STATE OF ENVIRONMENT& NATURAL RESOURCE DATA PREPARATION DESK,

ENVIRONMENT & NATURAL RESOURCE DEGRADATION & PREVENTION OF HARARI REGION ETHIOPIA

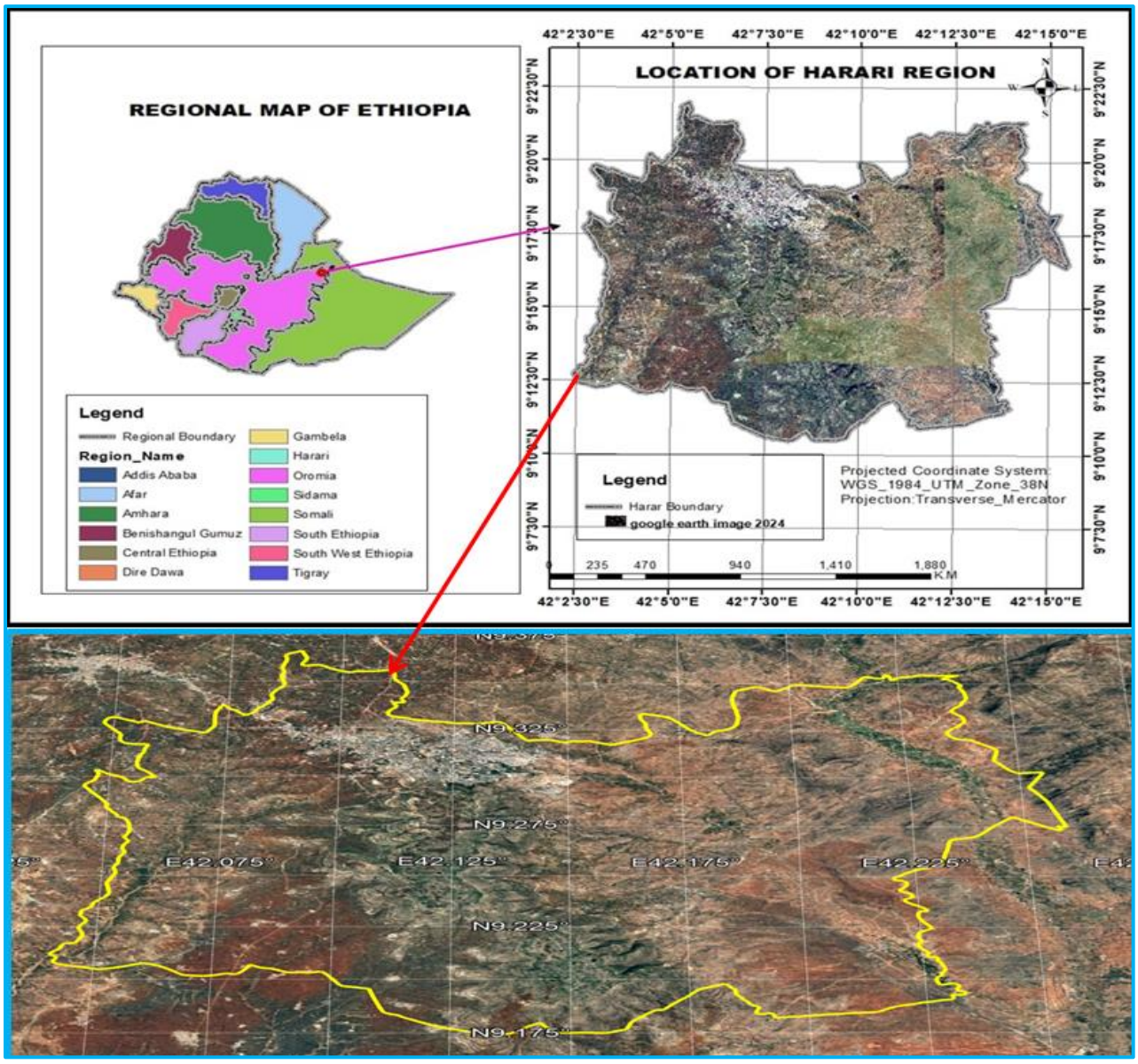

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

CRGE----------Climate Resilient Green Economy

FAO----------World Food Organization

FDA----------United States Food and Drug Administration

GDP----------Growth and Development Plan

GTP----------Growth and Transformation Plan

KM^2 ----------Square Kilo Meters

MASL----------Meter above Sea Level

MEFCC----------Ministry of Environment, forest and climate change commission

MRV----------Measurement, reporting and verification of carbon credit

NDVI----------Normalized Differential Vegetation Index

NIR----------Near Infrared Band

REDD----------Reducing Emission from Deforestation and forest degradation

SWC----------Soil and Water Conservation

UNESCO----------United Nation Educational, Scientific and Cultural organization

UN----------United Nations

1. SPATIAL PROFILE OF THE REGION

Location

Harari Region is found in the eastern part of the country. Harar city, the capital of the region, is located at distance of 525 Km, from the capital city of Addis Ababa. The region is geographically located between 42.03°– 42.16° north latitude and 9.11°-9.24° east of longitude. The region shares common boundaries with six Wereda's of the East Harerge Zone of Oromia region, namely, Kombolcha and Jarso woredas in the North; Gursum and Babile woredas in the East, Fediswereda in the South and Haramaya wereda in the West. The total geographical area of the region is about 343.21 km^2. Administratively, Harari people's regional state is divided in to six urban and three rural administrative woreda and 19 kebeles.

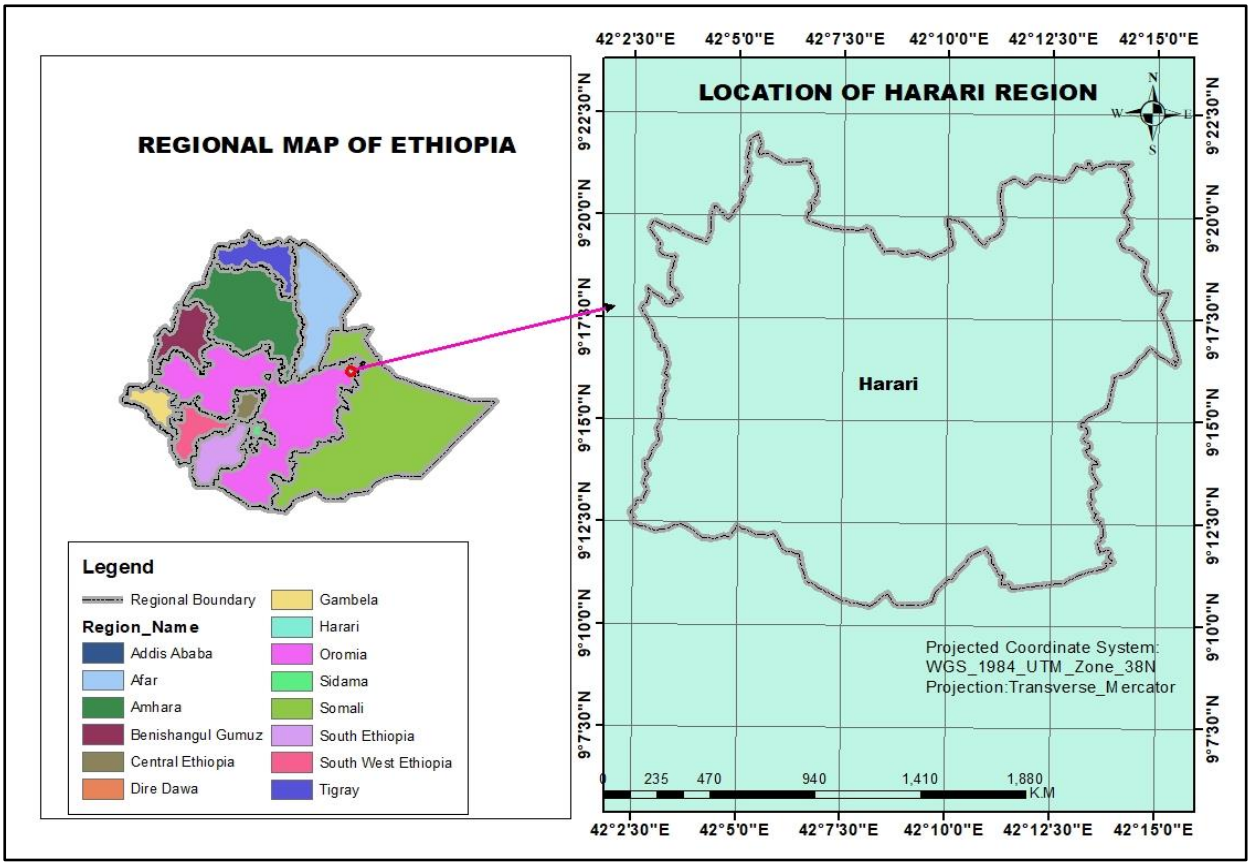

Figure 1: Location Map of Harari Region

1.2 ENVIRONMENT AND NATURAL RESOURCE MANAGEMENT

1.2.1 NATURAL RESOURCES BASE

Natural resources: - are the natural materials or substances that are available on Earth in raw form without any human effort or intervention. Some of these resources include air, water, sunlight, oil, stone, gas, minerals, metals, etc. These resources are of utmost importance for human survival. Natural resources are materials that occur naturally in nature and are useful to humans for their various needs such as food, clothing, building, etc. Based on their availability, natural resources can be divided into 2 categories – **Renewable resources and non-renewable resources**.

