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Journal of Science and Sustainable Development (JSSD)

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Journal of Science and Sustainable Development (JSSD)

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- To promote the effective teaching of science, technology and management; identifying problems and developing solutions through dissemination of new information from researches align in the direction of solving the basic need of the country.

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The **Abstract** should be informative and completely self-explanatory, briefly present the topic, state the scope of the experiments, indicate significant data, and point out major findings and conclusions. The abstract should be 200 to 250 words in length. Complete sentences, active verbs, and the third person should be used, and the abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited.

Following the abstract, about 3 to 5 **key words** that will provide indexing references should be listed.

A list of non-standard **Abbreviations** should be added. In general, non-standard abbreviations should be used only when the full term is very long and used often. Each abbreviation should be spelt out and introduced in parentheses the first time it is used in the text. Only recommended SI units should be used. Standard abbreviations (such as ATP and DNA) need not be defined.

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Tables should be kept to a minimum and be designed to be as simple as possible. Tables are to be typed double-spaced throughout, the captions. Each table should be numbered consecutively in Arabic numerals. Tables should be self-explanatory without reference to the text. The same data should not be presented in both table and graph forms or repeated in the text.

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Chikere CB, Omoni VT and Chikere BO (2008). Distribution of potential nosocomial pathogens in a hospital environment. Afr. J. Biotechnol. 7: 3535-3539.

Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing *Escherichia coli* in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

Pelczar JR, Harley JP, Klein DA (1993). Microbiology: Concepts and Applications. McGraw-Hill Inc., New York, pp. 591-603.

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RESEARCH PAPER

Status of Selected Properties of Soils and the Response of Malt Barley (*Hordeum distichum* (L.) to Lime and Phosphorus Fertilizer Rates at Chaliya and Jaldu Districts, West Shewa Zone, Ethiopia

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Abstract

Soil acidification and unavailability of phosphorus (P) are among the major problems limiting the productivity of crops in most highlands of Ethiopia. To improve these conditions lime and P fertilizer application is an important strategy. Accordingly, these field experiments were conducted to evaluate the effect of agro-lime and P fertilizer rates on the yield of malt barley and their influence on soil properties. Experimental treatments comprised four levels of agro-lime (0, 1.1 2.2 and 3.3 t ha-1) and four levels of P2O5 (0, 30, 60 and 90 kg ha-1) that was laid out in a randomized complete block design in a factorial arrangement and replicated three times. The results showed that the soils of the two sites were categorized as clay loam in texture and suitable for the production of malt barley. On contrary to this, pre-sowing soil analysis showed very low available phosphorus and acidic soil pH in both sites. The highest values of grain yield of malt barley 4.97 and 4.68 t ha-1 was obtained as a result of the application of 3.3 t ha-1 of lime rate and 90 kg P ha-1 fertilizer at Jeldu and Chaliya, respectively. Hence, the application of lime at the rate of 3.3 t ha-1 and 90 kg P ha-1 could serve as a reference for better malt barley production for the study areas. Nevertheless, the most generalized recommendation should be suggested after inclusion of economic analysis.

Keywords: Lime rates, p-fertilizer, malt barely, yield

Introduction

The problem of soil acidity is considered to be one of the major bottlenecks to malt barley production in the highlands of Ethiopia. Soils can be acidified under natural conditions over thousands of years, especially in high rainfall areas. Soil acidity is developed under high-rainfall conditions and it can be considered as one of the major limiting factors to acid-sensitive crop production. Soil acidification can also pose several problems for successful agricultural crop production and limit plant growth not only because of the deficiency of major nutrients such as phosphorus (P), calcium (Ca) and magnesium (Mg) but also due to toxicity of aluminum (Al), manganese (Mn), and hydrogen (H) ions as well as the depletion of the soil fertility. Over 41% of Ethiopia's agricultural land is impacted by acidity, featuring soil pH of 5.5 or lower. Soil acidity prevents plants from releasing the nutrients in the soil, and thus biomass production on acid soils is stunted. Thus, soil acidity is best addressed through integrated soil fertility management, in which a series of technologies are applied in tandem to safeguard the health and fertility of the soil as well as to enhance the productivity of acid-sensitive major cereal crops such as barley, bean, and wheat (Achalu *et.al.*, 2012a; Aboytu, 2019; Achalu, 2022).

Soil acidity has grown in scope and magnitude across different highland areas of Ethiopia. The effect of soil acidity in these areas has caused mineral stress in the soils. Because of these circumstances, a number of adverse effects are observed such as loss of crop diversity, decline

in the yield of existing crops, lack of response to ammonium phosphate and urea fertilizers, and complete failure of cropping land. Studies on plant growth-limiting nutrients, like P, show that acid soils dominate most of the southern and southwestern parts of the country and generally have low P content (Mesfin, 1998, Achalu, *et al.,* 2012a). In Ethiopia, soil acidity is a problem that has not been addressed in depth and most of these soils are found in the highlands which receive high rainfall areas. Currently, there is increasing awareness that soil nutrient depletion from the agro ecosystem is a very widespread problem and it is an immediate crop production constraint in Ethiopia. Low soil fertility resulting from land degradation, soil erosion, crop removal of nutrients from the soil, total removal of plant residue from farmlands and lack of proper crop rotation programs are some of the major factors causing low agricultural production and productivity in western highlands of the country.

Furthermore, crop diversity and yields are declining due to the pronounced influence of soil acidity on plants and soil infertility. Barley is one of the major cereal crops that are largely produced in the central and southeast mid and high altitude areas of Ethiopia. It is the staple food grain for Ethiopian highlanders who manage the crop with indigenous technologies and utilize different parts of the plant for preparing various types of local food such as *Kita, Kolo, Beso, Enjera,* local beverage called *Tela* and as an important raw material for many industries (Achalu *et al.,* 2012b). Although barely crop is the major staple food in the highlands, used as the source for many nutritional values and industrial applications, there was no much research work done on the combined application of different liming and P-fertilizer rates to improve its productivity in acidic soils in the particular districts of the present study. Due to the lack of sufficient and detailed scientific research work in the area, barley production and productivity have been decreasing from year to year and the crop is forced to go out of production leading to a shortage of barley food sources in most areas of western Oromia Region. Moreover, most of the crops that are very susceptible to soil acidity like barley, bean, and wheat are almost forced to be out of production in the region. Therefore, the present study was initiated to evaluate the effects of different rates of lime and P fertilizer application on yield of malt barley and selected soil properties.

Materials and methods

Description of Study Areas

The study was conducted in Jaldu and Chaliya districts, which are located in west Shewa zone of Oromia National Regional State (Figure 1). The two districts are located at a distance of about 115 and 193 km, respectively, from Addis Ababa.

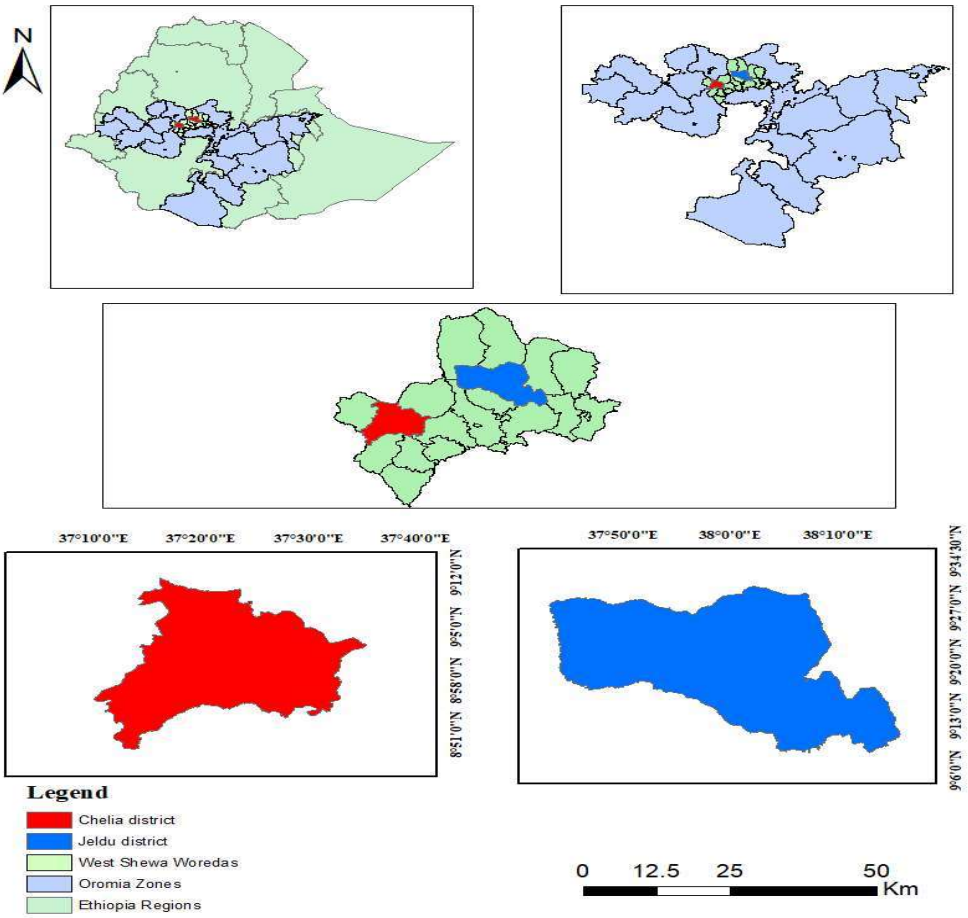

Figure1. Location map of the study areas

Climate, Topography and Farming Systems of the Study Areas

As per the local and traditional practice, the study areas are agro-climatically classified as highland (*Baddaa)* and mid-altitude *(Badda Darree) (*Districts Agricultural Extension Office, 2020). According to the weather data recorded at the west Shewa zone Meteorological Station, the average annual rainfall of the study areas is 875 mm and 900 mm for Jaldu and Chaliya, respectively and the mean minimum and maximum temperatures are 17 and 22 ^{0}C for Jaldu, and 8 and 25 ^{0}C for Chaliya districts (Districts Agricultural Extension Office, 2020). The topography of both study districts is largely mountainous and has gentle sloping landscapes. The economic activities of the local community of the study areas are primarily mixed farming system that involves crop production and animal husbandry (MOFED, 2002). The major crops in the study districts are Potato (*Solanum tubersoum),* Tef (*Eragrostis tef*), Wheat *(Triticum aestivum)*, Faba bean (*Phaseolus vulgaris*), Maize (*Zea mays*), and Barley (*Hordeum vulgare*) are usually produced once a year.

Treatments, Experimental Design, Experimental Procedures and Field Management

The experiment was laid out in a randomized complete block design and arranged in a factorial arrangement with three replications. The treatments were four levels of agro-lime (0, 1.1, 2.2 and 3.3 t ha-1) and four levels of P2O5 (0, 30, 60 and 90 kg ha-1). After site

selection was done in each area; ploughing was done three times with traditional oxen-driven practices. Agricultural lime obtained from Guder lime factory was broadcasted by hand and the whole P fertilizer was applied to each experimental plot per site except the control.

Malt barley variety was used as a test crop and hand drilled at a recommended seeding rate of 75 kg ha-1. Sowing was conducted in the last week of June 2020. The experimental malt barley seeds were drilled by hand at 0.2 m spacing between rows for both test fields in the plot with an area of 10 m2 (2.5 m x 4 m). The spacing between plots and blocks was 0.5 m and 1 m, respectively. Weeds were removed 40 days after planting and the second weeding was 35 days after the first weeding periods. The lime requirement of the soil was calculated based on its exchangeable acidity as described by Kamprath (1984). Soil samples of (0-20 cm) were collected from test fields before sowing. Representative soil samples were collected for soil physioc-chemical determination. The yield was recorded from each experimental plot. The yield was measured after harvesting was done from a net plot area of 4.4.m2. All management aspects (seed bed preparation, sowing, fertilization, weeding, harvesting) were done by adopting the recommended practices of malt barley production and local practices of the farmers of the two districts. Soil sample preparation and analysis were done at Oromia Water Work and Construction Design Soil Laboratory Center.

Soil Sampling and Analysis

Twelve representative soil samples per experimental site was randomly collected using auger at a depth of 0-20 cm and then one composite soil sample was prepared to determine the physioc-chemical properties of soils before sowing. The samples were air dried, ground by mortar and pestle and passed through a 2-mm sieve for analysis of selected physico-chemical properties, while total N was determined from soil samples sieved by 0.5-mm sieve.

Particle size distribution was determined by the hydrometer method (Day, 1965). Bulk density was determined using the core sampler method and computed from the values of oven-dry soil mass and volume of core sample as described by Jamison *et al*. (1950). The particle density (ρ_p) was considered as an average value of 2.65 g cm^{-3} for the calculation of the total porosity of the experimental soils at both study sites. Total porosity was calculated from the values of bulk density and the average value of particle density using the method described by Rowell (1994). Soil samples taken by core sampler were saturated and used in a pressure plate extractor for measuring water content at -33 and -1500 kPa matric potential. The equilibrium moisture content at -33 and -1500 kPa matric potential points was determined gravimetrically as described by Reynolds (1970). The gravimetric water content was converted into volume wetness by multiplying it with the ratio of dry bulk density to the density of water (assumed to be 1 g/cm^3). Available water holding capacity (AWC) was computed as the difference between water retained at field capacity (FC) and permanent-wilting point (PWP) (Hillel, 1998).

Soil pH in water was determined by the glass electrode pH meter (Peech, 1965) at 1:2.5 soil water ratios. The cation exchange capacity (CEC) was determined by the method described by Chapman (1965). Exchangeable potassium (K) and sodium (Na) were determined using a flame photometer as described by Rowell (1994), while calcium (Ca) and magnesium (Mg) were determined by the atomic absorption spectrophotometer method (Hesse, 1971; Rao *et al* 2005). Total exchangeable acidity was determined by saturating the soil samples with 1M KCl solution and titrating with 0.02M HCl as described by (Rowell, 1994). From the same extract, exchangeable Al^{3+} in the soil samples was titrated with a standard solution of 0.02M HCl. Then the exchangeable H^+ was obtained by subtracting exchangeable Al^{3+} from total exchangeable acidity, which is Al^{3+} and H^+ ions (Rowell, 1994). The percent base saturation of the soil samples was calculated from the sum of the exchangeable cations (Ca^{2+}, Mg^{2+} and Na^+) as a percentage of CEC (Baruah and Barthakur, 1997, Sahlemedhin, and Taye, 2000). Available P was analyzed using Bray II (Bray and Kurtz,

1945). Total N content in the soils was determined using the Kjeldahl procedure (Jackson, 1958). To determine organic carbon (OC), the Walkley and Black (1934) method was employed. Finally, the organic matter (OM) content of the soil was calculated by multiplying the OC percentage by 1.724. The relative amount of carbon to nitrogen was determined by taking the ratio of soil OC to total N.

Agronomic Data Collection

Grain yield was measured from all experimental units. Grain yield was determined by harvesting from the middle rows (4.5 m^2) area and converted into hectares bases after adjusting the grain moisture content to 12.5%.

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Data Analysis and Interpretations

The analysis of variance for grain yield was made for each site. The collected data on the grain yield of malt barely was subjected to analysis of variance (ANOVA) by using SAS version 9.4 statistical software (SAS Institute, 2002). All pairs of treatment means were compared using the Least Significant Difference (LSD) test at a 5% level of significance (Steel and Torrie, 1980).

Results and discussions

Pre-sowing status of selected physical and chemical properties of experimental soils

The mean value of analytical results of selected soil physico-chemical properties of Chaliya and Jaldu districts were shown below in Tables 1 and 2. The results of laboratory analysis for soil physical properties indicated that the soils have 32% sand, 40% silt and 28% clay for Chalyia, and 24% sand, 46% silt and 30% clay for Jaldu site. On the basis of the USDA (1999) soil textural triangle, the soils of the two districts could be categorized as clay loam textural class. The textural classes of both study sites were the same might be due to the similarity in the parent material. Malt barley is best adapted to loams, sandy loam and clay loam soils. Thus, in terms of textural class, the soils of the experimental sites were suitable for the production of malt barley.

Table 1. Pre-sowing of mean values selected physical properties of soils

Soil parameters	**Mean values and experimental sites**	
	Chaliya district	Jaldu district
Textural class	Clay loam	Clay loam
Sand (%)	32	24
Silt (%)	40	46
Clay (%)	28	30
Bulk density (BD) in (gcm^{-3})	0.91	0.93
Total porosity (%)	65.6	64.9
Field capacity (%)	35.9	36.6
Permanent wilting points (%)	26.1	25.9
Available water capacity (mm/m)	98	107

The BD in soils of Jaldu district was relatively higher than that of soils of Chaliya district. The relatively lower and higher BD of soils at Chaliya and Jaldu districts may be attributed to the high SOC, porosity and fewer disturbances of soils of Chaliya district. Basically, an increase in SOC lowers bulk density while compaction increases bulk density. Therefore, compaction of the soil surface caused by intensive field traffic by livestock for grazing and deforestation may cause an increase in the soil bulk density of the soils of Jaldu district.

The soil volumetric water content at field capacity, permanent wilting point and available water holding capacity at both study sites showed slight variation might be due to differences in their clay content and organic matter percentage. The relatively higher values of AWC of Jaldu district may be due to its higher clay contents. This was in agreement with the finding of Emerson (1995) who concluded an increase in AWC with an increase in the clay content of the soil. As per rating by Landon (1991) the values of available water holding capacity of both study areas were categorized under low class. The optimal AWC of soil for most crop production is greater or equal to 150 mm per meter depth. Soils under both study sites are by far below this threshold value, which indicates that the soils of the two sites are out of the optimum range of AWC for agricultural production.

Table 2. Pre-sowing mean values of selected chemical properties of soils

Soil chemical parameters	Experimental sites and mean values	
	Chaliya district	Jaldu district
pH(H_2O)	5.12	5.01
OC (%)	2.04	1.96
TN (%)	0.22	0.18
C:N ratio	9.27	10.89
Available P(mgkg^{-1})	9.53	9.22
Total P (mgkg^{-1})	971.2	908.4
Exchangeable Ca(cmol(+)kg^{-1})	9.83	10.0
Exchangeable Mg(cmol(+)kg^{-1})	1.69	1.83
Exchangeable K(cmol(+)kg^{-1})	1.10	0.39
Exchangeable Na(cmol(+)kg^{-1})	1.07	0.27
CEC(cmol(+)kg^{-1})	31.00	28.63
Exchangeable Al(cmol(+)kg^{-1})	1.13	1.36
Exchangeable Acid(cmol(+)kg^{-1})	4.18	5.31
Acid saturation percentage (%)	13.5	18.84
Base saturation percentage (%)	49.22	46.10

The pH of the soils at Chaliya and Jaldu sites, respectively, were 5.12 and 5.01 which was in the very strong acidic soil reaction. Basically, in acidic soils with pH < 5.5, the solubility of

Al increases to toxic levels which severely restrict root systems and reduce the normal pattern of plant growth. Moreover, the acidic nature of soils with low soil pH obtained at the representative experimental soils of both districts may be attributed that, soils at both experimental districts were derived from weathering of acidic igneous granites and leaching of basic cations such as K, Ca and Mg from surface soils (Frossard *et al.,* 2000). The very strongly acidic soil reaction at the two sites indicated the unsuitability of the soil for malt barley production unless amendment options such as the application of agricultural limes to neutralize soil acidity (Achalu *et al*., 2012b; Achalu, 2022).

There was a variation of organic and total nitrogen between the two experimental sites. Across the two sites, the mean values were 2.04 and 1.96% (for soil organic carbon) and 0.22 and 0.18% (for total nitrogen), respectively, for Chaliya and Jaldu sites (Table 2). The most probable source of variation in soil organic carbon and total nitrogen contents between the two sites could be due to differences in slope, organic inputs, moisture content, temperature, pH and management practices. According to the rating suggested by Tekalign (1991), the soil organic carbon and total nitrogen percentage of the study areas can be categorized under the medium class. Comparatively, the higher mean percentage of total N recorded at Chaliya site than Jaldu site might be due to better organic carbon content scored at Chaliya site than Jaldu site.

The C: N ratio of both Chaliya and Jeldu sites was in the low rating class which might be accredited to continuous cultivation, plant uptake and volatilization. The low carbon-to-nitrogen ratio for the two sites further might be due to high microbial activity and more CO_2 evolution as a result of rapid decomposition and improvement in aeration during tillage operation which enhances mineralization rates in croplands. Similarly, Achalu *et al*. (2012a) reported that exposure of the topsoil to rainfall brings about erosion, rapid decomposition of soil OM and intense leaching of basic nutrients rendering the soil infertile and the agricultural production unsustainable.

Soil available P was 9.53 and 10.71 ppm, respectively, for Chaliya and Jaldu sites (Table 2). The relatively better available P content recorded at Chaliya site might be due to better SOM status at Chaliya site and the dominance of the $H_2PO_4^{1-}$ anion in strongly acidic soils than HPO_4^{-2} anion (Bati and Achalu, 2021). Available soil P of the study areas was categorized in the very low range as suggested by EthioSIS (2014). The very low soil available P could be due to continuous cultivation and lack of incorporation of enough organic materials into the soils, degree of P fixation, crop uptake, crop residue removal, and soil pH. The result of this study was consistent with Paulos's (2001) finding who observed that variations in available P contents in soils are related to the intensity of soil disturbance and the degree of P-fixation with Fe and Caions. Similarly, Dawit *et al*. (2002a) and Bati and Achalu (2021) reported SOM as the main source of available P and the availability of P in most soils of Ethiopia declined by the impacts of fixation, abundant crop harvest and erosion. The distribution of total P content followed a similar pattern to available P distributions and ranged from 908.2 to 971.2 mg kg^{-1}. The relatively lower amount of total P obtained in the soils of Jaldu site may be due to the intensive cultivation of lands which results in a decline in the distribution of soil total P in the area.

Before sowing mean values of exchangeable (Ca, Mg, K and Na), CEC, PBS and PAS according to FAO (2006) rating; soil exchangeable $Ca^{2+}$and Mg^{2+}were in medium class for both sites, exchangeable K^+ and Na^+ ions were relatively classified under high range in Chaliya and exchangeable K and Na ions were in low and medium classes, respectively, at Jeldu site. The order of exchangeable base cations is generally in the order of Ca > Mg > K > Na similar to what is in most agricultural soils. Variations in exchangeable bases among the two districts were insignificant. The insignificant variations might be due to differences in particle size distribution, degree of weathering, and the intensity of cultivation and the parent material from which the soil is formed (Table 1). In line with this, a study by Heluf and Wakene (2006) revealed that variations in the distribution of exchangeable

bases depend on the mineral present, particle size distribution, degree of weathering, soil management practices, climatic conditions, degree of soil development, the intensity of cultivation and the parent material from which the soil is formed.

As per the ratings recommended by Hazelton and Murphy (2007), the value of CEC of the topsoil (0-20 cm) depth of both sites can be classified as high status of CEC. The trends of the distribution of CEC showed similarity with the distribution of PBS, exchangeable Ca and Mg, since factors that affect these soil attributes also affect the cation exchange capacity (CEC) and percentage base saturation (PBS) suggesting that intensive weathering and might be the presence of more 1:1(kaolinitic) clay loam minerals in the soils of both districts. Previous research work conducted by Eyelachew (1999) on the fertility status of some Ethiopian soils indicated that exchangeable bases, especially Ca and Mg ions dominate the exchange sites of most soils and contribute higher to the PBS and CEC. The relatively higher CEC values recorded, respectively, in Chaliya districts may be attributed to the fact that the soil relatively accumulates high percent OC and has a greater capacity to hold cations thereby resulting in greater potential fertility in the soil.

There were inverse relationships between PAS and PBS of soils at both sites. Because the more acid the soil, the greater Al will be dissolved into the soil. Once the soil pH is lowered much below 5.5, aluminosilicate clays and Al-hydroxide minerals begin to dissolve and release Al-hydroxy cations from soil colloids and fractions of exchange sites occupied by Al-H. The soil chemical reaction processes that affect the extent of acidic cations ($Al^{3+}$and H^{+}) also affect the PAS. At low soil pH, oxides of Al and Fe get into the solution and through step-wise hydrolysis and release H^{+} ions resulting in further soil acidification. Basically, the relative severity of acidity of the soils in both districts comes from intensive cultivation, which results in the leaching of basic cations from soil solutions. Therefore, the soils in both districts need some reclamation options such as the use of agricultural liming materials. Because liming is commonly used to improve the productivity of acidic soils in agricultural systems and also increases the availability of nutrients, which would otherwise be strongly limited by low soil pH.

Effect of lime and P- fertilizer rates on grain yield of malt barley

The mean grain yield of malt barely grown in Chaliya and Jaldu sites is presented in Table 3. The mean values of grain yield were significantly ($p < 0.05$) affected by different rates of application of lime and P fertilizer at both experimental sites. However, the interaction effects of lime and P were not significant for yield at both sites; their main effects are presented in Table 3. The highest values of yield (4.97 t ha^{-1}) were obtained from the application of 3.3 t ha^{-1} of lime. For instance, the application of lime at the rate of 3.3 t ha^{-1}, increased the grain yield of malt barley by 48.8 and 64.21%, respectively, at Jaldu and Chaliya sites compared with the control plots. While the lowest values of grain yield (2.85 t ha^{-1}) were recorded from control plots of Chaliya site (Table 3). The highest yield following the application of lime might be due to increased pH which creates improved nutrient availability, increased available P to plants as a result of decreased Al toxicity and favorable effects of lime on soil chemical and microbial properties. In conformity to this, Getachew *et al.* (2017) and Temesgen *et al.* (2016) reported the amelioration of acid soils by additions of lime in order to increase the yield of barely. Similarly, Wang *et al.* (2011) reported increasing in yield due to liming which is mainly associated with an increase in soil pH and a reduction in acidic cations.

Similarly, the effect of different levels of P-fertilizer applications significantly ($P<0.05$) affected the grain yield (Table 3). The highest barley grain yield (4.21 t ha^{-1}) at Chaliya site, was obtained at Jeldu site due to the application of 90 P kg ha-1. For instance, the application of 90 kg ha^{-1} P fertilizer increased grain yield by 13.8 and 16.29% than the control plots, respectively, at Jaldu and Chaliya sites. Whereas the lowest grain yield (3.62 t ha^{-1}), was obtained at Chaliya site from control plots.

In general, successive applications of phosphorus fertilizer also resulted in increased grain yield of barley compared with control plots. Large levels of phosphate fertilizer application to acid soil better improved grain yield of barley crop by counteracting against Al toxicity. This could be due to the sufficient availability of P to barley crop as a result of soil sorption sites being satisfied and the decrease of sorption of soil P availability. In line with this, Anetor and Akinrinde, (2006) findings showed that with high rates of P fertilizer additions, the soil sorption sites are satisfied and P-level increases to a sufficient level for crop production in acid soils. Similarly, Haynes, (1982) reported that applications of phosphates to acid soils reduced the toxicity effects of Al ions by precipitating it from the soil and supplying enough phosphate for plant growth.

Table 3. Grain yield as affected by different rates of lime and phosphorus fertilizer

Treatments	Chaliya	Jaldu
Lime rate (t ha^{-1})	Grain yield (t ha^{-1})	
0	2.85^{d*}	3.34^{d}
1.1	3.92^{c}	4.21^{c}
2.3	4.38^{b}	4.62^{b}
3.3	4.68^{a}	4.97^{a}
LSD (0.05)	2.17	2.27
P rates (kg ha^{-1})		
0	3.62^{c*}	3.98^{c}
30	3.90^{b}	4.23^{b}
60	4.08^{ab}	4.40^{ab}
90	4.21^{a}	4.53^{a}
LSD (0.05)	2.17	2.27
CV%	6.21	6.42

LSD = least significant difference; CV = coefficient of variation; numbers followed by the same letter in the same column are not significantly different at 5% probability level

Conclusion

The results of this study showed that the soils of the two sites were categorized as clay loam in texture and suitable for the production of malt barley. In contrast to this, the very low value of available P, unsuitable values of available water holding capacity and soil pH of both experimental sites recorded from pre-sowing soil analysis revealed that the availability of essential nutrients such as P for malt barley crop is critically affected by low pH. Moreover, the mean values of grain yield of malt barley was significantly ($p < 0.05$) affected by different rates of agro-lime and P fertilizer at both experimental sites. The highest values of grain yield of malt barley 4.97 and 4.45 t ha-1 were obtained as a result of the application of 3.3 t ha-1 and 90 kg P ha-1 fertilizer at Jeldu site and the yield was increased by 48.8% and 13.8% compared with control plots, respectively, for 3.3 t ha-1 agro-lime rate and 90 P kg ha-1 fertilizer. Hence, the application of agro-lime at the rate of 3.3 t ha-1 and 90 P kg ha-1 could serve as a reference for better malt barley production at Chaliya and Jeldu districts even though malt barely gave maximum yield at Jaldu. Nevertheless, the most generalized recommendation should be suggested after inclusion of economic analysis.

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Data Availability

The data used to support the results of this study are included within the manuscript and any further information is available from the corresponding author upon request.

Conflict of interest

The authors declare that they have no competing interest.

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RESEARCH PAPER

Importance of seed-borne inoculum level on the development of common bean bacterial blight disease and associated yield loss of common bean in the central rift valley of Ethiopia

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Abstract

*Common bacterial blight (CBB), caused by Xanthomonas axonopodis pv. phaseoli (Xap) is one of the major constraints to common bean production worldwide, with up to 40% yield loss. Xap is a seed-borne pathogen, and the worldwide distribution of the disease it causes can be attributed to transport on or within the seed. However, the relationships between seed inoculum level and disease developed in the field and associated yield loss have not been investigated so far in Ethiopia. Therefore this study aimed to determine the relationships of seed inoculum level with seedling infection, disease intensity and yield loss. The experiment was carried out during the 2015 main growing season at two sites of Malkassa Agricultural Research Center trial site. The experimental design was a split-plot, with the seed infection type as the main plot and the infection level as a subplot. Treatments were sown onto 2m * 2m (4m2) plots and each treatment was replicated three times. Germination and seedling infection were recorded 10 and 21 days after sowing respectively. After that, disease incidence and severity records were taken at 35, 49, 63 and 77 days after planting. At harvest, yield component and yield data were recorded from the net plot. All the data were subjected to ANOVA using SAS and treatment means were separated using the LSD test. The results of the study revealed significant differences among seed infection-type treatments for most of the parameters measured. Seed infection levels were also significantly different for all disease and yield and yield component parameters at both locations. From the results, it can be concluded that infected seeds were effective sources of initial inocula for common bacterial blight disease development in the field. Hence the production and use of disease-free seeds can be implemented as effective disease management strategies where environmental conditions permit common blight outbreaks.*

Keywords: CBB, common bean, inoculum threshold, seed transmission, yield loss

Introduction

Common bean (*Phaseolus vulgaris* L.) is the most important grain legume for human consumption both as dry and snap bean because of its health benefits (Willet et al., 1995). Dry beans are a key source of proteins, with high contents of lysine and methionine and have 22% protein, while the green snap bean has 6.1% protein (Purseglove., 1988). In developing countries, dry beans are consumed as an animal protein substitute by low-income families, while immature pods are grown mainly for export. Common bacterial blight (CBB), caused by *Xanthomonas axonopodis pv. phaseoli* (*Xap*) is one of the major constraints to common bean production worldwide where it causes up to 40% yield loss (Iacobellis et al., 2004; Mutlu et al., 2005).

Xap is a seed-borne pathogen, and its worldwide distribution is attributed to transport on or within the seed (Gilbertson and Maxwell, 1992; Lopez et al., 2006). Contaminated and/or infected seeds are an important primary

inoculum source and can lead to extensive colonization of common bean seedlings and plants (Weller and Saettler, 1980a, b; Darrasse et al., 2007). In tropical and sub-tropical areas infected common bean debris is also an important inoculum source allowing spatial and temporal dispersal of these pathogens (Arnaud-Santana et al., 1991; Fininsa and Tefera, 2001; Fininsa and Yuen, 2002) even though the survival period is the subject of controversy. Gilbertson *et al.* (1988) showed that *Xap* can survive in dry leaves under laboratory conditions for at least six years. Karavina *et al.* (2008) isolated *Xap* from bean debris kept in a greenhouse for 12 months in Zimbabwe, while Opio *et al.* (1994) reported that the pathogen survived for more than 18 months in dried leaves kept in a laboratory in Sudan. Santana *et al*. (1991) reported that pathogen survival occurs in bean debris placed on topsoil, but not 20 cm below the soil surface. Moreover, Torres *et al*. (2009) reported that high rainfall and warm temperatures were shown to limit *Xap* survival in residues left on the soil surface.

However, *Xap* has recovered from three, ten and fifteen-year-old bean seed (Schuster and Coyne, 1974; Rideout and Roberts, 1997). The recovered seed-borne isolates were viable and virulent. Thus, contaminated seeds are the primary source of inoculum (Gilbertson *et al*., 1990; Grum *et al*., 1998), and is an extremely efficient means of both local and widespread dissemination of the pathogen. The inoculum threshold of a seed-borne pathogen is the amount of seed infection or infestation with plant pathogens that will cause a disease in the field under a conducive environment and lead to economic loss (Kuan, 1987). In this regard, it is important to establish the inoculum threshold level when clean seed is used as a disease control measure for seed-borne pathogens in general and common bacterial blight in particular. Opio et al. (1993) have reported a positive correlation between *Xanthomonas* campestris pv. Phaseoli seed infection, seed transmission and disease incidence.

The inoculum load and contamination rate of seed lots required to initiate disease varies according to the environmental conditions in which the crop is growing. According to studies made in Canada, in southern Ontario infection of approximately 1 in 10,000 seeds was capable of causing an outbreak of CBB (Sutton and Wallen, 1970). Another study in the same country indicated a 0.5 % seed infection level has been shown to lead to disease epidemics (Zaumeyer and Thomas, 1957). Furthermore, a report from Uganda indicated a 0.2 % seed infection level resulted in a serious disease outbreak (Opio et al., 1993). Hence it is imperative to study the level of inoculum for seed-borne pathogens in general and CBB in particular. However, such studies have not been done so far for CBB in Ethiopia; as a result, information is lacking concerning inoculum levels, and subsequent disease development and associated yield losses. Therefore the purpose of this study was to determine the relationships of seed inoculum level with seedling infection, disease intensity and associated yield loss under field conditions in major common bean growing areas.

Materials and methods

Description of Study Areas

The experiment was carried out during the 2015 main growing seasons at two trial sites of Melkassa Agricultural Research Center (MARC); Malkassa and Arsi Negele. Melkassa is located 15 km southeast of Adama in the semi-arid region of Central Rift Valley at 8o24’ N latitude, 39o 12’ E longitude and an altitude of 1550 m.a.s.l. The area receives an average of 763mm annual rainfall and the maximum and minimum annual mean temperatures are 28oC and 14oC, respectively. The soil type of the site is Andosol which was cultivated for a long period of time (MARC, 1997).

Arsi Negelle is also one of the sub-centers of MARC, situated north of Shashmane, Western Arsi zone at 7o 25’ N latitude, 38o 31’ E longitude and an elevation of 1900 m.a.s.l. The area receives an average annual rainfall of 1100 mm and the maximum and minimum annual mean temperatures are 25oC and 10oC, respectively. The soil type of the site is Nitosol (MARC, 1997).

Experimental Materials and Treatments

To study the correlation between the extent of seed infection and disease transmission to seedlings in the field, and the resulting yield loss, different levels of infected seeds from different infection types were prepared by mixing naturally infected bean seeds of the Awash -1 variety with their respective seed lots obtained from disease free healthy crops of the same cropping season. Diseased seeds were visually inspected for symptoms of common bean blight, which include darkening spots confined mostly to the hilum region and butter-yellow discoloration on the seed coat. The seeds were grouped into three infection types (type1: symptomless, no lesion or discoloration on seeds; type 2: slight to moderate symptoms, seeds with less than 10% discoloration or with discoloration in the hilum region; type 3: severe symptoms, seeds with greater than 10% discoloration with partial shrivelling). The infection level of the seeds in each category was examined before use. Disease free seeds were also examined in the laboratory to confirm that they were free from *Xap* infection. Then one hundred seeds of 0, 1, 2, 4, and 8% disease infection level were prepared from each infection type for planting.

Experimental Design and Management

The experimental design was a split plot, with seed the infection type as the main plot and the infection level as a subplot. Treatments were sown on to $4m^2$ plots and each treatment was replicated three times. Planting was performed on July 15, 2015, at Arsi Negele and on July 18, 2015, at Malkassa. Main plots were separated by 2m and a row of maize variety MH 130 plants was sown between each block and plot to reduce inter-plot interference. Moreover, a dense row of maize was also planted in the whole surroundings of the experimental fields as a natural barrier. The experimental field was isolated by 10m from other common bean fields to avoid splashing bacterial cells from other sources. The experiment was conducted in fields where beans are not grown for at least for two consecutive years. Cultivation and weeding were performed manually.

Data Collection

Germination and seedling infection were recorded 10 and 21 days after sowing respectively. The infected seedlings were identified by the typical water-soaked spots on the underside of the leaf. Seedling infection was determined as the percent infected seedling per plot and seed-to-seedling transmission efficiency (TE) of Xap was calculated using the formula developed by Carmona *et al.*, (1999) $TE = \frac{C}{S} \times 100$ where, C is the percentage of infected seedlings, while S is the percentage of seed infection. Disease incidence and severity were recorded at 35, 49, 63 and 77 days after planting. Disease incidence was determined as the number of plants affected per plot and expressed as a percentage. Disease severity was assessed as the modified CIAT 0 – 9 scales CIAT (1998) where 0 = no infection, 1= 1%, 2=2 - 5%, 3=6-10%, 4=11 - 15%, 5= 16 -30%, 6=31 - 50%, 7=51-75%, 8=75 - 855% and 9= >85% lesion area on the infected leaves. The severity grade was converted into percentage severity index (PSI) with the following formula: $PSI = \frac{Snr}{Npr \times Mss} \times 100$, Where Snr = the sum of numerical ratings, Npr = number of plants rated, Mss = the maximum score of the scale. Disease severity was assessed on 10 randomly selected and tagged plants per plot. PSI was fitted to the disease progress curve to see the progress of disease epidemics at different growth stages of the crop. The area under the disease progress curve (AUDPC) was calculated according to Shaner and Finney (1977). $AUDPC=\Sigma^{n}_{i=1}$ 1/2[(Yi+1+Yi)] [(X i+1-Xi)] where Yi=disease severity score at time i, and Xi=time of scoring (days after planting).

At harvest, the two border rows of each plot were discarded to give a net plot size of $2.4m^2$. For yield and yield components, the mean number of pods per plant from each treatment was recorded at harvest by counting the number of pods from 10 plants randomly taken from the net plot and computing the average. The

mean number of seeds per pod was computed as the average number of seeds from randomly sampled 10 pods. Grain yield was measured as grain weight from the net plot. The hundred seed weight (Hswt) was measured as the weight of 100 randomly sampled seeds. Percent seed discoloration was determined from randomly sampled 100 seeds from the total seed yield per plot. The relative percent yield loss (RPYL) from each plot was calculated in relation to the yield of control treatment of each seed infection category using the formula: $\text{Relative yield loss}(\%) = \frac{Yct - Yit}{Yct}$ where Y_{ct} is the yield of the control treatment (treatment with 0% seed infection level) and Y_{it} is yield of infected treatments (treatments with 1, 2, 4 & 8 % seed infection level).

To analyze and relate prevailing weather conditions meteorological data for each experimental site was obtained from Melkassa Agricultural Research Center, Meteorology and Geospatial Research Program.

The rainfall distributions, and minimum and maximum temperatures and relative humidity for the 2015 main growing season for Melkassa are shown in Figure 1 whereas meteorological information for Arsi Negele was unavailable due to recording problems at the site. The seasonal rainfall was 318 mm and the total amount received after sowing (after July 18) was 210.6 mm. The maximum monthly rainfall for the growing period (80.8 mm) was received in August which lies in the vegetative growth of the crop while the minimum rainfall (8.2 mm) was in October.

Results

Weather Data

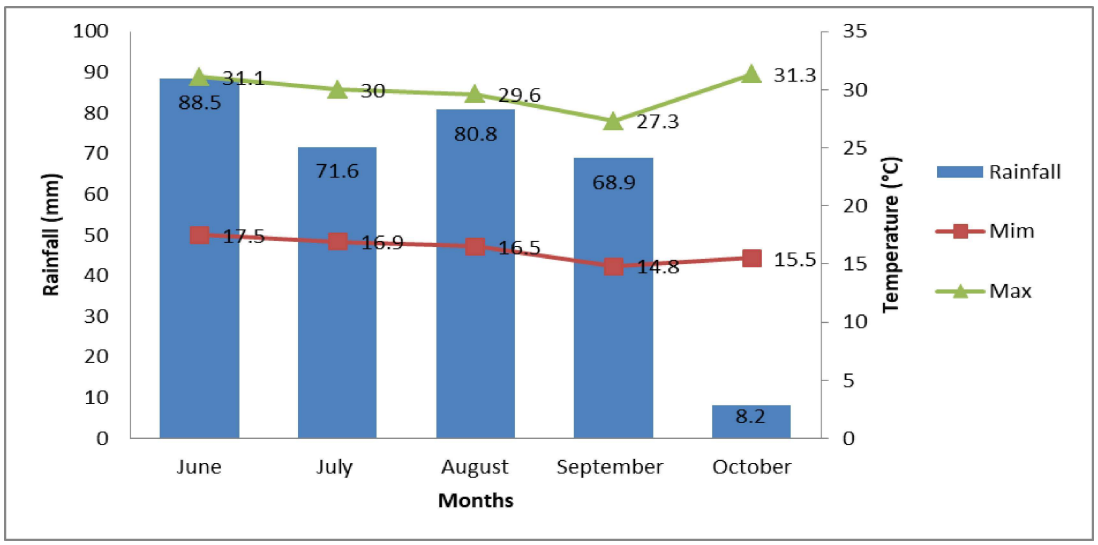

Figure 1. Total monthly rainfall and mean monthly maximum and minimum temperatures for Melkassa
Source: Meteorological and Geospatial Research Program Department of MARC, 2015

The minimum and maximum temperatures for the site are also given in Figure 1. The temperature ranges were narrower at the beginning of the season and slowly became wider at the end. The maximum temperature ranged from 27.3°C to 31.3°C in the trial period while the minimum temperature ranged between 14.8°C to 17.5°C. The relative humidity data also show that maximum humidity (63%) occurred in August while the minimum humidity (48%) occurred in October (Figure 2).

