosion is considered to be among the major factors responsible for environmental challenges and food insecurity of the population and for impeding future development prospects of the country (Wagayehu 2003). With one of the highest rates of soil erosion in Africa, Ethiopia is highly vulnerable to the effects of land degradation (Jolejole-Foreman et al. 2012). In Sidama region the causes of the degradation are generally the same for all of Ethiopia's catchments. The major ones are deforestation mainly for agricultural purposes and settlement as a result of population pressure and the need for grazing land, over-grazing as a consequence of overstocking and soil erosion and land degradation.

4.2. State of the Land

4.2.1. Land use land cover changes

The land use changes have transformed land cover to farmlands, forest, woodland and shrub land, unproductive land, and perennial cropland at the expense of grazing land and uncultivated land, leading to a significant decline in grazing land as well as a reduction in wetlands and water body.

The definition of land use and land cover has been used interchangeably in the land use research community because of the availability of many existing information systems. However, these two terms explain two different issues and meanings. Land cover refers to the observed biophysical cover on the earth's surface including vegetation, bare soil, hard surfaces, and water bodies. Whereas land use is the utilization of land cover type by human activities for agriculture, forestry, settlement,

and pasture by altering land surface processes including biogeochemistry, hydrology, and biodiversity (Di Gregorio and Jansen, 2000). Land use and land cover changes became prominent as a research topic on the global environmental change several decades ago with the idea of processes in the earth's surface influence climate.

Changes in land use and land cover are caused by direct and indirect consequences of human activities on the environment to have a better life. One of the direct impacts of humans is population growth where its increase and decrease have effects on land use, especially in the developing world at longer time scales. According to Lambin et al., (2003), it can also be caused by the mutual interactions between environmental and social factors at different spatial and temporal scales as land use and land cover change is a complex process. Land use / Land cover change plays a vital role in the study of global change. Land use / Land cover and human or natural modification have largely resulted in deforestation, biodiversity loss, global warming, and an increase in natural flooding. Thus environmental problems are often related to Land use/ Land cover change.

The trends of total area covered by each land use land cover type and percentage share of each land use land cover of the total area for the years 2007 and 2013 E.C. is collected from (Plan and Development Bureau of the Region. It also depicts net area change and percentage change of net area change in land use and land cover change for each land use land cover. According to Plan and Development Bureau of the Region, from the total area, forest covered 11%, and 17.5% in 2007 and 2013, respectively. The proportion of the total area of the region was covered by grazing land (7.4%) and 6.5% in 2007 and 2013 respectively and uncultivated land (1.6%) and (1.2%) in 2007 and 2013, respectively while woodland and shrub land 3% and 2.6% in 2007 and 2013, respectively and annual cropland took the largest share of the total land in 2013. of the total area of the region. Annual cropland accounted for 25.1% and 27.6% of the total area in 2007 and 2013, respectively. However, it showed a significant increment to 2.5% of the total area of the region in the year 2013. The area coverage of perennial cropland has shown an increasing trend between 2007 and 2013. It covered 43.6% in 2007, and 47.4% in 2013. The trend further shows that the percentage shares of uncultivated land declined from 1.6% in 2007 to 1.2% in 2013. On the contrary, a decrease of unproductive land from 1% in 2007 to 0.9% in 2013 was observed. The area covered by cropland was increased by 17411.3 hectares between 2007 and 2013. The expansion of cropland is driven by population pressure and the conversion of grazing land and uncultivated land.

The general land use land cover of the region of 2022 is also extracted from the Landsat 8 Satellite images and presented in Figure 28.

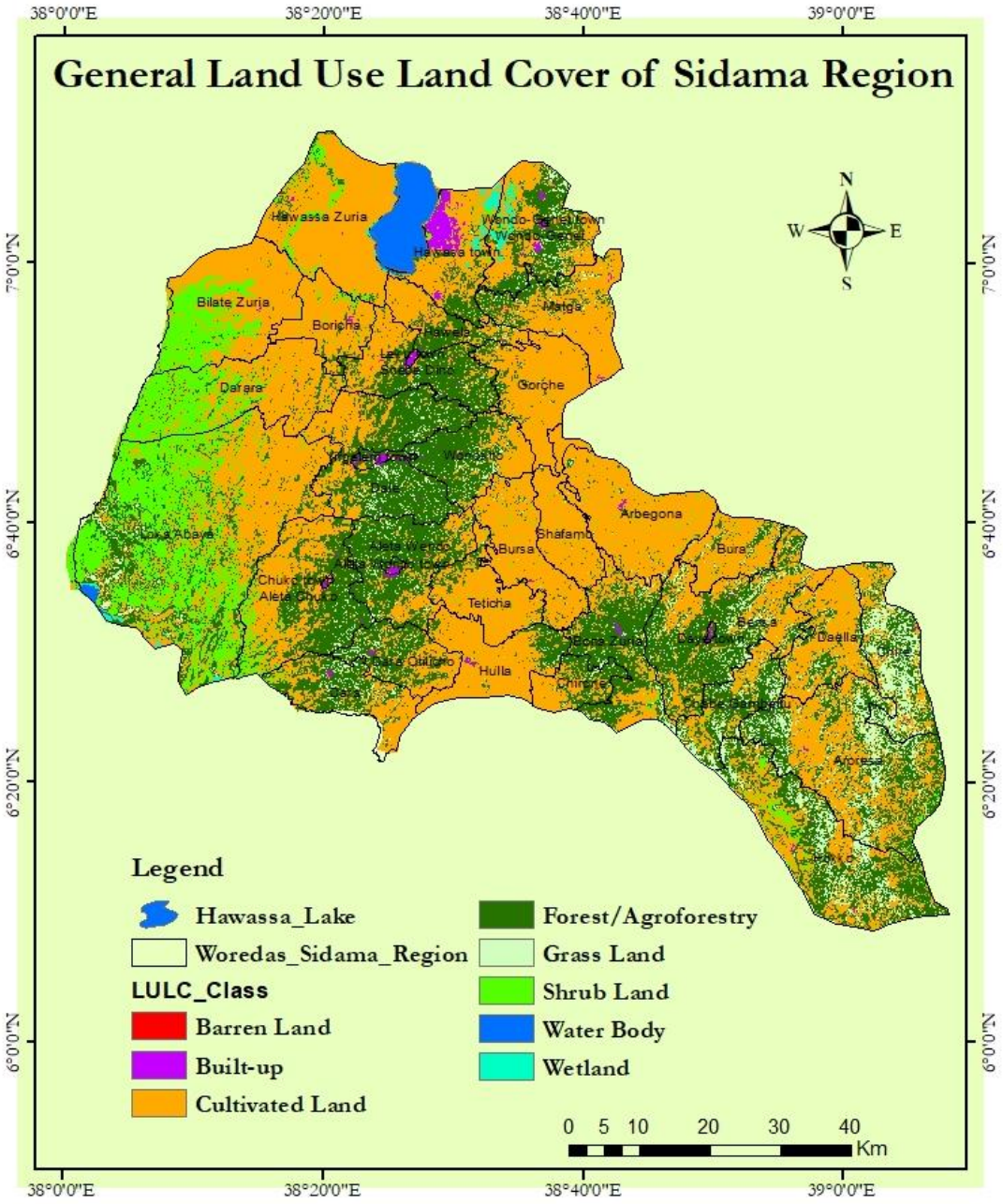


Figure 28 Land Use Land Cover of the region (2022)

As it has been depicted from this Land Use Land Cover, 52.12% of the total is cultivated (crop land), 30% of the total area is forest and agroforestry, 9.2% of the total area is shrub land, and the rest are grass land, water body, wetland, built-up and barren land (Table 16).

Table 16 Land use Land cover of Sidama Region (2022)

Value	Land use Land cover Class	Area (ha)	Percentage
1	Shrub Land	62613.69	9.24
2	Cultivated Land	353194.52	52.12
3	Built-up	5256.47	0.78
4	Barren Land	512.15	0.08
5	Water Body	9476.59	1.40
6	Wetland	3151.23	0.47
7	Forest/Agroforestry	203676.75	30.06
8	Grass Land	39799.50	5.87

Table 17 Estimated area and net area change of land use land cover types (Plan and Development Bureau)

Land use and land cover type	Area (2007)		Area2013		Net area change 2007-2013	
	ha	%	ha	%	ha	%
Annual cropland	75850.2	25	193262	27.6	17411.3	2.5
Perennial crops	305165	44	332059	47.4	26894	3.8
Grazing land	51000	7.4	45491.7	6.5	-550.3	-0.8
Currently unproductive land	7120	1	6530.6	0.9	-589.4	-0.1
Currently uncultivated land	11230	1.6	8564.9	1.2	-2665.1	-0.4
Forest	76914.2	11	122360	17.5	45445.8	6.5
Wood land and shrubs land	21120	3	18800.3	2.6	-2319.7	-0.4
Other occupation's	50820.6	7.3	27848	3.98	-22972.6	-3.2
Total	699,220	100	699,220	100	There is a change	

1.6. The Soil Type of the Region

The soil map of the region is obtained from FAO Soils Portal of Harmonized World Soil Database (HWSD). The soil type is also one of the factors for land degradation. Loose and alluvial soils will be eroded easily when there are the drivers like runoff and wind. On the basis of classification there are eleven soil types in the region. The major soil of the region is chromic luvisols which accounts about 33% of the region and the other soil types are presented in Figure 29 and Table 18.

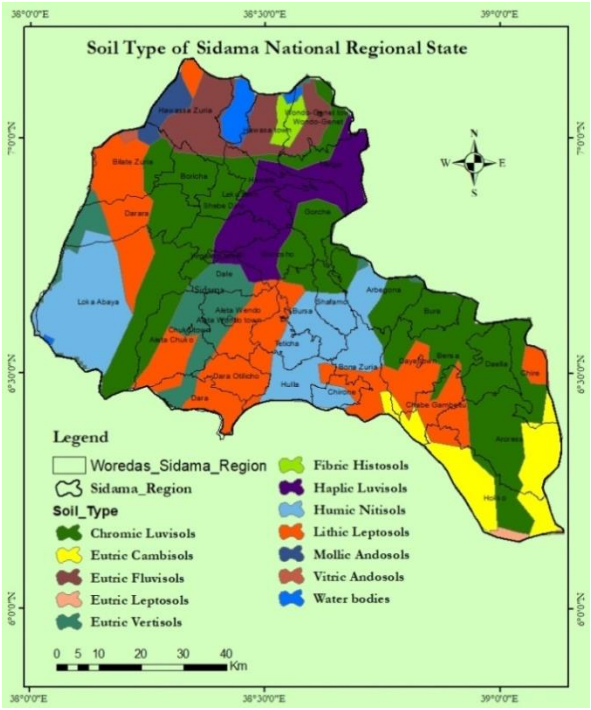


Figure 29 The Soil Types in Sidama Region

Table 18 Soil Types of the region

Soil Type	Area (ha)	Percentage (%)
Chromic Luvisols	222111.35	32.77
Eutric Cambisols	42453.47	6.26
Eutric Fluvisols	40778.02	6.02
Eutric Leptosols	2022.84	0.30
Eutric Vertisols	41289.19	6.09
Fibric Histosols	6804.78	1.00
Haplic Luvisols	57405.35	8.47
Humic Nitisols	105726.87	15.60
Lithic Leptosols	140360.64	20.71
Mollic Andosols	8556.04	1.26
Vitric Andosols	947.33	0.14

4.3. Drivers & Pressure of Land degradation

4.3.1. Population Density

Sidama population is estimated to be over 4,710,648 million, one of the most densely populated in Ethiopia with 676 people per kilometer square. Due to this reason increased demand for food, settlement, fuel and expansion of farm land, land fragmentation, deforestation, over grazing, unsustainable agriculture practice like limited crop rotation repeated plowing & construction**.** The major drivers are population growth, climate change, limited land area, and ineffective or non-existent land use policy. The pressures are land fragmentation, expansion of agriculture to marginal areas, unsustainable agricultural practices or poor land management (mining), excess use of alkaline fertilizers, and overgrazing.

Physical land degradation

Soil erosion by water is the dominant degradation process and occurs particularly on cropland, with annual soil loss rates on average of 42 t/ha/year for croplands, and as high as 300 t/ha/year in extreme cases (Hurni 1986). Other degradation processes include intensified runoff from grasslands and related gullying, as well as high soil erosion rates from heavily degraded lands. However, this study did not consider the impact of the soil and water conservation activities over the past years and the net erosion/deposition factors.

Figure 30 Degraded land and flooding on Boricha woreda

4.3.2. Lack of Strong Policy enforcement

Problems of inappropriate land uses, population growth, over-exploitation of natural assets and environmental degradation are complex and long-term. Their linkage exacerbates them with poverty, inequality, and social conflicts because many people have in adequate access to land or to the benefits from its use. Many land management practices, such as soil and water conservation (SWC) structures, involve long-term investments that require greater tenure security for widespread adoption. It is necessary to promote desirable land investments or protection and conservation of land-based resources by linking provision of increased tenure security. A viable land use policy and environmental impact assessment laws are believed to be a fundamental base for sustainable land management and hence, sustainable agricultural development.

In response to the escalating land degradation, the Rural Land Administration and Land Use Proclamation (Proclamation No. 456/2005) and Environmental Impact Assessment Proclamation (Proclamation No. 9/1995) are enacted. The proclamations provide a new system of administration for rural land management and use and for sustainable rural land use planning based on the different agro-ecological zones of the country necessary for the conservation and development of natural resources. The Proclamation, among other things: provides rules relative to acquisition and use of rural land by farmers and pastoralists transfer of rural land use rights, distribution of rural land, resolution of disputes, and restrictions on the use of rural land; and defines responsibilities of the Federal Ministry of Agriculture and Rural Development and Regions. Article 10 of the policy states that "a holder of rural land shall be obliged to use and protect his land and if the land gets damaged, the user of the land shall lose his use right."

The Environmental Impact Assessment law (Proclamation No. 9/1995) was enacted to contribute to environmentally sound development cooperation by identifying, predicting, and evaluating the foreseeable environmental effects both beneficial and adverse, of public and private big land development activities. However, these policies have not been fully implemented due to limited political commitment from the sectors, lack of awareness among different stakeholders, limited capacity, insufficient structure to effectively put the policies to use, lack of functional linkage with regional and sectorial organs.