- Renewable resources are available in abundance and can be used again. For example water, wind, etc.
- Non-Renewable resources cannot be used again and are limited in abundance. For example minerals, fossil fuels, etc.

1.2.2 Degradation of Natural Resources

The degradation of natural resources is a cause of concern as they are of utmost importance to us for our daily needs.

Resources available in nature are consumed by the population on earth at a very fast rate. This causes the resources to decrease or deplete at a fast rate too. With the ever-growing demand for these resources due to the increasing population, it is becoming increasingly important to replenish the resources to meet these demands. But the rate of consumption is much faster than the rate of replacement. This leads to the degradation of natural resources or deterioration of the available resources.

1.2.3 Causes of Natural Resource Degradation

The causes of degradation of natural resource degradation are as follows:

1. Land and Soil Degradation

The topmost layer of soil on earth called the topsoil is the most fertile and full of nutrients, it is generally 2 to 8 inches deep. This topsoil is continuously being exposed to

bad irrigation and farming practices which degrade the quality of the topsoil and leech the nutrients out of it making it lose its flora, fauna and wildlife. This leads to soil erosion and desertification of once-fertile land.

- Soil Erosion

Soil erosion and desertification: A form of soil degradation called soil erosion is the blowing or washing away of the topsoil by agents such as water and wind. Some of the main causes of soil erosion are malpractices such as overstocking, overgrazing, deep ploughing, over-cultivation for crop production, deforestation, lack of crop rotation, improper surface drainage, monoculture and excessive use of fertilizers, etc. Soil erosion drastically affects soil fertility and renders it useless. The practices responsible for the degradation of natural resource – topsoil are as follows:

- Excessive use of pesticides and fertilizers destroys the microorganisms in the soil responsible for replenishing soil nutrition.
- Poor irrigation practices lead to water logging and an increase in soil salinity.
- Lack of crop rotation.
- Over-cultivation to meet the growing demand for food for the increasing population.
- Unrestricted grazing with an increase in animal husbandry to meet food demands.
- Leakage from landfills used for dumping industrial and domestic waste.
- **Deforestation** as a result of an increase in demand for the land requirement for agriculture and urbanization.
- **Mining** is done to extract minerals from the earth. With an increase in demand and improvement in mining technology, there is a higher rate of extraction causing the depletion of minerals. Apart from this, mining causes irreversible damage to a much larger area surrounding the mining site disturbing the ecology through greenhouse gases, loss of flora and fauna and land erosion.

1.2.4 Effects of Resource Degradation

The effects of the degradation of natural resources are :-

- Desertification – As a result of deforestation and soil erosion, many fertile lands once thrived with plants and wildlife are now barren and have turned into deserts.

- Water Scarcity – The increase in contamination of water bodies due to human activities is resulting in acute water shortages, which may even lead to world wars.
- Loss of Biodiversity – Cumulative effect of climate change, deforestation, overpopulation and pollution has caused great damage to biodiversity in the form of huge losses of plant and animal life, also leading to the extinction of several species.
- Climate Change and Ozone Layer Depletion – The degradation of natural resources is leading to global warming and climate change all across the globe. The ozone layer responsible for protecting the earth from harmful ultraviolet rays of the sun is fast depleting with the effect of air pollution.
- Loss for the Tourism Industry – The degradation of natural resources due to several types of contamination is leading to loss of greenery and biodiversity, causing a huge dent in the tourism industry.
- Economic Impact – The cost of restoration projects in place for replenishment and restoration of natural resource degradation has a great economic impact.

Topography

Figure 2 Elevation map of Harari region

The altitude of the region ranges from the lowest of 1308 meter above sea level (masl) which is found at Kille peasant association to 2235 mas' lat the Peak of Hakim Mountain. As depicted in the, most part of the region (78%) has higher altitude which ranges from 1500 to 2300 masl. The low land which ranges from 1300 to 1500-meter elevation is found in the

eastern part of the region, especially forming N-S elongated segment in Erer woreda. Generally, the topography of the region is characterized by undulating and rugged terrain which comprises of hills, mountains and escarpment commonly dissected by gullies. The slope analysis map depicted revealed that, most part of the region (77%) has moderate slope gradient (2-20%) which is suitable for promoting multiple development activities.

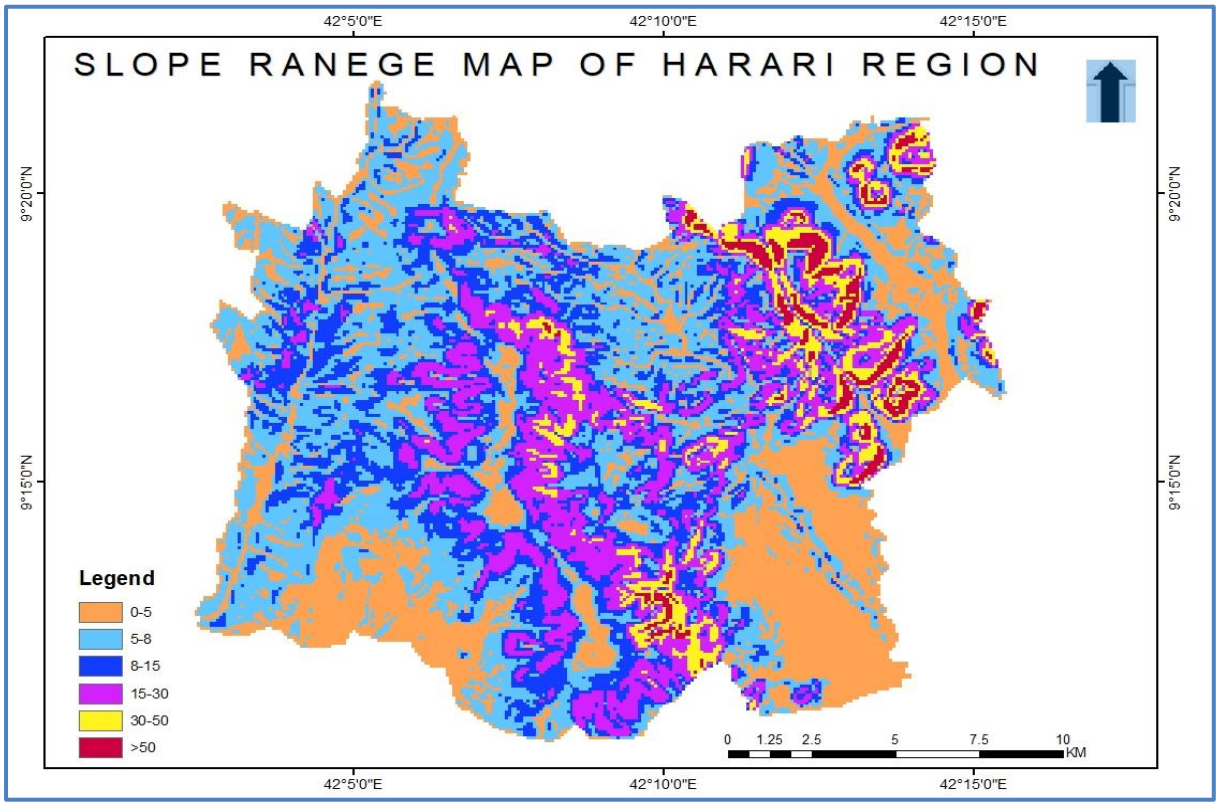

Figure: 3 Slope gradient map of Harari region

Table 1: Slope percentage of Harari region

No	Slope class	Slope coverage in ha	Slope coverage in %
1	0-5	11671.19	34.98
2	5-8	12429.97	37.26
3	8-15	5283.6	15.84
4	15-30	2379.67	7.16
5	30-50	1096.37	3.28
6	>50	495.66	1.48
	Total	**33357.46**	**100**