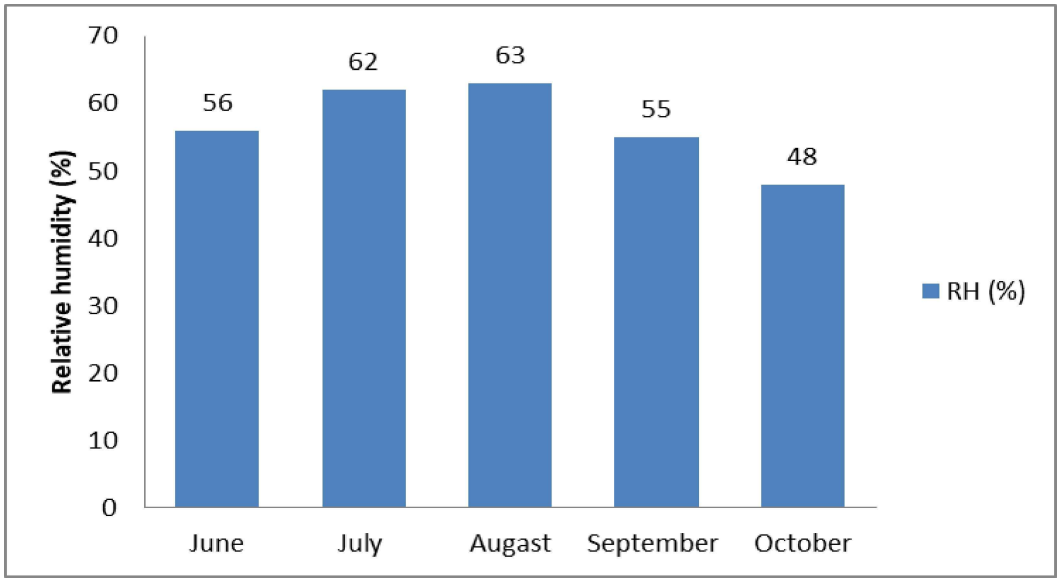

Figure 2. Mean monthly relative humidity for Mellkassa during main growing season

Source: Meteorological and Geospatial Research Program Department of MARC, 2015

Germination percentage

There was no interaction effect of seed infection type and seed infection level on seed germination percentage. However, the main factors, infection type and % seed infection levels significantly affect seed germination at both trial locations. For seed infection type treatments, low seed germination or crop stand was recorded for infection type-3 both at Arsi Negele and Melkassa and high germination was observed in infection type-1(Figure 3). However, infection type 2 was comparable with both infection-type treatments in both sites (Figure 3). For percent seed infection level treatments, a higher seed germination percentage was observed in the control (0% infection level) at both locations and lower seed germination was obtained from 4% and 8% seed infection level treatments at Arsi Negele and 8% seed infection at Melkassa trial sites (Figure 4).

Seed to seedling transmission efficiency (TE)

At both locations, seedling infection was observed at 21DAP for higher seed infection levels, but no infection was observed in plots planted with disease-free seeds and seeds with 1% seed infection level at this time. The Xap seed-to-seedling transmission ratio or transmission efficiency (TE) was not significantly different among the seed infection type treatments at both locations but there was a significant difference in TE among seed infection level treatments. At Arsi Negele higher transmission efficiency (65.421%) was recorded in 8% followed by 4% and 2% infection-level treatments. At Melkassa higher

TE (62.742%) was recorded in 2% followed by 4% and 8% infection-level treatments. Low TE was obtained in 0 and 1 % seed infection level treatments at both locations (Table 2).

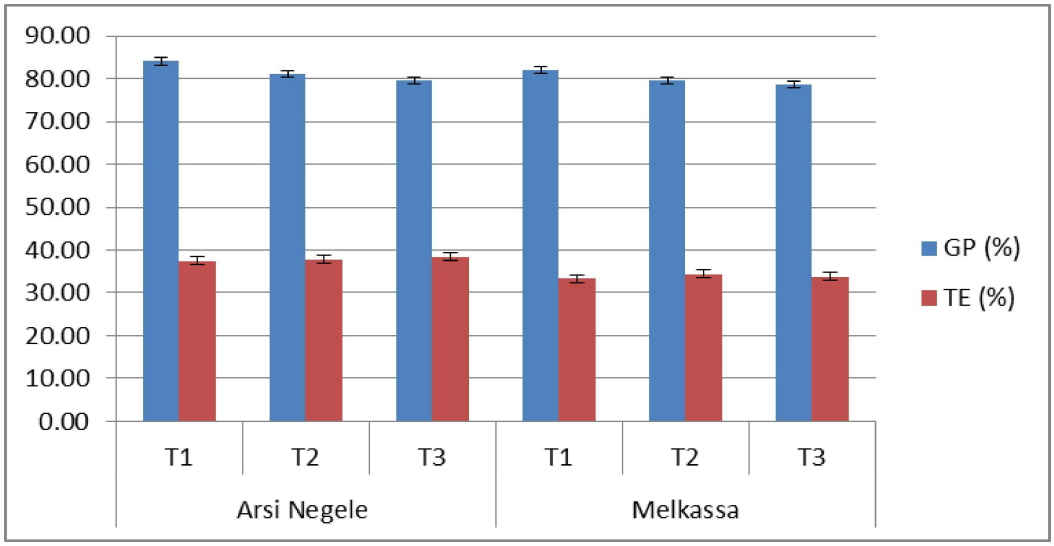

Figure 3. Effect of CBB seed infection type on germination percentage (GP) and seed-to-seedling transmission efficiency (TE) at Arsi Negele and Melkassa

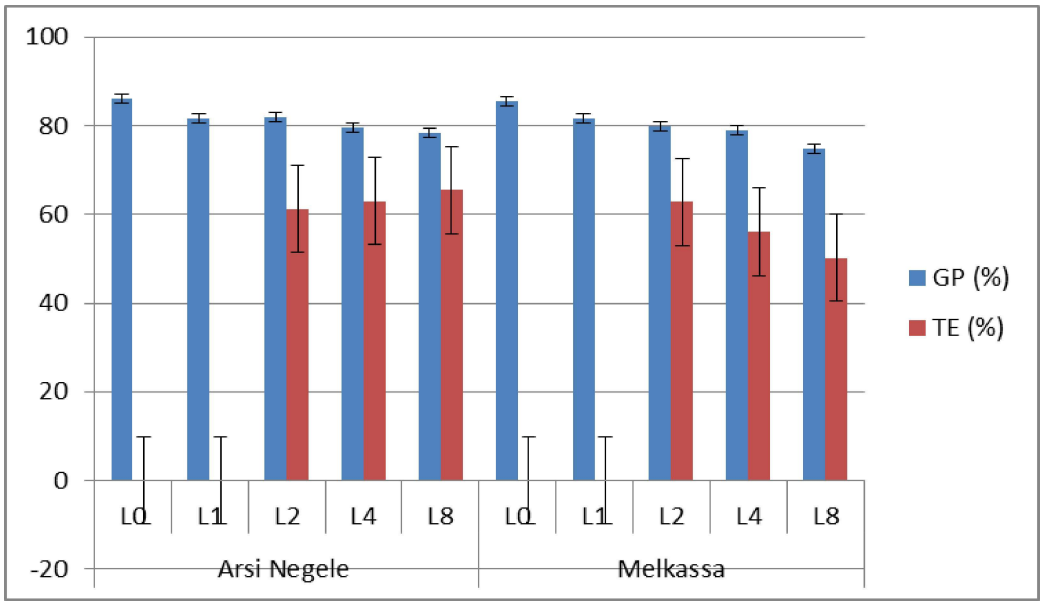

Figure 4. Effect of CBB seed infection level on germination percentage (GP) and seed to seedling transmission efficiency (TE) Arsi Negele and Melkassa

Disease incidence

In both sites, Xap symptoms were observed on bean plants at the early stage of crop development for higher initial seed infection. At all the crop growth stages, there were no significant differences among seed infection type treatment means for disease incidence; but significant differences among treatment means were obtained among seed infection level treatments. At the initial disease assessment, 21DAP no disease was observed for 0 and 1 % seed infection and lower disease incidence were recorded in treatments with 2% initial seed infection while higher incidence was recorded with 8% seed infection treatments at both locations. In general treatments with higher seed infection levels consistently gave rise to higher disease incidence throughout the plant growth stage at both trial sites and lower disease incidence was observed in the control treatments (Table 1). Generally, disease incidence increased with time and lower incidence was observed at Melkassa than at Arsi Negele trial site.

Disease severity

Like for disease incidence significant differences in disease severity were not observed among seed infection-type treatments. However, seed infection levels were significantly different in terms of disease severity index at all disease assessment times. High seed infection levels resulted in higher disease severity scores than did low seed infection levels treatments at both sites in all disease assessment times (Table 2). At the initial disease assessment time (21DAP) the control (0% seed infection level) and 1% seed infection level resulted in no infection symptoms and lower severity resulted in treatment with 2% seed infection while the higher severity was associated with treatment with 8% seed infection at both locations. At the final date of disease assessment, the control treatment resulted in a lower severity of 42.592% and 31.481% at Arsi Negele and Melkassa respectively, while the higher seed infection level (8%) treatments resulted in 79.62% and 69.26% severity at Arsi Negele and Melkassa respectively. Generally, the trend in PSI shows that disease severity increased as seed infection level increased and time progressed (Table 2).

Table 1. Effect of CBB seed infection level on disease incidence (DI) at different days after planting at Arus Negele and Melkassa

% Seed infection level	Arsi Negele					Melkassa				
	21D AP	35D AP	49D AP	63D AP	77D AP	21D AP	35D AP	49D AP	63D AP	77D AP
0	0.00 0d	0.000 e	7.497 e	31.14 6e	50.09 8e	0.00 0d	0.000 e	3.637 e	17.67 0e	34.79 3e
1	0.00 0d	9.650 d	27.24 3d	47.83 3d	71.14 2d	0.00 0d	5.301 d	18.35 0d	30.90 3d	55.97 7d
2	1.22 2c	22.70 9c	40.49 9c	61.47 2c	84.11 7c	1.25 4c	10.57 2c	27.37 3c	39.22 3c	69.05 8c
4	2.51 8b	27.21 8b	48.36 4b	68.86 1b	89.27 7b	2.24 2b	12.96 6b	34.05 3b	45.02 6b	74.44 2b
8	5.23 2a	37.23 6a	61.29 3a	81.98 9a	99.00 1a	4.01 8a	18.90 0a	40.32 8a	53.01 7a	82.84 3a
CV%	20.1	14.2	10.0	7.0	4.4	23.4	12.6	10.6	9.7	4.4
LSD	0.4	2.7	3.6	4.0	3.4	0.3	1.2	2.5	3.5	2.7

Means with the same letter in the same column are not significantly different

Table 2. Effect of CBB seed infection on disease severity index at different days after planting at Arsi Negele and Melkassa

% Seed infection level	Arsi Negele					Malkassa				
	21D AP	35D AP	49D AP	63D AP	77D AP	21D AP	35D AP	49D AP	63D AP	77D AP
0	0.00 0d	0.000 e	8.150 e	30.49 4c	42.59 2d	0.00 0d	0.00 0d	5.680 e	16.66 8e	31.48 1d
1	0.00 0d	9.013 d	27.03 7d	54.56 8b	70.74 0c	0.00 0d	5.06 1c	25.06 2d	37.53 0d	60.49 3c
2	1.11 0c	19.38 3c	33.95 2c	57.90 1b	74.19 7b	1.11 0c	8.39 7b	30.86 4c	45.92 7c	63.82 6b
4	2.34 3b	22.59 2b	38.64 2b	62.84 0a	75.92 6b	1.97 3b	10.8 63a	35.06 2b	50.74 1b	62.92 6b
8	4.44 1a	25.06 2a	44.81 4a	62.71 8a	79.26 0a	3.33 0a	10.7 40a	38.76 6a	54.93 9a	69.26 0a
CV%	21.0 3	15.88	9.09	92.16	4.96	24.9 8	9.75	13.62	8.94	4.99
LSD	0.32 3	2.349	2.697	4.816	3.309	0.31 2	0.66 5	3.589	3.582	2.828

Means with the same letter in the same column are not significantly different

Area Under Disease Progress Curve (AUDPC) and Disease Progress Rate

At both trial sites AUDPC was not significant for the interaction effect of seed infection type and level. A significant difference in mean AUDPC among seed infection-type treatments was only observed at Arsi Negele. Lower AUDPC was observed in treatment with symptomless seed infection type (type 1) whereas in treatments with slight and heavy visual seed infection, the AUDPCs were significantly the same and greater (Table 3). For infection levels, a higher AUDPC resulted in higher seed infection level treatments whereas lower values of AUDPC were observed in lower infection level treatments at both trial sites. In general, the AUDPC increased with increasing seed infection levels among the treatments for both trial sites (Table 4). Higher AUDPC values were recorded at Arsi Negele than at Melkassa.

Table 3. Effect of CBB seed infection type on AUDPC and disease progress rate at Arsi Negele and Melkassa

Seed infection type	Arsi Negele		Melkassa	
	AUDPC	r	AUDPC	r
1	1829.85b	0.103a	1469.48a	0.108ab
2	1912.81a	0.104a	1460.67a	0.107b
3	1906.07a	0.105a	1479.85a	0.110a
CV%	4.883	5.444	7.207	2.929
LSD(0.05)	80.1	ns	ns	0.0018

Means with the same letter in the same column are not significantly different

For disease progress rate, there was a significant difference among seed infection level treatments at both locations while seed infection type treatments were significantly different only at Melkass site trial. A higher infection rate was observed in the infection type3 (seed with heavy visual infection symptoms) than infection type2. For seed infection level treatments, a higher disease progress rate resulted in the control treatments at both locations while a lower rate was obtained in treatments with 2, 4 and 8 % seed infection levels at Arsi Negele and with 4% seed infection level at Melkassa.

Table 4. Effect of CBB seed infection level on AUDPC and disease progress rate at Arsi Negele and Melkassa

% Seed infection level	Arsi Negele		Melkassa	
	AUDPC	r	AUDPC	r
0	839.14e	0.2669a	533.21e	0.255a
1	1763.83d	0.0768b	1370.62d	0.080b
2	2084.44c	0.0593c	1647.16c	0.071c
4	2284.94b	0.0570c	1828.64b	0.066d
8	2442.22a	0.0582c	1970.37a	0.070c
CV%	4.883	5.444	7.207	2.929
LSD	89.457	0.0055	103.080	0.003

Means with the same letter in the same column are not significantly different

Yield Components

An interaction effect was not significant for any of the yield component parameters either Arsi Negele or Melkassa. For the seed infection type treatments, only mean pod per plant (ppplt) and seed discoloration percentage (SDP) varied considerably among treatments at Arsi Negele. PPPlt was higher in seed infection type1 treatment compared to type3 treatment. SDP was lower in seed infection type1 treatment while seed infection type2&3 were statistically the same and had higher SDP. At Malkassa, only seed per pod (SPP) and seed discoloration percentage were significantly different for seed infection-type treatments. Seed infection type1 resulted in higher seed per pod than seed infection type3 while seed infection type2 was statistically comparable with both treatments. SDP is lower in infection type1 and higher in infection type3 (Table 5). For seed infection level, treatments were significantly different in all yield component parameters. Control treatments resulted in higher mean pods per plant (PPPlt), seed per pod (SPP) and hundred seed weight (Hswt) at both locations except mean Hswt was not significant at Melkassa. Higher seed infection level treatments were associated with lower PPPlt and SPP both at Arsi Negele and Melkassa. For SDP, the lowest seed discoloration percentage r occurred in the control treatment and the highest was obtained in treatment with the highest (8%) seed infection level at both site trials (Table 6).

Table 5. Effect of CBB seed infection type and on yield and yield components at Arsi Negele and Melkassa

Seed infection type	Arsi Negele				Melkassa					
	PPPlt	SPP	HSwt	SDP	PPPlt	SPP	HSwt	SDP	yield	RYLP
1	13.527 a	4.55 3a	15.86 7a	8.267 b	10.62 0a	4.133 a	15.80 0a	7.93 3c	1.589 a	23.225 ab
2	13.160 ab	4.54 7a	15.80 0a	9.667 a	10.56 7a	3.867 ab	15.73 3a	8.40 0b	1.574 ab	24.587 ab
3	12.893 b	4.34 0a	15.80 0a	10.26 7a	10.40 7a	3.793 b	15.53 3a	8.66 7a	1.541 ab	25.128 a
CV%	3.036	3.64 5	4.639	8.829	5.388	7.702	4.482	13.5 65	3.843	11.724
LSD(0.05)	0.6	ns	ns	1.229	ns	0.324	ns	0.26 2	ns	ns

Means with the same letter in the same column are not significantly different

Table 6. Effect of CBB % seed infection level on yield and yield components at Arsi Negele and Melkassa

% Seed infection level	Arsi Negele				Malkassa					
	PPPlt	SPP	HSwt	SDP	PPPlt	SPP	HSwt	SDP	yield	RYLP
0	16.58 9a	5.26 7a	16.222 a	6.111 e	12.98 9a	4.367 a	15.778 ab	5.111 e	2.07 1a	0.000 e
1	13.60 0b	4.60 0b	16.111 ab	7.556 d	11.16 7b	3.989 bc	16.111 a	7.111 d	1.73 7b	16.23 7d
2	12.33 3c	4.33 3c	15.778 ab	9.111 c	10.20 0c	4.056 b	15.778 ab	8.222 c	1.62 0c	21.81 1c
4	11.97 8c	4.16 7d	15.444 b	10.66 7b	9.900 c	3.722 cd	15.333 b	9.778 b	1.49 8d	27.65 6b
8	11.46 7d	4.03 3d	15.556 ab	13.55 6a	8.400 d	3.522 d	15.444 ab	11.44 4a	0.91 3e	55.86 2a
CV%	3.036	3.64 5	4.639	8.829	5.388	7.702	4.482	13.56 5	3.84 3	11.72 4
LSD	0.389	0.15 9	0.714	0.807	0.552	0.295	0.684	1.099	0.05 9	2.773

Means with the same letter in the same column are not significantly different. PPPLt = number of pods per plant, SPP =number of seeds per plant, HSwt = hundred seed weight, SDP =seed discoloration percentage, yield = grain yield of the crop, RYLP = relative yield loss percentage

Seed yield

There was a significant difference among treatment combinations at the Arsi Negele trial site. Control treatment i.e. treatment with 0% bean seed bacterial blight infection level had the highest seed yields regardless of the bean infection type. However, at 1% seed infection level higher seed yield was observed in bean seed from type1 (symptomless) seed infection type followed by treatment from slight disease symptom seed infection type. The lowest seed yield was obtained from treatment with 8% infection level from seed infection type 3 (Table 7). At the Melkassa site experiment, no significant differences among seed infection-type treatments were observed. However, all seed infection levels show significant differences. The highest yield was obtained from 0% seed infection treatment followed by treatment with 1% seed infection level and the lowest seed yield was from treatment with the highest seed infection (8%) level in this experiment (Table 8). Generally, trends in seed yields among treatments across both sites were

similar and there were low seed yields at the Melkassa experimental site (Table 8 & 9).

Relative yield loss

Similar to seed yield, there were significant differences in mean relative yield loss among treatment combinations at Arsi Nagele. The highest yield loss (35.827%) resulted in treatment with a higher seed infection level (8%) from seed infection type3 followed by treatment with a similar seed infection level from infection type2 and type1 (Table 7). The lowest yield loss (6.493%) resulted from a lower infection level of type 1 seed infection type. At Melkassa, mean yield losses were significantly different among seed infection levels regardless of their infection type sources. The highest yield loss (55.862%) resulted from the highest seed infection level and the lowest yield loss (16.237%) was obtained from the lower infection level (Table 6). In general, the relative yield losses have similar trends at both trial sites. However, the relative yield loss is much more at Melkassa than at Arsi Negele.

Table 7. Effect of CBB seed infection type and % infection level on yield and relative yield loss at Arsi Negele

seed infection type	% seed infection level	yield	RYLP
1	0	2.667a	0.000j
1	1	2.493b	6.493i
1	2	2.170e	18.743f
1	4	2.030gh	23.903de
1	8	1.807j	32.167b
2	0	2.650a	0.000j
2	1	2.340c	11.693h
2	2	2.103f	20.450f
2	4	1.987h	25.057d
2	8	1.763j	33.340b
3	0	2.670a	0.000j
3	1	2.240d	15.967g
3	2	2.057g	22.803e
3	4	1.887i	29.367c
3	8	1.713k	35.827a
CV%		1.318	5.463
LSD		0.046	2.2037

Means with the same letter under the same column are not significantly different

RYLP = relative yield loss percentage, CV = coefficient of variation, LSD = least significant difference

Relation between parameters

The interactions between parameters were generally the same in both locations. At both locations, all yield parameters i.e. mean crop stand per plot (germination percentage), pod per plant, seed per pod and hundred seed weight were positively correlated with seed yield and negatively correlated with relative yield loss percentage (Table 8 and 9). In contrast, all the disease parameters except disease progress rate; disease incidence, percent severity index, AUDPC, disease transmission efficiency (TE) and seed discoloration percentage (SDP) were negatively correlated to seed yield and positively correlated to yield loss (Table 8 and 9). Moreover, disease parameters i.e. disease incidence, disease severity, AUDPC, disease transmission efficiency and SDP were

positively correlated to each other. Yield attribute parameters: germination percentage, pod per plant, seed per pod and hundred seed weight were also positively correlated with each other (Table 8 and 9). Hundred seed weight (HSwt) was weakly correlate with all parameters at both site and significantly correlated ($p<0.05$) only with seed discoloration percentage (SDP) and disease transmission efficiency (TE) at Melkassa.

Table 8. Correlations between disease parameters; yield and yield component variables at Arsi Negele

Variables	TE	DI	PSI	AUDPC	rate	GP	PPPlt	SPP	Hswt	SDP	yield	RYLP
TE												
DI	.881**											
PSI	.723**	.903**										
AUDPC	.839**	.975**	.971**									
rate	-.678**	-.881**	-.967**	-.939**								
GP	-.602*	-.754**	-.775**	-.801**	.700**							
PPPlt	-.837**	-.964**	-.960**	-.987**	.937**	.819**						
SPP	-.830**	-.946**	-.945**	-.968**	.897**	.829**	.975**					
Hswt	-.675**	-.669**	-.511^{ns}	-.636*	.529*	.583*	.652**	.560*				
SDP	.792**	.879**	.736**	.837**	-.645**	-.860**	-.840**	-.863**	-.622*			
yield	-.882**	-.973**	-.869**	-.950**	.811**	.836**	.951**	.948**	.691**	-.949**		
RYLP	.883**	.972**	.868**	.949**	-.811**	-.833**	-.951**	-.950**	-.692**	.948**	-1.000**	

Table 9. Correlation relation of disease, yield and yield component variables at Melkassa

Variables	TE	DI	PSI	AUDPC	rate	GP	PPPlt	SPP	Hswt	SDP	yield	RYLP
TE												
DI	.826**											
PSI	.695**	.923**										
AUDPC	.788**	.983**	.973**									
rate	.648**	-.877**	-.973**	-.936**								
GP	-.665**	-.881**	-.823**	-.853**	.720**							
PPPlt	-.764**	-.978**	-.901**	-.956**	.828**	.930**						
SPP	-.519*	-.783**	-.766**	-.778**	.660**	.929**	.820**					
Hswt	-.520*	-.469^{ns}	-.229^{ns}	-.372^{ns}	.173^{ns}	.490^{ns}	.452^{ns}	.494^{ns}				
SDP	.746**	.956**	.856**	.927**	-.757**	-.944**	-.973**	-.889**	-.547*			
yield	-.627*	.899**	.785**	-.854**	.681**	.921**	.954**	.839**	.454^{ns}	.950**		
RYLP	.627*	.900**	.785**	.855**	.683**	.920**	.954**	.838**	.450^{ns}	.950**	1.000**	

Discussion

There were significant variations between seed infection types and seed infection level treatments on seed germination at both sites. Low seed germination was resulted from treatment for seed infection type3 (seed with severe discoloration). For seed infection level treatments, higher seed infection level treatments in all infection types resulted in low seed germination. This result was in agreement with the finding of Hall (1994). Weller and Saettler (1980b) also reported that heavily infected seeds fail to germinate resulting in reduced crop stand. Agrios (1988) also reported that seedling mortality resulting from heavy seed infection may reach up to 60%. Even if the seed emerges and the seedling does not die, the bean plant will be infected with common blight at an earlier stage in the season resulting in both quantitative and qualitative yield losses.

Different Xap infection levels also resulted in significant differences in seed-to-seedling transmission efficiency. High transmission efficiency (TE) is obtained from higher infection-level treatments. The control treatment and low seed infection (1%) level treatment does not show seedling infection at 21DAP at both trial sites. As disease symptoms at this stage i.e. early crop stage were only confined to higher seed infection levels, this observation suggested that the lower seed infection levels had not attained the minimum bacterial numbers required for symptom initiation. Similarly, Weller and Saettler (1980a) reported that Xap displayed epiphytic growth during early inoculation stages, whereby it multiplies and survives on the bean canopy without showing visible symptoms. This allows bacterial populations to attain quantities that permit disease development under favorable environments (Hirano and Upper, 1983). Then after, the incidence and severity of common bean blight infection in the

field gradually increased with time both at Arsi Negele and Melkassa. This is typical of seed-borne diseases because they develop relatively slowly, and disease increase is logarithmic with time and the rate of increase is unaffected by initial inoculums (Hewett, 1978). Bowen (2003) also reports that disease development increases in time and weather, particularly temperature and moisture, influences the rate of disease development. However, in this study, the amount of disease was also affected by initial inoculum i.e. lower seed infection levels generally resulted in lower proportions of plants infected with common bean blight, and higher seed infection levels resulted in higher disease incidences at both sites at all disease assessment times.

These trends suggest that seed infection levels, (number of infected seeds) are important in determining the number of plants that can potentially become diseased under suitable conditions for common bean blight development although they may not directly influence the rate at which the disease spreads. On the other hand, as the infection levels directly affected disease incidence, this, in turn, influenced disease severity. High disease incidences caused by high infection levels corresponded to high disease severity at all assessment times at both sites. This is characteristic of most diseases, where disease incidence and severity are positively correlated (Bowen, 2003).

As CBB is seed-borne, the initial inoculum occurs on infected seed and the epidemic starts as these seeds germinate to yield seedlings bearing lesions (Weller and Saettler, 1978). Bacteria from the lesions could then be transmitted by wind and splashing rain throughout the period of crop development (Hirano et al., 1996). Weller and Saettler (1980b) reported the incidence and severity of common bean blight in bean fields as being closely related to the stage of plant development. In this study, although common bean blight symptoms were first observed at 21DAP for higher seed infection levels (2%, 4% and 8%) only both at Arsi Negele and Melkassa; later on disease developed in all treatment plots even on plants from control plot at both locations and disease incidence and severity were at a peak at maturity (77DAP). Finisa and Yuen (2001) also reported a high severity of common bean blight on bean plants at crop maturity. During the vegetative stages of plant development, the foliage would be rapidly expanding and therefore disease severity, as measured by the area of diseased tissue (James, 1974), would be very low (Imhoff et al., 1982; Weller and Saettler, 1980b), because new leaves got zero or very low ratings in disease severity assessments.

Variation in common bean blight incidence and severity and its relation to yield between the two locations trials seems to have been influenced by differences in seasonal weather between the locations. Although the weather data was not obtained from the metrological station for Arsi Negele because of an instrument problem, it was observed that the total seasonal rainfall and the amount received after sowing was much better both in intensity and distribution than that received at Melkassa and it was expected being within the range (350-500mm) required for optimal bean growth and development (EARO, 2004). However, at Melkassa both total seasonal rainfall and the amount received after sowing were less than the optimal range for crop development and the relative humidity was also fairly low (63%), for that a relative humidity above 80 % for some time is required to allow sufficient bacterial multiplication (Darrasse et al., 2007). The maximum temperature ranges from 27.3 to 31.3°C which is in the range (28–32 °C) of optimal temperature for CBB disease development (Opio et al., 1992). For the fact that there were more conducive weather conditions observed at Arsi Negele, common bacterial blight was more severe at Arsi Negele than at Melkassa for all seed infection treatments in the trial. However, better seed yield and low relative yield loss under these conducive conditions for common bean blight development were observed at Arsi Negele. A comparison of the seed yield differences between the two locations indicates that the general reduction in seed yield at Melkassa was highly influenced by rainfall shortage and aggravated by the disease which resulted in

much more relative yield loss (55.86%) than at Arsi Negele (35.82).

Conclusion and recommendations

The study revealed that X. axonopodis pv.phaseoli (Xap) was seed borne and therefore, infected seed was effective sources of initial inocula for common bacterial blight disease development in the field. Hence production of disease free seed in dry high land areas and seed certification and use of disease free seed can be implemented as effective disease management strategies where environmental conditions permit common blight outbreak. Furthermore a careful examination of seed lots following a suitable seed health testing method is of prerequisite to check the spread of disease from disease endemic to disease free areas.

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Conflicts of interest

The authors declare no conflicts of interest regarding the publication of this paper.

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RESEARCH PAPER

Land Use and Land Cover Change and Its Impacts on the Ecosystem Services in Guder River Sub-Basin, Ethiopia

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Abstract

In developing nations, land use and cover, change rates have doubled due to rapid population expansion, economic growth, and agricultural development. This study aimed to analyze the impacts of land use and cover change on ecosystem services in the Guder River sub-basin. Satellite imageries from the United States Geological Survey for 1990, 2000, and 2020 were used to detect and classify land use and cover types using Remote Sensing, ERDAS, and ArcGIS software. Ground truth data were gathered using GPS. The areas of different land use and cover types were analyzed using ArcGIS's geometric tool and the ecosystem values were calculated by multiplying the global biome coefficients by the area of each land use type. The study identified six land use types: grassland, forestland, cultivated land, settlement shrub, and barren lands. The results revealed significant changes in land use and land cover types over the study period compared to 1990. In 2020, the grassland, forestland, and shrubland areas decreased by 64.62%, 36.50%, and 15.20%, respectively. Conversely, cultivated land increased by 48.20%, settlement land by 386.66%, and barren land by 1644.1%. These changes in land use and land cover types led to a decrease in the overall ecosystem services (ESV) value between 1990 and 2020. The degradation of grassland, forestland, and shrubland significantly decreased the ESV by 64.7%, 36.47%, and 15.07%, respectively, while the expansion of cultivated land ESV increased by 48.21%. The total ESV across the study river basin decreased from $15.62 million in 1990 to $11.11 million in 2020, a 28.87% reduction. The study highlights the urgent need for land use planning and administration strategies to mitigate these impacts and promote sustainable land management in the sub-basin.

Keywords: Biome, ecosystem service values, Guder River basin, land use and cover change

Introduction

Land-use and land-cover change (LULC) is a complicated socioeconomic and environmental issue that requires a thorough understanding of how human-caused activities interact with the environment. It is a historical process relating to how people use the land. Large-scale changes in the Earth's environment are being brought on by expanding anthropogenic activities and natural phenomena in the biosphere (Lambin *et al*., 2001; Liu *et al*., 2020). Changes in land use and cover are the outcomes of socioeconomic factors and natural phenomena combined with how people have managed them over time and space (Halefom *et al.,* 2018; Lambin and Meyfroidt, 2010). Anthropogenic alterations of the natural landscape through urbanization, agriculture, and forestry have been a continuous and increasing process for the past millennium (Brown *et al*., 2012; Ellis, 2015). The rates of land use and land-cover change (LULC) have multiplied due to the late 20th and early 21st centuries' rapid and unchecked population growth and economic and industrial development, particularly in developing nations (Talukdar *et al*., 2020). The rise in the population in the highlands at the beginning of the 20th century sped up deforestation and increased land cultivation (Hurni et al., 2005). Physical factors, including topography, slope

condition, soil type, and climate change, also affect land use and cover types through accelerating soil erosion (Chinzila, 2018; Megersa *et al*., 2019; Siswanto and Sule, 2019).

Ecosystem services, which are defined as the cumulative form of ecosystem goods and services that benefit human life from various ecosystem functions, have been devalued by these LULC changes (Chalchissa *et al*., 2022; Kamble *et al*., 2012). Land use and cover change modify the availability of different resources, including vegetation, soil, and water (Tewabe and Fentahun, 2020) and climate, evaporation, and runoff, particularly in small catchment areas (Babiso *et al.,* 2016; Nzunda *et al.*, 2013). Its numerous ecosystem services (ESs), such as recreational opportunities, biodiversity, habitat quality, soil formation, nutrient cycling, climate regulation, erosion control, and water regulation, are threatened by the conversion of LULC to various settlements and agricultural purposes (Hu et al., 2020; Sahle *et al*., 2019; Sun *et al*., 2018; Zhao *et al*., 2019).

Even though ecosystems offer numerous services in the form of public goods, it is challenging to estimate their economic value as marketable goods present a significant challenge in quantifying ecosystem system valuation for a long time (Huq *et al*., 2019). However, to address this issue, Costanza *et al*. (1998) devised value coefficients for various land biomes and, in a ground-breaking method that has drawn significant interest from international research scholars, roughly calculated global ESVs. This method was employed in several studies to assess the effects of economic and population growth on ecosystem services (Gashaw *et al*., 2018; Ghosh and Bhunia, 2021; Kindu *et al.,* 2016; Rwanga and Ndambuki, 2017; Sahle *et al*., 2019; Tolessa *et al*., 2017).

Ethiopia is the second most populous country in Africa (Groth and May 2017; Nuñez and Murakami-Ramalho, 2012) and is experiencing one of the fastest economic growth rates in East Africa (Berhanu & Poulton, 2014). On the other hand, the country is one of the most environmentally troubled countries in the Sahel belt (Belay and Mengistu, 2021; Tschakert *et al*., 2010). The critical environmental problem in Ethiopia is land degradation in the form of soil erosion, gully formation, soil fertility and productivity loss (Benti & Balemi, 2016), and severe soil moisture stress, which is partly the result of land use land cover change (Fitsum *et al.*, 2000; Gashaw *et al*., 2018). The socio-economic well-being of the people and the environment in the country are continuously and adversely changing due to degraded land resources, and subsequently give rise to various types of socio-economic challenges (Gashaw *et al.*, 2018). Population pressure, urbanization, and a lack of land use planning are the main causes of LULC change in Ethiopia, which contribute to the free riding of forestland, grassland, and shrubland conversions to cultivated and settlement areas (Demissie *et al*., 2017; Megerssa & Bekere, 2019).

On the other hand, previous studies have often lacked a detailed temporal analysis of land use and land cover (LULC) changes over an extended period, particularly in the Guder River Sub-Basin. Furthermore, while many studies have focused on LULC changes, they frequently overlook the direct impacts these changes have on ecosystem services, creating a gap in understanding how shifts in land use affect ecological balance and community well-being. Additionally, there is a scarcity of research specifically targeting the Guder River Sub-Basin, leaving a gap in localized insights into LULC impacts in this ecologically and agriculturally important area. The study also addresses the need for integrating socio-economic factors with LULC changes and their effects on ecosystem services, as well as the lack of advanced remote sensing and GIS techniques in previous analyses.

This study is rooted in the urgent need to address environmental degradation and the loss of ecosystem services caused by rapid and unchecked land use changes in the Guder River Sub-Basin. The research aims to inform sustainable land management practices by providing insights into how LULC changes affects vital ecosystem services, which are essential for maintaining biodiversity, agricultural productivity, and water resources.

Therefore, generating scientific data and insights necessary for policy development, the study seeks to mitigate the negative impacts of LULC changes, aligning land use practices with environmental conservation and climate resilience goals. Furthermore, understanding these impacts is crucial for improving the livelihoods of local communities who rely on these ecosystem services. The study also aims to contribute to global research on LULC changes and their environmental impacts, offering valuable data from the Ethiopian context that can be compared with other regions facing similar challenges.

Materials and methods

Description of Study Areas

The study was carried out in the Guder River sub-basin in the West Shoa Zone, Oromia National Regional State. The study area is situated between 8°46' 30" N and 9°1'37" N latitude and 37°37'36" E and 37°51'32.4" E longitude, with 1880 to 3194 m of elevation above sea level (Figure 1). The average annual rainfall for the area is 970 mm per year. The sub-basin receives an unimodal rainfall distribution, with the summer months receiving heavy rainfall and the autumn months receiving little. Heavy rainfalls occur from the onset of July to the end of mid-September. The temperature is between 10 and 26 °C, with an average of 18 °C throughout the year. The farmers are almost entirely devoted to rainfed agriculture, as agriculture is the principal income source of the community that lives in the sub-River basin. Cereals such as corn, wheat, barley, and teff are the main crops grown in the catchment (Benti & Balemi, 2016).

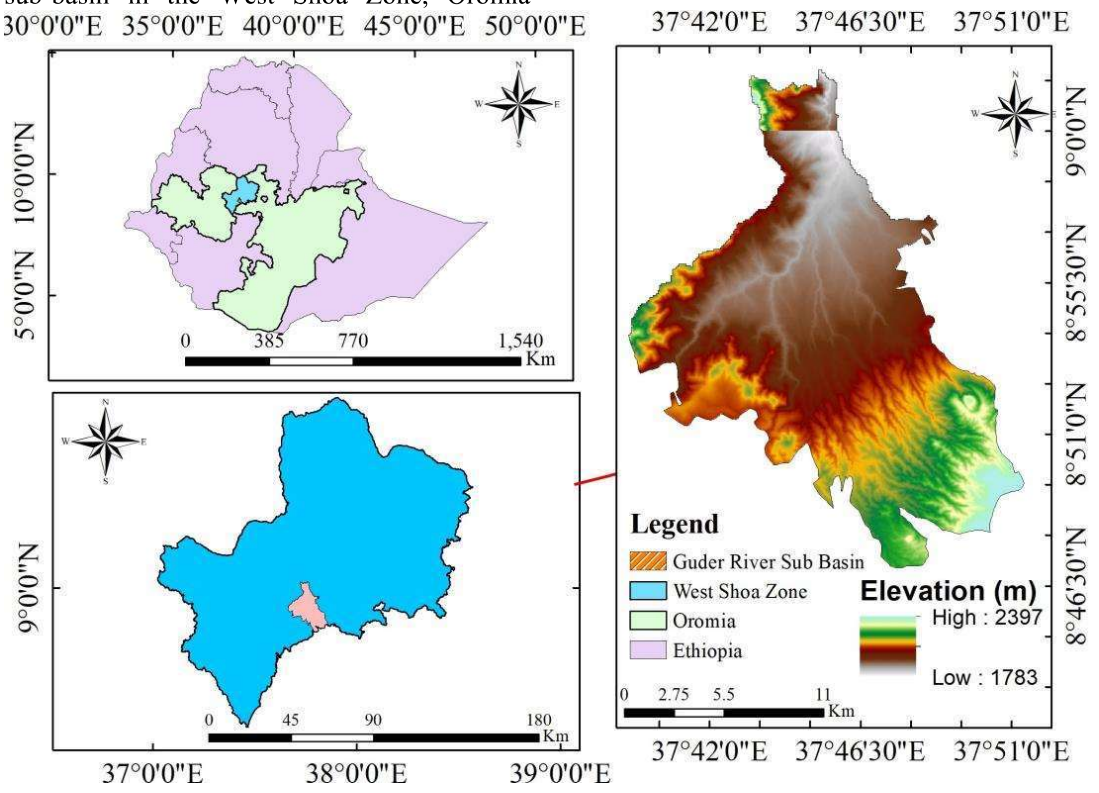

Figure 1. Location map of Guder River sub-basin

Data collection

The satellite images of global land cover change data were downloaded from the United States Geological Survey's (USGS) Earth Resource Observation and Science Center. It is freely available at the website https://www.mrlc.gov/. It is a time series of satellite images derived from remote sensing data, featuring multiple temporal and differential spatial scales with a spatial resolution of 30 x 30 meters. It includes Multi-Spectral Scanner (MSS), Enhanced Thematic Mapper (ETM+), and Operational Land Imager (OLI) Landsat images from 1990, 2005, and 2020. The USGS Earth Explorer platform was utilized to filter satellite images systematically based on cloud coverage percentages below 10%. The process ensures the provision of high-quality imagery for detailed analysis, enhancing the reliability and accuracy of research outcomes. Cloud cover is one of several constraints on the ability of sensors on Landsat to provide a continuous time series of data for glaciological studies (Marshall et al., 1994). The 240 ground control points (XY coordinates), which were selected at random from six different land use types using the handheld Garmin 72 GPS, were used to validate the accuracy of the satellite images. The total number of ground control points consists of 46, 28, 50, 44, 40, and 32 for grassland, forestland, cultivated land, settlements, shrubland, and 28 barren lands, respectively. Table 1 displays the gathered Landsat satellite images.

Table 1: List of Satellite image data and sources

Satellite images	Sensor	Path and row	Resolution	Date of acquisition	Sources
Landsat	MSS	169/54	30X30	11/01/1990	USGS
Landsat	ETM+	169/54	30X30	09/01/2005	USGS
Landsat	OLI	169/54	30X30	15/01/2020	USGS

Data preparation and pre-processing

In today's high-tech world, nearly all image interpretation and analysis need digital processing because most satellite images are stored in digital formats. Numerous steps were taken, including data formatting and correction, and digital enhancement for improved visual interpretation. Image preprocessing such as geometric correction and image enhancement is applied to avoid geometric distortion and unnecessary atmospheric effects. The geo-referencing process is also undertaken by ground control points (GCPs), as described by Obsa et al. (2021).

Data Analysis

Classification of land use and cover types

The classification of land use and land cover (LULC) for this study involved three key steps: image enhancement, image classification, and accuracy evaluation. To improve the visual interpretability of Landsat ETM, ETM+, and OLI/TIRS satellite images, we employed image enhancement techniques, specifically using the tasseled cap transformation. This spectral enhancement method combines multiple spectral bands to highlight vegetation and other features, thereby enhancing object distinction within the images.