4.3.3. Agricultural practices

Unsustainable and inappropriate land management is the main cause of physical, chemical, and biological degradation of cultivated land, grazing lands, and forestland. Vulnerability to degradation can arise from the number of plowing during field preparation depending on the crop; the absence of contour plowing, terracing, or perennial crops which grow throughout the year and the lack of manure or crop residue to increase soil fertility through organic cycling. Cross plowing is practiced because the traditional plow in Ethiopia, called Maresha, cannot be efficiently used over the same line of plowing in consecutive tillage operations (Temesgenet al.2008).

Inadequate capacity of farmers to maintain and enhance environmental services by preventing and reducing degradation and deforestation due to lack of appropriate technology is also a very important driver. Loss of soil fertility and increased moisture stress result in low crop yields and high levels of poverty. There is inadequate knowledge on watershed management and other related sustainable land management practices to allow informed decision- making at all levels. All these intertwined factors present constraints for making progress in reducing land degradation, implementing SLM, and enhancing environmental services.

Land shortage and poverty, taken together, lead to non-sustainable land management practices. Subsistence farmers are led to clear forests, cultivate steep slopes without conservation, overgraze rangelands, make unbalanced fertilizer applications, and the other causes noted above. Farmers are reluctant to invest in measures to conserve land resources if their future rights to use these resources are not secure. Enforcing the land use policy and solving the land tenure issue should be included as components in sustainable land development efforts.

4.4. Impact of land degradation

Its impacts can be far-reaching, including loss of soil fertility, destruction of species habitat and biodiversity, soil erosion, and excessive nutrient runoff into water body. Land degradation also has serious knock-on effects for humans, such as malnutrition, disease, forced migration, cultural damage, and Degradation through erosion processes is not restricted to soil loss in detachment areas but includes impacts on transport and deposition areas as well (less commonly, deposition areas can have their soils improved by these inputs). Larger-scale degradation processes related to the whole continuum of soil erosion, transport and deposition include dune field expansion/ displacement, development of gully networks and the accumulation of sediments in natural and artificial water-

bodies (siltation) (Posen and Hooke 1997; Ravi et al. 2010). Long-distance sediment transport during erosion events can have remote effects on land systems, as documented for the fertilization effect of African dust on the Amazon (Yu et al. 2015)

Other physical degradation processes in which no material detachment and transport are involved include soil compaction, hardening, sealing and any other mechanism leading to the loss of porous space crucial for holding and exchanging air and water (Hamza and Anderson 2005). A very extreme case of degradation through pore volume loss, manifested at landscape or larger scales, is ground subsidence. Typically caused by the lowering of groundwater or oil levels, subsidence involves a sustained collapse of the ground surface, which can lead to other degradation processes such as salinization and permanent flooding. Chemical soil degradation processes include relatively simple changes, like nutrient depletion resulting from the imbalance of nutrient extraction on harvested products and fertilization, and more complex ones, such as acidification and increasing metal toxicity. Acidification in croplands is increasingly driven by excessive nitrogen fertilization and, to a lower extent, by the depletion of cation like calcium, potassium or magnesium through exports in harvested biomass (Guo et al. 2010). One of the most relevant chemical degradation processes of soils in the context of climate change is the depletion of its organic matter pool. Reduced in agricultural soils through the increase of respiration rates by tillage and the decline of below-ground plant biomass inputs, SOM pools have been diminished also by the direct effects of warming, not only in cultivated land, but also under natural vegetation (Bond-Lambert et al. 2018).

Land degradation has negative implication house hold food security and contributes directly to the redaction in livelihoods among the rural community in Sidama. Immediate consequences of land degradation are lower crop yield, leading to higher poverty rate among agricultural households.

4.5. Response to land degradation

Training and extension, soil conservation measures with farmers' participation, enactment of new laws and amending of current laws (for monitoring agricultural activities such as fertilizers and pesticide application and burning of crop residues), forest preservation, improving the current grazing systems. Responses to land degradation from mineral resource extraction include: on-site management of mining wastes (soils and water); reclamation of mine site topography; conservation and early replacement of topsoil; and passive and active restoration measures to recreate functioning

grassland, forest and wetland ecosystems (well established) . The responses to invasive species and mineral extraction-related degradation are successful where restoration plans are fully implemented and monitored following an adaptive management approach.

- Framework to evaluate effectiveness of land degradation and restoration Responses, including prevention, mitigation and rehabilitation.
- Policy, institution, and governance
- Sustainable land management practices
- Sustainable soil management techniques
- Water conservation techniques Scale
- Decision-making instruments
- Land degradation and restoration responses

4.6. Outlook

Underlying every environmental problem is the issue of human population related to their opinion on forest cover change, drivers of deforestation, their impact, existing remedies and the solution relays on peoples of the area. As indicated in land use land cover detection the coverage of wetland was declined from 14,089 ha to 12,885 ha between the years 2007 to 2013 by 1204 ha (8.5%).The deterioration of wetland contentious as the existing rate the coverage of the wetland will be declined by 2014.7ha (14.3%) next 10 years. This indicates that the number of population in the region was increased in each year, which directly and indirectly affects water resources exist around the wetland and also damage the wetland itself.

As per solving the problem of environmental degradation, it is suggested that alternative environment outlook issues should be developed to reduce the risk posed by carry out environmental impact assessment and put in place mitigation measures to invest more in the biodiversity conservation on each issues. This can be achieved through means of creating awareness.

SECTION FIVE

5. WATER

5.1. State and trend of Water resource in Sidama Region

Sidama region shares 2 major river basins from the 12 major river basins in Ethiopia. From the total area of the region 62.4% is located in Rift Valley Lakes Basin and 37.6% of its area is found in Genale Dawa river basin (Figure 31). The region comprises one lake, swamps, major and minor rivers and small ponds. Though the region contains a number of perennial rivers of high surface water potential, uneven spatial and temporal distribution of the available water resources either demand huge investment to develop and extend to the water scarce areas or constrained the utility at required time and place. This is again due to the fact that most perennial springs and streams exist only in the highlands, whereas there is hardly any surface runoff and perennial springs and streams in areas below 1500 meters above sea level (masl) that comprise the majority of the region. Even the groundwater which distributed in the lowlands of the region could not be appropriately developed and utilized because of financial and available technology problems. Such failures in developing and utilizing the region's water resources and mismanagement to the sparsely available water have already been reflected as a root cause for overall environmental degradation.

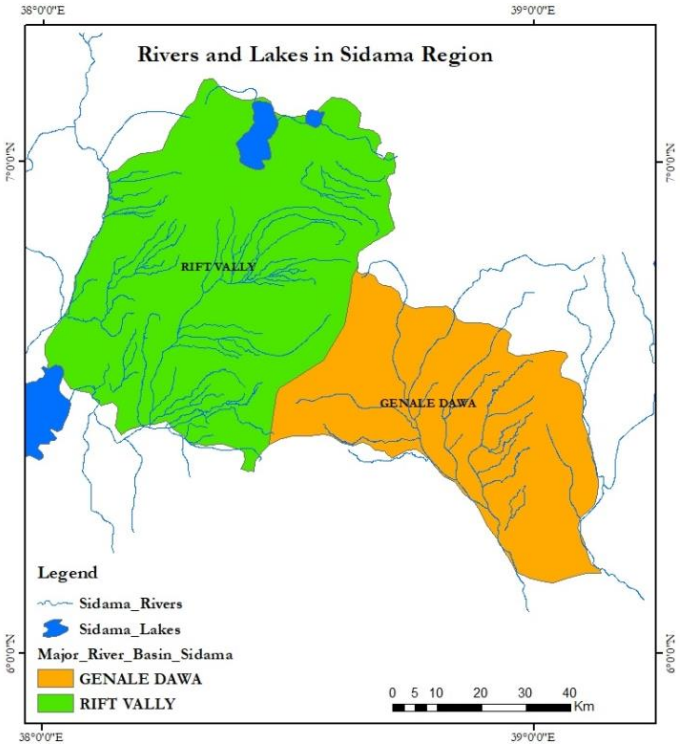


Figure 31 River Basins, Rivers and Lakes of Sidama Region

Table 19 Major Rivers found in the region

Name	Origin	Destination
Bilate	SNNPR	Lake Abaya
Gidabo	Sidama	Lake Abaya
Laga Dara	"	Gidabo
Ererte	"	Ganale
Logita	Oromiya	Ganale
Gambelto	Oromiya	Ganale
Hamile	Oromiya	Oromiya
Genale	"	Oromiya
Kolla	Sidama	Gidabo
Bonora	"	Ganale
Jigessa	"	Gidabo
Kado and Boga	"	Lake Hawassa

There are many admirable rivers and waterfalls in Sidama National Regional State. Logita, Galana, Gange, Genale, Morodo, Gambelto, Hamile, Asarado, Bo'nora, Gidabo, Ererte and Qinqamo are the rivers which have very interesting water falls with beautiful colours. Most of the rivers in the Region are originated from Garamba and Galalla mountains in Arbegona and Gorche Woredas. Logita and Galana water falls are found at the same topography close to each other. Logita water fall is found between the administrative boundary of Bona Zuriya and Bensa woredas. Whereas, Gelana water fall is found in Bona Zuriya woreda. These two rivers after creating waterfalls join or create a confluence (Timo) and after that they left their former names and form a river called Genale which is part of the main Ethiopian river basin (Genale Dawa). The Galana fall creates natural fountain on its step by step natural setting. Logita and Galana falls are accessible to visit in all the seasons. The other astonishing or amazing fall is Bo'nora fall around Daye Town in Bensa Woreda. This fall is the widest fall in the Sidama Region. It is located at 133 km and 408 km distance from Hawassa and Addis Ababa respectively.

Hot springs

The Region is on the floor of the Great Rift Valley and characterized by active and dormant volcanoes. As a result, Hawassa, Yirgalem, Wondogenet, Loka Abaya and Dara Woredas have got a number of thermal springs. There are more than 10 thermal springs in Loka Abaya woreda, around Loka Abaya national Park, 10 hot springs in Yirgalem Town Administration, 2 hot springs in Dara Woreda and 8 hot springs in Wondogenet woreda. Wondogenet, Gidabo in Yirgalem Town and Macisho Riftvalley in Dara hot springs are well established hot springs in the region by their services for the foreign tourists and local communities. The other 7 hot springs in Wondogenet woreda are serving local society in Wondogenet, which is found at 20km distance from Hawassa city. From those, only one thermal spring is facilitated to service with Olympic size swimming pool and individual bath and steam rooms. Out of these, Chiqa thermal spring uses local as steam for health purposes by local community.

Water scarcity

Water scarcity refers to the situation where the potable, unpolluted water is lower than the demand in the region. According to recent reports, nearly 1.2 billion people of the world lack access to clean drinking water. From this amount the majority of people found in developing countries and Ethiopia is one of the countries suffering from the water scarcity. In Sidama region various woredas like Boricha, Hawassa Zuriya, Bilate Zuriya, Darara, Lokka Abaya and Shebedino are mainly suffering from the water scarcity. Furthermore, the other remaining woredas are also encountered water scarcity partially. The livelihood of these woredas depends on the rainfall and rainfed agriculture. Water shortages in the region are causing a variety of illnesses which can range from food poisoning to cholera. Typically, water scarcity in the region is driven by two important factors such as the increasing use of freshwater due to high population growth and depletion of usable freshwater resources. Furthermore, the scarcity can be of two types which are physical water scarcity and economic water scarcity. Physical water scarcity is caused when a natural water resource is unable to meet the demands of a particular region where the physical lack of water available to satisfy demand exist. Economic water scarcity is caused by the mismanagement of sufficiently available water resource where the lack of infrastructure development that controls storage, distribution and access exist.

About 31 percent of Ethiopian population (32 million) relied on unsafe water for their daily needs, according to the Joint Monitoring Programme (JMP), a global database of water, sanitation and hygiene data. The people who are living in water scarce woredas in the region are expected to travel more than an hour to retrieve safe water. They buy one Jerrycan (20lit) of water by 15 birr which is highly expensive related with 1 birr of price in urban area. More than 62 million people live without basic access to safe drinking water in Ethiopia. In fact, Ethiopia alone accounts for 7.5 per cent of the global water crisis.

The demand for drinking water in rural areas is mostly fulfilled using groundwater through shallow wells, deep wells and spring wells. Those who have no access to safe water supply, usually obtain water from rivers, unprotected springs, artificial ponds and hand-dug wells. Several rivers found in coffee belt of the region are highly polluted which makes it unfit for drinking, and household purpose.

Figure 32 Group of peoples waiting to fetch water in Bilate Zuriya woreda

5.2. Driving force for Water Scarcity

The main reason for water scarcity in the region is climate change, fast population growth, uncontrolled urbanization and industrialization and poor waste management practices. The rivers in Sidama region especially in coffee livelihood belt are simply used as a receptacle of wastes from wet coffee mill whereas the Hawassa Lake in the capital of the region are simply receptacle of wastes released from the city. The major causes of water shortage are climate change, natural calamities such as droughts and floods, increased human consumption, overuse and wastage of water, a global rise in freshwater demand and overuse of aquifers and its consequent slow recharge.

5.2.1. Climate Change

Ethiopia is, relative to many African countries, richly endowed with water resources; and water is the vital resource for national development prospects. Despite overall abundance, irregular spatial and temporal distribution makes water an extremely scarce resource in some parts of the country and in certain times of the year. The fact that Ethiopia has one of the lowest water storage infrastructures in the world (World Bank, 2006) contributes to the challenge of inter-temporal variability in water availability. Water resources are inextricably linked with climate, so the projected climate change has serious implications for water availability. Although rainfall is projected to increase in parts of East Africa including over the Ethiopian highlands because of climate change, evapotranspiration will also increase due to a rise in temperatures, thus reducing the benefit of the increase (IPCC, 2013). Projected rise in temperature and increased variability in rainfall due to climate change will adversely affect water resource systems. Ethiopia's rainfall is highly variable in space and time.

A large part of the region (~70.62%) is believed to be kola and Woina Dega. Water availability in these kolas and Woina Dega regions is particularly sensitive to changes in rainfall and evapotranspiration amounts and temporal patterns. Thus, a reduction in amount or reliability of rainfall or an increase in evaporation will exacerbate the already serious shortage of water in many places and dry months of the year.