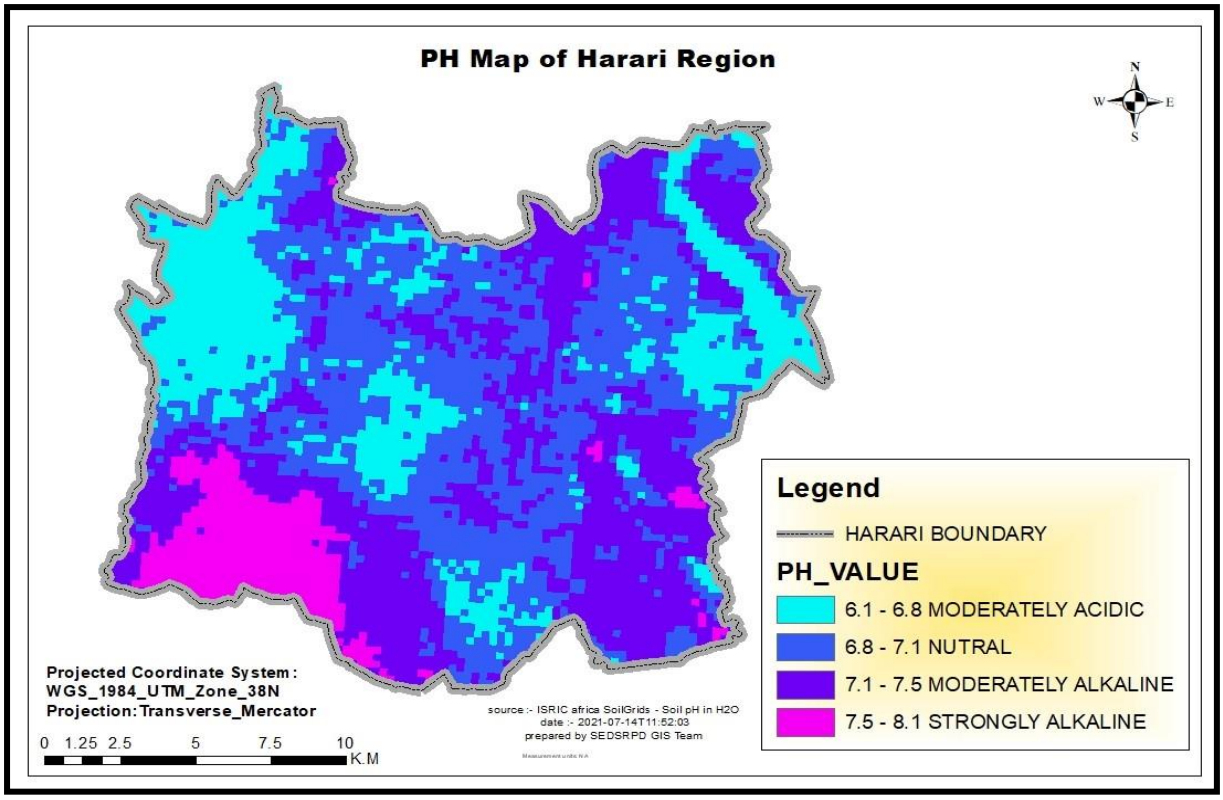

Figure 4 Soil PH map of Harari region

Table 2: PH value of Harari region, 2024

No	PH range	Name	Coverage in %	Remark
1	6.1-6.8	Moderately acidic	17.64	
2	6.8-7.1	Nuteral	38.04	
3	7.1-7.5	Moderately Alkaline	35.66	
4	7.5-8.1	Strongly Alkaline	8.66	
	Total		**100**	

Impact of salt for soil fertility

According to current studies, more than half of the world's agricultural fields will be salt-affected by 2050 (Ullah, etal 2021). Soil salinization affects 19 million hectares of land in Sub-Saharan Africa · Ethiopia is first in Africa in terms of the size of **saline**-affected soils caused by both human activity and natural sources, and seventh in the globe in terms of the proportion of total land area impacted by salinity (Sileshi, 2016).

Salinity is a major challenge to rural livelihoods because it has devastating effects on agricultural productivity. As a result, understanding farmers' views on salinity and adaptive mechanisms to deal with salinity problems is a good starting point for recommending interventions that can help solve the problem. The salinity problem initially impacts soil fertility, resulting in lower agricultural production, food insecurity, and poverty. As we have seen from the figure, from 7.5-8.1 PH value is mostly found in the south west direction Harari region.

Soil acidity is a serious chemical problem that limits agricultural productivity in most of the highlands of Ethiopia as well as in the western part of the country. These acidic soils, which cover an estimated 41% of the arable land in Ethiopia, are inherently infertile and exhibit aluminium (Al) or manganese (Mn) toxicity, which are generally considered to be the major limiting factor for plant growth in acidic soils. In Harari region of Ethiopia, the Acidic soil map shows that most parts of the region were affected by acidic soil and it was distributed in every corner of the region.

The major factors leading to acid soils in western Ethiopia include erosion of topsoil by heavy rains and high temperatures, which increase the greatest loss of organic matter and leaching of exchangeable basic cat-ions (Ca2+, Mg2+, Na+ and K+). Organic matter can be easily degraded and lost through conventional land clearing practices such as burning and direct sun and rain exposure, which is exacerbated by improper agricultural practices.

According to the PH map of Harari region 2024, more than 38% of land was covered by Neutral which is more productive, and more than 35% is Alkaline and 17.6% of land is Acidic respectively. Currently more than 53% of land in the region was affected by both Alkaline and Acidic soils.

1.2.1 SOIL

The soils of Harari region is dominated by Luvisols which is characterized by having an argillic B horizon and a high base saturation (50 % or more). Chromic Luvisolswitha strong brown or red B-horizon covers most part of the region. EutricNitosols and Chromic Vertisols cover small area in the southern and southwestern fringe of the region respectively.

On the other hand, the recent soil survey of Harari Region has identified and defined the major soil groups and soil units on the bases of their physical and chemical properties by employing the FAO-UNESCO soil map of the world. Accordingly, the major soil types are Aerosols, Luvisols/Nitisols, Regosols, Leptosols/Lithosols,Cambisols, Fluvisols and Rendzinas. Hills and ridges occupying half of the region's total area, comprised with soil types Leptisols, Regosols and Rendzinas. The prevailing soil forming parent materials in the region include metamorphic rock (mainly gneiss), volcanic rocks (such as granites and syenites) and sedimentary rocks (primarily lime stones and sandstones). Moreover, the study conducted by NTZ EIS LIS in 2020 shows that the depth of the soil in the region ranges from 100 cm to above 150 cm.

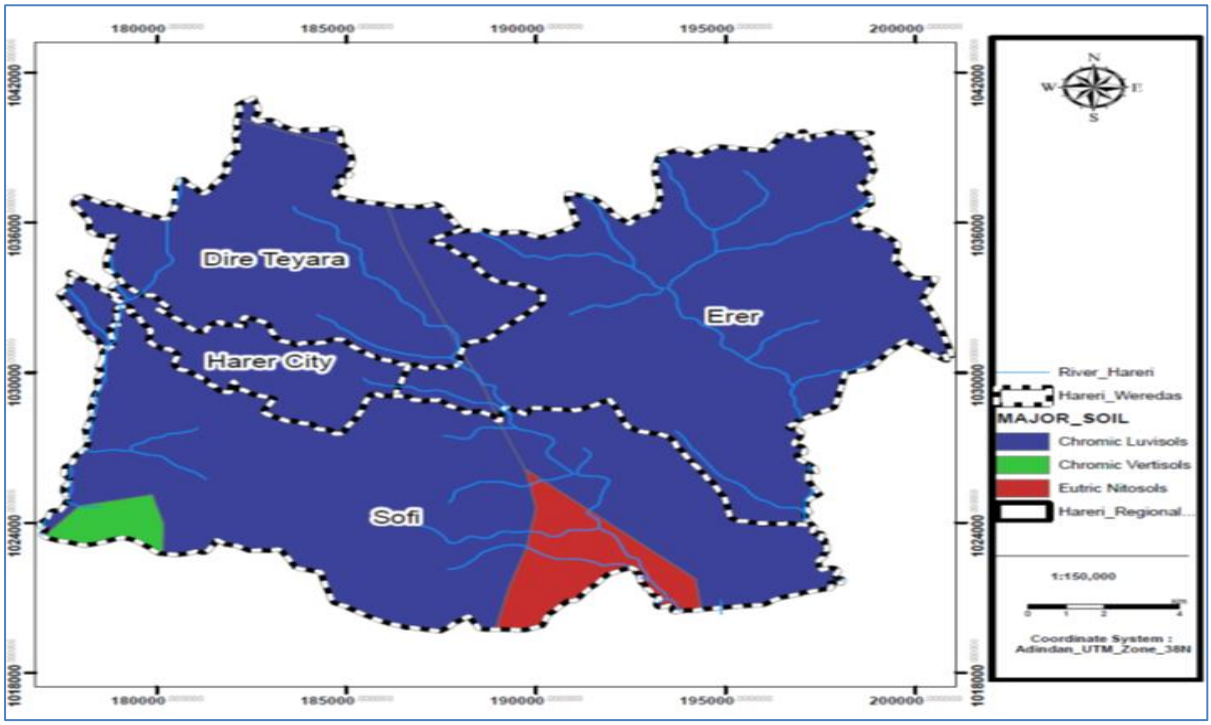

Figure 5: Soil Map of Harari Region

1 STATE OF LULC HARARI REGION OF ETHIOPIA

Regional land use and land cover analysis as an instrument was premised on providing an in-depth understanding of the overall image of the region as a coherent spatial unit in order to lay down the bases for effective planning and management of the region.

