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Research Article

Prevalence and potential risk factors of bovine clinical mastitis in Bonke District, Gamo Zone, Southern Ethiopia

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Abstract

Ethiopia has the largest cattle population in Africa with an estimated population of 56.71 million. Among these, the cow represents the biggest portion of the cattle population of the country. Currently, around 20.7% of the total cattle heads are milking cows. 85-89 percent of milk is contributed from cattle out of the total annual national milk production in Ethiopia that ranges from 797, 9000 to 1, 197, 500 metric tons of raw milk equivalents.. However, this amount does not satisfy the national demand for milk and milk products in the country due to a number of complex and interrelated factors including inadequate feed and nutrition, widespread diseases, the poor genetic potential of local breeds, poor market chain, and inefficiency of livestock development. Concurrently, mastitis is one of the major and expensive diseases which can alter milk composition, reduce the quality and quantity of milk yield, and indeed cause the culling of dairy cows at their age of high productivity. Clinical mastitis is the types of mastitis emphasized in this study. A cross-sectional study was conducted on 384 lactating cows to assess the prevalence of bovine clinical mastitis and its potential risk factors in the study area. Out of these 41(10.7%) were found positive for clinical mastitis. All the potential risk factors considered in this study showed statistically significant difference ($P < 0.05$). The present study concludes that mastitis was a key health problem of lactating cows in the area. Therefore, deliberate control measures against the disease and regular reconnaissance measures are recommended.

Keywords: Bonke; Bovine clinical mastitis; Prevalence; Risk factor

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1. Introduction

Ethiopia, a country located in the tropical region, is greatly dependent on Agriculture. Livestock production represents a major national resource and forms an integral part of the Agricultural production system and livelihood of the society. Ethiopia has the largest cattle population in Africa with an estimated population of 56.71 million. Among this cow represents the biggest portion of the cattle population of the country. Around 20.7% of the total cattle heads are milking cows (CSA, 2014).

Milk and milk products collected from these animals provide an essential dietary source for the majority of the rural population as well as a considerable number of the urban and peri-urban population. The total annual national milk production in Ethiopia ranges from 797, 900 to 1, 197, 500 metric tons of raw milk equivalents. Out of these, 85-89 percent of milk is contributed from cattle. However, this amount does not satisfy the national demand for milk and milk products in the country (FAO, 2003). This is associated with a number of complex and interrelated factors such as inadequate feed and nutrition, widespread diseases, the poor genetic potential of local breeds, problem of market , and inefficiency of livestock development (Solomon et al., 2003; Negassa et al., 2011). Mastitis is one of the major and expensive diseases in terms of production losses in dairy production (Abebe et al., 2016; Bardhan, 2013).

The study area is one of the residences of the cattle population in which bovine mastitis is a potential problem in milk production. Yet there are no sufficient studies conducted. Therefore, this study was designed with the intention of estimating the prevalence and assessing associated potential risk factors of bovine clinical mastitis in the study area.

2. Materials and Methods

2.1. The study area

The study was conducted in Bonke ~~D~~istrict, Gamo Zone, Southern Ethiopia. Bonke is bordered in the South by the Geresse, in the West by Kamba, in the North by Dita, in the Northwest by Daramalo, and in the East by the Gacho Baba districts. The climatic condition of the study area included a long rainy season (beginning of May to November) and a short sunny season (December to April). The annual mean temperature and rainfall of Bonke is 13^0C and 1200mm, respectively. The minimum elevation of the district is 2500m.a.s.l. while the maximum elevation is 4200m.a.s.l. The dominant livestock species in the study area are cattle, sheep and poultry, but there are also some goats, mule, and donkeys.

2.2 Study population

The study population included lactating cows of different farmers and they were at different ages, lactation stages, parity and breeds. They were selected randomly from the cattle population present in the study area.

2.3. Study design

A cross-sectional study was conducted to estimate the prevalence of bovine clinical mastitis and assess risk factors in the study area. The study was carried out from June 2021 to November 2021 by collecting events associated with mastitis from owners of lactating cows.

2.4. Sample size and sample size determination

The simple random sampling technique was used for the study of the prevalence of bovine clinical mastitis and its risk factors in Bonke District, Gamo Zone Southwestern Ethiopia. If previous studies were available in the study area, total sample size of the new could be calculated from the value determined during the previous study.

However, since there was no previous work done on the prevalence of bovine clinical mastitis and its risk factors in the selected study area, the sample size was determined with 95% confidence interval and at 5% desired absolute precision, assuming the expected prevalence of the bovine clinical mastitis in the study area to be 50 % (Thrusfield, 2005). Therefore, the formula (Eq. 1) and total estimated results (Eq. 2) are shown here:

$$N = \frac{1.96^2\ (\text{Pexp})\ (1 - \text{Pexp})}{d^2} \quad (1)$$

Where N is the required sample size, Pexp is the expected prevalence and d is the desired absolute precision.

$$N = \frac{1.96^2\ (0.5)\ (1 - 0.5)}{0.05^2} = 384 \quad (2)$$

2.5. Clinical examination of mastitis

A clinical examination was conducted to determine the prevalence of clinical Mastitis. Udder was examined for visible abnormalities, symmetry, size, consistency, presence of lesions and/or ticks.

Clinical Mastitis was recognized by some pathology in udder, which is manifested by signs of inflammation like swelling, pain, redness and heat in case of acute mastitis. Whereas, hardening of the udder, blockage of the teats, atrophy or fibrosis and abscess formation were manifested in chronic Mastitis. Acute Mastitis was also recognized by changes in milk color, and the presence of flakes and clots (Moges et al., 2012).

2.6. Data analysis

The data was entered into a Microsoft excel spread sheet to create a database and transferred to the Stata Version 9 before analysis. The association between the prevalence of bovine clinical mastitis and the assumed risk factors were tested with Pearson chi-square procedure. The prevalence of bovine clinical mastitis was calculated for all data as the number of infected cows divided by the total number of cows and multiplied by 100. Values were considered statistically significant when the P-value was less than 5%.

3. Results

3.1 Prevalence of bovine clinical mastitis

A total of 384 local and crossbreeds were included in the study. Out of these lactating cows 41(10.7%) were found to be affected with clinical mastitis. When bovine clinical mastitis was compared between local and crossbred cows, a higher prevalence was observed in crossbred cows, with a prevalence percentage of 75.6 (Table 1).

3.2. Prevalence of bovine clinical mastitis based on risk factors

Breed, age, parity and stage of lactation have significant influences ($P < 0.05$) on the prevalence of bovine clinical mastitis.

3.2.1. Breed

The effect of breed on the prevalence of bovine clinical mastitis was studied and analyzed and the result revealed that breed had a significant effect ($P < 0.05$). Among the breeds studied in the study area, crossbreeds have higher prevalence of clinical mastitis (75.6%) than local breeds (24.4%).

Table 1. The prevalence of bovine clinical mastitis on the basis of breed

Breed	Studied cows	Mastitis positive	Prevalence (%)	χ^2	P-value
Local	202	10	24.4		
Cross	182	31	75.6	13.81	0.000

3.2.2. Lactation stage

The stage of lactation was the risk factor for bovine mastitis. The lactation stage was found to play a vital role in the prevalence of bovine clinical mastitis in the study area. The difference in the presence of bovine mastitis in the study population according to the category set was statistically significant indicating that those cows at the end stage of lactation were affected the most.

Table 2. The prevalence of bovine clinical mastitis based on stage of lactation

Lactation stage	Sampled cows	Mastitis positive	Prevalence (%)	χ^2	P-value
Early	105	18	43.9%		
Mid	171	4	9.8%	54.93	0.001
Late	108	19	46.3%		

3.2.3. Parity

The prevalence measure on the basis of parity in this study was statistically significant at (P < 0.05). A higher prevalence (46.3%) was recorded in cows that gave birth to five calves and a lower prevalence (4.9%) was recorded in cows that gave birth to one calf.

Table 3. The prevalence of bovine clinical mastitis on the basis of parity

Parity	Recorded cows	Mastitis positive	Prevalence %	χ^2	P- value
Parity 1	62	2	4.9	26.03	0.000
Parity 2	84	3	7.3		
Parity 3	73	7	17.1		
Parity 4	76	10	24.4		
Parity 5	89	19	46.3		

3.2.4. Age group

There was a significant difference in the prevalence of bovine mastitis between animals of different age categories (P<0.05). Higher prevalence (65.9%) was found in adult lactating cows (ages greater than six years) compared to young lactating cows (ages less or equal to six years) (34.1%).

Table 4. The prevalence of bovine clinical mastitis on the basis of age

Age	Sampled cows	Mastitis positive	Prevalence %	χ^2	p- value
Young	218	14	34.1	7.42	0.006
Adult	166	27	65.9		

Young= cows less or equal to six years, Adult = cows greater than six year

4. Discussion

This study focused on the prevalence and risk factors of clinical bovine mastitis only. The study revealed that 10.7% of the cows were positive for clinical mastitis which agrees with a study by Zeryehun and Abera (2017) who reported 10.7% prevalence of clinical mastitis in selected districts of Eastern Hararghe Zone. It is also congruent with of the findings of Tollosa et al. (2009) who reported 9.5% prevalence of bovine clinical mastitis at Wolayta Sodo town of South central Ethiopia. This in turn agrees with the study of Alemu et al. (2013) who reported

9.7% prevalence of bovine clinical mastitis in and around Gondar town. Similarly, Mitiku et al. (2017) reported 9.31% clinical prevalence at Sebeta. The finding of this study is nearly similar with the reports of Mekbib et al. (2010), Sarba and Tola (2017), Lakew et al. (2009), Girma et al. (2010) and Bitew et al. (2010) who reported 10.0%, 9.9%, 10.3%, 10.3%, and 11.9% clinical prevalence of bovine mastitis at Holeta Town, Ambo District, Asella, around Holeta Town and around Bahir Dar and its surroundings, respectively. On the other hand, the study showed differences in prevalence of mastitis with studies in other areas, which could be attributed to the variation in management, environmental hygiene and difference in the handling of lactating cows.

This study on the prevalence of bovine mastitis revealed a higher prevalence in cross-breed cows (75.6%) than in local breeds (24.4%). This agrees with the report of Alemu et al. (2013) who described a higher prevalence of mastitis (60.2%) in cross-breed cows than in local breeds (23.1%) in dairy farms in and around Gondar town, which might be due to differences in the anatomical structure of the teats and difference in genetic resistance to disease (Radostits et al., 2007). In addition, high-yielding cows are more susceptible to mastitis than low-yielding ones. This may be due to the ease with which injuries are sustained in large udders, so the foci for the entrance of pathogens are created, and stress associated with a high milk yield may upset the defense system of the animal (Radostits et al., 2000). This is consistent with the report of Sarba and Tola (2017) who described a higher prevalence of mastitis (47.2%) in cross-breed cows than in local breeds (15.4%) in Ambo district.

The relationship between the prevalence of bovine mastitis at different lactation stages was studied; and the result showed significantly higher infection ($P < 0.05$) in cow with late (46.3%) and early (43.9%) lactation than in cows with mid-lactation stage (9.8%). This finding closely agrees with the finding by Gebremichael et al. (2013) who reported the higher prevalence of bovine mastitis (51.2%) in the late stage of lactation, 37.5% in the early stage of lactation and 10.1% in the mid stage of lactation in and around Areka town. This in turn came to agreement with 48.4%, 47.4% and 45.1% prevalence of bovine mastitis at late, early and mid-stage of lactation in and around Gondar Town as reported by Alemu et al. (2013).

This study showed statistically significant association ($P < 0.05$) between parity and prevalence of bovine mastitis and observed a higher prevalence of bovine clinical mastitis in cows having greater than parity of four. This is in agreement with Moges et al. (2012) who reported cows with many calves (4-7 calves) had higher clinical prevalence (58.5%) than those of cows having (1-3) calves (22.5%) in lactating dairy cows in Hawassa. This is also consistent with the work of Kerro and Tareke (2003), Mungube et al. (2004), Biffa et al. (2005), Getahun et al. (2008) and Lakew et al. (2009). Quinn et al. (1994) have also stated that older cows, especially after four lactations are more susceptible to mastitis.

This study also showed a significant relationship (P < 0.05) between the age and prevalence of bovine clinical mastitis in the study area. Similarly, studies reported by Sarba and Tola (2017) showed a significantly higher prevalence of mastitis (72%) in older cows than in young cows (28.0%) in Ambo district. The study also agreed with Zenebe et al. (2014) who reported cows with having 4-7 calves (69.8%) were at greater risk than cows having 1-3 calves. Also, similar findings were stated by Moges et al. (2011) who reported a higher prevalence in old cows than young ones. The highest prevalence in older cows is because of their largest teats and more relaxed sphincter muscles, which increase the accessibility of infectious agents in the cows' udder (Radostits et al., 2007)

5. Conclusion

In conclusion, bovine clinical mastitis in the study area was more prevalent in crossbreeds than in local breeds. It was also higher in late lactation stages than early and mid-lactation, in cows with more than three parities, and in adult cows than young cows. Breed, lactation stage, parity, and age are relevant factors in the epidemiology of bovine clinical mastitis. This study attests that bovine clinical mastitis plays a role in milk yield loss which in turn leads to financial loss at a household level. Hence further comprehensive epidemiological and microbiological study of clinical and sub clinical mastitis involving different potential risk factors, economic impact and ways to improve milk production should be conducted in the study area.

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Conflict of Interest

There was no conflict of interest, according to the author

References

Abebe, R., Hatiya, H., Abera, M., Megersa, B. & Asmare, K.,. (2016). Bovine mastitis: Prevalence, risk factors and isolation of Staphylococcus aureus in dairy herds at Hawassa milk shed, South Ethiopia. BMC Veterinary Research, 12(1), 270.

Alemu, S., Tamiru, F., Almaw, G., & Tsega, A. (2013). Study on bovine mastitis and its effect on chemical composition of milk in and around Gondar town, Ethiopia. Journal of Veterinary Medicine and Animal Health, 5(8), 215-221.

Bardhan, D. (2013. Estimates of economic losses due to clinical mastitis in organized dairy farms. Indian Journal of Dairy Science, 66(2), 168-172.

Biffa, D., Debela, E., & Beyene, F. (2005). Prevalence and risk factors of mastitis in lactating dairy cows in Southern Ethiopia. International Journal of Applied Research in Veterinary Medicine, 3(3), 189-198.

Bitew, M., Tafere, A., & Tolosa, T. (2010). Study on bovine mastitis in dairy farms of Bahir Dar and its environs. Journal of Animal and Veterinary Advances, 9(23), 2912-2917.

Central Statistical Agency (2004). Agricultural sample survey Vol. II. Statistical Bulletin No.446. Addis Ababa, Ethiopia.

FAO (Food and Agriculture Organization of the United Nations). (2003). Livestock sector. Brief livestock information, Sector Analysis and Policy Branch, pp. 1-15.

Lidet, G. M., Benti Deressa, B. D., Feyissa Begna, F. B., & Abebe A. M. (2013). Study on prevalence of bovine mastitis in lactating cows and associated risk factors in and around Areka town, Southern of Ethiopia.

Getahun, K., Kelay, B., Bekana, M., & Lobago, F. (2008). Bovine mastitis and antibiotic resistance patterns in Selalle smallholder dairy farms, central Ethiopia. Tropical Animal Health and Production, 40(4), 261-268.

Girma, D. (2010). Study on prevalence of bovine mastitis on cross breed dairy cows around Holeta area. Global Veterinarian, 5, 318-321.

Kerro Dego, O., & Tareke, F. (2003). Bovine mastitis in selected areas of southern Ethiopia. Tropical Animal Health and Production, 35(3), 197-205.

Lakew, M., Tolosa, T., & Tigre, W. (2009). Prevalence and major bacterial causes of bovine mastitis in Asella, South Eastern Ethiopia. Tropical Animal Health and Production, 41(7), 1525-1530.

Mekibib, B., Furgasa, M., Abunna, F., Megersa, B. & Regassa, A. (2010). Bovine mastitis: Prevalence, risk factors and major pathogens in dairy farms of Holeta Town, Central Ethiopia. Veterinary World, 3(9), 397-403.

Mitiku, Y., Gizaw, Y., & Kassa, T. (2017). The prevalence of bovine mastitis and associated risk factors in cross breed lactating dairy cows in Sebeta, Central Ethiopia. European Journal of Biological Sciences, 9(3), pp.106-112.

Moges, N., Asfaw, Y., & Belihu, K. (2011). A cross sectional study on the prevalence of sub clinical mastitis and associated risk factors in and around Gondar, Northern Ethiopia. International Journal of Animal and Veterinary Advances, 3(6), 455-459.

Moges, N., Hailemariam, T., Fentahun, T., Chanie, M., & Melaku, A. (2012). Bovine mastitis and associated risk factors in small holder lactating dairy farms in Hawassa, Southern Ethiopia. Global Veterinaria, 9(4), pp.441-446.

Mungube, E. O., Tenhagen, B. A., Kassa, T., Regassa, F., Kyule, M. N., Greiner, M., & Baumann, M. P. O. (2004). Risk factors for dairy cow mastitis in the central highlands of Ethiopia. Tropical Animal Health and Production, 36(5), 463-472.

Negassa, A., Rashid, S., Gebremedhin, B. & Kennedy, A. (2012). Livestock production and marketing. Food and agriculture in Ethiopia: Progress and policy challenges, 159-189.

Quin, P. J., Carter,M. E., Markey, B. K., & Carter, G. R. (2002): Clinical veterinary microbiology. Harcourt Limited, USA.

Quinn, P. J., Markey, B. K., Carter, M. E., Donnelly, W. C., & Leonard, F. C. (1994). Veterinary microbiology and microbial disease (pp. 465-473). Blackwell Science, London

Radostits, O. M., Gay, C. C., Blood, D. C., & Hinchclif F, K. W. (2000).Veterinary medicine (9th ed.) (pp. 603-700). Harcourt Limited, London.

Radostits, O.M., Gray, C. G., Hinchcliff, K. W., & Constable, P. D. (2007). Veterinary medicine: A text book of the disease of cattle, horses, sheep, pigs and goats (pp. 673-749). Saunders Elsevier, London.

Sarba, E. J., & Tola, G. K. (2017). Cross-sectional study on bovine mastitis and its associated risk factors in Ambo district of West Shewa zone, Oromia, Ethiopia. Veterinary World, 10(4), 398.

Solomon, A., Workalemahu, A., Jabbar, M. A., Ahmed, M. M., & Hurissa, B. (2003). Socioeconomics and policy research working paper 52. Nairobi: ILRI (International Livestock Research Institute).

Thrusfield, M. (2013).Veterinary epidemiology (3rd ed). Singapore, Blackwell Science.

Tolosa, T., Gebretsedik, Z., & Regassa, F. (2009). Bovine mastitis and its associated risk factors in lactating cows in Wolayta Soddo, Southern Ethiopia. Bulletin of Animal Health and Production in Africa, 57(4).

Zenebe, N., Habtamu, T., & Endale, B. (2014). Study on bovine mastitis and associated risk factors in Adigrat, Northern Ethiopia. African Journal of Microbiology Research, 8(4), 327-331.

Zeryehun, T., & Abera, G. (2017). Prevalence and bacterial isolates of mastitis in dairy farms in selected districts of Eastern Harrarghe zone, Eastern Ethiopia. Journal of Veterinary Medicine, 2017(1), p.6498618

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Research Article

Effects of variety and seeding rate on performance of sweet lupin (*Lupinus angustifolius*) at Holetta, in the Central Highlands of Ethiopia

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Abstract

The study was executed to evaluate the agro-morphological and nutritional performance of four narrow-leafed blue sweet lupin varieties (Australian lupin, Probor, Sanabor, and Vitabor) sown with five seeding rates (60, 70, 80, 90, and 100 kg/ha) during the main cropping seasons of 2014 and 2015 at Holetta in the central highlands of Ethiopia. Randomized complete block design replicated three times in factorial arrangements was used for experimenting. The lupin varieties were sown in rows with an inter-row spacing of 30 cm. At sowing, diammonium phosphate fertilizer at the rate of 100 kg/ha was uniformly applied for all treatments in both years. Data were collected on plant height, dry matter yield, number of pods per plant, number of seeds per pod, seed yield, and nutritive value. All measured data were subjected to analysis of variance using procedures of SAS general linear model. The result revealed that plant height, number of pods per plant, and number of seeds per pod of lupin varieties were significantly ($P<0.001$) affected by experimental years. The varietal difference was the major cause of variation ($P<0.05$) for dry matter yield, the number of pods per plant, and seed yield. The Sanabor, Probor and Vitabor varieties had 38, 23, and 20% dry matter yield advantage over the introduced Australian lupin variety, respectively. The Sanabor variety which produced the highest seed yield had 25, 17, and 14% seed yield advantages over Vitabor, Australian lupin, and Probor variety, respectively. The seed yield performance of lupin varieties was positively correlated with the number of pods per plant while it was negatively correlated with the number of seeds per pod. The dry matter yield and number of seeds per pod were also significantly ($P<0.05$) affected by seeding rates of lupin varieties. The dry matter yield of lupin varieties increased with increasing seeding rates indicating the tested lupin varieties had a low tillering performance. The number of seeds per pod of lupin varieties decreased with increasing seeding rates. On the other hand, the nutritive values did not differ significantly ($P>0.05$) among the tested lupin varieties.

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However, Vitabor variety gave better CP and IVDMD followed by Australian lupin while Probor variety gave the lowest CP and IVDMD. Vitabor variety which exhibited better ash, CP, and IVDMD contents produced the lowest NDF, ADF, and ADL contents when compared with other varieties. Generally, Sanabor and Probor varieties had better forage dry matter yield and seed yield but Vitabor and Australian lupin had relatively better nutritive values. For forage production, lupin varieties should be sown with the highest seeding rate (100 kg/ha) while the lowest seeding rate (60 kg/ha) is recommended for seed production. However, this research should be done across locations and over years to prove the above-recommended seeding rates for forage and seed productions in the study area and similar agro-ecologies.

Keywords: Dry matter yield; Herbage quality; Plant height; Pod number; Seed yield; Seeding rate

1. Introduction

Livestock resources have significant economic and social importance at household levels and make significant contributions to the national economy and foreign currency earnings of the country through the export of live animals, meat as well as hides, skins, and leather products (Adugna et al., 2012). However, feed shortage in terms of quantity and quality is a critical problem for the production and productivity of livestock in the country (Fekede et al., 2015). The potential livestock feed resources in Ethiopia are grazing natural pasture, crop residue, cultivated forage crops, agro-industrial byproducts, and non-conventional feed resources (Alemayehu et al., 2017). However, the livestock feeding in Ethiopia mainly depends on natural pasture and crop residue, both of which have low nutritional quality (Adugna et al., 2012; Getu, 2019). However, the utilization of forage crops is increasing due to the reduction of pasture lands in the mixed crop-livestock farming system (Minta et al., 2012). Among the cultivated forage crops, sweet lupin is one of the most important dual-purpose annual legume crops to reduce the feed shortage problem in different parts of the country (Likawent, 2012).

Lupin cultivation most likely began in Egypt or the Mediterranean region before 2,000 years (Putnam et al., 1989). Lupin seeds grown in Ethiopia and locally known as ‘Gibto’ are used to prepare local alcoholic drink ‘Areqe’ and other food products especially in the northwestern part of the country (Tizazu & Shimelis, 2010). When it is used as human food mostly used as a snack and as a local sauce called ‘Shiro’ in Ethiopia (Likawent et al., 2010). There are about over 300 species of the genus Lupinus, but many have high levels of alkaloids (bitter-tasting compounds) that make the forage and seed unpalatable and sometimes toxic. High-level alkaloids in animal diets have been known to depress feed intake and growth (Zulak et al., 2006). The alkaloid level of lupin (0.5–4%) varies among cultivars, soil type, and growing season (Gladstones, 1970). The mean alkaloid content of marketable sweet lupin seed is on average 130-150 mg kg^{-1} (De Carvalho, 2005). However, it has been possible to grow sweet genetic varieties with low alkaloid contents ranging from 0.008% to 0.012% (Tsaliki et al., 1999). Within the species, there are sweet and bitter varieties (McDonald et al., 2002). Historically, most alkaloid of lupin is water-soluble, can be decreased to 0.04% from the seed by soaking into running water for a longer time. But the alkaloid-free or "sweet" lupin which can be directly consumed by humans or livestock was developed by plant breeders in Germany in the 1920s (Putnam et al., 1989; Faluyi et al., 2000).

The most commonly found and commercially important species of this genus are the four sweet and large-seeded annuals namely; narrow-leafed blue lupin (*Lupinus angustifolius*), white lupin (*Lupinus albus*), yellow lupin (*Lupinus luteus*), and pearl lupin (*Lupinus mutabilis*) cultivated for human food, green manure, and ruminant feed in the world (Kurlovich, 2006). The ability of the crop to be grown in acidic soils is one of the major important features of the crop in the traditional lupin growing areas of Ethiopia. Lupin is widely grown in the northwestern part of Ethiopia for soil fertility maintenance, forage, human consumption, and a supplement to low-quality roughages. The alkaloid content in bitter varieties limits its use (food and feed). In bitter varieties, alkaloid content ranges from 0.5 to 6% but in sweet lupin, it is less than 0.02%. The high protein content in lupin species makes them valuable feed resources for livestock production systems as they are cost-competitive with a wide range of other protein sources (Edwards & Bameveld, 1998). There are different varieties of sweet lupin in different parts of the world with low alkaloid content that could be introduced to our country. Lupin varieties have different responses when sown with different agronomic managements under various environmental conditions. Therefore, the study was initiated to evaluate the performance of sweet lupin (*Lupinus angustifolius*) varieties and to determine their optimum seeding rate for yield and nutritional quality in the central highlands of Ethiopia.

2. Materials and Methods

2.1 Description of the study area

The experiment was conducted at Holetta Agricultural Research Center during the main cropping seasons of 2014 and 2015 under rainfed conditions. The center is located at 9°00'N latitude, 38°30'E longitude at an altitude of 2400 m above sea level. It is 34 km west of Addis Ababa on the road to Ambo and is characterized by the long-term (30 years) average annual rainfall of 1055.0 mm, average relative humidity of 60.6%, and average maximum and minimum air temperature of 22.2°C and 6.1°C, respectively. The soil type of the area is predominantly red nitosol, which is characterized by an average organic matter content of 1.8%, total nitrogen 0.17%, pH 5.24, and available phosphorus 4.55ppm (Gemechu, 2007).

2.2 Experimental treatments and design

Four varieties of blue sweet lupin (Australian lupin, Probor, Sanabor, and Vitabor) with five different seeding rates (60, 70, 80, 90, and 100 kg/ha) were used as a treatment. The three varieties (Probor, Sanabor, and Vitabor) used in the experiment were obtained from Amhara Agricultural Research Institute and the remaining variety (Australia lupin) was introduced from Australia. The experiment was conducted in randomized complete block design in a factorial arrangement with three replications. The treatments were combined in factorial arrangements to produce 20 treatment combinations.