Climate change impacts on river flows show mixed results. Increased rainfall variability due to climate change, which is more likely to occur, can cause shrinkage of wetlands in some parts, affecting breeding sites of some bird species and other biodiversity. On the other hand, drainage density could increase because of the predicted increased heavy rainfall events, contributing to

drainage efficiency, soil erosion, and floods hazards. In general, the combined effects of climate change and increasing water demand to be expected from population growth and economic development indicate that water resource management will present special challenges of meeting competing demands for water.

5.3. Pressure for Water Scarcity

Population increase has a profound impact on the already vulnerable status of water scarcity within the region. The region is the most densely populated region in the country. Population increase and lifestyle changes increase the demand for water supply. The irrigation water demand for food security is also another pressure exerted for water scarcity. Peoples living in the upstream catchment of the rivers are using the river water for irrigation intensively and cause those who are living the downstream of the river for water scarcity for irrigation. Moreover, climate change is the most important pressure causes changes in rainfall patterns and extreme events are likely to increase in the future. Climate change will have severe impacts on water resources and freshwater availability in the region due to inundation of land, change in rainfall patterns, and increase in frequency of extreme events such as the El Nino.

5.4. Impact of Water Scarcity

Health professionals contend that in Ethiopia, 70% of all diseases and 40 to 60% of all skin diseases are caused by lack of adequate potable water. Seventy precent or over 45 million of the Ethiopian population does not have access to potable water supply and relies on untreated and unprotected supplies from rivers, lakes, ponds, and springs.

Besides the direct effect of consuming poor-quality water, rural women carry heavy loads over long distances and difficult terrain to reduce the number of trips required to provide water for their household. Carrying heavy loads damages the spine, causing difficulties during pregnancy and childbirth, uses up substantial energy, and is a cause of frequent accidents.

Floods and droughts are also the primary water related hazard in the region which are associated with rainfall extremes. Boricha, Loka Abaya, Hawassa Zuriya and Bilate Zuriya woredas are facing these hazards due to rainfall extremes. The extent of exposure to the two extremes is growing due to increase in the population in the vulnerable areas, construction of industrial activities in flood prone areas, and growing frequency and severity of the extremes due to climate change.

5.5. Water Quality Degradation/Water Pollution

5.6. State of Water Quality in the Region

The water quality of rivers and lake in Sidama Region is remarkably getting deteriorated due to land-use and land cover changes because of agricultural land expansion, an increase in investment in river and lake shore. The base flow of the rivers is getting decreased due to the increased consumption of river waters for irrigation and other purposes. Water quality assessment in few rivers showed that there was an increase in mineral content, likely because of agriculture inputs, and mining activities from river surface. Nutrient concentrations were found to be highest in crop cultivation area, while organic matter was most abundant at the river's source and mouth in the wetlands around Lake Hawassa. The highest concentrations of sediments from the cultivated as well as degraded land and fluoride were found in Lake Hawassa. Moreover, the wastewater generated from coffee processing has high concentrations of organic pollutants like pectin, proteins and sugars (Dadi et al., 2018) has been affecting the rivers' water quality. Due to high pollutant content, its disposal without treatment in water bodies has become undesirable due to the danger this poses for the water bodies and to human health. Disposing untreated coffee wastewater into local water bodies polluted the downstream water sources and people residing in the vicinity of the wet coffee processing plants. This polluted water causes the people living in the downstream suffer from different types of diseases.

5.7. Driving force for Water Pollution

The driving forces for the water quality degradation of the region's surface water resources (Rivers and Lakes) are population growth (2.9%), coffee processing wet mills, agricultural expansion, deforestation, livestock raising, mining (sand and pumice) from the lake's and the rivers' watersheds. The highlands areas of the rivers watersheds are favorable for agriculture, pastoralism and wildlife activities, whereas the mid and the lowlands areas of the rivers watersheds are favorable for coffee production which attracts an increasing number of investment and location of service providers such as Hotels and Hospitals near the lake are also causing the water quality to be degraded..

5.7.1. Growing Population and Agricultural Expansion

It's obvious that the growing population is the root of all anthropogenic activities and resultant pressures exerted on the rivers basin land and water resources in the region. Agriculture intensification and expansion can be considered the largest driving force in the region for water

quality degradation. These require land cover conversion, especially deforestation and reduction of shrub land, water abstraction for irrigation, water access and biomass competition with wildlife, agrochemical pollution and excess nutrient discharge. Since crop cultivation in the lowlands are mainly restricted by unreliable rainfall, pests and soil infertility, deforestation for agriculture is mostly occurring on the highland forests and arable land expansion for agriculture is concentrated in the upper midlands and upper lowlands along the river. Growing population and demand for cultivation land have been rapidly driving the large-scale conversion of forests into agricultural lands.

5.7.2. Coffee Processing Wet Mills

The coffee processing wet mills are another driving force for rivers' water pollution in Sidama Region. There are about 383 functional coffee processing wet mills in Sidama Region. All wet coffee processing plants in Sidama Region are constructed close to rivers and streams. This is because a lot of water is needed for washing the beans, removing the pulp and the mucilage. The coffee processing wet mills use the water bodies for direct disposal of the wastewater released from the wet coffee processing plants. While there are some wet coffee processing plants that use disposal pits to stabilize the generated wastewater, these disposal pits are constructed without following the correct design and dimensions. In addition, they lack the proper linings to protect against leakage of the effluents into the underground water and the holding capacity of the disposal pits is not taken into consideration during construction. Thus, the coffee processing water and its wastewater are routinely discharged into nearby streams and rivers.

This practice in coffee production involves hand-picking of ripe coffee cherries, followed within a few hours by manual selection to eliminate defects and mechanical pulp removal. After the skin and pulp of the ripe coffee cherry are eliminated by pulp removal process, the coffee beans retain a sticky, firmly attached mucilage layer that must be removed prior to drying and storage. The mucilage-coated beans are generally placed in an open tank, where natural fermentation is allowed to proceed for 10-48 hours. At some point the fermentation process has loosened the mucilage from the bean surface, such that it can then be washed away with water. The clean beans are moved to a patio on the farm, where they are sun-dried to approximately 40% water content. In most cases, they are then sacked and quickly transported to hotter and drier locations. After further sun-drying to approximately 12% water content, the beans are sufficiently stable for storage prior to export as green coffee.

The process described above includes discharge of large amounts of wastewater resulting from the various processing steps: sorting of cherries by flotation, pulp removal, and washing of the beans after fermentation is complete. Overall, this water is acidic, deoxygenated, and laden with suspended solids and organic material from the pulp and mucilage. In all wet mills the wastewater is simply stored in large ponds and then discharged into the nearest stream or river. Almost all the rivers in coffee producing livelihood belt of Sidama Region are being polluted by the effluent from the coffee processing wet mills. To give an example; as the report (December 2021) of TechnoServe Ethiopia (Non-governmental Organization) depicted that there are about 87 wet mills along the kola rivers, as well as other neighboring rivers including the Malawo, Jigesa, Raro, Bisandima, and Chico rivers in Aleta Wondo woreda. These wet mills are even the one got support from the organization.

Figure 33 Coffee processing wet-mill, washing process Lagoons filled by wastewater in Shebedino woreda (TechnoServe Ethiopia)

TechnoServe Ethiopia depicted that approximately 600 million liters of effluent were discharged into the rivers of the Sidama region as a result of poor waste water management and overconsumption of water during the coffee processing season. This polluted water is then used as source water for communities and wet mills downstream. This problem is becoming so acute that

legislation was introduced to prevent wet mills from being constructed within five kilometers of one another in an effort to limit the production of waste water.

5.7.3. Industries and Factories

Various industries and factories found in the region are major cause for water pollution. In Hawassa city the effluent from industrial parks, the effluent from Etab Soap industry, effluent from Brewery factory, effluent from Pepsi factory and other factories are the sources for the deterioration of Hawassa Lake water quality. However, the amount and the type of effluent were not studied yet and we didn't find the data to quantify the amount of the effluent from these industries and factories.

5.8. Pressure of Water Pollution

The extensively growing population led to increasing water demand for domestic use, agriculture, livestock, and industries, which reduced the reserve flow for environment baseline and wildlife. Farmers use water from the nearby rivers for irrigation and coffee processing wet mills also uses river waters intensively during the coffee harvesting season. Moreover, farmers living near Lake Hawassa also use the lake water for irrigation. Due to the lack of capacity to enforce the water abstraction permit, the total amount of water used for irrigation and coffee processing wet mills might be much higher. These activities usually peak during dry season, which exerts more stress on the water supply in the region. Based on field observation water resources availability and demand in the region was found to be highly stressed and the water quality was getting deteriorated.

Land use and land cover changes due to deforestation, agriculture expansion and unfathomable natural conversion also have impacts on the water quality and environmental flow of the region's water resources. A decrease in closed forest land, shrub-land, and grassland because of an increase in cultivated land and an increase in sediment flow due to erosion of cultivated land cause the water quality deterioration. The faster runoff caused by vast land cover change eroded the catchment and led to high sediment load into receiving water bodies. Waste water generated by the increasing population and anthropogenic activities such as agriculture, livestock, industrialization, and sand mining in the region's water resources have adverse impacts on the quality of surface and ground water resources. The most important pollutants determined in the region's water resources include nutrient, pesticides and sediments from agriculture and heavy metals and toxic chemicals from industry zone. High load of sediments during rainy season from agricultural and degraded land are

the most important pollutant of the lake's water resources. During dry season, the low flows can even aggravate the pollution and nutrient concentration in the river.

According to Zigde et al., (2019) the concentration of potassium range from 53.2 ± 1.56 mg/L to 89.1 ± 2.54 mg/L with an overall mean concentration of 74.8 mg/L. This value is higher than WHO (2008) standard. This highest level of potassium might be due to the effect of hospital effluents, septic system, and other anthropogenic activities apart from the natural sources (Admasu, 2015). Copper concentration of Lake Hawassa ranges from 1.40 ± 0.11 mg/L to 18.2 ± 0.82 mg/L with an overall mean concentration of 6.04 mg/L. And this value exceeded WHO limit for drinking purpose. Moreover, high levels of copper were recorded at some points of the lakes are ranging from (18.2 ± 0.82 mg/L) and (15.16 ± 0.78 mg/L). And these might be due to incineration of waste, industrial discharge, sewage disposal and antifouling paints. Chromium concentration ranges from 0.173 ± 0.01 mg/L to 0.665 ± 0.07 mg/L with an overall mean concentration of 0.380 mg/L. And this value exceeded WHO limit for drinking purpose. These might be due to industrial discharge from pigments, paints, ceramic, glass and leather tanning industries (Zigde et al., 2019).

5.9. Impacts of Water Pollution

The land cover and land use changes, flow regime, and deterioration of water quality in the region's water resources have impacted both human well-being and ecosystem. In the highlands and midlands of the region, the expansion of cultivated land caused pastoralists difficulty in supporting their families and increased their vulnerability to drought and causes cattle to suffer a lot due to lack of cline water to drink. The lower water levels during dry season caused by land cover changes not only affect pastoralists but also people whose livelihoods depend on agriculture. Loka Abay Woreda is the one suffering from lack of adequate clean water resource for cattle as well as for human. Flow regime changes cause faster surface runoff from the catchment which decelerates water infiltration into subsurface layers and decrease the groundwater recharge. As a result, soil erosion and degradation are enhanced resulting in decrease in base flow of the rivers. Nutrient concentrations in the lake exceed natural levels, and apparently lead to eutrophication. The source of this eutrophication is unfathomable, but agriculture is presumed to be the main driving force since the highest nutrient concentrations are found in the most intensive agriculture area near the lake shore. Pollution is also a growing risk in the region. This is primarily attributed to rapid urbanization and industrialization, limited capacity of the regularity institution to enforce pollution prevention, and

underdeveloped urban wastewater systems. The most vulnerable water body is in the region is lake Hawassa. Moreover, sand mining activities in Lake Hawassa watershed are often conducted in perilous manner which might cause high sediment load. Since the region is new and on the process of organizing data for various purposes, we didn't find the relevant data to describe all the impacts in figurative/numerical way.

5.10. Response to Water Pollution

The region is working with international NGOs to reduce the rivers water pollution of the rivers. The TechnoServe Ethiopia has been started working with the region to support wet mills to implement innovative waste management solutions to prevent both wastewater and coffee pulp from being released in the rivers. After its three-phase program in which the project supported 87 wet mills along the kola rivers, as well as other neighboring rivers including the Malewo, Jigesa, Raro, Bisandima, and Chico rivers. TechnoServe continued to work a three-year period (2019-2021) to improve wastewater treatment at an additional 20 wet mills in Dale and Shebedino Woredas of Sidama region through the installation of pulp separation and Vetiver grass wetlands to treat and filter wastewater. Consequently, 11 new wetlands were established in 2019, and an additional 11 wetlands in 2020. The project provided technical support and management to make the wetlands fully functional.

5.11. Outlook to Water Pollution and Scarcity

Degradation of the water quality of lakes and rivers because of urban, agricultural and industrial source pollution is becoming a major problem. City and towns in the region should establish organized waste disposal systems. Nevertheless, some of the damages, like the impact on the aquatic resource systems could be irreplaceable unless vulnerable water bodies are identified, management plans developed and implemented. Moreover, Hawassa Lake, which the base for the beauty of the city, will be disappeared due to sediment load if the management plan is not implemented. The urban wastewater management strategy developed by MoWIE, (2017) should be implemented well. When this is fully implemented, the pollution into the rivers and lakes is expected to reduce substantially. Reservoir siltation will continue to be a problem and storage capacity of Lake Hawassa will quickly decline unless the land husbandry practice is transformed guided by appropriate land policy and planning. The current watershed development through community mobilization campaign should be transformed into a land husbandry culture applied to every parcel of land by the

landowner by following the conditions set in the land use right of landowners. The coffee processing mills in the region should be given a clear and regulatory guideline not to pollute the rivers water and wastewater management plan should be developed regarding the river water use for the coffee processing mills.

SECTION SIX

6. Forest

6.1. Introduction

Forests play an important role in environmental protection, including protection against soil erosion and sedimentation and in controlling water flow, floods and water quality. The loss of forest cover due to unplanned harvesting or land use conversion will result in serious consequences. Forests are very important in reducing surface water flow and increasing infiltration. Sidama forest estimated the total natural forest area to be 35,952 ha 5.1% of the total area of the region, woodland and shrub land cover 18800.3ha 2.6% respectively.