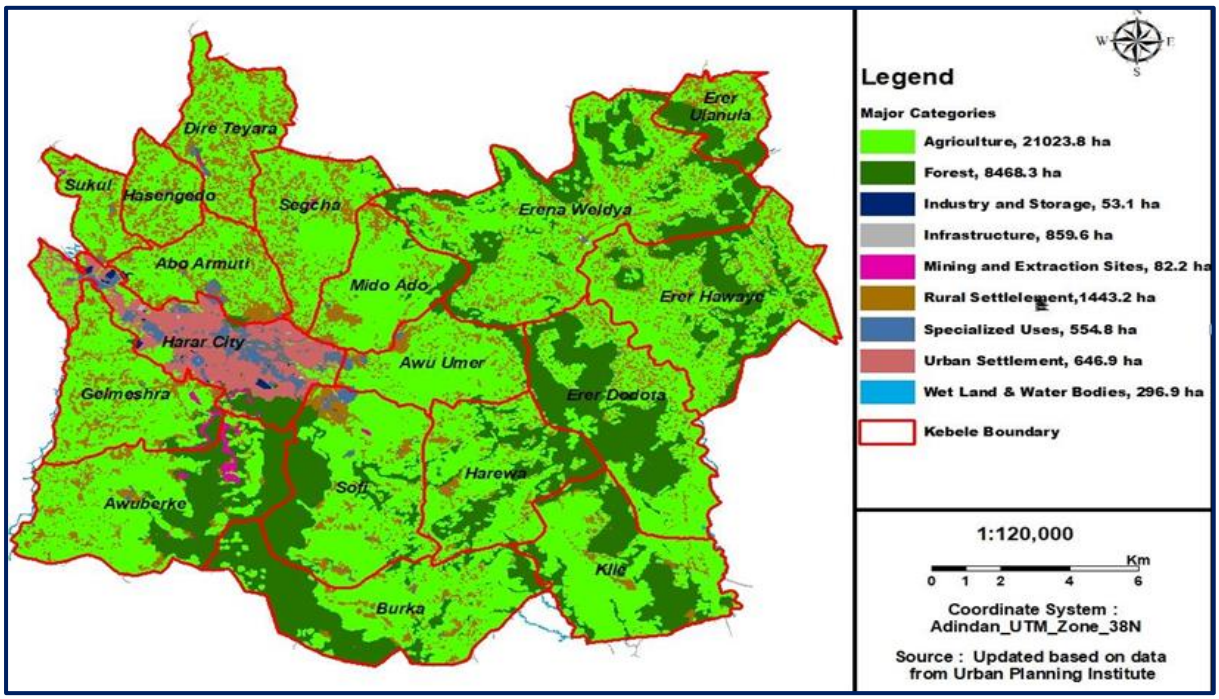

Figure 6: Major land use types in the region

Source: Harari regional state, 2021

Table 3: Major land use types in the region

No	Land use type	Coverage in Ha	Coverage in %	Remark
1	Agricultural land	21022.8	62.89	
2	Forest land	8468.3	25.33	
3	Industry	53.1	0.16	
4	Infrastructure	859.6	2.57	
5	Mining site	82.2	0.25	
6	Rural settlement	1443.2	4.32	
7	Specialized uses	554.8	1.66	
8	Urban settlement	646.9	1.94	
9	Wet land & water bodies	296.9	0.89	
	Total	**33427.2**	**100**	

Source: According to UN habitat project projection, 2021

Analysis of land use and land cover has also revealed that the dominant Land Use is Agriculture, which hints agriculture to be the main source of livelihood of the rural population. The primary and permanent farm activity being the cultivation of “chat”; other permanent farm activities, that include fruits and vegetables, are also observable in the rural settlements of the Region. Vegetable farming is practiced following water courses which are locally structured to irrigate the farmlands.

Another land use feature in the region is forest cover. The forest areas in Harari region are concentrated on mountains and hills. Trees and shrubs coverage is concentrated following regional drainages and river courses. A variety of different low height plants are also observable that characterize the regional land use at various ecological zones covering large areas of land, variety of different low height plants including shrubs, bushes and grasses which are restricted to human and animal intervention one also observes few men made water bodies created as micro dams which are yet to be developed for agricultural irrigation purposes.

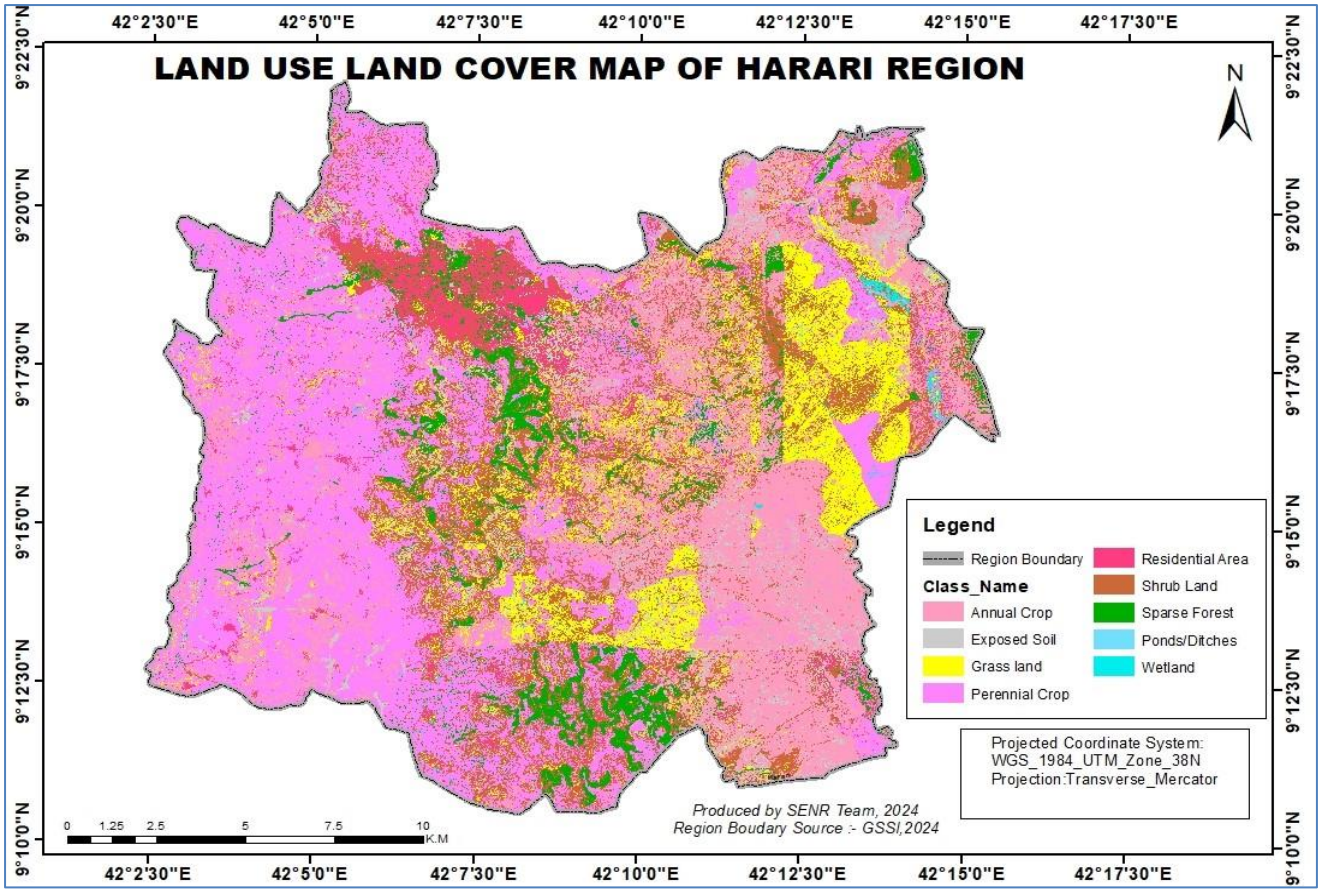

Figure 7: land use land cover map of Harari region, 2024

Table 4: Land use land cover map of Harari region, 2024

No	Major Land use type	Area in ha	Area in %
1	Water Body	8.36	0.03
2	Sparse Forest	1917.46	5.74
3	Wetland	166.09	0.50
4	Grass Land	3437.87	10.30
5	Residential Area	2007.74	6.01
6	Exposed Soil	1913.42	5.73
7	Shrub Land	5191.15	15.55
8	Perennial Crop	10631.88	31.85

9	Annual Crop	8105.06	24.28
	Total	**33379.03**	**100**

Land Degradation

Land degradation seriously affects livelihoods and food security of million in Ethiopia and threatens the livelihood of many more. In Harari region the main land degradation arises due to poverty, high population which arises from high soil erosion rates as a result of steep slopes, continuous encroachment and cultivation of marginal lands, and long history of deforestation over grazing, negative coping strategies such as extensive use of charcoal, firewood, reduced rotation periods, and others recurrent cycles of drought have further aggravated the problem. Consequently, the farming systems that exist in the region are progressively impoverished and more vulnerable to shocks. These are serious constraints to sustainable development and a main cause of unstable over-simplified and drought prone production systems.

Therefore, participatory watershed development is a vital necessity in complex landscapes and for these constraints. Besides, Degradation refers to deterioration on the quality of the environment for humans, vegetation's, animals; soil degradation may be manifested by a reduction in the actual or potential productivity of soil to produce food, fodder, fibre.

In addition, for the last 2-3 decades poor economic performance, low technology base with low productivity unable to satisfy the demands. So this driving force again exerts pressure on the environment. For example the excessive use of natural resources such as forests for fire wood that lead to deforestation, need of farming area followed by cultivation of marginal land lead to land degradation both which have been contributing to soil erosion and poor soil fertility. These pressure, changes the state of environment and such changes might have economic impact on people which leads to poverty. One of the causes of land degradation is over use of natural resource, especially deforestation for fuel wood consumption in urban or rural area.

Soil degradation is the loss of soil productivity quantitatively or qualitatively through various processes like erosion, acidification, salinization, nutrient depletion, and deterioration of soil physical properties; of which soil erosion is the most contributing process to

unsustainable agricultural productivity in most developing countries. Soil erosion is the most dangerous ecological process observed in Ethiopia, degrading the precious soil resources which are the basis of agricultural production and food for the country's people and which provide numerous other ecosystem services. The speed and extent of soil degradation depends on different factors especially soil type, relief, climate, farming system.

The Ethiopian government first recognized the severity of Soil degradation problem was following the 1973-1974 famine. As soil productivity loss due to erosion goes on increase, the issues of soil erosion & conservation became questions of survival. Many endeavours were carried out by the Ethiopian government to combat the land degradation problem. The Ethiopian government launched a massive soil conservation Programme which includes physical and biological conservation measures in between 1976 and 1992.

2.1 IMPACTS

Impact of land degradation

Land degradation was a complex phenomenon influenced by natural, social and economic factors. It generally refers to the loss of the land's biological and or economic productivity. Land degradation remains an important global priority issue for the 21st century requiring renewed attention by individuals, communities, and governments because of its adverse impact on agricultural productivity and the environment, and its effect on food security and quality of life.