Seeds were sown in rows of 30 cm spacing on a plot size of 3 m x 4 m = 12m^2. A spacing of 1.5 m and 1.0 m were used between blocks and plots, respectively. At sowing, Diammonium phosphate (DAP) fertilizer at the rate of 100 kg/ha was uniformly applied for all treatments. Plots were hand-weeded twice per year to reduce the effect of weeds on crop performance. Moreover, appropriate agronomic management was uniformly applied at the right time to improve the yield per unit area.

2.3 Data collection and measurements

Sampling for plant height, dry matter yield, number of pods per plant, number of seeds per pod, seed yield was made from the interior rows. Plant height was measured using steel tape from the ground level to the tip of the plant at the forage harvesting stage. Five randomly selected plants were used to determine the plant height of each treatment. The plants were clipped at 5 cm above the ground from the two interior rows at the 50% flowering stage to determine the biomass yield. The weight of the total fresh biomass yield was recorded from each plot in the field and the estimated 500 g sample was taken from each plot to the laboratory. The sample taken from each plot was weighed to know the total sample fresh weight using sensitive table balance and oven-dried for 24 hours at a temperature of 105^oC for herbage dry matter yield determination.

Five plants were randomly taken and uprooted at the seed filling stage from each plot for the determination of the number of pods per plant. Five pods were then randomly taken to count the number of seeds per pod. The innermost two rows of each plot were maintained for seed yield determination. The plants were harvested at optimum seed harvesting time and seed yield was determined from two rows after threshing and winnowing. Seed samples were taken and oven-dried at 100°C for 48 hours to adjust the moisture content of 10%, a recommended percentage level for legumes (Biru, 1979). Seed yield (t/ha) was then calculated at 10% moisture content.

2.4 Herbage quality analysis

The plants were clipped at the recommended (50% flowering) harvesting stage of the lupin variety. The harvested forage samples were oven-dried at a temperature of 65°C for 72 hours to determine the chemical composition and *in-vitro* dry matter digestibility. The dried samples were then ground to pass a 1 mm sieve for laboratory analysis. The total ash content was determined by oven drying the samples at 105^0C overnight and by combusting the samples in a muffle furnace at 550°C for 6 hours (AOAC, 1990).

The nitrogen (N) content was determined following the micro-Kjeldahl digestion, distillation, and titration procedures (AOAC, 1995), and the crude protein (CP) content was estimated by multiplying the N content by 6.25. The NDF, ADF, and ADL contents were determined according to Van Soest & Robertson's (1985) procedure. The two-stage *in-vitro* fermentation technique of Tilley and Terry as modified by Van Soest & Robertson (1985) procedure was used to determine *in-vitro* dry matter digestibility (IVDMD).

2.5 Statistical analysis

The collected data were subjected to the analysis of variance procedures of the SAS general linear model statistical software package (SAS, 2002). Only traits that show a significant difference in ANOVA were promoted to mean comparisons using the least significance difference (LSD) at a 5% probability level. The data were analyzed using the following model (Eq. 1):

$$Y_{ijkl} = \mu + V_i + S_j + Y_k + (VS)_{ij} + (VY)_{ik} + (SY)_{jk} + (VSY)_{ijk} + (B)_l + e_{ijkl} \quad (1)$$

Where, Y_{ijkl} is the dependent variable; μ is overall mean; V_i is the effect of variety i; S_j is the effect of seeding rate j; Y_k is the effect of year k; $(VS)_{ij}$ is the interaction effect of variety i and seeding rate j; $(VY)_{ik}$ is the interaction effect of variety i and year k; $(SY)_{jk}$ is the interaction effect of seeding rate j and year k; $(VSY)_{ijk}$ is the interaction effect of variety i, seeding rate j and year k; B_l is the effect of the block I and e_{ijkl} is a random error.

3. Results and Discussion

3.1 Analysis of variance

The combined analysis of variance for measured agro-morphological traits of sweet lupin varieties sown with different seeding rates over years is indicated in Table 1. The result revealed that plant height, number of pods per plant, and number of seeds per pod of lupin varieties were significantly (P<0.001) affected by cropping years. The varietal difference was the major cause of variation (P<0.05) for dry matter yield, the number of pods per plant, and seed yield.

The dry matter yield and number of seeds per pod were also significantly (P<0.05) affected by seeding rates of lupin varieties. The plant height, dry matter yield, number of pods per plant, number of seeds per pod, and seed yield of lupin varieties were not significantly affected (P>0.05) by the interaction effects of variety by seeding rate, variety by the year, seeding rate by year, and variety by seeding rate by year. These non-significant interaction effects indicate the genotypes perform consistently over years for measured agro-morphological traits when sown with different seeding rates. The change in the relative behavior of the genotype in different environments is due to the differential response of genotypes to different growing conditions (Bernardo, 2002).

Table 1. Combined analysis of variance for measured agro-morphological traits of lupin varieties

Sources of variation	Parameters				
	PH	DMY	NPPP	NSPP	SY
Variety	NS	*	*	NS	*
Seeding rate	NS	*	NS	*	NS
Year	***	NS	***	***	NS
Variety * seeding rate	NS	NS	NS	NS	NS
Variety * Year	NS	NS	NS	NS	NS
Seeding rate * Year	NS	NS	NS	NS	NS
Variety *Seeding rate*Year	NS	NS	NS	NS	NS

NS= Non-significant; *** = P<0.001; * = P<0.05; PH = Plant height; DMY = Dry matter yield; NPPP = Number of pods per plant; NSPP = Number of seeds per pod; SY = Seed yield

3.2 Varietal differences in plant height and dry matter yield

In the combined analysis of variance, plant height was not significantly (P>0.05) affected by varieties of lupin at Holetta as shown in Figure 1. The result indicated that the mean plant height of lupin varieties ranged from 57.7–63.1 with a mean of 60.0 cm at the forage harvesting stage. The highest plant height was recorded for the Probor variety followed by Vitabor and Sanabor while the introduced Australian lupin variety produced the lowest plant height.

The variation in plant height among varieties was in agreement with Friehiwot et al. (2019), who reported that the plant height of Probor, Sanabor, and Vitabor varieties ranged from 53.8–67.6 with a mean of 60.5 cm. However, the mean plant height of Vitabor and Sanabor varieties was relatively higher (Riga et al., 2021) while the mean height of Vitabor, Sanabor, and Probor varieties was lower (Alemu et al., 2017; Alemu et al., 2019) when compared with the current study. On the other hand, the plant height of narrow-leafed lupin varieties had wide variations which varied from 20 to 100 cm (Edwards et al., 2011). The variation might be occurring due to environmental differences in experimental areas. The varietal differences and the response of the varieties to soil and weather conditions are the main factors for plant height variation in lupin varieties.

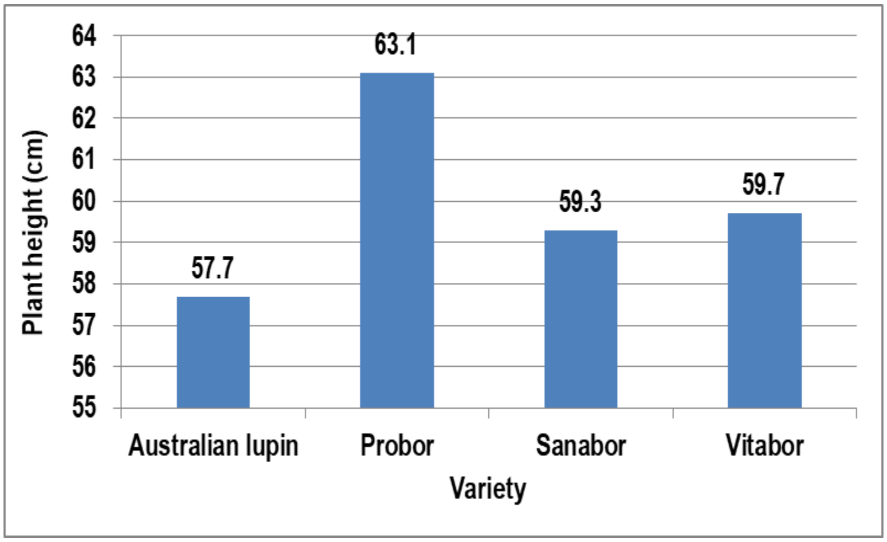

Figure 1. Mean plant height (cm) of lupin varieties at Holetta

In the combined analysis, lupin varieties responded differently ($P<0.05$) for dry matter yield at Holetta as indicated in Figure 2. The dry matter yield of lupin varieties ranged from 1.3–1.8 with a mean of 1.5 t/ha at the recommended forage harvesting stage. The highest dry matter yield was recorded from the Sanabor variety followed by Probor and Vitabor while the lowest dry matter yield was obtained from the Australian lupin variety. The Sanabor, Probor and Vitabor varieties had 38, 23, and 20% yield advantage over the introduced Australian lupin variety, respectively. Similarly, Sanabor variety had 14, and 11% yield advantages over Vitabor and Probor varieties, respectively. The three lupin varieties viz., Sanabor, Vitabor, and Probor produced the mean dry matter yield of 1.89 t/ha (Friehiwot et al., 2019) which was comparable with the mean dry matter yield of the respective varieties tested in this study.

Generally, annual blue lupin varieties produced lower dry matter yields because this species has a shorter plant height when compared with other forage legumes. Weerakoon & Somaratne (2013) indicated that varietal differences had a significant effect on forage dry matter yield. On the other hand, no difference in mean dry matter yield was observed for narrow-leafed lupin varieties (Alemu, 2016). The recorded mean dry matter yield (3.45 t/ha) for Vitabor and Sanabor was higher (Riga et al., 2021) than the current reported dry matter yield for the respective lupin varieties while the current reported forage dry matter yield was higher than those reported (1.4 t/ha) in narrow-leafed sweet lupine in Ethiopia (Likawent et al., 2010). Similarly, the mean dry matter yield (2.03 t/ha) of Vitabor, Sanabor, and Probor varieties was relatively higher (Alemu et al., 2019) than in the current study.

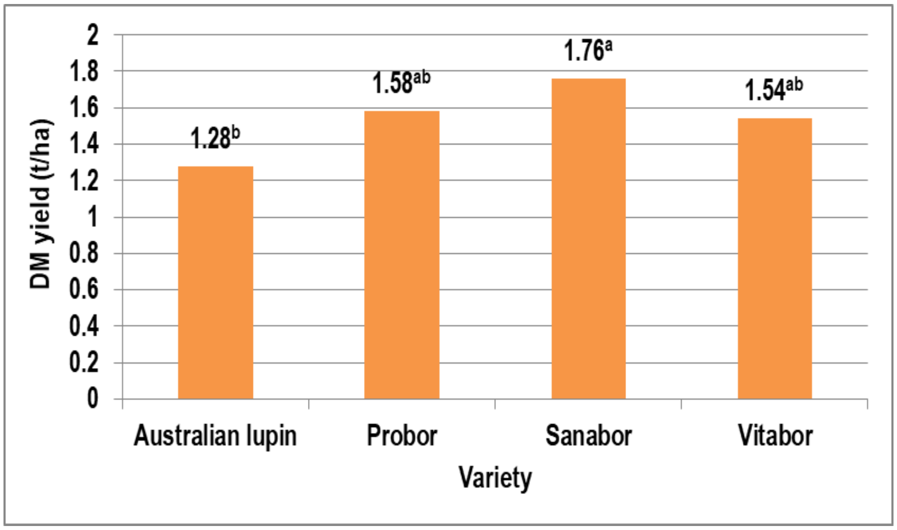

Figure 2. Mean dry matter yield (t/ha) of lupin varieties at Holetta

3.3 Varietal differences on seed yield and its yield components

The mean of podes per plant of lupin varieties tested at Holetta is indicated in Figure 3. The result indicated that the number of pods per plant varied significantly ($P<0.05$) among the tested lupin varieties at Holetta. The number of pods per plant of lupin varieties ranged from 27.3–32.7 with a mean of 29.4 at the seed maturity stage. The highest number of pods per plant was recorded for Sanabor followed by Vitabor (30.1) while Probor and Australian lupin produced the lowest number of pods per plant.

The number of pods per plant variation among the tested lupin varieties attributed to differences in the number of branches per plant. The mean of pods per plant of Sanabor, Vitabor, and Probor was 10.2 (Friehiwot et al., 2019) which was too low when compared with the respective lupin varieties tested in this study. On the other hand, the mean of pods per plant (53.9) of Vitabor and Sanabor varieties was relatively higher (Riga et al., 2021) than the respective lupin varieties tested in this study. However, Kurlovich et al. (2011) reported no significant difference in the number of pods per plant among narrow-leafed lupin varieties.

The mean of seeds per pod of lupin varieties tested at Holetta is indicated in Figure 4. The result revealed that the tested varieties did not differ significantly ($P>0.05$) for the number of seeds per pod at the seed maturity stage. The number of seeds per pod of lupin varieties ranged from 4.27– 4.43 with a mean of 4.38. The introduced Australian lupin variety produced the highest number of seeds per pod followed by Probor (4.42) and Vitabor (4.40) while Sanabor produced the lowest number of seeds per pod. Generally, the highest number of pods per plant producing variety produced the lowest number of seeds per pod and vice versa.

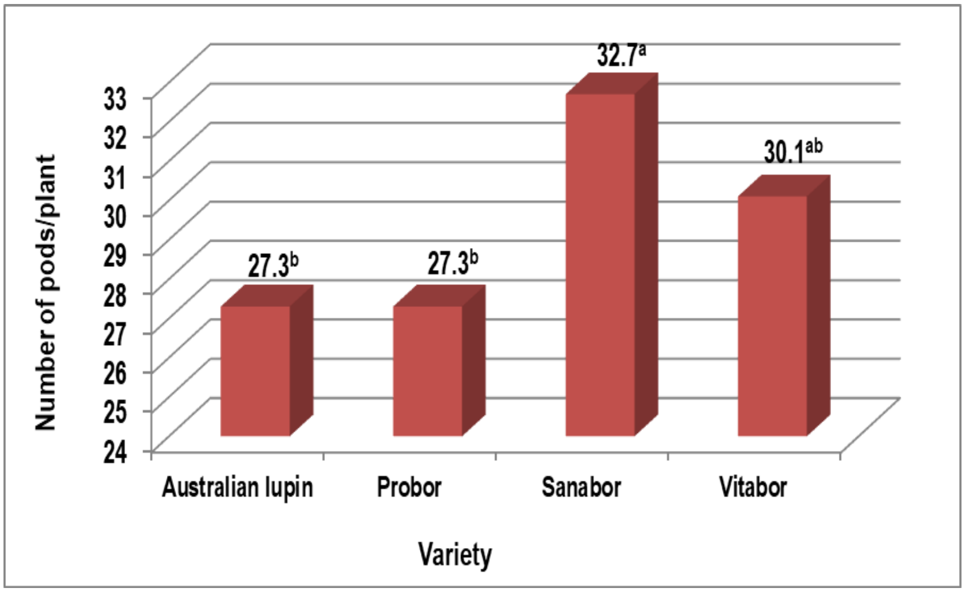

Figure 3. Mean number of pods per plant of lupin varieties at Holetta

The reported mean of seeds per pod (3.67) for Sanabor, Vitabor, and Probor varieties was lower (Friehiwot et al., 2019) than the respective lupin varieties tested in this study. Significant differences in the number of seeds per pod were exhibited among lupin varieties as shown by Yang et al. (2016). The number of seeds per pod of Vitabor and Sanabor varieties reported by Riga et al. (2021) was higher than the respective lupin varieties in the current study. Tizazu & Shimelis (2010) reported that the number of seeds per pod ranges between 4.33 and 4.67 which almost agreed with this study.

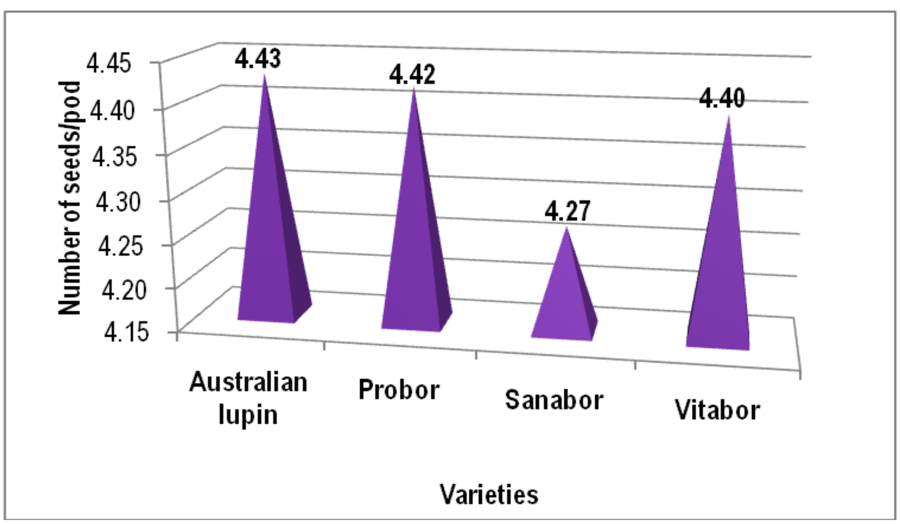

Figure 4. Mean of seeds per pod of lupin varieties at Holetta

The mean seed yield performance of lupin varieties tested at Holetta is indicated in Figure 5. The seed yield performance varied significantly ($P<0.05$) among the tested lupin varieties at the seed harvesting stage. The seed yield of lupin varieties ranged from 23.3–29.1 with a mean of 25.73 qt/ha. The highest seed yield was recorded for the Sanabor variety followed by Probor (25.6 qt/ha) and Australian lupin (24.9 qt/ha) while the lowest was produced from Vitabor variety. The variety which produced the highest number of pods per plant gave the highest seed yield.

The Sanabor variety which produced the highest seed yield had 25, 17, and 14% seed yield advantages over Vitabor, Australian lupin, and Probor variety, respectively. Similarly, Probor variety had 10 and 3% seed yield advantages over Vitabor and Australian lupin variety, respectively. The Australian lupin variety had a 7% yield advantage over the Vitabor variety. The reported mean seed yield (13.9 qt/ha) of Sanabor, Vitabor, and Probor varieties was too lower (Friehiwot et al., 2019) than the respective lupin varieties tested in this study. These differences could be due to variation in agro-ecologies among the study areas. Alemu (2016) also found that Sanabor gave higher grain yield than other tested narrow-leafed lupin varieties which was in agreement with the current study. The seed yield of narrow-leafed sweet lupin in this study was in line with the reports of Fraser et al. (2005) and Riga et al. (2021), but higher than the findings of Tizazu & Shimelis (2010). Generally, the seed yield performance of lupin varieties was positively correlated with the number of pods per plant while it was negatively correlated with the number of seeds per pod.

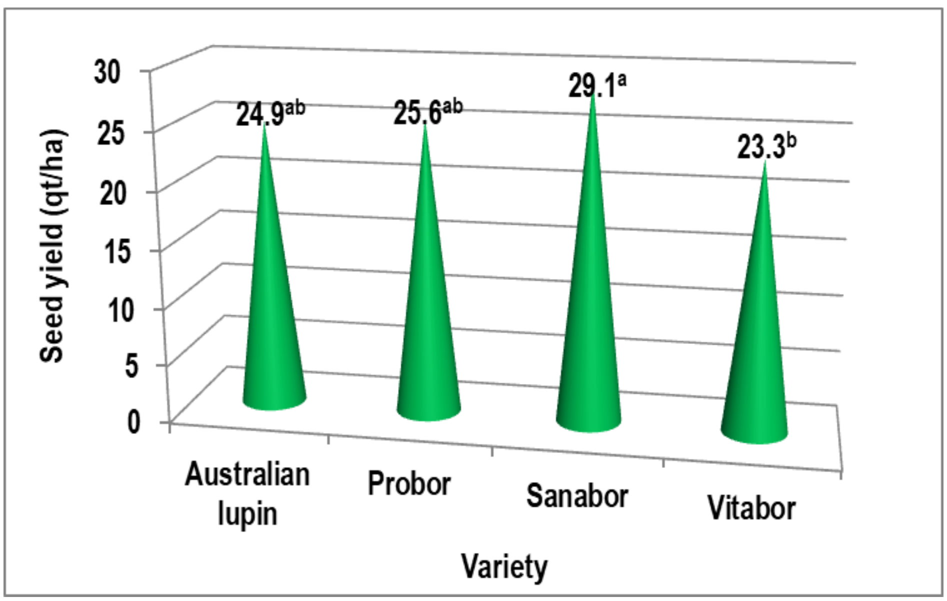

Figure 5. Mean seed yield qt/ha of lupin varieties at Holetta (1 qt = 100 kg)

3.4 The effect of seeding rate on plant height and dry matter yield

The effect of seeding rates on the mean plant height performance of lupin varieties tested at Holetta is indicated in Figure 6. The result showed that the plant height of lupin varieties did not vary significantly (P>0.05) for different seeding rates at the forage harvesting stage. The mean plant height of lupin varieties sown with different seeding rates ranged from 59.6–60.8 with a mean of 60.0 cm at the forage harvesting stage. The lupin varieties sown with a seeding rate of 80 kg/ha gave the highest plant height followed by varieties sown with seeding rates of 100 and 70 kg/ha while the lowest plant height was recorded for varieties sown with seeding rates of 60 and 90 kg/ha.

Generally, due to competition for limited growth resources, the plant height of lupin varieties was higher with increasing rates of seeding. The reason could be plants under narrow spacing between plants, and the interplant competition will be too high that the individual plant increases in height (Rasul et al., 2012). The largest increment in mean plant height was recorded in the forage harvesting stage due to massive root development and efficient nutrient uptake allowing the plant to continue the increase in height. Similar results had also been reported by another worker (Tizazu & Shimelis, 2010).

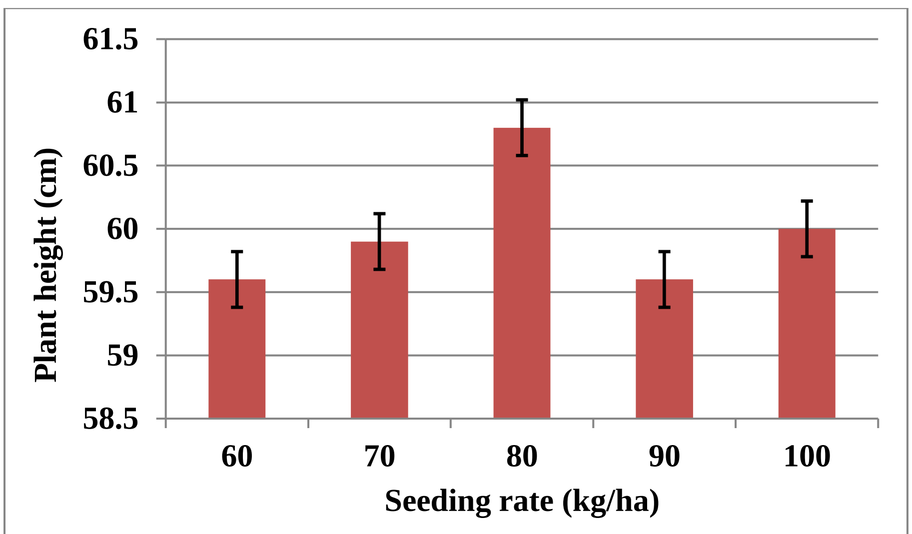

Figure 6. Mean plant height (cm) of lupin varieties as influenced by seeding rates at Holetta

The effect of seeding rates on dry matter yield performance of lupin varieties tested at Holetta is indicated in Figure 7. The lupin varieties sown with different seeding rates responded differently (P<0.05) for dry matter yield at the forage harvesting stage. The varieties sown with a seeding rate of 100 kg/ha produced the highest (1.77 t/ha) dry matter yield followed by the varieties sown with seeding rates of 90 kg/ha and 80 kg/ha while the lowest dry matter yield

(1.10 t/ha) was recorded for varieties sown with a seeding rate of 60 kg/ha. Generally, the dry matter yield of lupin varieties increased with increasing seeding rate indicating the varieties had a low tillering performance. So, the varieties should be sown with the highest seeding rate to get a better dry matter yield. The result of this study agreed with Pholsen & Sornsungnoen (2004), who reported that higher yield was attributed to high plant populations that allowed the fodder crop to thrive well in terms of nutrient uptake from soil and a solar interception in the early period of plant growth and development.

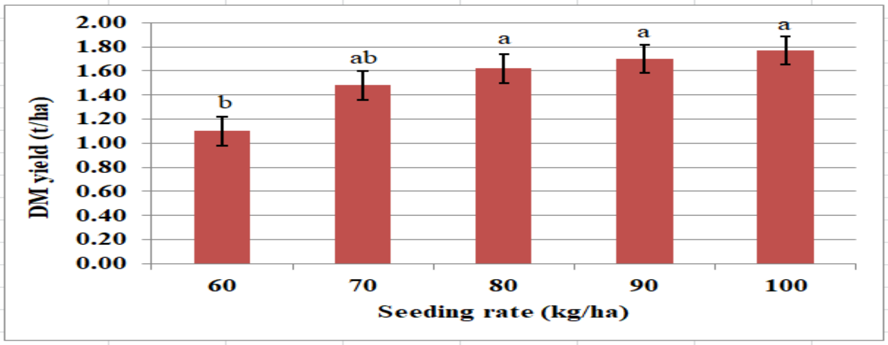

Figure 7. Mean DM yield (t/ha) of lupin varieties as influenced by seeding rates at Holetta

3.5 The effect of seeding rate on seed yield and its yield components

The effect of seeding rates on the number of pods per plant of lupin varieties tested at Holetta is indicated in Figure 8. The result showed that the number of pods per plant of lupin varieties sown with different seeding rates did not differ (P>0.05) at the seed harvesting stage. The number of pods per plant of lupin varieties sown with different seeding rates ranged from 26.7–31.2 with a mean of 29.3.

The highest number of pods per plant was recorded when the varieties were sown with a seeding rate of 90 kg/ha followed by 80 kg/ha while the varieties produced the lowest number of pods per plant when sown with a seeding rate of 100 kg/ha. The varieties sown with a seeding rate of 90 and 80 kg/ha had 17 and 12% increments in the number of pods per plant, respectively, over the varieties sown with a 100 kg/ha seeding rate. High plant populations tended to produce plants with fewer branches and a greater number of pods on the main stems. As a result, a greater proportion of the yield was derived from the pods on the main stem. On the other hand, a lower seeding rate gave a better number of pods per plant by increasing the number of branches per plant. Plants were sown at wider spacing resulted in a higher pod number per plant compared to narrower spacing (Riga et al., 2021). Generally, the results indicated that the number of pods per plant increased as the planting population decreased since sweet lupin varieties were affected by the number of branches.