The main threats to forests, highlighted in the 2013 report of the sector, were deforestation exacerbated by high population growth and a growing demand for crop and grazing land, forest products, particularly fuel wood, charcoal and construction wood; resettlement, and recurrent droughts because of extreme weather conditions. Furthermore, the environmental outlook highlighted the following issues and constraints, concerning forest conservation and development:

- Poor valuation of forest and woodland resources;
- Under-development of non-timber forest products;
- Ineffective monitoring of forest resources;
- Limitedinvolvementoflocalpeopleinthemanagementofforestandwoodland;resou rces, Lack of off-farm employment opportunities;
- Gap between sustainable yield supply and demand of forest; products, Weak policy and regulatory frameworks; and
- Inadequate institutional arrangement and capacity.

The threats and issues, the government realized the need for a new management strategy to guide efforts aimed at protecting the remaining forests and promoting reforestation. In view of emerging climate change risks and the need for a national action, the government has initiated a number of climate change mitigation/adaptation strategies/plans that integrate forestry actions. More specifically, the Government of Ethiopia invested in the following actions to reverse the rate of deforestation and forest degradation:

- Decentralized forest management with a focus on the participation of people living within and around forests, and those depending on forest products for their livelihood; Promoted the integration of forestry with other land uses, and facilitated sectorial integration for sustainable development FDRE, 2007);
- Formulated the Conservation Strategy of Ethiopia, the Ethiopian Forestry Action Plan, and the National Action Plan to Combat Desertification and promote the development and proper utilization of forest resources;
- Developed and implemented programs and plans for sustainable use and development of forest resources; Developed policies to encourage and attract private investment in the forestry sector (FDRE, 2007);
- Strengthening national capacity and institutional framework to reduce GHG emissions from deforestation and forest degradation, and access potential benefits from a future international REDD+ mechanism (R-PP, 2011);
- Building a climate resilient economy through support for adaptation at sectorial, regional and community levels; including improving agricultural productivity and livelihood diversification, crop and livestock insurance mechanisms, grain storage, and renewable energy. (EPACC, 2011);
- Protect the country from the adverse effects of climate change and help realize its development goals through building of a green economy across sectors including the protection and re-establishing forests for their economic and ecosystem services as well as carbon stocks (CRGE, 2011);
- Implementation of sustainable land and water management practices, reducing GHG emissions from land use change, and increasing carbon stocks in biomass and organic soil; reduce land degradation and improve land productivity in selected watersheds in targeted regions in Ethiopia (SLMP I, 2008 and SLMP II, 2013); and
- Reducing GHG emissions with actions that includes among others, the use of renewable energy resources; implementation of agro-forestry practices for livelihood improvement and increased carbon sequestration and forestry projects targeted at reducing deforestation and forest degradation and increasing carbon sequestration through reforestation of degraded areas and sustainable management of existing forests (FDRE, 2010, NAMA)

These developments have been instrumental in bringing increased emphasis to the forest sector through formulating and reviewing policies; increasing investment in institutional capacity building; improving community-based management of forests; conducting comprehensive studies and developing plans that guide forest development.

6.2. State and trends of forests

6.2.1. Forest types

Ethiopia is endowed with diverse agro-ecological zones, ranging from temperate and moist tropical highlands to hot and arid lowlands, which support diverse forest types and livelihood systems.

Potential Aggregated Forest Types

Driven by the CRGE strategy and as part of Ethiopia's REDD+ program implementation, Ethiopia's forests were aggregated into four biomes. The aim of this classification is, to better represent reliable carbon stock estimates based on homogenous carbon contents of the different forests and woodlands, by building on the potential vegetation map of Ethiopia released in 2009 and 2010 (MEFCC 2016a). A description of the characteristics of species and the state of human disturbance in natural forest vegetation of Ethiopia based on the aggregated biomes is found in MEFCC (2017).

6.2.2. Forest Cover

Over the past 10 years, the status and trends of Ethiopia's forests have been influenced by the following factors: institutional streamlining; internal capacity-building at the federal and regional levels; high staff turnover; development and implementation of polices, programs and laws; socio-economic, bio-physical and climatic conditions; livelihood strategies and outcomes; planned economic growth and development initiatives; and relentless deforestation and forest degradation.

Sidama region Finance and economy development bureau (2012) forest resource assessment based on reports and analysis of regional forest resources with its own methodology, puts Sidama region forest cover at 122,360 million ha 17.5% of the total land area.

Figure 34 Natural forest on hula woreda

6.3. Forest Resource Base

Sidama region forest resources, including natural forests, riverine forest, woodlands, and trees on farms provide goods and services that have economic, ecological, and social value. Furthermore, forests are important for maintaining the health of protected areas and thus for the conservation of biodiversity. The total land area of region is 6992 km2 of this; the total natural forest area was estimated to be 35,952ha, 5.1% of the land. The woodland was estimated to cover 18,800.3ha, 2.6% of the total land area, and plantation land 55957.7ha, covering 8% of the total land area and bamboo forestland 11650ha, covering 1.6% of the total land area. Sidama region Finance and economy development bureau (2011) MEFCC recognizes that there is lack of consistent and reliable data on the area coverage, standing stock, growth rate, production, and productivity of forest resources.

Ethiopia has no standardized forest inventory system in place and no information about the growing stock and increment rates of the remaining forests (Yitebitu et al., 2010). Later in 2013/14 with the emergence of the REDD+ program, Ethiopia has initiated a process for the establishment

of a National Forest Monitoring System (NFMS). In the subsequent years, the country concluded a national forest inventory following a standard procedure and put in place a system for subsequent monitoring in the future. Consequently, estimates of forest area, growth rate, total volume, etc. from different sources vary considerably.

Table 20 Estimates of the current forest cover of the region (Sidama regional Finance & Economic Development Bureau, 2012 E.C.).

Forest types	Area (ha)
Natural Forest	35,952
Dense wood	18,800.3
Plantation	55957.7
Bamboo	11650
Total	122,360

Plantation forests

Plantation forests, comprised mainly of exotic tree species, include woodlots industrial and peri-urban stands used for the production of fuel wood and poles. The oldest industrial plantations were established mostly during the 1970s and 1980s and most of them are over-mature.

The total area of plantation forests in Sidama region is estimated to be 55957.7 ha with an estimated potential short-term wood flow of 268,596.9 m3 per year for industrial wood consumption (World Bank 2016). Out of this, about 23% is commercial (industrial) plantation owned by the State through its regional forest and natural resources bureaus. Farmers and communities own the bulk of plantations (eucalyptus woodlots). Private woodlots are rapidly expanding and are making significant contribution to annual wood production. After natural high forests, they are the major sources of domestic wood production and supply, particularly wood used for fuel, poles, scaffolding, and furniture.

Non-timber forest products

Non-timber forest products (NTFP) contribute to food security, and maintain rural livelihoods for millions of households. NTFPs, including, honey, gum and resin, spices, and forage provide huge economic benefits to a considerable number of people. Fodder from forests provides 10% and 30% of the livestock feed during wet and dry seasons, respectively. Similarly, many edible wild plants

serve as supplementary sources of food during times of critical food shortage (Institute of Biodiversity 2015).

The NTFPs, obtained from Ethiopia's forests, include forest coffee, honey, bees wax, spices, wild food, traditional medicinal plants, gum and incense, bamboo, fodder, firewood, charcoal, farm implements, and climbers. The production and monetary value of selected NTFPs

Medicinal plants

In Ethiopia, traditional medicine plays an important role in the health care system. It is estimated that more than 80% of the population relies upon traditional medicine due to 1) cultural acceptance 2) relatively low cost and 3) lack of access of modern health facilities. The Sidama people have relied on plants to treat illnesses and diseases for generations. Spiritual practices play a large part in the healing process and have been integrated with the knowledge of medicinal plants. This indigenous knowledge has been passed down through generations, but is facing the threat of being lost due to cultural change and declining resources for natural medicinal products. The preservation of traditional practices is not only important in ensuring the continued access to medicine, but also for the preservation of the Sidama culture (Handbook of Sidama traditional medicinal plants 2017).

Fodder

Woodlands and shrub lands are major grazing sites and sources of fodder for Ethiopia's livestock population. Forests and woodlands provide 11% and 17.5% of total feed requirements for livestock during summer and winter, respectively, for the estimated 35 million TLU, which is equivalent to 70 - 80 million herds in Ethiopia. Assuming a six-month dry and rainy season and an average of 3 kg of dry matter per TLU per day, the total fodder obtained from forests and woodlands of Ethiopia is equal to 14.2 million tons of dry matter per year.

6.4. The Contribution of Forests to the National Economy

Ethiopia's national GDP accounting system does not sufficiently reflect the contribution of the forestry sector (CEEPA 2010). This is because aggregate data on the production and monetary value of forest products and services are fragmented and inadequate. In addition, the existing system of national accounting lacks indicators that capture the value of Ethiopia's forest ecosystem services. Moreover, some of the goods obtained from the forestry sector, such as forest coffee, are included in the agricultural sector. Therefore, there is a need to revise the existing national accounting methods related to the sector by integrating indicators that value the ecosystem services provided by

the country`s forest resources. The contribution of forestry to the total GDP is estimated to be 4% in Sidama region report (EFCCA, 2013). However, a number of studies suggest that the figure does not fully capture the full contribution of the forest sector to the economy.

6.5. Drivers and pressures

6.5.1. Deforestation and forest degradation

A distinction is commonly made between proximate (direct causes) and underlying (indirect causes) of deforestation and forest degradation. Proximate causes (pressures) are human activities or immediate actions that directly impact forest cover and loss of carbon.

Underlying causes are complex interactions of fundamental social, economic, political, cultural, and technological processes that are often distant from their area of impact. These underpin the proximate causes and they operate at the local level or have an indirect impact from the national or global level. They are related to international, i.e., markets and commodity prices; national, i.e., population growth, domestic markets, national policies, and governance; and local circumstances, i.e., change in household behavior.

The report shows that the vegetation cover in other wooded land was declined by 465ha/year and forests expanded by 9089.2 ha/year in 2013, Finance and economic development bureau (2012). but this data contradict with country forest loss analysis.

It was in 2014 that MEFCC conducted a country wide forest inventory, which also analyzed the forest cover change (based on a new forest definition) between 2000 and 2013 using a combination of ground data and remote sensing data. According to this study, the gross forest loss is approximately 92,000 ha/year and the gain 19,000 ha/year with a net deforestation of ca. 72,000ha per annum (MEFCC, 2017). This indicates the huge imbalance between the rate of deforestation and reforestation in the region.

A detailed analysis of the drivers of deforestation and forest degradation across the country is provided in MEFCC (2017). The direct causes include the expansion of smallholder, fuel wood collection and charcoal production, free grazing by livestock, seasonal wild fires (largely human-induced), and illegal harvesting of poles and timber.

The underlying causes of deforestation and forest degradation in Ethiopia include population growth, limited governance and monitoring capacities of institutions; , insecure land tenure, unclear

or absence of benefits/income- sharing mechanism, poor law enforcement, inadequate coordination among sectors and seasonal unemployment, and/or underemployment.

The lack of guidelines and implementation procedures for implementing federal and regional forest proclamations exposes forests to illegal wood harvesting and extraction of other forest resources. The absence of tools, standards, directives or guidelines for determining the timeliness, reliability, predictability, and appropriate level of benefits, that need to accrue to local communities, engaged in participatory forest management, contribute to low outputs and poor outcomes of forest development initiatives.

In the long-term, an invariable process of deforestation exposes smallholder peasant agriculture to drought and eventually to significant reduction in the productivity of livelihood systems. This in turn creates underemployment and/or unemployment. Under such circumstances, people living in and around forested areas resort to illegal woodcutting for producing timber, fuel wood, or charcoal to augment their income. Consequently, a vicious cycle of natural resource degradation, food insecurity, and poverty is set in motion, causing increased vulnerability to extreme weather conditions and climate variability and change. Table 21 Direct causes of deforestation and forest degradation.

Table 21 Direct causes of deforestation and forest degradation

Drivers and Pressure	**Description**
Small-scale agriculture	Permanent and shifting cultivation in natural forest and woodland areas
Fuel wood extraction and charcoal production	Biomass energy accounts for more than 90% of the total domestic energy demand. Still significant proportions of urban households use charcoal for cooking. The high biomass energy consumption, along with inefficient utilization, aggravates deforestation, biodiversity loss and land degradation.
Logging (legal and illegal) for timber and lumber production	Private wood-based industries carry out timber extraction. Squatters and trace- passers also carry out illegal logging in high forests. Such practices are not guided and regulated because of weak law enforcement, and thus result in forest ecosystem degradation.

Forest coffee plantations	Coffee trees are planted after removing the forest undergrowth in the Lower strata (only leaving the high canopy shades) cause significant loss of biodiversity, disrupt the ecosystem functions, services, and reduce the forest productivity.
Free grazing of livestock	Increasing livestock population and continued shrinking of grazing lands promoted increased use of forestlands as grazing areas.
Infrastructure development	The road and rail network expansion, power infrastructure and industrialization are some of the important planned drivers of deforestation in high forest and woodland ecosystems.
Fire (wild and human caused)	Deliberate fire is used as a management tool in rangeland ecosystems. Wild and deliberate fires commonly rage in woodlands and high forest areas. In all cases, fire causes degradation by affecting the diversity and composition of species, structure, and primary productivity of the forests.
Droughts	Droughts affect vegetation diversity, composition, and structure. Extreme dry Climate causes fires, exposes the soil to erosion, and culminates in ecosystem degradation.
Pests and diseases	The experience in Ethiopia shows that there are very few incidences of pests and diseases on forests.

Table 22 Ranking of drivers of deforestation and forest degradation in terms of impact (Bekele et al. (2015) and MEFCC (2017))

Causes of deforestation	Level of impact
Expansion of traditional smallholder agriculture in forest areas driven by population growth of communities around forests	High
Population growth because of internal migration to forested lowland areas	High
Increased extraction of wood and other forest products following massive Population growth and the resultant demand for biomass to produce domestic energy	Medium
Forest fires related to raising livestock and making charcoal, due to poor incentives to local communities for sustainable forest use and weak forest protection.	Medium

6.5.2. Drivers of Deforestation and Forest Degradation in Various Forest Areas

Odi-boko and Bubisa Natural forest

Direct causes: unplanned human activities including: expansion of agricultural activities (small-holder farming, market driven crops and livestock rearing) into forest lands, unmanaged fuel wood and construction wood collection from the forest.