It is obviously clear that when man influences the natural environment for the sake of fulfilling needs, in turn the natural environment influences man and vice versa. When the natural forests are extensively cleared out, carbon dioxide over the environment highly concentrated and can bring desertification. Not only intensify (increase) desertification but also reduces bio diversity, increases Green House Gas emissions because of the depletion of Ozone O3 gases (FCC),disrupting of water cycles, increases soil erosion, creating acid rain ,disrupting livelihoods.

2.3 RESPONSE

Soil and Water Conservation Measures in Ethiopia

Many soil and water conservation measures (SWC) have been carried out at individual or community levels in Ethiopia. In Harari region there were identified the most common soil

and water conservation practices such as physical structures like soil bunds, stone bunds, and soil-stone, bunds, check dam, hill side terraces while the agronomic practices includes area enclosure, traditional ditches.

The roles of soil and water conservation measures in reducing nutrient and soil losses, and hence increasing agricultural productivity have been reported by several researchers. As we have seen as sample plot of land, in Erer district of Etisa forest ecosystem, most of the hillsides of the area were covered by different moisture conservation practices. To rehabilitated the degraded land, more than 5,000 ha of land was covered by soil and water conservation measures among this about 2,000 ha of land was also covered by biological soil and water conservation, however, 1069 ha of land was treated by area closer.

Figure 8: moisture conservation structure in Harari region

Source: - Field photo, 2024

2 STATE OF FOREST RESOURCES

According to Forest Development, Conservation and Utilization Proclamation (Proclamation No 1065/2018) states "forest" means trees, plants and other bio-diversity accumulation at and in the surrounding of forest lands, roadsides, riversides, farms and grazing lands as well as residential areas or parks that grow naturally or develop in some other ways." In 2015, MEFCC adopted a new technical definition for REDD+ MRV purposes of forest, which states, "Land spanning more than 0.5 ha covered by trees attaining a height of more than 2m and a canopy cover of more than

20% or trees with the potential to reach these thresholds in situ in due course" (MEFCC 2017c). Ethiopia's definition of forest (meant for REDD+ -MRV purposes).

The region forests and woodlands are depositories and gene pools for several domesticated and/or important wild plants and wild relatives of domesticated plants. For example Coffee (*Coffeaarabica*) is found in the region. Forests are important not only for the products that can be harvested from them and for the complex interactions they make with other organisms to build up and/or maintain the complex fabric of biodiversity, but also for preventing erosion and for affecting the climate in a positive way.

Forest are developed and managed in very many ways. Thus, could be developed and managed as productive forests which could be the source of industrial construction and fuel wood and managed through various systems. In Harari region however, what we can observe is the remnant of the natural vegetation indicate that the high land area such as Awhakim (Hakim Gara), Aboker plateau and the north eastern part of Harar town covered with natural shrub and wood land. This indigenous species remnant indicator also coverings that the low lands in the eastern and south east were also covered with low land wood land vegetation in the past.

In the last 2-3 decades Harari region was known to one of the potential area for the production of agricultural products including high economic value fruits. The vegetation of the region predominantly composed of various species such as ground nut, Mango, Orange and coffee which had high economic value for the region and indigenous forest trees, such as, cordial Africa, Rosa Abyssinia etc. It was also a place for crop species with genetic diversity. There were also various wild plants that are used by communities for various purposes including medicinal use.

The amount of coverage of the forest in the region less than 1% this is as result of deforestation due to different practices on forest for different purposes such as charcoal making, fuel wood sealing and construction purposes.

Erer districts

By now and over the past 5 years Argoba mountains, Itisa mountains, Gola mountains, at ulanula and at hawayie jebertii, qimataro mountains, Marko mountains in waldiya in dodota and few private farmers are planted among them the model farmer forester known by the name as shame yonis is one of the person .

The negative signs spoken now against the forest development at erer qimataro dodota cattle let into forest land and now the forest is being ruined unless sound measures is taken and kept well as other forest lands with guarders installed destruction is inevitable in qamataro mount forest

Sofi districts

In sofi woreda forest land extends from Mariam church to Lugo Burqa Mountains and, at Gelmeshira and Awberkale hakim mountains, Koromi Mountain at burqa qabelei and also Adnan and qabelei forests at Harawei respective mountains are found afforested and at qile qabelei, at sofi Jamila mountains afforested and all kept with safety net pay, various projects including water shade and GSF and regular budgets are paying for guarders who keep those forest sites.

Normalized differential vegetation index

The Normalized differential vegetation index (NDVI) is standardized vegetation index which allows us to generate an image showing the relative biomass. The chlorophyll absorption in Red band and relatively high reflectance of vegetation in Near Infrared band (NIR) are using for calculating NDVI. An NDVI is often used worldwide to monitor drought, monitor and predict agricultural production assist in predicting hazardous fire zones, and map desert encroachment.

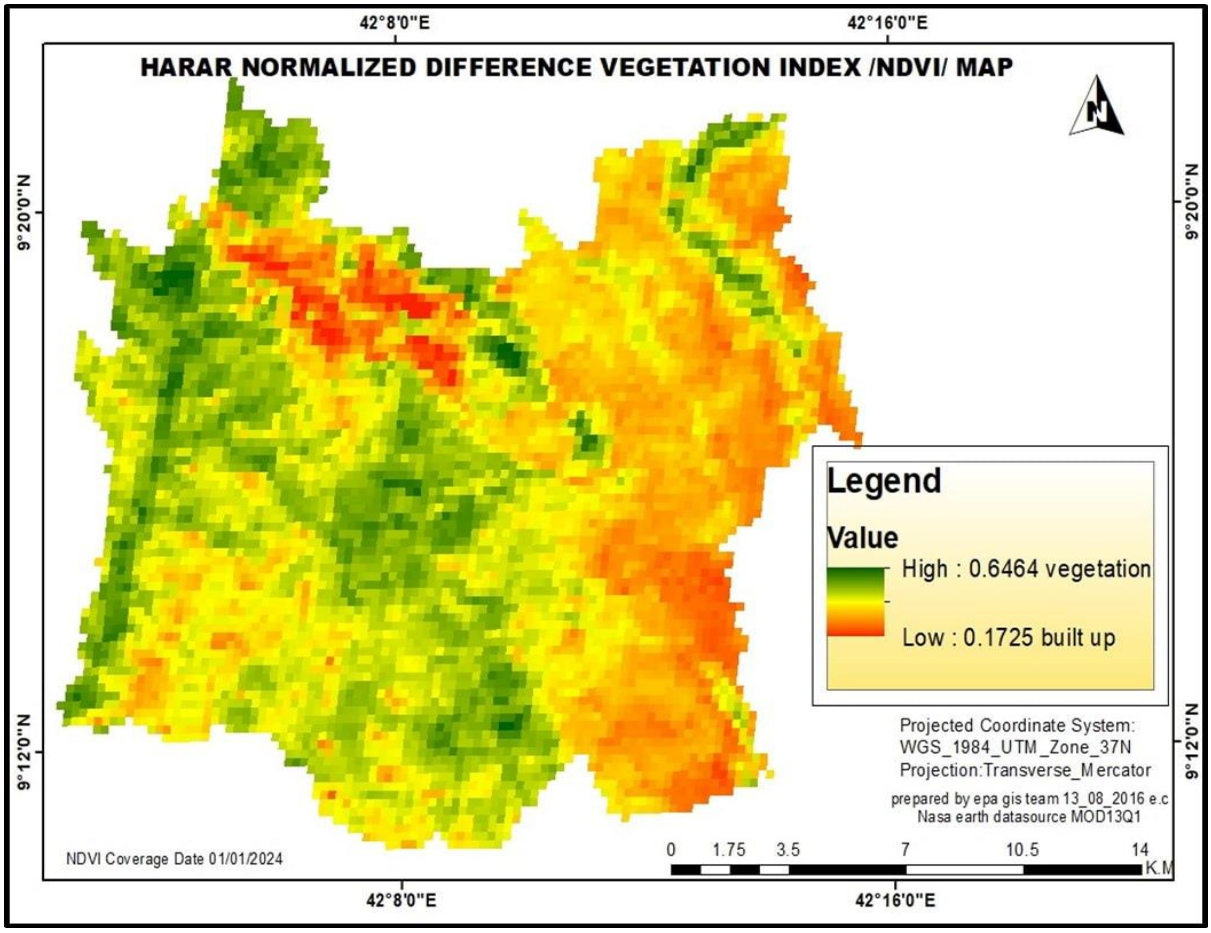

Figure: 9 Normalized differential vegetation index (NDVI)

Normalized differential vegetation index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). NDVI always ranges from -1 to +1. But there isn't a distinct boundary for each type of land cover. For example, when we have negative values, it is highly likely that it is water. On the other land, if we have a NDVI value close to +1, there is a high possibility that it is dense green leaves. But when NDVI is close to zero, there isn't a green leaf and it could even be an urbanized area.

Based on the above definition of NDVI, the projected map of Harari region shows that the majority of area coverage is high its valve 0.6464 which is near to +1 indicates that there is health or dense vegetation while the vale 0.1725 is near to zero indicates that there is built up or bare land in the region.

3.1 IMPACTS /CHALLENGES/

Though Ethiopia is the centre for diverse flora and fauna, these resources are under immense pressure from deforestation and forest degradation, overexploitation, overgrazing, habitat loss, invasive species and pollution (Moges et al., 2014). Extensive clearance of the vegetation has resulted in massive soil erosion in the highland part of the country. Erosion hazard from Ethiopian highlands has also significant national and international impact in water flows and sedimentation in particular to the regions which are using the Blue Nile such as Egypt and Sudan (Zeleke and Huruni, 2001).