The LULC classification process was conducted in two phases: unsupervised classification followed by supervised classification. Initially, unsupervised classification was performed to generate a preliminary classification map. This involved clustering algorithms that grouped pixels with similar spectral characteristics without prior knowledge of the land cover types. The unsupervised classification provided a

preliminary categorization, aiding in the identification of areas requiring further investigation during the field survey. Following the field survey, supervised classification was conducted to refine and validate the LULC categories. Ground truth data collected from ten reference sites for each LULC type were used, and the satellite images were geo-referenced to the X and Y Earth coordinate system using GPS data. The Bayes' maximum likelihood method, a parametric classifier, was employed for supervised classification, as it quantitatively evaluates the variance and covariance of the spectral response patterns of different categories, ensuring a more accurate categorization of unknown pixels.

Ground truth data collected during the same season as the satellite image acquisition was essential for validating the supervised classification results. The accuracy of the classification was assessed by comparing the classified images with the reference data. To quantify changes in each land use class, the difference in area between the initial Landsat MSS data from 1990 and the final Landsat OLI data from 2020 was calculated. This involved subtracting the 1990 area values from the 2020 area values for each LULC type. The results were then compared with the most recent map of 2020 and the initial map of 1990 to identify and analyze the changes in land use and land cover over the study period. This methodology provides a comprehensive and technically robust approach to LULC classification, focusing on the specific procedures and methods used in this study to ensure accurate and reliable results

The accuracy assessment is one of the most significant last steps in the classification process. The quantitative accuracy assessment measures how well the pixels were sampled into the appropriate land cover classes. The produced image classification was made by Congalton (1991) procedures, who confirmed the accuracy of the classified images. In this technique, the reference pixels are points on the classified image for which actual data is represented. Google Earth, practical experience, and random sample points were all considered in their development. Six land use and land cover categories such as grassland, forestland, cultivated land, settlements, shrubland, and bare land were created as standards for the categorization and accuracy evaluation of GCPs. Components like overall accuracy, user accuracy, producer accuracy, and Kappa coefficient could be accurately derived after the accuracy evaluations.

The producer's accuracy level was computed by dividing the total number of correctly classified pixels by the total number of ground control points (GCP) as indicated in Equation 1

$$PA\ (\%) = \frac{\sum GCP}{\sum CCP} * 100 \quad (1)$$

where PA represents producer accuracy in percentage, GCP is ground control points, and NC is correctly classified pixels.

The user's accuracy was also computed by the total number of correctly classified pixels divided by the total number of reference points (RP) as indicated in Equation 2.

$$\mathrm{UA}\ (\%) = \frac{\sum \mathrm{RP}}{\sum \mathrm{CCP}} * 100 \quad (2)$$

Where UA represents the user's accuracy in percentage and RP is reference points.

KAPPA analysis is a discrete multivariate technique used in accuracy evaluations (Jensen & Lulla, 1987). The Khat statistics are a metric for agreement or accuracy that comes from KAPPA analysis. It represents a Kappa estimate. Khat statistics were computed using Equation 3.

$$K = \frac{\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} (X_i + Xx_{+i})}{N^2 - \sum_{i=1}^{r} (X_{ii} * Xx_{+i})} \quad (3)$$

where K indicates Khat statistics, r is the number of rows and columns in the error matrix, N is the total number of observations, Xii is an observation in row i and column i, Xi+ is the marginal total of row i, and X+i is the marginal total of column i.

For computational purposes, equation 4 frequently takes the following form:

$$\widehat{K} = \frac{\theta_1 - \theta_2}{1 - \theta_2} \quad (4)$$

where $\widehat{K}$ is Khat statistics, $\theta_1 = \sum_{i=1}^{r} {}^{X_{ii}}/_{N}$ and $\theta_2 = X_{i+}\, X_{+i}/N^2$

The Kappa statistics (K) were evaluated concerning various limits according to Landis and Landis & Koch (1977). The agreement is poor if K is less than 0, slight if K is between 0 and 0.20, fair if K is between 0.21 and 0.40, moderate if K is between 0.41 and 0.60, substantial if K is between 0.61 and 0.80, almost perfect if K is between 0.81 and 1.00 and perfect if K is equal to 1.00.

Following classification and accuracy evaluation, ArcGIS performed geometric calculations to determine the areas of each land type in the study area.

Ecosystem service valuation (ESV)

Ecosystem Service Value (ESV) was assessed using global ecosystem service values as the technique described in Ghosh and Bhunia (2021). This study used the global ecosystem service assessment table for environmental benefit consumption with the appropriate biomass costs to estimate EVS per hectare (Table 2) for different land use and land cover types in the Guder River sub-basin for 1990, 2000, and 2020.

Table 2. Lists the LULC classifications, with the equivalent biomes and the overall ESV coefficients

LULC Categories	Equivalent Biome	ESV Coefficient (USD/ha/year)
Grassland	Grass/rangeland	232
Forestland	Tropical forests	2007
Cultivated land	Crop land	92
Settlement	Urban	0
Shrubland	Forest	969
Bare land	Urban	0

Source: Costanza et al. (1998)

The area of land use and land cover type was multiplied by the coefficient ecosystem value using equation 5 to get the overall ecosystem value for each specific land use type:

$$ESV_a = A_a * VC_a \quad (5)$$

where ESV is the ecosystem service value, A_a is the area (ha) of land use land cover types, and VC_a is the coefficient value for the land use category ‘a’ as US$ per ha per year.

$$ESV_b = \sum(A_a * VC_{ab}) \quad (6)$$

where is the ESV of ecosystem service function 'b'; is the value coefficient of land use type "a" as US$ per ha per year with ecosystem service function type 'b'.

The total ecosystem service function of the entire sub-basin was obtained by summing the estimated ESV from each LULC category using Equation 3 t to estimate the values of 17 ecosystem services as per the methods in Hoque et al. (2020) and Tolessa et al. (2017).

$$ESV_C = \sum_{a=1}^{n} A_a * VC_a \quad (7)$$

where $ESVc$ is the total ESV in US$

The rate of change in the ecosystem value over the research period was calculated using the formula below.

$$ESV\% = \frac{EVS_f - EVS_p}{EVs_p} * 100 \quad (8)$$

where $ESV\%$ is the rate of change in the period from the previous year to the final year, $ESVf$ is total ESV for the year of 2020, and $ESVp$ is the total ESV for the year of 1990 or 2000.

Table 3 shows the lists of LULC classifications with the equivalent biomes and the overall ESV coefficients. The equivalent biomes for each LULC category were chosen for this study. Thus, cropland represented cultivated land, tropical forest represented forest land, shrubland represented forest land, grassland represented rangeland, and settlement and bare land represented urban land.

Table 3. The annual ESV's global coefficient of ecological service values

Major service	Ecosystem Services	The coefficient of the annual ESV model (USD/ha/year)					
		Crop land	Forest land	Shrub land	Grass land	Settlement area	Bare land
Provision service	Food Production	54	32	43	67	0	0
	Raw materials	0	315	138	0	0	0
	Genetic resources	0	41	16	0	0	0
	Water supply	0	8	3	0	0	0
Regulating services	Climate regulation	0	223	141	0	0	0
	Gas regulation	0	0	0	7	0	0
	Disturbance regulation	0	5	0	0	0	0
	Waste treatment	0	87	87	87	0	0
	Water regulation	0	6	2	3	0	0
	Biological control	24	0	2	23	0	0
	Erosion control	0	245	96	29	0	0
Supporting	Nutrient cycling	0	2	2	0	0	0
	Pollination	14	0	0	25	0	0
	Soil formation	0	112	66	2	0	0
Cultural	Cultural values	0	922	361	0	0	0
	Recreation	0	10	10	1	0	0
	Total	92	2007	969	232	0	0

Source: Costanza (1997)

Results

Evaluation of data accuracy

Table 4 presents the evaluation results of the land use and land cover accuracy-testing matrix for the Guder River sub-basin from 1990 to 2020. The accuracy assessment of land-use and land-cover categories in the provided table reveals varying levels of classification precision. Cultivation land exhibits the highest accuracy, with a classification accuracy of 92.97% to 95.97%, indicating strong reliability in identifying this category. Forestland also shows robust accuracy, ranging from 86.36% to 90.48%, while grassland achieves a perfect accuracy of 100% in one assessment and 80% in another, reflecting a generally high level of classification certainty. Conversely, bare land and shrub land categories show lower accuracy, with bare land ranging from 62.50% to 66.67% and shrub land from 83.33% to 88.24%, suggesting some challenges in distinguishing these categories accurately. Settlement areas, with an accuracy of 80.00% to 85.71%, and grassland show mixed results but still fall within acceptable accuracy ranges. Overall, the classification process demonstrates high reliability for most land-use categories, particularly cultivation and forestland, with

some areas needing improved accuracy, particularly for bare land.

Table 4. Land use and cover test accuracy matrix for the Guder River sub-basin (1990–2020)

LULC categories	LULC2020	%	GCP	Reference total	Clarified total	No of Correct	Producer accuracy (%)	Users' accuracy (%)
Grass Land	2074.66	7.90	15	12	15	12	100	80
Forest Land	3229.84	12.31	22	21	22	19	90.48	86.36
Cultivation land	18119.26	69.03	124	128	124	119	93	96
Settlement area	140.793	0.54	15	14	15	12	85.71	80
Shrub land	2575.25	9.81	18	17	18	15	88.24	83.33
Bare land	107.96	0.41	15	16	15	10	63	67
Total	26247.76	100	209	209	209	187		

Land use and cover classification and changes over decades

The findings indicate that the asymmetrical changes of the six land use types continued over the last three decades, while some expanded while others shrank (Figure 2). Land use and cover analysis results reveal six land use types: cultivated land, forestland, grassland, shrubland, settlements, and barren land. The results also show that the study river basin's land use and cover types changed significantly over time. In the 1990s, these land use types varied across grassland, forestland, cultivated land, settlements, shrubland, and bare land, covering 5,863.81, 12,226, 28.93, and 3,036.75 ha, respectively. From 1990 to 2000, grassland areas declined sharply by 56.07% with a continued decrease of 19.46% from 2000 to 2020, totaling a 64.62% reduction over 30 years. This reflects a significant shift from grasslands to other uses, particularly cultivated land. Forestland also saw a notable decline, decreasing by 23.02% from 1990 to 2000 and by 17.50% from 2000 to 2020, resulting in a 36.50% decrease over the same period, indicating ongoing deforestation.

Conversely, cultivated land increased significantly, with a 41.99% rise from 1990 to 2000 and a more modest 4.38% increase from 2000 to 2020, culminating in a 48.2% growth over 30 years. Settlement areas expanded dramatically, rising by 103.53% from 1990 to 2000 and by 139.11% from 2000 to 2020, highlighting rapid urbanization. Shrub land experienced a 23.57% decline from 1990 to 2000 but saw a slight recovery with a 10.96% increase from 2000 to 2020, resulting in a 15.20% overall decrease. Bare land saw the most dramatic change, with a 180.94% increase from 1990 to 2000 and a staggering 520.82% rise from 2000 to 2020, indicating severe land degradation or conversion. The data shows a clear trend of increasing agricultural and settlement areas, significant reductions in grassland and forestland, and a dramatic rise in bare land, underscoring the need for effective land management and conservation to address environmental impacts.

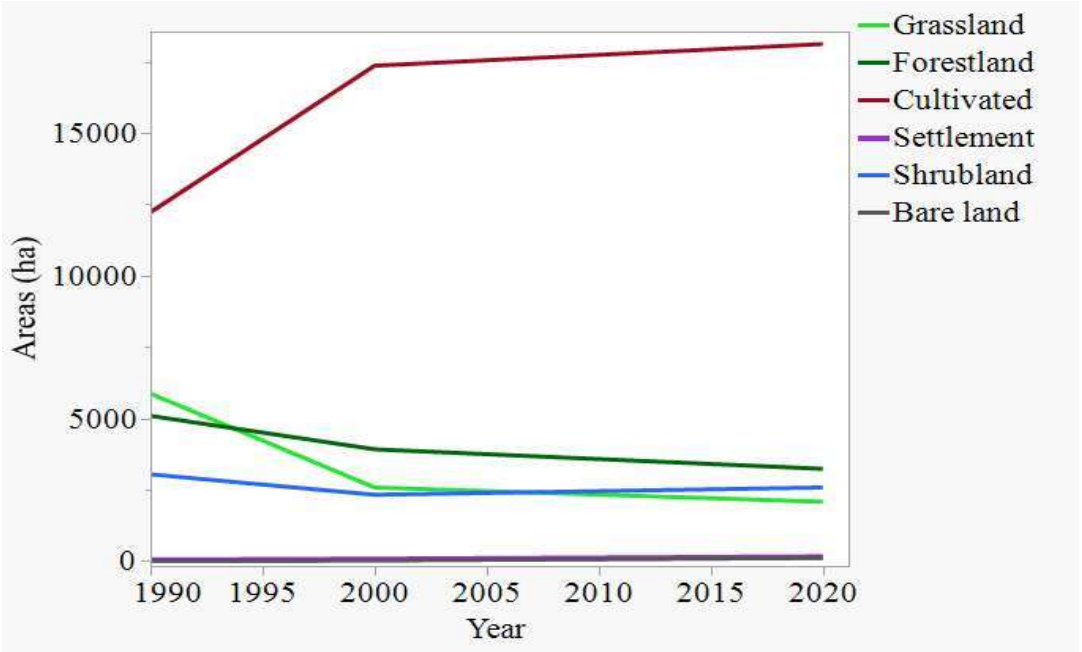

Figure 2. Land use and cover test accuracy matrix for the Guder River sub-basin (1990–2020)

Figure 3 shows spatial distribution patterns of six land use land and cover types over the period from 1990-to-2020. The distribution of each land use type has varied over the last three decades. As shown in Figure 2a, the sub-basin was primarily covered by cultivated land (46.58%), followed by grassland (22.34%), with barren land being the smallest at 0.02%. The spatial distribution of the cultivated land is widely extended in the central and northern parts of the sun-basin, where it has continued to expand in all directions by replacing forests, grasslands, and shrublands. The forestland is widely occupied in the western and southern portions of the sub-basins (Figure 3a).

However, significant changes in land use areas occurred over ten years. By 2000, grassland decreased from 22.34% to 9.81%, forestland from 19.38% to 12.92%, and shrub land from 11.57% to 8.84% In contrast, cultivated land increased from 46.58% to 66.17%, settlement land from 0.11% to 0.22%, and bare land from 0.02% to 0.07% (Figure 3b). The decline of forest and shrub land is predominant in the northwestern and northern parts of the water basin, while cultivated land is increasing in these regions and settlement land is expanding in the northeastern part of the basin, it signals a significant transformation from natural landscapes to agriculture and urban areas. This shift may lead to increased soil erosion, loss of biodiversity, and disruption of the natural water cycle, potentially causing long-term environmental degradation (Bare land) and challenging the sustainability of both agriculture and settlements in the region

By 2020, these trends continued, with grassland, forestland, and shrubland further decreasing to 7.9%, 12.31%, and 9.81%, respectively, while cultivated land rose to 69.03%, settlement land to 0.54%, and bare land to 0.41% (Figure 3c). These shifts indicate a significant expansion of cultivated and settlement land, likely driven by agricultural and urban development, at the expense of natural landscapes like grasslands, forests, and shrublands. This trend may lead to reduced biodiversity, altered ecosystems, and increased environmental degradation in the area. The shrubland area in the 2020s unexpectedly increased as compared to its area in 2000. Even though more research will be needed, the increment of shrubland may be related to the national green legacy program for the rehabilitation of the land use type over the past two years. The plantations established during

the national Green Legacy program may be considered shrubs due to their current growth stage and characteristics. Initially, these planted areas consist primarily of young plants and saplings, which have not yet developed into mature forests. They exhibit the features typical of shrubland, including a predominance of smaller, bushy vegetation (West, 2006).

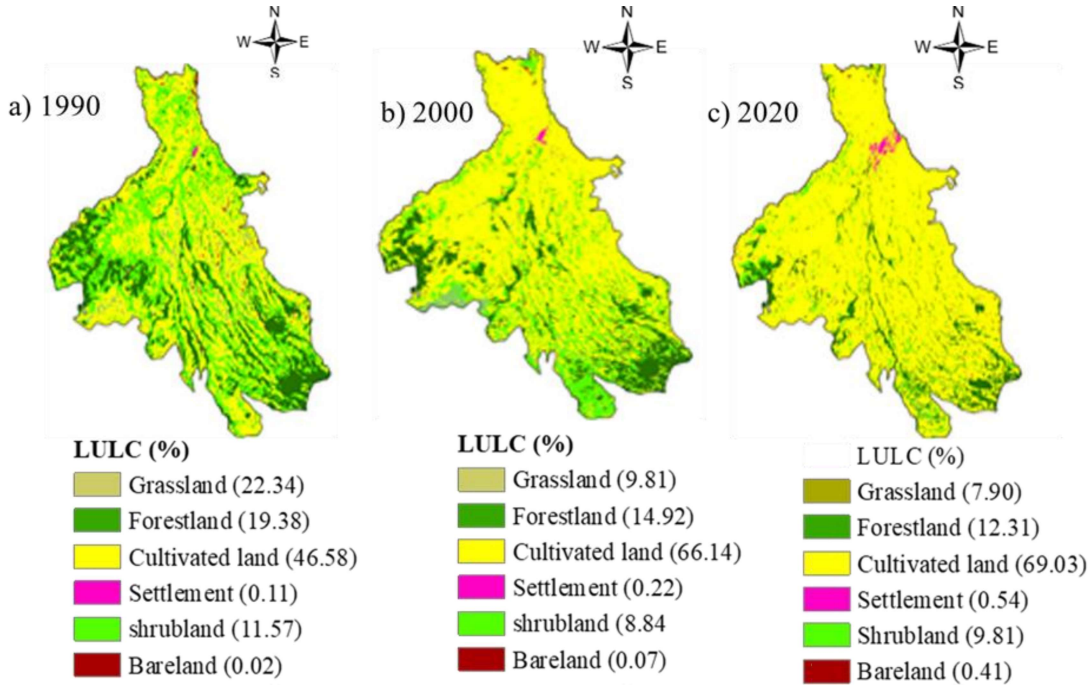

Figure 3. Land use and cover change map of the Guder River sub-basin (1990-2020)

Land Use and Cover Transition Matrix

From 1990 to 2000, the Guder River Sub-Basin experienced notable land use and land cover changes. Grassland saw a significant reduction of 3,287.91 hectares, transitioning primarily to cultivated land, which expanded by 5,134 hectares. This shift indicates a substantial conversion of grassland to agricultural use. Forestland also decreased by 1,170.88 hectares, with a portion of this area likely being converted to cultivated land as well. Settlement areas increased modestly by 29.95 hectares, reflecting urbanization trends. Shrubland experienced a decrease of 715.75 hectares, contributing to the expansion of cultivated areas. Bare land increased slightly by 11.20 hectares, indicating a minimal change in this category during this period.

Table 5. Land use land cover transition Matrix 1990-2000

LULC	Grassland	Forestland	Cultivated	Settlement	Scrubland	Bare land	Total changes
Grassland	2575.90	-1470.88	4563.00	29.95	-715.75	11.20	-3287.91
Forestland	-1170.88	3915.20	-2170.88	29.95	1074.20	11.20	-1170.88
Cultivated	4563.00	-1170.88	17360.00	29.95	1074.20	11.20	5134.00
Settlement	29.95	29.95	29.95	29.95	29.95	11.20	29.95
Scrubland	-715.75	1074.20	1074.20	29.95	2321.00	11.20	-715.75
Bare land	11.20	11.20	11.20	-11.20	11.20	17.39	11.20

Between 2000 and 2020, the trends observed in the previous decade continued, though with some variations. Grassland further decreased by 501.24 hectares, transitioning into cultivated

land, which saw a notable increase of 759.30 hectares. Forestland continued to decline by 685.36 hectares, with areas being converted to other land uses, particularly cultivated land. Settlement areas experienced a more substantial increase of 81.91 hectares, indicating ongoing urbanization. Shrub land, after a decrease in the previous decade, saw a slight increase of 254.25 hectares, suggesting some reforestation or natural shrubland regrowth. Bare land expanded by 90.57 hectares, reflecting continued degradation or clearing of other land cover types.

Table 6. LULC transition Matrix: 2000 to 2020

LULC	Grassland	Forestland	Cultivated	Settlement	Scrubland	Bare land	Total changes
Grassland	2074.66	-685.36	759.30	81.91	81.91	90.57	-501.24
Forestland	-685.36	3229.84	-2170.88	81.91	81.91	90.57	-685.36
Cultivated	759.30	-2170.88	18119.30	81.91	81.91	90.57	759.30
Settlement	81.91	81.91	81.91	140.79	81.91	140.79	81.91
Scrubland	254.25	254.25	254.25	81.91	81.91	90.57	254.25
Bare land	90.57	90.57	90.57	90.57	90.57	107.96	90.57

Overall, from 1990 to 2000 and 2000 to 2020, there has been a consistent trend of decreasing grassland and forestland areas, with a corresponding increase in cultivated land. This indicates a significant shift towards agricultural land use, likely driven by population growth and the need for increased food production. The minimal changes in settlement and bare land areas suggest that the primary land use changes are occurring in natural and semi-natural landscapes, influencing the ecosystem services provided by these areas.

Impacts of land use and land cover change on ecosystems service

Figure 3 shows the overall estimated value of ecosystem service change between the 1990 and 2020 timeframes. The ecosystem service value of grassland experienced a significant decline from $1.36 million in 1990 to $0.48 million in 2020, representing a decrease of 64.70%. Similarly, forestland also showed a notable decrease in ESV, dropping from $10.20 million in 1990 to $6.48 million in 2020, which corresponds to a 36.47% decline. The ecosystem service value of shrubland experienced a moderate decline from $2.94 million in 1990 to $2.49 million in 2020, a reduction of 15.30%. In contrast to grassland, forestland, and shrubland, the ESV of cultivated land increased from $1.12 million in 1990 to $1.66 million in 2020, marking a 48.21% rise. The total ecosystem service value across all land use and land cover types decreased from $15.62 million in 1990 to $11.11 million in 2020, a reduction of 28.87%. This overall decline highlights a significant loss in ecosystem services over the three decades, primarily driven by the reductions in forestland and grassland values.

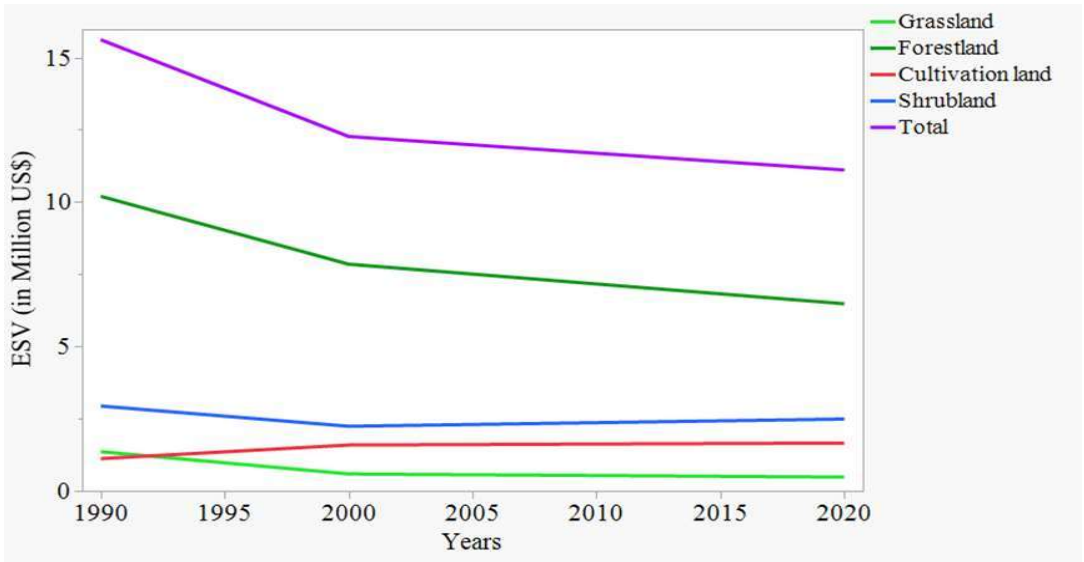

Figure 4. Trends of land use and cover types ecosystem service value (ESV) from 1990 to 2020

Specific ecosystem service changes

The impacts of land use and cover changes on each ecosystem service are presented in Table 6. In 1990, specific ecosystem service values in US dollars ranged from $2.0 x 104 to 5.79 x 106, with the highest recorded for nutrient cycling and the lowest for cultural services. In 2000, the ecosystem service value in US dollars varied between $2.0 x 104 and $4.45 x 106, with the highest recorded in nutrient cycling and the lowest in cultural services. The highest and the lowest values of ecosystem service value ranged from $10 x 103 to $3.91 x 106 million US dollars were recorded in nutrient cycling and cultural services, respectively. Except for food production and biological control, the specific values of all ecosystem services have decreased over the last three decades. The values of ecosystem service in food production and biological control in the US dollar increased by $3.5 x 104 and $5.4 x 104, respectively. This rise in ecosystem service values of food production may be related to the expansion of cultivated land use types over the study period. The highest ecosystem service loss was observed in raw materials ($6.50 x 105), erosion control ($6.01 x 105), waste treatment ($5.51 x 105), and climate regulation ($4.80 x 105) (Table 7). The Guder River sub-basin lost approximately $4.51 million of total ecosystem service value throughout the study period. The decrease in grassland, forestland, and shrubland in the study area may have contributed to the decline in total ecosystem service values.

Table 7. The estimated annual value of each ecosystem service (ESV) (in millions of US$)

Major services	Ecosystem services	ESV_c1990	ESV_c2000	ESV_c2020	Change 1990-2020
Provisioning service	Food Production	1.26	1.28	1.29	0.03
	Raw materials	2.02	1.55	1.37	-0.65
	Genetic resources	0.26	0.2	0.17	-0.09
	Water supply	0.05	0.04	0.03	-0.02
Regulating service	Climate regulation	1.56	1.20	1.08	-0.48
	Gas regulation	0.04	0.02	0.02	-0.02
	Disturbance regulation	0.03	0.02	0.02	-0.01
	Waste treatment	1.22	0.77	0.69	-0.53
	Erosion control	1.70	1.18	1.10	-0.60
	Biological control	0.32	0.31	0.31	-0.01
	Pollination	0.05	0.05	0.03	-0.02
	Water regulation	0.43	0.48	0.49	0.06
Supporting services	Nutrient cycling	0.02	0.05	0.01	-0.01
	Soil formation	0.78	0.6	0.54	-0.24
	Habitat/refuge	5.79	4.45	3.90	-1.89
Cultural service	Cultural	0.09	0.07	0.06	-0.03
	Recreation	-	-	-	-
	Total	15.62	12.27	11.11	-4.51

Conclusion

The current study examined the significant land-use and land-cover changes in the Guder River Sub-Basin from 1990 to 2020 and their impacts on ecosystem service values. The land classification analysis, based on classification of satellite imagery, revealed a substantial reduction in grassland, forestland, and shrubland, while areas of cultivated, settlement, and barren lands expanded. This expansion is largely attributed to continuous agricultural activities and overgrazing, which have contributed to land degradation and the spread of barren areas. The dominance of cultivated land throughout the study period underscores the heavy reliance of the local population on agriculture, leading to the displacement of grassland, forest, and shrubland to accommodate growing agricultural demands. The findings suggest that the decline in these natural land covers is driven by the need to expand agricultural and residential areas, fueled by population growth. Historical evidence indicates that Ethiopia experienced rapid population growth from the mid-19th to early 20th century, which accelerated deforestation and increased cultivation in the highlands, a trend that is reflected in the land-use changes observed in the Guder River Sub-Basin (Hurni et al., 2005).

The current findings align with numerous national and international studies reporting similar trends (Bhat, 2022; Deng et al., 2019; H. Hu et al., 2008; Rwanga and Ndambuki, 2017; Tolessa et al., 2017). Specifically, the present results are consistent with those of Gashaw et al. (2018) and Tolessa et al. (2017), who observed the expansion of cultivated, built-up, and barren lands as well as the withdrawal of grass, forest, and shrublands in Ethiopia's central highlands and the upper Blue Nile basin, respectively. Furthermore, our findings resonate with the assessments of land use and land cover change by Hassan et al. (2016) and Obsa et al. (2021), which noted the decline and loss of forest and shrub land due to the continuous expansion of cultivated and settlement lands in Islamabad, Pakistan and central highlands of Ethiopia, respectively. The findings also concur with those of Miheretu and Yimer (2018) and Chalchissa and Kuris (2024), who found that the degradation of environmental resources was caused by a rapid decline in shrubland and other natural resources and an increase in the arable land of the northern highlands of Ethiopia. Mikias (2015) also stated that the expansion of cropland is at the expense of grassland, bushland, and forestland in the Jijiga watershed of eastern Ethiopia. Assefa and Bork (2014) and Chalchissa et al (2022)also reported that forest tree cover had decreased at the highest rates in southern Ethiopia due to the growing population pressure and its associated problems, such as the need for land resources for agricultural production and settlement areas.

The analysis of ecosystem service values revealed that the reduction in areas of key land use types, such as forestland, grassland, and shrubland, led to a significant decline in the overall value of ecosystem services. While cultivated land showed an increase in ecosystem service value, this increase was considerably lower than the losses associated with the degradation of natural landscapes like forests, grasslands, and shrublands. The data indicates that the conversion of these natural ecosystems to agricultural and residential land has diminished the ecosystem's ability to provide essential services, including provisioning, regulating, and supporting functions. This decline is particularly concerning given the critical roles that forests and grasslands play in carbon sequestration, water regulation, soil conservation, and biodiversity support. The results suggest that the long-term sustainability of the Guder River Sub-Basin's ecosystem is at risk if the current trends in land use change continue, emphasizing the need for strategies that balance agricultural expansion with the preservation of natural ecosystems to maintain essential ecosystem services.

The current findings are consistent with several studies on how land use and cover have changed over time and affect the ecosystem service functions (Bhat, 2022; Halefom et al., 2018; Kindu et al., 2016; Sewnet & Abebe, 2018). It coincides with the findings of Gashaw

et al.(2018) , who found the slight increase of ecosystem service in cultivated land while continuous decline in forests, shrubland, and grassland decreased in the upper Blue Nile basin of Ethiopia, ensuring that for the next thirty years, these trends will persist. Our findings also highly support those of Tolessa et al. (2017), who reported the significant impacts of LULC change on the ecosystem service values from 1973 to 2015 in the central highland of Ethiopia.

Conclusions

The most widely used methods were employed in this study, notably remote sensing and GIS, which are powerful tools for identifying and classifying land use and cover types. Our findings revealed that six major LULC types were detected such as grassland, forestland, cultivated land, building-up areas, shrubland, and barren lands. In the last three decades, the cultivated land and built-up land use types continually expanded, causing severe destruction to the grassland, forestland, and shrubland at the highest rates. Following the land use and cover changes, there was a sharp decline in total ecosystem service values of grassland, forestland, and shrubland and a rise in cultivated land, which is nevertheless less valuable than the former or less valuable than each land use category that was transformed into cultivated land. All ecosystem service values of the biomes in the study area decreased except in crop production, with the highest values declining in habits. Therefore, we suggest that it is critical to establish awareness-building for local government bodies, stakeholders, and the community on the importance of ecological services, forest conservation, and land use planning.

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RESEARCH PAPER

Physicochemical Analysis of Wastewater as Performance Evaluation of Wastewater Treatment Plant of Debre Berhan Dashen Brewery

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Abstract

Currently, the evaluation of the performance of wastewater treatment plants (WWTP) of every industry in Ethiopia attracts great attention because of the increase in industrialization and consequently increase in environmental pollution. This study was conducted to evaluate the efficiency of the wastewater treatment plant of Debre Berhan Dashen Brewery by analyzing the physicochemical parameters of the wastewater discharged from the brewery. Wastewater samples were collected from the influent and outlet of each treatment unit. The pollutant removal efficiency of each treatment unit was evaluated. In addition, the major physicochemical parameter values of the wastewater samples were analyzed using standard methods. The results showed that the influent had the mean value of pH(10.95±0.83), temperature (29.5±0.93 ^{o}C), EC (3203±1.05 µS/cm), COD (6133±1.63 mg/L), BOD5 (2304±3.96 mg/L), TDS(2737±5.61 mg/L), TSS (866±1.32mg/L), NH4-N (15.6±0.03 mg/L) and NO3-N (16.3±0.07 mg/L) and the final effluent had a mean value of pH(7.85±0.15), temperature (26.97±1.07 oC), EC (2160±1.83 µS/cm), COD (835.0±2.23 mg/L), BOD5 (192±8.0 mg/L), TDS (1119.5±7.6 mg/L), TSS (268±1.22 mg/L), NH4-N (11.3±0.06 mg/L) and NO3-N (6.96±0.67 mg/L). The value of COD, TSS, and BOD were higher than the national industrial wastewater discharge limits set by EEPA 2003. Thus, the Debre Berhan Dashen brewery waste treatment plant needs improvement so as to meet the standard limit and minimize environmental pollution.

Keywords: COD, BOD, TSS, wastewater, treatment plant

Introduction

Ecological and human disasters can arise from the discharge of industrial wastes causing the degradation of ecosystems and human health (Chala et al., 2012; Alebel, 2014). Human activities on rivers and their ecosystem affect one or more of the five attributes of watersheds and streams: water quality, habitat structure, stream flow patterns, sources of energy and nutrients, and biotic interactions (Kebede, 2018; Andargachew and Samuel, 2013). Compromised environmental quality as a result of effluent discharge from industrial sectors has become a serious environmental concern for many countries especially in developing nations like Ethiopia (Chala et al., 2012).

In Ethiopia, the large and medium-scale manufacturing sub-sectors are dominated by four consumer goods-producing industrial groups, like food and beverage, chemical, textile, leather, and shoe groups are the main industrial sectors that contribute to the national and local economic activities in the country (Alebel, 2014). Breweries are the conventional industries in the agro and food sector using cost-effective techniques to manufacture the best quality beer. During the process of beer brewing, beer mainly passes through three very important chemical and biochemical reactions (mashing, boiling, fermentation, and maturation) and three solid-liquid separations (wort separation, wort clarification and rough beer clarification) (Chala et. al., 2012).

Wastewater is one of the major waste products of brewery operations. Untreated effluents typically contain suspended solids (TSS) from 200- 1000 mg/L, biochemical oxygen demand (BOD) from 1,200-3,600 mg/L chemical oxygen demand (COD) from (2,000-6,000 mg/l) and nitrogen (N) in range (25-80 mg/l) (Kebede, 2018). Phosphorus (P) can be present at concentrations of (10-50 mg/l). The effluent pH can also vary from 3 to 12 depending on the use of acid and alkaline cleaning agents as well the temperature average becomes about 30 ℃ but can fluctuate from (18-40℃) (Kebede, 2018; Choi, 2016).

The wastewater treatment system employed at Debre Berhan Dashen Brewery is UASB with a re-aeration system. A prerequisite for the successful operation of a UASB system is the presence of well-settling (granular) sludge, which can stand the up-flow velocity of the wastewater and is retained in the reactor. In the UASB processes, the wastewater to be treated is introduced at the bottom of the reactor. The treated effluent from the system is released through the canal and farmers use it for different activities and irrigation purposes before mixing with a tributary of the Beresa River. However, no study has been conducted on the performance evaluation of its treatment plant and the quality of treated wastewater released to the surrounding environment. The main objective of this study was to evaluate the performance of the treatment plant and analyze the physicochemical parameters: Temperature, pH, electrical conductivity (EC), chemical oxygen demand (COD), Biological oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), Nitrate-nitrogen (NO3- N), and Ammonium Nitrogen (NH4+-N) of the effluent released to the environment.

Materials and methods

Description of Study Areas

The study was conducted at Debre Berhan Dashen Brewery Share Company. Debre Berhan City is found in the North Shoa Zone, Amhara Regional State, Ethiopia (Figure 1). The area is located 120 km north of Addis Ababa. It has latitude and longitude of 9°41′N, 39o32′E and an elevation of 2840 meters above sea level. The brewery officially started production on November 15, 2015 and is located at 09 Keble, North part of Debre Berhan city. The GPS (UTM), location of the factory is Northing 106908.94 and Easting 558472.03 an altitude of 2822.21 meters above sea level. The annual production capacity of the brewery is approximately 2,000,000 hectoliters of bottled brand and drought beers.

The factory produces a substantial volume of wastewater approximately 1680 m3/day. The wastewater treatment system employed at Dashen Brewery is a UASB reactor coupled with an aeration tank. The treated effluent from the system is released to the surrounding agricultural area and then discharged to the nearby Beresa River. Physicochemical analysis and removal efficiency of the treatment plant was done by taking the sample from four parts of the treatment plant (the initial point of discharge, influent tank effluent, buffer tank effluent, bioreactor effluent and final effluent).

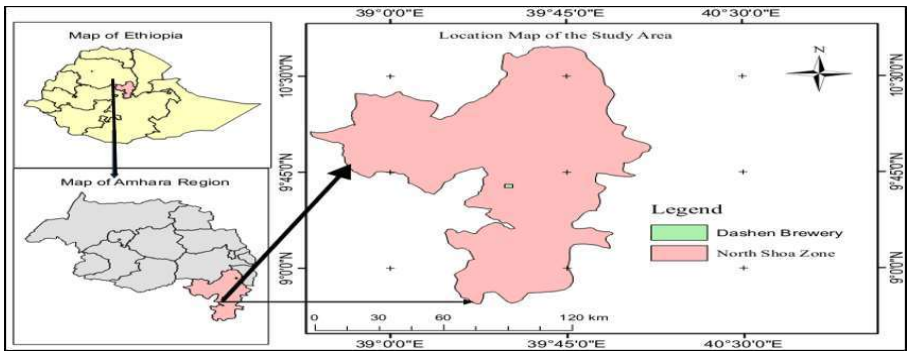

Figure 1. Map of Debre Berhan Dashen Brewery

Materials

The materials which were used during conducting this study were polypropylene bottles for collecting the brewery wastewater samples, an incubator, a Digital pH meter (pH and Temperature Meter HM PH-80 and PH-200), a BOD meter, DRB 200 Reactor, a Conductivity meter (LFF330 SET model), HACH spectrophotometer model DR/5000, HACH spectrophotometer model DR/3900, HACH spectrophotometer (HACH DR/900 Model, Loveland, CO, USA).

Wastewater sampling and preservation

Wastewater samples were collected from Debre Berhan Dashen Brewery at each outlet, while wastewater was discharged into the environment. The Wastewater Treatment Plant (WWTP) of the brewery consists of four main units namely: influent tank, equalization (buffer), anaerobic effluent tank (UASB reactor) and post-aeration tank (SBR) (Figure 2). The wastewater samples were collected from the inlet point and an outlet of each treatment unit and at the final discharge point. Samples were collected between 08:00 and 11:00 AM during the dry season. Considering the variability of the nature of brewery effluent, a snap sampling method was used (Firew et. al., 2018). Five rounds (forty-five) of samples were taken for the analysis of physicochemical parameters. Each wastewater sample was taken using cleaned polyethylene bottles stored in an ice box until transported to the laboratory.

Figure 2. Wastewater Sample collection from the outlet of treatment plants

Physicochemical Analysis

Physicochemical Parameters such as Temperature, biological oxygen demand (BOD5) total suspended solids (TSS), total dissolved solids (TDS), electrical conductivity (EC), and chemical oxygen demand (COD), were analyzed in the Debre Berhan Dashen Brewery Water and Wastewater treatment laboratory. Ammonium Nitrogen NH4-N and Nitrate-nitrogen NO3-N were analyzed in Horticoop Ethiopia water and soil laboratory at Bishoftu, Oromia Regional State, Ethiopia).

The pH and temperature were measured by digital temperature and pH measuring electrode (pH and Temperature Meter HM pH-80 and pH-200 model). Total Dissolved Solid (TDS) and conductivity (EC) were measured by a digital conductivity meter (LFF330 SET model). Nitrate-nitrogen (NO3-N) and Ammonium Nitrogen (NH4+-N) were determined using a spectrophotometer (HACH

DR/3900 Model, Loveland, CO, USA) according to the manufacturer's instructions. The TSS of the sample was determined using Whatman No.1 filter paper. A filter paper was weighed initially and then filter 50 ml of the sample was, the filter paper with wet TSS was oven-dried at 100oC. TSS was calculated thus: TSS (mg/l) = (final- initial weight)/volume of sample (Ogbu et. al., 2016).

The Biological Oxygen Demand (BOD) was determined as the difference between the initial oxygen concentration in the sample and concentration after 5 days of incubation in BOD bottles at 20 ℃ using the Oxi-Trop BOD system method (APHA, 2005). The Chemical Oxygen Demand (COD) was determined by the colorimetric determination method using the HACH DR/900 spectrophotometer.

Pollutant Removal Efficiency of each treatment plant

The pollutant removal efficiency of each treatment unit of the plant was evaluated from the difference in pollutant concentration in the influent and effluent from each unit, using the following formula:

Removal Efficiency (%) = [(Ci – Ce)/Ci] x100…. (Enitan et. al., 2015).

Where Ci = is the concentration of the waste material in the influent
Ce = is the concentration of the waste material in the effluent

Results and discussions

Analysis of physicochemical parameters

The average physicochemical parameters results obtained from the laboratory analysis of raw brewery wastewater and each treatment unit are summarized in Table 1. Comparison of the mean value of the parameters in the raw effluent with that in effluent from the influent tank indicated (Table 1) a significant difference ($p<0.05$) only for the parameters NO3-N and NH4-N.