Underlying causes: policy implementation gaps, legal and institutional weakness, demography, market system, poverty, inappropriate land management practices, and capacity gaps.

Impact: Loss of biodiversity, acceleration of soil erosion and flooding, decline in quality and quantity of several other ecosystem services including GHG emission are some of the consequences.

Response: policy and institutional development reforms, establishment of Sidama Forest development, controlling and utilization addressing capacity and resources limitations; creating a sustainable financing mechanism to fill critical resource gaps and build the capacity of government and local communities to bring meaningful changes in the management of natural resources and forests in the Eco-region.

Halo natural forest

Underlying causes: natural increase in local population, increased demand for fuels wood

products, lack of off-farm employment opportunities, poverty and lack of credit availability, inappropriate emphasis on annual crops to the detriment of root crops, which are better, suited to high rainfall areas, breakdown in traditional institutions that promote environmental Protection and control access to natural resources, inappropriate crop and livestock production systems cause land degradation and increase demand for land, which in turn leads to deforestation.

Direct causes: increasing land requirements for annual crops, perennial crops, grazing land and settlement, expansion of managed coffee forest.

Loka Abaya national park:

Direct causes: (planned policy-driven actions and unplanned human activities) including: expansion of agricultural activities (small-holder farming, market driven crops and livestock rearing) into forest lands, unmanaged fuel wood and construction wood collection from the forest, and growing incidence of forest fires.

Underlying causes: policy implementation gaps, legal and institutional weakness, market system, poverty, inappropriate land management practices, and capacity gaps.

Impact: Loss of biodiversity, acceleration of soil erosion and flooding, decline in quality and quantity of several other ecosystem services including GHG emission are some of the consequences.

Figure 35 Loka Abaya National Park

6.6. Response to Forest Degradation

Policy and institutional development reforms, establishment of Forest and Wild animal; addressing capacity and resources limitations; creating a sustainable financing mechanism to fill critical resource gaps and build the capacity of government and local communities to bring meaningful changes in the management of natural resources and forests in the Eco-region.

6.6.1. Create stakeholder awareness and community mobilization

Community awareness will be developed through training and experience sharing within and outside the community those having best management practice on afforestation/reforestation. The capacity building work will last until the fulfills skill gap of the community and Stakeholders will be actively engaged on activities. Such afforestation program is not an easy task, so it needs wider stakeholder collaboration. To mobilize stakeholders there will be workshops. The workshop could also help to get missing idea for success of the program while it can help to engage stakeholders for sustainability of the task.

6.6.2. Reforestation and Limiting Forest Cover Loss

Since the establishment of MEFCC in 2013, the Government of Ethiopia is focusing on reinforcing the forest sector; rehabilitating degraded lands, increasing vegetation cover, and limiting the rate of deforestation in line with its CRGE (MEFCC, 2017a). The Ethiopia's national REDD+ Strategy (2016- 2030) further aims at increasing timber supply through community and private plantation

and promotion of area closure through the rehabilitation of degraded lands covering by vegetation (EFCCA, 2013).

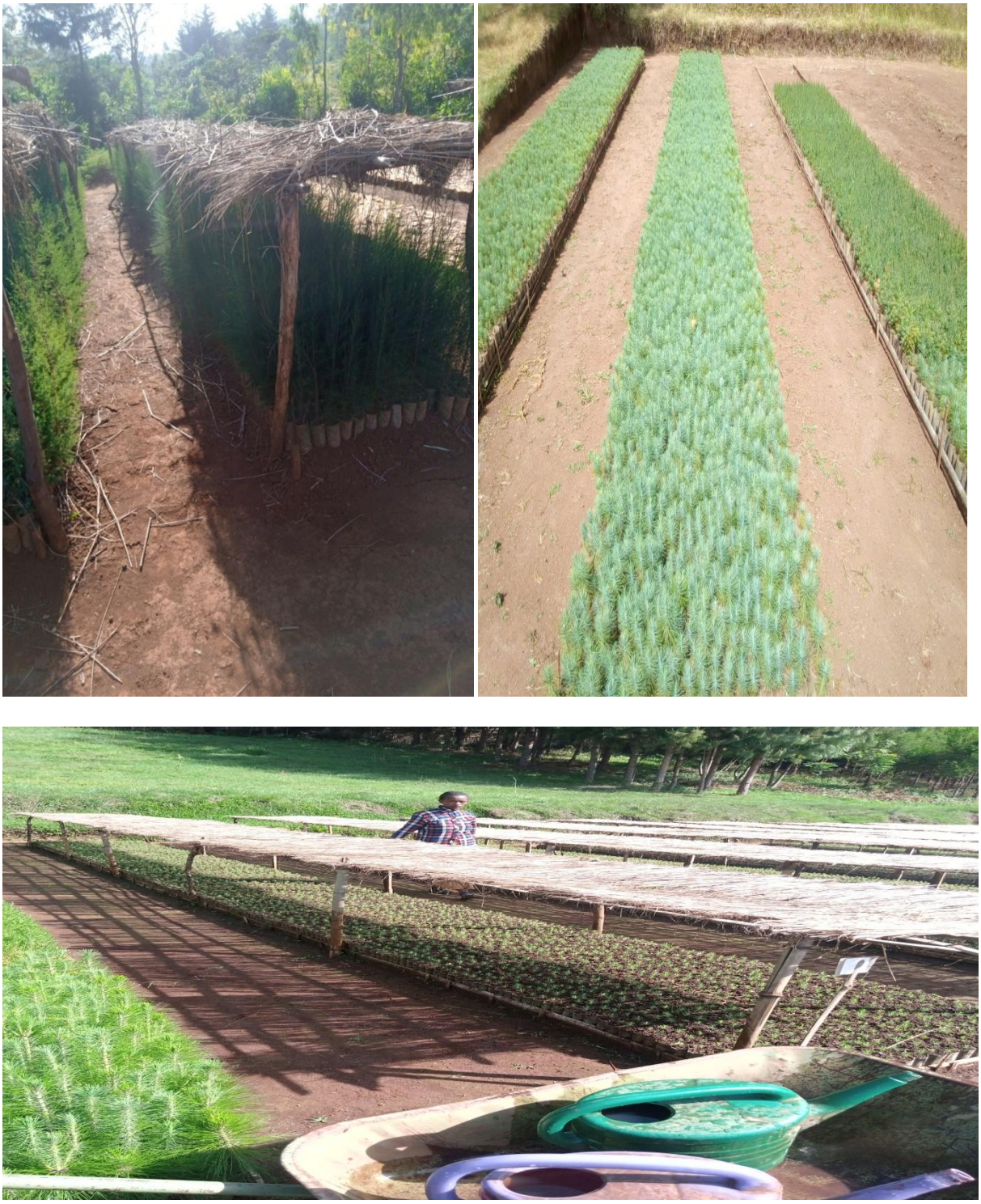


Figure 36 Nursery site on Darra Otilcho and Arbegona Woreda(2014)

6.6.3. Implementing Polices, strategies and plans

Forest Development, Conservation and Utilization Policy and Strategy (2007) has been formulated and implemented to meet public demand for forest products and foster the contribution of forests in enhancing the economy of the country through appropriately conserving and developing forest resources. The proposed actions of the policy and strategy as stipulated in specific objectives include: rendering technical assistance of farmers, pastoralists, investors and institutions engaged in forest resource development; enhancing the production of forest resources; identifying, rejuvenating, multiplying and distributing tree species that have multiple benefits; and maintaining the natural ecological balance by preventing threats, conserving and developing forest resources.

6.6.4. Reducing Greenhouse Gas Emission

Ethiopia has embarked on an ambitious green (low emissions) economy strategy, which has made forestry one of the pillars of the Climate-Resilient Green Economy (CRGE) growth and sustainable development path. The CRGE (2011) states in 2010, the estimated Green House Gas (GHG) emission from forests (because of human activities) amounted to 55 Mt CO2e. Forestry emissions are driven by deforestation to expand agricultural land (50% of all forestry-related emissions) and forest degradation due to wood consumption (46%)as well as formal and informal logging(4%).

SECTION SEVEN

7. Biodiversity

7.1. State of biodiversity loss

7.1.1. Introduction

Biodiversity in most simple terms means the diversity of life. The internationally agreed definition as per Convention on Biological Diversity (CBD) 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 of ecosystem"(CBD, 1992) .

Biodiversity is fundamental to sustaining life, supplying critical ecosystem services such as food provisioning, water purification, flood and drought control, nutrient cycling, and climate regulation. These services are essential to support human well-being and economic growth. Yet despite the significant economic, social and cultural values of biodiversity and ecosystem services, biodiversity worldwide is being lost, and in some areas at an accelerating rate.

Biodiversity secures various resources for our survival from uncontaminated water, air, and food to traditional and modern medicines. Biodiversity loss is not only an environmental problem, but it would also eventually turn to developmental challenge if left neglected. Development boosts is at higher risk due to loss of biodiversity loss. The uninterrupted biodiversity loss could lead to less nutrition, decreased wild foods, impoverished pollination, and subordinate and less irrepressible agriculture systems. This can further result in more vulnerability to Agri-chemicals, decreased traditional medicines access, less chance for development of drugs, further leading to surpassing disease strains.

Managing agricultural landscapes as well as enhancing plant biodiversity in agro-ecosystems is and will continue to be one possible strategy to preserve biodiversity, ensure an ecosystem service supply and sustain agricultural productivity.

State of Biodiversity

7.1.2. Ecosystem diversity

The status and trends of ecosystems, plants, animals and microbial biodiversity in the region are described below.

7.1.2.1. Forest Ecosystem

Moist Mountain Forest Ecosystem is found mostly on the Southeastern parts of Sidama region with altitudinal range between 2800m and 3360m (Figure 37). The mountain is surrounded by bamboo forest; and it is convenient for tourists who have mountain trekking hobby. There is an attractive topography round the foot of the mountain. One can watch Garamba Mountain from here, and comprises the high forests of the region. The mountain is home for various wildlife and bird species. Human activities such as timber extraction, small-scale agriculture and grazing expansions and settlement are the major threats to this Forest Ecosystem. Regional governments are taking measures to manage and maintain the Forest Ecosystem.

Figure 37 Garamba Mountain forest (Sidama Region Culture,Toursim & Sport Bureau)

7.1.2.2. Wet land ecosystem

Wetland ecosystem consists of areas of swamps, marshes, flood plains, peat land or water, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters. Wetlands mitigate floods, protect coastal areas from storms, improve water quality, recharge groundwater aquifers, serve as sinks, sources, or transformers of materials, and produce food and goods for human use. When evaluating the economic value of these various functions, Costanza *et al.* (1997) concluded that the economic value provided by wetland ecosystems exceeded that provided by lakes, streams, forests, and grasslands and was second only to that provided by coastal estuaries. Wetland ecosystem

is threatened by conversion into agricultural lands; especially for rice production, over exploitation of wetland resources, deforestation, soil erosion and land degradation, siltation, settlement, climate change and pollution. For example, Cheleleka and wondogenet district wetlands in Sidama national regional state are highly affected by Agricultural expansion and urbanization use and plantation forest (EFCCA, 2013).

Figure 38 Cheleleka Wetland

7.1.3. Aquatic ecosystem

Rivers, reservoirs and lakes are included in the aquatic ecosystems. The big rivers and their tributaries forming the drainage systems of the country support riverine forests. The vegetation in this ecosystem consists of taller trees and riparian woodlands along flowing water in areas below 1800 m (Friis et al., 2010). Human activities affecting aquatic ecosystems are more likely to disrupt natural patterns and processes because species do not have the ability to adapt to the rapid changes to their environment that can occur. Aquatic ecosystems in Ethiopia harbor various species of mammals such as Hippopotamus, and birds, reptiles, amphibians, fishes, and invertebrates. Several microorganisms such as bacteria, fungi, algae, and protozoa also exist in this ecosystem. This ecosystem also serves as a feeding and breeding site for a large number of resident and migrant birds such as Flamingos, Ducks, and other birds. The ecosystem is under threat from anthropogenic factors such as pollution, overexploitation of fish stocks, invasive species such as deforestation, soil erosion, and land degradation. Despite this, conservation efforts towards safeguarding aquatic ecosystems of Ethiopia are minimal (EBI, 2015).

7.1.4. Plant Diversity

The majority of the Sidama who live in areas with temperate and semi-temperate types of climates subsist on mixed agriculture as means of livelihood. The diversity of cultivated plants in sidama is enset (Ensete ventricosum), and coffee (Coffea arabica), along with varieties of fruits and vegetables, is a key staple diet of the people. The region is also a center of diversity for species such as wheat (Triticum sp.), barley (Hordeum vulgare), and chat (Catha edulis). Species richness varies across forests, depending on environmental factors characterizing the forests. (EBI, 2016).

Table 23 Some of Plant diversity list in the region

No	Local name	Botanical name	Family	Habit
1	Qaraaro	Acokanthera schimperi (A.D Schweinf.	Apocynaceae	Shrub
2	xonxolooma	Allophyllus abyssinicus (Hochst) Rodalkofer	Sapindaceaea	Tree
3	Doongiicho	Apodytes dimidiata E.Mey ex. Am.	Icinacaceae	Tree
4	Qolcooma	Arisaema flavum (Forssk.) Schott.	Araceae	Herb
5	Bohe	Diascorea abyssinica Hochst.ex Kunth	Dioscoreaceae	Climber
5	Gidiincho	Ehretia cymosa Thonn.	Boraginaceae	Tree
6	Olooncho	Ekebergia capensis Sparrm.	Meliaceae	Tree
7	Odakko	Ficus sur Forssk.	Moraceae	Tree
8	Qilxo	Ficus vasta Forssk	Moraceae	Tree
9	Daanshiicho	Galiniera saxifraga (Hochst.) Bridson	Rubiaceae	Tree
10	Garbicho	Prunus africana (Hook.f.) Kalklm	Rosaceae	Tree
11	Leemmicho	Yushania alpina K. Schum	Poaceae	Tree

7.1.5. Cultivated Plants

Although the majority of arable land in Ethiopia is cropped with farmers' varieties, there is a decreasing trend in the number of these varieties maintained by farmers. Factors affecting the state of field crop resources are displacement of local varieties by the improved ones, shift to market-oriented crop production, disease and pests, and frequent drought and unreliable rainfall.