The forest, woodland, shrub lands/bush lands and other tree resources of the country greatly contribute to the national economy through exports, import substitution, employment generation and expansion of gross domestic production (Lemenih and Woldmariam, 2010). Forestry sector contributes 4-5.2% to the GDP of Ethiopia, and to 5% of the workforce through the production of honey, forest coffee and timber (CRGE, 2011; FAO 2011).

Total rural household consumption of fuel wood in 2013 is estimated to be 91.2 million tonnes per year, of which charcoal accounts for 4.2 million tonnes per year of (Geissler et al, 2013). The contribution of the forest resources in providing various ecosystem services such as watershed protection,, biodiversity conservation and climate regulation are not well accounted as part of economic contribution.

According to climate Resilient Green Economy (CRGE, 2011) document the total cropland of the country is expected to reach 27 million hectares, with an annual business-as-usual growth rate of 3.9%, which is needed for crop growth target of 9.5% per year to ensure food security and poverty alleviation as per the Growth Transformation Plan (GTP). This new agricultural lands mainly come from the woodland forests. However, the deforestation rate on high forest will be declined from 70 to 55% in 2030. At the same period, the fuel wood consumption will rise by 65% – resulting in forest degradation of more than 22 million tonnes of woody biomass. This is due to more than 90% of rural households' energy supply comes from biomass energy sources (firewood, charcoal, and branches, leaves and twigs). The same way, in Harari region due to charcoal production and fuel wood consumption by the community is higher.

3.2 RESPONSE

Establishing area closures has become common in Ethiopia, especially in northern and central highlands, where they serve as a response to persistent soil, vegetation and water degradation affecting forest resources, agricultural biodiversity and ecosystems.

- Ethiopia plans to rehabilitate 22 million hectares (15+7) of degraded forests and lands by 2030;
- Area closures contribute a lot and as widely promoted rehabilitation practices (1.5 million ha in one region only), contributed to the vegetation cover change of the country (12-15%).
- Ethiopia is aggressively moving to increase the forest cover from 15% to 20% during the GTP period mainly through afforestation activities. In Harari region is also more than 170.52 ha of land was covered by forest plantation, 200 ha by afforestation 140 ha by restoration respectively.

Table: 5 planation forest distribution in Harari region.

No	Planation site name	Area in ha	Area in %
1	Awubar	19.13	11.2
2	Garad	7.19	4.2
3	Hassengay	2.6	1.5
4	Muti	2.8	1.6
5	Hacalupark	4.4	2.6
6	Karra	21.4	12.5
7	Ittisa	10.95	6.4
8	Kormi	6.75	3.95
9	Keyra	4.32	2.5
10	Dabane	10.2	5.98
11	Kabbale	11.8	6.9
12	Kile	12.56	7.36
13	Jaberti	56.42	33.31
	Total	**170.52**	**100**

3 STATE OF WATER RESOURCE

Harar was one of the first town to get piped water supply in Ethiopia about 120 years ago using “SOFI” spring as a sources (10 l/s), by a family called Haji Abrahim Abdela Muslimano and his son Ahmed Bomba "Hajji Bomba. “. The pipe line system get renewed by a new pipe purchased by the regional government in1989 E.C, then The sofi spring system was backed up during the Italian occupation of 1936 by constructing 100 m3 at Feres-megala that includes developing of springs Jinela Alta, Jinela Basa with the constructions of 600 m3 at Jenila, 600 m3 at Niguss-shira and 100 m3 reservoirs at Tassinary (Medfe Metekosha) and connecting these reservoirs by a series of 125 /150 mm diameter asbestos cement pipelines.

4.1. Ground Water Resource

The groundwater potential of the region in general is very poor. This is attributed to the unfavourable geologic material of the region. The eastern, south-eastern, north-eastern and some parts of the western and south-western parts of the Harari Region area are covered by Precambrian Rocks such as granite, granite gneiss and other high metamorphic rocks. Occurrence of ground water resource is known to be low-moderate in Harari Region due to prevalence of metamorphic formation and undulating terrain in the region. The metamorphic rock which is characterized by gneiss rock has lower primary and secondary permeability. Thus, it inhibits percolation and storage of surface runoff to the ground. Besides, it has lower openings for storage of percolated water. The Mesozoic sedimentary formation and the recent alluvial sediment have limited spatial coverage in the region. However, there is high potential of ground water resource in the surrounding area, especially in the Dire Dawa Administration.

Groundwater potential is being exploited for drinking in this region as hand dug well, tube wells dug by machine and deep wells. Other ground water sources in this region are springs found in southern part namely Burqa, Lugo and Sofi spring. These are used both for water supply and irrigation. Groundwater is the sole water source for supply of water to urban and rural areas of Harari Region. Currently, Harar City is getting from three well fields, namely i) Hula Hulu and Hasseliso well field (Dire Dawa well field), ii) the Ifabatee well field (near Alemaya town and University), and ii) the new Erer well field which require special care to safeguard them from pollution.

4.2. Surface Water Resource

Harar Region has a total of eight rivers, out of which Erer and Hamaresa Rivers are the most prominent ones. These two rivers are major surface water sources in Harar town and they are located to the east and west of Harar Town respectively. Both rivers are intermittent or seasonal, with water during and for a few months after the rainy seasons.

Erer River is tributary of Wabeshabelle River and has a length of about 2km in this region. All three rivers are used for irrigation purpose and in small scale irrigation. Communities living adjacent to these rivers use it as water supply both for drinking, domestic use and livestock's. Another surface water source is Haramaya Lake found in eastern Hararghe (Oromia Region) which was used as water supply source for Harar town (65%) and community irrigation purpose (35%) from 1960 E.C up to 1977E.c but at present it has dried up and filled with silt.

4.3 IRRIGATION

The potential irrigable land of Ethiopia is estimated at 5.3 million ha of which surface and groundwater irrigable schemes are 3.13 and 2.03 million ha, respectively (NPC,2015). However, by 2015 only 6.2% of the potential was developed.

In Harari region, irrigation has long history as Harari used culturally long ago cultural irrigations ponds and today too there are an ample of cultural ponds used for irrigating their permanent crop like Harari coffee and as Chat is believed to be the birth place is harar, in dry seasons, Chat grown in dry seasons. On top of this in regions there are more than 30 moderately constructed diversion weir, micro dams and diversion weir with night storage ponds.

4.2.1. Water Scarcity

It is defined as the point at which the aggregate impact of all users impinge on the supply and quality of water under prevailing institutional arrangement to the extent that the demand by all sectors including the environment, cannot be satisfied fully. With the existing climate change almost half the population will be living in areas of high water stress by 2030.G.C. Therefore, scarcity also becomes one challenge in getting fresh water in our region. Even though most of the population in this region uses ground water for water supply, the source is

not reliable. The scarcity is due to topography of the land which is hilly that has no potential recharging.

Drought seasons result in water shortage. Therefore, the ecosystem, which is the source of rain and water resource, will be affected. Rain water scarcity would affect the human life, botany and zoology by deteriorating the quantity and the quality of water bodies.

Impact of water scarcity caused by climate change (drought) needs additional budget for human resources. This leads to the reduction in the allocation of budget and human resources for education, health, water supply, environment hygiene and sanitation.

Hence the major challenge in this region is water scarcity both in rural and urban areas in different sectors using water, including water supply, irrigation, industrial and commercial use.

4.3 DRAINAGE

Harari region is fully situated in Wabe Shebelle drainage basin. There are three sub-basins in the administrative boundary of the region, namely Hamaressa, Bisidimo and Errer. These three main river basins cover with the distance of 2019.42 km.