Table 1. Physicochemical parameters values. The data are presented as mean+ SD, n=7

Parameters	Units	Mean ± Standard deviation				
		Brewery raw wastewater	Influent tank Effluent	Equalization tank Effluent	Anaerobic (UASB) reactor Effluent	Post-aeration (SBR) tank Effluent
pH	-	10.95±0.83	10.86±1.02	8.27±1.54	7.44±0.25	7.85±0.15
T	^{o}C	29.5±0.93	27.25±0.26	27.19±1.43	28.33±1.20	26.97±1.07
EC	µS /cm	3203±1.5	3092±8.6	2956± 3.8	2383±4.15	2160±1.83
TDS	mg/l	2737±5.61	2540±1.1	2160±3.61	1406±2.17	1199.5±7.6
COD	mg/l	6133±1.63	6017±1.81	5825±1825	971±2.51	835±2.23
BOD_5	mg/l	2304±3.96	2259±4.15	2105±4.56	288±1.12	192±8.0
TSS	mg/l	866±1.32	714±1.12	546±9.6	342±6.6	268±1.22
H_4-N	mg/l	15.6±0.03	14.2±0.02	14.0±0.04	15.7±0.04	11.3±0.06
NO_3-N	mg/l	16.3±0.07	14.3±0.12	12.6±0.25	5.06±0.89	6.96±0.67

The determined temperature, electrical conductivity (EC) and total dissolved solids (TDS) in this study were 26.97± 1.07 ^{o}C, 2160 ± 1.83µS /cm and 1199.5 ± 7.6 respectively (Table 1). These values are higher than the WHO standard (Ogbu et. al., 2016). The results of the analysis showed that the quality of the brewery discharge from the treatment plant does not meet the effluent standards in terms of COD and BOD_5. The effluent had average COD and BOD_5 values of 6133 ± 1.63mg/l and 2304.3 ± 3.96 mg/l respectively as indicated in Table 1. Which were above the standard reported values (Abimbola et. Al., 2014). The higher organic masses in the wastewater resulted from the alcohol from drip beer, dissolved carbohydrates and a high content of suspended solids such as malt, spent grain and surplus yeast could possibly be the causes of high COD and BOD5 in the discharge (Firew et. al., 2018). The nitrogen content was NH_4-N and NO_3-N in the wastewater were 15.6±0.03 mg/l and 16.3 ± 0.07 mg/l, respectively as shown in Table 1, which were in the effluent standards range (Firew et. al., 2018). The sources of the nitrogen might be the malt processing followed by the hydrolysis of protein for NH_4-N and NO_3-N (Firew et. al., 2018).

The obtained TSS value was 866 ±1.32 mg/l within the range of the reported value (Geoffrey et. al., 2011; Gangagni et. al.,2007). Malt processing, packaging and possible label pulp from the bottle washer could be the cause of TSS in the wastewater. The analysis also showed a pH value of 10.95±0.83 which was within the wide range (4-12) reported value (Teklit, 2018). The wide range in pH of wastewater might be due to the batch-processing nature of the brewery and the amount and type of chemicals (e.g. caustic soda, phosphoric acid, nitric acid, etc.) used at the CIP units (Teklit, 2018).

Performance Efficiency of Each Treatment Unit

The recorded physicochemical parameter values of each treatment unit (after their respective retention time) are depicted in Table 2. The removal efficiencies of the influent tank with 5 minutes retention time was pH (0.82%), T(^{o}C) (7.6 %), COD (1.89%), BOD_5 (1.95%), TSS (17.6%), TDS (7.2%), TP (4.21), NH_4-N(8.9%), and NO_3-N (12.26%) (Table 2).

The retention time in the equalization tank is 3 hrs with an average flow of volume of 720 m^3. This step time is required to obtain sufficient hydraulic peak shaving and sufficient rubbing out of peaks in pH and the organic load (COD, BOD, and TSS). In addition, the complex organic material will hydrolyze partially to sugars, amino acids and fatty acids (acidification), Firew et. al., 2018). The comparison of the average values of effluent from the influent tank with that of the equalization tank showed a significant decrease in pollutants ($p<0.05$) only for pH, TDS, TSS, EC, TP and NO_3-N (Table 2).

Table 2. Removal Efficiency of each treatment unit of the system

Parameters	units	Percentage Removal (%)			
		Influent tank Effluent	Equalization tank Effluent	Anaerobic (UASB) reactor Effluent	Post aeration tank Effluent (SBR)
pH	-	0.82	23.84	10.03	0.51
T	^{O}C	7.60	0.20	-4.19	0.45
EC	µS/cm	3.50	10.86	19.40	9.40
TDS	mg/l	7.20	14.96	34.90	14.70
COD	mg/l	1.89	3.18	83.32	4.97
BOD_5	mg/l	1.95	6.18	86.30	4.24
TSS	mg/l	17.55	23.50	37.40	21.60
NH_4-N	mg/l	8.90	1.42	-1.02	28
NO_3-N	mg/l	12.26	11.89	59.80	-37.50

The average equalization tank removal efficiencies were pH (23.84%), T (0.2%), COD (3.18%), BOD5 (6.18%), TSS (23.55%), TDS (14.96%), EC (10.86), NO3-N(11.89%) and NH4-N(1.42%) (Table 2). Relatively higher removal efficiencies of equalization tank for Hawasa St. Georgis brewery than the present study for TSS, NH4N, and NO3-N, but lower efficiencies for EC, TDS, COD and BOD5 than reported values Gulnur et. al., 2018; Firew *et. al.*, 2018).

The retention time in the UASB tank is 6 hrs. on average 700 m3 of waste flows. After the wastewater passed over the UASB reactor, the values of most pollutants decreased and comparisons of the measured value in this unit with the equalization tank indicated significant differences ($p<0.05$) for COD, BOD5, NO3-N and NH3-N (Table 1). The percentage treatment efficiency of the UASB reactor was for pH (10.03%), T (-4.19) BOD5 (86.3%), COD (83.32%), TSS (37.4%), NO3-N (59.8%), EC (19.4%), TDS (34.9%), SO4(34.8%), TP (28.7) and NH4-N (-1.02%) (Table 1). The UASB reactor removal efficiency for BOD5 and COD was 86.38% and 83.32% respectively which has low efficiency compared to the reported efficiency of UASB reactor BOD5 (94.6%), COD (91.2%) (Avinash et.al., 2013). The increment in the concentration of ammonia is related to the anaerobic conversion of organic matter and protein-containing compounds (Fuerhacker *et. al*., 2000). Nitrate-reducing bacteria may also be involved in anaerobic digestion, reducing NO3- to ammonium (NH4+). This increment amount of ammonia nitrogen in the rector may lead to decreases in the removal efficiency of ammonia nitrogen in the reactor. Also in anaerobic systems, the low removal efficiency of nutrients is expected because organic nitrogen is hydrolyzed to ammonia which is difficult to remove in anaerobic processes (Ferew *et. al*., 2018).

The anaerobic effluent flows to the re-aeration tank where it is post-aerated in order to remove odor compounds mainly H2S from the anaerobic effluent and further reduction of organic matter. In comparisons of mean differences of pollutants in effluent from the UASB reactor with effluent from the post-aeration tank reactor, there were significant differences ($p<0.05$) (Table 2).

Physicochemical characteristics of the treatment plant effluent and overall removal efficiency

The results of the physicochemical analysis and overall removal efficiency of the wastewater treatment plant are presented in Table 3. The mean values of some parameters were within the acceptable ranges of the discharge limits of EEPA, 2003).

Table 3. Physicochemical parameter values showing before treatment, after treatment and overall removal efficiency of the treatment plant.

Parameters	Mean (Before treatment)	Mean (After treatment)	Overall Removal efficiency	EEPA (2003) Discharge limits
pH	10.95±0.83	7.85±0.15	28.31	6-9
T (^{O}C)	29.5±0.93	26.97±1.07	8.6	40
EC (µS /cm)	3203±1.5	2160±1.83	32.6	1000
TDS (mg/l)	2737±5.61	1199.5±7.6	56.17	80
COD (mg/l)	6133±1.63	835±2.23	86.38	250
BOD_5 (mg/l)	2304±3.96	192±8.0	91.7	60
TSS (mg/l)	866±1.32	268±1.22	69.05	50
NH_4-N (mg/l)	15.6±0.023	11.3±0.06	27.56	20
NO_3-N (mg/)	16.3±0.07	6.96±0.67	57.3	10

The Brewery effluent had a mean pH, temperature, NH4-N, NO3-N, SO42-, 7.85±0.145, 26.97±1.07 oC, 11.3±0.06 mg/l, 6.96±0.67 mg/l,8.48±0.71 mg/l, respectively (Table 3), which were within the set limit of Ethiopian Environmental Protection Authority (EEPA, 2003). The mean value BOD5 (192±80 mg/l), COD (835±123 mg/l), TDS (1199.5±76 mg/l), TSS (268±122 mg/l), EC (2160±183 µS /cm), TP (29.33±0.12 mg/l) were higher than the acceptable ranges of the discharge limits set, (EEPA, 2003).

In general, the assessment of this study indicated that Debre Berhan Dashen Brewery discharged partially treated wastewater. The disposal of partially treated or untreated effluent into the environment can cause severe pollution problems since the effluents contain organic compounds that require oxygen for degradation (Geoffrey *et. al*., 2011). For example, the levels of COD and BOD above the standard limit in water are typically signs of low water quality and possible threats to human health and the environment and effluent that contain excessive nutrients like nitrogen and phosphorus could also result in algae bloom and cause a disturbance in the water body ecosystem. The Debre Berhan Dashen Brewery effluent must be monitored and controlled efficiently in order to safeguard the public health and environmental concerns in the surrounding area. Therefore, the concerned bodies need to check continuously and give advice to the owners to improve the wastewater treatment plant efficiency.

Conclusion

The result of the analyzed physicochemical parameters of the effluent revealed that the parameters pH, Temperature, NH4-N, NO3-N and SO42- meet the permissible limit set by EEPA, 2003. However, the values of BOD5, COD, TDS, TSS, EC and TP of the final effluent were above the range of the standard discharge limit. This indicates that the wastewater was partially treated and the ineffectiveness of the Debre Berhan Dashen Brewery wastewater treatment plant. From the result of this study, it is recommended that improving the efficiency of the treatment plant units or implementing additional treatment plants should be needed. The municipality office should prevent the release of properly untreated wastes into the environment. It is also recommended that further studies should be conducted on the heavy metal analysis of the effluent. That will be very important for the full assessment of the wastewater and the efficiency of the treatment plant. It is also recommended that monitoring programs should be implemented for the discharge of effluent to address all actions that have been identified to have potentially significant environmental impact.

Conflict of interest

The authors declare no conflict of interest.

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RESEARCH PAPER

Impact of socio-economic factors on members' sales volume to cooperative societies: The case of selected districts of Southwest Shewa Zone, Oromia National Regional State, Ethiopia

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Abstract

Multipurpose Agricultural cooperatives are believed to play a crucial role in curbing the lack of modern inputs and access to markets by providing services ranging from making credit and modern inputs available to creating market opportunities and selling members' output. This study aimed to identify demographic, social and economic factors that affect members' Sales Volume in Multipurpose Agricultural Cooperative Societies. This research was conducted in two selected Districts of the Southwest Shewa Zone of Oromia National Regional State to identify the Impact of socioeconomic Factors on Members' Sales Volume in Multipurpose Agricultural Cooperative Societies: In Some Selected Districts of the Southwest Shewa Zone. The main participants/target populations of the study were Members of Multipurpose Agricultural Cooperative Societies found in Bacho and Waliso districts. For the sake of achieving the objectives of this study, different-stage sampling procedures were followed to select four Multipurpose Cooperative Societies and a total of three hundred fifty-one (351) respondents. A random sampling technique has been used to select a sample of respondents. A multiple linear regression model and descriptive statistics were used to analyze the data. The result of this study indicated that the sales volume of members of Multipurpose Cooperative Societies was significantly influenced by educational level, family size, duration of membership, household land size, agricultural inputs credit and production capacity. Therefore, the study recommended that cooperatives should not set the purchase prices below the market prices, they should try to follow the market price every time and create awareness for members about engagement in other agricultural activities and the advantages of selling their products to cooperatives.

Keywords: Agricultural cooperative; member sales volume; multipurpose cooperative

Introduction

According to Stefano and Cornelis (2010), one would expect that members also supply their products to their cooperative and non-members to private processing companies. However, an extensive dataset on Italian farmers and cooperatives shows that this is not automatically the case. Some cooperative members do not deliver their products to their cooperative, whereas non-members are delivering their products to cooperatives.

As pointed out by Ernita *et al* (2014), the participation of members consists of several kinds, namely participation in business activities (buying and selling/loan and saving), participation in the capital of fertilization (consciousness members in meet their obligation, that is paying the major deposits, mandatory deposits, and voluntary deposits), participation members in make decisions and participation members in monitoring.

Farmers' commitment to cooperatives is increasingly important as a result of increased encouragement to enter the market through them. In Sub-Saharan African countries,

farmers face high transaction costs which prohibit their access to better-paying markets and worsen their poverty level (Barret, 2008). Lack of information on prices, lack of linkages between farmers and other market actors, credit constraints and other market imperfections lead peasants to sell their crops at the farm gate to intermediaries, often at a low price, and to not take advantage of market opportunities (De Janvry *et al*., 1991, Fafchamps and Vargas-Hill, 2005).

Lack of information on prices, lack of linkages between farmers and other market actors, credit constraints and other market imperfections lead peasants to sell their crops at the farm gate to intermediaries, often at a low price, and to not take advantage of market opportunities (De Janvry et al., 1991, Fafchamps and Vargas-Hill, 2005).

Muthyalu's (2013) study in Adwa District, Ethiopia shows Farmer member's active participation in agricultural input and output marketing in Multipurpose Cooperatives is influenced by various demographic, socioeconomic and institutional factors. To the best knowledge of the researcher, no studies have been conducted on the impact of socio-economic factors on members' sales volume to cooperative societies in which they are members in developing countries in general and in Ethiopia in particular. In this circumstance, the researcher conducted a study on the impact of socio-economic factors on members' sales volume in cooperative societies. In view of the problems, the central question of this study was: what is the impact of socio-economic factors on members' sales volume to the cooperative societies at the selected districts of Southwest Shewa Zone? Hence, the present study is unique and it makes an attempt to bring forth regarding the impact of socio-economic factors on members' sales volume to cooperative societies in selected districts of the Southwest Shewa zone of Oromia National Regional State. This study aimed to identify demographic and economic factors that affect members' Sales Volume in Multipurpose Agricultural Cooperative Societies.

The findings of this study will help members of Multipurpose Agricultural Cooperative Societies found in Woliso and Becho districts in general and those who are the members of the sampled Multipurpose Agricultural Cooperative societies in the study area in particular by pinpointing the impact of socio-economic factors on members' sales volume to cooperative societies. In addition, it serves as literature for other researchers. Furthermore, it may help cooperative promoters, cooperative managers, committees of cooperatives and employees of cooperatives to provide appropriate support to solve the actual challenges of Multipurpose Agricultural Cooperative Societies by revealing areas of deficiency.

Materials and methods

Description of Study Areas

The study was conducted on the impact of socio-economic factors on members' sales volume to cooperative societies in selected districts of the Southwest Shewa zone of Oromia National Regional State, Ethiopia. According to the Census conducted by the Central Statistical Agency of Ethiopia (2007), this Zone has a total population of 1,101,129, of whom 556,194 are men and 544,935 women. 149,878 or 13.61% of the population are urban inhabitants. A total of 233,916 households were counted in this Zone, which results in an average of 4.71 persons per household, and 227,102 housing units. The Oromo (87.08%), Amhara (6.16%), and Gurage (5.06%) were the three largest ethnic groups in Southwest Shewa according to reports; the remaining ethnic groups comprised 1.7% of the total population. Afaan Oromo was spoken as a first language by 84.85%, 8.41% spoke Amharic and 5.57% spoke Guragiegna; the remaining 1.17% spoke all other primary languages reported.

For the purpose of the study, a descriptive research design was employed to identify the impact of socioeconomic factors on members' sales volume in cooperative societies. Qualitative and quantitative approaches were employed by the researcher to investigate the

impact of socioeconomic factors on members' sales volume in cooperative societies.

According to the Southwest Shewa Zone Cooperative Agency Bureau representative (2020) orally said, all Multipurpose Agricultural Cooperatives were not equally engaging and many of them were not engaged in the purchase of farmers' agricultural outputs. This was the reason for selecting Multipurpose Agricultural Cooperatives found in the Becho and Waliso districts among the Cooperatives found in eleven districts of Southwest Shewa Zone. Southwest Shewa was selected purposefully due to it being near the residence of the researcher.

Sampling techniques and size

For the study, four multipurpose agricultural cooperative societies with a total of 2,862 members as the target population were selected through criteria-based sampling (that is, those actively engaging in the marketing of farmers' agricultural outputs). Such cooperatives are Tullu Katta Multipurpose Agricultural Cooperative Society, which has 340 total members; Nano Soyama Multipurpose Agricultural Cooperative Society, which has 846 total members; Daka Guda Multipurpose Agricultural Cooperative Society, which has 530 total members; and Badessa Koricha Multipurpose Agricultural Cooperative Society, which has 1,146 members (Data obtained from each Cooperatives Society during the study 2022/23).

To meet the objectives of the study, different stages of sampling procedures would be adopted to select the sample of respondents. In the first stage, four Multipurpose Cooperative Societies found in two districts were selected due to these cooperatives actively engaging in purchasing agricultural outputs.

In the second stage, the sample size for the all-target population would be determined by a statistically representative sample size determined by (Yemane, 1967).

Finally, to have a number of respondents from each Multipurpose Agricultural Cooperative Societies, probability proportionate to sample size (PPS) was used. Then a random sampling technique was used to select a sample of respondents. Because employing a random sampling technique eliminates biases in having a sample of individual respondents.

A variety of factors should be considered in determining sample size. Budget and time available, statistical methods used, variability of the population characteristic under investigation, and the level of confidence desired in the estimate and degree of precision desired in estimating the population characteristic were the usual parameters.

Finally, the sample size was determined by statistically representative sample size determining the methodology for a large population as follows:

$$n = \frac{N}{1+N\,(e^2)}$$ (Yemane, 1967)

Where:

n= Sample Size

N= total population

e= is the desired level of precision required which is (0.05)

$$n = \frac{2862}{1 + 2862\,(0.05^2)}$$

$$350.95 = 351$$

After having the sample size for the whole population, further calculation was needed to decide the number of respondents to be taken from each of the four Multipurpose Agricultural Cooperative Societies by using proportional allocation.

In this study, while employing probability proportionate to sample size (PPS) care was taken by the researcher to represent all four cooperative members in the total sample. So, each respondent contributed to the sample a number that was proportional to its size in the

population. To determine the sample size in each of the four cooperatives, the following formula was used.

$$n_k = (\frac{n}{N})N_k$$

Where:

n_k= the sample size for k^{th} Cooperative,

N_k=the population size of k^{th} Cooperative,

N= the total population size, n=the total sample size

Accordingly; 42, 104, 65, and 140 sample respondents were taken from Tullu Kata, Nano Soyama, Daka Guda and Badessa Koricha Multipurpose Agricultural Cooperative Societies respectively.

Data type, sources and methods of data collection

The study employed both primary and secondary sources of data for collecting the crucial data that were necessary to accomplish the research. Primary data involves surveys that were collected from the members through structured questionnaires (close-ended and some open-ended questionnaires). Secondary data was collected from both published and unpublished documents of Multipurpose Agricultural Cooperative Societies, district, regional, Federal Cooperative Agency, CSA, government policy documents and other relevant organizations to collect sufficient information about members' participation in Multipurpose Agricultural Cooperative Societies which supplemented the primary data. Since secondary data was gathered from existing sources, it saved time and costs for the researcher. Besides, there would be the possibility of collecting vast data that was relevant for the researcher.

For data collection, the questionnaire was prepared in English language and then translated into 'Afaan Oromo' language to address the varied educational and language backgrounds of the respondents. It was pilot-tested for reliability and validity via scale by Cronbach's Alpha before their actual use. Data enumerators would generate data using close-ended and some open-ended questionnaires by joining the respondents at their residences as the work plan of the researcher. Secondary sources like past studies, journals and documents of cooperatives were accessed from various databases like Business Source Premier, and office documents in order to obtain some reliable literature and empirical findings that can be applied to have a better understanding of members' sales volume in Multipurpose Agricultural Cooperative Societies.

Data analysis would be carried out by descriptive statistics (frequency, percentage, average, minimum and maximum) and Multiple Linear Regression analysis model through Statistical Package for Social Science (SPSS) Version- 20windows. This helped to test the influence of the explanatory variables on the dependent variable (members' sales volume).

Descriptive analysis would be used to reduce the data into a summary format by tabulation (the data arranged in a table format) and measure of central tendency (mean).

Before running the model for all variables that were entered into the model, multi-collinearity problems were checked using variance inflation factors (VIF) and normality problems were checked for all the hypothesized variables. Multi-collinearity refers to the existence of more than one exact linear relationship among explanatory variables, and co-linearity refers to the existence of a single linear relationship (Gujarati, 2004).

Thus, the VIF stated as,

$$\text{VIF (Xi)} = \frac{1}{1 - \text{Ri}^2} = \frac{1}{\text{Tolerance}}$$

Ri^2= It is the multiple correlation coefficients between Xi and other explanatory variables. The largest value of Ri^2 will result in a higher

value of VIF (Xi) which causes higher co-linearity among the variables.

Most of the time as a rule of thumb for continuous variables values 1< VIF< 5 specify that the independent variables are moderately correlated to each other (Shrestha, 2020) and Tolerance greater than 0.10 is taken as a signal for the existence of multi-collinearity in the model (Gujarati, 2004). In respect to this, table 1 indicates the value of VIF < 5 which indicates independent variables were moderately correlated and the value of tolerance > 0.10 which implies there was a signal for the existence of multi-collinearity in the model. However, it has no series multi-co-linearity problem.

According to Ghasemi (2012); when testing for normality, probabilities > 0.05 indicate that the data are normal. When it is < 0.05, probabilities indicate that the data are not normal. Hence, the result of the test for normality in Table 2 depicts that the data were normal due to the values of probabilities (statistic) > 0.05.

Model specification

The process of deciding which independent variables to include or leave out of a regression equation is known as model specification. A multiple regression model is, in fact, a theoretical statement about the causal relationship between one or more independent variables and a dependent variable (Sirika, 2013). Ernita et al. (2014) have used the Multiple Linear Regression model to investigate Factors Affecting the Members' Participation in Cooperatives in North Sumatera. So, for this study, since multiple independent variables were related to a dependent variable and the sample respondents that would be used as primary sources were homogeneous. The researcher employed Multiple Linear Regression to identify the factors affecting Members' Sales Volume in Multipurpose Agricultural Cooperative Societies.

According to Gujarati (2004), the model was specified as follows:

$$Y= \beta 0 + \beta 1\ X1i + \beta 2\ X2i + \beta 3\ X3i + \ldots + \beta nXni + \varepsilon i \quad (1)$$

Where:

Y - is the value of the dependent variable (in the case of this study members' sales volume);
β_0– the intercept that shows the average effect on Y if all variables are excluded from the model;
The parameters β_1, β_2 …β_n are the regression coefficients of parameters
i= the i^{th} observation

ε = the total error of prediction (residual)

X = independent variable
X_i= f (Age (Ag), Marital Status (MS), Educational Level (EL), Family Size (FS), Duration of Membership (DM), Household Land Size (LS), Number of oxen (NO), Price (P), Annual Income (AI), Agricultural inputs credit (AgIC), Production Capacity (PC)).

The dependent variable is members' sales volume which refers to the act of members engaging in the marketing activities of a multipurpose agricultural cooperative society through supplying outputs of agricultural products. This engagement in marketing activity is considered as members' participation. According to Dejane (2014), members' participation refers to the tendency of the members to actively associate in planning, executing monitoring and evaluating activities related to cooperatives. For this study, the researcher has measured sales volume participation based on the quintals of agricultural outputs members supplied to cooperatives which is continuous. The selected independent variable was sex (X1) – which is a dummy variable that takes a value of 1 for males and 2 for females. Members' participation may vary based on sex differences. In this study, it was assumed that male members have more exposure and access

to resources and information regarding the importance of active participation in multipurpose agricultural cooperatives than female members. Thus, the male member was taken as a reference variable and expected to participate more than female members, age (X2) - this is a continuous variable and defined as the number of years the member completed up to the time of the interview. So, it was assumed positively or negatively influences members' sales volume in cooperative, level of education (X3)-it is a continuous variable and refers to the number of years of formal schooling the member attended. Thus, in this study, it was expected that those who are literate and have at least some education were better able to participate in the cooperative, duration of membership (X4)– is a continuous variable that refers to years of experience/membership duration in cooperative by the member in cooperatives. Thus, longer or shorter duration of membership has been assumed to positively or negatively influence members' sales volume in cooperatives through, family size (X5). This is a continuous variable and it refers to the total number of members of families who are living together in one home. Therefore, family size has been assumed to positively or negatively influence members' sales volume in cooperatives, household land size (X6) - is a continuous variable that is one of the major and key assets for farmers and members of multipurpose agricultural cooperative societies everywhere. Thus, the decision made by any member to sell more is positively or negatively influenced by their land holding size, and the number of oxen owned by members (X7) - many of our country's farmers are cultivating their farmland by oxen. It is a continuous variable. For this study, it was expected that those who have more oxen were better able to sell in cooperatives, price (X8) – is a continuous variable that indicates the price of agricultural products at cooperatives and is to be compared with the market price. In this study, the price would be assumed to positively or negatively influence members' sales volume in a multipurpose agricultural cooperative society. The annual income of members (X9) - is a continuous variable and it would be deemed to positively or negatively influence the sales volume of members in a multipurpose agricultural cooperative society, transportation service (X10) – is a dummy variable that indicates the facilitation of transportation service by the cooperatives to distribute agricultural inputs for its members. The variable was assumed to positively influence the sales volume of members in the cooperative, access to combiner service (X11) – indicates that the members of the cooperative have a way to acquire combiner service. Hence, it was assumed that positively influences the participation of members in cooperative, distribution of agricultural inputs (X12)– is a dummy variable that shows the provision of improved seeds, fertilizer and herbicides by Cooperatives for its members on time. Hence, the variable was assumed to positively influence the sales volume of members in the cooperative, agricultural inputs credit service (X13)-This reveals the provision of agricultural inputs by the cooperative through arrangement for deferred payment for the price of inputs. It is a dummy variable that would be assumed to positively impact members' sales volume in cooperative, production capacity (X14)-this indicates the production capacity of the members in the production year. It is one of the continuous variables that would be hypothesized to affect members' sales volume positively.

Validity and reliability of the instrument

The ability of an instrument to measure consistently is what reliability is all about. One of the most significant dependability estimates is Cronbach's Alpha. It is a reliability coefficient that indicates how the item in a set is positively correlated to one another. It measures internal consistency (reliability) by determining the degree to which instrument items are homogeneous and reflect the same underlying construct(s) (Field, 2008). It detects whether the indicators of a construct, also known as variables have an acceptable fit on a

single factor. The test of the coefficient of a Cronbach α for the economic and demographic factor variables output indicates 0.714 and 0.70 respectively which shows both of them are reliable. Hence, the closer alpha values to 1, the higher the internal consistency. Whereas the furthest the value of alpha from 1 the lower internal consistency and stability among the answers of the respondents. As per the regulations' interpretation proposed by Scheepers et al. (2008), 0.7 indicates an acceptable level of internal reliability. If the value is lower than 0.5 the internal reliability is questionable and if the value is 0.8 or more the internal consistency is sound. As indicated in the above, it appears that the values of all the variables were above 0.7, which is in the range of very good. This implies that sample respondents of Multipurpose Agricultural Cooperative Societies answered the whole questions consistently.

Results and discussions

Before the result of data was estimated the necessary diagnostic tests were conducted. Accordingly, the model has no serious multi-multi-collinearity and no normality problem (Table 1 and 2 below respectively).

Table 1. Coefficients table of Multiple Linear Regression Analysis

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.616	.425		3.799	.000		
Age	.010	.084	.016	.122	.903	.429	2.330
Marital status	-.002	.045	-.004	-.042	.966	.846	1.182
Educational level	.43	.050	.063	.86	.0476**	.908	1.101
Family size	-.034	.020	.069	1.70	.000*	.564	1.773
Duration of membership	.051	.049	.112	1.040	.0352**	.488	2.051
Land size	-.030	.019	-.059	-1.57	.00546*	.742	1.348
Number of oxen	.001	.059	.001	.012	.990	.961	1.041
Price of cooperative	.056	.047	.007	.080	.00937*	.963	1.038
Annual income	-.042	.059	-.061	-.711	.478	.967	1.034
Agricultural inputs credit	-.19	.137	-.006	-1.386	.0946***	.953	1.049
Production capacity	-.067	.040	-.072	-1.675	.0402**	.957	1.045

a. Dependent Variable: Average amount of teff supplied to Cooperative in between 2020 – 2022/23 production years. *Significant at1%, ** significant at less than 5% and*** significant at less than 10% probability level respectively.
Source: Survey result, 2022/23

Table 2. Tests of Normality

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Age of respondent	.358	351	.000	.703	351	.000
Marital Status	.474	351	.000	.515	351	.000
Educational level of respondent	.286	351	.000	.805	351	.000
Family size of respondent	.386	351	.000	.670	351	.000
Duration of membership in cooperative	.242	351	.000	.842	351	.000
Land size owned by member	.282	351	.000	.854	351	.000
Number of oxen owed by member	.426	351	.000	.669	351	.000
Members' three Production years (2018/19/ and 2020) Annual Income from selling of crops and other products	.387	351	.000	.671	351	.000

a. Lilliefors Significance Correction,
Source: Survey Data Model Output, 2022/23 df = Sample Size

Demographic factors

As far as demographic factors are concerned, the output of descriptive statistics indicated in the study area, the majority of the members of the cooperative were male which accounted for 84 percent and the majority of members aged ≥ 46 years accounted for 52.26 percent. As the output of the multiple linear regressions model in Table 1 above indicated even though age and members sales volume have a positive relationship, it was insignificant. The majority of sample member respondents can read and write and as per the output of the multiple linear regression model depicted in Table 1 above, the educational level has a positive relationship with members' sales volume. The highest percentages of members of Multipurpose Agricultural Cooperative Societies in the study area were characterized by large number family size. Besides, the output of the multiple linear regression model in Table 1 above indicated family size and members' sales volume were inversely related. As per this study, members of cooperatives who had large families' supplies fewer quintals of their product to cooperatives due to they were feeding their families. The output of the multiple linear regression models in Table 1 revealed that the duration of membership and members' sales volume have a positive relationship.

Economic factors

Table 3. Land size owned by sample respondents

Land Size	Frequency	Percent	Mean	Std. deviation	Minimum	Maximum
< 1 Hector	70	20.0	2.2533	0.92095	0.25	8.00
1 - 3 Hectors	166	47.3				
3.5- 4 Hectors	71	20.0				
> 4 Hectors	44	12.7				
Total	351	100.0				

Source: Survey Result, 2022/23

Moreover, as economic factors, Table 3 shows that majority of the respondents that accounted for 47.3 percent had 1-3 hectors of land, and the minimum and maximum land size owned by member households were 0.25 hectors and 8 hectors respectively. Hereof, this indicated that members of cooperatives who had large land sizes supplied less quintals of their product to cooperatives because they were selling their products to merchants at their home. The result of the survey indicates the majority of the members sample respondents which accounts for 89.74 percent produce more teff than wheat and other crops (Survey Result, 2022/23).

Table 4. Consecutive three years members teff production (2020 – 2022/23)

Range of Production (Quitals)	2020		2021		2022/23	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
10 – 20	63	17.95	70	20.0	63	17.95
25 – 30	171	48.71	117	33.30	159	45.30
35 – 40	72	20.51	92	26.20	94	26.78
45 – 50	45	12.82	72	20.50	35	9.97
Total	351	100.0	351	100.0	351	100.0

Source: Survey Result, 2022/23

Table 4 shows in the past three consecutive production years (2020 – 2022/23); out of three hundred fifty one (351) sample member respondents, the majority of them which accounts for 48.7 percent, 33.3 percent of them and 45.3 percent produced 25 – 30 quintals of teff.

Table 5. Three consecutive Production years Members Sales Volume to Cooperatives

Range of Teff Sales Volume (Quitals)	2020		2021		2022/23	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
1 - 5	262	74.64	279	79.49	299	85.18
6 - 10	54	15.38	35	9.97	31	8.83
11 - 15	24	6.84	26	7.41	10	2.85
16 - 20	11	3.14	11	3.13	11	3.14
Total	351	100	351	100	351	100

Source: Survey Result, 2022/23

Table 6: Members sales volume to merchants in the past three production years

Range of Teff Sales Volume (Quitals)	2020		2021		202223	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
1 - 5	16	4.56	9	2.56	7	2.0
6 - 10	50	14.25	35	9.97	58	16.52
11 - 15	74	21.08	82	23.36	96	27.35
16 - 20	211	60.11	225	64.10	190	54.13
Total	351	100	351	100	351	100

Source: Survey Result, 2022/23

Table 5 shows that sample member respondents reported only 3.14 percent of them sold large quantities of teff (16 – 20 quintals) to cooperatives in the past three years (2020 – 2022/23). Table 6 indicates in the past three consecutive production years (2020 – 2022/23); out of the total sample respondents, a greater number of them which accounts for 60.11 percent, 64.10 percent and 54.13 percent sold many quintals (16 – 20 quintals) teff to merchants.

Table 7. Three consecutive years average price of cooperatives and market (2021-2022/23)

Price Ranges of Cooperative (ETB)	Respondents		Price Ranges of Market (ETB)	Respondents	
	Frequency	Percent		Frequency	Percent
2,800 - 3,000	168	47.86	3,000 - 3,200	103	29.34
3,200 -3,300	173	49.29	3,400 - 3,500	154	43.87
3,500 -3,600	10	2.85	3,600 - 3,800	94	26.78
Total	351	100	Total	351	100

Source: Survey Result, 2022/23

As Table 7 depicts merchants kept higher price advantages for suppliers than cooperatives. This study depicted that due to the prices of cooperatives being less than the market price cooperative members were not interested in supplying their products to cooperatives.

Table 8. Services areas of cooperatives to their members

Degree of Agreement	Services areas of Cooperatives to their members								
	Priority giving during agricultural input distribution			Giving Mechanization			Agricultural inputs provision		
	Freq.	%	Mean	Freq.	%	Mean	Freq.	%	Mean
SDA	196	56		152	43.3		318	90.6	
DA	155	44		115	32.76		33	9.4	
N	-	-		49	13.96		-		
Ag	-	-	1.44	35	9.97	1.9067	-		1.0933
SA	-	-		-	-		-		
Total	351	100		351	100		351	100	

Source: Survey Result, 2022/23 Note: SA= Strongly Disagree, DA= Disagree, N= Neutral, Ag= Agree, SA=Strongly Agree

Table 8 depicts that out of three hundred fifty one (351) sample cooperative member respondents, 56 percent and 44 percent of them strongly disagree and disagree with the statement that priority is given to members during agricultural inputs distribution respectively. This study indicated that cooperatives were not giving priority to members during agricultural inputs distribution. The above table shows that the average response of sample respondents was 1.9067 which is very much related to disagreeing responses in the context of this study with the statement cooperatives provide mechanization services for their members. This study depicted that the cooperatives did not provide mechanization services for their members. The same table reveals that the average responses of all sample respondents was 1.0933 which is very much related to strongly disagree responses with cooperatives providing agricultural inputs credit for its members. This indicates that cooperatives were not providing agricultural inputs credit for their members and agricultural inputs were directly sold to members and non-members of cooperatives on cash. Besides, the output of the multiple linear regression model in Table 1 shows there was an inverse relationship between agricultural inputs credit and members' sales volume. Finally, the output of the multiple linear regression model in Table 1 depicted that the production capacity of members and their sales volume have a

negative relationship. This indicates that those who had the capacity for production, supplied less quantity to cooperatives because they are selling their products to merchants at their homes.

Explanation of significant explanatory variables on dependent variable

The maximum likelihood estimation of the multiple linear regression model showed that education level, family size, duration of membership, household land size, price of cooperatives, agricultural inputs credit and production capacity were important factors affecting members' sales volume in Multipurpose Agricultural Cooperative Societies in the study areas.

Age: is one of among continuous variables that would be hypothesized to affect members' sales volume positively or negatively. The output of the multiple linear regression model in Table 1 shows that even though age and members' sales volume have a positive relationship, age was not significant.

Educational Level: is a continuous variable and refers to the number of years of formal schooling the member attended. Thus, for this study, it was assumed those who are literate and have at least some education were better able to participate in cooperatives. The output of the multiple linear regression model in Table 1 indicates that a positive relationship exists between the education level of members and their sales volume. This shows that a unit change in education level increases members' sales volume by unstandardized coefficients of beta at 0.43 quintals. This is statistically significant at a 5 percent probability level (P = 0.0476). This implies that members of the cooperatives who are literate supply their product to cooperatives more than illiterate members because they have more awareness than illiterate members.

Family size: is one of among continuous variables that would be hypothesized to affect members' sales volume positively or negatively. The output of the multiple linear regression model in Table 1 reveals that family size and members' sales volume have a negative relationship. This implies that a unit change in family size decreases sales volume by 0.034 quintal. This is statistically significant at a 1 percent probability level (P = 0.000). This indicates that those who had large family sizes supplied fewer quintals of their product to cooperatives because they were feeding their families.

Duration of membership: is a continuous variable that refers to years of experience as a member of a cooperative. Thus, longer or shorter duration of membership has been assumed to positively or negatively influence members' sales volume in cooperatives. The output of the multiple linear regression model in Table 1 reveals that the duration of membership and members' sales volume have a positive relationship. This implies that a unit change in duration of membership increases sales volume by 0.051 quintals. This is statistically significant at a 5 percent probability level (P = 0.0352). This indicates that those who had a longer duration of membership sold greater quintals of their product to cooperatives due to experience with the benefits of a greater supply of products to cooperatives.

Land size: is one of the continuous variables that would be hypothesized to affect members' sales volume positively or negatively. The output of the multiple linear regression model in Table 1 depicts land sizes and members' sales volume having an inverse relationship. This implies that a unit change in land size decreases sales volume by 0.030 quintals. This is statistically significant at a 1 percent probability level (P = 0.00546). This indicates that those who had large hectors of land supplied fewer quintals of their product to cooperatives because they are selling their products to merchants at their homes.

Number of oxen: is one of the continuous variables that would be hypothesized to affect members' sales volume positively. The output of the multiple linear regression model in Table 1 indicates even though a number of oxen owned and members' sales volume has a positive relationship, it is statistically not

significant due to its probability level (P = 0.990).

Price: is a continuous variable that indicates the price of agricultural products at cooperatives and to be compared with market price. In this study, the price would be assumed to positively or negatively influence members' sales volume in a multipurpose agricultural cooperative society. The output of the multiple linear regression model in Table 1 indicates price and members' sales volume have a positive relationship. This implies that a unit change in price increases sales volume by 0.056 quintals. This is statistically significant at less than 1 percent probability level (P = 0.00937). This indicated that when the price of cooperatives rose, members supplied to cooperatives. However; due to prices of cooperatives being less than the market price, cooperative members were not interested in supplying their products to cooperatives. The reason was cooperatives set prices on the meetings of committees whereas merchants' prices fluctuate depending on the market situations.

Annual income: is one among continuous variables that would be hypothesized to affect members' sales volume positively or negatively. The output of the multiple linear regression model in Table 1 shows that even though annual incomes and members' sales volume have a negative relationship, it is statistically not significant because of the probability level (P = 0.478).

Agricultural inputs credit is a dummy variable that would be assumed to positively impact members' sales volume in cooperatives. In contrast, the output of the multiple linear regression model in Table 1 shows there was an inverse relationship between agricultural inputs credit and members' sales volume. This implies that a unit change in agricultural inputs credit decreases sales volume by 0.009 quintals. This is statistically significant at a 10 percent probability level (P = 0.946). This implies that members of the cooperatives had no access to agricultural inputs credit or services from their cooperatives.

Production capacity: is one among continuous variables that would be hypothesized to affect members' sales volume positively. By contrast, the output of the multiple linear regression model in Table 1 depicts that production capacity and members' sales volume have an inverse relationship. This implies that a unit change in member production capacity decreases sales volume by 0.067 quintals. This is statistically significant at less than a 5 percent probability level (P = 0.402). This indicates that those who had production capacity /produced many quintals/ supplied less to cooperatives because they are selling their products to merchants at their homes.

Conclusions

The study was conducted on the impact of socio-economic factors on members' sales volume to cooperative societies in selected districts of Southwest Shewa Zone of Oromia National Regional State.

The result of this study indicated that the sales volume of members of Multipurpose Agricultural Cooperative Societies was significantly influenced by educational level, family size, duration of membership, household land size, agricultural inputs credit and production capacity.

Given the descriptive statistics (frequency, percentage, mean, Standard Deviation, minimum and maximum) and multiple linear regression analysis results for the purpose of enhancing members' sales volume in Multipurpose Agricultural Cooperative Societies, the following recommendations are made: it is recommended that as cooperatives conduct market assessment especially at the local market and they should not set purchase prices below market price, as well as they should try to follow the market price every time, it is important if the cooperatives give priority for the members, it is crucial if the cooperatives render agricultural inputs credit services for its members, it is suggested that the cooperatives should distribute dividend for the members every year after the audit was conducted, it is vital if the cooperatives perform awareness creation on those who have

a large family sizes to use family planning and for members who had a large land sizes regarding to advantages of selling their products to cooperatives.

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RESEARCH PAPER

Intensity of Chickpea Dry Root Rot [*Macrophomina phaseolina* (Tassi.) Goid] and Its Association with Biophysical Factors in Chickpea-producing Regions of Central Ethiopia

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Abstract

Chickpea (Cicer arietinum L.) is an important pulse crop in Ethiopia as well as worldwide. Due to the present shift in climate patterns, dry root rot (DRR) has become a threat to chickpea production. A field survey was conducted to assess the intensity and association of biophysical factors with chickpea DRR in three zones of central Ethiopia. A logistic regression model was used to evaluate the association between disease parameters and biophysical factors. A total of 165 chickpea fields were inspected in ten districts. DRR was prevalent in all ten districts. The incidence and severity of the disease were variable among the districts and with biophysical factors. The highest incidence was recorded in Liben (10.8%) and Ada'a (9.6%) districts. The highest severity was in Ambo (42.5%), whereas the lowest incidence (2.3%) and severity (18.3%) were in Sebeta Hawas. The incidence and severity were higher in Kabuli type and areas with altitudes ≤2100 meters above sea level (m.a.s.l). High DRR incidence (≥6%) showed a high probability of association with East Shewa, early sowing, low plant density, and Kabuli type. High severity (≥30%) was highly associated with altitudes ≤2100, early sowing, and Kabuli type. This study showed that DRR is an important disease in Ethiopia, necessitating the development of effective management strategies that could avoid heat and moisture stresses in the post-flowering stages of chickpeas.