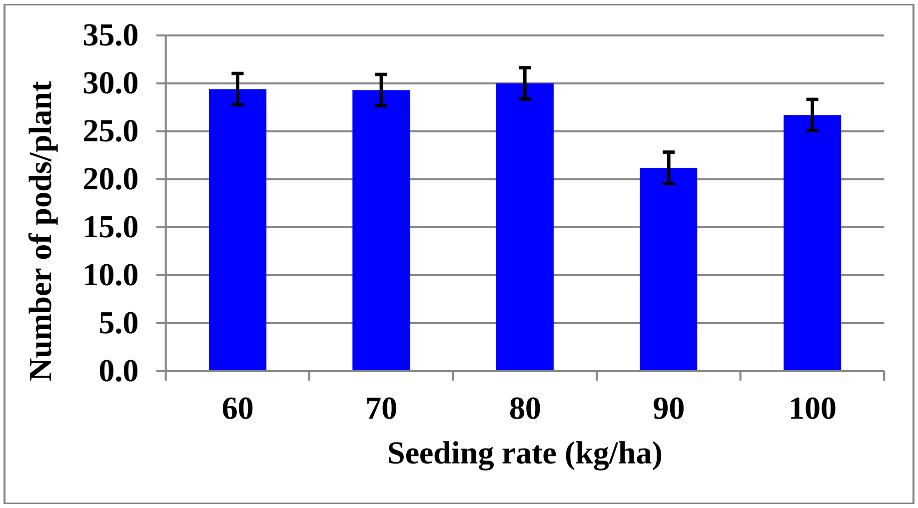

Figure 8. Mean number of pods per plant of lupin varieties as influenced by seeding rates at Holetta

The effect of seeding rates on the number of seeds per pod of lupin varieties tested at Holetta is indicated in Figure 9. The result revealed that the number of seeds per pod of lupin varieties sown with different seeding rates varied significantly ($P<0.05$) at the seed harvesting stage. The number of seeds per pod of lupin varieties sown with different seeding rates ranged from 4.09–4.64 with a mean of 4.38. But the potential number of seeds per pod of lupin varieties ranges from 3 to 6, depending on the location of the plant. As branch order increases up the plant, the number of seeds per pod decreases.

Different genotypes showed different performances in the number of seeds per pod which could be associated with the variations in agro-ecology and edaphic conditions. The highest number of seeds per pod was recorded when the varieties sown with a seeding rate of 70 kg/ha while the varieties sown with a seeding rate of 60 kg/ha produced the lowest number of seeds per pod. Seed set is determined mainly by temperature and moisture during flowering, both of which affect assimilate supply.

Generally, the number of seeds per pod of lupin varieties decreased with increasing seeding rates. The presence of critical competition among plants for limited growth resources is the major reason for decreased number of seeds per pod with increasing seeding rates of lupin varieties. Riga et al. (2021) reported that a higher number of populations per unit area increased the number of seeds per pod of lupin varieties by reducing the number of pods per plant which was not in line with this study.

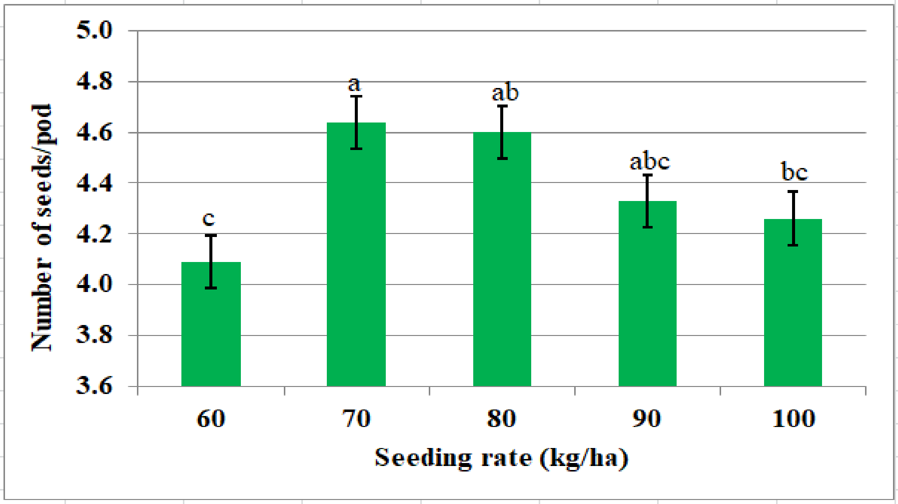

Figure 9. Mean of seeds per pod of lupin varieties as influenced by seeding rates at Holetta

The effect of seeding rates on the seed yield performance of lupin varieties tested at Holetta is indicated in Figure 10. The result showed that the varieties did not differ (P>0.05) in seed yield performance when sown at different seeding rates. The seed yield performance of lupin varieties sown with different seeding rates ranged from 22.8–27.3 with a mean of 25.8 qt/ha at the seed harvesting stage. The highest seed yield was recorded when the lupin varieties sown with a seeding rate of 90 kg/ha.

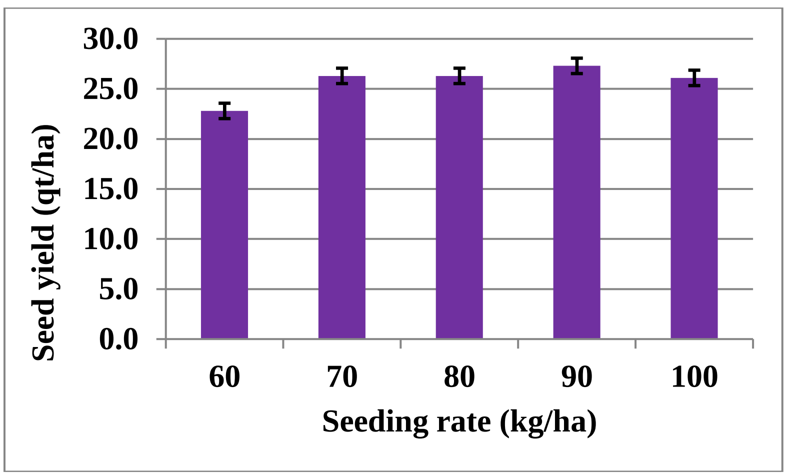

Figure 10. Mean seed yield qt/ha of lupin varieties as influenced by seeding rates at Holetta (1 qt = 100 kg)

On the other hand, the lupin varieties sown with the lowest and highest seeding rates generally produced the lowest seed yield. The seed yield of lupin varieties sown with a seeding rate of 90 kg/ha had a 20% yield advantage over the varieties sown with a seeding rate of 60 kg/ha. Seed yield from lupin varieties is determined by the number of pods per square meter (pod density), number of seeds per pod, and seed weight. The seed yield obtained from lupin varieties sown with less population density was higher than more population density (Riga et al., 2021).

Sowing with a higher seeding rate reduced the seed yield performance of lupin varieties because the competition for limited growth is higher when the varieties sown with a higher seeding rate.

3.6 Varietal differences of herbage nutritive value

The mean ash, crude protein (CP), and *in-vitro* dry matter digestibility (IVDMD) of lupin varieties tested at Holetta are indicated in Figure 11. The result indicated that the varieties did not vary (P>0.05) in ash, CP, and IVDMD at the forage harvesting stage. The ash content of lupin varieties was ranged from 14.0–14.8 with a mean of 14.3%. The highest ash content was recorded for the Sanabor variety while the Probor variety produced the lowest ash content. The highest CP content was recorded for Vitabor variety (21.6%) followed by Australian lupin (20.8%), and Sanabor (19.8%) while Probor variety produced the lowest (19.5%) content of CP. The IVDMD of lupin varieties ranged from 75.4–77.3 with a mean of 76.6%. The Vitabor variety gave the highest IVDMD followed by Australian lupin and Sanabor variety while Probor variety gave the lowest IVDMD.

Generally, Vitabor variety gave better CP and IVDMD followed by Australian lupin while Probor variety gave the lowest CP and IVDMD. The ash and CP contents of Vitabor and Sanabor varieties reported by Riga et al. (2021) were 14.5% and 22.1%, respectively, which were in agreement with the current study. The CP content in yellow lupin forage ranged from 18.4–21.5% (Bruno-Soares et al., 1999), and the CP content in blue lupin was 16.7% (Bruno-Soares & Mira vaz, 1999) which were lower than the CP content of this study. Similarly, the IVDMD content (67.5%) reported by Riga et al. (2021) was lower when compared with this study. Differences in variety, location, soil, and management conditions could cause variations in the nutritive values of lupin varieties.

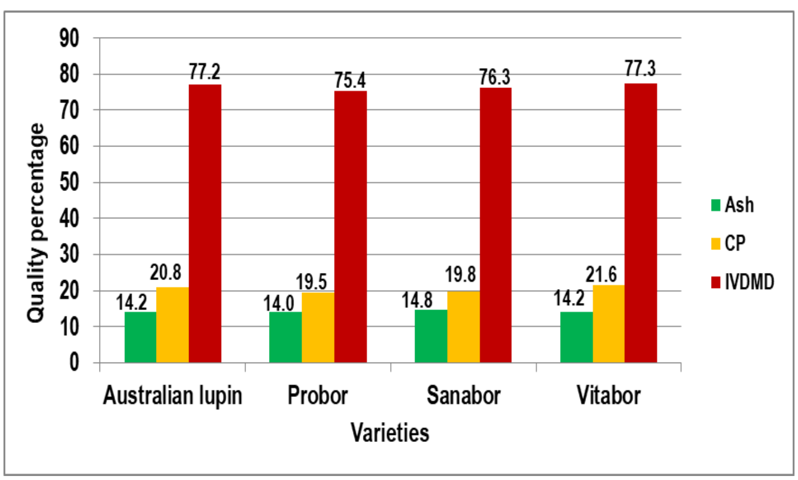

Figure 11. Mean ash, crude protein, and in-vitro dry matter digestibility of lupin varieties at Holetta

The mean neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) contents of lupin varieties tested at Holetta is indicated in Figure 12. The result showed that a non-significant difference (P>0.05) for NDF, ADF, and ADL contents was recorded among lupin varieties at the forage harvesting stage. The highest NDF was recorded for Probor (49.9%) followed by Sanabor (48.3%), Australian lupin (47.0%) while the lowest was recorded from Vitabor (46.8) variety. The Prober variety gave the highest ADF (36.2%) and ADL (35.6%) contents followed by Sanabor while Vitabor gave the lowest contents of ADF (33.8%) and ADL (8.7%).

Generally, Vitabor variety which exhibited better ash, CP, and IVDMD contents produced the lowest NDF, ADF, and ADL contents when compared with other varieties. The NDF and ADF contents of lupin varieties in this study were comparable with the study done by Riga et al. (2021) and Bruno-Soares et al. (1999). However, the ADL reported by Riga et al. (2021) was lower when compared with the current study. Feed value is the potential of a feed to supply the nutrients required by an animal both in terms of quantity and quality to support a desired type of production. The feed value of a given feed is influenced by feed factors such as chemical composition, digestibility, physical structure and intake level of the feed, and animal factors such as the physiological status of the animal (Mlay et al., 2006). Lupin forage has the potential to be used as a protein supplement in livestock feed. Dairy cows supplemented with 4–8 kg of lupin forage dry matter per day after grazing Kikuyu grass pasture produced a higher milk yield of up to 3.8 L/day/cow, especially at early lactation, as compared to the control group (Hughes et al., 1988).

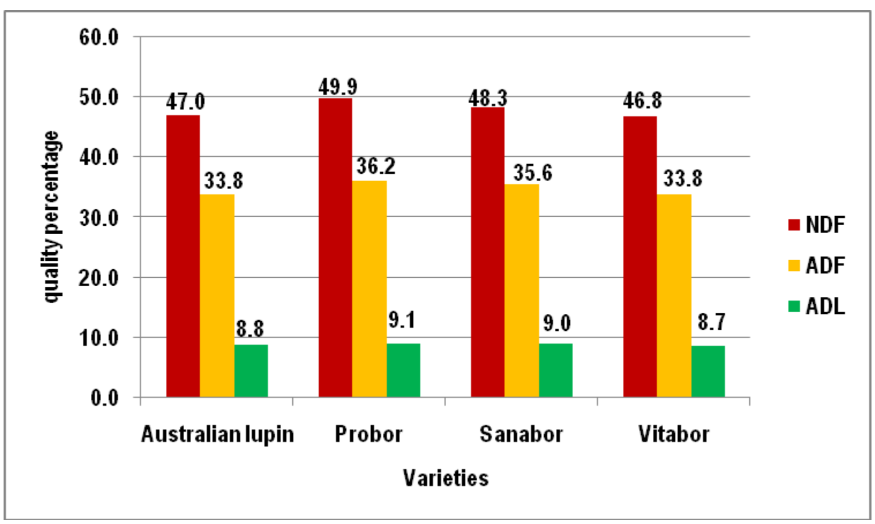

Figure 12. Mean Neutral detergent fiber (NDF), Acid detergent fiber (ADF), and acid detergent lignin (ADL) of lupin varieties at Holetta

4. Conclusion

The tested lupin varieties had different plant height, forage dry matter yield, number of pods per plant, number of seeds per pod, seed yield, and nutritive values and the varieties responded differently for measured traits when sown with different seeding rates. Among the tested lupin varieties, Sanabor and Probor varieties had better forage dry matter yield and seed yield but Vitabor and Australian lupin had relatively better nutritive values. The forage dry matter yield of lupin varieties increased significantly with increasing seeding rates. But, the seed yield performance of the varieties did not vary significantly with increasing seeding rates. Generally, for better forage dry matter yield and seed yield, the varieties should be sown with seeding rates of 100 and 60 kg/ha, respectively. However, this research should be done across locations and over years to prove the above-recommended seeding rates for forage and seed productions in the study area and similar agro-ecologies.

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References

Adugna, T., Alemayehu, M., Diriba, G., Alemu, Y., & Yirdaw, W. (2012). The need for transforming the Ethiopian feed sector. In Livestock feed resources in Ethiopia: Challenges, opportunities and the need for transformation. Ethiopian Animal Feed Industry Association, Addis Ababa, Ethiopia.

Alemayehu, M., Gezahagn, K., Fekede, F., & Getnet, A. (2017). Review on major feed resources in Ethiopia: Conditions, challenges, and opportunities. Academic Research Journal of Agricultural Science and Research, 5(3), 176–185.

Alemu, T. (2016). Evaluation of the adaptability of different sweet lupin (*Lupinus* spp. L.) varieties for feed production. International Center for Agricultural Research in the Dry Areas, Amman, Jordan.

Alemu, T., Dessalegn, A., & Kifetew, A. (2019). Evaluation of feed production potential of different sweet lupin (*Lupinus* spp. L.) varieties in the highland areas of North Gondar, Ethiopia. In Adaptation and generation of agricultural technologies: Workshop proceedings, April 30–May 4, 2018 (pp. 118–127). Bahir Dar, Ethiopia.

Alemu, T., Likawent, Y., Belete, S., Yengusie, D., Desalegn, A., Solomon, T., Menegesha, A., Shambel, K., Molla, B., Getachew, W., Misganaw, W., Mulatu, G., Bewketu, A., Bekahgn, W., & Baye, B. (2017). Study on the adaptability of different sweet lupin (*Lupinus* spp. L.) varieties for feed production in different agro-ecologies of Amhara Region, Ethiopia. In proceedings of the 10th annual regional conference on Completed livestock research activities, March 13–16, 2017 (pp. 387–407). Bahir Dar, Ethiopia.

AOAC (1990). Official methods of analysis (15th ed.). Association of Official Analytical Chemists, Washington, DC, USA.

AOAC. (1995). Official methods of analysis (16th ed). Association of Official Analytical Chemists, Arlington, Virginia, USA.

Bernardo, R. (2002). Genotype × environment interaction. In R. Bernardo (Ed.), Breeding for quantitative traits in plants (pp. 147-171). Stemma Press, Woodbury, MN.

Biru, A. (1979). Agronomy research manual. Part III: Formulae and tables. Ethiopian institute of igricultural Research, Addis Ababa, Ethiopia.

Bruno-Soares, A. M., & Mira Vaz, M. M. (1999). Nutritive value of white and blue lupin forages at different stages of plant growth and the relationship to alkaloid and saponin contents. In E. van Santen, M. Wink, S. Weissmann, & P. Roemer (Eds.), *Lupin*, an ancient crop for the new millennium: Proceedings of the 9th International Lupin Conference, Klink/Muritz, June 20–24, 1999 (pp. 411-413). International *Lupin* Association, Canterbury, New Zealand.

Bruno-Soares, A. M., C'ampos-Andrada, M. P., Falcao, E., & Cunha, L. (1999). An evaluation of the chemical composition and rumen degradability of a new Portuguese Lupinus luteus L. cultivar. In G. D. Hill (Ed.), Towards the 21st century: Proceedings of the 8th International Lupin Conference, Asilomar, California, USA, May 11–16, 1996 (pp. 115–119). International *Lupin* Association, Canterbury, New Zealand.

De Carvalho, I. M. M. S. (2005). Effects of water stress on the proximate composition and mineral contents of seeds of two lupines (*Lupinus albus* and *Lupinus mutabilis*). Journal of Food Quality, 28, 325–332.

Edwards, A. C., & van Bamveled, R. J. (1998). Lupins for livestock and fish. In J. S. Gladstones, C. Atkins, & J. Hamblin (Eds.), *Lupins* as crop plants: Biology, production and utilization (pp. 385–409). CAB International, New York, USA.

Edwards, J., Walker, J., & McIntosh, G. (2011). Lupin growth and development. New South Wales Department of Industry and Investment, Orange, New South Wales, Australia.

Faluyi, M. A., Zhou, M. X., Zhang, F., Leibovitch, S., Migner, P. L., & Smith, D. (2000). Seed quality of sweet white lupin (*Lupinus albus*) and management practice in eastern Canada. European Journal of Agronomy, 13, 7–37.

Fekede, F., Getnet, A., Gezahagn, K., Alemayehu, M., & Driba, G. (2015). Cultivated forage crops research and development in Ethiopia. In Y. Alemu, A. Getnet, & G. Lemma (Eds.), Proceedings of Pasture and Rangeland Research and Development in Ethiopia. Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia.

Fraser, M. D., Fychan, R., & Jones, R. (2005). Comparative yield and chemical composition of two varieties of narrow-leafed *lupin* (*Lupinus angustifolius*) when harvested as whole-crop, moist grain, and dry grain. Animal Feed Science and Technology, 120(1–2), 43–50.

Friehiwot, A., Bimrew, A., & Likawent, Y. (2019). Growth, yield, and yield component attributes of narrow-leafed lupin (Lupinus angustifolius L.) varieties in the highlands of Ethiopia. Tropical Grasslands Forrajes Tropicales, 7(1), 48–55.

Gemechu, K. (2007). Phenotypic diversity for biological nitrogen fixation in Abyssinian field pea (*Pisum sativum var. abyssinicum*) germplasm accession. Unpublished Ph.D. study report, Science Faculty, Addis Ababa University,.

Getu, K. (2019). Assessment on the production, conservation, and utilization practices of brewery spent grain across selected districts in Ethiopia and its supplementary value for dairy cows. Ph.D. Dissertation, Addis Ababa University, College of Veterinary Medicine, Department of Animal Production Studies, Bishoftu, Ethiopia.

Gladstones, J. (1970). *Lupins* as crop plants. Field Crop Abstracts, 23, 123.

Hughes, P. M., Royal, A. J. E., & Ayres, J. F. (1988). Milk production of cows grazing long or short Kikuyu grass (*Pennisetum clandestinum*) and with access to forage lupins (*L. luteus*). Australian Journal of Experimental Agriculture, 28, 307–313.

Kurlovich, B. S. (2006). Lupinus albus: Plant for a future edible medicinal and useful plants for a healthier world. Plant for a Future, Charity No. 1057719, Company No. 3204567. Registered England and Wales

Kurlovich, B. S., Stoddard, F. L., & Laasonen, R. (2011). Breeding of narrow-leafed lupin (Lupinus angustifolius L.) for Northern European growing conditions.

Likawent, Y. (2012). Potential of lupins (*Lupinus* spp. L.) for human use and livestock feed in Ethiopia (Ph.D. Dissertation). The Humboldt University of Berlin, Berlin, Germany.

Likawent, Y., Kijora, C., Solomon, M., Anteneh, G., & Peters, K. J. (2010). White lupine (Lupinus albus L.), the neglected multipurpose crop: Its production and utilization in the mixed crop-livestock farming system of Ethiopia. Livestock Research for Rural Development, 22(74).

McDonald, P. R. A., Edwards, J. F. D., Green, H., & Morgan, C. A. (2002). Animal nutrition (6th ed.). Penfiee Hall, Halow, England, London.

Minta, M., Assefa, G., Feyissa, F., Kebede, G., & Tekletsadik, T. (2012). Strengthening Forage Seed Supply through Farmers-Based Seed Production. Forage Seed Research and Development in Ethiopia.

Mlay, P. S., Pereca, A., Phiri, E. C., Balthazary, S., Igusti, J., Hvelplund, T., Weisbjerg, M. R., & Madsen, J. (2006). Feed value of selected tropical grasses, legumes, and concentrates. Veterinarski arhiv, 76, 53–63.

Pholsen, S., & Sornsungnoen, N. (2004). Effects of nitrogen and potassium rates and planting distances on growth yield and fodder quality of a forage sorghum (Sorghum bicolor L. Moench). Pakistan Journal of Biological Science, 7(10), 1793–1800.

Putnam, D. H., Oplinger, E. S., Hardman, L. L., & Doll, J. D. (1989). Lupine. Department of Agronomy, College of Agricultural and Life Sciences and Cooperative Extension Service, University of Wisconsin–Madison, WI 53706.

Rasul, F., Cheema, M. A., Sattar, A., Saleem, M. F., & Wahid, M. A. (2012). Evaluating the performance of three mungbean varieties grown under varying inter-row spacing. E Journal of Animal & Plant Sciences, 22(4), 1030–1035.

Riga, F. T., Retta, K. S., & Derseh, M. B. (2021). Yield and nutritional quality of sweet lupine (Lupinus angustifolius) grown in Midaltitudes of Lemo District, Hadiya Zone, Southern Ethiopia. International Journal of Agronomy, 2021(1), 6674452.

Statistical Analysis System (SAS). (2002). SAS/STAT guide for personal computers (Version 9.0). SAS Institute Inc., Cary, NC, USA.

Tizazu, H., & Shimelis, E. (2010). Chemical composition, physicochemical and functional properties of lupine (Lupinus albus) seeds grown in Ethiopia. African Journal of Food Agriculture, Nutrition and Development, 10(8), 3029–3046.

Tsaliki, E., Lagaouri, V., & Doxastakis, G. (1999). Evaluation of the antioxidant activity of lupin seed flour and derivatives (Lupinus albus ssp. Graecus). Food Chemistry, 65, 71–75.

Van Soest, P. J., & Robertson, J. B. (1985). Analysis of forages and fibrous foods: A laboratory manual for Animal Science 613. Cornell University, Ithaca, New York, USA.

Weerakoon, S. R., & Somaratne, S. (2013). Agronomic potential of lupin (*Lupinus* spp.) in Sri Lanka as an alternative crop: Growth and yield performance in different agro-ecological regions. Asian Journal of Agricultural Research, 7, 1–14.

Yang, Y., Shi, J., Wang, X., Liu, G., & Wang, H. (2016). Genetic architecture and mechanism of seed number per pod in rapeseed: Elucidated through linkage and near-isogenic line analysis. Scientific Reports, 6, 24124.

Zulak, K. G., Liscombe, D. K., Ashihara, H., & Facchini, P. J. (2006). Alkaloids. In A. Crozier, M. N. Clifford, & H. Ashihara (Eds.), Plant secondary metabolites: Occurrence, structure, and role in the human diet. Blackwell Publishing Limited.

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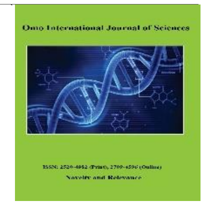

Research Article

Milk production, handling, processing and marketing practices in selected districts in Southern Ethiopia

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Abstract

This study was conducted in Segen Area Peoples Zone, Southern Ethiopia, to analyze milk production, handling, processing, and marketing techniques. A total of 204 people were chosen for the study using simple random sampling technique, and data were collected utilizing a semi-structured questionnaire. During the research, both primary and secondary data were gathered. SPSS version 20 software was used to analyze the data using descriptive statistics, chi square test, and analysis of variance. 85 percent of the 204 houses surveyed were male headed household while the remaining 15% were female headed. The respondents' average age was 43.8610.064 years. In the current study, the age of the respondents ranged from 23 to 80 years old. In the Derashe district, almost 36.5 percent of respondents washed their udders before and after milking, indicating that the importance of udder cleaning was higher than in other regions. The majority of those polled (83 percent) smoked milk handling equipment to improve the taste and flavor of milk and milk products, as well as to eradicate harmful bacteria and promote milk fermentation. To churn milk, 17 percent of respondents use a gourd while 43 percent use a clay pot. The primary limits discovered in the 69 percent, 3 percent, 7.5 percent, 2.5 percent, 8 percent, and 10 percent were shortage of feeds, scarcity of water, disease, lack of market and market information, poor infrastructure, absence of improved breed, and inadequate artificial insemination. Farmers' attitudes should be modified through training and other means, and powerful dairy cooperatives should be founded, mainly in rural regions, to improve milk and milk product handling procedures and reduce cultural barriers in milk marketing.

Keywords: Handling; Marketing; Milk production; Processing

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1. Introduction

Ethiopia has one of the largest livestock populations in Africa with the estimated domestic animal population of 56.71 million cattle, 29.33 million sheep and 29.11 million goats (CSA, 2015). This has been contributing a considerable portion to the economy of the country, and it is still a promising potential for the economic development of the country (CSA, 2014). Livestock productions have diverse use and important contributions to livestock keepers and the nation. It also performs multiple functions in the Ethiopian household economy mainly in providing food and input for crop production and increasing soil fertility, in being used for fuel and in creating job opportunities (Metaferia *et al*., 2011).

Ethiopia's increasing human population, urbanization trends and rising household income are leading to a substantial increase in the demand for livestock products, particularly milk and meat. In order to meet the growing demand for milk in Ethiopia, milk production has to grow at least at a rate of 4 percent per annum (Azage, 2003). Dairy sector is a major contributor to economic development especially among the developing countries. As an engine of growth, it provides increased income, employment, food and foreign exchange earnings as well as better nutrition in Ethiopia (Yilma et al., 2011). According to CSA (2014) 2.9 billion liters of cow milk are estimated to be produced by sedentary populations annually. The average daily milk production is only 1.69 liters with average lactation length of about 180 days and mean annual milk yield per cow of 305 liters and the per capita/ milk consumption in the country is about 19.24 kg/year, which is much lower than African and world per capita average of 27 kg/year and 100 kg/year, respectively (MoA, 2012).

In Ethiopia, there is no standard hygienic condition followed by producers during milk production. Therefore, the hygienic conditions are different according to the production system. The common hygienic measures taken during milk production especially during milking are mostly not properly applied in smallholder cases. This is due to, the quality of the water used for cleaning purpose (washing the udder, milk equipment, hands)(Zelalem, 2011).