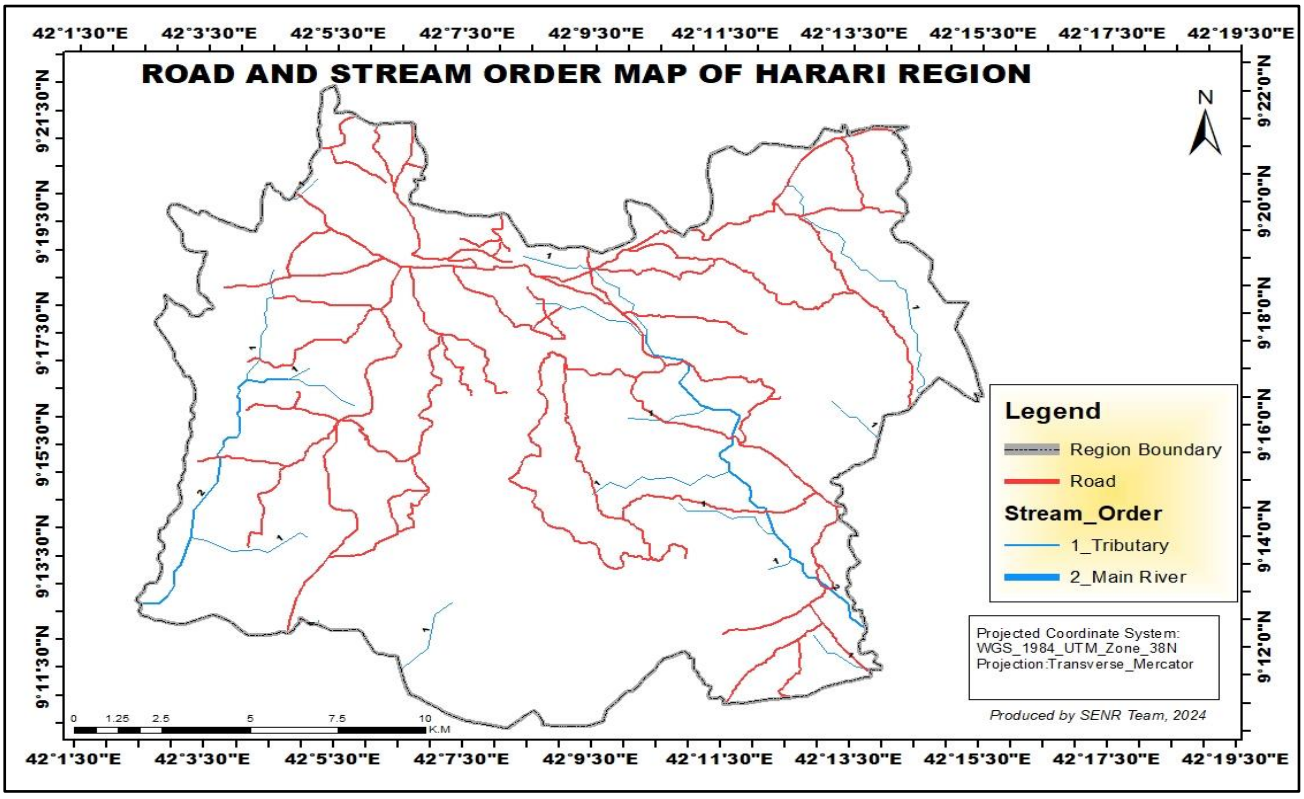

Figure 10: Road & stream order map of Harari region, 2024

4.4 IMPACTS

Challenges facing fresh water and Water Scarcity in Harari region

Fresh water is vital to life and yet it is a finite resource. Of all the water on Earth, just 3% is fresh water. Although critical to natural and human communities, fresh water is threatened by a myriad of forces including overdevelopment, polluted runoff and global warming. With this in mind, all development actors, private partners with communities, businesses and others to decrease pollution, increase water efficiency and protect natural areas to ensure enough clean water exists to conserve wildlife and provide a healthy future for all.

Currently, Harar City and its surroundings, including the towns of Aweday, Haromaya and Adele are highly dependent on external water supply from Dire Dawa at 32 Km away from the city called Asseliso and Hulan Hulul from ground water source (Deep Well with 450-500 m depth). The water is transmitted over a distance of 80 km and a height/elevation difference of 1,000 m with 4 bosting stations to lift up the mountain. The current water supply is not sustainable in technical, climate and financial terms. The current aquifer is rapidly depleting. Moreover, production and distribution costs are extremely high due to high energy costs (4 KWh per m^3). Besides the loss at the main and distribution system is very high, frequent power/Electric interruption due to the intermittent Power/Electric interruption, as the system immediately release the water to back flow with high pressure, which usually causes great water loss with total estimated Non-Revenue Water to be 35-40% in average, with the possibility to be escalated dramatically.

In general, the current water demand of the region is from 25,000-26,000 m^3/day; however, the water source of the region was polluted by different factories by unsafe disposal of waste of Harer beer factory is influencing discharge problem. Therefore, in the region about 67% shortage drinking water deficit between water demand and supply.

4.5 RESPONSE

In regular time interval water reservoirs are treated, numbers of moisture conservation technologies were constructed in hilly lands of the region.

Figure 11: Moisture conservation technologies or Hillside construction

SATE OF MINERAL RESOURCES

Mining in Ethiopia is currently predominantly controlled by low skilled, small scale miners utilizing low technological machineries and inputs.

Naturally Occurrence minerals in Harari Region

Metallic and non-metallic minerals are available in Harar city and in the surrounding areas.

Names /IUPAC name = Iron (III) oxide other names (ferric oxide, haematite, ferric iron, red iron oxide, rouge, Magnetite, colcothar, iron Sesqui oxide, rust, and ochre).

Iron (III) oxide or ferric oxide is the inorganic compound with the formula Fe_2O_3. It is one of the three main oxides of iron, the other two being iron(II) oxide (feo), which is rare; and iron(II,III) oxide (Fe_3O_4), which also occurs naturally as the mineral magnetite. As the mineral known as hematite, Fe_2O_3 is the main source of iron for the steel industry. Fe_2O_3 is readily attacked by acids. Iron (III) oxide is often called rust, since rust shares several properties and has a similar composition; however, in chemistry, rust is considered an ill-defined material, described as hydrous ferric oxide (Haynes, William M., ed. (2011).

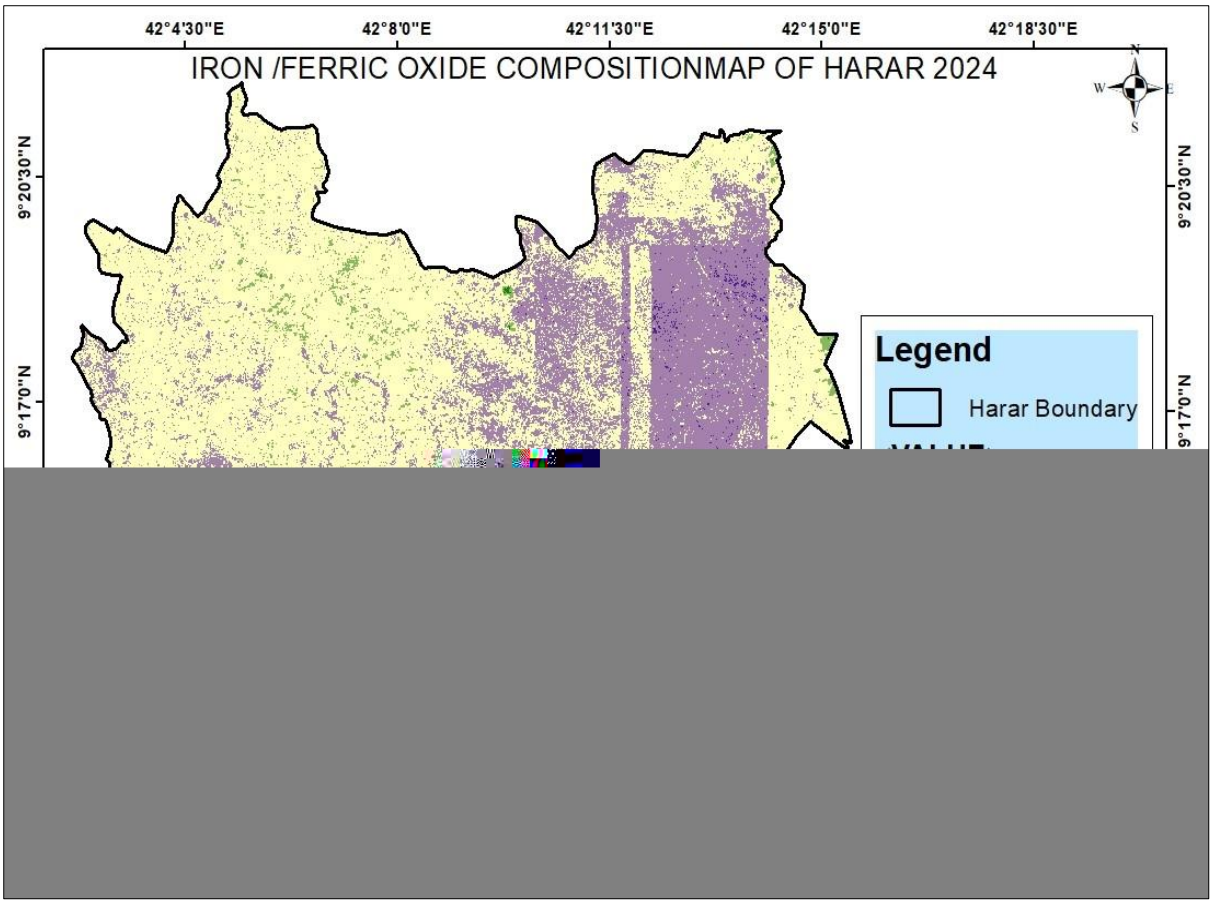

Figure 12: Iron distribution map of Harari region, 2024

Uses of Iron oxide

Iron industry

The overwhelming application of iron (III) oxide is as the feedstock of the steel and iron industries, e.g., the production of iron, steel, and many alloys (Greenwood, N. N.; Earnshaw, A. (1997)).

Polishing

A very fine powder of ferric oxide is known as "jeweler's rouge", "red rouge", or simply rouge. It is used to put the final polish on metallic jewelry and lenses, and historically as a cosmetic. Rouge cuts more slowly than some modern polishes, such as cerium (IV) oxide, but is still used in optics fabrication and by jewelers for the superior finish it can produce. When polishing gold, the rouge slightly stains the gold, which contributes to the appearance of the finished piece. Rouge is sold as a powder, paste, laced on polishing cloths or solid bar (with a wax or grease binder). Other polishing compounds are also often called "rouge", even

when they do not contain iron oxide. Jewellers remove the residual rouge on jewellery by use of ultrasonic cleaning. Products sold as "stropping compound" are often applied to a leather strop to assist in getting a razor edge on knives, straight razors, or any other edged tool (Greedan, J. E. (1994)). "

Pigment

Figure 13: Red α and β yellow phases of hydrated of iron oxide

Sample of the red α- and yellow β-phases of hydrated of iron (III) oxide; both are useful as pigments.

Iron (III) oxide is also used as a pigment, under names "Pigment Brown 6", "Pigment Brown 7", and "Pigment Red 101" Some of them, e.g., Pigment Red 101 and Pigment Brown 6, are approved by the US Food and Drug Administration (FDA) for use in cosmetics. Iron oxides are used as pigments in dental composites alongside titanium oxides (Banerjee, Avijit (2011).