Keywords: Biophysical factors, Central Ethiopia, chickpea, intensity, dry root rot

Introduction

Chickpea (*Cicer arietinum* L.) is an ancient cultivated pulse crop in the Leguminosae family. It is the third most crucial crop worldwide after dry beans and field peas (Nene *et al.,* 2012). Chickpea seed is a good source of proteins, carbohydrates, vitamins, and minerals (Gaur *et al*., 2012; Wallace *et al*., 2016). The crop has low lipid content and is an excellent source of nutritionally essential unsaturated fatty acids like linoleic and oleic acids (Rashid *et al*., 2020). In developing countries, chickpea is valued for its cheap protein source and for improving soil fertility by nitrogen fixation (Gaur *et al*., 2010). Chickpea is widely cultivated in over 50 countries on 14.8 million hectares (Mha) of land with 18.1 Metric tons (Mt) of grain production. India is the leading producer, accounting for 72.5% of area coverage and 74.8% of world chickpea production, followed by Pakistan with area coverage of 5.8% and Australia in terms of production volume of 5.9% (FAOSTAT (The Food and Agricultural Organization of the United Nations Statistical Database), 2022). With over 0.23 Mha (1.5% of the world) under cultivation, Ethiopia is the eighth largest producer in terms of area coverage and the third largest producer with a production of 0.49 Mt (2.7% of the world) (FAOSTAT, 2022).

Despite its nutritional and economic values, Ethiopia's average national chickpea yield remains far below its potential (5 tons per

hectare), which is attributed to several biotic and abiotic factors. Among biotic constraints threatening chickpea production in Ethiopia, 16 diseases were reported of which Fusarium wilt (*Fusarium oxysporum f.sp. ciceris*), dry root rot (*Macrophomina phaseolina*), Ascochyta blight *(Ascochyta rabiei*) and Chlorotic Stunt virus diseases (Abraham *et al*., 2006; Tadesse *et al*., 2017; Mengist *et al*., 2018; Ayana *et al*., 2019) are economically important. However, due to the present shift in climate patterns, chickpea DRR has emerged as the most serious constraint in Ethiopia. The disease is widely distributed in semi-arid chickpea growing areas with high temperatures and water-stressed conditions, causing substantial yield losses to the crop worldwide (Sharma and Pande, 2013; Rai *et al*., 2022). The average yield loss ranged from 5-50% and up to 100% losses in susceptible cultivars under favorable conditions (Pande *et al.,* 2012). In chickpeas, DRR causes significant yield loss by reducing plant population; that is, when roots of chickpea plants contract dry root rot, petioles, and leaflets droop and results in sudden complete drying during the flowering to maturity growth stage (Sharma *et al*., 2016).

In Ethiopia, chickpeas could be vulnerable to DRR disease because the crop is grown on residual moisture largely on vertisols which are characterized by fast cracking nature causing rapid moisture loss from the crop's root zone (Korbu *et al*., 2021). This farming system makes the crop face progressive depletion of reserve moisture at the critical chickpea growth stages, leading the system to experience terminal drought and heat stress (Mohammed *et al*., 2017). The dry and warm conditions would create a more favorable environment and further intensify the incidence and subsequent damage to the chickpea fields by soil-borne diseases including DRR, and such problems were common in the highland and semi-arid chickpea growing areas like our study areas, including Southwest, West, and East Shewa zones (Damte and Ojiewo, 2016; Mohammed *et al*., 2017; Yimer *et al.,* 2018).

Several attempts were made to design control strategies against chickpea DRR disease in many countries across the globe. Plant host resistance is the most economically and environmentally feasible approach, but its utilization has been restricted due to the absence of chickpea lines with high levels of resistance and genetically diverse pathogen populations (Pande *et al*., 2004; Sharma *et al*., 2012). Seed treatment and soil inoculation with strains of bio-agents are recommended as an alternative option for managing soil-borne pathogens including *M. phaseolina* (Rangeshwaran and Prasad, 2000; Patel *et al*., 2011). Systemic fungicide applications through seed dressing and soil application were also found effective for the control of DRR of chickpeas (Khan and Gangopadhyay, 2008; Manjunatha and Saifulla, 2021). However, the fungicide treatment may not provide the desired control due to the soil-borne nature and ability of the pathogen to persist in the soil in the form of sclerotia (Baird *et al.,* 2003). Moreover, the continuous evolution of the pathogen races and unpredictable features of environmental factors require frequent evaluation of cultural control strategies at each locality (Mengistu *et al*., 2009). Unfortunately, limited attempts were made to control chickpea DRR disease in Ethiopia, as the disease has been gaining importance recently due to climate change.

Thus, as the occurrence and extent of damage caused by the chickpea DRR disease are interlinked with additional heat and water stress abiotic factors (Sharma and Pande, 2013; Sinha *et al*., 2021), control strategies alone could not provide complete protection. That is, because of the continuous cultivation of chickpeas in major chickpea-growing areas of central Ethiopia and in connection with the current climate change scenario, DRR is a constant threat every year in the region. Therefore, designing a sustainable chickpea DRR management approach requires a primary understanding of the intensity and associated biophysical factors influencing epidemics of the disease.

So far, several disease survey studies on the distribution and biophysical factors influencing epidemics of chickpea soil-borne fungal diseases (wilt and root rot complex) have been carried out and reported together in different

chickpea-growing areas of Ethiopia (Damte and Ojiewo, 2016; Bekele *et al*., 2018; Yimer *et al.,* 2018). However, no separate attempts were made to understand the status of chickpea DRR and its influencing biophysical factors in central chickpea-producing areas of Ethiopia. In addition, quantitative information on the current status of chickpea DRR disease is lacking. Therefore, this survey study was conducted to determine the importance, intensity of chickpea DRR and its association with biophysical factors in major chickpea-producing regions of the central highlands of Ethiopia.

Materials and methods

Description of Survey Areas

A field survey for chickpea DRR was carried out in ten primary chickpea-producing districts within three administrative zones (East, West, and Southwest Shewa) of central Ethiopia (Figure 1). The agroecological features of the surveyed districts viz., Ada'a, Lume, and Liben are found in East Shewa; Becho, Illu, Kersana Malima, and Sebeta Hawas are found in Southwest Shewa; while Ejersa Lafo, Dendi, and Ambo districts are found in West Shewa zone, central Ethiopia. Geographically, the districts are located between 08o26' to 09o59' N and 037 o47' to 039 o10' E, and their elevations range from 1590 to 2445 meters above sea level (m.a.s.l). Southwest and West Shewa are found in Ethiopia's highlands and have relatively colder weather. In contrast, East Shewa is located on the Eastern escarpment of the country's central rift valley with a semi-arid climate. Based on meteorological data records in the last six years (2016-2021), each study district in the East, Southwest, and West Shewa zones received an average of 872.6, 1018.3, and 1053.8 mm annual rainfall, respectively.

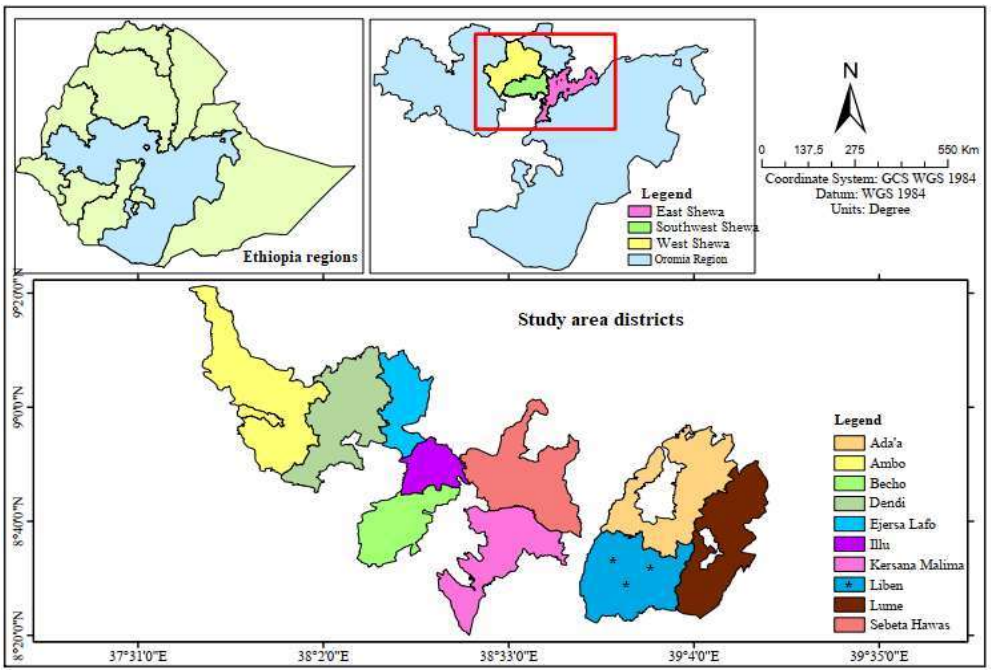

Figure 1. The geographical location of major chickpea-producing districts in central Ethiopia.

Survey procedures and sampling unit

The field survey was undertaken from the flowering to the physiological maturity growth stage of chickpeas from November to February for two years (2020-2021). In this study, a total of 165 chickpea fields (64 in 2020 and 101 in 2021) were assessed for the disease. Based on accessibility, 8-25 chickpea fields were randomly sampled in each district at 3-5 km intervals along the main and feeder roads. Three spots in each field (15-20 m apart) were inspected by making diagonal moves in a 'Z' pattern and a 1 m2 quadrant and the mean disease incidence of the three samples was calculated and utilized as one field.

Disease assessment

Based on the number of DRR infected and the total number of chickpea plants in each quadrant, the percent disease incidence was calculated using the following formula: Disease incidence (%) = Number of infected plants x100
Total no. of plants observed

In each sample quadrant, three infected chickpea plants with visible above-ground symptoms were randomly considered for assessing severity. Thus, the disease severity was estimated by up-rooting and evaluating the proportion of root volume infection on three chickpea plants in each sampled field. It was assessed using a 1-9 disease rating scale suggested by Nene *et al.,* (1981) and Sharma and Pande (2013). Where; 1 = No infection on roots; >1 and <3 = Very few small lesions (black discoloration) on roots; >3 and <5 = Lesions (black discoloration) on roots clear but less; new roots free from infection; >5 and <7 = Lesions (black discoloration) on roots more; many new roots generally free from lesions and >7 = Roots infected and completely discolored (black). Severity scores were converted to the Percent Severity Index (PSI) (Wheeler, 1969).

PSI= Sum of numerical ratings x 100 No. of plants scored x maximum score on the scale

Similarly, the same quadrant was used to assess the incidence of chickpea Fusarium wilt disease. The disease was distinguished by its symptoms like wilting and the death of the seedlings exhibiting dull green leaves and shrunken stems, usually visible in the pre-flowering stages of the crop (at seedling and vegetative) (Sharma *et al*., 2016). In addition, data on biophysical factors, including chickpea types, plant density, weeding practices, previous crops, altitude range, sowing dates, soil types, and crop growth stages were recorded to investigate the association of these factors with DRR disease parameters. Visual observation of the fields was made to classify the soil types into heavy black, intermediate, and light soils. Likewise, the collection of data on previous crops and sowing dates was carried out by questioning the growers. Moreover, root samples of diseased chickpea plants showing characteristics of DRR symptoms were collected from surveyed fields to isolate and identify the pathogen.

Data analysis

Survey data were summarized and analyzed using descriptive statistics to describe the spatiotemporal distribution and relative importance of chickpea DRR across the districts. Disease incidence and severity were classified into distinct class boundaries (Fininsa and Yuen, 2001; Yuen, 2006) to analyze the relationship between DRR and biophysical factors (Table 1). Based on the approximate similarity of the variables to the total assessed fields in each zone, class boundaries were chosen for disease incidence and severity data separately. Accordingly, class boundaries of ≥6 and <6% and ≥30 and <30% were selected for DRR incidence and severity, respectively. A contingency table of dependent (incidence and severity) and independent variables were constructed to represent the bivariate distribution of the fields (Table 1). The association of DRR with various biophysical factors was analyzed by the logistic regression model (Yuen, 2006) using the SAS procedure of GENMOD version 9.4 (SAS Institute Inc, 2017).

Table 1. Class boundaries used in the analysis of the association of biophysical factors with DRR incidence and severity in central Ethiopia (n=165

Variable	Variable class	No. of fields	DRR incidence		DRR severity	
			≥6	<6	≥30	<30
Zones	East Shewa	54	37	17	39	15
	Southwest Shewa	56	27	29	20	36
	West Shewa	55	21	34	24	31
Year	2020	64	36	28	23	41
	2021	101	49	52	60	41
Altitudes	≤2100	74	44	30	47	27
(m.a.s.l)	>2100	91	41	50	36	55
Soil type[a]	Heavy black	107	59	48	58	49
	Intermediate	49	23	26	21	28
	Light soil	9	3	6	4	5
Sowing dates	Late Aug to early Sept	22	14	8	16	6
	Mid-to-late Sept	78	49	29	43	35
	October	65	22	43	24	41
Density[b]	Low (<20 plants m^{-2})	30	21	9	19	11
	Normal (20-30 plants m^{-2})	79	39	40	37	42
	High (>30 plants m^{-2})	56	25	31	27	29
Growth stage[c]	Flowering	15	6	9	8	7
	Podding	90	48	42	41	49
	Maturity	60	31	29	34	26
Weed management[d]	Weeded	44	27	17	23	21
	Unweeded	121	58	63	60	61
Chickpea types	Kabuli	98	61	37	59	39
	Desi	67	24	43	24	43
Previous crop[e]	Teff	119	61	58	60	59
	Wheat/barley	33	17	16	16	17
	Legumes	5	2	3	1	4
	Other crops[f]	8	5	3	6	2

[a]The soil type is classified based on visual observation as heavy black when it is deep black clay or vertisols; light soil: soil with light red or brown color, and intermediate between the black and light soil.

[b]Crop density was determined from $1m^2$ as low (<20 plants m^{-2}), normal (20-30 plants m^{-2}) and high (>30 plants m^{-2})

[c]Growth stage refers to flowering when 50% of the plants in the quadrant show flowers, podding when 50% of the plants in the quadrant start pod formation; and maturity when the plants reach the physiological maturity stage.

[d]Weed management practices were recorded as weeded (fields free of any weed infestation) and non-weeded (presence of few to high weed infestation).

[e]Previous crop refers to a crop that grew before chickpea in the same field.

[f]Onion, tomato and cabbage.

The importance of the independent variables was evaluated twice in terms of their effect on disease incidence and severity. Firstly, the degrees of association of all the independent variables with the two disease parameters (incidence and PSI) were tested using a single-variable model. Secondly, the association of the independent variable with percent disease

incidence and PSI was tested, when entered first and last with all the other variables in the model. Selected independent variables that have a significant association with disease parameters were sequentially added to a reduced multiple-variable model (Yuen, 2006). Deviance reduction and odds ratios were calculated for each independent variable as it was added to the reduced model. The deviance, the logarithm of the ratio of two likelihoods was used to compare the single- and multiple-variable models. The difference between the likelihood ratio statistics (LRTs) was then used to examine the importance of the variable and tested against chi-square ($\chi 2$) values (McCullagh and Nelder, 1989).

Results

Characteristics of surveyed fields

Among the assessed farmers' chickpea fields, most were planted to the Kabuli type (59.4%), while 40.6% of the fields were planted to the Desi type. During the survey, five improved chickpeas, namely Arerti, Habru, Natoli, DZ 10-4, and Dubie were grown. Nearly 49.9% of the surveyed chickpea fields were sown at a recommended plant density (20-30 plants m-2), but 18.2% and 33.9% of the fields had low and high plant densities, respectively. The altitude of the surveyed chickpea fields was in a range of 1590 (Liben) to 2445 (Dendi) m.a.s.l.

Figure 1. Chickpea types, and above-and below-ground DRR symptoms: DRR-infected fields planted to Kabuli type in East Shewa (a and b); fields planted to Desi type in Southwest Shewa (c); Dry, straw-colored foliage and fallen leaves symptoms of DRR (d); and black discolored tap root devoid of lateral roots (e).

Chickpea sowing dates were variable across the surveyed districts and zones, starting from the end of August and extending up to mid-October. The survey was carried out throughout the three crop growth stages of chickpeas. Of which 9.1%, 54.5%, and 36.4% of the chickpea fields were found at flowering, podding and physiological maturity stages, respectively. Most surveyed fields had heavy black soil (64.8%), whereas 29.7% and 5.5% of the fields had intermediate and light soil types, respectively. About 26.7% of chickpea fields were weed-free, while the majority (73.3%) were infested with different levels of weeds. Burclover (*Medicago polymorpha*), Adeyabeba (*Bidens macroptera*), and Nutgrass (*Cyperus rotundus*) were the major weeds encountered during the survey. Farmers use hand weeding to control weeds.

In all districts surveyed, farmers plant chickpeas as the main crop (98.2%) and double-crop (1.8%) after-harvesting cereals. Moreover, most percentages of the surveyed

chickpea fields (92.1%) were sown in fields where cereal crops were previously grown, primarily teff followed by wheat and barley. Farmers exhaustively practice insecticides against stem borer (*Helicoverpa armiger*) in all fields assessed. Though almost all the chickpea fields visited were affected by DRR, farmers in the study areas were not using any management practices against this disease (Figures 2 a-e).

Dry root rot incidence and severity

DRR of chickpea was prevalent in all the surveyed districts of central Ethiopia. However, the incidence and severity recorded were variable across the districts (Table 2). The highest (10.8%) average incidence was recorded in Liben district, followed by Ada'a (9.6%), Ambo (8.9%), and Lume (8.2%). Contrarily, the lowest incidence was recorded in Sebeta Hawas (2.3%), followed by Ejersa Lafo (3.3%), Dendi (4.8%), and Becho (5.2%). Regarding DRR severity, the highest average severity (46.2%) was recorded in Ambo, followed by Kersena Malima (42.5%), Lume (42.2%), Ada'a (39.1%), and Liben (37.7%). In contrast, the lowest average DRR severity was recorded at Sebeta Hawas (18.3%), followed by Ejersa Lafo (23.3%) and Becho (24.2%).

Similarly, the incidence and severity of DRR varied among chickpea types and over the two cropping seasons when compared at the zonal level. East Shewa had the highest DRR incidence for the year 2020 (11.6%) followed by Southwest Shewa (5.7%) (Figure 3 a). Despite a slight decline in incidence, East Shewa (7.7%) recorded a higher incidence in 2021 than the West and Southwest Shewa. The disease severity recorded in 2021 exceeded the severity in the year 2020 in all three zones of central Ethiopia. In both years, the severity was higher in East Shewa than in West and Southwest Shewa zones (Figure 3 c). Concerning the disease status on chickpea types, higher incidence, and severity were recorded in Kabuli than on Desi type except for a slightly higher severity in West Shewa on Desi type (Figure 3 b and d).

Table 1. Prevalence, mean incidence and percent severity index of DRR and Fusarium wilt (FW) incidence in three major chickpea growing zones of central highlands of Ethiopia

Zones	Districts	DRR Preva	DRR incidence		DRR PSI		FW incidence	
			Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM
East Shewa	Ada'a	96	0-40.4	9.6±1.8	11.1-	39.1±2.7	0-35.3	9.9±1.8
	Lume	100	1.2-	8.2±0.9	13.6-	42.2±4.0	0-22.6	5.3±1.4
	Liben	100	2.9-	10.8±2.4	23.5-	37.7±2.6	0-15.1	7.2±2.1
Southwest Shewa	Becho	100	1-10.0	5.2±0.2	16-	24.2±2.0	0-10.6	4.0±0.7
	Ilu	100	1.8-	6.2±1.1	16.1-	26.1±6.9	0-25.3	7.8±1.0
	Kersana	93	0-13.7	6.9±1.1	11.1-	42.5±5.1	0-18	4.5±1.4
	Sebeta	50	0-6.1	2.3±0.9	11.1-	18.3±10.9	0-9.5	2.9±1.0
West Shewa	Ambo	100	5.1-	8.9±1.4	27.2-	46.2±2.6	1.5-	5.1±0.8
	Dendi	96	0-10.3	4.8±0.6	11.1-	29.1±4.2	0-14.4	4.8±0.7
	Ejersa Lafo	85	0-7.4	3.3±0.5	11.1-	23.3±1.9	1-14.7	5.8±0.8

Preva=prevalence; Mean±SEM=Mean and standard error of means; PSI=Percent Severity Index.

Chickpea fields located at altitudes ≤2100 m.a.s.l had higher average incidence (7.9%) and severity (36.9%) than fields located at altitudes >2100 m.a.s.l (Table 3). The highest mean incidence and severity were recorded from chickpeas sown on vertisols compared to chickpea fields sown on light and intermediate soil types. The highest average incidence (8.81%) and severity (39.0%) of DRR were recorded from fields sown from late August to early September. In contrast, the lowest incidence (4.79%) and severity (26.9%) were recorded from early October sown fields (Table 3).

Fields with lower plant density (less than 20 plants m^{-2}) had recorded the highest incidence and severity as compared to fields with recommended (20-30 plants m^{-2}) and high (>30 m^{-2}) plant density. Both average incidence and severity showed increasing trends through flowering to podding and physiological maturity growth stages of chickpea. Thus, DRR incidence was higher by 27% and 13.5% at physiological maturity than at flowering and podding stages, respectively. Similarly, severity was higher by 26.2% and 7.8% at the maturity stage than at the flowering and podding growth stages, respectively.

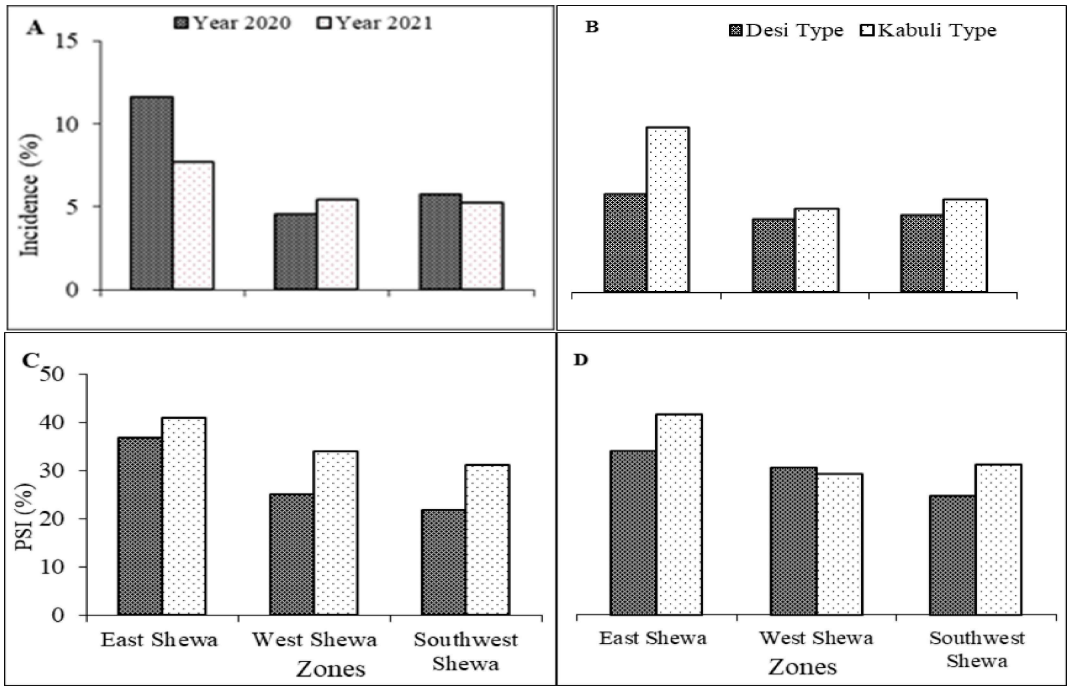

Figure 2. Incidence (a & b) and PSI (c & d) of DRR recorded on chickpea types and in the year 2020 and 2021 growing seasons from 165 fields surveyed in three zones of central Ethiopia

A higher average DRR incidence was observed in weed-free fields compared to weed-infested fields. Meanwhile, weed-free and infested fields recorded a relatively equal degree of severity. Concerning the reaction of chickpea types to DRR, the highest incidence (7.5%) and severity (35.2) were recorded when farmers sow their fields with the improved Kabuli type, while the lowest incidence (5.1%) and severity (29.1%) were exhibited from fields sown to local Desi type.

Table 2. Disease incidence and severity (Mean±SEM) of chickpea DRR for different independent variables in three zones of central Ethiopia during the 2020 and 2021 cropping season

Variables	Variable class	DRR incidence	DRR PSI
Zones	East Shewa	9.22±0.95	40.08±2.02
	Southwest Shewa	5.34±0.47	28.14±2.00
	West Shewa	5.00±0.47	30.08±1.79
Year	2020	7.38±0.82	27.86±1.37
	2021	5.94±0.42	35.76±1.66
Altitude (m.a.s.l)	≤2100	7.87±0.76	36.90±1.93
	>2100	5.38±0.38	29.27±1.37
Soil type	Heavy black	7.17±0.56	33.88±1.36
	Intermediate	5.40±0.54	30.16±2.24
	Light soil	4.45±1.48	32.37±8.00
Sowing date	Late Aug to early Sept	8.81±1.83	39.00±2.88
	Mid-to-late Sept	7.27±0.54	35.74±1.93
	October	4.79±0.46	26.90±1.35
Density	Low	9.35±1.44	33.05±2.25
	Normal	5.88±0.49	31.69±1.78
	High	5.83±0.56	33.93±2.11
Growth stage	Flowering	5.26±1.35	25.84±3.05
	Podding	6.23±0.46	32.29±1.61
	Maturity	7.20±0.83	35.01±2.00
Weed management	Weeded	8.26±1.08	32.01±1.91
	Unweeded	5.85±0.39	32.94±1.46
Chickpea types	Kabuli	7.49±0.60	35.17±1.58
	Desi	5.04±0.45	29.07±1.69
Previous crop	Teff	6.23±0.44	32.84±1.31
	Wheat/barley	7.07±1.06	32.70±3.14
	Legumes	5.46±3.78	21.98±5.56
	Other crops	8.27±2.52	31.19±6.21

Mean ± SEM=Mean±standard error of means

Isolation frequency of MP and associated diseases

In addition to DRR, FW of chickpea was prevalent in all surveyed districts of central Ethiopia (Table 2). The highest average incidence of FW was recorded at Lume (9.9%), whereas the lowest was at Sebeta Hawas (2.9%). In terms of individual fields, the maximum incidence of FW was recorded in the Ada'a (35.3%) district. *Macrophomina phaseolina* (MP) was the most frequently isolated pathogen from the root samples collected post-flowering, followed by *Fusarium oxysporium* (FOC) in East Shewa. FOC followed by MP were dominantly isolated in Southwest and West Shewa. On average, the highest percentage of FOC (49.7%) was isolated, followed by MP (35.6%), *Fusarium solani* (7.6%), *Rhizoctonia solani* (3.5%), and 3.6% unidentified (Figure 4).

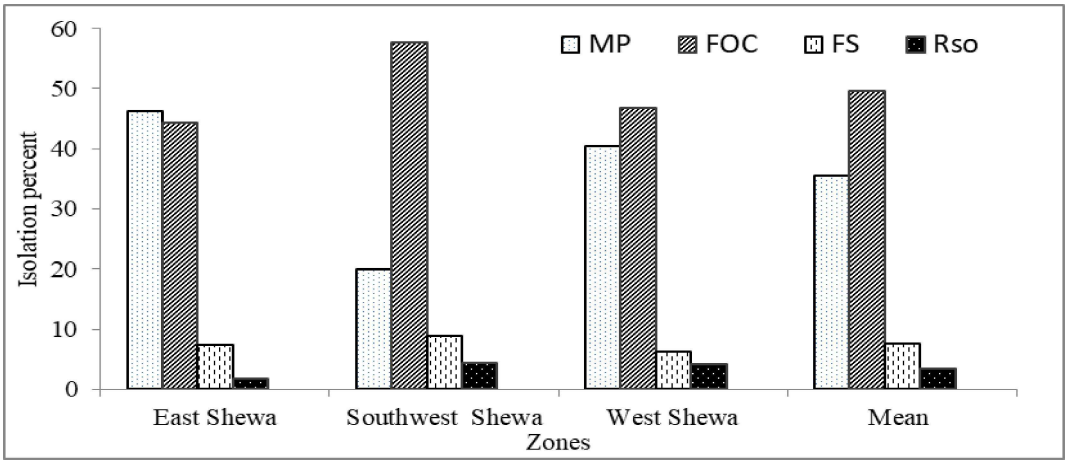

Figure 3. Percent isolation of fungi causing chickpea wilt-root rot complex from root samples collected in three zones of central Ethiopia. MP, *Macrophomina phaseolina*; FOC, *Fusarium oxysporium*; FS, *Fusarium solani* and Rso, *Rhizoctonia solani*

Association of DRR incidence and severity with biophysical factors

Associations of DRR disease parameters with biophysical factors were analyzed using a logistic regression model, and the results are shown in Table 4. The zones, sowing dates, and chickpea types were highly associated with the DRR incidence when entered first into a logistic regression model (Table 4). The zones, sowing date, and chickpea-type variables maintained their significance when entered last into the model. Meanwhile, plant density gained significance when entered into the model last by adding other variables. Zones (χ^2=10.6, 11.1), sowing date (χ^2=13.6, 9.7), and chickpea type (χ^2=11.2, 5.0) were the most significant variables associated with DRR incidence when entered first and last into the model.

Table 3. Logistic regression model of chickpea DRR incidence and percentage severity index in central Ethiopia and likelihood ratio test on independent variables in the two cropping seasons

Independent variable	DF	DRR incidence, LRT				DRR PSI, LRT			
		VEF		VEL		VEF		VEL	
		DR	Pr >χ^2	DR	Pr > χ^2	DR	Pr > χ^2	DR	Pr > χ^2
Zones	2	10.61	0.005	11.10	0.0039	16.57	0.0003	17.54	0.0002
Year	1	0.94	0.33	0.94	0.33	8.72	0.0031	5.43	0.02
Altitude	1	3.40	0.065	0.04	0.85	9.46	0.0021	2.15	0.1427
Soil type	2	2.18	0.34	2.33	0.31	1.87	0.39	1.14	0.5666
Sowing date	2	13.60	0.0011	9.70	0.0078	10.03	0.0066	3.36	0.1861
Plant density	2	5.44	0.066	13.73	0.001	2.54	0.28	0.24	0.3269
Growth stage	2	0.92	0.63	0.42	0.81	1.84	0.40	1.39	0.4988
Weed	1	2.35	0.13	0.13	0.71	0.09	0.76	0.20	0.6564
Chickpea type	1	11.25	0.0008	4.98	0.026	9.57	0.0021	4.50	0.0338
Previous crop	3	0.66	0.88	1.86	0.60	4.05	0.26	3.64	0.3033

DF=Degrees of freedom; DR=Deviance reduction; VEF=Variables entered first; VEL=Variables entered last; LRT=Likelihood ratio test; Pr=Probability of a value χ^2 exceeding the deviance reduction

A group of four independent variables: zones, sowing date, plant density, and chickpea type significance were tested in a reduced multiple-variable model. The parameter estimates

resulting from a reduced regression model and their standard error are shown in Table 5. A low DRR incidence (<6%) showed a high probability of association with the Southwest Shewa zone, Desi type, October sowing, and high plant density. Whereas high DRR incidence (≥6%) had a high probability of association with East Shewa, August to September sowing, low plant density, and Kabuli type. East Shewa, August to September sowing (early sowing), low plant density and Kabuli type had about 2.05, 3.16, 3.06, and 2.4 times DRR incidence than West Shewa zone, October sowing, high plant density, and Desi type, respectively. Year, altitude, soil types, growth stage, weed management, and previous crop did not show a significant association with DRR incidence.

Table 4. Analysis of deviance, odds ratio, and standard error of explanatory variables in the reduced model on mean percent DRR incidence in central Ethiopia

Added variables	RD	DF	LRT		Variables class	Estimate	SE	Odd ratio[c]
			DR	Pr > χ^2				
Intercept	87.58[a]	1				-1.88	0.50	0.15
Zones	76.97	2	10.61	0.0050	East Shewa	0.72	0.52	2.05
					Southwest Shewa	0.09	0.45	1.09
					West Shewa	0[R]		
Sowing date	69.75	2	7.23	0.0270	Late Aug to early Sept	1.11	0.65	3.16
					Mid-to-late Sept	1.2	0.42	3.32
					October	0[R]		
Plant density	60.85	2	8.89	0.0117	Low	1.12	0.56	3.06
					Normal	0.47	0.43	1.60
					High	0[R]		
Chickpea	55.29	1	5.56	0.0184	Kabuli	0.89	0.38	2.44
					Desi	0[R]		

RD=residual deviance; DF=Degrees of freedom; DR=Deviance reduction; LRT=Likelihood ratio test; Pr=Probability of χ^2 value exceeding the deviance reduction; R=reference group; a=Variables are added into the model in order of presentation in the table; Estimates are from the model with all independent variables added; SE=Standard error; c=Exponentiating the estimates.

With regard to severity, five variables, viz. year, zone, altitude, sowing date, and chickpea types had significant association with the DRR percent severity index when entered as a single variable into the model. However, altitude and sowing date lost their significance when entered last into the model along with other variables (Table 4). Zones (χ^2=16.57, 17.54) and chickpea types (χ^2=9.57, 4.50) were the most highly associated variables with PSI when entered first and last with other variables into the model. The variables showing significant association were tested in a reduced multiples variable model. The parameter estimates resulting from a reduced regression model and their standard error are shown in Table 6. The 2020 cropping year, Southwest Shewa zone, altitudes >2100 m.a.s.l, and Desi type reduced the DRR severity. On the other hand, high severity was highly associated with altitudes ≤2100 m.a.s.l, early sowing, and Kabuli type. The probability of occurrence of high severity (≥30%) was about 2.66 times at altitudes ≤2100 than at altitudes >2100 m.a.s.l, 2.18 times in early (late August to September) than October sowing, and 2.71 times in Kabuli type than Desi type. The biophysical factors such as soil type, plant density, growth stages, weed management, and previous crops grown did not show significant associations with DRR severity. Zones, sowing dates, and chickpea types significantly influenced DRR incidence and severity.

Table 5. Analysis of deviance, odds ratio, and standard error of explanatory variables in reduced model on mean DRR Percent Severity Index in central Ethiopia

Added variables	RD	DF	LRT		Variables class	Estimate	SE	Odd ratio[c]
			DR	Pr > χ^2				
Intercept	86.2993[a]					0.56	0.42	1.75
Zones	60.0378	2	17.54	0.0002	East Shewa	0.012	0.65	1.01
					Southwest Shewa	-1.16	0.55	0.31
					West Shewa	0^R		
Years	77.5783	1	8.72	0.0031	2020	-0.98	0.34	0.38
					2021	0^R		
Altitudes	57.8895	1	2.15	0.1427	≤2100	0.77	0.52	2.66
					>2100	0^R		
Sowing date	54.9243	2	2.97	0.2270	Late Aug to early	0.78	0.68	2.18
					Mid-to-late Sept	0.78	0.43	2.18
					October	0^R		
Chickpea	48.0453	1	6.88	0.0087	Kabuli	0.96	0.37	2.71
					Desi	0^R		

RD=residual deviance; DF=Degrees of freedom; DR=Deviance reduction; LRT=Likelihood ratio test; Pr=Probability of χ^2 value exceeding the deviance reduction; a=Variables are added into the model in order of presentation in the table; R=reference group; Estimates are from the model with all independent variables added; SE=Standard error; c=Exponentiation of the estimates.

Discussion

The current study revealed that zones and districts had variable DRR distribution. East Shewa had higher incidence and severity than the Southwest and West Shewa zones. Moreover, higher incidence and severity were recorded at Liben, Ada'a, Lume, and Ambo than in the remaining districts. Similar wide distributions of chickpea root rot diseases were previously documented by several authors (Damte and Ojiewo, 2016; Yimer *et al.*, 2018; Bekele *et al*., 2021). Previous studies showed that warm temperatures in a range of 30-35^{o}C and the presence of moisture-stressed conditions had a significant influence on the development of DRR disease (Sharma and Pande, 2013; Srinivas *et al*., 2017; Chilakala *et al*., 2022). In the surveyed areas of central Ethiopia, chickpeas were grown in the post-rainy season under progressive depleting moisture levels towards terminal growth stages with differing degrees of stress in each district (Desta *et al*., 2015). This condition, therefore, increased the chickpea's vulnerability and enhanced the pathogen's aggressiveness, resulting in increased incidence and severity of the disease in the surveyed districts. Similar findings of variable distribution of DRR on legume crops such as chickpea, common bean, pigeon pea, and cowpea were reported by many authors in several areas with prolonged dry periods and low rainfall (Maruti *et al*., 2017; Deepa *et al*., 2018; Lamini *et al.,* 2020).

Similarly, the incidence and severity of DRR varied with biophysical factors, and a significant association was found with chickpea type grown and sowing date. Most farmers (59.4%) in central Ethiopia were found to practice the Kabuli type mono-cropping system, and chickpea production is constrained by the high distribution and intensity of DRR as well as wilt disease. The Kabuli types being grown by farmers in Ethiopia are improved cultivars. However, the improvement program

did not yet target the development of DRR-resistant cultivars, although DRR is getting increasingly important in connection with the current climate change. Mono-cropping of chickpea crops was known to impose frequent disease occurrences through continuous buildup of inoculums (Deepa *et al*., 2018). According to the report by Sinha *et al.,* (2021), evaluation of the reaction of chickpea genotypes to DRR revealed that the genotypes became susceptible to the disease when tested under high temperatures and moisture stress conditions, irrespective of their levels of resistance. Meanwhile, Chiranjeevi *et al*., (2019) reported through a survey that variable DRR pressure was recorded at different locations regardless of cropping systems, chickpea types, and cultivars, corroborating this study's results. A recent evaluation of improved chickpea genotypes against moisture stress reported higher sensitivity of improved Kabuli than the Desi type (Korbu *et al*., 2021). This might have contributed to the high incidence and severity of DRR in the present study.

The comparison of chickpea sowing dates extending from the end of August to mid-October revealed a significant association with DRR. Farmers in the study area widely practice chickpea sowing dates to utilize residual moisture at the end of the main rainy season. Thus, early sowing (end of August to early September) predisposes chickpea to wet, collar, and black root rot disease complexes, which can be aggravated by wet soil conditions (Nene *et al*., 1981; Tarafdar *et al*., 2018; Yimer *et al*., 2018). In contrast, the late sowing practice made to escape the earlier biotic stress exposes chickpea to acute terminal drought consequences, which could result in substantial yield losses to the crop (Mohammed *et al*., 2017; Korbu *et al*., 2020). Conversely, early sowing followed by a sudden drop in soil moisture status could enhance DRR infection and cause immediate associated damage to the crop.

The probability of association of low and normal plant population to high (≥6%) incidence was about 3.1 and 1.6 times higher than high plant population. The high plant population in crop fields is important to maintain changes in microclimate within the crop canopy (Elad and Pertot, 2014). Conversely, open areas in fields with low crop stands are vulnerable to soil moisture loss due to evaporation from the soil surface, which would result in warm and decreased moisture levels around the crop root zone. Likewise, a low plant density may provide a space for weed growth that would impair crop vigor by competing for available resources. As a result, a weaker crop plant is likely to be more susceptible to soil-borne diseases. Furthermore, Fuhlbohm *et al*., (2012) reported that MP isolates were recovered from several symptomless weed species and verified that weeds may act as an alternate host or a source of inoculum. Similar roles of weeds in the epidemic development of chickpea Fusarium wilt were reported by Hawere and Nene, (1982). The increased incidence of DRR under low plant populations may be related to either the decrease in moisture levels via evaporation from sparse surfaces or the impact of weeds on disease development.

The probability of association of lower (≤2100 m.a.s.l.) altitudes with high DRR severity (≥30%) was 2.66 times higher than high (>2100 m.a.s.l) altitudes. The low altitude areas are characterized by relatively high temperatures and erratic rainfall patterns than the reverse class that were responsible for the occurrences of several diseases on chickpea. With regards to DRR, high altitude areas with wet soils under extended rainfall negatively impact the survival of sclerotia (Olaya and Abawi, 1996). On the other hand, low altitude semi-arid areas exhibiting frequent stresses (high temperature and moisture stress) are conducive to excessive sclerotia production that could account for increased incidence and severity of the disease (Soni *et al*., 2022). These suggest that the mid-altitude areas (1500-2100 m.a.s.l) with warm climates and erratic rainfall were more favorable for developing DRR epidemics.

High incidence and severity of DRR were obtained in chickpeas grown on vertisols than intermediate and light soil types, though a non-significant association was observed in a logistic regression model. In contrast, Mallaiah

and Krishna Rao, (2016) and Partap and Godara, (2022) assessed the intensity of DRR on different soil types and obtained that increased incidence and severity of DRR in sandy loam than clay soils. The high incidence and severity of the DRR disease recorded could be explained by the fact that sandy soils have better aeration and less water-retention capacity than clay soils, which creates an environment favorable to MP activity. On the other hand, as vertisols or clay soils are well-suited to providing residual moisture following the end of the rainy season, farmers in central Ethiopia have been using them for the cultivation of chickpeas year after year (Korbu *et al.,* 2020; Allito and Geda, 2021). This continuous cultivation of chickpeas together with other environmental and management factors might have contributed to the high intensity of DRR on vertisols. Similar reports of high wilt and root rot pressure on vertisols than light soils in major chickpea-growing areas of Ethiopia were previously reported by Yimer *et al*., (2018) and Bekele *et al*., (2021).