Milk is the most easily contaminated and perishable product of animal origin. This is mainly due to its high nutritional value creating an ideal medium for the growth of spoilage as well as pathogenic microorganisms. The handling and safety of milk and milk products is of great concern around the world. This is especially true in developing countries where production of milk and various dairy products takes place under rather unsanitary conditions and poor production practices (Zelalem, 2011). Poor handling of traditional milk and milk products during the processing activities account for a loss of about 40% in terms of quality and quantity (CSA, 2010).

As reported by Muriuki et al. (2008) the majority `of milk produced outside urban centers in Ethiopia are processed into milk products at household level using traditional technologies such as '*Ergo'* (Ethiopian naturally fermented milk), butter, ghee and Ayib (Ethiopian cottage cheese) that are marketed through informal channel. In areas where the climate is hot and humid, the raw milk gets easily fermented and spoiled during storage unless it is refrigerated or preserved. However, such storage facilities are not readily available in rural areas and cooling systems are not feasible due to lack of the required dairy infrastructure and when available they are too costly for poor smallholder producers (O'Mahony *et al*., 2004).

In Ethiopia, milk and milk products are marketed through both informal and formal marketing systems. In the dominant informal marketing system, producers sell to consumers directly or to unlicensed traders or retailers. Price is usually set through negotiation between the producer (seller) and the buyer; this system is predominant in the rural dairy production system. In the formal marketing system there are cooperatives and private milk collecting and processing plants that receive milk from producers and channel to consumers, supermarkets and retailers; this system does exist in urban and per-urban dairy system of milk shed, although the number of cooperatives is few and its performance is low (Woldemichael, 2008).

Milk consumption pattern and marketing of dairy products fluctuate with the amount of milk produced per household, dairy production system, market access, and season of the year, fasting period, and culture of the society (Amistu *et al.,* 2015). Amistu *et al.* (2015), who reported major challenges of milk marketing, stated that price fluctuation during fasting months, distance to selling centers or market, milk quality, cultural beliefs affect the marketing of milk. Diversification of agro-ecological zone, availability of huge areas of communal grazing land, availability of indigenous fodder tree and huge number of local cows, regarded as an opportunity for milk production and marketing (Kedija *et al*., 2008).

South Nations, Nationalities and Peoples Region is the third largest potential region of the country in livestock production having 11.04 million cattle population next to Oromia and Amhara which owns about 22.50 million and 14.22 million cattle population respectively (CSA, 2014). With average productivity of 1.65 liter per day per cow, the total annul milk yield in SNNPRS is 667, 562 tons (CSA, 2010), from which 88.62% is consumed at home, 2.29% is sold, 0.36 is paid in kind for wage and 8.73% is processed into other dairy derivates (CSA, 2010).

According to SNNPRS's BoA (2014), the total number of dairy cows is 4, 943, 854, from which 933,225 tons of milk is produced per annum. However, the productivity of the livestock resources and the benefits obtained from the sector does not commensurate with the high livestock population in the region *(*Abebe *et al., 2014)*. The current study areas; Derashe, Alle and Konso Districts are well known in livestock population, having different agro-ecology for dairy production (SAPZANRD, 2017) whereas; milk production potential, milk and milk products handling, processing and marketing system were not yet well studied and the information of milk production, handling, processing and marketing practices is not documented well. As a result, determining the current state of milk production, as well as the handling, processing, and marketing of milk and milk products, is critical in order to establish effective dairy development interventions that will boost milk production and usage in the studied region. The project's goals are to evaluate milk production techniques, milk and milk product handling, processing, and marketing practices, as well as to identify important milk production limitations and opportunities in the study districts.

2. Materials and Methods

2.1. Description of study area

The study was conducted in Derashe, Konso and Alle districts of Southern Nations and Nationalities and People's Region (SNNPR) from December 2019 to November 2021. Derashe District is located at 500 km from Addis Ababa, 318 km from regional capital, Hawassa. Derashe district consists of 16 *kebeles* (ANRO, 2016). The elevation of the district ranges from 1140 to 2614 m.a.s.l. The annual rain fall ranges from 600 to 1600 mm and the annual temperature ranges from 15.1 ^{0}C to 27.5 ^{0}C. The Agro-ecologies of the district is characterized as highland (2301-2622 m.a.s.l), mid altitude (1501-2300 m.a.s.l) and lowland (below1500 m.a.s.l) (DPDAO, 2015).

The common agricultural practice of the district is mixed crop-livestock production system. The major growing crops in the study area are maize, sorghum, teff and wheat. Livestock production systems are characterized by minimal management inputs in terms of production and breeding management, disease control and nutrition are mainly traditional and subsistence oriented. The livestock population in the district is estimated to be 134,056 cattle, 47,404 Sheep, 83,660 Goat, 3 Camel, 13740 Donkey, 297 Horse, 1024 Mule and 161, 544 Poultry are existing in the district (Derashe District Livestock and Fishery Development Office, 2016). The district has 142,758 total human populations, out of this 70,111 are males and 72,647 are females (CSA, 2007).

The second study district, Konso, is located 595 kilometers southwest of Addis Ababa in Ethiopia. The Konso district is divided into 39 kebeles. The elevation of the district ranges from 600 to 2100 meters above sea level (Konso district agricultural office 2008). The annual temperature ranges from 12 and 330 degrees Celsius. The annual rainfall varies between 400 and 1000 millimeters. The rain follows a bimodal pattern, with two rainy seasons: the "Belg" major rains, which begin in mid-February and extend until April, and the "Meher" tiny rains, which begin in October and November. The crop-livestock production system is integrated (Yohannes, 2015). The district's livestock population is expected to be 154,222 cows, 39,458 sheep, and 49,868 goats (Konso district agricultural office 2008). According to the CSA's 2007 Census, the district has a total population of 235,087 people, with 113,412 men and 121,675 women.

The third district of the study, Alle, is located at 640 km from Addis Ababa, 410 km from Hawassa. The district has three agro-ecological zones such as Kolla, Woynadega and Dega and consists of 17 kebeles. The annual temperature ranges from 19 ^{0}C to 28 ^{0}C and the annual rain fall ranges from 480 to 800 mm. The district has a total of 7690 ha of which 4640 ha used for crop-cultivation and the remaining 3050 hectors are covered with natural vegetation’s. The production system of the area is mixed – crop livestock production system with crop cultivation as primary and livestock as secondary production (AWAO, 2004). The major crops grown in the area includes, Dagussa/Millet, maize, teff, and mashilla/sorghum and at high lands enset is recognized. The livestock population in the district is estimated to be 104,047 cattle, 39,270 Sheep, and 52, 009 Goat. The district has 122,568 total human populations (AWAO, 2004).

2.2 Sampling techniques and sample size

The three districts (Derashe, Alle, and Konso) were chosen on the basis of dairy production and potential dairy development appropriateness. Two, three, and four kebeles, respectively, were purposefully chosen based on dairy production from the Alle, Konso, and Derashe districts which accounted a total of nine kebeles. Finally, using simple random sampling, homes with at least one local milking cow and/or cross-bred milking cow were chosen. There were 85, 68, and 51 HHs from the Derashe, Konso, and Alle districts, for a total of 204 HHs from the three districts. With a 3.5 percent standard error, the sample size of respondent homes was calculated using Arsham's (2005) calculation of N=0.25/SE2. The proportion of each kebeles' sample size to the total sample size was used to determine the sample size.

2.3 Methods of data collection

A cross-sectional survey was used from December 2019 to November 2021. During the research, both primary and secondary data were gathered. Primary data was gathered using a semi-structured questionnaire administered by skilled enumerators via face-to-face interviews, with an emphasis on herd composition and structure, as well as animal husbandry techniques. Milk and milk products marketing restraints and opportunities, milk yield/single cow, milking procedures, kind of milk products, milking material, traditional ways for raw milk preservation, processing methods, hygienic practice, milk and milk product tools. Secondary data was gathered from the respective agricultural and rural development offices in each town. The questionnaires were pre-tested to ensure that they were appropriate and accurate in generating all of the necessary data to achieve all of the stated goals. The survey was translated into the local dialect.

2.3.1 Focused group discussion

Focused group discussions were held with selected milk producers, model farmers, development agents and *kebele* administrative bodies in three districts with three focus groups (10 individuals were selected from each district) considering their age, sex, education and experience with milk production, milk and milk products processing and marketing. Focus group discussion was carried out by using checklists prepare for this purpose. During focus group discussion, issues such as dairy production system, milk and milk product handling practices, traditional milk processing practice, marketing of milk and milk products and constraints of milk marketing were discussed.

2.3.2 Farm observation

Farm observations was made to collect the data about the type of management systems used by the dairy producers (feeding systems, proper housing) and to describe some of the routine dairy activities (cleaning, milk handling and processing system) practiced by producers.

2.4 Method of data analysis

SPSS version 20 was used to code, input, and analyze the obtained data. The results of the survey were summarized using descriptive statistics such as percentage, mean, and frequency, and presented in tables and figures. The significance level for categorical data was set at P0.05, and statistical variations were assessed using chi-square; numerical data was treated to one- way analysis of variance (one-way ANOVA). The numerical values were also tested for significance using P 0.05.

3. Results and Discussion

3.1 Socio-economic characteristics of respondents

About 85 % of the 204 houses surveyed were male headed households, while the remaining 15% were female headed. The majority of the household heads who were involved in milk production in the research area were males. The fact that there were fewer female-headed households in the current study could be due to their lower socioeconomic status and the nature of the industry, which requires a lot of energy for proper dairy cattle handling and management practices like feed collection, feeding, and dairy cattle purchasing and selling, which could be difficult for females.

The current study is substantially identical to Wondatir and Mekasha (2014) study in the highlands and central rift valleys of Ethiopia, which had 86.7 and 13.3 percent male and female-headed households, respectively. The current figure, however, is higher than that of Bekele *et al.*, (2015), who found 77.78 percent and 22.22 male and female households in Dangila district's urban and peri-urban areas. Moges *et al.* (2021) observed that 86.4 percent of the total interviewed dairy cattle producers in the urban dairy production system (N = 66) were male-headed households, whereas 13.6 percent were female-headed households.

Table 1: Socio-economic Household Characteristics

Sex	Derashe		Konso		Alle		Overall	
	N = 85	%	N = 68	%	N = 51	%	N = 204	%
Male	73	85.88	51	75	50	98.03	174	85
Female	12	14.12	17	25	1	1.97	30	15
Total	85	100	68	100	51	100	204	100
Education level Illiterate	27	31.76	36	52.94	25	49.01	88	43.3
Basic Education	3	3.52	6	8.82	3	5.88	12	5.95
Elementary school	26	30.58	6	8.82	10	19.6	42	20.6
High school	11	12.94	7	10.29	8	15.68	26	12.7
College	5	5.88	8	11.76	3	9.8	16	7.8
Age of respondent	41.71	-	48.62	-	41.1	-	43.86	-
Higher Education	13	15.29	5	7.35	2	3.92	20	9.8
Total	85	100	68	100	51	100	204	100

3.2 Feed resources of dairy cattle

According to dairy farmers, different feed sources are used to raise dairy cows in the study district (Table 2). These feed sources include: hay (5.3%), crop by-products (51%), natural pastures (35%), improved forages (6.2%) and by-products agriculture and industry (2.5%). Most of the household heads do not use supplementary feed such as Furshika for dairy cows but use locally available feed, which is consistent (Takele and Habtamu, 2009). This may be due to the lack of availability of agricultural by-products and the lack of awareness among producers. The majority of interviewees in the study area did not use improved forage; this is due to lack of awareness, poor extension services and lack of feed/seed inputs. Extension services are needed to increase the adoption of forage technology.

The lack of seed and sowing material in terms of quantity and quality has significantly limited the development of improved pasture and forage growth, especially around the study area. Feed scarcity can be viewed in terms of quality and quantity and seasonal feed supply to meet the nutritional needs of dairy animals. Animal feed and concentrates are either too expensive or inaccessible in sufficient quantity and quality to improve milk yield (Azage et al., 2013). Fayo, (2006) reports that food shortage is a major problem that has contributed to low livestock production and productivity in the southern Gamo region, Ethiopia. Likewise, Derese (2008) reports that food shortages are the most important constraint on milk production in the western Shoa area of the Oromia region. In the lowlands, scarcity of food and water during the dry season forces animals and herders to travel long distances in search of food (Azage et al., 2013). Daniel (2000) points out that the conversion from natural grassland to cropland and the degradation and fragmentation of grasslands is a serious problem for livestock production in Bahir Dar, Ethiopia.

Table 2. Major feed resources

Feed resource	Derashe		Konso		Alle		Total	
	N = 85	%	N = 68	%	N = 51	%	N = 204	%
Hay	2	2	8	1	1	2	11	5
Crop residue	55	64.7	24	3	25	4	104	5
Grazing land	15	17.6	34	5	22	4	71	3
Improved forage	9	11	1	1.5	3	6	13	6
Agro-industry	4	4.7	1	1.5	0	0	5	2
Total	85	100	68	100	51	100	204	100

3.3 Water source and frequency of watering

Table 3 shows the water sources and watering frequency in the research locations. Dairy farmers in the research locations have four distinct water sources for their dairy cows, according to the findings. Ponds, rivers, springs, and piped water are examples of these. River is used by 44 percent of the dairy farms in this survey, followed by piped water (30%), pond (20%), and spring (20%). (6). Water quality must be examined since poor water quality generally contributes to low dairy cattle output and health. It is clear from the data in Table 3 that the Derashe area is improving water availability and quality by ensuring that growers have access to more piped water.

Table 3: Water source for dairy cattle and watering frequency

Water source	Derashe		Konso		Alle		Total	
	N = 85	%	N = 68	%	N = 51	%	N = 204	%
Pond	5	6	17	25	19	37	41	20
River	33	39	28	41	29	57	90	44
Spring	9	11	3	4	0	0	12	6
Piped water	38	44	20	30	3	6	61	30
Total	85	100	68	100	51	100	204	100
Water frequency								
Once a day	18	212	41	60	7	14	66	32
Twice a day	58	68.2	6	9	25	49	89	44
Three times	7	8.2	2	3	1	2	10	5
Ad libitum	2	2.4	19	28	18	35	39	19
Total	85	100	68	100	51	100	204	100

3.4 Housing system

According to the current study (Table 4), the three types of dwellings used to keep fattening cattle were a separate room in the family house (14%), a separate house built just for the cattle (47%), and an enclosed barn with a simple shed (39 percent).

Table 4. Housing system

Housing system	Derashe		Konso		Alle		Total	
	N = 85	%	N = 68	%	N = 51	%	N = 204	%
Separate room	10	12	15	22	5	10	30	14
Separate house	44	52	24	35	27	53	95	47
Enclosed barn	31	36	29	43	19	37	79	39
Total	85	100	68	100	51	100	204	100

According to Shitahun (2009), producers employed three types of buildings to store fattening cattle in Bure Woreda, Amhara National Regional State: a separate room in the family house, a separate house constructed for the cattle, and an enclosed barn with a modest shed, in that sequence. The aforementioned findings support Yisehak et al. (2013) conclusions that animal homes are too rudimentary and animals are maintained in poor conditions.

3.5 Milking hygienic practice

The results of the poll revealed that 24.5 percent of respondents washed the udder before and after milking, and 11.5 percent washed the udder before milking (Table 5). No washing of the cow's udder and hand washing before and after milking werereported by 41% and 23% of the respondents, respectively. Cows' udders must be cleaned before milking since they may come into contact with the ground, urine, feces, and feed refusals while resting. In the Derashe district, almost 36.5 percent of respondents washed their udders before and after milking, indicating that the importance of udder cleaning was higher than in other regions. Failure to cleanse the udder before milking can result in pollutants entering the milk. Milk hygiene was statistically significant ($P<0.05$) in all study districts.

Gezu and Haftu (2015) disagreed with the current finding, reporting that all respondents (100%) cleanse their udders before milking in Hadya Zone, Southern Ethiopia. The current finding contradicts with Abebe et al. (2013), who claimed that 100% of respondents in the Ezha district Gurage Zone do not wash the udder before milking. About 82 percent, 93 percent, and 84 percent of respondents cleaned milk storage equipment before and after milking in Derashe, Konso, and Alle, respectively

The majority of respondents in the research area cleaned the milk storage equipment before and after milking, however a soiled milking area and the failure to use a separate towel for each cow can result in significant pathogenic microorganism contamination of the milk. According to the Food Hygiene Regulations (2006), the milking area must be free of contamination from any source, such as dust, flies, birds, or other animals. However, in the current study, milking was frequently done in an unsanitary manner, and most households did not have a distinct milking area. This could make milk more bacterially contaminated from the milking environment. According to Almaz et al. (2001) the use of correct milking processes and the cleanliness of milking instruments most significantly influences the quality of dairy products.

Table 5. Milking hygienic practice

Parameters	Derashe		Konso		Alle		Overall		P-value
	N=85	%	N=68	%	N=51	%	N	%	
Washing udder before and after milking	31	36.5	8	12	11	21	50	24.5	
Washing udder before milking	14	16.5	7	10	2	4	23	11.5	
No washing at all	16	19	35	51.5	33	65	84	41	0.000
Hand washing before and after milking	24	28	18	26.5	5	10	47	23	
Total	85	100	68	100	51	100	204	100	
Clean the milk storage equipment	70	82	63	93	43	84	176	86	

3.6. Smoking practice of milking and handling equipment

Smoking practices and smoking purposes in the study areas are presented in Table 6. Most of the respondents (83%) milk handling equipment was smoked. The purpose of smoking is to improve the taste and aroma of milk and dairy products, kill bad microorganisms and improve the fermentation of milk. 17% of respondents did not smoke milk handling equipment in the study area. Derashe and Konso use Tobacco to kill bad microorganisms more than the Alles due to their better awareness of proper handling of dairy products. Consistent with this, Abebe et al. (2013) reported that the purpose of smoking was to improve the taste and aroma of dairy products, reduce bad microorganisms and increase shelf life of products in the Ezha district of Gurage.

Fikireneh et al. (2012) also reported that 93.3% of respondents used smoking herbs for better taste and aroma of milk and dairy products in Ethiopia's Rift Valley. The smoking plants like Woira (Olea africana), woybeta, Cheba (Acacia nilotica), Kega (Rosa abissinica) are the most commonly used smoking plants in the study area. In agreement with this finding, respondents in Kenya, Bahir Dar Zuria and Mecha districts, Wolaita area and West Gojjam area used the same crop as reported by Wayua et al. (2012), Eyasu and Asaminew (2014), Tsegaye and Gebreegziabhar (2015) and Melku (2016), respectively. As shown in Table 6, the majority of respondents (14%, 3% and 16% of respondents in Derashe, Konso and Alle) washed the milk cartons with water without using fumigation techniques. However, 71%, 93% and 76% of interviewees in Derashe, Konso and Alle used both rinsing and suction techniques to clean milk containers. Tobacco smoking has antibacterial activity, thereby inhibiting microbial growth in milk (Teshome et al., 2014).

Table 6. Smoking practice of milking handling equipment's

Parameters	Derashe		Konso		Alle		Overall	
	N=85	%	N=68	%	N=51	%	N=204	%
Smoking equipment								
Yes	62	73	62	91	45	88	169	83
No	23	27	6	9	6	12	35	17
Total	85	100	68	100	51	100	204	100
Method of cleaning								
Washing	12	14	2	3	8	16	22	11
Smoking	13	15	3	4	4	8	20	10
Both	60	71	63	93	39	76	162	79
Total	85	100	68	100	51	100	204	100

3.7 Milk storage and processing materials

Table 7 shows the various containers used for milk storage and processing. Traditional milk storage and processing materials were used. Natural fermented/sour milk is used for storage and processing. Traditional materials such as plastic containers (20%) gourds (70%), clay pots (4%), and stainless steel (6%) are used to turn the sour milk into butter. Sintayehu and Birhanu (1991) and Alganesh (2002), who found that 96.5 percent and 91 percent of dairy producers in Southern and Western Ethiopia, respectively, employed clay pot and gourd for churning, disagreed with the current finding. Traditional milk processing materials and procedures employed in the study, according to respondents, are time consuming, difficult, and poor at extracting fat. As a result, reducing the stress on women in the conventional process of processing milk into butter requires the adoption of enhanced and low-cost technology that saves time and adds to optimal fat recovery.

It's possible that the disparity in equipment utilization in the study area is related to a lack of materials. The majority of responders (70%) said they utilized gourd for milk storage and processing. Gourd was generally used in low-altitude settings because the plant is primarily grown in this area. According to Sale *et al*. (2018), the majority of respondents (96.3 percent), (84.2 percent), and (95.7 percent) in the mid altitude, high altitude, and Motta town, respectively, utilized clay pot. Melku (2016) found that in rural portions of West Gojjam Zone, 73 percent and 27 percent of respondents utilized gourd and clay pots, respectively. The gap could be attributed to people's cultural patterns and equipment availability.

Table 7. Traditional milk storage and processing materials

Material	Derashe		Konso		Alle		Overall		P-value
	N = 85	%	N = 68	%	N = 51	%	N = 204	%	
Clay pot	8	9	1	1	0	0	9	4	
Gourd	37	44	59	87	46	90	142	70	0.000
Plastic container	30	35	6	9	5	10	41	20	
Stainless steel	10	12	2	3	0	0	12	6	
Total	85	100	68	10	51	10	204	100	

3.8 Traditional butter (Kibe) making equipment

In the study area, 43 percent, 17 percent, and 40 percent of respondents utilized clay pots, bottle gourds, and plastic containers to manufacture traditional butter, respectively (Table 8). The equipment used for milking, processing, and storage determines the quality of milk and milk products because they allow germs to proliferate on milk contact surfaces during the time and between milkings. Traditional containers may be a source of bacterial contamination in milk. As a result, dairy farmers must pay particular attention to the quality and cleanliness of their milking equipment. They should use aluminum and stainless steel because they are easy to clean and they are the most widely used materials for milking equipment.

None of the respondents used modern appetizers to make butter in the study area. According to respondents, ergo is often semi-solid and is made from whole milk on small dairy farms. Milk is usually stored in clay pots or pumpkins for 1 to 4 days to generate acid. Fermented milk, along with other fermented dairy products, was the main ingredient in the production of traditional butter, ghee, cottage cheese, buttermilk, and whey.

Table 8. Traditional butter making equipment

Butter making equipment	Derasbe		Konso		Alle		Overall		P-value
	N = 85	%	N = 68	%	N = 51	%	N = 204	%	
Clay pot	42	49	25	37	21	41	88	43	
Bottle gourd	4	5	21	31	10	20	35	17	0.000
Plastic container	39	46	22	32	20	39	81	40	
Total	85	100	68	100	51	100	204	100	

The majority of respondents use clay pots to make traditional butter, but some farmers use gourd containers instead. 17% and 43% of the surveyed people use pumpkins or clay pots to stir the milk. According to respondents, the amount of fermented milk that is milked at any given time depends on the number of cows, the amount of milk produced, and the amount consumed by the family. No additives are used to preserve the raw milk produced in the study area. Instead, milk can ferment naturally.

3.9 The major traditionally fermented milk products

The main products of traditional milk processing were fermented milk (Ergo), 42% ghee (Neterkebe), 12% sour skimmed milk (Arerra) and 3% cheese (Ayib) (Table 9). Therefore, naturally fermented milk is the main ingredient used in the production of a wide variety of traditional Ethiopian dairy products. Fermented dairy products are traditionally made in Ethiopia by naturally fermenting fresh milk in traditional unsmoked milk containers for at least two days. The majority (57%) of respondents in the Derashe area produce fermented milk (ergo) compared to other study areas, which is statistically ($P<0.05$) very important. Ergo is Ethiopia's most popular dairy product and is usually made by naturally fermenting milk at room temperature for at least 2 days without the addition of starter culture. However, depending on general environmental conditions, temperature and incubation time will vary from location to location. Ethiopian milk is of poor quality and does not meet international standards. These are due to the very perishable properties of milk, in addition to poor pre-milking and post-harvest handling techniques (Tsadkan and Gurja, 2018).

Ethiopian traditional butter (Kibe) is made from yoghurt (traditional Ergo) (Abebe et al., 2014). The most frequent milk products produced and consumed by different parts of the country were fresh milk, Ergo, whey, Ethiopian cottage cheese (Ayib), and traditional butter (Abebe et al., 2014).

Table 9. The major traditionally fermented milk products

Fermented milk products	Derasbe		Konso		Alle		Overall		P-value
	N = 85	%	N = 68	%	N = 51	%	N = 204	%	
Fermented milk (Ergo)	48	57	8	12	6	12	62	30	
Butter (Kibe)	14	16	39	57	32	63	85	42	
Ghee (Neterkibe)	8	9	13	19	5	10	26	13	<0.001
Sour defatted milk (Arrera)	9	11	7	10	8	15	24	12	
Cheese (Ayib)	6	7	1	1.5	0	0	7	3	
Total	85	100	68	100	51	100	204	100	

3.10 Length of milk fermentation time

As shown in Table 10, 50.5%, 25% and 24.5% of respondents said that milk was left to sour for 3 days, 45 days and for one week respectively in the study area (Table 10). Belay and

Janssens (2014) reported that the majority of respondents (86%) reported that milk left to sour for 3 days and 62% of household processes consumed an average of five liters of milk at a time, with variable frequency. Weekly (64%). The majority of respondents (69%) let milk ferment for 3 days in Alle district, which is better than other districts. The efficiency of the stirring process is determined by the amount of milkfat recovered as butter and the granulation time of the butter. Temperature, milk fat, milk acidity, and volume of milk in the clay pot all affect the effect. Differences in fermentation times may be due to regional differences in temperature, as well as their preferred mode of consumption.

According to Belete et al. (2010), the traditional Ethiopian method is to preserve milk for two to three days until yogurt is made. According to Table 11, 7%, 18%, 53%, 16%, 13% of the respondents gave milk more often in the fasting period, the rainy season, the dry season and no specific time respectively. During the fast, when Orthodox Christians abstain from any animal products, a minority of respondents (7%) processed milk on the fasting day, extending the shelf life of milk by converting it into dairy products. The majority of respondents (53%) process milk more often during the rainy season, because during the rainy season (March to August), excess milk is often available and manufacturers process it into dairy products. such as fermented milk (Ergo), ghee (Neterkebe), reduced-fat yogurt (Arerra) and cheese (Ayib). The majority of respondents (53%) process milk more often during the summer (rainy season). This is because there is a lot of grass available for animals to eat during this time of year.

Table 10. The major traditionally fermented milk products

Length of milk fermentation time	Derashe		Konso		Alle		Overall	
	N = 85	%	N = 68	%	N = 51	%	N = 204	%
For 3 days	35	41	33	49	35	69	103	50.5
For 4-5 days	15	18	24	35	12	24	51	25
For a week	35	41	11	16	4	7	50	24.5
Total	85	100	68	100	51	100	204	100
When do you process milk more frequently								
Fasting period	14	16	7	10	15	29	36	18
Wet season	46	54	33	49	30	59	109	53
Dry season	9	11	17	25	6	12	32	16
No specific time	16	19	11	16	0	0	27	13
Total	85	100	68	100	51	100	204	100

3.11 Purpose of butter making

The quantity of milk needed to stir was 35 liters, 67 liters, 710 liters and more than 10 liters respectively for 61%, 13%, 17% and 9% in the study area (Table 10). The amount of milk required for milk stirring in the whole district of Alle was 810 liters, which was higher than in other study areas, which may be due to the relatively high amount of milk produced per day and per household. The present conclusion is almost similar to Eyasu and Asaminew (2014), who reported that 7.5 ± 1.8 liters was required for stirring in both Bahirdar Zuria and Mecha districts. However, Bekele et al. (2015) in Dangila district reported that 25.14 liters of milk were required to stir at a time in Dangla district.