7.1.6. Animal Genetic Resources

In terms of livestock population, Ethiopia stands first in Africa and 10th in the world. Because of its diverse ecology, Sidama is regarded as a center of origin for most of the domestic animals. Farm animals of the region are categorized into mammals, birds, and honeybees. Cattle, sheep, goats, camels, donkeys, horses, and mules are the major farm animals under the mammalian category. (IBC, 2009)

The major threats to wild animal genetic resources are livestock encroachment, human settlement, agricultural expansion, deforestation, illegal hunting, invasive species, and bushfire. As a result, the wildlife resources are facing habitat destruction and fragmentation, population decline, overexploitation, disease, human-wildlife conflict and bush encroachment and incompetent tourism destination quality.

7.2. Driving Forces of Biodiversity Loss

7.2.1. Demographic Change

Human population growth and resource use, mediated by changes in climate, land use, and water use, increasingly impact biodiversity and ecosystem service provisions. Human and livestock populations are rapidly increasing in Ethiopia with undue pressures on all ecosystems and biodiversity of the country. Sidama region population is increasing steadily over the last three decades from 2.6 million in 1984 to 4.2million in 2012, and is expected to reach 6.3 million by 2020 (CSA, 2014). Because of the limited access to land and its degradation in the highlands, many are migrating to urban center. In addition, a series of government resettlement programs have been underway, causing a rapidly building up of human and livestock population, particularly in the dry lands of the country. Biodiversity loss and subsequent degradation of the land are among the inevitable results of increasing population. Higher population implies increasing demand for forest products, space for settlement, grazing and farming areas (Mulugeta and Habtemariam, 2010).

7.2.2. Agricultural Expansion

The fast growth in human population in the region, coupled with the low productivity of smallholder agriculture, drives the need for more cultivated and grazing land. As a result, smallholder agricultural expanding at the expense of land under forest and other forms of biodiversity hotspot areas. Conversion of natural forests, grazing lands, woodlands, and wetlands into agricultural land and settlement areas are threats well experienced by Ethiopian biodiversity resources. This led to the increasing fragmentation of the remaining ecosystems (MoFED, 2011).

7.2.3. Resource Overutilization

Overfishing along with other factors, such as soil erosion and unsustainable utilization of water resources for developments, has threatened fish varieties was presented Lake Hawasa. Similarly, overharvesting has threatened timber tree species such as Hagenia abyssinica (koso), and medicinal plants species such as Aloe vera. Overgrazing/browsing by livestock in many ecosystems, including rangelands has also contributed to the degradation (increased erosion, decreased quality and productivity of range resources, reduction or elimination of the natural regeneration of woody species and highly palatable forage species of rangelands and forest ecosystems). Similarly, the increase in population in Hawasa city town and in the lake Hawasa watershed has raised a high

demand for municipal water supply. Besides, farmers in the watershed of the lake were pumping

water mainly to Building, Greenfication & irrigation purpose. These eventually resulted in biodiversity lose, which is severely affecting the communities whose livelihoods based on the lake resources (EFCC, 2013).

7.2.4. Low Level of Awareness

Decision makers and the public often influence biodiversity through their actions because of lack of awareness on biodiversity values. This arises from lack of effective communication mechanisms to raise awareness on biodiversity and its values. Biodiversity and ecosystem services are not well mainstreamed into the formal education system and other relevant sectors. Community knowledge on biodiversity and its cultural practices in the management of biodiversity and ecosystems are not well promoted and applied. Specifically, awareness creation on biodiversity policy and strategies was not carried out properly at all levels to the concerned stakeholders to mobilize support for implementation. As a result, the contribution of biodiversity and ecosystem services to the national economy and sustainable development are undervalued.

7.3. Pressure of Biodiversity Loss

7.3.1. Pollution

Living organisms have developed over an extended period, however they strive to adapt to existence on a polluted planet. Air pollutants such as soot, dust, ammonia, or carbon dioxide can directly and indirectly influence biodiversity. Air pollution; -Air pollutions influence the respiratory apparatus of the animals and negatively impact their well-being including the egg laying capability and behavioral alteration**s.**

Water pollution

Water pollution had detrimental effect on biodiversity. Chemical fertilizers generally contain nitrogen and phosphorous and are added to soil to boost the crop productivity. Nitrogen and phosphorous sweep away from the soil to the water bodies or underground. The presence of these nutrients in the water bodies lead to eutrophication or excessive plant growth. Eutrophication causes the depletion in the oxygen level which is deleterious for biodiversity. Fish and other aquatic animals die because of lack of dissolved oxygen in water. Alike fertilizers, pesticides may also accumulate in water bodies. The pesticides negatively affect non-flowing water bodies such as lakes and ponds given the fact that fertilizers are not washed away and animals in water bodies have difficulty in reproducing Bhateria R, Jain D (2016). Heavy metals affect the behavior as well as the survival rates

of aquatic animals specially fish. Further, events such as oil spills greatly impact the wildlife specially in the deeper oceans. The birds and the larger animals display the apparent hostile effects. Oil spills cause disruption of the animal senses, suffocation, impair the vital organs of the organisms, reduction in growth rates and induce the higher mortality of the larvae Bhateria R, Jain D (2016).

Soil pollution

Soil pollution is another factor adversely affecting biodiversity. Soil contaminated with heavy metals greatly impacts the welfare of the microorganisms essential for the sustaining life of the living organisms. The over-use of fertilizers, pesticides and antibiotics used in agriculture is also very deleterious for the biodiversity. These agricultural pollutants such as nitrogen from fertilizers alter the pH and the nutrient level of the soil. The enhanced presence of nutrients in the soil causes the vigorous growth of grass species, leading to stifle in the growth of wildflowers, essential for bees and other pollinating insects.

7.3.2. Habitat loss

The habitat destruction is the massive destruction of the natural habitat of the species that it becomes incapable of upholding the native ecosystems and the species. This ultimately results in species extinction i.e., biodiversity loss Marvier, Michelle; Kareiva, Peter; Neubert, Michael G. (2004). The cutting the forests for preparing the fields for agricultural use, filling the wetlands and mowing fields for creating residential or commercial sites, harvest of the fossil fuels, etc. are all examples of habitat destruction. Development of agricultural practices, reduced resources such as food, water, air quality, mining, pollution, logging, catastrophic fishing activities, activities related to urbanization, and the interruption of processes related to ecosystem are the predominant elements of degradation of habitat.

7.3.3. Hunting

Hunting is the root cause of extinction of large numbers of animals holding position in food web. Due to this, the various species in the region are adversely affected as they face food scarcity or complete food unavailability compared with the normal situation. Hunting is extensive operator of loss of biodiversity.

7.3.4. Climate change

The biodiversity and climate change are strongly associated. Even though the climate has consistently altered during the whole of earth's history with ecological communities and species

evolving and extinguishing, accelerated climate change disturbs ecological systems and species capability to acclimate and hence the loss in biodiversity enhances. https://www.cifor.org/knowledge/publication/1888/. The swift climate change, stimulating biodiversity loss jeopardize human interests and security for clean water, air, medicines, and additional natural resources we depend on, would be difficult to attain due to reduced or vanished flora and fauna they are obtained from. Climate change, beside other components such as habitat loss, land degradation, hunting, overexploitation of certain species etc., is turning up as a high threat to biodiversity on region. Climate change will have significant impacts on biological \diversity (e.g., shifting the distributional location of some ecosystems as well as altering their composition, including via impacts on invasive species) and thus will also affect the quantity and quality of the services provided by ecosystems in cause of Sidama.

7.3.5. Invasive species

The introduction of invasive species is the tremendous threat to biodiversity crisis. The species, which is not native to the ecosystem, arrives or is introduced mostly via humans in the new ecosystem and start to pullulate, is called as invasive species (Sala et al 2000). Such species are detrimental as they affect the ecosystem disproportionately compared to any other species. Most of the new species introduced in the ecosystem do not become invasive, but few of them turn into invasive species and adversely affect the ecosystem.

Figure 39 invasive species (Water hyacinth)

7.3.6. Natural disasters

Natural catastrophes, for instance volcano's, wildfires, floods, draughts, epidemics etc. cause a heavy loss of biodiversity. Due to flooding, large amount of nutrients from the soil gets washed away. Drought too led to dry soil and decline in the level of water table. In this situation, both animals as well as plants suffer.

7.3.7. Weak Implementation of Policies and Laws

Some development policies that were intended for desirable outcomes turned out to result in undesirable ecological consequences. Policy measure of the government of Ethiopia is a major change driver, particularly in terms of deforestation, loss of biodiversity and land degradation in many lowland dry lands of the region, particularly those in the western lowland dry lands (EFCC, 2014). Similarly, investment policy that encourages commercial agriculture is driving significant dry land woodland degradation. Between 2009 and 2014, 350 ha land, which are mostly in the dry lands, have been leased for agriculture-oriented investments (Bossio et al. 2012). This mainly results from lack of alignment among different sectorial policies and implementation of policies and laws.

7.4. Impacts of Biodiversity Loss

Pressures and driving forces of biodiversity loss could cause increase in major ecosystem

disturbances such as ecosystem processes and functions; degradation and loss of habitats; shifts in geographical ranges of some native plants and animals; change in timing of life history events; spread of invasive species and disease; decline in species, populations, and genetic resources as well as extinction.

7.4.1. Habitat Fragmentation

One of the basic potential effects of fragmentation is that a decrease in fragment size, an increase in fragment isolation, or both, lead to fragments with fewer species due to both increasing extinction and decreasing immigration rates. In Ethiopia, deforestation and forest degradation driven by anthropogenic factors has resulted in habitat fragmentation, leading to reduced gene flow among populations. Assessment of loss of forest cover in all regions due to deforestation and degradation shows that the loss of forest cover is greater than the gain, resulting in a net loss of forest cover over the period of 2000 to 2015 (MEFCC, 2016).Deforestation and conversion of dry land ecosystems in the country resulted in decline of natural ecosystems. Furthermore, invasion by alien species are threatening local livelihoods by altering several ecosystem processes and native biodiversity, particularly affecting availability of animal feed.

7.4.2. Threatened Species

Based on the International Union for Conservation of Nature (IUCN) red list assessment, 64 plant species are threatened (IUCN, 2018). Apart from this, the population of some species is declining, resulting from anthropogenic disturbances. Some medicinal plants with their roots as medicine are also threatened because of direct

7.5. Response to Biodiversity Loss

7.5.1. Protected areas

Ethiopia has so far established several protected areas (PAs) which include 1 national parks, one wildlife reserves, six community conservation areas and 58 regional forest priority area of which 37 are protected forests (Young, 2012; IBC, 2012a). Proportion of area of the country covered by PAs varies from one source to the other. According to EFCCA, (2013.), it covers 19.05% of the regions. According to EFCCA, (2013.),, however, PAs of region constitute 14% of area of the country. The variation in proportion of PAs emanated from continuing re-demarcations of the PAs that have been conducted since 2009.

7.5.2. Control of invasive species

In order to control invasive species, Ethiopia is taking various measures. To control the spread of Latana camara, Partinum & Water hyacinth awareness raising, guideline preparation and clearance of areas invaded by the species have been conducted. Thus, about 100 ha of land at more than 15hr in Borcha woreda, Lokka abaya, Dara Qawado. Daara Otilch, Aleta wondo, Shebedino, Bilate Zuriya, Darara Woreda & Hawasa wet-land has been cleared manually (EFCCA, 2012). Efforts are being made to clear Parthenium weed from farm and range lands of the region employing manually controllingmethods. Measures taken to control Water hyacinth are mainly limited to manually clearing lokka abaya lake & Hawasa lake surrounding wetlands (EFCCA,2013).

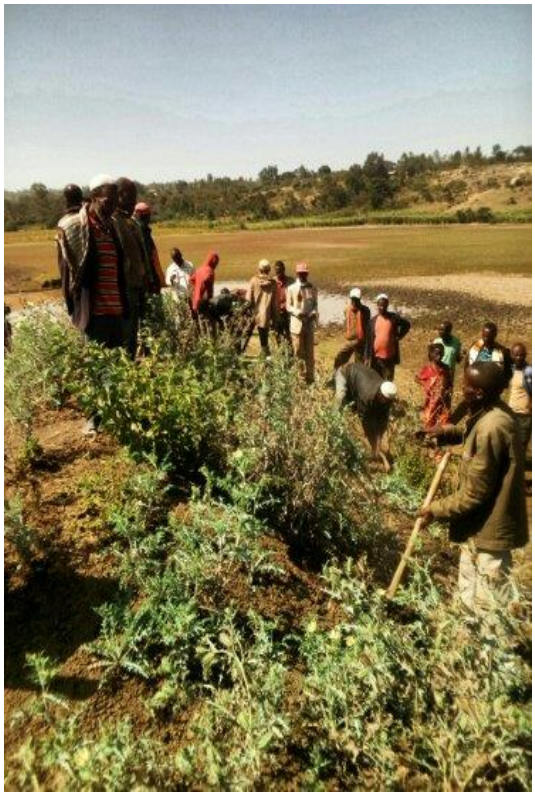


Figure 40 Control of invasive species

7.5.3. Rehabilitation and restoration

Environment forest & Climate change Authority, Agriculture &Natural resource bureau is leading various schemes to restore and rehabilitate degraded areas in region. The schemes include area closure, integrated community based watershed management and natural forest management. Two main types of area closure are being implemented for rehabilitation and restoration of degraded areas in the region. One is by closing an area from livestock and people so that natural regeneration of the vegetation can take place and the other is closing off degraded lands while implementing additional measures such as planting of seedlings, mulching and establishing water harvesting structures to enhance and speed up the regeneration process. Using these approaches, about seven 11744.8 hectares of degraded area has been rehabilitee since 2007/14.

Forest management plans have also been prepared for 35,952 hectare of natural forests. Moreover, about 55957.7 hectares of land have been afforested with different tree species. In years 2007 through 2014, for example, a total of 148million seedlings of indigenous and exotic trees have been planted in various parts of the region (EFCC, 2013). Consequently, rehabilitation, restoration and

afforestation schemes that have been implemented so far have made large contribution to enhance biodiversity and increase the forest cover of the region.

7.5.4. Sustainable biodiversity management

To use natural resources sustainably; resource assessment, developing management plans for PAs, forest management and land use and users of non-timber forest products are among the actions that have effectively been carried out in national regional states of Ethiopia since 2009.(EFCCA,2013.) Moreover, Reduced Emissions from Deforestation and Forest Degradation (REDD+), launched in 2010, is evolving as an integral part of a wider green economic growth, through the Climate Resilient Green Economy (CRGE) Strategy. It is also evolving in the context of a policy environment that is promoting reforestation and afforestation. Some Forest areas of the country such as Aroresa district REDD+ Project have already been selected for piloting REDD+ initiatives.