The survey data analyzed using logistic regression revealed that biophysical factors influence the incidence and severity of DRR epidemics when evaluated singly and in combination. The results identified biophysical factors, namely, zones, plant density, sowing dates, altitude, and chickpea types as important variables influencing DRR epidemics. The regression model quantified the relative importance of biophysical factors favoring DRR epidemics. The analysis revealed that the East Shewa, early sowing, low plant density, and Kabuli type were associated with DRR incidence. In contrast, early sowing, lower altitude, and Kabuli type were associated with severity and significantly contributed to the disease epidemics. Yimer *et al*., (2018) reported that the incidence and severity of soil-borne fungal diseases of chickpea (wilt and root rots) were influenced by cultural practices and genotypes.

The present study revealed that DRR disease is widely distributed and a major problem in major chickpea-growing areas of the central highlands of Ethiopia. Under the threat of climate change, the distribution and intensity of DRR disease are expected to increase rapidly in many areas. The result of this study suggests the importance of utilizing appropriate cultural and climate change-resilient agronomic practices that create unfavorable conditions for disease development. Furthermore, the evaluation of chickpea genotypes and breeding for resistance to DRR should be a prior agenda for chickpea researchers to manage the disease effectively.

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Data availability

The authors confirm that the data supporting the findings of this study are available within the article and/or its supplementary material.

Conflict of interest

No potential conflict of interest was reported by the authors.

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RESEARCH PAPER

The Effect of the Student Team Achievement Division (STAD) Learning Method on the Students' Reading Comprehension and Attitude: Fresh Man Students of Oromia Police College in Focus

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Abstract

The student team achievement division (STAD) cooperative learning method allows learners to work together toward common learning goals rather than individual learning. Accordingly, the purpose of this study was to investigate the effect of the STAD learning method on EFL Oromia Police College first-year students' reading comprehension in the academic year 2023-2024. Two groups took part in the study: the control group (N = 20) and the experimental group (N = 21). Students in the experimental group participated in the STAD cooperative learning method for 12 days, whereas the students in the control group were taught by the usual method, which is mostly whole-class teacher-centered and later divided into the traditional group work method. After administering the pretest and posttest of reading comprehension, the independent sample t-test was used to test the research hypothesis. Thus, a reading comprehension posttest was given from the content taught at the end of the instruction to gather data to ascertain whether there was a substantial difference in the student's achievement or not. To determine whether there was a significant difference in student's posttest at alpha 0.05 levels, independent and paired samples t-tests were used. The finding of this study showed that there is a significant difference between the control and experimental groups, which is reported as t (8.025), P =.000 <0.05. Finally, the students who participated in the STAD method had a positive attitude toward the use of STAD in improving reading performance. Therefore, the student team achievement division (STAD) learning method had a positive effect on the student's reading comprehension.

Keywords: Effect, student team achievement division, cooperative learning, reading comprehension

Introduction

Cooperative learning is an educational strategy that aims to integrate social and academic learning into classroom activities Mulugeta (2021). Thus, from this, it is understandable that cooperative learning is one of the teaching methods which require teachers to divide students into small groups to practice group work and student-centered teaching (Wondwosen, 2016).

Jamaludin and Mokhtar's 2018 study highlights the Student Team Achievement Division (STAD) as a cooperative learning method that involves small groups working together to achieve common goals. Zeleke (2015) emphasizes cooperative learning in language learning, with Almuslimi (2016) and Farzaneh (2014) found positive attitudes towards it among students. Overall, cooperative strategies are generally viewed positively in teaching and learning contexts. As a result, STAD is one of the important and helpful cooperative learning strategies for students because it directly instructs them by establishing ways for them to work together, or because it helps students by fostering the conditions required for the

successful completion of tasks, especially when it comes to reading comprehension (Naibaho and Sangga, 2019). Amin (2012) states that cooperative learning based on STAD is good to progress reading comprehension of learners because it is a good cooperative in which students paired each other. This indicates that STAD teaching method is essential to improve students' reading comprehension (Sunarti, 2012).

Good teaching and learning need to be able to draw more students' attention, serve different groups of students, and emphasis more on skill practice, thinking process and situational management (Tiantong and Teemuangsai, 2013). Regarding this, Sanfo and Malgoubri (2021) conducted research on teaching quality and students' EFL achievement in the Ethiopian context; and their findings disclosed that student support related to students' EFL achievements but mainly for high achievers. In contrast, Sanfo and Malgoubri revealed that even if student support is very important in improving the students' EFL achievements, there might be hidden mechanisms or classroom-specific circumstances that exist that need to be addressed for all students to profit from the support of teachers. They further add that teacher perceptions of students might lead them to build up high expectations for high achievers and offer the most or the best of the quality of support to them. In such circumstances, low achievers are left behind and will likely not profit from the support of the teacher.

Thus, to avoid this, the teaching method that helps the learners to share knowledge with each other is very important. To confirm this, it has been stated that student-team achievement division (STAD) is a method of teaching that is helpful for the students in improving their reading skills and to comprehend material easily because they can share knowledge with friends (Damanik and Handayani, 2023). Reading habit plays a great role in education for reading prepares individuals to be victorious in all areas of life and every aspect of education and is considered a primary asset for academic performance and it is an ongoing intellectual process (Balan *et al*., 2019).

Although reading plays a great role in education and even if Ethiopian higher institutions students have learned English starting from Elementary schools, many of the higher institutions' students are not good at reading comprehension. For instance, the researcher observed that the Oromia Police College students would prefer to remain silent when they are asked to express what they understood from what they read. In similar to this, a descriptive study that was conducted by Belilew (2015) on the relationship between reading strategy use and reading comprehension among Ethiopian EFL learners, revealed that Ethiopian students' reading comprehension is below what is expected of them. That means they are not as well as they should be. They are below the level they are expected to do in reading comprehension. Thus, it is understandable that what makes Oromia Police College students be observed when they prefer to remain silent to express what they comprehend from the reading passage may be because they are poor in their reading comprehension.

So, it was clear that it is necessary to look for important teaching methods to improve the learners' reading comprehension and attitude. There are several international studies conducted on the effectiveness of STAD as an active teaching method in terms of its effects on students' academic performance, language skills and their attitude towards the use of STAD outside of Ethiopia.

Students' attitude toward reading skills can also affect their reading performance. For instance, Xiao (2023) argues that students with a positive attitude are more likely to be motivated to read and engage with the text. This increased engagement leads to better focus and comprehension. However, students with a negative attitude may avoid reading or approach it half-heartedly, resulting in poor engagement and comprehension. For example, Glomo-Narzoles and Glomo-Palermo (2020) found that STAD is one great strategy that fosters good interaction, enhances positive attitudes toward English, and improves the academic performance of students. The study also confirmed that Students exposed to STAD

have enhanced academic performance in English. Saragih (2017) conducted on the effect of student team achievement division on students' reading comprehension. The study showed that there is an effect of the student team achievement division method on reading comprehension. Barokah (2020) researched the effectiveness of the student team achievement division method toward students' motivation in reading comprehension. The study concluded that the student team achievement division strategy can improve students' reading comprehension. Syafiq and Rahmawati (2017) investigated the effect of students' team achievement division in teaching reading comprehension. The findings of the study indicated that students developed their reading performance in the classroom. Yanti and Helmi (2023) conducted the implementation of the STAD to improve students' reading skills. The study revealed that students improved their reading comprehension through the STAD technique.

The findings of these studies all agree that the student team achievement division (STAD) strategy is effective in improving students' reading comprehension. Depending on this evidence, this teaching method is one of the teaching methods that are greatly concerned and valued in other parts of our world and needs to be included in EFL teaching methods in Ethiopia as well. However, in Ethiopia, there is no available research that has been conducted on the effect of the student team achievement division (STAD) teaching method as far as the researcher knows from his searching and reading apart from some related research that has been conducted on the issues of cooperative learning.

For example, Anwar (2017) conducted research on perceptions and practices of cooperative learning in preparatory schools of East Hararge Zone in the Oromia regional state. The result of the study showed that the perception of both teachers and students towards the benefits of cooperative learning was neutral. It was neither positive nor negative. Regarding the practice of CL, the study indicated that: students, teachers and principals were sometimes performing their roles. Birknesh (2010) conducted research on the practice and challenges of implementing the cooperative language learning method. The study by Belsti (2020) revealed poor practicality and uneven implementation of cooperative learning in English classes. Teachers did not provide equal opportunities for student reflection, with only a few active students presenting their points. Traditional teaching methods, student disinterest, and large class sizes contributed to this issue. Zeleke and Taye (2019) conducted research on the practices, challenges and opportunities of cooperative learning at Hawassa University. The findings of the study revealed that the instructors do not practice the techniques of cooperative learning. Instead, they adopted a mixed approach where both cooperative learning and lecture style co-exist in lessons and that prevented them from using cooperative learning for the whole class. For this reason, teachers face challenges in effectively implementing cooperative learning and they rush to content coverage because they misunderstand cooperative learning. On the other hand, teachers faced challenges of students' reluctance to participate in group work.

Dagninet (2021) carried out research on the perception of preparatory schoolteachers and students towards cooperative learning in English Classrooms. The findings of the study revealed that the majority of teachers and students in the study had a high level of perception principle. Although the participant teachers and students had a positive perception towards cooperative learning, the study shows that they failed to implement it in their actual classrooms. However, none of these studies have tried to see the student team achievement division (STAD) teaching strategy technique. Yet in Ethiopia, hardly any single research has been done on STAD teaching strategy and its effects on students' reading comprehension even though there are lots of empirical studies that have been done on it outside Ethiopia. As a result, the empirical studies that have been done on STAD teaching methods outside of Ethiopia advocate the researcher to conduct the study depending on the problems students have regarding reading comprehension and the existence of the research gap in this area.

Accordingly, the researcher is initiated to conduct experimental research to find out if the STAD teaching strategy improves the Oromia Police College EFL learners' reading comprehension.

Hypotheses of the Study

H1= There is a significant difference between the students who participated in the student team achievement division (STAD) teaching technique and those who did not participate.

H0= There is no significant difference between the students who participated in the student team achievement division (STAD) teaching technique and those who did not participate.

Research Question

The study answered the Following Question

1. What is the difference between students who were taught reading comprehension using the STAD cooperative learning method and those who were taught using the conventional method in terms of their mean achievement scores?

2. What is the students' Attitude towards the Student Team Achievement Division (STAD) Teaching Method?

Theoretical Framework

Constructivism theory pays great attention to the fundamental roles of the original experience, psychological structure, and beliefs in constructing knowledge (Huang, 2016). Thus, constructivism suggests that learners need to be proactive in how they learn, taking new information and shaping it to their understanding, rather than just sitting still and passively absorbing information like a sponge. It embraces a "top-down" rather than a "bottom-up" instructional methodology. This means that, rather than teaching all of the details that lead to a main idea, students find out the main idea and then derive the details. It is suggested that constructivism is a theory of learning in which cooperative learning is an important element (Aljohani, 2017; Ramsook, 2018).

Student Team Achievement Division (STAD) was developed by Robert Slavin and his colleagues at John Hopkins University. In the implementation of the STAD, students are divided into small groups to work together to fulfill their learning objectives. By using STAD it is expected that the students can be more effective in the process of learning by working as a team than learning alone because they can share information about the subject (Prasetiyo, 2021). So, by incorporating the constructivism theory into the STAD cooperative learning method students could construct knowledge by themselves from their experience, and what they share in collaboration with other students. Accordingly, the student team achievement division (STAD) is one of the cooperative learning systems in which the students share their knowledge with each other also the STAD is one of the major variables for this study and as a result, constructivism theory was one of the theoretical frameworks that dictate the present study.

The theory of constructivism looks at the way a learner learns. It, therefore, has direct application to education. Thus, constructivists believe that the learner learns best when he/she is actively engaged. The student is observed as one who acts on objects and events within his or her environment and in the process, gains understanding and derives the meaning of those objects and events. The theory suggests that humans build knowledge and meaning from their experiences (Nikou *et al*., 2014).

Materials and methods

Research Design

This study used the quasi-experimental pretest and posttest design. Quasi-experimental designs test causal hypotheses. In quasi-experimental research, a treatment, an intervention, or an experimental factor is used. The objective of quasi-experiments is practical. Finding linkages and causal links based on correlations between the phenomena themselves is the goal of quasi-experiments. When a teacher adopts a new method in the classroom, it is a quasi-experimental method rather than an experimental one (Osmanović and Maksimović, 2022). Accordingly, the present study hypothesized that using the STAD cooperative learning method intervention causes the Oromia Police College freshman students to improve their reading comprehension. Hence, the main objective of this study was to examine the effect of STAD (student team achievement division) on reading comprehension, the pre-test and post-test were designed both for the control and experimental group.

Participants of the Study

The participants of the study were first-year undergraduate students of Generic Degree in Crime Prevention and students of Management Degree officers at Oromia Police College in the 2023/24 academic year. On the other hand, the undergraduate students of Management Degree officers and Generic Degree in Crime Prevention were chosen for this study. The participants of the study were decided by drawing lots. The students were randomly assigned to the experimental and control groups. The undergraduate students of Management Degree officers and Generic Degree in Crime Prevention were chosen as experimental and control groups, respectively. The experimental group students were treated by the STAD cooperative learning technique whereas the control group students were not treated. Five participants of the experimental group of students were selected for the interview purposely. Then the participants were assessed individually on their attitudes towards the STAD method.

Two sections of the first-year degree program students were selected as samples of the study at Oromia Police College. In these two sections, the students were required to have two groups for the study, which means the experimental group and the controlled group. The selection of the two groups was done randomly using the lottery method. The allocation of the groups as a treatment or as a controlled group was also made in a similar way to randomization.

The number of students for the experimental and control groups are 21 and 20 respectively. Then after the allocation of the groups either as a treatment or as a controlled group, the treatment group was divided into small groups that had five members within the group depending on the pretest result. The pretest was used to get the high, average and low achievers within the experimental group based on their scores of the pre-test to have the behavior of heterogeneousness and the best combination of diverse abilities within their respective groups.

Sampling Technique

Data Gathering Instrument

Reading comprehension test was prepared by the researcher based on the objectives formulated in the syllabus of the course Communicative English Skills. The test was administered to students of both groups before and after learning the course through two different methods. The pre-test had two purposes. The first purpose was to form two comparable groups for the control and experimental work. The second purpose was to see both group students' reading comprehension before the intervention and to see later improvements. That means the post-test was conducted after the program in the same way as the pre-test to find out the improvements that the students of both

groups would make in their reading comprehension. On the other hand, to comprehend the experimental group students' attitude towards student team achievement division (STAD), semi-structured interviews were utilized. The students who participated in the interview were coded as S1, S2, S3, S4 and S5 instead of using their names in data analyses.

Reliability was calculated for the reading comprehension test by using test-rest reliability. In addition to this, the validity of reading comprehension tests and interviews was checked by advisors and experts in the field of EFL.

Methods of Data Analysis

The data was quantitative for the objective of the study was to see the effect of students' team achievement division on the student's reading comprehension. Therefore, the data analysis requires computation of the numerical data obtained from the pre-test and post-test results to know the mean score differences of the subjects before and after the experimental treatment.

The students' test scores were analyzed and interpreted by using the independent samples t-test. Accordingly, the independent sample t-test was used to make a comparison of reading comprehension between the two independent samples before and after the treatment. Thus, to serve this purpose, the independent t-test was used making use of the Statistical Package for Social Sciences (SPSS) version 22 to calculate the data analysis of reading comprehension. For further analysis, it was necessary to study the attitudes of students toward the student team achievement division (STAD) learning technique. Thus, at the end of the treatment, the learners in the experimental group were asked to complete a questionnaire about their attitudes towards student team achievement division (STAD) learning technique when studying reading comprehension. The data collected through interviews was analyzed qualitatively.

Findings of the Study

The effects of the STAD teaching strategy on the students' reading comprehension involved pre-tests to find out the students' current status and post-tests to evaluate the effectiveness of the method in causing the required improvement. Accordingly, an independent t-test was implemented to compare the students' pre-test and post-test. The analysis was calculated by the hypothesis of the research. Thus, the t-test was used to examine whether there was a significant difference between the mean scores of the control and experimental groups on the reading comprehension tests. The level of significance was 0.05. The results of this research also pointed out that the greater part of the experimental group of students had a positive attitude towards the student team achievement division (STAD) learning method.

Reliability of reading comprehension test

Table 1. Reliability of reading comprehension test

		First score on reading comprehension test	Second time reading comprehension test
First score on reading comprehension test	Pearson correlation	1	0.899
	Sig. (2 tailed)		0.000
Second time reading comprehension test	Pearson correlation	0.899	1
	Sig. (2 tailed)	0.000	

The linear association or correlation between the reading comprehension test results from the first and second attempts was seen using Pearson correlation or simple linear correlation. Strong test-retest reliabilities were demonstrated by the reading comprehension test-retest. The overall test-retest Pearson correlation coefficient over a five-week period was r=.899, p=.001, as indicated in Table 5 above. This indicates a high degree of correlation between the first and second-time trials. Positive one (+1) to negative one (-1) is the range of the Pearson correlation. According to Groves et al. (2004), a positive correlation of (+1) denotes a perfect positive correlation, while a negative correlation denotes a negative correlation. Similarly, according to Bryman and Cramer (2005), a correlation value of +1.00 denotes a complete positive connection.

Table 2. A comparison of the Students' Reading Comprehension of both the Experimental and Control Groups

Tests	Group	No	Mean	SD	Df	t–value	Sig.(2-tailed)	Remark
Pretest	Experimental	21	49.00	2.145	39	0.359	0.722	Not significant
	Control	20	49.50	5.996				
Posttest	Experimental	21	80.29	8.736	39	8.025	0.000	Significant
	Control	20	62.45	4.850				

The level of significance is at P < .05

There was no significant difference in pre-test results between the experimental group (M= 49.00, SD = 2.145 and the control group (M = 49.50, SD = 5.996) at the results; t (0.359), P = 0.722 > 0.05. On the other hand, there was a significant difference in the post-test results between the experimental group (M = 80.29, SD = 8.736) and control group (M =62.45, SD = 4.850) at the results; t (8.025), P = .000 <0.05. So, the results suggest that there is a group difference for the post-test whereas not for the pre-test.

Accordingly, when the students' mean scores of the pre-test and post of both the control and experimental groups were compared, it was found that the students of the experimental group increased their mean scores from 49.00 to 80.29 by 31.29. So, this result indicates that there was a significant improvement in the reading comprehension of the experimental

group students over the control group in the post-test. Therefore, the study's hypothesis "student team achievement division (STAD) teaching method has a significant effect on students' reading comprehension" is accepted. Students were introduced to teamwork through the STAD cooperative learning method. They were also introduced to individual accountability and competition. So, it is understandable that the high reading comprehension performance has been caused by individual responsibility, competition and teamwork factors.

Analyses of interview

Research question number two was answered by the data collected through the interview. Five students from the experimental group took part in the interview. The data collected through the interview indicated that the students enjoyed and engaged in the STAD method. They reported that they improved their reading comprehension after participating in 12 days of training and practice of reading comprehension. They also said that they increased their motivation in reading skills and reading comprehension in particular. They also improved their social skills. The students appreciated the opportunity to work collaboratively, which helped develop their social and communication skills. As a result, they improved their grades in other subjects. This shows that they developed transferable skills. Finally, they also developed confidence since the STAD method helped them to reduce anxiety about learning and assessment.

Discussions

The main objective of this study was to ascertain how the STAD teaching method affects the reading comprehension and attitudes of first-year EFL students at Oromia Police College in the academic year 2023–2024. For the investigation, a quasi-experimental design was adopted. The data was collected using the reading comprehension tests with all experimental and control group students and interviews with five selected students from the experimental group. Reading comprehension tests and interviews were utilized to gather data. The researcher's observations of the student's weak reading comprehension abilities from his prior experience prompted the researcher to start the study. As a result, a randomized pre-post-test control group research design was put into practice, with 21 and 20 experimental and control classes respectively. The experimental group received instruction for 12 days using the STAD cooperative learning method, while the control group received instruction as a usual method which is mostly whole class teacher-centered and later divided into the traditional group work method. In order to collect information and determine whether there had been a significant change in the student's performance in this area, a post-test on reading comprehension was administered using the material covered in the lesson. To determine whether there was a significant difference in students' post-test at alpha 0.05 levels, an independent t-test was used to analyze quantitative data and interview results were analyzed qualitatively. There was no significant difference in pre-test results between the experimental group and the control group, which is reported as t (0.359), $P = 0.722 > 0.05$. However, there was a significant difference in the post-test results between the experimental group and control, which is reported as t (8.025), $P = .000 < 0.05$. So, the results suggest that there is a group difference for the post-test whereas not for the pre-test. The study also indicated that the students had a positive attitude toward the use of the STAD method. These findings were found because of the active learning methods used during the STAD training. In addition to this, materials were prepared to train the experimental group of students.

The result indicated that the STAD method positively affected the learners' reading comprehension and the experimental group students had a positive attitude towards the STAD as an active teaching method. The result of this study agrees with the study findings of other researchers that the STAD cooperative learning method enhances learners' reading comprehension achievement. Specifically, the

finding of Adi et al. (2023) revealed that the STAD cooperative learning method has a significant effect on the learners' reading comprehension achievement among the experimental and control groups. Julianti *et al.* (2022) and Siti and Isnaniah (2023) study findings also showed that STAD cooperative learning methods improve students' reading comprehension. Julianti and his colleagues' study was conducted in elementary school which focused on grade eight students and the current was conducted on college students. Therefore, further study may examine whether there is a different effect of STAD cooperative learning techniques for different grade levels.

To sum up, the results of the current study indicated that the experimental group students progressed more than the control group students and the STAD cooperative learning technique is a helpful learning method in teaching reading skills of English as a foreign language. So, the finding of the study exposed that STAD cooperative learning is more helpful in teaching reading skills than the conventional learning method.

Even though the conventional teaching method which has been implemented in the Oromia Police College also helps the learners improve their reading comprehension, the STAD cooperative learning technique contributed to students' success more in their reading comprehension. While the classroom teacher-centered and sometimes the traditional group work (i.e. group work outside of the class after the keynote address class) method has been used at Oromia Police College in education, teachers had no guidance as the STAD cooperative learning method is the most effective in teaching reading comprehension skill and how to implement it in the classroom. From this viewpoint, this study contributed to the foreign language teaching of reading comprehension and recommended that EFL teachers implement STAD cooperative learning techniques to enhance their students' reading comprehension improvement.

Conclusions

The purpose of this study was to investigate how the STAD teaching method affects the reading comprehension and attitudes of first-year EFL students at Oromia Police College in the academic year 2023–2024. For the investigation, a quasi-experimental design was adopted. The data was collected using the reading comprehension tests with all experimental and control group students and interviews with five selected students from the experimental group. Reading comprehension tests and interviews were utilized to gather data. The Student Team Achievement Division (STAD) learning method is a cooperative learning strategy that can significantly enhance students' reading comprehension and attitudes toward reading skills. The findings of this study showed that STAD enhanced freshman students' reading comprehension. The experimental group students progressed more in reading comprehension than the control group students. The STAD as a form of cooperative learning technique is a helpful learning method for teaching reading skills of English as a foreign language. In addition to this, the students who participated in the STAD improved their attitude toward reading skills. The interview results indicated that the students in the experimental group increased their engagement and interest in reading skills. So, the finding of the study exposed that STAD as cooperative learning is more helpful in teaching reading skills than the conventional learning method.

Recommendation

This study found The STAD learning method is effective in improving student's reading comprehension. Therefore, EFL teachers should use the STAD method to enhance the student's reading comprehension.

The study also found that the use of STAD as a form of cooperative learning enhanced student's attitude toward reading skills. Therefore, EFL teachers should create a positive environment where students can increase students' interest in reading, making it a more enjoyable experience.

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RESEARCH PAPER

Analysis of Health Science Students` Academic English Language Needs: The Case of Samara University

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Abstract

The objective of this study was to investigate the English language needs of health science students at Samara University. The study is significant because it looks into the English language skills that health science students require for academic success. This would help determine the type of English language instruction that health science students will require in their academic fields of study. Hence, 131 students from the Health Science College in the academic year 2021/2022 were chosen using a stratified sampling technique, along with, two English language course instructors and, six subject area instructors from Samara University, Ethiopia. To attain this purpose, a mixed-methods research approach was used. The data for this study were collected using a questionnaire, interviews and observations. The quantitative data was analyzed quantitatively by using descriptive statistics, mean and percentage via SPSS 25 version computer software, whereas qualitative data analysis was carried out using descriptive and theme-based procedures and was qualitatively interpreted. The coding and analysis were carried out using the NVivo version 10 computer software. This study found out why each English language skill is used in the health science academic field of study. The findings also showed that during their internship program, health science students prioritize Basic English language skills, specifically writing and speaking. Therefore, it is recommended that for health science students, English language courses should be designed throughout the undergraduate program taking into account students' academic field of study.

Keywords: Academic needs; health science; necessities; need analysis; wants

Background

In most parts of the world, English language instruction at higher education institutions receives more priority. For example, Reinders et al. (2019) argue that English is conceptualized as a lingua franca (ELF), i.e., the language used for communication among people who do not share the same mother tongue(s), as opposed to ELT or EFL approaches, which aim to develop students' language ability with native speakers of English (NESs) as the unquestioned model for successful global communication. In recent years, teaching EFL at universities across China has been increasingly influenced by the desire and need to innovate and attempt to cover general English teaching and ESP, including EAP and intercultural communication, for students at three recognized levels (primary, intermediate, and advanced) (Reinders *et al*., 2017). According to Reinders et al. (2019), English was most likely chosen as the lingua franca (ELF) for Japanese for two reasons. The first reason is that the centralization of all faculties' ELT programs required the university to develop a type of English that could be useful to every student

(for example, the College of Agriculture provided English for science and the College of Business focused on business English), and many students were expected to work as professionals in international society after graduation. The second is that including the most recent theory of English language use might distinguish the university's curriculum.

Fortanet-Gomez and Raisanen (2008) state that students coming into higher education are assumed to have prior knowledge of the language. They emphasized that now most of the English taught at universities in Europe is English for specific purposes (ESP). Basturkmen (2010) points out that the needs analysis process can answer questions of when, where, and why language learners need their target language. Hutchinson and Waters (1987) suggest that any language course should be designed based on learner needs. Setting up an Undergraduate Medical English course program that takes into account the learner's aims and social demands, as well as organizing speaking and writing module hours and teaching material (Li, 2015). As Basturkmen (2010) indicates, most European universities, including American and English universities, deliver English for specific purposes.

Health care is a situation in which the success of the activities in every procedure is greatly influenced by the exchange of information(Orr, 1998). Healthcare professionals need good communication skills, reflective and practical skills, and an understanding of the ethical and social dimensions of healthcare practice (Basturkmen, 2010). McCorry and Mason (2011) point out that students preparing for careers in health care must be strong communicators; they must not only master the science and clinical skills necessary to provide quality patient care. Paltridge and Starfield (2013) indicate that language plays a significant role in most professions but is more significant in medicine than any other field because it is where effective communication is widely recognized as important to clinical outcomes. Students learn English not only to improve their language skills but also to get specialized skills that will allow them to perform the language in their major subject area of study(Masyhud, 2018). English is certainly necessary for medical students to learn and advance in their jobs (Wahyuni, 2021).

However, in all Ethiopian universities, two English language skills courses, locally called "communicative English language skills I" and "communicative English language skills II," are given in the first year as common courses. In Ethiopia, where English is taught as a foreign language, health science, and medical students take only common courses, most likely general English, in their first year. Hence, it might be difficult to satisfy health science or medical students' specific language and communication needs according to the language needs of their field of study. Though it is difficult to deliver ESP courses in each college or department in Ethiopia, the demands of the language in the health science field of study need to be considered.

In general, the common point among the above researchers and scholars is that in higher education institutions, English language courses should be designed to address learners' fields of study and professional needs. However, in the case of English language courses in use in Ethiopia's universities, they might be designed without considering the students' needs, as they are used for all students in all fields of study.

Statement of the problem

Ethiopian higher education institutions, like others across the world, have student diversity in terms of ethnicity, language (mother tongue), socioeconomic status, educational background, fields of study, aptitude, motivation, and other factors. Thus, because English is used as a language of instruction at the tertiary level, it is crucial to the success of students studying a variety of disciplines at Ethiopian higher education institutions. Beyond educational goals, the role of language is becoming increasingly significant in professional settings, particularly in the health science sector. In this context, as mentioned earlier, English language teaching at the tertiary level seeks special attention in Ethiopian higher education

institutions. However, communicative English language skills courses are taught as a common course in all higher education institutions. At Samara University, for example, all first-year students in any discipline attend similar communicative English skills courses throughout the first year of a four- or five-year program as common courses. The courses were designed in 2019 and 2020 respectively by the Ministry of Education (MoE). There are two courses: Communicative English Skills I (FLEn 1011) and Communicative English Skills II (FLEn 1012). Both include five units; however, the second module includes three extra supplementary reading resources. The first module is taught in the first semester and the second in the second semester. The first communicative English skills course is required before proceeding to the second.

Basturkmen (2006) points out that ESP has functioned to help language learners cope with the features of language or to develop the competencies needed to function in a discipline, profession, or workplace. An ESP program is thus based on an assessment of the goals, demands, and functions for which English is required (Hans and Hans, 2015).

However, in light of students' English language needs as mentioned by the above scholars and researchers and the researcher's experience, the communicative English courses in use cannot meet the needs of the health science students as they do not enable the learners to function in their academic fields of study. The researcher confirmed that no English language courses have been designed to address medical or health science students' English language needs in higher education institutions in Ethiopia.
However, the researcher has not come across local studies conducted at the PhD level in the Ethiopian context, with the exception of recent Ph.D. theses conducted by Silesh and Tamene (2022), who investigated the importance of academic language in Ethiopia. This study focuses on the needs analysis of English for Academic purposes for university students in all fields of study, but the current study focuses on the English language academic needs of health science students to help develop appropriate courses. Several MA theses have been conducted on the problem area, including Yigzaw (1990) conducted a study to identify the communicative needs of high schools in Addis Abeba in terms of language skills and language activities, and discovered that language skills and language activities are the most common communicative needs of high schools. He stated that his research was only a partial effort to develop a course.

Seid (2007) conducted research to identify the English language needs of freshman diploma students in the police force. His study found that Cadets have high English language needs in the three domains (skills, activities and micro skills). He suggested emphasizing the type of English that Cadets should learn in order to advance their careers. Elias (2007) investigated the target and learning needs of electricity students at Dilla TVET College with the goal of developing criteria for designing an appropriate English course. Desta (2008) investigated the English language needs of fine art students at Mekelle College of Teacher Education (MCTE). Zerihun (2008) also sought to investigate the English language needs of construction TVET trainees with particular reference to Entoto TVET College. These four studies were conducted on Student' English language needs and recommended ESP for the field they studied, but studies were not about health science students' English language needs.

Teka *et al.* (2015) investigated English for university students in Ethiopia, focusing on the implications of a needs analysis at Haramaya University. The study did not specify the fields of study. Mola (2015) also studied the need for ESP among adult English language learners at Sandford International School Adults' Evening EFL classes. His primary goal in conducting the research was to determine why adult students at Sandford International School drop out of their EFL courses. Both studies recommend ESP for higher education, but they did not specify the fields of study.

Tufaro Bunkure (2009) investigated the English language needs of third-year students at Shashamane Health Science College. His main objective was to identify more important

language skills for third-year students in order to succeed academically, in their future careers, and in their personal and social lives. This study differs from the current study in that it focuses on identifying more important language skills, whereas the current study focuses on English language needs that help health science students function in academic settings, with the goal of designing appropriate course materials. Gessese (2009) also conducted research on identifying students' language needs at private medical colleges in Bahir Dar. His main objective was to identify the language needs of medical students in Bahir Dar town in relation to ESP principles, existing textbooks, teacher opinions, executive bodies of the Bureau of Education, and medical colleges. However, the study did not consider the target situation needs.

As a result, none of these studies had the focus of the current investigation. The current study, on the other hand, investigate the English language needs of health science students in academic fields of study in order to develop relevant course material. As a result, this study sought to answer what Health science college students needs to function effectively in English as a means of learning their university academic studies. Then, the findings obtained from this study could help to design appropriate course materials that match the student's English language needs in the academic field of study. On the other hand, the current study investigates the academic English language needs of health science students to properly build course content. As a result, the goal of this study was to answer two key research questions:

1. Why are each of the English language skills used in the health science field of study?

2. What English language do health science students want to learn in their academic fields?

Materials and methods

Research design

The study employed a sequential explanatory mixed methods design to achieve the intended objectives. Plano Clark and Creswell (2015) point out that the best-mixed method design is a sequential explanatory design in which quantitative results are obtained in the first phase to provide a general picture of the research problem, and then these findings are refined or elaborated through an in-depth qualitative investigation in the second phase.

The participants

The study was conducted at Samara University, located in Afar National Regional State, Ethiopia, 590 km from the capital Addis Ababa. There was a total of 199 target health science college students. From a total population of 199, the required sample size for the study with 5% margin of error and 95% confidence level was 131 students so as to get a representative sample of the students from each department in the college. As a result, 131 students from the College of Health Science were chosen and included in this study. Specifically, 43 participants were chosen from 66 fourth-year students and 88 from 133 second-year students. The determination of sample size participants was made according to a scientific sample size calculation of Kothari (2004). Kothari (2004) states that stratified sampling techniques are generally applied to obtain a representative sample if the population from which a sample is to be drawn does not constitute a homogenous group. The researcher used this sampling method because there was homogeneity within the department and heterogeneity among the departments. Systematic random sampling was applied to obtain respondents from each section and was included in filling out the questionnaire.

However, for the interview, 18 students were systematically selected. Dornyei (2007) suggests that a sample size of 6-10 people is appropriate for qualitative research. As a result, 18 students (6 from each department) from the College of Health Sciences were selected for the interview using a simple random sampling technique. However, due to data saturation, the

researchers only interviewed twelve students. According to Plano Clark and Creswell (2015), "saturation" occurs when researchers believe they are no longer obtaining new information from new informants and are instead repeating what previous informants have already revealed. Dornyei (2007) also points out that saturation is the point when researchers have all the data needed to answer the research questions and become 'empirically' confident. Two English language course instructors,

This study also employed two English course instructors as well as six instructors of major subject area courses. Two English instructors who were teaching English language courses to health science students were purposefully selected. Similarly, there were eight main major area course instructors. The interview and observations were purposefully conducted with six instructors who were teaching the major subject area courses during this study. Subject area course instructors were included in this study believing that they could provide necessary data regarding the English language needed for their students in their academic studies because instructors have experienced students' difficulties performing tasks and activities in English language. The researchers believed that subject area instructors can provide necessary data regarding the English language needed for their students from their experiences in teaching subject area courses.

Data collection and processing

Quantitative instruments (questionnaire) and qualitative instruments (observation and interview) were used to collect the necessary data required for this study.

The questionnaire sought students' opinions to assess their target needs and learning needs. The data obtained from the questionnaire gave a general picture of the research problems, which were later refined or elaborated through an in-depth qualitative exploration. The questions were on the Likert scale, which required respondents to rate frequencies on a scale ranging from never needed to always need, numbered (1-5), and on the Likert scale, which required respondents to rate their agreement or disagreement on a scale ranging from strongly disagree to strongly agree, numbered (1-5). The questionnaire was adapted from commonly used needs analysis models (e.g., Basturkmen, 2010; Dudley-Evans and St. John, 1998; Hutchinson and Waters, 1987) and earlier empirical studies (e.g., Abdullah, 2005; Alfehaid, 2011; Abuklaish, 2014, Chatsungnoen, 2015; Farhat, 2012; Fortanet-Gomeze and Raisanen, 2008; Long, 2005; Richards, 2001). Furthermore, the questionnaire was tested for validity in a pilot study.

Observation was the first qualitative data collection instrument used in this study. The rationale for using it was to directly observe what, how, and why the English language was used in health science subject area courses depending on the general picture of the results obtained by quantitative data and results.

The interview was another qualitative data-gathering instrument used in this study. It was also used to confirm the data collected through observation. The type of interview used was a semi-structured interview.

Data Collection Procedures

For ethical issues, the researcher discussed this with the concerned university's administrators and university staff and asked for their willingness. The university's academic president expressed his willingness to assist the researcher with the data collected from their college.

The researcher went to Dubti General Hospital with a letter written by the university. Then, he discussed the concern with the chief executive director of the hospital. The director expressed his willingness and wrote a letter of consent to the chief clinical director. The clinical director informed the inpatient director. The inpatient director also told other case managers to cooperate in conducting the study. The researchers obtained the following information with permission after obtaining ethical clearance and receiving informed verbal consent from the participants.

First, the questionnaire was administered. The student participants were given some instructions regarding the purpose of the study, and they were requested to respond to all the questions genuinely. They were also told that they could ask any question they wanted about any ambiguity. All 131 students completed and returned the questionnaire.

After analyzing the quantitative data, the qualitative data were shaped based on the results. From the qualitative data, observations were conducted first. The observations preceded the interview for two main reasons. Firstly, the researcher thought that if the interviews were conducted first, the instructors might modify themselves after getting the clues from the interview. The second was that the researcher wanted to add probing questions to the semi-structured interview for new behaviors observed.

Then, the interviews were conducted with a health professional after the observation was completed. Then, major subject area courses' instructors were interviewed. The next section describes the method of analysis regarding both data collection instruments.

Data analysis

In the first phase, the quantitative data (questionnaires) were collected and analyzed. Then, the qualitative data were shaped to obtain in-depth information regarding health science students' English language needs. A sequential explanatory mixed methods design is a plan used by a researcher to collect and analyze quantitative data in the first phase and obtain quantitative results which helps to plan the second phase and then collect and analyze qualitative data in the second phase to help explain or elaborates on the quantitative results (Creswell, 2014; Plano Clark and Creswell, 2015). Then, the data were collected and analyzed accordingly.

Students' responses to questionnaires were analyzed quantitatively by using SPSS 25 computer software to determine the individual responses for each of the items in the questionnaire. Using the SPSS 25 computer software, data were analyzed using descriptive statistics (mean, standard deviation and percentage). The findings from the quantitative data were discussed with the findings from the qualitative data vis-à-vis the research questions. The qualitative data were analyzed using the following procedure: First, the audio-recorded interviews and the observations were transcribed. Then, the transcripts were coded and grouped thematically. Analyses were made based on the thematic category. In the present study, computer assisted qualitative data analysis softer (CAQDA) NVivo version 10 was used. This software assisted the researchers in coding the interview and transcription of the audio-recorded classroom observations in the form of free and tree nodes. The free node can be coded in parallel with the open (initial) node, whereas the tree node is coded in axial order. NVivo version 10 was used to supplement open coding procedures, with the primary goal of creating models and visualizing data presentation in this study.

The data from the three instruments were then triangulated in order to support or validate one another. The sample quotes were also chosen and presented in the subsequent results and discussion section.

In order to maintain anonymity, the findings were analysed without revealing the names of the participants. Their names were changed to codes; for example, instructor one (Inst 1), instructor two (Inst 2), student one (S1), student two (S2), etc., and for clinical practitioners who taught internship students in hospital wards, doctor one (Dr.1), doctor two (Dr. 2), and etc. In this study, we made a rigorous effort to carefully define the research questions and conduct a methodical review of the literature in accordance with the study's purpose to ensure data dependability. Similarly, to ensure the study's possible transferability, the researchers attempted to provide information about the study's participants as well as the research setting.

Results

This section includes the findings and relevant discussion. The presentation was created in response to the research questions. The quantitative results were given first in tables, followed by the qualitative results, which were then analyzed utilizing sample extracts from the data. As a result, the section that follows explains why each of the English language skills is required when performing activities in the target situation of health science, as well as what English language and skills health science students need for their academic careers.

Students' Experiences of Why are each of the English language skill used in the health science field of study

In part one of the questionnaires, respondents were asked to rate the frequency of each type of English language skill needed to do activities in their academic field of study.

Reading Skills in the Academic Field of Study

Items Q1A-Q1H were designed to find out the types of reading activities frequently needed in the health sciences field of study. Hence, health science students were assigned to indicate how often they needed reading activities in their field of study. Table 1 below shows their responses.

Table 1. Health science students' experiences regarding reading activities is frequently needed in their field of study

No.	Activities	Frequencies in %					mean	SD
		NN	RN	SN	ON	AN		
Q1A	Reading textbooks	0	13.3	60.0	17.8	8.9	3	.795
Q1B	Reading course handout	0	6.7	8.9	35.6	48.9	4.27	.89
Q1C	Reading instructions for Assignments	0	6.7	13.3	24.4	55.6	4.29	.9
Q1D	Reading study notes	0	6.7	20.0	35.6	37.8	4.04	.93
Q1E	Reading instructions for labs	2.2	4.4	17.8	28.9	46.7	4.13	1.01
Q1F	Reading test and exam questions	2.2	6.7	0	20.0	71.1	4.51	.97
Q1G	Reading newspapers and magazines	2.2	17.8	11.1	24.4	44.4	3.91	1.22
Q1H	Reading manual guide	2..2	11.1	13.3	35.6	37.8	3.96	1.09
	Total						4.01	

Note: NN=never needed, RN= rarely needed, SN= sometimes needed, ON= often needed, AN= always needed, SD= standard deviation

As shown in the table above, the majority of health science students seemed to believe that they frequently needed reading test and exam questions, reading instruction for assignments, reading course hand out, and reading instruction for labs respectively. As the responses to item Q1F above indicates 71.1% always needed reading test and exam questions and 20% of them often needed them with a mean of 4.51. The next reading they frequently needed in English was item Q1C 48.9% and 35.65% of them were always needed and often needed consequently with the mean of 4.29. Items Q1B and Q1E are also frequently needed with a mean of 4.27 and 4.13 respectively. Hence, it can be concluded that the types of reading that were often needed in the health science field of study were reading tests and

exam questions, reading instructions for assignments, reading course handouts, and reading instructions for labs, respectively.

Writing Skills in Health Science Academic Field of Study

In items Q1J-Q1Q in the following table, students were asked to rate the types of writing for which health science students always needed to do activities in English in their field of study. This could assist the researcher in identifying the writing-related activities that are always required for the health science field of study.