Table 11. Purpose of butter making

Amount of milk required for churning	Derashe		Konso		Alle		Overall	
	N=85	%	N=68	%	N=51	%	N	%
3-5 liters	51	60	43	63	31	61	125	61
6-7 liters	15	18	7	10	5	10	27	13
8-10 liters	8	9	12	18	15	29	35	17
More than 10 liters	11	13	6	9	0	0	17	9
Total	85	100	68	100	51	100	204	100
Purpose of butter making								
For market	16	19	11	16	11	22	38	19
Ointment	10	12	9	13	3	6	22	11
Used raw milk only	15	17	21	31	12	23	48	23
Total	85	100	47	100	39	100	156	100

The normal stirring process takes a long time, sometimes more than two hours. The goal of making butter from yogurt is to extract as much fat as possible from the milk. Buttermilk, the liquid left over after making butter, is used to make a cheese. Accordingly, the stirring time and, more importantly, the amount of fat remaining in the buttermilk or the amount of fat extracted from the milk can be used to determine the efficiency of the butter making process. About 47%, 19% and 11% of the respondents made butter for consumption, for the market and for making ointment, respectively. 52% of respondents made avocados for consumption in Derashe county, which is higher than in other study areas. About 23% of respondents do not want to make butter, only eat raw milk. Bacteria such as Salmonella and E. coli can be found in raw milk. E. coli and other bacteria that cause foodborne illness, also known as "food poisoning," can harm the health of anyone who consumes raw milk or raw milk products.

3.12 Reasons for processing milk

Reasons for milk processing in the study area are presented in Table 12. The majority of respondents processed milk to preserve products (27%), generate income (29%), diversify products (35) %), customer satisfaction (2%) and product hygiene (7%). The results are almost similar to Ayantu (2006) who reported that milk is processed to increase family income, diversify consumer products and increase shelf life of products in the primary sector. Delbo's source from the Wolayta area. Befekadu et al. (2019) wrote that the majority of respondents (72.73%) process milk to diversify products, preserve products and generate income. In Ethiopia, milk and dairy products are mainly used for home consumption because of their high nutritional value. In addition, it is a source of cash income to purchase agricultural inputs such as animal feed, fertilizers and improved crop varieties as well as food and non-food items such as educational materials for children. their own (Melese and Tesfaye, 2015).

Table 12: Reasons for processing milk

Reason for processing milk	Derashe		Konso		Alle		Overall	
	N=85	%	N=68	%	N=51	%	N	%
For preservation of products	23	27	21	31	12	24	56	27
For income generation	28	33	17	25	15	29	60	29
For diversify products	27	31	20	29.5	24	47	71	35
Customer satisfy	3	4	1	1.5	0	0	4	2
To keep the product hygienic	4	5	9	13	0	0	13	7
Total	85	100	68	100	51	100	204	100

3.13. Dairy products marketing

As shown in Table 13, whole milk (35%), fermented milk (Ergo), 57% butter (Kibe), 5% dairy (Arerra) are milk and dairy products marketed. In the study area, milk and dairy products are sold almost exclusively through an informal marketing system. The marketing of milk is very loosely structured and only a few merchants use a formal marketing strategy for butter and milk. The present results are in contrast to those of Abebe et al. (2013) and Amistu et al. (2016), who stated that in the Ezha and Alle districts of the Guragie region and the Segen region, 100% of respondents do not sell milk. However, dairy marketing practices were more important in this study than Menal and Yilkal (2015), with 30.83% in Chencha district and 12.78% in Kutcha district. In addition, the results are lower than those reported by Zewdie (2010), Hanfer et al.

(2016) and Melku (2016), who found that 90%, 50%, and 48.3% of respondents in Sebeta town, Asayita district and western Gojjam area, respectively, were assigned to follow up fresh milk market. Very few respondents (13%) have commercially available sour skimmed milk (Arrera) in Derashe district but none of the respondents have commercially available avocado milk (Arrera) in Konso and Alle districts. Compared with Konso and Alle counties, the majority of respondents (57%) in Derashe use fermented milk (Ergo). This could be the presence of a dairy marketing location nearby.

Around Holetta, about 83% of farmers are selling butter for processing milk into butter, and Ayib has a financial advantage of about 40% over selling whole milk at the time of reporting. However, processing may not have a financial advantage over selling whole milk, given the very high cost of feed and other inputs for dairy production, as well as rising milk prices. According to Zelalem (1999), between 57% and 40% of smallholder farmers in Holetta and Selale do not sell raw milk but process it into butter. According to Rahel (2008), the sale of liquid milk is virtually non-existent due to consumer preferences for processed dairy products such as butter and cheese, as well as cultural factors and lack of fruit demand. against the current results. The present finding disagrees with Lemma (2004) reporting that 96.7 percent of respondents in Adami Tulu and Arsi Negelle counties, and 93.3 percent in Lume counties, do not sell raw milk. Next to whole milk, butter was the most important item on the market to research, with around 57% of respondents saying they sell this type of butter. This can be attributed to the increase in milk production as well as the approval of most of the customers about the taste of the butter. Disagree with Zewudie (2010) and Abebe et al. (2013), the marketing of raw milk is not widespread in and around Zeway town, Oromia region and Ezha district due to cultural constraints, milk scarcity and lack of market.

Table 13: Milk and milk products marketing

Dairy product marketing	Derashe		Konso		Alle		Overall	
	N = 85	%	N=68	%	N=51	%	N	%
Whole Milk	39	46	23	34	9	18	71	35
Fermented Milk (*Ergo*)	5	6	1	1	42	82	6	3
Butter (*Kibe*)	30	35	44	65	0	0	116	57
Butter Milk (*Arrera*)	11	13	0	0	0	0	11	5
Total	85	100	68	100	51	100	204	100

3.14 Mode of milk delivery and means of transportation

Centralized milk collection, milk produced on farms is either sold at the farm gate or delivered to individual milk contractors (Table 14) are not available. So, the majority of the milk (54%) is provided by family members or hired workers, while 34% is collected at the farm gate, and the other 12% is brought by either consumer collect at the farm gate or by family (12 %). The distance between milk producers and marketing outlets, such as small stores and hotels/cafeterias, determines the mode of milk transportation. Producers who are close to marketing places take public transportation, whereas those who are further away walk with their milk.

Table 14: The mode of milk delivery in the study areas

Mode of milk delivery	Derashe		Konso		Alle		Overall	
	N = 85	%	N = 68	%	N = 51	%	N	%
Family or hired labor	32	38	45	66	34	67	111	54
Collected by consumer	43	51	16	24	10	20	69	34
Both	10	11	7	10	7	13	24	12
Total	85	100	68	100	51	100	204	100
Means of Transportation								
On foot	84	99	67	99	49	96	200	98
Public transport	1	1	1	1	2	4	4	2
Total	85	100	68	100	51	100	204	100
Milk Marketing place								
Local market	42	49.4	46	68	35	69	123	60
Neighbor/consumer/home	40	47	20	29	15	29	75	37
Cafeteria/ hotel	2	2.4	0	0	0	0	2	1
Shop	1	1.2	2	3	1	2	4	2
Total	85	100	68	100	51	100	204	100

3.15 The major constraints of milk production

Lack of food, lack of water, disease, lack of information on markets, inadequate infrastructure, lack of improved varieties and inadequate artificial insemination were the main constraints for 69%, 3%, 7.5%, 2.5%, 8% and 10% (Figure 1). The present conclusion is in agreement with the results of Tsegaye et al. (2015) who reported feed, animal health, water and labor shortage problems as major challenges affecting dairy cow production and productivity in several districts of the Sidama region, southern Ethiopia.

The first important factor causing low performance and low milk production in dairy cows was identified as nutritional deficiency in the study area. This is consistent with the findings of Bekele et al. (2015) and Gezu and Haftu (2015) who identified feed scarcity as the most important constraint contributing to low production and performance of dairy cows in different parts of the Ethiopia. This may involve the conversion of cropland to arable areas, with less use of crop by-products and treatment practices. The present conclusions indicate that the second and third major constraints to milk production in the study area are poor infrastructure, lack of improved varieties, and inadequate artificial insemination. The present finding is consistent with Teshome and Tesfaye (2017), who found that the most important dairy production constraints identified by the sampled farmers were food shortages, land scarcity and Disease. According to the same author, the other most important limitations of the marketing system are the accessibility of marketing sites, limited market knowledge, lack of improved varieties, insufficient artificial insemination. (AI) and lack of infrastructure. These constraints interact to affect the genetic potential of the animal, resulting in milk production at subsistence levels.

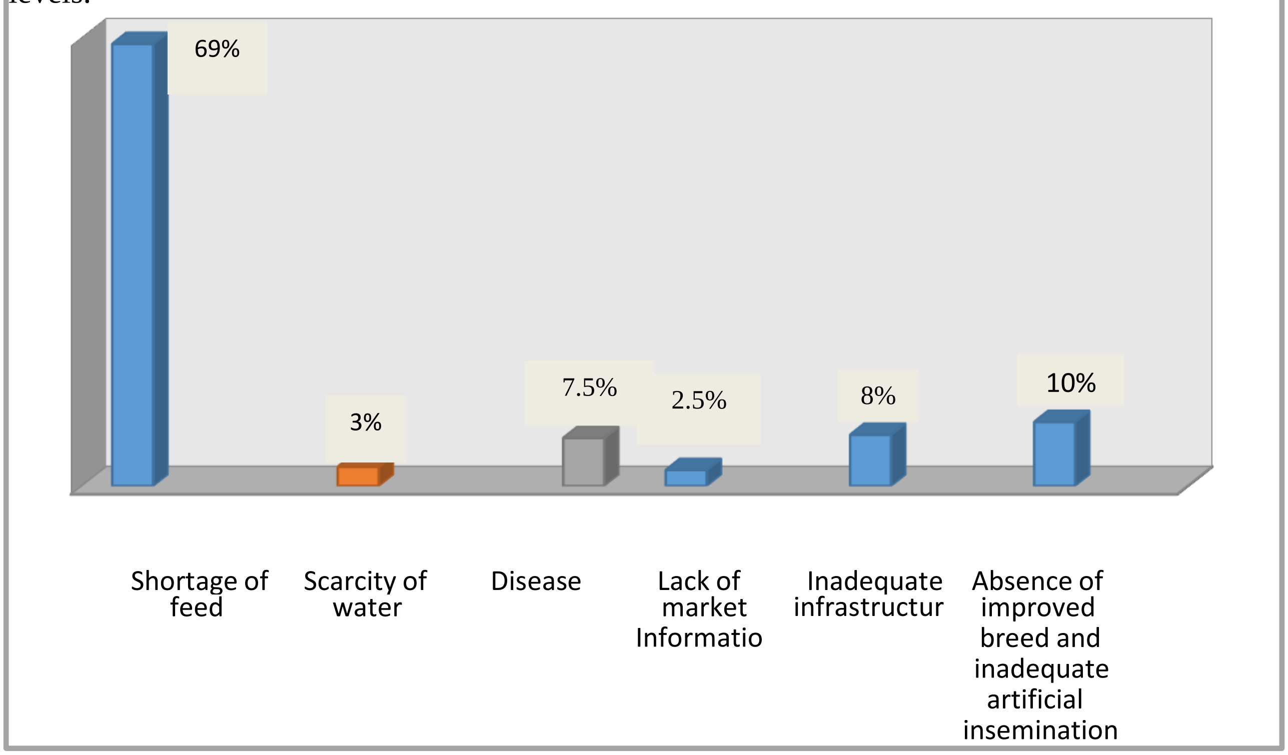

Figure 1. The major constraints of milk production in the study area

A dairy marketing difficulty (Figure 2) was shown to be milk shortage (47 percent), lack of markets or purchasing centers (27 percent), milk quality (3 percent), low prices (2 percent), a lack of demand (1 percent), and restricted culture (20 percent). In the research area, milk scarcity is the biggest impediment to marketing challenges. Fasting is the most common cause of insufficient milk consumption. People who practice Orthodox Christianity avoid dairy products, particularly during the Easter fast (55 days). Orthodox Christians abstain from dairy products for about 200 days a year (Ahmed Mohamed et al., 2004). Only 20% of the people polled thought that a taboo culture was a barrier to milk marketing. This study contrasts a survey conducted by Tegegne in the Showa region of eastern Oromia, which revealed that low milk production and cultural constraints are the most common impediments identified by farmers (Tegegne et al., 2013).

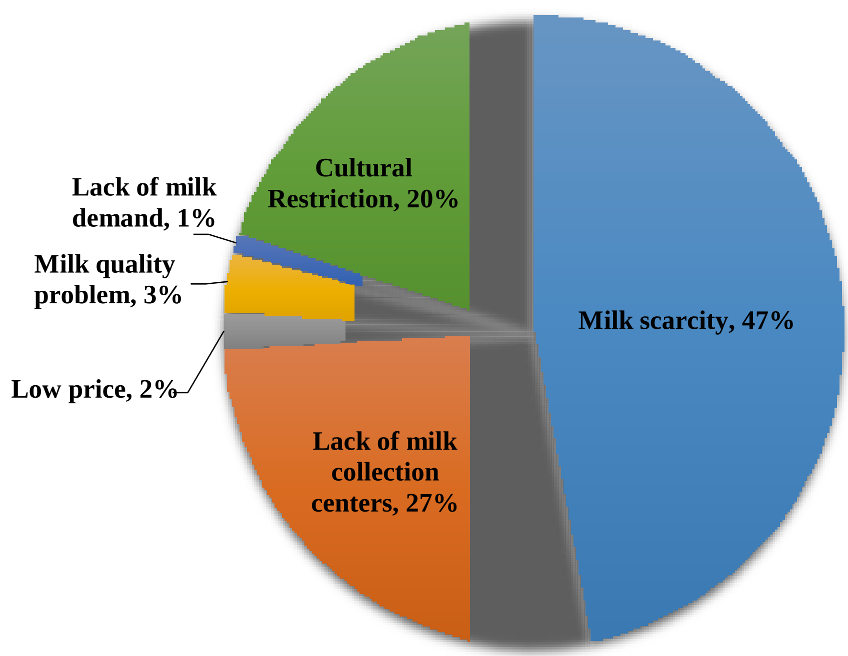

Figure 2. Milk marketing constraints

3.16 The major opportunities of milk production

Availability of large communal pasture areas (20%), large numbers of local cows (25%), increased demand for milk (33%), population growth (12%), urban proportions high marketing (4%) and income (6%) turned out to be the main dairy production opportunities in the study area (Figure 3). According to Solomon (2014), dairy production provides dairy farmers with income generation opportunities due to rapid urbanization, significant population growth and changing living standards of the inhabitants of Mekelle, because as this is a product in great demand, it is appropriate for the research being conducted. Asrat et al. (2016) notes what is consistent with current findings. Per the authors, allowing smallholder farmers to use their land, labor and food resources while generating constant income. Azage et al. (2006) conclude that urban and peri-urban dairy systems can contribute to overall development by providing income and employment opportunities. Azege et al. (2013) also mentioned the diverse and large genetic resources of dairy animals adapted to many types of agriculture, the establishment of different structures and service centers such as veterinary and fertilization centers. artificial intelligence (AI), high demand for dairy products. products and a large population

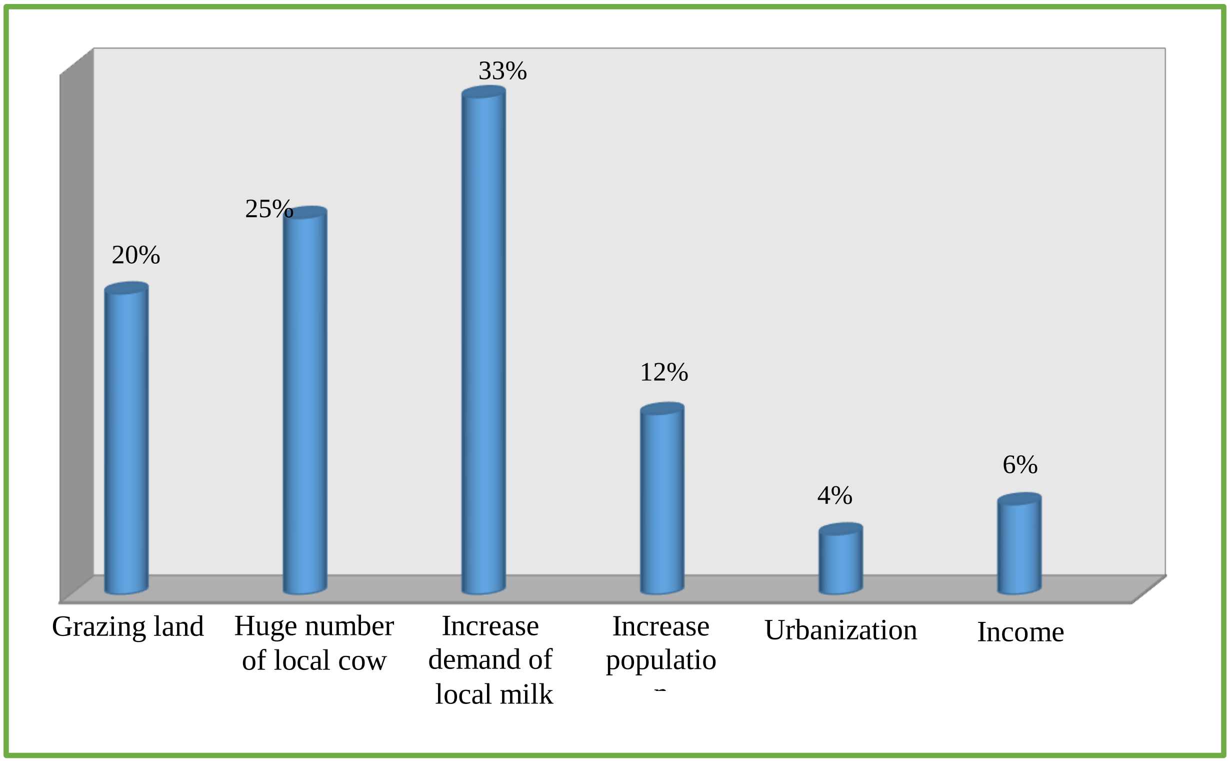

Figure 3: Major opportunities of milk production

4. Conclusions

The majority of household heads engaged in dairy production in the study area are men compared to women. The lower number of female-headed households in the present study may be due to the nature of the industry, which requires more energy to handle and practice proper dairy management. The average level of education of dairy farming households is mainly illiterate. Households with low educational attainment may be slow in adopting technology. In this study, milking was often done in poor sanitary conditions and most households did not have their own milking place. This can increase bacteria in milk contaminated from the milking environment. The use of tobacco smoke to kill bad microorganisms was higher in Derashe and Konso than in Alle county due to the respondent's raising awareness about the proper handling of dairy products. The majority of respondents use clay potting for traditional butter making, although some farmers use potting soil instead. 17% and 43% of respondents used gourds and clay pots to stir milk, respectively.

The quality of milk and dairy products is determined by the equipment used for milking, processing and storage. Traditional containers can be a source of microbial contamination for milk because they allow germs to multiply on milk contact surfaces between milking sessions. Lack of food, lack of water, disease, lack of information on markets and markets, inadequate infrastructure, lack of improved varieties and inadequate artificial insemination were the main constraints for 69%, 3%, 7.5% 2.5%, 8% and 10%. . The first important factor causing low performance and low milk production in dairy cows was identified as nutritional deficiency in the study area. Milk scarcity (47%), lack of markets or purchasing centers (27%), milk quality (3%), cheap prices (2%), lack of demand (1%) and limited culture (20 %) turned out to be a dairy marketing problem.

Conflict of Interest

The author(s) did not disclose any potential conflicts of interest

References

Abebe, B., Mitiku, E., & Zelalem, Y. (2014). Microbial properties of Ethiopian dairy products: Areview. African Journal of Microbiology Research, 8(23), 2264-2271.

Abebe, B., Zelalem, Y., & Ajebu, N. (2013). Handling, processing and utilization of milk and milk products in Ezha district of Guragie zone, Southern Ethiopia. Journal of Agricultural Biotechnology and Sustainable Development, 5(6), 91-98.

Abebe, B., Zelalem, Y., & Ajebu, N. (2014). Dairy production system and constraints in Ezha districts of the Gurage zone, Southern Ethiopia. Global Veterinaria, 12(2), 181-186.

Ahmed Muhamed, M., Ehui, S. K., & Yemisrach Assefa. (2004). Dairy development in Ethiopia. (Socio-economic and Policy Research Working Paper-58). ILRI.

Alganesh, T. (2002). Traditional milk and milk products handling practices and raw milk quality in eastern Wollega. (Unpublished Master’s Thesis) Alemaya University, Ethiopia.

Almaz, G., Howard, A. F., & Wilhelm, H. H. (2001). Field survey and literature review on traditional fermented milk products of Ethiopia. International Journal of Food Microbiology, 68, 173-186.

Amistu, K., Melese, A., & Degefa, T. (2015). Evaluation of Hygienic Status and Marketing System of Raw Milk in Different Points of Oromia Special Zone, Oromia, Ethiopia.

Amistu, K., Sanago, S., & Dawit, C. (2016). Assessment of traditional dairy production, milk marketing and processing system: In the case of Alle district, Segen Peoples Zone, Southern Ethiopia. Journal of marketing and consumer research, 24.

Asrat, A., Feleke, A., & Ermias, B. (2016). Characterization of Dairy Cattle Production Systems in and around Wolaita Sodo Town, Southern Ethiopia. Scholarly Journal of Agricultural Science, 6(3), 62-70.

Ayantu, M. (2006). Women's role on production, processing and marketing of milk and milk products in Delbo watershed of Wolayta. [M. Sc. Thesis, Hawassa University].

Azage, T. (2003). Financing Market-oriented Dairy Development: The case of Ada'a Liben District Dairy Association, Ethiopia. Urban Agricultural Magazine, 9, 45.

Azage Tegegne, Berhanu Gebremedhin, Hoekstra, D., Berhanu Belay, & Yoseph Mekasha. (2013). Smallholder Dairy Production and Marketing Systems in Ethiopia: IPMS Experiences and Opportunities for Market-Oriented Development. (Working Paper No. 31). International Livestock Research Institute (ILRI).

Azage Tegegne, Million Tadesse, Alemu Yami, & Yoseph Mekasha. (2006). Market-oriented urban and peri-urban dairy systems. Urban Agriculture Magazine, 2, 23-24.

Bekele, A., Fekadu, B., & Mitiku, E. (2015). Handling, processing and marketing of cow milk in urban and peri urban area of Dangila Town, Western Amhara Region, Ethiopia. Global Journal of Food Science and Technology, 3(3), 159-174.

Belay Duguma, & Janssens, G. P. J. (2014). Smallholder milk processing and marketing characteristics at urban dairy farms in jimma town of oromia regional State, Ethiopia.

Belete, A. T., Azage, T., Fekadu, B., & Berhanu, G. (2010). Cattle milk and meat production and marketing systems and opportunities for market-orientation in Fogeraworeda, Amhara region, Ethiopia. International Livestock Research Institute (ILRI).

Central Statistical Agency. (2010). Agricultural Sample Survey 2009/10. Livestock, Poultry and Beehives population. Federal Democratic Republic of Ethiopia.

Central Statistical Agency. (2014). Agricultural Sample Survey 2013/14. Volume 2, Report on Livestock and Livestock Characteristics. Federal Democratic Republic of Ethiopia.

Central Statistical Agency. (2015). Agricultural Sample Survey 2014/15 Volume II Report on Livestock and Livestock Characteristics (Private Peasant Holdings). Federal Democratic Republic of Ethiopia.

Central Statistics Agency. (2007). Welfare monitoring survey. Analytical Report.

Daniel. (2000). Role crop residues on livestock feed Ethiopia high lands. In B. HDowela (Ed.), African plant genetic resource, evaluation and forage germ plasm and extensive livestock production system: Proceedings of the third PANESA workshop held in Arusha, Tanzania, 27-30 April 1999 (pp. 430-439).

Derashe District Livestock and Fishery Development Office (DDLF). (2016). Annual report. Gidole, Ethiopia.

Derashe Peoples Development Association Office (DDAO). (2015). Annual report. Gidole, Ethiopia.

Derese, T. (2008). Present situation of urban and peri urban milk production and quality of raw milk produced in west Shoa zone, Oromia Region Ethiopia. [M.Sc. Thesis, Haramaya University].

Eyasu, S., & Asaminew, T. (2014). Small-scale milk processing, utilization and marketing of traditional dairy products in Bahir Dar Zuria and Mecha districts, Northwestern Ethiopia. Journal of Food Technology Research, 1(2), 122-132.

Fayo, D. (2006). Assessment of Milk Production Marketing, Feeds and Feeding System of Dairy Cows in and Around Dire Dawa Town. [M.Sc. Thesis, Alemaya University].

Food Hygiene Regulations. (2006). A practical guide for milk producers to the food hygiene regulations, England.

Gezu Tadesse, & Haftu Kebede. (2015). Production, processing and constraints of cow milk in and around Hosanna Town, Hadya Zone, Southern Ethiopia. Global Journal of Dairy Farming and Milk Production, 3, 92-98.

Hanfer, M., Nigussie, A., & Patrick, E. (2016). Cattle and camel milk production and marketing: The case study in Asayita district, Afar Regional State, Ethiopia. Journal of Marketing and Consumer Research, 22.

Kedija, H., Azage, T., Mohammed, Y., & Berhanu, G. (2008). Traditional Cow and Camel Milk Production and Marketing in Agropastoral and Mixed Crop–livestock Systems: The Case of Mieso District, Oromia Regional State, Ethiopia.

Lema, F. (2004). Assessment of butter quality and butter making efficiency of new charns compared to smallholders' butter making techniques in east showa zone of Oromia, Ethiopia. [MSc. thesis, Alemaya University].

Melese, A., & Tesfaye, W. (2015). Bacteriological Quality and Safety of Raw Cow's Milk in and around Jigjiga City of Somali Region, Eastern Ethiopia. International Journal of Research Studies in Biosciences, 3(5), 48-55.

Melku, M. (2016). Milk production and reproductive performance of local and cross breed cows in selected districts of West Gojjam Zone, Amhara National Regional State Ethiopia. (Unpublished Master's Thesis) Bahir Dar University, Ethiopia.

Menale, G., & Yilkal, T. (2015). Dairy production, processing and marketing in Chencha and Kutcha districts, Southern Ethiopia. Journal of Marketing and Consumer Research, 9.