7.5.5. Public awareness

Raising awareness of the general public and decision makers has been integrated in most of the activities related to biodiversity and other environmental issues. Most of the government institutions and NGOs incorporate awareness creation as one of their major activities in their annual plans. Watershed management and PFM programmes that are being implemented in the region are, for example, making awareness raising activities an integral part of their works to address decision makers and local communities. Awareness raising activities that are geared towards mobilizing the public to control different invasive species are also being carried out in national regional states. Guidelines to prevent and control the spread Latana camara, Argimonia, water hyacinth & partinum have been prepared in local language in Sidama national regional state. Public awareness raising activities are getting momentum through the use of media and annual events such as International Day for Biological Diversity, the World Environment Day, Green Award Programs and Annual Tree Planting programmes that are organized and carried out by governmental and non-governmental organizations. In addition, knowledge created through research, carried out by various institutions in the areas of biodiversity is communicated using different media outlets, and these have been used to devise plans to conserve and sustainably utilize biodiversity resource of the country.

7.5.6. Ex-situ and in situ conservation

Ex situ conservation In region, over 25 accessions of plants have been conserved under ex-situ

conditions in cold storage and field gene banks so far. Two(2) new field gene banks have been established to conserve coffee, medicinal plants ,Inset, maize in four Varity like local names Sidancho, Jalile, Buritame, Gelesho and forest species. Ranches have also been established in different parts of the region between 2009 and 2014 for conservation and sustainable utilization of Abera sheep, Loka sidama goat, and Horn less cattle breeds.

7.5.7. In situ conservation

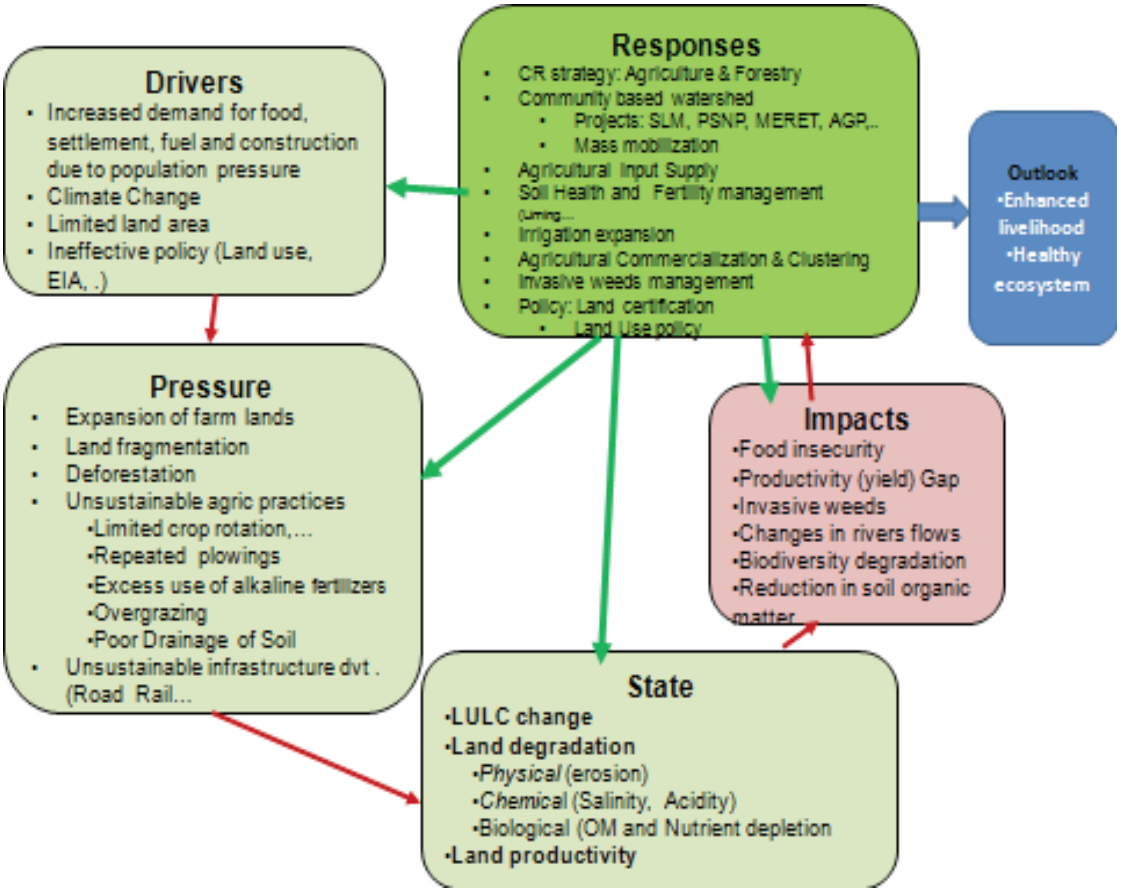
Five in situ conservation sites are under establishment to conserve Enset, Wheat, Teff, Coffee, medicinal plants and forest plant species. In addition, three community gene banks, and bio-parks have been established in the region since 2009. Two in situ conservation sites have been established for sheep and goat between 2009 and 2013.

Figure 41 in-situ conservation practices

7.5.8. Mainstreaming Biodiversity

The Regional Government has implement in place policies and strategies for sustainable natural resource management including biodiversity conservation. The region is taking various measures to mainstream biodiversity into sectorial and cross-sectorial plans and programs. Devising and implementation of rules and regulations that will reduce adverse and promote beneficial impacts of different sectors on biodiversity are some of the measures that have been conducted.

7.6. The Driver-Pressure-State-Impact-Response framework for state of biodiversity in sidama region



SECTION EIGHT

8. Health and Environment

8.1. Introduction

There is a consensus that the poor state of the environment affects human health. The Ethiopian Panel on Climate Change (2015), states that the effects of weather variability and climate change on human health are morbidity and mortality caused by vector-borne infectious diseases. The Panel's report further suggests how climate change impacts the health of Ethiopians.

Mortality and morbidity due to floods and heat waves, vector-borne diseases, water-borne diseases, meningitis, and air pollution-related respiratory diseases are increasing in Ethiopia (Belay et al 2016). In view of Ethiopia's vulnerability to climate change, the impacts of climate change will not be abated in the short-term. The long-term of effects of climate change on health will be injury, disease, and death because of intense heat waves and fires; increased risk of under nutrition resulting from reduced food production; reduced workforce capacity and labor productivity; and increased risks of food- and water borne diseases and vector-borne diseases.

To reduce the effect of climate change on public health, there is a need to have clear policy directions, inter-sectoral commitments and collaboration as well as monitoring and accountability system within country (Belay et al. 2016).

In urban areas of Ethiopia, chemical pollutants hazardous to human health may accumulate in harmful concentrations. Combustion of fossil fuels, as well as poorly-regulated industrial processes, release Sulphur and nitrogen compounds, volatile organic compounds, heavy metals and other pollutants that cause respiratory and heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, aggravating pre-existing heart and lung disease and/or triggering asthma attacks. Industrial chemical pollutants such as methyl mercury, poly chlorinated biphenyls (PCBs), and toluene are neurotoxic and recognized causes of sub clinical brain dysfunction and neuro developmental disorders; these are found in potentially harmful concentrations in urban areas. Occupational exposure occurs in large factories and small workshops; domestic exposure occurs when biomass/coal is used for cooking and heating homes; and vehicle traffic creates ambient air pollution in urban areas.

Chemical pollutants may affect more severely on urban poor populations as both unhealthy working conditions and the use of biomass fuels in indoor cooking stoves and heaters are characteristic features of a typical urban poor lifestyle.

8.2. Waste Management

Collecting and managing solid and human waste is a problem in Ethiopia, particularly in cites and major towns where there is high population density. Inappropriate waste management affects water quality and health. In Ethiopia, economic growth and the expansion of urban centers attracts a significant number of people to cities and towns. This puts an increasing pressure, particularly in the municipalities of major cities to manage waste for preventing potential outbreaks of disease. In cities and towns where there are permanent water bodies, the tendency to dispose waste in water systems is high.

In Hawasa, huge quantity of waste is believed to be removed through rivers and lakes. With ever increasing solid waste generation rates and complex arrays of wastes coupled with inadequate organized systems of waste handling in major urban centers, focus on identifying waste management problems and evaluating the current performance of waste handlers will bring about an effective solid waste management practice to put in place. An understanding of what materials are in the waste stream will also enable for better and informed waste management practices at the household level.

Colby Environmental Policy Group (2011) states that waste management in Ethiopia is important because only a small percentage of the country's inhabitants have access to safe drinking water: 21% in rural areas, 84% in urban areas, and 30% country-wide. Additionally, only 7% of populations in rural areas, 68% in urban areas, and 15% of people countrywide have adequate access to latrines or other improved human waste disposal options. Access to latrines is a critical aspect of waste management, especially since the practice of open defecation is prevalent in the country, which can contaminate groundwater and lead to disease. This situation is important in terms of the link between the quality of the environment and human health.

The problem of waste management emanates primarily not only from lack of policy and legislation ,but because of unplanned historical settlement patterns in several cities and towns across the country; low level public awareness on hygiene and sanitation and inappropriate waste disposal

methods to human health; limited access to waste disposal facilities including latrines; limited awareness and application of formal waste recycling; inadequacy of sewage systems in urban areas; inappropriate landfill sites; and limited public and private investment in solid waste management. Furthermore, the lack of transparency concerning the types of chemical inputs used in manufacturing plants, the harmful by products, wasted disposal standards and methods, safeguards put in place for factory and farm workers exposed to chemicals, etc. are issues that need the attention of policy makers, owners and managers of manufacturing plants and commercial farms.

With regard to policies and proclamations, the Constitution of the Federal Republic of Ethiopia states the following:

- Article 92.1: Government shall endeavor to ensure that all Ethiopians live in a clean and healthy environment; and
- Article 92.4: Government and citizens shall have the duty to protect the environment.

The first article specifies the government's duty in ensuring that the environment is conducive for people to live in, and the second article articulates the obligation of citizens to protect the environment. In this regard, the Constitution provides for public-private partnership to improve waste management. This is pronounced in Proclamation No.513/2007, which specifies the importance of community participation to maximize the benefits of enhanced solid waste management.

The Environmental Policy of Ethiopia issued in 1997 , (Human Settlement, Urban Environment and Environmental Health); (Control of Hazardous Materials and Pollution from Industrial Waste); and (Atmospheric Pollution and Climate Change) outline the key policy directions concerning waste management.

The Solid Waste Management Proclamation No.513/2007 provides legal guidelines for solid waste management planning, collection and storage, transportation, treatment, disposal, incineration, recycling, and the disposal of hazardous waste.

Proclamation No.513/2007 in compliance with Proclamation No. 300/2002 for Environmental Pollution Control stipulates urban administrations to devise and implement safe and effective mechanisms to handle, transport, and store municipal waste. The Environmental Impact

Assessment Proclamation No.299/2002 is also pertinent to waste management. Despite the prevalence of such good polices and laws, very little progress is made in implementation because of the mismatch between the intended objectives of the policies and laws and the objective reality on the ground. For example, the Hawassa City and other towns Administration advises residents to sort and dispose their waste. However, in many areas waste collectors provide one trash bag and many of the city's and town residents cannot afford to buy several bags to organize household waste in assortments. In addition, several containers are overflowed with waste and people who are willing to dispose waste at a disposal sites are forced to leave the waste in open spaces next to overflown containers.

To address policy implementation gaps and to make solid waste management more efficient and effective, public-private partnerships (PPP) have become prominent vehicles for investments and in the provision of solid waste collection (SWC) services in several countries. According to Mohammed and van Dijk (2017), there are two main reasons behind this trend. One reason is the restrained capacity of public finance to bear the costs of new equipment. The other reason is the increased need for proper public services delivery that requires innovative capacity and management skills in private partners and risk that is more adequate and task sharing among partners. The study identifies key factors affecting service performance by investigating investments, operational management capability, and regulation in 40 private companies involved in SWC in Hawasa city, Yirgalem and Aleta wondo town.

8.3. State/trend/of urban waste management

Waste is unwanted materials that is discarded or left as unwanted. Urban waste means household waste, waste from administrative, social and public facilities. This term also describes waste resulting from commercial, recreational and similar activity the amount and composition of which enables treatment as part of urban waste.

The term waste management is defined as the process of collecting, transporting, processing or disposing, managing and monitoring of waste materials. It usually relates to materials produced by human activity and the process is generally undertaken to reduce their effect on health, the environment or aesthetics.

In Sidama region many different type of waste are being generating, including municipal solid waste, hazardous waste, industrial non-hazardous waste, agricultural and animal waste, medical waste, radioactive waste, construction and demolition debris, extraction and mining waste, oil and gas production waste, fossil fuel combustion waste, and sewage sludge

The sources of urban waste are domestic waste - waste generated from household rubbish, Commercial waste - waste produced by businesses such as offices, manufacturing industries, restaurants, schools and other. (tewp.2011). In Sidama region context, the more urban wastes are generating in Hawassa and Yirgalem cities as well.

In Sidama region there are 1 city and 6 town administration , which include urban, touristic and rural areas, has a population of 764,223 and for instance Hawassa city generates approximately 348 t/day of municipal solid waste (MSW), out of which, 8% (15.94) is plastic waste. Urban areas generate the majority of the plastic waste, 63.9%, followed by touristic and rural areas at 25.6% and 10.5% respectively. The types of plastic generated in Hawassa include; dense/heavy (PET, LDPE, HDPE, PP), film/light (bags and wrappers) and most interestingly fishing nets. Light plastic forms the majority of plastic waste being generated at 60.9% followed by dense plastic and fishing nets at 38.9% and 0.2% respectively. Despite the large amount of light plastic being generated, none of it is recycled since it has no market value. On the other hand, dense plastic, especially PET, has high market value in the recycling industry. Fishing nets that are illegal at the end of their life span i.e., 1 year are often disposed directly into the lake as a convenient disposal method and also to hide them from the authorities.