Magnetic recording

Iron (III) oxide was the most common magnetic particle used in all types of magnetic storage and recording media, including magnetic disks (for data storage) and magnetic tape (used in audio and video recording as well as data storage). Its use in computer disks was superseded by cobalt alloy, enabling thinner magnetic films with higher storage density (Piramanayagam, S. N. (2007).

Photo catalysis

α-Fe_2O_3 has been studied as a photo anode for solar water oxidation. However, its efficacy is limited by a short diffusion length (2–4 nm) of photo-excited charge carriers and subsequent fast recombination, requiring a large over potential to drive the reaction. Research has been focused on improving the water oxidation performance of Fe_2O_3 using Nan

structuring. Surface functionalization, or by employing alternate crystal phases such as β-Fe_2O_3 (Emery, J.D. (2014).

Medicine

Calamine lotion, used to treat mild itchiness, is chiefly composed of a combination of zinc oxide, acting as astringent, and about 0.5% iron (III) oxide, the product's active ingredient, acting as antipruritic. The red color of iron (III) oxide is also mainly responsible for the lotion's pink colour.

Jewellery

Hematite is often shaped into beads, tumbling stones, and other jewellery components. Hematite was once used as mourning jewelry. Certain types of hematite- or iron-oxide-rich clay, especially Armenian bole, have been used in gilding. Hematite is also used in art such as in the creation of intaglio engraved gems. Hematine is a synthetic material sold as *magnetic hematite* (17 April 2024 Wikipedia).

Industrial purposes

As mentioned earlier, hematite is an important mineral for iron ore. The physical properties of hematite are also employed in the areas of medical equipment, shipping industries and coal production. Having high density and capable as an effective barrier for X-ray passage, it is often incorporated into radiation shielding. As with other iron ores, it is often a component of ship ballasts for its density and economy. In the coal industry, it can be formed into a high specific density solution, to help separate coal powder from impurities (Haynes, William M., ed. (2011).

According to UN habitat project, 2022, the distribution, potential use and level of development are shown in the **Error! Reference source not found.** below.

Table 6: Distribution of mineral resources in Harari Region

No	**Type of mineral**	**Location**	**Reserve**	**Potential use**	**Level of development**
1	Granite	Sigicha and Hamaressa	15 Mm3	Dimension stone	Under production

2	Marble	Aw Hakim, Sukul	150,000 tonn	Dimension stone	Under exploration
3	Gemstone	Mehay	Not estimated	Ornamental	Under Reconnaissance survey
4	Kaolin	Hara-Kombolcha road	3 Mm3	Industrial mineral	Dimension stone
5	Molybdenite	Bisidimo river	Not estimated	As mineral for molybdenum	Reconnaissance survey
6	Limestone	Aw Hakim	60 Mm3	Dimension stone and industrial mineral	Under production

Quarry sites

Quarry sites are important resource areas for urban centres. However, unless attention is given their exploitation damages the natural setup and affect the way urban centres are developed and managed. There are a total of 16 active and 4 old quarry sites in Harar city. Although they are important in the supply of stone construction materials, they affecting the city in different ways.

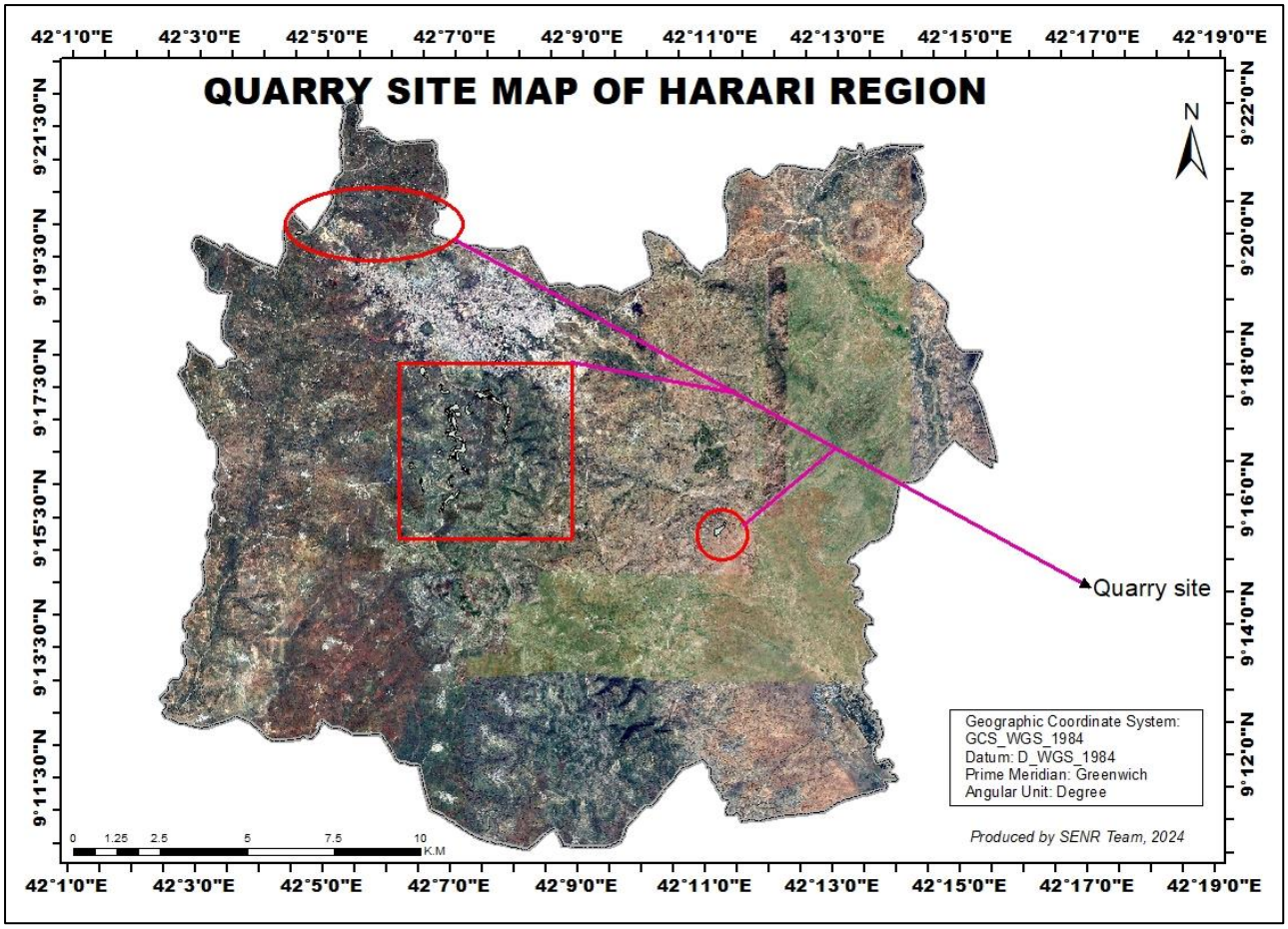

Figure 14: quarry location map of Harari region

Figure 15: Quarry sites in Harari region

As we confirmed in the field observation, the region has high potential of quarry and lime stone and more than, 77.39 ha of land has been covered by quarry.

Industrial investment in Harari region

In the region there is no Agricultural investment rather there are only the industrial, manufacturing and service investment are found in the region.

Figure 16: Industrial investment sites in Harari region

Table: 7 Type of industrial investment in Harari region

NO	OWNERS NAME	INVESTMENT SECTOR
1	Halifa jami	Plastic recycle
2	Abubker Ahmed	Pen
3	Mohamed Ahmed	Mattress
4	Mask PLC	Biscut
5	Hindia Jamil	Dry goods
6	Salah Muhamed	Mattress
7	Emamin PLC	Lime stone
8	Asha Abas	Oxygen
9	Muhamed Salah	Oxygen
10	Muhamed Salah	Tin
11	Adem Mekonnen	Food processing
12	Selomon Asefa	Food processing
13	Anewar Yesuf	Furniture
14	Mewulud Usman	Car
15	Wati Giranaite PLC	Giranite
16	Metro Politin PLC	Paper
17	Tisayna Rim PLC	Soap
	Total	**17**

More than 128 investors were registered to invest in Harari region, in different sectors like industry, manufacturing and service. Among these, only 17 investments sectors were valid and they entered on product processing.

5.1 IMPACTS OF NATURAL RESOURCES

- Natural resource degradation is super high consumption with low or almost no replenishment of natural resources like air, water, soil, minerals, fossil fuels, etc.
- The main cause of natural resource degradation is overpopulation.
- The increasing population causes overconsumption of natural resources leading to its depletion.
- Natural resource degradation leads to loss of biodiversity which directly impacts the ecological balance in nature.
- Irrigation practices and agricultural invasion of forest lands cause soil erosion and deforestation.
- Advancement in technology is not always a boon; it is causing more damage to the environment than the benefits it brings along.

5.2 RESPONSE TO NATURAL RESOURCES

Some of the measures to prevent the degradation of natural resources are as follows:-

- ✓ Stop deforestation and promote the planting of more trees.
- ✓ Improve irrigation and agricultural practices.
- ✓ Stop overconsumption by reducing over-cultivation, mining, fishing and other such practices.
- ✓ Government Regulations and policies should be created to save precious natural resources and restore biodiversity.
- ✓ Punish and penalize industries contributing to pollution.
- ✓ Efforts to Reduce Consumption of natural resources.
- ✓ Recycle, Reuse and Reduce waste generation.
- ✓ Create Awareness by educating people about natural resource preservation and helping them understand their responsibility towards nature and saving the planet.

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