Metaferia, F., Cherenet, T., Gelan, A., Abnet, F., Tesfay, A., Ali, J. A., & Gulilat, W. (2011). Review to Improve Estimation of Livestock Contribution to the National GDP. Ministry of Finance and Economic Development and Ministry of Agriculture.

Miles, T. (2000). Agribusiness sub sector assessments. In D. Giovannucci (Ed.), A guide to developing agricultural markets and agro-enterprises. World Bank.

Ministry of Agriculture (MoA). (2012). Livestock growth strategy and action. draft discussion paper. (Amharic version).

Moges Abebe, Asaminew Tassew, & Bimrew Asmare. (2021). Appraisal of milk production, processing and marketing in selected urban and peri- urban dairy production systems of Northwestern Ethiopia.

Muriuki, H. G., & Thorpe, W. (2008). Smallholder dairy production and marketing in Eastern and Southern Africa.

O'Mahony, F., & Peters, J. (2004). Options for smallholder milk processing in sub-saharan Africa. International Livestock Center for Africa (ILCA) Bulletin, 27, 206-247.

Rahel, G. (2008). Traditional and improved milk and milk product handling practices and composition and microbial quality of raw milk and butter milk Delebo water shed of Wolayita Zone, Ethiopia.

Sale, A., Dehinenet, G., & Zemenu, Y. (2018). Handling, processing, utilization and marketing system of milk and milk products in Huet Eju Enesie district, East Gojjam Zone, Ethiopia.

Shitahun. (2009). Feed resources availability, cattle fattening practices and marketing system in Bure Woreda, Amhara Region. (Unpublished Master's Thesis), Mekelle University.

Sintayehu, D., & Berhanu, A. (1991). Dairy marketing in Ethiopia: markets of first sale and producers' marketing patterns. ILCA.

Solomon Mebrahtu. (2014). Exploration of challenges and prospects of dairy production: A survey study of Mekelle City, Ethiopia. [MSc Thesis, Mekelle University].

Southern Nations, Nationalities and People Regional State's Bureau of Agriculture. (2014). livestock resource extension annual plan cooperative agreement. The next stage in dairy development for Ethiopia.

Takele, T., & Habtamu, L. (2009). Traditional backyard cattle fattening in Wolayta: Systems of operation and the routine husbandry practice. Ethiopian Journal of Animal Production, 9(1), 39-56.

Tegegne, A., Gebremedhin, B., Hoekstra, D., Belay, B., & Mekasha, Y. (2013). Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development. International Livestock Research Institute (ILRI).

Teshager, A., Belay, D., & Taye, T. (2013). Traditional cattle fattening and live animal marketing System in Different Agro-Ecologies of Ilu Aba Bora Zone, Oromia, Ethiopia. Global Veterinaria, 10(5), 620-625.

Teshome, & Tesfaye. (2017). Dairy cattle milk production, handling, processing, utilization and marketing system in Bench Maji Zone, Southwest Ethiopia.

Teshome, G., Fikadu, B., & Mitiku, E. (2014). Handling practices and microbial quality of raw cow's milk produced and marketed in Shashemene town, Southern Ethiopia. International Journal of Agriculture and Soil Science, 2(9), 153-162.

Tsadkan, Z., & Gurja, B. (2018). Handling and utilization pattern of cattle milk and milk products in Northern Ethiopia. African Journal of Agricultural Research, 13(34).

Tsedeke, K. (2007). Production and marketing systems of sheep and goats in Alaba, Southern Ethiopia. (Unpublished Master's Thesis), Hawassa University, Ethiopia.

Tsegaye, L., & Gebreegziabhar, Z. (2015). Marketing of dairy products in selected districts of Wolaita Zone, Southern Ethiopia. Journal of Marketing and Consumer Research, 14.

Wayua, F., Okoth, M., & Wangoh, J. (2012). Survey of postharvest handling, preservation and processing practices along the milk chain in Isiolo district, Kenya. African Journal of Food, Agriculture, Nutrition and Development, 12(7).

Woldemichael, S. (2008). Dairy marketing chains analysis: The case of Shashemene, Hawassa and Dale districts' milk shed, Southern, Ethiopia.

Wondatir Zewdie, & Mekasha Yoseph. (2014). Feed resources availability and livestock production in the central rift valley of Ethiopia. International Journal of Livestock Production, 5(2), 30-35.

Yilma, Z., Emannuelle, G. B., & Ameha, S. (2011). A Review of the Ethiopian dairy sector. (R. Fombad, Ed.). Food and Agriculture Organization of the United Nations, sub regional office for Eastern Africa (FAO/SFE).

Yisehak, K., Taye, T. M., & Aynalem, H. (2013). Characteristics and constraints of livestock in Jima Zone, Southern, Ethiopia. OAU.

Yohannes, G. (2015). Conflicts of indigenous farming practices and modern agriculture in Konso Community, Southern Ethiopia.

Zelalem, Y. (1999). Smallholder milk production systems and processing techniques in the central highlands of Ethiopia, (Unpublished Master's Thesis), Swedish University of Agricultural Sciences.

Zewudie, W. (2010). Livestock production system in relation with feed availability in the Highlands and Central Rift Valley of Ethiopia (Unpublished Master's Thesis). Haramaya University, Ethiopia.

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Research Article

Landslide threat evaluation and zoning in birbir mariam district, Gamo Highlands, Ethiopia Great Rift Valley escarpment

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Abstract

The current research focuses on landslide assessment and hazard zonation in the Birbir Mariam district of the Gamo Highlands. The study examined landslide causative factors and used the slope susceptibility evaluation parameter to create a landslide hazard zonation covering an area of 110 square kilometers. The landslide hazard zonation was classified using facet-wise observation. As a result, the intrinsic and external causal parameters of score schemes have been held responsible for slope instability. Inherent causative elements consist of slope geometry, slope material (rock or soil), structural discontinuities, land use or land cover, and groundwater conditions. Rainfall and human interest have seemed like external elements. The intrinsic and external triggering elements for every facet (a total of 106) were rated for their contribution to slope instability. Finally, an evaluated landslide hazard value was calculated and classified into three landslide hazard classes. According to the findings, the area has a high hazard zone of 18.87 percent (20.76 km^2), a moderate hazard zone of 54.72 percent (60.19 km^2), and a low hazard zone of 26.41 percent (29.05 km^2). The methodology employed in this investigation, as well as the resulting landslip susceptibility zonation map, were both reliable and applicable to other places with similar geology and topographic circumstances.

Keywords: Ethiopia; Hazard zonation; Landslide; Landslide evaluation; Slope stability

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1. Introduction

Landslides are a series of events in which a mass of rocks, soil, or debris slides down a slope due to gravitational pull. The mechanisms include sliding, falling, or flowing material down a slope (Woldearegay, 2013). Landslides are one of the most common geological hazards in the world, with a high incidence, a wide range of distribution, and catastrophic severity, resulting in numerous fatalitie s each year (van Western et al., 2008; Abbate et al., 2015; Bernat et al., 2019).

Landslides are caused by inherent causative parameters that define the unfavorable stability conditions within the slope, such as slope geometry, slope material, structural discontinuities, land use, land cover, and groundwater conditions (Erener & Duzgun, 2012; Santangelo et al., 2015; Kannan et al., 2015). External causative factors, such as rainfall, volcanism, seismic motion, and human activities, are also relatively variable or dynamic, temporary, and forced by upcoming events (Santangelo et al., 2015; Raghuvanshi et al., 2014; Silalahi et al., 2019). The slope is prone to instability when the slope characterization is steep, and the possibility of a landslide increases as the slope steepness increases (Raghuvanshi et al., 2014).

Landslides such as rockfall, toppling, and rockslides/avalanches are common in the area because the slope material has been covered by highly fractured bedrock such as basalt and ignimbrite (Ayalew & Yamagishi, 2004; Lee & Pradhan, 2007). Discontinuities in the slope, such as bedding, joints, and faults are potentially weak planes that affect slope stability (Ayalew & Yamagishi, 2004; Dahal et al., 2012). As a result, the strength of fractured rocks is typically less than that of intact rocks. They are the most vulnerable component of slope geology and critical to understanding their orientation, spacing, continuity, roughness, separation, and type of filling material with slope angle, slope direction, and strength along such potential weak planes (Raghuvanshi et al., 2014; Santangelo et al., 2015).

Land use and land cover affect slope stability, and groundwater conditions on the slope reduce the material's shear strength. It creates pore water pressure, both of which are important in slope stability conditions (Mulatu et al., 2011). Landslides are one of the most common natural disasters in Ethiopia, which includes the current study area of Birbir Miriam district. Slope conditions, slope angle, lithology, soil type, and hydrologic conditions are all factors that can influence slope stability (Silalahi et al., 2019). Human activities such as deforestation, changes caused by the construction of engineering structures on the slope, undercutting the toe of the slope for road construction, and so on all contribute to potential factors. Human fluctuations on the hill can cause the slope to become less stable (Anbalagan, 1992; Ayalew and Yamagishi, 2004; Woldearegay, 2013). The negative impact of landslides is the destruction of infrastructure (houses, roads, buildings, irrigation, canals, etc.), geological and environmental damage, and severe injuries and loss of human and animal life due to landslide events. In the meantime, an organized landslide hazard zonation is critical to minimizing damage to infrastructure, houses, cultivated lands, and loss of life. This significance will be evident when decision-makers employ these landslide zonation maps in regional land use planning, landslide prevention, and mitigation measures (Ayalew &

Yamagishi, 2005; Das et al., 2012). The focus of landslide investigation is to assess the nature of susceptibility and the damages to human life, land, roads, buildings, and other properties (Wubalem, 2020). As a result, identifying landslide-prone areas is critical to ensuring human life safety and avoiding adverse effects on regional and national economies (Kundu et al., 2013; Shahabi & Hashim, 2015). Landslides are common in the Birbir Mariam district along riverbanks, slope toes, and slope faces. Landslides are responsible for any losses and also affect much of the farmland and farmers' income. Moreover, landslides in the study area cause significant damage to properties and massive destruction, particularly in Zala Gutisha and Waro localities, among the height-prone areas.

2. Materials and Methods

2.1 Study area

The current study area is in the Birbir Mariam district of Ethiopia's Gamo Highlands, in the rift valley escarpments. It is approximately 450 kilometers from Addis Abeba's capital city and 47 kilometers from the Zonal capital of Arba Minch town. It has a total area of 110 km^2 and is geographically bounded (UTM Zone 37N) by latitudes ranging from 692000 mN to 702000 mN and longitudes ranging from 342000 mE to 360000 mE. The area can be reached from Arba Minch town via the Chencha-Ezo main road and the Birbir Mariam gravel road (Figure 1).

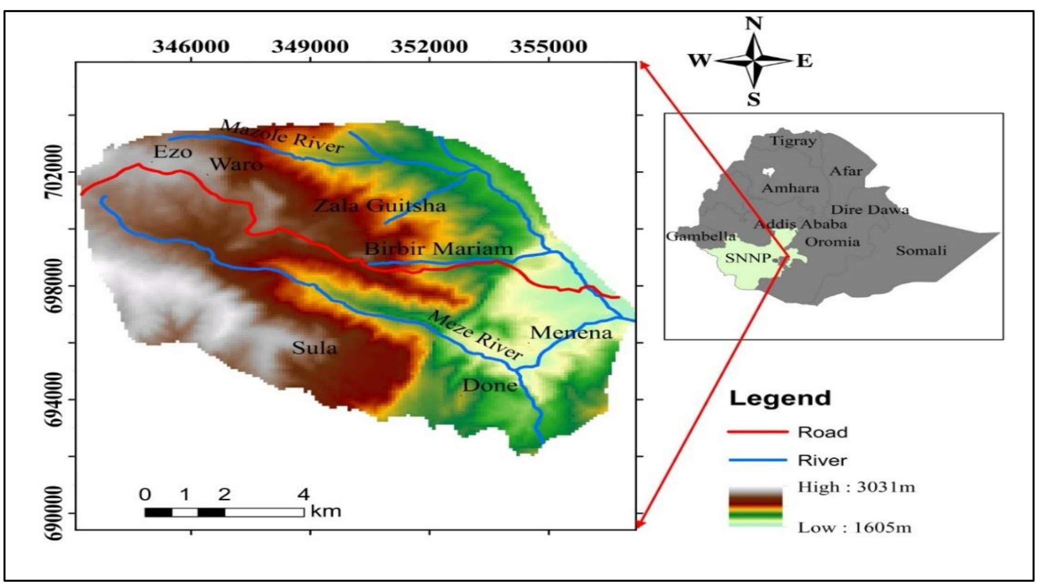

Figure 1. Location map of Birbir Mariam district

The geological setting has a significant impact on the occurrence of landslides in the study area. Volcanism has affected the southern part of the Main Ethiopian Rift (MER), which includes the Ganjuli graben (Lake Abaya), and the western side of Lake Abaya, which consists of the plateau and the Chenecha escarpment, since the Oligocene (Ebinger et al., 1993; Bonini et al., 2005; Abbate et al., 2015). Pre-rift and post-rift deposits dominate the geology of the study area, and the stratigraphy (Bonini et al., 2005) has the following significant units in the Galena and north Abaya basins: Pyroclastic, early flood basalts, alkaline basalt intermediate flows, pyroclastic rocks, pleistocene basalt, trachyte, and rhyolites field investigations can be used to map the geology of the study area. Basalt, tuff, and Igeniberite are among the geologic units found in the study area (rock units). The measurement's rock units can be present along rivers, road cuts, and natural hillsides. Overall, the dominance of destructive materials, basalt, and ignimbrite is a crucial feature of the lithologies of this region (Figure 2).

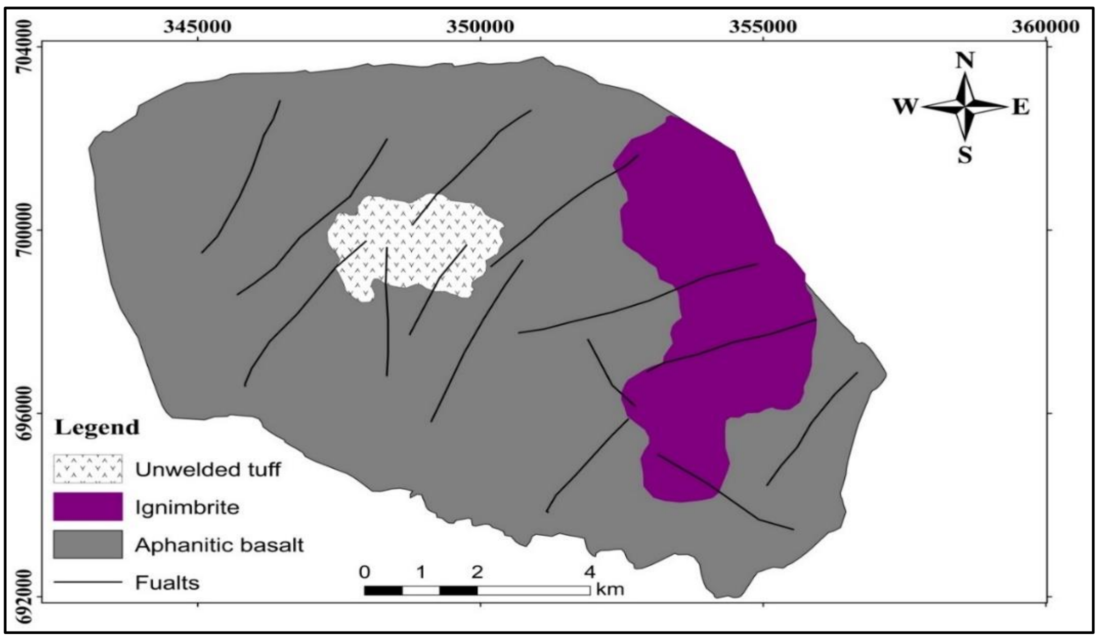

Figure 2. Geological map of the study area

2.2 Materials

The datasets used in the current study, including the Ethiopia Mapping Agency's topo-sheet number (0637 D1) at a scale of 1:50,000, were used to delineate the study area and land facet. DEM (Digital Elevation Model) with a spatial resolution of 12.5 m has been downloaded from the Alaska Satellite Facility site. It was used to extract the slope morphometry and relative relief map. The cloud-free optical satellite data acquired by Landsat-8 Operational Land Imager (OLI) with path-row numbers 170-051 obtained on 10 January-2019 was also inputted in the following portal (http://earthexplorer.usgs.gov/), exact and was used to develop a land use /land cover/ map of the current study area.

2.3 Methods

The entire study area was initially divided into 106 slope facets (Figure 3). Facets are land units with more or less uniform slope geometry in slope inclination and direction (Wubalem, 2020). Topographical maps were used to delineate the slope facets for this purpose. Significant and minor hill ridges, primary and secondary streams, and other topographical undulations defined facet boundaries (Bonini et al., 2005; Wubalem, 2020). The prepared facet map was then used as a base map to collect data on the various causative factors. Relative relief, land use, land cover, groundwater conditions, rain-induced manifestations, and human activities are all factors that contribute to slope instability (Ayalew, 1999; Santangelo et al., 2015). As a result, the susceptibility evaluation parameter rating was assigned for each causative factor to evaluate the landslide hazard.

The total maximum susceptibility evaluation parameter rating for the various causative factors is 15. The maximum value was accounted for for slope morphometry, groundwater condition, and seismicity 2.0. Land use, land cover, rainfall-induced surface manifestation, and human activity contributed to a maximum susceptibility evaluation parameter rate of 1.5. Furthermore, relative relief and slope geomaterial each contribute at a rate of 1.0. Structured discontinuity, on the other hand, contributes a maximum susceptibility evaluation parameter rate of 2.50 (Table 1). The evaluated landslide hazard is the total sum of susceptibility evaluation parameter ratings for all causative factors; therefore, the greater the value of the susceptibility evaluation parameter, the greater the degree of hazard.

Table 1. Rating methods for both intrinsic and external causative factors (Anbalagan, 1992; Raghuvanishi et al., 2014, 2015)

Code	Susceptibility evaluation parameter (SEP) Parameters		Maximum rate assigned (R)	Landslide hazard zone	Landslide hazard class	Evaluated landslide hazard
	Intrinsic parameters			Hhz	IV	12-8
R1	Slope Geometry	Rr	1.0	Mhz	III	7.9-5
		Sm	2.0	Lhz	II	4.9-2
R2	Slope geo–material		1.0	Vlhz	I	<2
R3	Structural discontinuity		2.5			
R4	Land use land cover		1.5			
R5	Groundwater condition		2.0			
	External parameters					
R6	Seismicity		2.0			
R7	Rainfall		1.5			
R8	Man-made activity		1.5			
	Total parameters		15.00			

Hhz= High hazard zone, Mhz= Moderate hazard zone, Lhz= Low hazard zone, Vlhz= Very low hazard zone, Rr+ Relative relief, Sm= Slope morphometry

The slope susceptibility evaluation parameter was developed by Raghuvanshi et al. (2014) through taking intrinsic (inherent) and external landslide causative parameters such as slope geometry, geo-material, discontinuity, land use, land cover, groundwater condition, rainfall, and artificial activity. Furthermore, the total likelihood of instability was established by assessing landslide hazards, and it was determined face-to-facet for which observations and investigations were made during the fieldwork. As a result, ratings from Table 1 have been assigned and evaluated. The landslide hazard is the total sum of the susceptibility evaluation parameter ratings for the various causative factors for each facet. Each causative parameter was assigned a rate based on subjective judgments acquired from past research on intrinsic and external causing factors and their relative contribution to slope instability. Field and literature review data on intrinsic and extrinsic causative parameters were incorporated. Finally, each causative parameter was rated on a facet-by-facet basis (Figure 3).

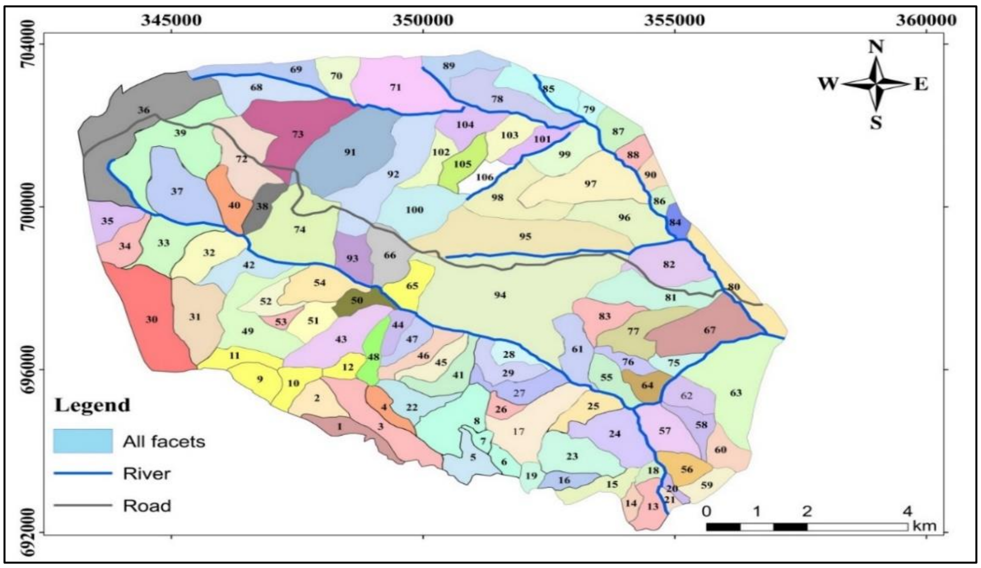

Figure 3. Land facet map of the study area

3. Results and Discussion

3.1 Landslide inventory

Landslide inventions serve as the foundation for classifying landslide hazards (Raghuvanishi et al., 2014, 2015; Silalahi et al., 2019). A thorough understanding of landslide conditions and a more detailed assessment of the area's risks are required for a systematic landslide inventory. Field investigations and previously identified landslide events have been compiled regarding their locations and the conditions of the existing landslide damages. These routine activities are required to proceed with slope stability analysis (Anbalagan, 1992). The landslide inventory map depicts the location and characteristics of past and present landslides. The map does not show the failure mechanisms or the triggering factors. The site's geologic, topographic, and climatic conditions indicate previous slope failures' causes and triggering mechanisms. As a result, landslide inventory mapping provides valuable information about the likelihood of future landslide occurrences. The landslide inventory on sliding processes is based on relevant literature, historical sources, and traditional field survey and mapping.

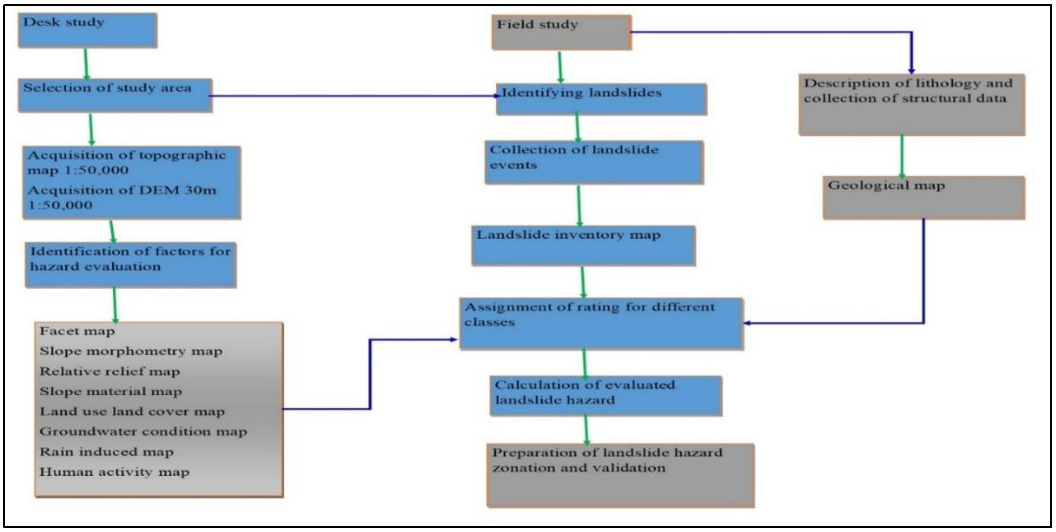

Figure 4. General methodology flow chart for the study

The inventory includes 46 past and present-day mass movements of various types distributed throughout the area. Followinf the methodology explained in flow chart for the study (Figure 4), the landslide inventories (Figure 5) were gathered using the direct field survey method. The density of landslides is very high in the central part of the area, which is covered by highly weathered aphanitic basalt.

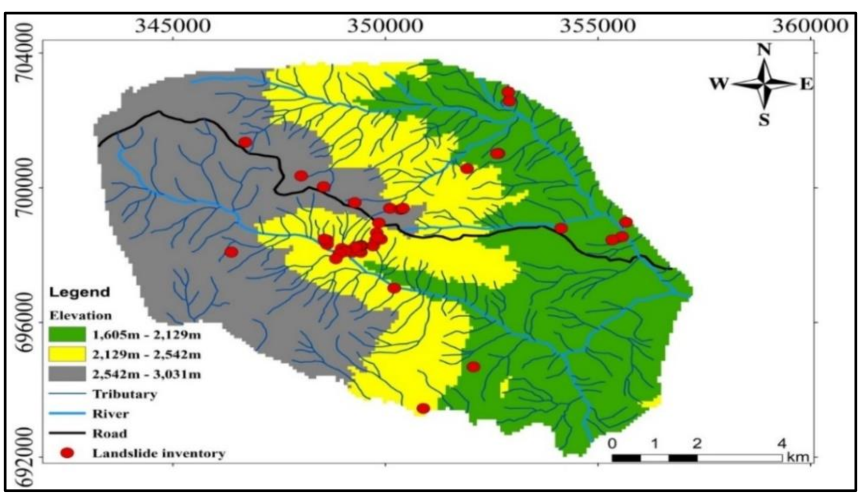

Figure 5. Landslide inventory map of Birbir Mariam district

3.2 Landslide causative parameters

Intrinsic parameters are the inherent or static causative parameters that define whether the slope is stable or unstable (Bonini et al., 2005; Wubalem, 2020). The main landslide causative factors selected for the Birbir Mariam area are summarized in Table 1, and brief descriptions are provided below. Groundwater condition: Groundwater has a significant impact on slope stability. Groundwater in hilly terrain does not follow a consistent pattern and is generally channeled along structural discontinuities in rocks. The assessment of groundwater behavior in hilly terrain over large areas is difficult and time-consuming. So, for a quick assessment, groundwater behavior was assessed based on surface indications of groundwater, which may provide valuable information on the stability of hill slopes for hazard mapping purposes (Bonini et al., 2005; Sarkar et al., 2013). Surface indications of groundwater (Figure 6a), such as damp, wet, dripping, and flowing, provide valuable information on the stability of hill slopes and are helpful in rating Chauhan et al., 2010; Dahal et al., 2012;).