Table 2. Health science students' experiences regarding writing skills frequently needed in English in their field of study

No.	Activities	Frequencies in %					Mean	SD
		NN	RN	SN	ON	AN		
Q1J	writing notes from lecture notes	0	6.7	13.3	20.0	60.0	4.33	.95
Q1K	writing a note from the course books	0	2.3	29.5	25.0	43.2	4.09	.91
Q1L	Writing project reports/term papers	0	4.4	11.1	24.4	60.0	4.40	.86
Q1M	Writing lab/field reports	0	15.6	17.8	20.0	46.7	3.98	1.12
Q1N	Writing summaries	4.4	8.9	35.6	28.9	22.2	3.56	1.08
Q1O	Writing personal letters	33.3	31.1	11.1	2.2	22.2	2.49	1.53
Q1P	writing business letters or job application letters	11.1	31.1	26.7	13.3	17.8	2.96	1.28
Q1Q	Writing paragraphs or essays on a variety of issues	2.2	11.1	33.3	37.8	15.6	3.53	.97
Q1R	Writing research papers	0	8.9	13.3	22.2	55.6	4.24	1.00

In the table 2 above, the respondents were asked to indicate information concerning the type of activities they always needed, they often needed, they sometimes needed, and they rarely needed or never needed in English in doing activities throughout their educational study in the health science field. Accordingly, an equal number of respondents, 60% of them indicated that they always needed to write project reports/term papers and write notes from lecture notes while 24% and 20% of them often needed and no students rated under never needed. On item Q1R, 56.6% indicated that they always needed to write a research paper and 22.2% indicated they often needed, 13.3% sometimes needed, 8.9% rarely needed and no student indicated never needed. The next always-needed writing activity was writing a note from the course book, which is rated by 43.2% as always needed, 25.0% often needed, 29.5 sometimes needed, 2.3% as rarely needed, and no students rated for never needed. On the other hand, writing personal letters, writing business letters or job applications, and writing summaries were rarely or never needed.

As a result of the information in the table above, writing skills in English were always required in the health science field to write project reports, term papers, lecture notes, and research papers. Personal letters, business letters, job applications, and summaries, on the other hand, were not frequently required by students.

Speaking Skills in Health Science Academic Field of Study

In items Q1T-Q1Z in the following table, students were asked to rate the speaking activities that they need in their learning of the health science field of study to improve their English language speaking skills. This could help a researcher identify the speaking skills that are necessary for health science fields of study.

Table 3. Health science students' experiences regarding speaking skills frequently needed in English in their health science field of study

Activities	Frequencies in %						
	NN	RN	SN	ON	AN	Mean	SD
Q1T) Asking and answering a question in class	0	8.9	48.9	24.4	17.8	3.51	.9
Q1U) Participating in class discussion	0	6.7	42.2	28.9	22.2	3.67	.91
Q1V) Giving a presentation	0	6.7	13.3	22.2	57.8	4.31	.93
Q1W) Introducing yourself and others in different situations	0	26.7	33.3	20.0	20.0	3.33	1.09
Q1X) Stating opinions or ideas on a variety of topics in the class	0	31.1	15.6	33.3	20.0	3.42	1.14
Q1Y) Requesting to obtain different information	4.4	22.2	42.2	17.8	13.3	3.13	1.06
Q1Z) Making a telephone call	64.4	4.4	11.1	15.6	4.4	1.91	1.35

Table 3 above reveals that the speaking skills activities frequently needed in English in the health science field when giving a presentation (mean= 4.1), Participating in Class discussion (mean= 3.67), and Asking and answering questions in class(mean= 3.5), whereas stating opinions or ideas in a variety of topics(mean=3.42),introducing oneself and others in different situations (mean=3.33) and making a request to obtain different information(mean= 3.13) were sometimes needed, but did not need making a telephone call in English(mean=1.35). Thus, from these data, it can be concluded that the speaking skills in English needed in the health science field were always needed to give presentations, participate in class discussions, and ask and answer questions in class.

Listening Skills Needed in Health Science Academic Field of Study

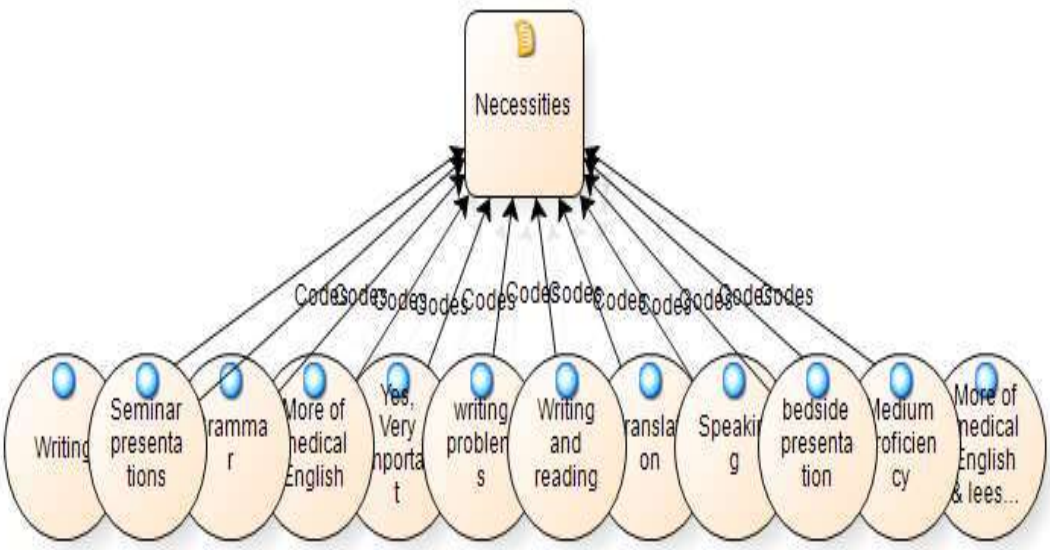
In items Q1Z2–Q1Z5 in the following table, the students were asked to rate the listening activities that health science students needed in their learning of the health science field of study in English. This could help the researcher identify the activities related to listening skills that are very necessary for the health sciences field of study.

Table 4. Health science students' experiences regarding listening skills' activities needed in English in their health science field of study

No.	Items	Frequencies in %					mean	SD
		NN	RN	SN	ON	AN		
Q1Z2	Listening to lecture	4.4	4.4	4.4	13.5	73.3	4.47	1.08
Q1Z3	Listening to class discussion	4.4	31.1	24	0.4	40.1	4	0.95
Q1Z4	Listening to the radio, TV programs, or films about health sciences	2.3	8.9	15.6	17.8	55.6	4.16	1.13
Q1Z5	Listening to instructions and explanations in labs	0	6.7	8.9	22.2	62.2	4.4	0.92

The table above reveals the health science students' opinions regarding the type of listening activities they needed in their learning of their fields of study. The finding indicated that the majority of students (86.6%) of them indicated that listening to lectures in English was frequently needed. The next most needed listening activity was listening to instructions and explanations in labs which were rated by 84.4% of the respondents. Listening to the radio, TV programs, or films about health sciences was the third listening activity that learners often needed to listen to in English as rated by 73.4% of the respondent. The mean value of each item (Mean= 4 and above) can also show that all of the listening activities mentioned were frequently needed though their degree was different. Accordingly, depending on the degree of recurrence, listening to lectures, listening to instructions and explanations in labs, listening to radio or TV programs or films about health sciences, and listening to the class discussion are listening activities frequently needed in English listening skills in the health science field of study.

Furthermore, the following models summarize why each English language skill is used in the health science field of study, based on the qualitative findings of the current study. In their semi-structured interviews, the participants of this study articulated the demands of each English language skill for the academic English language needs of health science students.



Modell 1: English language needed in health science academic fields of studies

Inst 6 responded in general that students learn English because they learn all subject in English. He explains**,** **"**That is why students eee… campus students are specially learning all courses or all subjects in English. They do research project in English. Especially, in our settings, in clinical hospitals, we assess all things in English, so without knowing English, even, eee… to attend their degrees even… their subjects all difficult." Similarly, T4 also stated that in their college, English is required for a variety of reasons. He says, "…in eee…. our college since it is the health science college, most of the terms or medical terms are in English and like most of the terms do not have eee… like a direct meaning in Amharic or in other language." Inst3 gives the following reasons for learning English:

> *They need to eee…m have bedside presentation or seminar presentations. all the cases are in English, so they will eee… they need to read or they read all the book, the medical books in English and they need to understand English language that is why I am recognizing for our teachers or our students.*

Dr.1 also stated that health science students must learn English skills because they are receiving instruction in English and English is the medium of instruction in their workplace: Taking the patient's medical history physical examinations, investigations, diagnosis, and

treatments, case reports all are written and documented in English. ET1 also added that health science students need English language for communication in order to collect, in order to diagnose, in order to diagnose and in order to do related activities.

The responses of the above respondents demonstrate that students require reading throughout their academic careers. They need to speak for professional communication purposes, such as seminar presentations and activity reports. They will need writing skills to write a research paper and to document all of their internship activities performed in hospital or health center.

Health Science Students' English Language Learning Preferences

Part three of the questionnaire was aimed to identify health science students' wants, so they were asked to rate what they wished to learn or the English language they preferred to learn. Table 5 illustrates their ratings.

Table 5. Health science Students' English language learning preferences

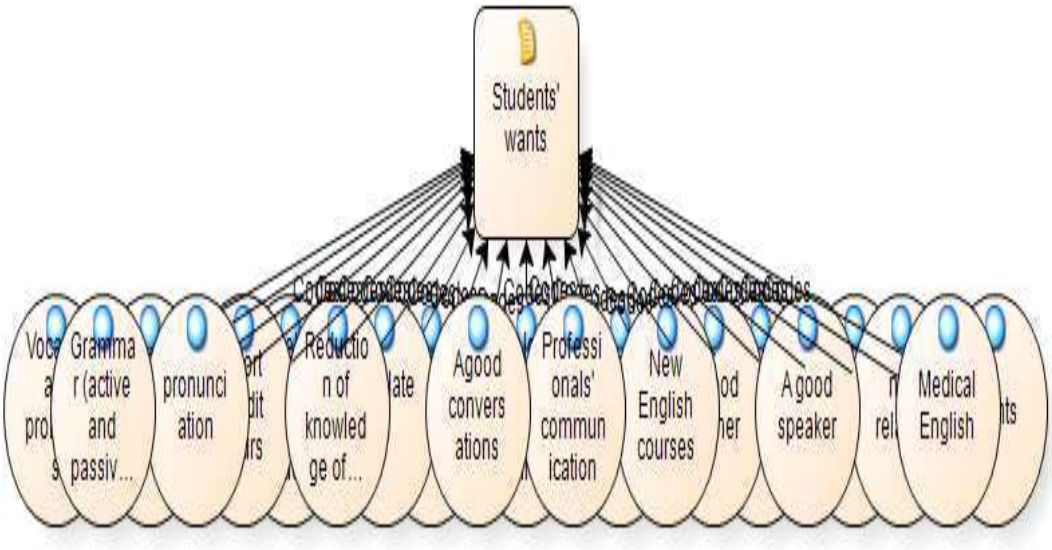
Descriptive Statistics

Items	N	Mean	Std. Deviation
Q3A. I like English for medical purposes more than general English	131	3.89	1.210
Q3B.Technical vocabulary (Vocabulary taken from health science/ the medical field is important for my academic study	131	4.51	0.727
Q3C. I prefer if the activities in the health science English language skills course materials are relevant to the health science field	131	4.24	0.981
Q3D. I want to learn English to help me in my academic study	131	4.49	0.757
Q3E. I want to learn English to be successful in my health profession	131	4.44	0.813
Q3F. I want to learn English to enjoy English culture	131	2.47	1.358
Q3G. I want to learn English just to obtain my degree	131	2.69	0.996
Q3H. I want to learn English because I enjoy learning it	131	3.02	1.234
Q3I.I like topics, activities, and content concerning health science to be included in English language skills courses	131	4.16	1.043
Q3J. I like health science vocabulary to be included in the English language skills courses	131	4.27	1.053
Q3K. I like the general vocabulary to be included in the English language skills course materials	131	3.47	.919
Valid N (listwise)	131		

The descriptive statistics in the table above show students' preference for learning the English language. The items of Q3B, Q3D, Q3E, and Q3J in the table above within the mean value (M= 4.5, 4.49, 4.44, and 4.27) respectively indicate that the respondents strongly agreed to these items. These revealed that they highly preferred technical vocabulary (Vocabulary taken from the health science/ medical field), learning English to help them in their academic study, learning English to be successful in their health profession, and wishing health science vocabulary to be included in the English language skills courses. The result also shows that they preferred topics, activities, and contents concerning health science to be included in the English language skills course materials (mean= 4.16), and they

preferred English for medical purposes to general English (mean= 3.89). However, as items Q3H, Q3G, and Q3F in the above table indicate, Students did not decide whether they learned English for personal interest (M=3.02) and they learned to obtain their degree, but they did not learn English to join English culture (M=2.47).

Furthermore, the following models summarize health science students' English language learning preferences (wants) based on the qualitative findings of the current study.



Modell 2: Health science Students' English language learning preferences

Respondents stated that they want to learn English to help them with their academic studies. They prefer to learn more medical English and less general English, pronunciation, professional communication, and grammar (active and passive). They want to be good English speakers and writers in both their academic and professional lives. For example, S3 said, “I expect to know the pronunciation of all medical English. If I know the pronunciation, I can speak and write with others that is my expectation.” S2 also emphasizes as, "Okay, the current communicative English course must contain more medical words eee…r because if it includes medical words, it makes it easy for the students to understand their study.”

Discussion

As indicated in the findings section, all the data collected through questionnaires, observations, and interviews were carefully analyzed, and the results were presented and carefully discussed. Investigating health science students’ English language needs through a need analysis for the target situation, significant findings were obtained. This study investigated why the English language and skills needed to do activities in academic settings to include in future English language courses. Besides, health science students’ English language learning preferences, which help to include suitable content in the course materials, were found out. In this section, therefore, the results are elaborated in line with answering the research questions based on the findings.

The study revealed that students always need reading skills for activities such as reading tests and exam questions, reading instructions for assignments, reading course handouts, and reading instructions for labs, respectively, in their field of study. The result of the observations also indicated highly technical medical English terms are used in academic study of health science students. These findings seem consistent with Karimnia and Khodashenas (2018). They investigated that reading articles and textbooks, reading medical articles in technical journals, reading medical and technical manuals, reading medical text on the net, reading instruction of medical instruments, reading course pamphlets, reading instruction of drugs and reading medical notes were the most important and frequently used English sub-skills. Lodhi *et al.* (2018) also found that English was used in different medical academic activities such as following lecture instructions, reading articles and journals, comprehending graphs and charts in academic study, and reading medical literature and understanding the manuals of the medical equipment in professional settings. Gylys and Wedding (2009) claim that the language of Medicine is a specialized vocabulary used by healthcare practitioners.

the study also found that English writing skills were always required by health science students when writing project reports or term papers, taking notes from lectures, writing research papers, taking notes from the course book, and writing lab or field reports. These findings are to some extent inconsistent with Karimnia and Khodashenas (2018). They found that writing articles were the most important and frequently used English sub-skills.

The finding of data obtained from the participants implied that speaking skills were always needed in the health science field in giving presentations, participating in class discussions, and asking and answering questions in class, but they were also always needed in the students' future health professions: making presentations at seminars and conferences, attending medical meetings and conferences, speaking about medically related topics, and communicating with colleagues, in that order of importance, but rarely or never communicating with patients and their caretakers. The finding of these study agree with Antic and Milosavljevic (2016) who found that in medical profession, the nature of the job is very often participating in the international conference, seminars and congresses and this force them to emphasize the need for better knowledge of the conference language, for the ability of participating in academic medical discussion with colleagues abroad for a successful professional exchange without the language barrier. Popa (2013) also found that students' tasks and activities in the class include ordinary communication in EMP like evaluation and opinion formation, expressing points of view and discussing particular patient-nurse issues to more complex simulations and role-play that are implemented to different medical situations. Hashim et al. (2014) also discovered that acquiring and developing English-speaking skills to become effective communicators in tertiary education and the workplace is very important. However, this finding is a little bit deviate from Antic and Milosavljevic (2016) who discovered health professionals need oral skills more closely related to communicating with foreign colleagues and medical staff on strictly medical topics. This difference may be due to the lack of foreign colleagues in the staff and often use of Amharic with the patients, and others in oral communications in Ethiopia.

As the findings indicated, learner thought that in the academic field of health sciences, listening skills were needed to listen to: lectures, instructions and explanations in labs, radio or TV programs or films about health sciences, and class discussions in their order of degree of recurrence The result of the observations and interviews further revealed that empathic listening skills were needed in the health care system, but it was done in Amharic, not in English. Karimnia and Khodashenas (2018) also found that listening to medical lectures and listening to the presentation in conferences were the most important and frequently used English sub-skills.

Regarding the students' wants, the findings revealed that the health science students preferred learning English for their academic studies and their future professional careers. This finding is consistent with the findings of (Silesh and Tamene, 2022). They discovered that present English language courses do not motivate first-year students to enhance their academic language proficiency to continue their studies. Similarly, Ibrahim (2020, p. 83) discovered that "most of the students need English for their medical study". Gaffas (2019) also revealed that the students valued the ESP course, particularly for improving their grasp of technical jargon. However, in Ethiopian higher education, health science or medical students studied English as a common course just like any other student.

The results of interviews and observations revealed the priority of English language skills needed in the target situation. Reading skills, writing skills, listening skills, and speaking skills are consequently needed in the health science field of study, whereas writing skills, reading skills, speaking skills, and listening skills are needed in health professional activities according to the frequency of need, from most needed to least needed. This is comparable to Karimnia and Khodashenas (2018), who discovered that students prioritize reading competence in terms of frequency of usage, significance, and proficiency. Abuklaish, (2014) also discovered that science students prefer a flexible ESP curriculum that includes practice in both receptive and productive skills, but with a larger emphasis on reading and writing, best delivered by a bilingual instructor. However, Wahyuni, (2021) revealed that medical students require greater listening and speaking abilities than reading and writing. Antic and Milosavljevic (2016) also found that the skill of speaking was considered to be the most important by all participants, and reading skill was the second, whereas writing skill was the third and listening skill was the least important. This disparity may exist because, in the current research environment, Amharic is more commonly employed than English while conversing.

As a result, the findings of this study will assist educators and policymakers in designing effective English language courses that can improve the communication skills of health science students. The study also aims to assist students in performing effective activities in their field of study despite language barriers, as well as functioning and communicating effectively in their future profession. Furthermore, it can increase learners' interest in taking English language courses and help them improve their English skills. These can provide health sciences students with insights into the skills they will need in their academic study, allowing them to equip themselves with the necessary English language backgrounds before beginning their careers in a hospital or healthcare setting.

Conclusion

This study identified the English language skills that health science students require to perform activities related to their academic field of study. Most of the health science students seem to always need health-related English but rarely need general English. They need to operate well in English as a means of learning their fields of study. The findings indicated that health science students' English language skills needed for their academic studies should be integrated into the course materials. As displayed in the discussion section, the findings revealed that the students did not learn English language skills needed in their academic field of study rather than the two English language skills courses, locally called "communicative English language skills I" and "communicative English language skills II," which are given in the first year as common courses. However, the language skills they learned from these courses never address the language demands in their academic field of study. The finding also revealed that reading skills, writing skills, speaking skills, and listening skills are consequently needed in the health science field of study according to the frequency of needs from most needed to least needed. Therefore, different English language courses that help students to pursue their academic study throughout their university education years, particularly, during their

internship programs need to be designed. The result also indicated that highly technical medical English terms are used in health science academic fields of study. Thus, it can also be suggested based on the findings that the course materials should incorporate these highly technical medical English terms. Lastly, it can also be suggested that ESP courses that incorporate teaching and learning activities, which the students need and prefer to learn from the English courses, should be designed.

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RESEARCH PAPER

Analysis of Mecha Oromo Safu-Moral system: Anthropological Linguistics Perspectives

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Abstract

The main purpose of this article is to analyse Mecha Oromo Safu as reflected in their language use and their culture. The data were gathered from some elders and community leaders selected purposely and by the researcher himself as he is native to the community. These data were collected through an open interview with the informants and through elicitation by the researcher. The major research methodology is qualitative and the research design is ethnographic. The findings and the conclusion were that safu themes: some linguistic expressions such as narration, and proverbs; cultural themes such as wisdom to lead, keep and empower the communities and harmony with nature. And thereby recommended the Oromo intellectuals should study these safu principles, and document and work collaboratively with the community and government so that they can be used in curriculum and social problem-solving strategies.

Keywords: Moral system, safu, anthropological linguistics, ethnography

Introduction

The Oromo people, one of Ethiopia's largest ethnic groups, inhabit diverse regions across the country, including the fertile lands of Mecha. With an estimated population exceeding 40 million, the Oromo are recognized for their rich cultural heritage, which includes the Safu moral system a complex framework governing ethical conduct and communal values (Central Statistical Agency, 2020).

The Mecha Oromo reside predominantly in the Mecha district of the West Gojjam Zone, Amhara Region, Ethiopia. This area is renowned for its agricultural productivity and cultural diversity, providing a fertile ground for the preservation of traditional practices and moral teachings (Smith, 2018).

Linguistically, the Mecha Oromo belong to the Cushitic branch of the Afro-Asiatic language family, primarily using Afaan Oromo as their medium of communication. This language not only serves as a tool for everyday interaction but also embodies cultural narratives and moral teachings passed down through generations (Hetzron, 1980).

Ethiopia hosts the largest population of Oromo people, representing a significant proportion of the nation's demographic landscape. The Mecha Oromo contribute to this demographic richness, fostering a diverse cultural tapestry within Ethiopia's broader socio-political context (Ethiopian Ministry of Culture and Tourism, 2019).

Central to Oromo cultural identity is the accumulated wealth of oral traditions, including proverbs, folk tales, and songs. These narratives serve not only as repositories of historical knowledge but also as vehicles for transmitting moral values encapsulated within the Safu system (Megersa, 2015).

Despite the cultural significance of Safu among the Mecha Oromo, scholarly attention remains limited. Existing literature often overlooks the

intricate intersections of language, culture, and moral systems specific to this community. This gap in research has motivated the current study to delve into the nuanced dimensions of Safu, exploring its role in shaping identity, fostering community cohesion, and adapting to contemporary challenges (Author *et al*., 2023).

By addressing these gaps in knowledge, this study seeks to contribute to a deeper understanding of Safu within the Mecha Oromo community, highlighting its relevance in contemporary Ethiopia and offering insights into the resilience and adaptation of indigenous moral systems.

This study seeks to conduct a comprehensive analysis of the Safu moral system among the Mecha Oromo of Ethiopia, exploring its cultural, linguistic, and anthropological dimensions. Safu, a foundational element of Oromo identity and societal cohesion, embodies a complex framework of moral teachings and communal values (Gufu, 2020; Tesema, 2019). Despite its profound significance, scholarly investigations into Safu among the Mecha Oromo, particularly from anthropological and linguistic perspectives, remain limited (Author *et al*., 2023).

The Safu system is intricately intertwined with Afaan Oromo, a language belonging to the Cushitic branch of the Afro-Asiatic family, which serves not only as a means of communication but also as a repository for cultural narratives and moral teachings (Hetzron, 1980; Tadesse, 2017).

This study aims to fill this gap by examining how Safu is linguistically expressed, culturally practiced, and socially embedded within Mecha Oromo society by employing ethnographic methods and thematic analysis.

The objective of this study is to explore how Safu is reflected in some Mecha Oromo linguistic expression, and cultural practices and to analyze some Safu principles in the indigenous knowledge.

Review of Related Literature

Moral Systems

Moral systems constitute essential frameworks that shape ethical behavior within societies, encompassing a complex interplay of values, norms, and principles that define what is deemed morally acceptable or objectionable. These systems serve as foundational guides for individual conduct and social interactions, contributing significantly to the cohesion and functioning of communities (Haidt, 2012).

Moral systems are defined as the collective set of principles and rules that govern ethical behavior within a society (Haidt, 2012; Gert, 2005). They provide a structured framework through which individuals navigate their interactions and decisions, influencing personal choices and societal norms. These frameworks are constructed and reinforced through cultural, religious, and philosophical perspectives, reflecting the values and priorities of a given community.

Societal Functions

Moral systems play a pivotal role in regulating behavior and fostering social cohesion. They establish shared expectations and norms that guide interactions within communities, promoting trust and cooperation among individuals (Gert, 2005). From a sociological perspective, Durkheim (1893) posited that moral norms function as a collective conscience, binding individuals together and reinforcing social solidarity through shared values and beliefs.

Ethical philosophers continue to debate the nature and justification of moral systems, examining questions of moral relativism versus universalism and the application of moral principles in diverse cultural contexts. Gert (2005) argues for a pluralistic approach to morality, acknowledging the diversity of moral beliefs while emphasizing commonalities in ethical reasoning across societies.

In today's globalized world, understanding and studying moral systems are crucial for addressing complex social issues and promoting ethical behavior across diverse

cultural settings. The study of moral systems not only provides insights into human nature and societal norms but also informs ethical decision-making in fields such as law, healthcare, business, and international relations (Durkheim, 1893).

In conclusion, moral systems serve as foundational frameworks that define and regulate ethical behavior within societies. Rooted in cultural, philosophical, and psychological perspectives, these systems shape individual identities and societal norms, fostering social cohesion and guiding ethical decision-making. By exploring the definitions, functions, and contemporary perspectives on moral systems, this review sets the stage for examining specific cultural expressions of morality, such as the Safu-Oromo moral system, within anthropological and linguistic contexts.

Moral Systems in African Societies

Moral systems within African societies are integral to the cultural, social, and ethical frameworks that guide behavior and interpersonal relationships. These systems are rooted in indigenous beliefs, traditional practices, and communal values, reflecting a diverse array of moral principles and ethical norms across the continent.

African moral systems exhibit significant diversity due to the continent's myriad ethnic groups and historical influences. Each community develops its own moral code, often shaped by indigenous religions, oral traditions, and customary laws (Wiredu, 1992). These systems are dynamic, adapting to social changes while retaining core values that emphasize communal welfare, respect for elders, and reciprocity among members.

Philosophically, African moral systems challenge Western-centric notions by prioritizing community-oriented ethics over individual autonomy. Traditional African philosophies, such as Ubuntu, emphasize interconnectedness and collective responsibility, asserting that individuals achieve moral fulfillment through harmonious relationships with others and the natural world (Gyekye, 1997).

The Concept of Safu in Oromo Culture

The concept of Safu holds significant importance within Oromo culture, representing a complex moral and ethical framework that guides behavior, social relationships, and community life. Safu encompasses a set of principles, values, and norms that are deeply embedded in Oromo oral traditions, religious practices, and customary laws. Safu can be understood as the Oromo moral code, prescribing ethical conduct and promoting social harmony (Legesse, 1973). It governs interpersonal relationships, resolves disputes, and regulates individual responsibilities within the community. Safu emphasizes virtues such as respect for elders, hospitality, integrity, and reciprocity, which are fundamental to maintaining Oromo identity and cohesion.

The origins of Safu trace back to the traditional governance system known as the Gadaa system. The Gadaa system organizes Oromo society into generational classes, each with distinct roles and responsibilities in governance and community affairs (Asmarom, 1992). Safu principles are transmitted orally through rituals, ceremonies, and communal gatherings, ensuring their continuity across generations.

Ethically, Safu promotes egalitarianism and collective decision-making, reflecting the democratic ideals inherent in Oromo social structures (Legesse, 1973). It upholds principles of fairness, justice, and mutual respect, fostering a sense of solidarity and unity among Oromo individuals and communities.

Linguistic and Cultural Expressions

Linguistically, Safu is expressed through Afaan Oromo, the Oromo language, which contains rich repositories of proverbs, folk songs, and moral teachings (Baxter, 1978). These linguistic expressions encapsulate the wisdom of Safu, offering practical guidance on ethical behavior and reinforcing cultural identity among the Oromo people.

In contemporary times, Safu continues to play a vital role in Oromo society amidst socio-political changes and modernization. It provides a framework for addressing challenges such as land disputes, environmental conservation, and social justice issues (Asmarom, 1992). Safu's resilience lies in its adaptability to evolving contexts while preserving core values that define Oromo cultural heritage.

The concept of Safu in Oromo culture represents a profound moral and ethical system that shapes individual conduct and community relations. Rooted in historical traditions and philosophical principles, Safu underscores the enduring significance of indigenous knowledge in fostering social cohesion and resilience within Oromo society.

This overview provides a comprehensive exploration of Safu in Oromo culture, highlighting its definition, historical context, ethical foundations, linguistic expressions, and contemporary relevance within Oromo society.

Linguistic Expressions of Safu

Linguistic expressions within the Safu-Oromo moral system play a pivotal role in conveying and reinforcing ethical principles and cultural norms among the Oromo people. These expressions are embedded within the Afaan Oromo language through proverbs, idioms, folk songs, and oral narratives, serving as vital mediums for transmitting the wisdom and values encapsulated in Safu.

Research Methodology

This segment outlines the approach and methodology adopted for the study. Employing a qualitative research design, the subsequent sections delve into detailing the study's geographical scope, data collection methods and procedures, sampling techniques, criteria for inclusion, procedures for data analysis, study limitations, and ethical considerations.

Consequently, the West Shoa Zone serves as the focal point of this study, renowned for its Mecha Oromo populace characterized by their Oromo lineage. Primary data sources were native speakers of the language, gathered predominantly through interviews and elicitation. Given the study's nature, it adopts an ethnographic research design. Five informants were purposefully selected to ensure data richness, particularly targeting elders and traditional leaders. Introspection also played a role in data collection. The researcher, having prior knowledge of indigenous knowledge and Oromo culture, also contributed as a data source. Qualitative analysis was employed to scrutinize the study's findings. All data collection adhered strictly to the informants' consent, and data gathering occurred at mutually convenient times agreed upon by the informants. The following figure reveals the summary of methodology of the researched utilized in the study.

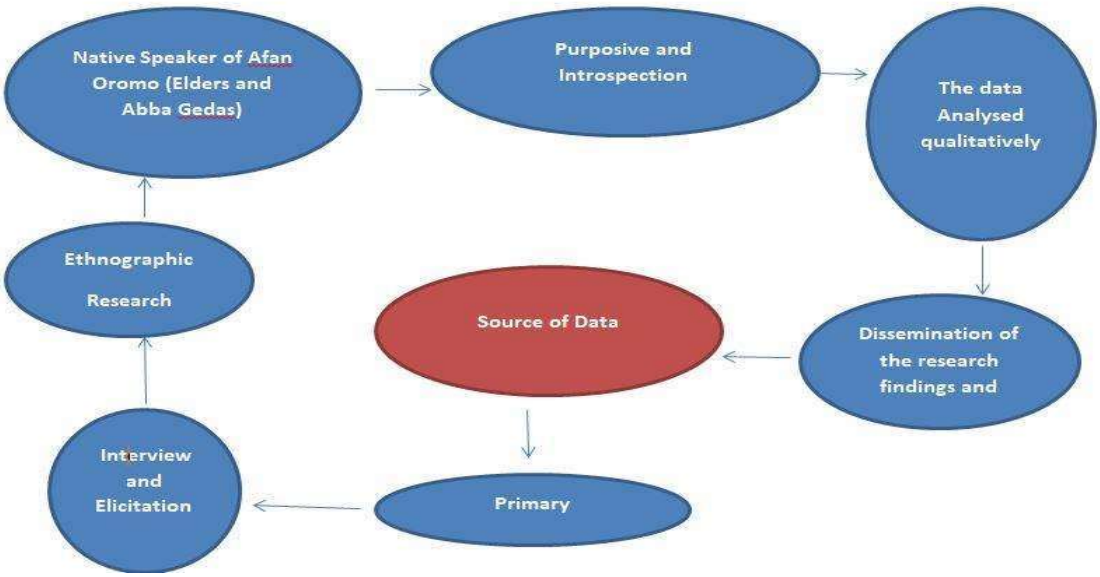

Figure 1: Research Methodology Designed by the Researcher for this particular study

Researcher engages in prolonged fieldwork within Oromo communities to observe and document the enactment of Safu in various contexts. Ethnographic data provide rich descriptions and contextual understanding of how Safu influences behavior, norms, and social relations.

These techniques for data analysis are particularly relevant for studying Safu in Oromo culture because they allow researchers to explore the intricate relationships between language, culture, and moral systems. By employing qualitative methods such as thematic analysis, ethnographic methods, and cross-cultural comparative analysis, researchers can gain deeper insights into how Safu is understood, practiced, and transmitted within Oromo society. These methods facilitate nuanced interpretations of qualitative data, contributing to a comprehensive understanding of Safu's cultural significance and adaptation in contemporary contexts.

The techniques for data analysis in a study of Safu in Oromo culture would typically involve qualitative methods that are well-suited to explore complex cultural and linguistic phenomena.

Thematic analysis involves identifying, analyzing, and categoraizing themes within qualitative data related to Safu. These themes could include moral principles, cultural values, linguistic expressions, and social contexts. Researchers systematically code qualitative data (interviews, texts, narratives) to identify recurring themes related to Safu. Themes are then organized and interpreted to provide insights into the cultural significance and variations of Safu within Oromo society.

Results and discussions

Result

Table 1. Responses of the research participants

L	Researcher's Questions	Informants' Response	Remarks
1	Mee. mammaaksa safuu ibsu tokko kennuuf yaalaa.	'Hindaanqoon yoo mana seentu, safuuf gadi jetti'	When a hen enters into a house, it bends down for norm of a house.
2	Sirna dinqisiffannaa Uumaa safuu ibsu tokko kennaa	Waaqni utubaa malee samii dhaabe.	God erects the sky without supporting pole.
3	Yaada safuu abba Murtummaa Waaqaa ibsu tokko kennaa	Waan facaafatan haammatan	You harvest what you sow."
4	Any proverb you know on plantation.	Kichuu hin kutan	A growing plants are not cut down.
5	Mee, fakkeenya sirbaa safuu oguma ibsu kennaa	'… wallaalaan nurraa goree beekaan nu fure…. Ali Birra's songs.	'… while an ignorant ignores us a wise relieves us from challwnges,'

Data Analysis

Some Linguistic expressions of Mecha Oromoo safu (Informant 1)

When this informant was asked to give an example safu oral narrative: 'Hindaanqoon yoo mana seentu, safuuf gadi jetti'

Translation: When a hen enters into a house, it bends down for the norm of a house.

1. Linguistic Analysis

"When a hen enters into a house, it bends its head for the respect of the house and its owners."

Language: This expression likely comes from an Oromo saying or proverb.

2. Cultural Analysis

Customs and Values: This practice reflects the Oromo value of Safu, which is an ethical and moral code emphasizing respect and proper conduct. The hen's gesture symbolizes how individuals should behave respectfully towards others and their property.

Cultural Symbolism: In many cultures, animals are used to teach and reflect human values. The hen's respectful gesture as it enters the house is a metaphor for how humans should show humility and respect when entering someone's home.

Moral Lesson The behavior of the hen is used to teach a moral lesson about respect and humility. It suggests that, like the hen, people should show deference and respect in others' homes, recognizing the sanctity and authority of the household and its owners.

This combination of linguistic and cultural expressions illustrates the depth and importance of Safu in the Oromo moral system, where respect and proper behavior are emphasized

through everyday actions and symbolic representations.

Some Linguistic expressions of Mecha Oromoo safu (Informant 2)

when informant was (2) asked: Waaqni utubaa malee samii dhaabe. Translatio: God erects the sky without a supporting pole.

1. Linguistic Analysis

"God erects the sky without any pole."

Language: This expression is likely a traditional Oromo saying.

Symbolism: The sky and the absence of a pole are symbolic. The sky represents vastness and the heavens, while the lack of a pole emphasizes the miraculous and omnipotent nature of God.

2. Cultural Analysis:

Divine Power and Omnipotence: This expression reflects the cultural belief in a powerful, omnipotent God who can accomplish the impossible. It underscores the community's faith and reverence for divine power.

Natural Order and Harmony: By highlighting that the sky is held up without physical support, the expression underscores a belief in a natural order maintained by divine will. It emphasizes the idea that the world is organized and harmonious under God's control.

Humility and Awe: The expression fosters a sense of humility and awe among people, reminding them of the limits of human power and the vastness of divine capability. This aligns with the concept of Safu, promoting humility and respect for forces greater than oneself.

Moral Lesson: The saying encourages people to acknowledge and respect the unseen forces that maintain the balance of the world. It suggests that just as the sky is held up without visible support, there are unseen moral and ethical principles (like Safu) that sustain societal harmony.

This analysis shows how the linguistic structure and cultural symbolism of the expression "God erects the sky without any pole" convey a deep respect for divine power and the natural order, reinforcing the values of humility, reverence, and ethical conduct central to the Oromo moral system of Safu.

Some Linguistic expressions of Mecha Oromo safuu (Informant 3)

Yaada safuu abba Murtummaa Waaqaa ibsu tokko kennaa, waan facaaffatan haammata. Translation: any one harvest what he sows.

1. Linguistic Analysis

"You harvest what you sow."

Language: This expression is a common proverb, likely found in many cultures, including Oromo.

Symbolism: "Harvest" and "sow" are agricultural terms. "Sow" symbolizes actions or efforts, and "harvest" symbolizes the outcomes or consequences of those actions.

2. Cultural Analysis

Moral and Ethical Conduct: This expression reflects the cultural belief in the principle of cause and effect. It emphasizes that actions have consequences, aligning with the concept of *Safu*, which stresses ethical behavior and personal responsibility.

Work and Reward: The saying underscores the value of hard work and diligence. It suggests that positive actions and efforts will lead to positive outcomes, while negative actions will lead to negative consequences.

Accountability: The expression promotes the idea of accountability. Individuals are responsible for their actions and must face the results of their behavior, whether good or bad.

Moral Lesson: The saying teaches a moral lesson about the importance of making good choices and putting in consistent effort. It encourages individuals to act wisely and ethically, knowing that their actions will determine their future outcomes.

This analysis demonstrates how the linguistic structure and cultural symbolism of the expression "You harvest what you sow" convey the values of ethical conduct, personal responsibility, and the connection between actions and outcomes. It aligns closely with the principles of Safu, reinforcing the importance of making positive contributions and understanding the consequences of one's actions within the Oromo community.

Some Linguistic expressions of Mecha Oromo safuu (Informant 4)

When the informant (4) was asked to give an example of safu that shows the respection of creatures, like plants and animals.

Linguistic Expression:

1. Linguistic Analysis:

"Do not cut growing plants or trees."

Language: This instruction is likely a traditional Oromo proverb or guideline.

- Symbolism: Plants and trees symbolize life, growth, and sustainability. The act of cutting them symbolizes destruction or disruption of natural processes.

2. Cultural Analysis:

Respect for Nature: This practice reflects a deep respect for the natural world, which is central to the Oromo moral system. It underscores the belief that all living things have intrinsic value and should be protected.

Sustainability and Stewardship: By prohibiting the cutting of growing plants or trees, the Oromo people demonstrate a commitment to sustainability and environmental stewardship. This practice ensures the continued growth and regeneration of natural resources.

Interconnectedness of Life: The belief highlights the interconnectedness of all life forms. Plants and trees are seen as integral parts of the ecosystem, contributing to the well-being of the community and the environment.

Moral and Ethical Standards: This practice aligns with the concept of Safu, which emphasizes ethical behavior and respect for all forms of life. It promotes harmony between humans and nature, encouraging actions that support the common good.

Cultural Symbolism: In many cultures, trees and plants are symbols of life, growth, and continuity. Protecting them reflects a broader cultural value of nurturing and preserving life.

Moral Lesson: The prohibition against cutting growing plants or trees teaches a moral lesson about the importance of conservation and respect for the environment. It encourages individuals to consider the long-term impact of their actions and to act responsibly.

This analysis illustrates how the linguistic expression and cultural symbolism of the practice "do not cut growing plants or trees" convey the values of respect, sustainability, and ethical conduct central to the Oromo moral system of Safu.

Some Linguistic expressions of Mecha Oromo safuu (Informant 5)

When informant (5) was asked to cite an oral song that express value of Oromoo sage: '… wallaalaa… beekaan nu fure…. Ali Birra's songs.

Translation:"While an ignorant ignores us, a wise relieved us from our challenges"

1. Linguistic Analysis

"While an ignorant ignores us, a wise relieved us from our challenges."

Language: This expression likely comes from an Oromo song.

Symbolism: "Ignorant" and "wise" are symbolic of two contrasting qualities: ignorance (lack of knowledge or understanding) and wisdom (knowledge, understanding, and the ability to make good judgments). "Challenges" represent difficulties or problems faced by individuals or the community.

2. Cultural Analysis:

Role of Wisdom: This expression emphasizes the value placed on wisdom and knowledgeable leadership within the Oromo culture. It reflects the belief that wise individuals are capable of providing solutions and relief during difficult times.

Critique of Ignorance: The reference to "ignorant" people ignoring the community's needs serves as a critique of those who lack understanding or awareness. It underscores the negative impact of ignorance on the well-being of the community.

Community Support: The idea that the wise "relieved us from our challenges" highlights the importance of communal support and the role of wise leaders in guiding and aiding the community. It aligns with the concept of Safu, which emphasizes ethical leadership and responsibility towards others.

Moral and Ethical Standards: This saying promotes the value of seeking wisdom and learning while criticizing neglect and ignorance. It encourages individuals to strive for knowledge and to value wise leadership.

Cultural Symbolism: In many cultures, wisdom is highly regarded, and those who possess it are seen as pillars of the community. This expression reinforces the cultural significance of wisdom and its role in overcoming challenges.

Moral Lesson: The song teaches a moral lesson about the importance of wisdom and the detrimental effects of ignorance. It encourages individuals to respect and seek guidance from the wise, and to be aware of the harm caused by ignorance and neglect.

This analysis demonstrates how the linguistic structure and cultural symbolism of the song "While an ignorant ignores us, a wise relieved us from our challenges" convey deep respect for wisdom and knowledgeable leadership. It aligns with the values of Safu, reinforcing the importance of ethical conduct, community support, and the pursuit of knowledge within the Oromo community.