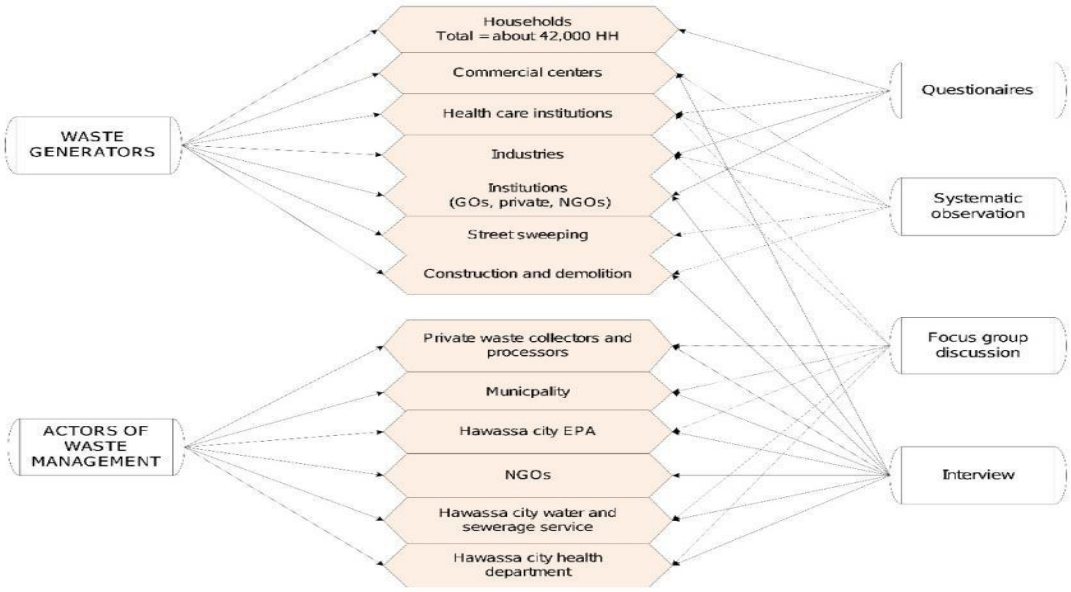


Figure 42 Baseline data of Waste Management of Hawassa City and the Lake

In addition to above information:-

- There is no formal sorting and/or recycling, apart from small self-help initiatives (like the Qoralew - who collect recyclable items from households in Addis Ababa);
- No separation of hazardous liquid and other wastes. Household and institutional wastewater as well as other toxic items are collected and dumped in an adjoining a wetland;
- The Hawassa University Referral Hospital and industries (textile and ceramics) have constructed treatment ponds, but these are not utilized in a way to protect Lake Hawassa, viz:
- The hospital's waste water enters the lake only partially treated, and The textile factory's waste water enters the wetland (through the Tikur Weha River), disrupting the Lake's ecosystem;
- There is a storm water drainage system in the city, which drains into the lake at three locations; a fourth location drains into the wetland.
- A study conducted in 9 health care facilities (HCFs) by (Israel Deneke, *et al.* 2012) showed that, the proportion of hazardous wastes (20-63.1%) generated at the different HCFs was much higher than the WHO recommendation (10-25%). There were no waste segregation practices in most HCFs. Solid waste and waste water were stored, transported, treated and disposed inappropriately in

all HCFs. Additionally, low levels of training and awareness of waste legislation was prevalent amongst the staff. The study showed the management of health care waste at HCFs to be poor.

- The most commonly practiced storage facilities are open containers. The community's perception on the inappropriateness of using open containers with the community's experience of the associated problems (odor, breeding sites for insects, and low aesthetic value) shows the need to provide alternative waste separation, transport and storage facilities. The door-to-door service of waste collection, which is used by the vast majority of the members of the community, seems to be a starting point that can be upgraded. In the chains of waste management, door-to-door service provision is an important link between waste generation and appropriate disposal. The remoteness of the Municipal dump site together with the limited coverage of transfer sites requires for the future waste management of the city to focus on the door-to-door service providers. The willingness of the community to pay for improved services is a green light.

- It is estimated that production of plastic increased from 335 million tons in 2016 to 348 million tons in 2022 and the trend is expected to increase. This increasing plastic production and consequently increased pollution demands new systemic solutions. In the manner, Yirgalem, city is one of polluted city in the region. And it generates more of solid waste as shown below.

Figure 43 Hawassa Municipal waste (photo from Hawassa city EP, Dep't)

Figure 44 Liquid waste from Yirgalem

8.4. Driving Forces of Urban Waste

Sidama region is one of the regions at which urbanization is rapidly growing. So that high economic growth is one of driving forces for poor waste management. In addition, a series of government resettlement programs have been under way, causing a rapidly building up of human and livestock population.

8.5. Pressure of Urban Waste

Despite the existence of policies and laws aimed at minimizing plastic pollution such as Proclamation No 62/1999 & 2007 which gives the directive on fishing and fishing nets and Proclamation No. 513/1999 which banned the production and import of plastic bags with thickness of less than 0.03 mm, there is no enforcement. Additionally, there are many development partners and financiers engaged directly and indirectly on the issue of litter prevention and conservation of the lake but their activities are not coordinated. The majority of households discharge their waste water into infiltration pits and most of the respondents confirmed that waste water is a problem. This contradiction needs further investigation. Low awareness of the community, on environmental policy, laws and enforcing mechanisms, complicated waste management system, Poor recycling mechanisms of wastes and Segregation problem of wastes from sources are the main pressure of the urban waste.

8.6. Impact of waste generation

A lack of proper solid waste management systems and low public awareness results in littering, illegal dump sites and consequently increased amounts of plastic waste in the environment, canals, rivers, lakes . This threatens human health, ecosystems and infrastructure yet consumption patterns are on the rise. The rapid growth of urbanization, illegal settlement, industrialization and poor waste management practices have led to an intense water quality impediment in Lake Hawassa Watershed. The environmental situation became worse in the last decade and Lake Hawassa watershed is known to be polluted. The dramatic worsening of the situation in Lake Hawassa Watershed was due to urbanization, usage of fertilizers in agricultural lands, effluents from industrial facilities, excessive usage of detergents in and industrial facilities, soil erosion, increased sewage pollution, practice of open defecation and urban run-off on top of that, there is insufficient sanitation in Lake Hawassa Watershed from diffused sources like sewage, animal waste pollution and the practice of open field

defecation. The point sources have been known to take the leading role in contributing more pollutants to the river and Lake Hawassa followed by non-point sources from agricultural and urban run-off showing an ongoing pollution. Due to urban waste, many plants species(trees, shrubs, herbs and climbers), and different aquatic species including clams, snails, worms and fish was damaged (Sidama EPA ,2021).

Figure 45 Yirgalem city municipal waste. (photo from sidama region EPA)

8.7. Response to Urban Waste

A group of young people in Sidama region Hawassa city is leading the fray to tackle the solid and organic waste menace that has dogged the city for years. The group moves door to door to collect the waste on their donkey carts. They have a recycling plant where they separate the waste and produce natural fertilizer from the organic waste.

Figure 46 Solid wastes are collected to recycle site. (photo from hawassa city EP,dep't)

Figure 47 Plastic wastes that are collected to transport to recycling industry. Source EPA, 2021 and Stockholm International Water Institute (SIWI) document, 2020

A critical component in any waste management program is public awareness and participation in addition to formulating appropriate laws and regulation. The involvement of communities, religious institutions, schools, private organization, and non-governmental organizations (NGOs) could probably lead to long- term sustainability. The high involvement of mothers in waste handling in households provides a clue to the entry point for future awareness creation programs.

Regarding the means of delivering information to the community, the use of available governmental organizations appears to be effective as the study has shown their role to be the highest, e.g. health extension workers in disseminating information on waste management. The large number of infiltration pits for safe disposal of waste water (though no assessment has been made to confirm their functionality and appropriateness) can be additional evidence for the role at the Kebele level in guiding the community towards improved waste management.

In addition to this Strategic and mid-term actions must be taken as follows:-

A. Multi-stakeholder process facilitation: The issue at hand calls for effective coordination and collaboration amongst the public sector, business, academia, civil society and donors. This is particularly true for the successful identification, packaging and implementation of policy instruments (See below). SIWI together with GIZ could help with an effective facilitation for the set-up and running of a multi-stakeholder platform.

B. **Coordinate various efforts:** There is an immediate need to harmonize the existing initiatives on the ground, amongst bilateral and multi-lateral donors, i.e. GIZ, CIFA, UN-HABITAT, UN Habitat, World Bank, UNDP, USAID, SOS Sahel, SIWI, etc.

C. **Facilitate policy interventions:** There is a need, amongst the multi-stakeholder partners, to clearly identify, package and implement policy instruments from within available options, namely informative, economic, regulatory and voluntary approaches with a view to transition from a linear culture of production and consumption to one that is circular as it applies to plastics. For plastic bags, there is a need to closely monitor the impending full ban on the manufacture and import of these items. If the full ban is enforced on plastic bags, then, in principle, it does not make sense to consider other policy approaches such as a levy or voluntary collection and recycling by supermarkets. Rather, the main question that needs to be addressed is if the full ban is approved, is there technical capacity to enforce it effectively? Have alternatives to plastic bags available? Does the ban have support from consumers, shops, markets and supermarkets?

D. **Financing/Investment:** While Ethiopia has committed to an ambitious Climate Resilient and Green Economy strategy, this is not matched by the necessary investment and finance. Importantly, access to finance is a serious constraint, especially to green businesses, e.g. recyclers and waste management companies. As confirmed through interviews with officials of different towns of Sidama region, the public waste management system is severely under-funded. There is a need to upgrade to modern equipment for the transportation, handling, sorting of MSW including, obviously, for a modern sanitary landfill site. Hence, there is an urgent need to address the finance/investment issue by working with government (including stakeholders such as the Ministry of Finance, Ministry of Trade and Industry, Ethiopian Investment Commission, Development Bank of Ethiopia, National Bank of Ethiopia) and donors. There is also a need to look into the role that the local financial sector could play to catalyst the green economy. For instance, plastic recyclers are constrained by lack of finance to buy recycling equipment and machinery, whereas, the local commercial banks usually request collateral before approving loans. Plastic recyclers usually cannot meet these collateral criteria as they have little in fixed assets such as buildings or trucks. While micro-finance institutions, play a positive but limited role in the green economy commercial banks have a negligible role in that sector. Mostly they cater for less-risky and established businesses, which could provide collateral for loans requested. In addition, the role that preferential, investment incentives could have in stimulating the green economy sector is another area that could be explored by engaging the Ethiopian Investment Commission.

E. Technical capacity building: Human capacity building in MSW management and partnering skills is another area for intervention if sound management of municipal solid waste is to be achieved. Transitioning to a true green (circular) economy calls for a much more advanced management and partnering capacity. This is particularly the case within the concerned ministries at the federal level but as well the regional government and city-administration counterparts.

8.8. Recommendation

The importance of viewing Lake Hawassa and its catchment as an ecological system where all the components are interlinked. Even though waste management, which is the subject of this study, is a critical issue in the management of lakes, the inclusion of other issues makes can make the approach holistic. For an effective management of the lake, the technical realities of what is going on in the nearby soil, water and biophysical resources is of paramount importance. The socio-economic realities are of the same importance because they determine the control of polluting activities.

The Lake Hawassa ecosystem needs to be viewed from the perspective of four technical dimensions: Biodiversity, Water Quality, Water Quantity, and Socio economics. The key knowledge gaps regarding the biodiversity of the ecosystem are the unresolved issues of optimum fishing and macrophyte invasion of the lake shore. The frequently voiced problems regarding water quality arise from pollutants released by factories, agricultural lands (in terms of agrochemicals and sediments), and municipal wastes. The lesson to be learnt from Lake Cheleleka (which had been serving as a natural silt-trap for the Lake Hawassa) may guide future interventions. The following are some examples of areas that require further investigation.

- Despite the presence of waste treatment facilities in the factories around the lake, the efficacy of their impacts requires explicit assessment.
- The issue of agro-chemicals has never been addressed in the catchment and we recommend its characterization, classification, and quantification.
- The ground water movement and its role in transporting and purifying the pollutants has remained unstudied despite its importance.
- The characterization, classification, and quantification of Municipal wastes are Recommended.

- The socio-economic component of the system is an essential part of an integrated water resource management system, and thus it deserves explicit assessment.
- A critical component in any waste management program is public awareness and participation in addition to formulating appropriate laws and regulation. The involvement of communities, religious institutions, schools, private organization, and nongovernmental organizations (NGOs) could probably lead to long- term sustainability. To understand factors contributing to the improper management of solid waste, this baseline survey on waste management in Hawassa City and the lake, including its surroundings, can serve as a bench mark to address the unrecognized aspects in an overall waste management system.

8.9. Outlook/future forecast

- It is estimated that production of plastic increased from 335 million tons in 2016 to 348 million tons in 2022 and the trend is expected to increase. This increasing plastic production and consequently increased pollution demands new systemic solutions. In the manner, Yirgalem, city is one of polluted city in the region and it generates more of solid waste. This generated waste continued in this un efficiently damping manner, next 5 years 450 peoples may be affeced by dfferent types of disease special those who are near arround the damping area..

A study conducted in health care facilities (HCFs) showed that, the proportion of hazardous wastes (20-63.1%) generated at the different HCFs was much higher than the WHO recommendation (10-25%). There were no waste segregation practices in most HCFs. Solid waste and wastewater were stored, transported, treated and disposed inappropriately in all HCFs. Additionally, low levels of training and awareness of waste legislation was prevalent amongst the staff. If the proportion of hazardous wastes generated at atdifferent HCFs continued in this situation the next 10 years hazardous wastes) generated should be reaching (40-75% at the different HCFs in the Sidama region.

The majority of households discharge their wastewater into infiltration pits and most of the respondents confirmed that wastewater is a problem. This contradiction needs further investigation. Regarding industrial wastes, pollutants such as concentrated sodium hydroxide and acids are in use. The present study identified that industry in Hawassa City lacks wastewater treatment infrastructure, the institutional capacity necessary to effectively manage industrial wastes and wastewater treatment networking to control pollution adequately. Wastewater from nearly all factories is discharged

directly into surrounding wetlands and into the lake without proper treatment. The factories seem either not well aware of, or not concerned about, environmental problems. Though legal enforcements are practical tools to ensure the safe disposal of industrial wastes, current practices show that existing environmental policies and laws are not fully implemented. This un effectively manage industrial wastes and wastewater treatment should be expected to be affect 10,250 people by pharmaceutical and industrial pollution related diseases.

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