Land use and land cover: Land use is also a significant factor responsible for landslide occurrences (Raghuvanshi et al., 2014; Jeong et al., 2018). Thereby, vegetation covers play an essential role in slope stabilization through a different mechanism. The study area's land use cover is divided into agricultural land, bare land, sparsely vegetated land, and moderately vegetated land categories (Figure 6b). Slope instability can also be described by land cover. Sparsely vegetated and barren areas cause more erosion and thus greater instability than reserves or protected forests, which are densely vegetated and less susceptible to mass wasting processes (Figure 6b).

Slope morphometry: Slope morphometry is the steepness of the slope (Anbalagan, 1992; Guzzetti et al., 2012). Slope morphology significantly affects the types of landslides that occur and the severity of the resulting damage to life and property. It is divided into five categories (Figure 6c): escarpment/cliff (> 45°), steep slope (36°–45°), moderately steep slope (26°–35°), gentle slope (16°–25°), and very gentle slope 15° (Erener and Duzgun , 2012).

Relative relief: relative relief is the difference between the maximum and minimum elevation within a given facet. The relative relief map (Figure 6d) depicts the maximum height difference between the ridge top and the valley floor within an individual facet. Based on the slope geometry classification system, this relative relief is classified as very high, high, medium, and moderate in the area. The very high-class value ranges from elevations more significant than 300m, high 201 m–300 m, medium 101 m–200 m, and moderate 51 m–100 m. As a result, a high relative relief area is more vulnerable to slope failures than a low relative relief area (Das et al., 2012; Kannan et al., 2015).

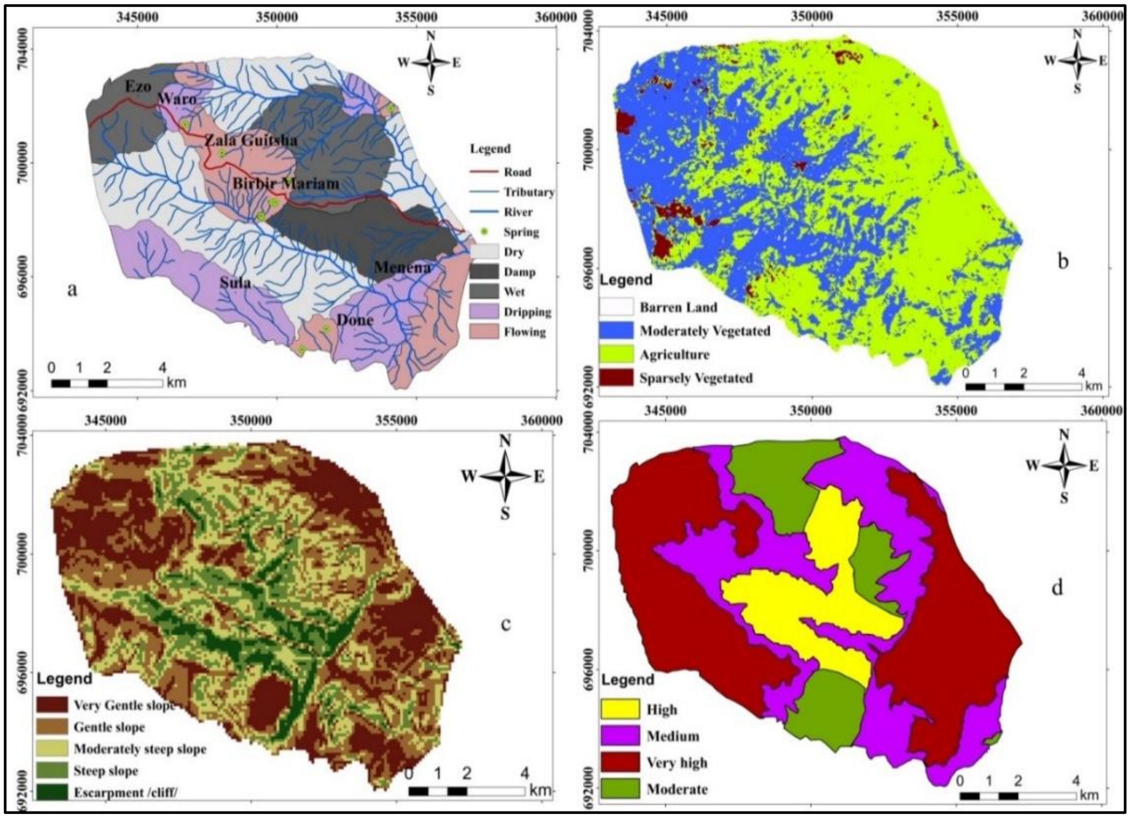

Figure 6. Landslide causative factor maps, (a) Groundwater condition manifestation, (b) land use land cover, (c) slope morphometry, (d) relative relief Lithology

Landslides in the study area are primarily caused by lithologies, with the dominant lithological units being highly weathered basalts, ignimbrite, and residual soils overlying the bedrock. Rocks like basalt and ignimbrites, for example, are complex, massive, and resistant to erosion, resulting in steep slopes. Soft rocks, on the other hand, such as tuff, are less resistant to weathering and more prone to erosion and slope instability (Figure 7).

Structural discontinuities: In bedding planes, joints, and faults, there are primary and secondary discontinuities. The preferred orientations of these discontinuities about slope inclination have a significant impact on slope instabilities. Data on the orientation of structural discontinuities were collected facet by facet from the exposed rock mass, and their relationship to slope inclinations was determined. Based on field observations and preliminary analysis, joints and faults were identified as the primary geologic structures for further hazard/susceptibility evaluations. Facet-by-facet, structural data were collected, and ratings were assigned based on the proposed slope susceptibility evaluation parameter and weight (Table 1).

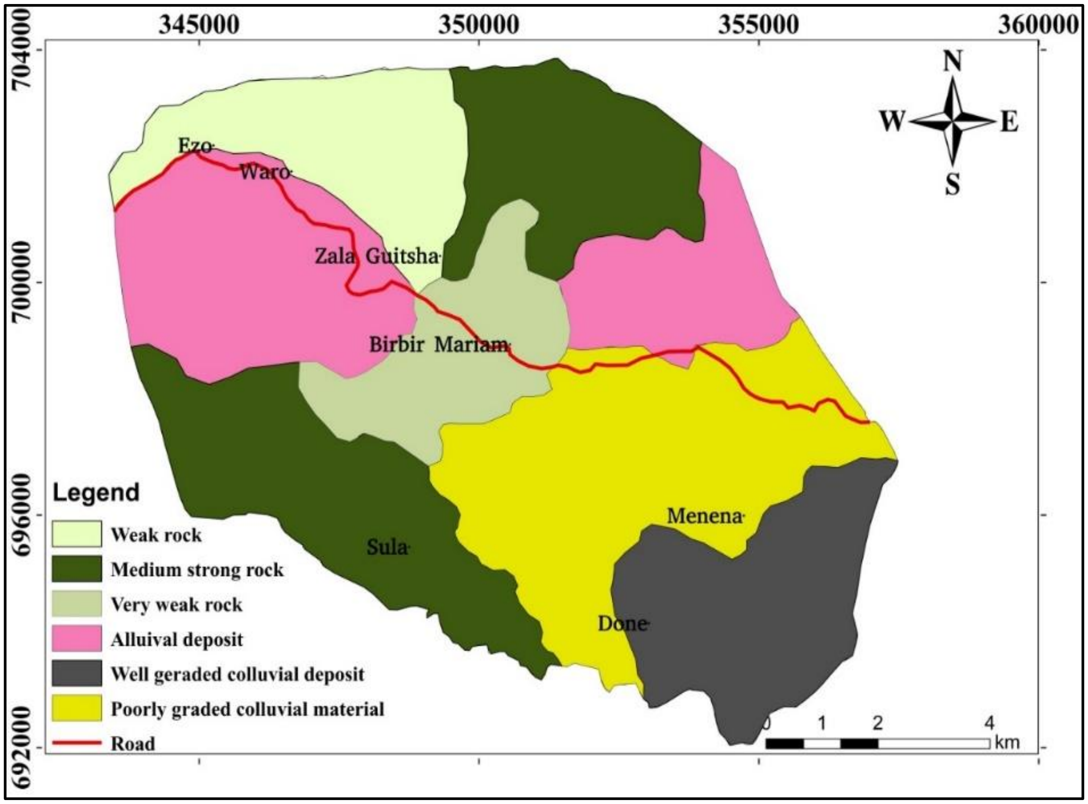

Figure 7. Slope geo-material map of Birbir Mariam district

Rainfall manifestation: The average annual rainfall in the study area is 1372.8 mm. Rain has a significant impact on the slope stability condition (Ayalew, 1999; Meten et al., 2015;). However, due to the nature of the materials exposed on the slopes and the drainage characteristics of the slopes, this is not always the case. As a result, rainfall-induced features are critical indicators for assessing the role of rainfall on slope instabilities. The rainfall-induced manifestations on slopes (e.g., gully formation, toe erosion, stream bank erosion) were considered when assigning the rainfall rating.

In addition to naturally causing parameters, Man-made activities are also increasing the potential instability (Kanungo et al., 2009). Developmental activities such as road construction and cultivation have a negative impact on slope stability conditions. Such anthropogenic activities increased the moisture content of soil or rock masses and decreased slope stability.

3.3 Landslide hazard zonation

The study area's slopes were divided into individual land facets for landslide hazard zonation. A total of 106 slope land facets were delineated (Figure 3). Individual slope facets were given class ratings based on their relative relief. From a total area of 110 km^2, 60.5 km^2 (55%) is in very high relative relief (> 300 meters), 24.2 km2 (22%) is in high relative relief (201-300 meters), 14.3 km2 (13%) is in medium relative relief (101-200 meters), and 11 km^2 (10%) is in moderate relative relief (51-100 meters) (Figure 6d). The steepness of the slopes is determined by slope morphometry. Around 18.87 percent of slopes in the study area are classified as escarpments or cliffs (> 45°), and 29.25 percent are classified as steps (36°–45°). Moderately steep slope (26°–35°), gentle slope (16°–25°), and very gentle slope (15°) account for 30.19 percent, 15.09 percent, and 6.60 percent of the remaining slope, respectively (Figure 6c).

The slope geomaterial of the study area is characterized by highly weathered and disintegrated rock masses due to the geological setting of the area. The study area's most dominant lithological units are highly weathered basalt. Chemical and physical weathering is very common in these rock types, and it was found in the northwest and central parts of the area. The dominant geological structures affecting the slope material are faults and joints. The most common slope materials are residual soils and alluvial and colluvial deposits (Chauhan et al., 2010; Guzzetti et al., 2012). The degree of weathering may impact the relative strength of the rocks, which was considered when assigning ratings to the different rock types. Fresh, slightly weathered, moderately weathered, extremely weathered, and residual soil are all terms used to describe the degree of weathering (Lee and Pradhan, 2007; Das et al., 2012).

Using the topographic map as a base map, a slope material map of the study area was created based on field observations. According to the map, soil mass covers 58.11 percent of the total area, disintegrated rock mass covers 28.3 percent, and medium-strong rock mass covers 18.87 percent (Figure 7). Residual soils are more consolidated and have a higher shear strength than alluvial or recently deposited soils (Anbalagan, 1992). Data related to the orientation of structural discontinuities were collected facet-wise from the rock mass outcrops, and their relation to slope inclinations was evaluated. The rock mass condition concerning structural discontinuities was also observed. Accordingly, ratings were assigned for structural discontinuities based on the standard table of slope susceptibility evaluation parameters.

A significant portion of the slopes is covered by agricultural land, according to land use land cover (43.4 percent). Furthermore, moderately vegetated, sparsely vegetated, and barren land cover 27.34 percent, 18.87 percent, and 10.39 percent of the total land area, respectively (Figure 6b). Surface indicators such as damp, wet, dripping, and flowing water were considered for each facet. Watermarks, algal growth, and other anomalies were also noted. As a result, each land facet was given a rating (Figure 6a). According to a rainfall record, the study area received more rain from

April to June and July to October. Rain-induced slope manifestations such as gully, toe, and stream bank erosion were also considered. Slope toe erosion, stream bank erosion, and gully erosion accounted for 24.53 percent, 20.75 percent, and 54.72 percent of total erosion (Figure 8).

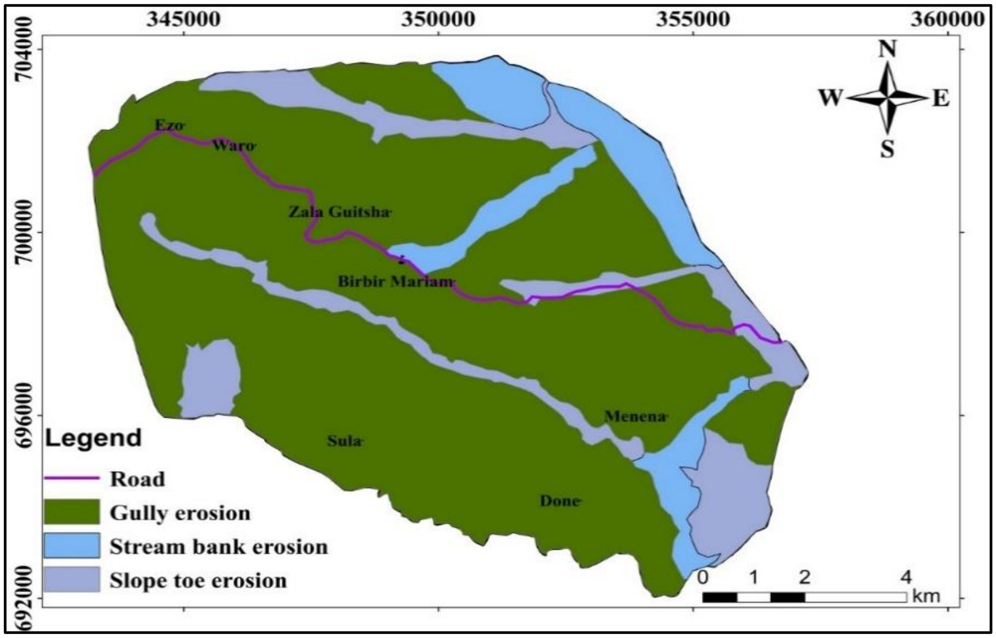

Figure 8. Rainfall induced surface manifestation map

Cultivation, road construction, and unsafe material dumping are examples of artificial activities that affect the slope stability of the study area. Field data showed that intensive cultivation activity accounted for 43.4 percent of the total, steep rock cuts for road construction accounted for 26.4 percent, and hazardous dumped materials accounted for 22.6 percent. Approximately 7.6% of the total area is unaffected by human activity (Figure 9).

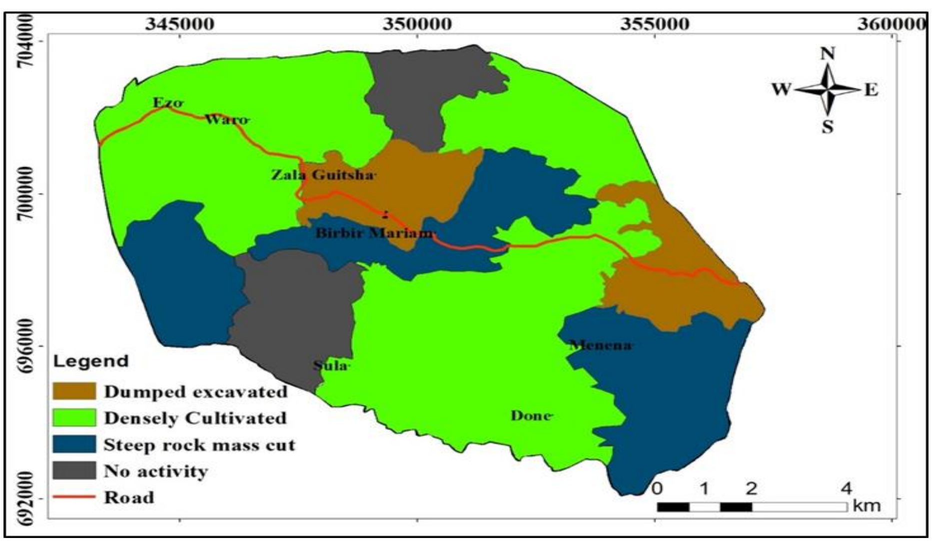

Figure 9. Anthropogenic developmental activities affecting slope stability

The study area's landslide hazard zonation was determined facet-by-face using the evaluated landslide hazard, which indicated the net probability of instability. The area was divided into three zones based on the assessed landslide hazard values: high hazard zone, moderate hazard zone, and low hazard zone (Figure 10a).

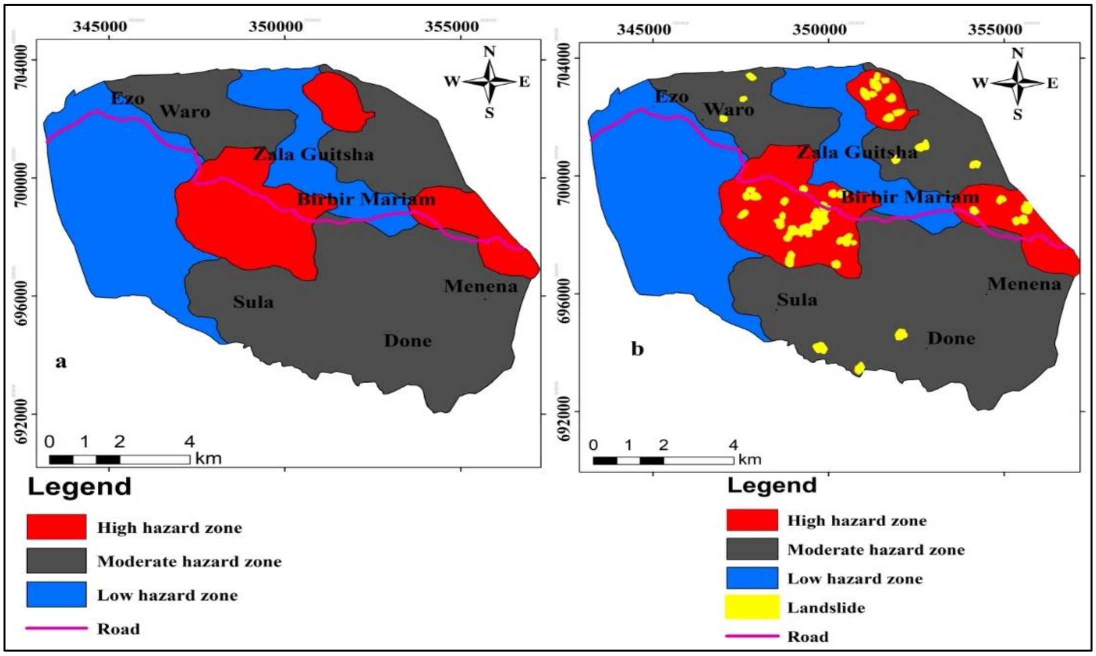

Figure 10. Map of of Birbir Mariam (a) Landslide hazard zonation, (b) Validation of present landslide hazard zonation

The high-hazard zones are mostly concentrated in the central and northeast parts of the current study area. These areas are primarily agricultural lands that have been subjected to a variety of anthropogenic activities. Most of the main roads that cross the area fall within the high-hazard zone areas. Along the main road, it is common to observe slope failures in the form of rock falls. Such failures mainly occurred following heavy rains. It was also reported that in the past, the main road had frequent failures and maintenance. The issue persists due to a lack of proper understanding of the causes and mechanisms of failures in the area. The area's southern and northeastern parts are in the moderate hazard zone, while the west and northwestern parts are in the low hazard zone (Figure 10a). The study area's landslide hazard map shows that 18.87 percent (20.76 km^2) are in the high hazard zone, 54.72 percent (60.19 km^2) are in the moderate hazard zone, and 26.41 percent (29.05 km^2) are in the low hazard zone.

3.5 Validation of susceptibility evaluation rating scheme

The prepared landslide hazard zonation map for the current study area was validated by comparing it to existing landslide inventory data. These landslide activities were primarily concentrated along the road section and river banks. The landslide inventories were superimposed on a landslide hazard map created for the area. Based on the validation (by overlying), 37 (80.43 percent) of the 46 landslide inventory data fall under the high hazard zone, 9 (19.57 percent) fall under the moderate hazard zone, and no landslide occurred in the low hazard zone. As a result, the landslide hazard zonation map produced by the slope susceptibility rating scheme is reliable and comparable to actual ground conditions (Figure 10b).

4. Conclusions

Landslide hazards and susceptibility zonation are critical for land use planning and development activities in highland and mountain terrain. A landslide hazard zonation was created using the susceptibility evaluation parameter rating. Based on their role and contribution to slope instability, this method considers intrinsic and external causative parameters used in the Birbir Mariam district. According to the findings, 18.87 percent of the total area (20.76 km^2) is in the high hazard zone, 54.72 % (60.19 km^2) is in the moderate hazard zone, and 26.41 percent (29.05 km^2) is in the low hazard zone. The generated landslide susceptibility zonation map was compared to actual past landslide activity data to ensure accuracy. According to the comparison, 37 (80.43 percent) of the 46 landslide inventory data fall into the high hazard zone, 9 (19.57 percent) fall into the moderate hazard zone, and none fall into the low hazard zone. As a result, the method used in this study and the resulting landslide susceptibility zonation map were reliable and could be used in other areas with similar geologic and topographic conditions.

Conflict of Interest

No potential conflicts of interest are reported by the authors.

References

Abbate, E., Bruni, P., & Sagri, M. (2015). Geology of Ethiopia: a review and geomorphological perspectives. Landscapes and landforms of Ethiopia, 33-64.

Anbalagan, R. (1992). Landslide hazard evaluation and zonation mapping in mountainous terrain. Engineering Geology, 32(4), 269–277.

Ayalew, L. (1999). The effect of seasonal rainfall on landslides in the highlands of Ethiopia. Bulletin of Engineering Geology and the Environment, 58(1), 9–19.

Ayalew, L., & Yamagishi, H. (2004). Slope failures in the Blue Nile basin, as seen from landscape evolution perspective. Geomorphology, 57(1–2), 95–116.

Ayalew, L., & Yamagishi, H. (2005). The application of GIS-based logistic regression for landslide susceptibility mapping in the Kakuda–Yahiko Mountains. Central Japan Geomorphology, 65.

Wubalem, A. (2020). Modeling of Landslide susceptibility in a part of Abay Basin, northwestern Ethiopia. Open Geosciences, *12*(1), 1440-1467.

Bonini, M., Corti, G., Innocenti, F., Manetti, P., Mazzarini, F., & Abebe, T. (2005). Evolution of the Main Ethiopian Rift in the frame of Afar and Kenya rifts propagation. Tectonics, 24, TC1007. https://doi.org/10.1029/2004tc001680

Calligaris, C., Poretti, G., Tariq, S., & Melis, M. T. (2013). First steps towards a landslide inventory map of the Central Karakoram National Park. European Journal of Remote Sensing, 46(1), 272-287.

Chauhan, S., Sharma, M., Arora, M. K., & Gupta, N. K. (2010). Landslide susceptibility zonation through ratings derived from artificial neural network. International Journal of Applied Earth Observation and Geoinformation, *12*(5), 340-350.

Dahal, R. K., Hasegawa, S., Bhandary, N. P., Poudel, P. P., Nonomura, A., & Yatabe, R. (2012). A replication of landslide hazard mapping at catchment scale. Geomatics, Natural Hazards and Risk, *3*(2), 161-192.

Das, I., Stein, A., Kerle, N., & Dadhwal, V. (2012). Landslide susceptibility mapping along road corridors in the Indian Himalayas using Bayesian logistic regression models. Geomorphology, 179. https://doi.org/10.1016/j.geomorph.2012.08.004

Ebinger, C., Yemane, T., Woldegabriel, G., & Aronson, J. (1993). Late Eocene–Recent volcanism and faulting in the southern Main Ethiopian Rift. Journal of the Geological Society, 150, 99–108. https://doi.org/10.1144/gsjgs.150.1.0099

Erener, A., & Düzgün, H. S. B. (2012). Landslide susceptibility assessment: What are the effects of mapping unit and mapping method? Environmental Earth Sciences, 66(3), 859–877.

Gazibara, S. B., Krkač, M., & Mihalić Arbanas, S. (2019). Landslide inventory mapping using LiDAR data in the City of Zagreb (Croatia). Journal of Maps, 15(2), 773–779.

Guzzetti, F., Mondini, A. C., Cardinali, M., Fiorucci, F., Santangelo, M., & Chang, K. T. (2012). Landslide inventory maps: New tools for an old problem. Earth-Science Reviews, 112(1–2), 42–66.

Jeong, S., Kassim, A., Hong, M., & Saadatkhah, N. (2018). Susceptibility assessments of landslides in Hulu Kelang area using a geographic information system-based prediction model. Sustainability, 10(8).

Kanungo, D. P., Arora, M. K., Sarkar, S., & Gupta, R. P. (2009). A fuzzy set based approach for integration of thematic maps for landslide susceptibility zonation. *Georisk*, *3*(1), 30-43. Kannan, M., Saranathan, E., & Anbalagan, R. (2015). Comparative analysis in GIS-based landslide hazard zonation, a case study in Bodi-Bodimettu Ghat section, Theni District, Tamil Nadu, India. Arabian Journal of Geosciences, 8(2), 691.

Kundu, S., Saha, A. K., Sharma, D. C., & Pant, C. C. (2013). Remote sensing and GIS-based landslide susceptibility assessment using binary logistic regression model: A case study in the Ganeshganga Watershed, Himalayas. Journal of the Indian Society of Remote Sensing, 41. https://doi.org/10.1007/s12524-012-0255-y

Lee, S., & Pradhan, B. (2007). Landslide hazard mapping at Selangor, Malaysia using frequency ratio and logistic regression models. Landslides, 4, 33–41. https://doi.org/10.1007/s10346-006-0047-y

Legorreta Paulín, G., Bursik, M., Hubp, J. L., Mejía, L. M. P., & Aceves Quesada, F. (2014). A GIS method for landslide inventory and susceptibility mapping in the Río El Estado watershed, Pico de Orizaba volcano, México. Natural Hazards, 71(1), 229–241.

Meten, M., Bhandary, N. P., & Yatabe, R. (2015). GIS-based frequency ratio and logistic regression modelling for landslide susceptibility mapping of Debre Sina area in central Ethiopia. Journal of Mountain Science, 12(6), 1355–1372.

Santangelo, M., Gioia, D., Cardinali, M., Guzzetti, F., & Schiattarella, M. (2015). Landslide inventory map of the upper Sinni River valley, Southern Italy. Journal of Maps, 11(3), 444–453.

Sarkar, S., Roy, A. K., & Martha, T. R. (2013). Landslide susceptibility assessment using information value method in parts of the Darjeeling Himalayas. Journal of the Geological Society of India, 82(4), 351–362.

Shahabi, H., & Hashim, M. (2015). Landslide susceptibility mapping using GIS-based statistical models and remote sensing data in tropical environment. Scientific Reports, 5, 9899. https://doi.org/10.1038/srep09899

Silalahi, F. E. S., Pamela, Arifianti, Y., & Hidayat, F. (2019). Landslide susceptibility assessment using frequency ratio model in Bogor, West Java, Indonesia. Geoscience Letters, 6(1).