Discussions

The exploration of Safu, the moral system inherent within the Oromo society, can be effectively analyzed through the theoretical frameworks and techniques proposed by prominent scholars. Kottak (2017) advocates for cultural analysis to understand the complexities and nuances of indigenous moral systems. His approach emphasizes examining cultural practices, symbols, and narratives to gain insights into the societal norms and values that underpin Safu. Alessandro Duranti (1997), on the other hand, provides a linguistic analytical framework that focuses on how language and discourse shape and reflect cultural practices and ethical principles. By employing these complementary methodologies, this section aims to delve into the linguistic expressions and cultural practices of the Oromo people, highlighting how Safu is manifested and perpetuated through their rich oral traditions and everyday interactions.

Some Linguistic expressions of Mecha Oromoo safu (Informant 1)

'Hindaanqoon yoo mana seentu, safuuf gadi jetti.'Translation: When a hen enters into a house, it bends down for norm of a house.

Linguistic Analysis

This expression likely comes from an Oromo saying or proverb. It metaphorically expresses that Oromo society bows when he /she/ enters into one's house.

Cultural Analysis

This analysis shows customs and values. This practice reflects the Oromo value of Safu, which is an ethical and moral code emphasizing respect and proper conduct. The hen's gesture symbolizes how individuals should behave respectfully towards others and their property. In many cultures, animals are used to teach and reflect human values. The hen's respectful gesture as it enters the house is a metaphor for how humans should show humility and respect when entering someone's home. as a moral lesson, the hen is used to teach a moral lesson about respect and humility. It suggests that, like the hen, people should show deference and respect in others' homes, recognizing the sanctity and authority of the household and its owners.

This combination of linguistic and cultural expressions illustrates the depth and importance of Safu in the Oromo moral system, where respect and proper behavior are emphasized through everyday actions and symbolic representations.

Some Linguistic expressions of Mecha Oromoo safu (Informant 2)

'Waaqni utubaa malee samii dhaabe.' Translation: God erects the sky without supporting pole.

Linguistic Analysis:

This expression is likely a traditional Oromo saying. The sky and the absence of a pole are symbolic. The sky represents vastness and the heavens, while the lack of a pole emphasizes the miraculous and omnipotent nature of God.

Cultural Analysis

Cultural analysis shows the Divine Power and Omnipotence: This expression reflects the cultural belief in a powerful, omnipotent God who can accomplish the impossible. It underscores the community's faith and reverence for divine power. By highlighting that the sky is held up without physical support, the expression underscores a belief in a natural order maintained by divine will. It emphasizes the idea that the world is organized and harmonious under God's control. The expression fosters a sense of humility and awe among people, reminding them of the limits of human power and the vastness of divine capability. This aligns with the concept of Safu, promoting humility and respect for forces greater than oneself. The saying encourages people to acknowledge and respect the unseen forces that maintain the balance of the world. It suggests that just as the sky is held up without visible support, there are unseen moral and ethical principles (like Safu) that sustain societal harmony.

This analysis shows how the linguistic structure and cultural symbolism of the expression "God erects the sky without any pole" convey deep respect for divine power and the natural order, reinforcing the values of humility, reverence, and ethical conduct central to the Oromo moral system of Safu.

Some Linguistic expressions of Mecha Oromo safuu (Informant 3)

'Waan facaaffatan haammatan'. Translation: Anyone harvests what he sows.

Linguistic Analysis

This expression is a common proverb, likely found in many cultures, including Oromo. "Harvest" and "sow" are agricultural terms. "Sow" symbolizes actions or efforts, and "harvest" symbolizes the outcomes or consequences of those actions.

Cultural Analysis

Moral and Ethical Conduct: This expression reflects the cultural belief in the principle of cause and effect. It emphasizes that actions have consequences, aligning with the concept of Safu, which stresses ethical behavior and personal responsibility. The saying underscores

the value of hard work and diligence. It suggests that positive actions and efforts will lead to positive outcomes, while negative actions will lead to negative consequences. The expression promotes the idea of accountability. Individuals are responsible for their actions and must face the results of their behavior, whether good or bad. The saying teaches a moral lesson about the importance of making good choices and putting in consistent effort. It encourages individuals to act wisely and ethically, knowing that their actions will determine their future outcomes.

This analysis demonstrates how the linguistic structure and cultural symbolism of the expression "You harvest what you sow" convey the values of ethical conduct, personal responsibility, and the connection between actions and outcomes. It aligns closely with the principles of Safu, reinforcing the importance of making positive contributions and understanding the consequences of one's actions within the Oromo community.

Some Linguistic expressions of Mecha Oromo safuu (Informant 4)

When the informant (5): ‘Kichuu hin kutani.’ Translation: "Do not cut growing plants or trees."

Linguistic Analysis

This instruction is likely a traditional Oromo proverb or guideline. Plants and trees symbolize life, growth, and sustainability. The act of cutting them symbolizes destruction or disruption of natural processes.

Cultural Analysis

This practice reflects a deep respect for the natural world, which is central to the Oromo moral system. It underscores the belief that all living things have intrinsic value and should be protected. By prohibiting the cutting of growing plants or trees, the Oromo people demonstrate a commitment to sustainability and environmental stewardship. This practice ensures the continued growth and regeneration of natural resources. The belief highlights the interconnectedness of all life forms. Plants and trees are seen as integral parts of the ecosystem, contributing to the well-being of the community and the environment. This practice aligns with the concept of Safu, which emphasizes ethical behavior and respect for all forms of life. It promotes harmony between humans and nature, encouraging actions that support the common good.

This analysis illustrates how the linguistic expression and cultural symbolism of the practice ‘do not cut growing plants or trees’ convey the values of respect, sustainability, and ethical conduct central to the Oromo moral system of Safu.

Some Linguistic expressions of Mecha Oromo safuu (Informant, 5)

When informant (7): ‘… wallaalaa nurraa goree… beekaan nu fure….,’ Ali Birra’s songs

Translation: ‘While an ignorant ignores us, a wise relieved us from our challenges.’

Linguistic Analysis

This expression likely comes from an Oromo song. ‘Ignorant’ and ‘wise’ are symbolic of two contrasting qualities: ignorance (lack of knowledge or understanding) and wisdom (knowledge, understanding, and the ability to make good judgments). ‘Challenges’ represents difficulties or problems faced by individuals or the community.

Cultural Analysis

This expression emphasizes the value placed on wisdom and knowledgeable leadership within the Oromo culture. It reflects the belief that wise individuals are capable of providing solutions and relief during difficult times. The reference to ‘ignorant’ people ignoring the community’s needs serves as a critique of those who lack understanding or awareness. It underscores the negative impact of ignorance on the well-being of the community. The idea that the wise ‘relieved us from our challenges’ highlights the importance of communal support

and the role of wise leaders in guiding and aiding the community. It aligns with the concept of Safu, which emphasizes ethical leadership and responsibility towards others. This saying promotes the value of seeking wisdom and learning while criticizing neglect and ignorance. It encourages individuals to strive for knowledge and to value wise leadership. The song teaches a moral lesson about the importance of wisdom and the detrimental effects of ignorance. It encourages individuals to respect and seek guidance from the wise, and to be aware of the harm caused by ignorance and neglect.

This analysis demonstrates how the linguistic structure and cultural symbolism of the traditional song. While an ignorant ignores us, a wise relieved us from our challenges' and conveys deep respect for wisdom and knowledgeable leadership. It aligns with the values of Safu, reinforcing the importance of ethical conduct, community support, and the pursuit of knowledge within the Oromo community.

Conclusions and Recommendations

As the objective of this article was to explore and analyze the concept of Mecha Oromo Safu-moral systems within the Oromo anthropological linguistics perspectives, the following conclusions and recommendations were forwarded.

Conclusions

The safu Oromo linguistically as a proverb (1) reflects safu deep-seated cultural values of respect and hospitality. Through discourse and ethnographic analyses, it was evident that such expressions play a critical role in teaching and maintaining social etiquette and respect within the community.

In proverb (2) as a linguistic expression and cultural practices of religious belief indicates safu for divine power and omnipotence. The linguistic and cultural analysis showed how this metaphor reinforces the community's reverence for divine creation and the acknowledgment of a higher power in the natural order.

In proverb (3) as both linguistic and cultural practices underscore the safu principle of personal responsibility and the consequences of one's actions. The thematic and ethnographic analyses highlighted how this expression is used to instill values of hard work, accountability, and justice within the community.

As in societal principle (4) in the meaning of narration or the text, both literal and metaphorically it illustrates the safu of nurturing and protecting natural resources. This reflects cultural values of sustainability, patience, and respect for life, which are central to the Oromo ethical system.

In the phrase from the Oromo song, (5) as both part of oral literature and cultural expression, in theme- 'while an ignorant ignores us, the wise relieve us from our challenges,'emphasizes the value of safu placed on wisdom and the role of knowledgeable individuals in overcoming difficulties. The analysis revealed how such expressions reinforce the importance of seeking guidance from the wise and respecting their contributions to the community.

In conclusion, through the analysis of these linguistic expressions and cultural practices, it is clear that Safu encompasses a broad spectrum of moral and ethical conduct in the Oromo culture. The proverbs and sayings not only reflect the community's values but also serve as tools for teaching and maintaining social order. By understanding these expressions, one gains insight into the cultural fabric that holds the Oromo community together, emphasizing respect, responsibility, wisdom, and the interconnectedness of all life.

Recommendations

As oral traditions are crucial for maintaining cultural identity and passing down ethical values, Oromo intellectuals / at educational, cultural, and research centers,/ together with the government, should conduct research on these Oromo linguistic expressions and cultural practices.

Oromo educational experts should conduct safu in indigenous knowledge of language and culture and incorporate educational systems at various levels, from primary to higher education. The government regional state /including the federal/ should provide establish research centers and provide resources and encourage oromo intellectual who works on these themes of safu. The government together with its educational and cultural research institutions should create awareness programs on the importance of safu for Oromo people and the country as well. The Oromia government with multidisciplinary experts / such as environmental protection, and political bodies should encourage the researchers to systematize the safu knowledge so as to solve the society's problems.

The Oromia government, together with the federal, and intellectuals should design a programme and should create a partnership with concerned international organizations such as UNESCO/ that can work on safu. Oromia regional state, including federal state, should play their roles in preserving, promoting, and adapting to contemporary contexts, the rich cultural heritage and ethical framework of the Oromo people and thereby help values of Safu continue to guide and inspire future generations.

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RESEARCH PAPER

Oromo Indigenous Parental Values, Practices and Child Behavioural Outcomes

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Abstract

Oromo indigenous parenting practices have a significant role in influencing children's behaviour and subsequent personality development. The main objective of this study is to investigate the role of Oromo Indigenous Parental Values, Practices, on Child Behavioural Outcomes. The study investigates the characteristics of Oromo Indigenous Parenting (parental values and practices) and their impact on child behaviour. The research follows qualitative approach. Data were qualitatively collected and organized from primary sources through interview and Focus Group discussion. Finding shows that in Oromo culture, parenting is not solely the responsibility of the biological family; it also involves extended family members, neighbours, and the community. Parents desire for their children to be confident, cooperative, socially conscious, and self-controlled. Children are encouraged to participate in age-appropriate activities and are expected to be disciplined. 'Safuu' disciplines and protects children from exploitation, forced labor, and physical punishment, among other things. As a result, Oromo people's child-rearing approaches are supportive rather than punitive. There are several indigenous knowledge practices within family to support positive parenting, promote children's' physical, social and cognitive development. For instance, folktales like diraamaa ijoollee and durdurii (children's folktales), mammaaksa (proverbs), Hibboo (riddles), and Hibboonteetee all contribute to the development of parental skills and behaviors. Interventions are needed to preserve and promote the Oromo positive parenting values and practices.

Keywords: Parenting practices; values; child behavioural outcomes

Introduction

'Parenting' can be referred to as activities aimed at ensuring the survival and development of children. It is the process of raising and educating a child from birth to adulthood, taking into account the physical, emotional, social, and cognitive capacities of the child. Throughout life time, parenting is the process of encouraging and supporting a person's survival and development (Martin, 2000). Hence, parenting is a lifetime interaction between children, parents, other family members and the communities.

Though the notion of African Parenting has been ignored in the past, professionals are now working hard to rejuvenate it. Dependency, expectations, substantial community involvement, extended family membership, sibling interdependence where the old guide and rear the young, and the involvement of neighbours in child upbringing are all characteristics of parenting in Africa. Interdependence and cooperation are major elements of an African lifestyle that reflect an African worldview as holistic, according to several reviews of African literature (Tefera, 2008; Nobles, 1978; White and Parham, 1990). As a result, parenting in Africa is not solely the job of individual parents; it is also a social, moral, and spiritual task of broader society. African Parenting has a distinct purpose of instilling in children a sense of responsibility,

emotional intelligence, interpersonal intelligence, and social intelligence.

One of the prototypes of African parenting is the extended family, which provides emotional needs, economic, social, and psychological security to all connected individuals. Similarly, Oromo Indigenous parenting entails children's involvement in an extended family, where they develop a strong sense of social obligation, as well as respect, responsibility, and support. The Oromo ethnic group is indigenous to Ethiopia's Oromia region and some areas of northern Kenya. They speak the Oromo language, also known as Afaan Oromoo, which is a member of the Cushitic branch of the Afroasiatic language family. Oromo is one of Ethiopia's largest ethnic groups in Ethiopia. The Gadaa system was historically the main system of government employed by the Oromo people.

In Oromo society, parenting is defined by interdependence, cooperation, respect, and hard effort among family members. For example, elder siblings may train younger siblings, and younger siblings may train older siblings. The parenting process involves extended families and communities. The entire community is responsible for the marriage process and child-rearing activities. This reveals that parenting begins in childhood and continues throughout life for the Oromo of Ethiopia.

The Oromo have indigenous societal norms that support positive parenting. Age-segregated respect for elderly citizens is a cross-cutting value asset shared by all Ethiopians. For instance, it is a norm in society that when family members debate anything, the oldest person normally speaks first, followed by the next in order in the family. When it is their turn, children are also permitted to express themselves. This is a societal value that has existed in societies for a long time.

The Oromo social values have been degraded due to a variety of circumstances. Poverty and exposure to Western culture are the most conspicuous among these issues. It has been observed that values such as patience and respect are being lost particularly among diverse sections of Ethiopian youth. Ethnic prejudices, hostility, and the use of foul language are replacing love among neighbors. Thus, to counteract the destructive values, it is imperative to revitalize indigenous parenting that enhances harmony and respect among individuals through investigating the Oromo indigenous parenting (Parental values, practices) and its role in child behavioural outcomes.

Statement of the Problem

Oromo indigenous cultures have been eroded because of different factors. Currently, in different settings such as in schools, community and the family the number of children who are not exhibiting respectful behaviour and not knowing '*safuu'* (Oromo morality) are increasing. According to Pence & Nsamenang (2008), the diversity of child and parent contexts was being steadily eroded. Globally, children are increasingly homogenous and western-driven with a tone of fabricating a "global child", a "global parent" and "global parenting. Thus, promoting indigenous parental values and activities helps individuals promote social and academic intelligence. Super and Hrkness (2008); Weisner (1997) indicated that African parents promote social intelligence. Nsamenang, (1992) also discussed that Community parenting in Africa helps the child develops a sense of responsibility through gradual engagements in work from early in life (e.g. older children serve as mentors for younger ones.

Weakening of Oromo parental values and activities may lead to producing generation/children who are disobedient, disrespectful of rules, untrustworthy, non-compassionate, immoral, non-religious, and less hard workers who, rather than being solutions, become parts of the different social and political problems that the country is currently facing. Preserving and using indigenous Oromo positive parenting practices could contribute to fostering positive behaviours in children and lay a foundation for societal values for collaboration, peaceful coexistence, stability and development. Thus, this research intended to examine the

characteristics of Oromo indigenous parenting (parental values and practices), and investigate the role of Oromo indigenous parenting (Parental values, practices) in child behavioural outcomes.

Methods

The study used a qualitative research approach and described the characteristics of Oromo Indigenous parenting (parental values, practices) and their role in children's behavioural outcomes. For this purpose, three community elders from Ambo town, and two academics (one from Ambo University and the other from Addis Ababa University), who have records for studying the Oromo indigenous childcare practices, were interviewed as primary informants for the study. In addition, 24 people were chosen from Ambo town for Focus Group Discussion (FGD) utilizing purposive sampling to ensure that the most resourceful people were included. Accordingly, three FGD with 8 members were carried out. These participants were selected based on their experience in raising children and believed to have a good knowledge about Oromo parenting. Secondary data, on the other hand, was acquired from both published and unpublished sources. The role of Oromo Indigenous parenting (parental values, practices) and its role in child behaviour outcomes were described, interpreted, and understood using thematic analysis. Thus, the qualitative data were coded, analysed and categorized into themes to produce a final report.

Results and discussions

In this part the organized data were presented and discussed.

Oromo Indigenous Parental Values and Practices

Family Establishment: Marriage Practices and Values

Parenting in Oromo society begins with the formation of a family. One of the most important practices in Oromo culture is marriage, which serves as the foundation for family formation. Oromo people talk about three things that are added to or taken away from an individual in a lifetime. These are birth, marriage, and death. Marriage is highly regarded and respected in Oromo culture, with mothers, fathers, and relatives preparing their children for marriage in order to form a stable family. Thus, Oromo indigenous parenting prepares the children for marriage which in turn plays a great role in forming successful parenting. Concerning this issue, an informant elder living in Ambo town pointed out that:

> *"A family does not form overnight; rather, it takes time for parents to counsel their children on marriage at a young age. They teach their children how to deal with their marriages and how to coexist with their partners. The Oromo mother gives her daughter instructions on how to start a healthy family, engage with her husband, respect his parents, and conserve resources, among other things. Safuu is taught to youngsters by their mothers and fathers (Oromo Morality). Parents also provide their son guidance on a variety of topics. A son is supposed to uphold his father's name by honoring his family, working hard, adhering to community standards and beliefs (learning Safuu, for example), and so on."Ilmi utubaa Abbaa qabata," an Oromo proverb says, "means son will take over father's livelihood."*

In Oromo culture families prepare their children for marriage because marriage holds a special place in the hearts of Oromo people, as it is a matter of survival. Marriage in Oromo society involves not only the interaction of spouses and their parents but also the interaction of relatives and clans on both sides. The father and mother of the bride will bless them while the bride and groom hold the glass together and say walitti *horaa bulaa*, which means have children, wealth, and all necessities of life and live together, according to Beyene and Tolera, 2006, in Practices of marriage among the Gidda, Wollega Oromo. *Garaan keessanii fi afaan keessan tokko haata'u*: be of the same mentality and attitude. The community also plays its part in preparing children for marriage. Marriage, according to

the Oromo people, is unavoidable for everyone and respected event. The Oromo proverb "*Duutii fi fuuti hin oolu*" backs this up, meaning: Death and marriage are inevitable events.

Parents prepare their children for marriage to occur with the permission of both the girl and the male rather than by force. Instead of arranging marriages for their offspring, the Oromo negotiate. During this negotiation, the boy's family requests that the girl's family give her to their son. Giving the daughter away to a man she does not wish to marry is 'Safuu' (immoral) throughout the marriage process. As the boy approaches marriageable age, his relatives and families, as well as the boy himself, look for girls for him. In relation to this informant, the elder from Ambo town stated:

"In the past, when an Oromo male would reach marriageable age, he and his parents used to speak with relatives to choose a suitable bride. They look for a girl who respects 'Safuu', values and norms, and comes from a large family. When they find a girl who meets the boy's requirements, they set up a meeting where they communicate and agree to marry. Following the girls' and boys' agreement to marry, the boy informs his parents to send elders with fresh grass and a note to the girl's family. The family of the girl requests that they be given additional time to respond to their request. The girl's family then inquires if she knows him and agrees to marry him."

The Oromo parenting practices have shaped and guided the indigenous Gada system. The Gada system regulates political stability, economic progress, social activities, cultural obligations, moral responsibility, and the society's ideology of religious order. Individual duties and obligations are recognized under this system. *Gada* plays a prominent role in keeping social order and maintaining positive family functioning through the elimination of social evil and unfairness. The *Gada* system requires each family member and all society members to fulfil their obligations and enjoy privileges at the appropriate times. Girls of three *Gadaa* periods (twenty-four years old) and males of four *Gadaa* periods and higher (over 32 years) would be allowed to marry under the '*rakoo*' (marriage rule). Because they were serving in the military, males from the three *Gadaa* periods would not be allowed to marry or have children. This is due to the worry that if they died in battle, their family would be put in jeopardy (Legesse, 1973). This demonstrates that the Oromo people are aware of and can predict the impact of today's decisions on future generations.

Today, especially in urban areas, parents' roles and Gada's guidance are declining and are not in existence. Individuals themselves inform their parents, as well as the church or mosque, once they choose someone to marry, especially in urban areas.

For the Oromo adolescent boy or girl, having sexual intercourse before marriage is outlawed and prohibited. Rape and drinking addiction were also strictly prohibited. Before getting married, a lady should not lose her virginity. For her parents and community, the lady's virginity is a source of pride. She and her family will be shunned in the community if she loses her virginity before marriage. Thus, families safeguard and counsel their children to instil respect for '*Safuu'*, refrain from having sexual relations before marriage, refrain from harming others or raping other girls, and refrain from using drugs.

Parental Values of bearing children

Parenting practices, goals, roles, and behaviours that parents value in their children are socially constructed rather than universal. Children's future development is influenced by their cultural, social, environmental, and physical environments. In Oromo Culture, children and childbirth are highly appreciated. Oromo people felt that marrying a woman was primarily to have a child and extend the family's existence in the future. Bearing offspring was highly treasured by the Oromo people, and it might be considered one of the most significant aspects of human life. According to Legesse (1973), the Borana woman desires children more than anything else in the world. Women who are capable of

bearing children are valued and respected in society. This belief was described in the Oromo proverb as follows:

Waaqaroobuu fi dubartii deessurraa waa argatu: A wet sky and a fertile lady provide something.

People in Oromo culture pay all necessary expenses to nurture their offspring. In Oromo, there is a saying that states, *"Dhalaa fi qoonqootu saree nama godha*," which means "It is a baby and a throat that makes you a dog." The proverb demonstrates that parents are extremely concerned about their children and will go to any distance to raise them. Parents are having a difficult time raising their children.

People also feel that the sacrifices they make today will pay off in the future. '*Ilmoon itti cabanii guddisan cabaa nama baasti'* is an Oromo saying, which means that "A child who is raised with scarifies brings out the broken". Children, according to the saying, are the future's hope. As a result, in order to be serviced in the future, everyone should raise the child by giving them what they require. People believe that properly protecting and nurturing a child will lead to them being a great person in the future and bringing benefits to the family and community. In Oromo society, this commitment is quite strong.

Having a large family is regarded as a source of pride.

In Oromo, infertile women ('*maseena*') practice *gudifacha* (adoption) to deal with the challenges that arise with infertility. Thus, *Gudifacha* (adoption) is a well-known Oromo practice for promoting positive parenting. Marriage and family formation were likewise considered to be God's work by the Oromo people. Waaqaa provides fertile ladies and their children (God). Having a large family is considered a blessing. The Oromo people say: *Niitii deessuu fi qalbiin kennaa Waaqat*i, which translates to: God's gifts are a fruitful bride and a psyche. One informant has stated:

> *"Bearing children is seen as a blessing in Oromo culture; no one can have a kid without the assistance of God. The Oromo people want to have a large family. People who have numerous children and a large family would get social stability, economic gain, and dignity, among other things."*

Children are the primary source of economic, social, and physical support in Oromo society. Hence, the Oromo women pray to *Waaqaa* (God) for a son. Belay Tefera and Dawit Solomon (2015) discussed that among Christian Ethiopian dads in Addis Ababa and Nashville, USA, the functional worth of children (psychological, social, and economic) was one of the reasons for childbearing. As a result, the Oromo people place a high emphasis on having a large number of sons. Folktales among the Oromo emphasize the value of having many sons. For example, the following "*geerarsaa*" (an Oromo folktale) expresses the problem of having too few boys.

Bara boqqoolloon bade :	*The year the maize disappear*
Ijoollee fi sareetu bade :	Children and dogs have ruined
Bara caamni dheerate:	When a drought lasts for a long time
Dullootaafi jabbiitu badee:	*The old and the jackals are gone*
Bara waraannihammaate:	*During the worst of the war*
Hadha ilma tokkootu bade:	*The mother of a son is missing*
Haati mucaa tokkittii:	*A mother with a single son*

Gaafa du'aa fokkifti. : She's ugly when she dies.

The presence of a family in Oromo society is seen to play an important role in child-rearing. Regardless of their socioeconomic situation, Oromo people believe that raising children in the family is the best option. *'Hadha dhabuu mannaa, haadha dhabduu wayyaa*,' according to an Oromo saying, "having a destitute mother is better than not having a mother at all." Another saying states, "*Ijoollee fi barcumni abbaa jalatti tolti,*" which translates to "Children and chair look good with the owner." Children require parental support and care, according to this saying. This is backed up by proponents of family-based child intervention, who highlight the significance of supporting and assisting children through their parents.

Family members play an important role in socializing their children to ensure their future success. Parental behaviour can have a significant impact on their children's future outcomes. For instance, when a young man wishes to marry a girl, he should take into account her entire family's qualities and behaviours. According to an Oromo saying, *"Haadha ilaalii intala fuudhi,*" one should marry the daughter after examining the mother.

Parental training in child-rearing

Parents train their children to form successful parents in the future and competent individuals. For instance, mothers counsel and train their daughters to become skilled wives with self-confidence to lead their family life when married.

In the past, girls are often trained for inside duties (firewood, caring for younger siblings, fetching water, and assisting moms in the kitchen) whereas boys are prepared for outdoor activities (herding cattle and helping fathers with farming activities). Currently, the community, particularly in towns, is not supportive of this trend. According to one female FGD participant;

> *"In the past, when boys were observed doing domestic chores like cooking or assisting their mothers in the kitchen, others would have laughed at them. This trend is currently changing; for example, when I am exhausted, both my son and husband help me."*

Even though child-rearing tasks and household chores remained gendered and traditionally defined in the past (Abera, 2014), the pattern is currently shifting. People are considering the importance of gender equality in all activities and want to raise their children in such a way. According to one FGD participant;

> *"In the past, and still today in rural areas, men did not consider themselves as they perform domestic activities such as assisting their wives in the kitchen, caring for their children, and cleaning. They believe they are only involved in outdoor activities. Both husband and wife assist each other in towns, especially among educated people. For example, my husband and I both work for the government, and he is always willing to assist me with household activities such as caring for and feeding our child, as well as completing unfinished chores. However, there are other activities that I do on my own. I want both daughters and son in such a manner; it enhances a sense of cohesion and love among family members".*

Hence, the value that people place on both girls and boys is equal. In reality, in the past, boys were given higher attention than girls. In relation to this issue, an informed elder added that;

> *"In the past, sons were favoured over girls for a variety of reasons, including generational transmission, family reproduction through marriage, protecting his father's property, and inheriting family wealth, and so on... But, currently, things are changing; children are in school, and they have all left home to work. In*

addition, the government announces that both men and women have an equal right to inherit their family's riches."

Parenting as a collective family and community responsibility

Parents' approaches to shaping their children's development vary by culture. Cultural context influences parental values, activities, and socialization goals for their children. Religion, age, gender, and place of residence all have an impact on how children live and grow up in Ethiopia (Tamene, 2008). Parental perspectives, expectations, and parental functioning are all influenced by culture (Tamminen, 2006). As a result, various studies divide our society into two wide and rigid parenting groups/cultures: (Individualistic/Independent/Western Vs. Collectivist/interdependent/non-western). The way these groups are seen varies by culture, and what is good in one community may be considered maladaptive in another. Most non-Western cultures, including Ethiopian parenting activities, that employ authoritarian parenting as the normative for rearing their children and promoting optimal development are considered group oriented since individuals are taught to cooperate with the bigger unit (family, community, country).

Parenting activities are culturally appropriate activities that include providing for a child's physical needs, protecting them from harm, and teaching them skills and cultural values. Parental activity to socialize children in Oromo society is multidirectional rather than solely the responsibility of biological parents. As a result, child-rearing activities involve not just biological family members, but also extended family members, relatives, and the community.

As a result, it takes a village to raise a child. In this process parental values; storytelling, folklore, and oral stories helped families and communities teach their children more about the real world. . Parents, friends, and communities have a critical role in nurturing and assisting youngsters to discover their hidden wealth, according to the report. Thus, every parent and community member bears responsibility for creating a cohesive family based on moral values.

Within the Oromo family structure, there is a division of work among family members based on personal qualities such as talents, gender, age, mental health, and knowledge/wisdom, with one family member responsible for a certain set of responsibilities. In Oromo culture, for example, each family member has distinct tasks and obligations that are determined by the leader.

Oral traditions in Oromo culture assist parents in guiding their children, providing proper control mechanisms, and assisting each family member in performing culturally appropriate actions that are expected of them. Even the implications of poor parental behaviour on subsequent development are described in folktales and proverbs. For example, the Oromo say, "*Intallii haati jajju hin heerumtu,"* which translates to "girls who are always prized by her mother cannot get married." This suggested that permissive parenting can result in subsequent societal problems at individual and societal levels.

Oromo Parenting and Child activity

Children in Oromo culture participate in a variety of activities. Some of the works are gendered in some way. Children are expected to assist with minor household duties and the care of goats and sheep from an early age. Children are expected to look after the cattle as they grow older, as well as assist with farm chores like planting corn and harvesting. Children are also responsible for collecting firewood and water, assisting with cooking and other home chores, and looking after siblings.

Children do not complain about their involvement in various activities; rather, they regard it as a pleasurable activity and an important element of their lives; they regard work as a vital component of their lives and social relationships. Oromo children are currently involved in a variety of activities. They work for their families as well as for themselves. Some youngsters work to support

their own expenses (e.g., educational and clothing fees). Children enjoy participating in various activities and carrying out their obligations.

Oromo Indigenous disciplining children

Parental guidance, sometimes known as discipline, is an important aspect of parenting. Parents want their children to be self-assured, socially responsible, self-controlled, and cooperative. Children in Oromo culture are raised to know '*Safuu'* (Oromo Morality) and to support their families and communities. Disciplining a child in Oromo culture is done verbally and/or psychologically rather than physically. Physically punishing children is *safuu* (morally wrong). *Safuu* forbids parents from physically punishing their children. " Oromo people appear to be able to discipline their children using verbal admonitions, threats, and withholding subtler psychological benefits to which the children are accustomed (Legesse, 1973). As a result, *Safuu* disciplines and protects children from exploitation, forced labor, and physical punishment, among other things. As a result, Oromo people's child-rearing approaches are supportive rather than punitive.

Folktales such as *diraamaa ijoollee* and *durdurii* (children's folktales), *mammaaks* (proverbs), *Geerarsa*, *weedduu*, and others are used to pass on indigenous knowledge that promotes parental skills and functions while reducing maladaptive behaviours from generation to generation. Oromo parents teach their children appropriate behaviour, apply social pressure, and exercise social control in order to maintain social stability in general and excellent parenting in particular, using their indigenous wisdom.

The function of *Safuu* to foster good parenting

Oromo people have a holistic and relational worldview that helps them grasp what is wrong and right. The Oromo people's moral code is called *Safuu*, and it is founded on the concepts of distance and respect for all things (Alamayo, 2015). The Oromo show respect for one another and all living things. Between parents and children, as well as between older and younger brothers and sisters, there is *safuu*. Between humans and animals, as well as between humans and plants, there is *safuu*. The Oromo people respect each other. This is a two-way regard in which the younger respects the elders, and children respect their parents and vice versa. Both the father and the mother have mutual respect for their children. Families who do not respect one another are families who do not know of *safuu*. *Safuu* also plays an important role in the functioning of the family by encouraging the husband and wife to stay faithful and listen to each other. They are seen to be breaking *safuu*, or the moral norm, if they oppose and refuse to take advice from each other (Kelbessa, 2005). Thus, safuu (Oromo morality) plays an important role in fostering good parenting and disciplining children.

The Oromo society places a high value on respecting and protecting children and women. Failure to protect any child from danger (not just his or her own) is also *safuu* (immoral). A man who does not appreciate a woman with a *siiqqee* (Stick) does not understand *safuu* (immoral). If the women stand between the battling parties holding *siiqqee*, they will immediately stop fighting; otherwise, it will be safuu (immoral). During wartime, the Oromo do not consider their enemies' women and children as adversaries. They say *'Ijoollee fi dubartiin diinummaa hin qabdu*,' This means that women and children are not enemies. During a conflict, it is *safuu* (immoral) to attack women and children.

Generally, the purposes of '*safuu'* (oromo morals) are varied. '*Safuu'* regulates the Oromo world by regulating people's activities (Østebø, 2009). Without *safuu*, we can't imagine Oromo society. When they eat and drink, or when they attend a wedding, they talk about *Safuu*. The *Gadaa* system's laws are formed on Safuu's essential principles. It is impossible to discuss Oromo religion, political system, or social structure without including *Safuu*. The parenting process is shaped and guided by *Safuu* (Abera, 2014). Therefore, *safuu* can direct family functioning and build societal well-being.

Oromo Indigenous oral traditions in promoting positive parenting

The Oromo people have a rich oral tradition through which they make sense of their surroundings and pass along knowledge to their children. Folktales are a device and resource for children in Oromo culture, as well as an instrument for adults to teach and approve social norms and culturally appropriate behaviours.

Oromo parents use proverbs (makmaaksa), sayings (jechama), riddles (hiibboo), folksongs (sirbaaadaa), nursery rhymes (ururssaa), religious songs (faaruuamantii), and fable stories (oduu durii) to teach culturally appropriate behaviour, communicate their beliefs about how a child should be reared, and educate their children Through maintaining family stability and socializing children, Oromo folklore has a significant role in promoting effective parenting and social stability. They are used to warn individuals, give counselling, teach morality, and guide people to follow prescribed societal values, mores or ideals. They play important roles in educating and guiding children, encouraging good behaviour and discouraging negative behaviour, fostering social conformity, promoting moral purity, and enhancing cultural belongingness, all of which contribute to healthy parenting.

Everyone does not play Oromo folklore at the same time. For example, among the various forms of folklore, Oromo youngsters frequently play riddles (*Hibboo*) and "*Hibboonteetee*" with each other at night, with the help of their elders. Later, they exclusively play riddles at night. At the moment, children are playing at school during the day.

Parental Practices and Child Behavioural Outcomes

Oromo parenting practices are critical in assisting children in achieving basic outcomes in the areas of physical health and safety, as well as social and cognitive capabilities as children engaged in the chores expected of them. Children are expected to be healthy and perform well at home, school, and in the community by their parents and communities. The Oromo people expect their children to grow up following the Safuu principles such as respect, truthfulness, Trustworthiness, helping, Integrity, etc.

Though parents play an important role in their children's growth, youngsters are expected to help themselves and be more capable than their forefathers. Families want their children to be self-sufficient and capable in all aspects of their lives. In Oromo tradition, there is a blessing for the son (literally stands for both sex), which is said to make him/her competent and capable of carrying out his/her responsibilities. When it comes to this topic, Oromo people often say: *Ilmi walii sadi*; sons can be divided into three categories.

- *Ilma abbaa dhaanu: the son who hit his father.*
- *Ilma abbaa dhaalu fi: the son who inherit his father, and*
- *Ilma abbaa caalu: the son who excels his father*

Oromo people bless their sons and express their expectations by saying: *Ilma abbaa caalu ta'i!,* meaning you may be the son who outperforms his father. Concerning the expected outcome of children, one elder informant said that:

> *"Oromo people expect his offspring to be lawfulness, honest, hard work, no defensiveness, flexible and respect".*

The Oromo people expected physical, social, and cognitive competence from their children.

Physical health and safety: Children in Oromo society participate in a variety of indoor and outdoor games and sports, which help them, improve their performance and minimize their chance of developing chronic diseases like diabetes and obesity later in life.

Expected Social Outcomes: It entails the willingness of a child to get along with and respect others including the elderly, siblings, peers, and other members of the community. It

also includes children's to develop prosocial behaviours, such as empathy and concern for others' feelings, cooperation, sharing, and perspective taking, which have been linked to academic and non-academic success. Parents in Oromo communities train their children to adopt culturally acceptable beliefs and practices that allow them to be socially competent and behave as members of a community. The socially competent child demonstrates social skills (e.g., has positive interactions with others, successfully expresses emotions), can form good peer relationships (e.g., is accepted by other children), and possesses particular personal characteristics (e.g., shows capacity to empathize, has coping skills).

Parents can assist their children in developing these skills by allowing them to participate in activities such as chores, caring for siblings, playing with siblings and other children, attending family rituals (e.g., church, *Irreecha*, *Wakenffanna*), and participating in various folktales such as riddles (*hibboo*), *hibbon Teetee*, *Oduu durii* (foltales).

Parents teach their children to respect seniors and others who are older than them. Children respect their elders; the younger sibling respects the older sibling, and the wives of the younger brother respect the wives of the older brother. All these instances can help individual children to model appropriate social skills and emotional development.

Expected Cognitive Outcomes*:* It includes language and communication abilities, as well as problem-solving, reading, writing, and numbers. Children in Oromo communities develop these skills by playing games such as folktales, riddles, and proverbs. These games includes *Hibboo*, *Hibboonteetee*, *Kuruttuu*, *oduu durii* and others.

Playing with blocks, puzzles, solving riddles and number games, and playing with fake money can all help a child's cognitive development.

For instance, "TokkoMaali?" is a classic game that youngsters play to help them strengthen their cognitive skills.

- *Tokkeenmaali? –tokkee ntokkichuma : What is one? – One is one*
- *Lame nmaali? – lamaan mucha re'ee – What is two? – Two is goat's breast*
- *Sadeen maali? –Sadan Sunsumani - What is three? – Three is 'Sunsuma'(stone or earthen for holding up cooking vessel in a fire place)*
- *Arfee nmaali? - Arfan Mucha sa'aa- What is four? – Four is cow's breast*
- *Shaneen maali? – shanan quba harkaa- what is five? – Five is human's finger*
- *Ja'a maali?- ……*

In general, children's physical, cognitive, and social intelligence can be improved by playing with peers in cattle herding grounds, as well as at home with oral tradition through interaction with their parents and siblings.

Conclusion and Recommendation

Conclusion and Implication

Parenting represents the quality of parent-child relationships, which varies depending on context and is influenced by cultural beliefs and values. The Oromo people have a unique set of parenting practices. Oromo Indigenous Parental Values, Practices, and Child Behavior Outcomes are outlined in this report. This study aims to revitalise positive parenting, present and advocate the qualities of Oromo Indigenous parenting (parental beliefs, practices, and child behavior outcomes). In Oromo society, parenting is not solely the responsibility of biological families; it also involves extended family members, neighbours, and the community. Furthermore, parenting is a moral, social, and spiritual responsibility shared by the entire community.

The Oromo have amazing oral traditions and folktales that teach, advise, and direct parents on how to institute discipline and socialize values that encourage effective parenting. Folklore, proverbs, story-telling, riddles, and poetry have all been used to transmit these oral traditions and make parental practices successful. Because of many socioeconomic causes, these traditions are eroding. Knowing

and applying this knowledge resulted in a smooth developmental transition from infancy to maturity, rather than a traumatic and unpleasant shift in many circumstances.

The main goal of Oromo communal parenting is to build interdependence, collaboration, care, respect, and hard work among family members and communities in order to improve individuals' physical, social, and cognitive development. It also helps to train the children for marriage and build successful parenting.

Oromo people used folktales to guide and correct children, which are thought to help children become physically, socially and mentally competent, socially responsible, and cooperative. Oromo folklore plays an important part in promoting successful parenting, socializing youngsters, maintaining societal stability, encouraging good behaviour, and resolving conflicts. Children's development can be aided by the practice of telling oral traditions such as folktales and riddles , which can increase their problem-solving skills, conversation and social skills, thinking, and reasoning abilities. Children are also expected to act in accordance with *Safuu* (Oromo Morality).

Oromo society reflects a collectivist worldview and communal culture. Sociability, security, harmony, obligation, family integrity, and obedience are all promoted in Collectivist cultures. As a result, such values must be safeguarded and fostered in order for individuals and communities to achieve effective development and a high quality of life. Because each culture has its own values, customs, and aspirations in terms of parenting style, there is no universally accepted parenting style. It's impossible to judging one parenting method as more effective than others. In Oromo society, for example, collectivist parenting plays an important role in child development. For example, (Abera, 2014) claimed that the majority of Arsi Oromo households foster collectivist authoritarian parenting.

Parental values, activities and outcomes are dynamic. They change overtime depending on the context because of the socio-economic and political changes that influence the culture of a specific group. Parenting strategies change depending on where parents live, their educational level, and their career. As a result of changes in society's socioeconomic condition and political transformation, parenting habits in Oromo culture are changing.

Recommendation and Future Direction

Although Oromo parenting is a relatively new topic in literature, the practice has a long history in society. Cultural contexts, parents' own experiences throughout childhood, and expectations learned from others, such as family, friends, and community, can all influence parenting values, practices, and child outcomes. As a result, the following recommendations have been suggested in order to improve the notion and conserve Oromo indigenous parenting practices in general, and Oromo parenting in particular:

First, the community needs to be made aware of how Oromo parental values influence children's behavior and later personality development through the media, educational institutions, and governmental and non-governmental organizations.
Second, studies on the role of a family's own childhood experiences in promoting culturally appropriate and positive parenting in their own children are needed.

Third, studies on the function of African parenting in general, and Oromo parenting in particular, are needed to produce competent citizen and address current parenting trends such as a high divorce rate, an increase in the number of single parents, and remarriage. Studies are also needed to see how poverty, neighbourhood, long-term job, and growth in female working affect Oromo parenting.

Fourth, indigenous knowledge must be incorporated into the Ethiopian educational system in general and school activities in particular in order to generate competent generations.

Fifth, Oromo indigenous practices (such as folktales, proverbs, and *safuu*) that are thought to promote effective parenting are not visible in our daily lives and are not taught in school. Thus, special attention should be given to indigenous knowledge promotion in order to maintain positive parenting.

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Conflict of Interest

The Authors declare that there is no conflict of interest

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