Van Westen, C. J., Castellanos, E., & Kuriakose, S. L. (2008). Spatial data for landslide susceptibility, hazard, and vulnerability assessment: An overview. Engineering Geology, 102(3–4), 112–131.

Woldearegay, K. (2013). Review of the occurrences and influencing factors of landslides in the highlands of Ethiopia: With implications for infrastructural development. Momona Ethiopian Journal of Science, 5(1), 3.

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Research Paper

Techniques for conservation tillage under 15–25% slope: soil and water conservation, maize yield and yield components in basketo zone, Southern Ethiopia

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Abstract

In steeply sloping regions of Ethiopia, water erosion is the primary cause of soil erosion and land degradation. Poor management of watersheds, inappropriate farming practices, and heavy rainfall all contribute to a continuous process of soil nutrient depletion in mountainous places. A quick loss of soil organic matter, soil deterioration, and a decline in environmental quality could result from the main farmer practice restrictions during plowing. To maintain agricultural productivity and environmental quality, a better farming system is therefore a significant method. This study was conducted in 3 farmer's fields to investigate the significance of different cultivation practices on soil loss and maize yield under a slope of 19 % during cropping season in 2016 and 2018 at Motkesa Kebele of Basketo Zone, southern Ethiopia. The trial was laid out using a randomized complete block design through four treatments replicated three times on run-off plots. Experimental treatments used in the area were (strip tillage, zero tillage, reduced tillage and farmer practice) with maize planting at a spacing of 25cm by 75cm between plants and between rows respectively. According to the research result zero tillage decreased mean soil loss by 70% -74 % compared with conventional tillage ($P < 0.05$) and zero tillage has a great potential of controlling soil erosion on steep lands. Additionally, zero tillage was effective in conserving soil moisture increased (36-42%) compared with conventional tillage practices. According to the results of our research data, we advise that in smallholder household farms, the implementation of conservation agriculture has a cost-effective production management method, saves raw materials, increases yield, and reduces manual labor. Further studies are also encouraged in the same agroecology to promote the conservation agriculture system.

Keywords: Conservation tillage; Maize yield; Soil loss; Soil moisture

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1. Introduction

Soil erosion in sloppy areas is an enduring problem for continuousness when the forest resource cover has been diminished and agriculture only depends on annual crops is implemented (Tuahn et al., 2014). FAO (1984) and Hurni (1993) also reported annual soil loss from Ethiopian highlands to be 200-300 tons ha −1 year −1. Similarly, Hurni et al. (2008) Dijo watershed is the largest watershed in the Rift Valley Basin of Ethiopia. Land degradation in the form of soil erosion is the major problem affecting agricultural productivity.

Conferring to Hurni et al. (2008), the original model effect due to erosion of cultivated fields in Ethiopia under normal conditions was 42 tons/ha/year. Soil erosion from the steep lands is the dominant cause of soil loss, disturbances deterioration of the ecosystem and reduction of crop production in our study areas. The reduction of soil quality that accompanies erosion can reduce the productivity of agricultural land (Montgomery, 2007).

Conservation agriculture has greater impacts on soil erosion, runoff and infiltration (Leys et al., 2010). The conservation tillage technique based on decomposable residue covered with zero tillage and sub-soiling in the crop-free period can efficiently decrease soil disturbance of the plow layer, grow the surface cover and soil organic matter content and encourage the storage of soil moisture (David et al., 2005; Zhao et al., 2016).CA could be a solution to the problem of the steep slopes of how to produce annual crops without eroding the soil does not necessarily need heavy investments for its implementation, and can help small-scale farmers stabilize their yields over time (Erenstein, 2003). Conservation practices also have to advance farmer production and profits and safeguard the production system against changes in climate and a significant increase in yield from 3.6 to 4.4 t/ha in CA practices (Mkoga et al., 2010).

Conservation agriculture has been encouraged and practiced as a solution for agricultural sustainability problems caused by soil erosion and fertility decline (Bram et al., 2016) and reduces farmers' exposure to drought, income and address low draught power ownership levels (Mashingaidze et al., 2012). Therefore it is a substantial approach to create a better farming system to sustain environmental quality and agricultural production. This study was conducted in 3 farmer's fields to investigate the significance of different cultivation practices on soil loss and maize yield under a slope of 19 % during cropping season in 2016 and 2018 at Motkesa Kebele of Basketo Zone, southern Ethiopia.

2. Materials and Methods

2.1 Description of study area

The study was conducted in the Basketo zone which is one of the zones of South Ethiopia Regional State; its capital is Laska, which is 626 km from Addis Ababa. The average daily temperature ranges from 15 °C-27 °C and mean yearly rainfall ranges from 1000 mm-1400 mm. The Basketo Zone is located from 780-2200m above sea level within 6018'00.5''N latitude and

36033’41.9’’E longitude. The zone has three ecological zones; low land (54%), highland (1%) and midland (45%) climatic zone (Vaughan 2011, SNNPR, 2011).

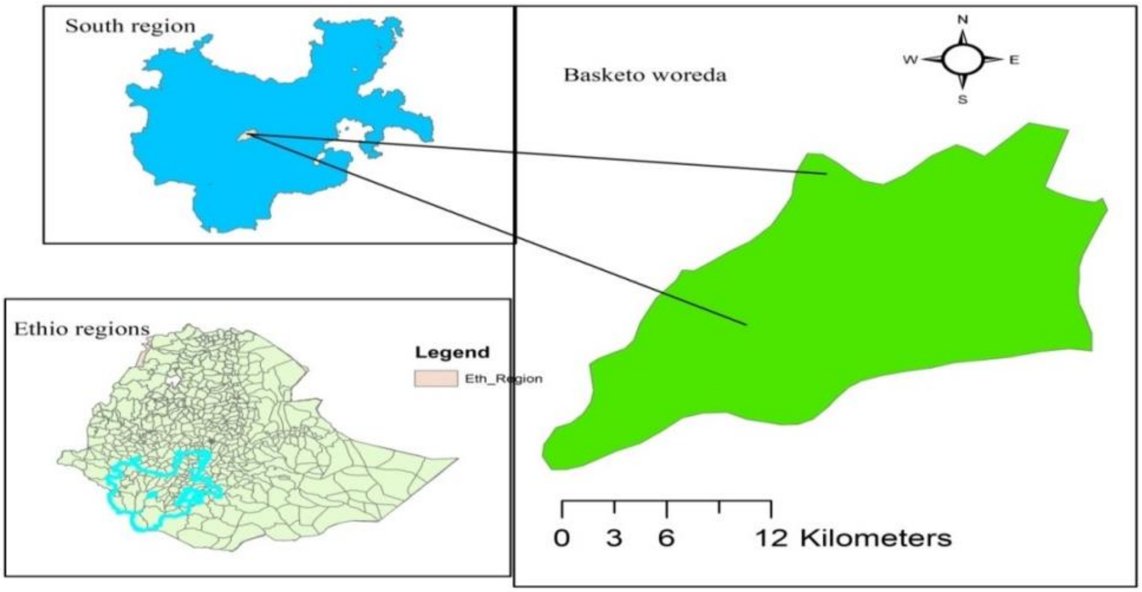

Figure 1. Map of the study area

2.2 Research Design

A field experiment was conducted on the effect of different tillage practices on soil loss and maize production under a slope of 19 % during cropping season in 2016 and 2018 at Motikesa Kebele of Basketo zone, southern Ethiopia. The experiment has a randomized complete block design with four treatments replicated three times on run-off plots. Experimental treatments used in the area were (strip tillage, zero tillage, reduced tillage and conventional tillage) with maize planting at the spacing of 25cm by 75cm between plants and between rows, respectively.

Strip tillage tilling a strip of about 40cm wide and 30cm deep on a seeding line only. Zero tillage involved making a hole with a hand hoe for seed placement without primary tillage. This system involves opening a narrow slot only wide and deep enough to obtain proper seed coverage with 30% mulch covering of planting area. Conventional tillage is making tillage frequency to plant maize 4 times plow land. Reduced tillage is a tillage type that was only two times plow land to plant maize. Planting of maize variety 540 was done during the main rainy season from the beginning of March up to the end of April each season at a spacing of 75cm × 25cm.

2.3 Methods of data collection

2.3.1 Determining of soil loss

The test field was built in February 2016 on three farmers' land on a slope of 19%. Each runoff field (catch pit) had a length of 5 m, a width of 1 m, and a 0.5m depth made from plastic sheets were set up in each plot and soil collected in the catch pit was measured after the end of rainfall. The plots were bounded by corrugated iron sheets, buried to a depth of 20cm and protruding 10cm above the ground to prevent runoff water from outside the plots from entering the plots and from runoff plots from flowing out unmonitored.

2.3.2 Determining soil moisture content

The stored moisture contents in the soil were determined by gravimetric (mass) methods. The gravimetric water content is the mass of water in a unit mass of dry soil (g of water/g of dry soil). The wet weight of the soil sample is determined; the sample is dried at 1050C for 24 hours to constant weight and reweighed (Gardner, 1986). Measuring soil moisture measurements was conducted at three periods (initial, development and mid-stage) after rainfall of 10 days to evaluate the amount of soil water during dry periods. The composite soil sample was taken by making "x" around the field to collect soil from various places on the field. An auger was used for soil sampling from the depth of 0-20cm and 20- 40 cm because 70% of moisture extraction was taken from the rooting depth (0.4m). The soil sample collected from the two different locations or depths was mixed in a plastic container. The amount of the wet soil was measured and put in an oven at 105°C for 24 hours and then reweighted of dried soil samples. The soil water stored (%) in each 0.4m incremental depth down was determined gravimetrically. Volumetric water content can be calculated from gravimetric water using the following equation (Eq. 1):

$$SMC = \frac{Ww-Wd}{Wd} * 100 \qquad (1)$$

Where, SMC = Soil moisture content, dry base (%), Ww = Weight of the wet soil (gm), W_d= Weight of the dry soil (gm)

Volumetric soil water content (cm^3/cm^3) is determined as Eq. 2:

$$\theta = w * \rho d \qquad (2)$$

Where, w = gravimetric water content, ρd = bulk density (g/cm^3)

2.3.3 Agronomic data parameters

Agronomic parameters including grain yield, above-ground biomass, and plant height data were collected. To measure plant height six stands from each plot were randomly selected and measured. Dried above-ground biomass of the six plants from each plot was measured and it was converted to a hectare base. From each, plot the number of six plants randomly selected during harvesting time was cut and grain yield was threshed and weighted.

2.3.4 Statistical analysis

Data collected were processed using Microsoft Excel and statistically analyzed using Analysis of variance was performed using the GLM procedure of SAS Statistical Software Version 9.1. Effects were tested under (P = 0.05). Means were separated using Fisher's Least Significant Difference (LSD) test.

3. Results and Discussion

3.1. Means of soil loss in the study site

As shown in below Table 1 the mean soil loss of year one was significant ($P < 0.05$) difference between zero tillage (18.5 ton/ha-1) and strip tillage (26.2 ton/ha -1) compared with conventional (69.2 ton/ha-1) and reduced tillage (57.7 ton/ha-1). But there was no significant difference ($p>0.05$) between reduced (57.7 ton/ha-1) with conventional tillage (69.2 ton /ha/-1 year) and strip (26.2 ton/ha -1) with zero tillage (18.5 ton/ha-1).

Table 1. Soil loss means in 2016 and 2018 year data

Treatments	Soil loss data (2016) ($t/ha^{-1}/year^{-1}$)	Soil loss data (2018) ($t/ha^{-1}/year^{-1}$)	Combined analysis of soil loss for ($t/ha^{-1}/year$)
Zero	18.6^{b}	24^{b}	21.33^{b}
Strip	27.33^{b}	29.33^{b}	28.33^{b}
Reduced	65.33^{a}	52.33^{a}	58.8^{a}
Conventional	71.66^{a}	58.66^{a}	65.16^{a}
LSD, (%)	26.43	18.22	14.27
CV, (%)	20.43	15.7	20

LSD=Least significant difference; CV= Coefficient of variation; ^{ab} means in the column with the same superscript are not significantly different ($P < 0.05$).

In year two there was also a significant ($P < 0.05$) difference between zero (27.8 ton /ha/-1) compared with conventional (58 ton/ha/-1) and reduced tillage (51.5ton/ha/-1). Significant ($P < 0.05$) difference between strips (25.7ton/ha-1) compared with conventional (58 ton/ha/-1) but no significant ($P > 0.05$) difference between reduced (51.5ton/ha-1). In both years, there was a significant difference between zero and strip tillage compared with conventional tillage. These results show that the soil loss was largest from conventional tillage and lowest from zero and strip tillage. Soil loss was significantly affected by the tillage practices (Table 1). Studies showed that conservation tillage systems such as zero tillage with surface mulch, strip tillage and reduced tillage decreased mean soil loss by 74%, 62%, and 17% compared to conventional treatments under a slope of 19 % in the first year and in the second year 70%, 56% and 12% soil loss reduction in percent. In high-rainfall areas, the soils are susceptible to soil erosion and fertility decline (Kagabo et al., 2013). Conservation agriculture consists of as little disturbing the soil as possible, keeping the soil covered potential remedy for soil degradation (Bayala et al., 2012). Several studies revealed that conservation tillage (any tillage system that maintains at least 30% of cover on the soil surface, e.g. no-tillage (Fusuo et al., 2007).

Conventional tillage has been asserted to lead to land degradation resulting from common, but exploitative farming practices such as plowing that destroys the soil structure & degrades organic matter, burning or removing crop residues, and mono-cropping among others (Rusinamhodzi et al., 2011). Soil erosion & the loss of organic matter are associated with conventional tillage practices (Chivenge et al., 2007), which leave the soil bare and unprotected in times of heavy rainfall wind & heat (Derpch, 2003). Conservation agriculture has significant potential to improve rainfall use efficiency through increased water infiltration and decreased evaporation from the soil surface, with associated decreases in runoff and soil erosion (Thierfelder & Wall, 2010).

3.2 Yield and yield components of the maize

As shown in the table above there was no significant ($P > 0.05$) difference between the treatments for the first and second years within maize yield and components. This result shows conservation agriculture improves farmers' yield in the long term at the same time conserving the environment.

Table 2. Least square means of maize yield and yield components under the different treatments

Treatment	2016 year data			2018 year data		
	Grain yield (ton/ha)	DMB (ton/ha)	PH (cm)	Grain yield (ton/ha)	DMB (ton/ha)	PH (cm)
Zero tillage	4.97	7	198.4	4.75	8.87	209
Strip tillage	4.87	6.12	181.6	4.2	8.26	211
Reduced tillage	4.52	6.2	197.5	4.35	8.82	208
Conventional tillage	4.1	7.5	196.2	4.3	8.65	193
LSD (%)	NS	NS	NS	NS	NS	NS
CV (%)	23	21	7	16	24	11

LSD=Least significant difference; CV= Coefficient of variation; NS = Non significant, DMB=Dry matter biomass, PH=Plan height

Producers will discover that the welfare of CA will get up later rather than earlier (Chivenge et al., 2007; Thierfelder & Wall, 2010) since CA takes time to accumulate enough organic matter and have soils become their fertilizer, the process does not start to work overnight. But if producers make it through the first few years of production, results will start to become more satisfactory. Even though conservation agriculture has been successfully implemented in fertile soil, its performance on degraded soil remains unclear (Siziba, 2008).

In conservation agriculture most studies agree there are yield benefits in the medium to long term which are more pronounced in lower rainfall environments (Pittelkow et al.,2015); Steward et al., 2018). CA not plow as conventional tillage and thus does not incorporate the manure, which may lead to partial efficiencies in the mobilization, access, uptake and cycling of nutrients from manure (Powell et al., 2004; Rufino et al., 2007).

In conventional tillage plough increases the amount of oxygen in the soil and increase the aerobic process more nutrient is available for crops but soil loss is depleted more quickly of its nutrients. As a principle of conservation tillage applied in semi-arid, humid and sub-humid areas but applied in wetlands or soil with poor drainage lands can challenge adoption. CA increases yield over time but farmers may not see yield benefits immediately.

Comparisons made between local cultivation and SWC measures at experimental sites in Ethiopia showed that Soil loss is reduced significantly for the majority of SWC treatments, but, production rarely increased as a result of SWC in three to five years (Herweg and Ludi, 1999).

3.3 Soil moisture content in the soil at different maize growth stages

As shown below in Table 3 there was a significant ($P < 0.05$) difference between zero with conventional and the others have no significant ($P > 0.05$) difference between treatments in 2016 years at mid-period in soil moisture content.

Table 3. Effect of treatments on soil moisture conservation during at different seasons

Treatments	2016 years	2018 year	
	At mid period SMC (%)	At planting SMC (%)	At mid period SMC (%)
Zero	53[a]	27.75	59.5[a]
Strip	44[ab]	29.75	52.5[ab]
Reduced	37[b]	26.5	45.7[bc]
Conventional	33.7[b]	26.33	34[c]
LSD (%)	12.75	NS	13.3
CV (%)	13.7	15	12.5

LSD=Least significant difference; CV= Coefficient of variation; NS= Non-significant, [abc] means in the column with the same superscript are not significantly different ($P < 0.05$).

In the 2018 year, there was also a significant ($P <0.05$) difference between zero with conventional tillage and reduced tillage but there were no significant differences between the treatments at mid-period and at planting time there were no significant differences between all treatments. These results show that zero tillage has the potential for soil moisture-holding capacity compared with other treatments. The advantage of CA over tillage agriculture in terms of the greater soil moisture-holding capacity and therefore duration of plant-available soil moisture is illustrated by Derpsch et al. (1991), who show that soil moisture conditions in rooting zones through growing seasons under CA are better than under both minimum and conventional tillage. Thus crops under CA systems can continue towards maturity for longer than those under conventional tillage. In addition, the period in which available nutrients can be taken up by plants is extended, increasing the efficiency of use. The greater volume and longer duration of soil moisture's availability to plants (between the soil's field capacity and wilting point) have significant positive outcomes both for farming stability and profitability.

3.4 Cost and benefit analysis

Economic analysis indicated that the net benefit/ha of treatments among the different tillage systems zero tillage recorded was a higher net return than conventional tillage systems (Table 4). This indicates higher profit and lower expenditure in terms of lab power.

Table 4. Estimated economic costs and benefit analysis of treatments

Treatments	Grain yield (ton/ha)	Adjusted yield (ton/ha)	Unit price (kg)	Gross field benefit (ha)	Total costs that vary (ha)	Net benefit (ha)	Benefit cost ratio
Zero	4.97	4.47	10	44,700	11890	32810	2.75
Strip	4.87	4.38	10	43800	13990	29810	2.1
Reduced	4.52	3.8	10	38000	15000	23000	1.5
Conventional	4.1	3.69	10	36,900	16990	19910	1.1

According to Friedrich et al. (2016), CA is a strategy for producing agricultural crops at high and sustained production levels with acceptable earnings while also protecting the environmet.

4. Conclusions

The findings indicate that, over the two consecutive years, there was no discernible difference ($P > 0.05$) between the treatments for maize yield and yield components. In the research area, zero tillage has, nevertheless, demonstrated superior outcomes in terms of soil moisture content and soil loss. There was a lot of soil erosion and loss in the farmed land areas on steep slopes. According to the current study's findings, conventional tillage causes a significant amount of soil loss, leaving the soil exposed after crop residues are removed and vulnerable to wind and rainstorms that erode organic materials and ruin the soil's structure. However, conservation tillage, which involves little soil disturbance and leaves the soil covered, is a viable treatment for soil deterioration. It involves zero tillage and stripping. By increasing water infiltration and reducing surface evaporation, zero tillage can significantly increase the efficiency of using rainwater in low-lying areas while simultaneously reducing runoff and soil erosion. It has been demonstrated that, in comparison to conventional tillage, zero tillage reduced mean soil loss by 70% to 74%. This suggests that zero tillage may be able to control soil erosion on steep terrain. In addition, compared to traditional tillage techniques, zero tillage proved successful in preserving an increase in soil moisture of 36-42%. One more benefit of conservation tillage is that it lessens the requirement for terraces. Under drier regions with a 19% slope, zero tillage is advised as a preferable way to minimize soil loss and preserve soil moisture. Therefore, even though further research needs to be done to provide a solid foundation for the advice, it is still necessary to share the findings of the current study with the end users.

Conflict of Interest

The authors declare no conflict of interest.

References

Acharya, C. L., & Sharma, P. D. (1994). Tillage and mulch effects on soil physical environment, root growth, nutrient uptake and yield of maize and wheat on an Alfisol in north-west India. *Soil and Tillage Research*, *32*(4), 291-302.

Bayala, J., Sileshi, G. W., Coe, R., Kalinganire, A., Tchoundjeu, Z., Sinclair, F., & Garrity, D. (2012). Cereal yield response to conservation agriculture practices in drylands of West Africa: A quantitative synthesis. Journal of Arid Environment, 78, 13–25.

Chivenge, P. P., Murwira, H. K., Giller, K. E., Mapfumo, P., & Six, J. (2007). Long-term impact of reduced tillage and residue management on soil carbon stabilization: Implications for conservation agriculture on contrasting soils. *Soil and tillage research*, *94*(2), 328-337.

David, C., Jeuffroy, M. H., Laurent, F., Mangin, M., & Meynard, J. M. (2005). The assessment of a decision making tool for managing the nitrogen fertilization of organic winter wheat. European Journal of Agronomy, 23, 225–242.

Derpsch, R. (2003). Conservation tillage, no-tillage and related technologies. In Conservation agriculture: environment, farmers experiences, innovations, socio-economy, policy (pp. 181-190). Dordrecht: Springer Netherlands.

Derpsch, R. (2008). No-tillage and conservation agriculture: A progress report. In T. Goddard et al. (Eds.), No-till farming systems. World Association of Soil and Water Conservation, Bangkok, 3, 7–39.

Derpsch, R., Roth, C. H., Sidiras, N., & Köpke, U. (1991). Controle da erosão no Paraná Brasil: Sistemas decobertura do solo, plantio direto e prepare conservacionista do solo. GTZ, Eschborn, Brazil

Erenstein, O. (2003). Smallholder conservation farming in the tropics and sub-tropics: A guide to the development and dissemination of mulching with crop residues and cover crops. Agriculture, Ecosystems and Environment, 100, 17–37.

FAO. (1984). World reference for soil resource. Rome, Italy.

Farid, A. T. M., & Hossain, S. M. S. (1988). Diagnosis of farming practices and their impact on soil resource loss and economic loss in the hill tract areas of Bangladesh. BARI.

Farooq, M., Flower, K. C., Jabran, K., Wahid, A., & Siddique, K. H. (2011). Crop yield and weed management in rainfed conservation agriculture. *Soil and tillage research*, *117*, 172-183.

Fusuo, Z., Zhenling, C., Jiqing, W., Chunjian, L., & Xinping, C. (2010). Current status of soil and plant nutrient management in China and improvement strategies, 687-694

Herweg, K., & Ludi, E. (1999). The performance of selected soil and water conservation measures—case studies from Ethiopia and Eritrea. Catena, *36*(1-2), 99-114.

Hurni, H. (1993). Land degradation, famine and land resource scenario in Ethiopia.

Hurni, H., Herweg, K., Portner, B., & Liniger, H. (2008). Soil erosion and conservation in global agriculture. In A. K. Braimoh & P. L. G. Vlek (Eds.), Land use and soil resources (pp. 41–71). Springer, Dordrecht.

Kagabo, D. M., Stroosnijder, L., Visser, S. M., & Moore, D. (2013). Soil erosion, soil fertility and crop yield on slow-forming terraces in the highlands of Buberuka, Rwanda. *Soil and tillage research*, *128*, 23-29.

Kamwendo, M. L. (2016). The effect of conservation farming on soil physical properties in Malawi (M.Sc. Thesis). Interuniversity Program on Physical Land Resources, Ghent University, Belgium.

Leys, A., Govers, G., Gillijns, K., Berckmoes, E., & Takken, I. (2010). Scale effects on runoff and erosion losses from arable land under conservation and conventional tillage: The role of residue cover. Journal of Hydrology, 390, 143–154.

Mashingaidze, N., Madakadze, C., Twomlow, S., Nyamangara, J., & Hove, L. (2012). Crop yield and weed growth under conservation agriculture in semi-arid Zimbabwe. Soil and Tillage Research, 124, 102–110.

Mkoga, Z. J., Tumbo, S. D., Kihupi, N., & Semoka, J. (2010). Extrapolating effects of conservation tillage on yield, soil moisture and dry spell mitigation using simulation modelling. Physics and Chemistry of the Earth, Parts A/B/C, *35*(13-14), 686-698.

Montgomery, M. (2007). The discourse of broadcast news: A linguistic approach. New York: Routledge.

Pimental, D. (1993). World soil conservation. Cambridge University Press, New York, pp. 27–61.

Pittelkow, C. M., Liang, X., Linquist, B. A., Van Groenigen, K. J., Lee, J., & Lundy, M. E. (2015). Productivity limits and potentials of the principles of conservation agriculture. Nature, 517, 365–368.

Powell, J. M., Pearson, R. A., & Hiernaux, P. H. (2004). Crop-livestock interactions in the West African Drylands. Agronomy Journal, 96, 469–483.

Rufino, M. C., Tittonell, P., van Wijk, M. T., Castellanos-Navarrete, A., Delve, R. J., de Ridder, N., & Giller, K. E. (2007). Manure as a key resource within smallholder farming systems: Analysing farm-scale nutrient cycling efficiencies with the NUANCES framework. Livestock Science, 112(3), 273–287.

Rusinamhodzi, L., Corbeels, M., Van Wijk, M. T., Rufino, M. C., Nyamangara, J., & Giller, K. E. (2011). A meta-analysis of long-term effects of conservation agriculture on maize grain yield under rain-fed conditions. Agronomy for sustainable development, *31*(4), 657-673.

Sarah Vaughan. (2003). Ethnicity and power in Ethiopia (Ph.D. Thesis). University of Edinburgh, Scotland.

Siziba, S. (2008). Assessing the adoption of conservation agriculture in Zimbabwe’s smallholder sector (Ph.D. Thesis). University of Hohenheim.

Southern Nations, Nationalities, and Peoples' Region. (2011). Ethiopia livelihood profiles. USAID/FEWSNET

Steward, P. R., Dougill, A. J., Thierfelder, C., Pittelkow, C. M., Stringer, L. C., Kudzala, M., & Shackelford, G. E. (2018). The adaptive capacity of maize-based conservation agriculture systems to climate stress in tropical and subtropical environments: A meta-regression of yields. Agriculture, Ecosystems & Environment, *251*, 194-202.

Thierfelder, C., & Wall, P. C. (2009). Effects of conservation agriculture techniques on infiltration and soil water content in Zambia and Zimbabwe. *Soil and tillage research*, *105*(2), 217-227.

Tuan, V. D., Hilger, T., MacDonald, L., Clemens, G., Shiraishi, E., Vien, T. D., & Cadisch, G. (2014). Mitigation potential of soil conservation in maize cropping on steep slopes. Field Crops Research, 156, 91–102.