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Tel: 0257753123|757097|757049

Fax: 0257753122

P.O.Box: 398, Jigjiga, Ethiopia

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PREFACE

Realizing the key role that it plays in the national economy; the Ethiopian government has given due emphasis to the agricultural sector development. The Agricultural and Rural Development Policy and Strategy of the country which was designed nearly a decade and half ago, has highly emphasized the important role of agriculture as a means of ensuring rapid economic growth, enhancing benefits to the people, eliminating food aid dependency, and promoting the development of a market-oriented economy. Guided by this national policy and strategy, different consecutive national plans, programs and projects focusing on the development of the agriculture sector has been implemented and is being implemented throughout the country. In addition to this, our country is designed 10 years strategic plan of which agriculture sector is once recognized as backbone for the national economy. It is believed that, in achieving and implementing these and other national plan, the role of research is expected than ever as it did in the previous plans and research component is added in these national plans.

The aim of the research component is to adapt or generate agricultural technologies, undertake pre-extension demonstration of proven technologies, produce source technologies that would serve as a base for large scale technology multiplication and enhance capacity of the research systems to improve technology supply. Being one of the implementing institutions, the Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI) is conducting various technology adaptation and generation, research report proceedings, source technology multiplication and capacity building activities.

SoRPARI is therefore working on generating/adapting technologies suited to the agro-ecologies of the region and demonstrating them in close collaboration with farmer research and extension offices. SoRPARI also supplies source technologies by multiplying them in the mandate areas on farmer's field, to address problems related to seed shortage and the like. As part of disseminating generating information and technologies, SoRPARI have prepared this proceeding where more than 23 research works and technologies from Crop, Soil & Water, Agricultural mechanization, Food Science &Nutrition, Seed, Extension research directorates and center as part of its implemented projects of 2022/23 plan. Demonstration of generated or introduced technologies and their multiplication needs serious attention from the stakeholders working in the agricultural system.

Mohammed Sharif (MSc.)

Director General of SoRPARI

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CROP RESEARCH DIRECTORATE

CROP RESEARCH DIRECTORATE

Effect of Planting Dates on Yield Related Traits and Yield of Different Upland Rice Varieties at Godey, In Somali Region, Ethiopia

Hassen Isken Yusuf

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjijiga. Ethiopia

Corresponding author: hassennour99@gmail.com

ABSTRACT

Rice is the most important cereal crop after wheat and one of the most widely consumed and indispensable grains in the world. Thus, for the proper growth and development of rice optimum planting time is imperative to complete all growth phases successfully. A study was conducted for one season in 2022/23 with the objectives to find the optimum planting date on yield related traits and yield of rice at Godey. The treatments consisted of three planting times (October 1st, October 15th and November 1st), three upland rice varieties (Narica-2, Narica-6 and Narica-14). The experiment was laid out in a randomized complete block design (RCBD) with factorial arrangement with three replications. The result revealed that the main effect of planting date was highly significant in influencing number tiller per plant, number of productive tillers per plant, grain yield, dry biomass yield. The main effect of varieties was highly significant in plant height and thousand weight. The highest (5.98) number tiller per plant, (3.73) number of productive tillers per plant, (2462 kg/ha) grain yield and (11,111 kg/ha) dry biomass yield was recorded at 1st October. Significantly the highest (73.96 cm) plant height was recorded at Narica-6 variety. Significantly the maximum (27.78 g) thousand seed weight was recorded at Narica-14. It can therefore, be concluded that to achieve higher rice grain yield, the sowing date should be adjusted. The optimum sowing date of rice varieties is recommended to October 1st for getting maximum yield.

Keywords: Upland rice, varieties, planting dates, Yield.

INTRODUCTION

Rice (Oryza sativa. L) is the most important cereal crop after wheat and one of the most widely consumed grains in the world. It is an indispensable food for more than half of the world's population within Asia and Africa. Asian countries are the largest producer (75% of the total global rice production) and consumer of rice (Lindner S, *et al* 2016). India is the secondlargest consumer of rice with 100 million metric tonnes after the most populous country in the world China which consumes 143.8 million metric tonnes of rice (Statista, 2019). The date of planting is an important non-monetary input and an indispensable agronomic factor for obtaining optimum rice yields (Deshmukh *et al* 2013). It also assumes the much greater significance of cultivation under changing climatic conditions, because planting time in rice cultivation is

indirectly responsible for soil temperature and weather conditions to which young rice seedlings and growing rice plants are exposed during different phenological stages (Yoshida S and Parao FT. 1976). Moreover, an optimum date of planting in a particular ecological setting provides an accumulation of desired heat units necessary for proper growth and development of rice crop (Rani BA and Maragatham N, 2013). Timely planting ensures greater yield attributing parameters and grain yield (Khalifa, 2009). However, late transplanting results in reduced yield promoting parameters and also limits the growth duration which further leads to a reduction in leaf area, productive tillers and test weight (Bashir *et al* 2010) Maximum productivity in rice can be achieved by simply adopting the optimum date of planting which is location-specific, and may vary from variety to variety (Reddy SN and Narayana P., 1984) Time of planting in rice crop is very important to be optimized because of the variation in the growth duration, photo sensitiveness, thermosensitivity and vegetative lag period of different varieties. (Dixit AJ *et al*, 2014) Reported that panicle initiation stage started late in early sown crop (5th and 10th June) and 50 per cent flowering was earlier in late crop (25th June) thus reducing the growth duration and the optimum photoperiod requirement.

The sowing time of the rice crop is important for three major reasons. Firstly, it ensures that vegetative growth occurs during a period of satisfactory temperatures and total sunshine hours. Secondly, the optimum sowing time for each cultivar ensures the cold sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, sowing on time guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved. Results from different studies revealed that the maximum yield potential of a rice crop is usually achieved when the crop is exposed to the most appropriate temperature range, which can be controlled by sowing at the proper time. Therefore, the objectives of this study will be Effect of planting dates on yield related traits and yield of different rice varieties at Godey.

MATERIAL AND METHOD

Experimental sites, Treatments and Experimental Design

The experiment was conducted under irrigation for one years (2023) on station at godey districts, Eastern Ethiopia, Somali region state. The treatments were consisted of three planting times (October 1st, October 15th

and November 1st), three upland rice varieties (Narica-2, Narica-6 and Narica-14). The experiment was laid out in a randomized complete block design (RCBD) with factorial arrangement with three replications. The gross plot size was 4 m^2 (2m x 2m) with 25 cm and row drill spacing between rows and plants, respectively. The spacing between plots and adjacent replications was 0.5 and 1. m, respectively. After the seedbed preparation and field layout works was over, the seed of each variety in each plot was sown at a seed rate of 150 kg/ha using drilling method at 25 cm spacing interval between rows. The trial was conducted using irrigation Weeding will be done 2-3 times in which the first weeding must be done within 25 - 30 days after sowing.

Data Collection and Analysis

Data on days to 50% emergence, days to 50% heading, days to 90% maturity, plant height, number tiller per plant, number of productive tillers per plant, grain yield, dry biomass yield and thousand weight was collected. Analysis of variance was performed as per the methods described by Gomez and Gomez (1984) using GenStat 15th software for randomized complete block design and treatment mean comparison was done by Fisher's list significance difference (LSD) at 5%.

RESULT AND DISCUSSION

Crop Phenology

Days to 50% emergence and heading

The analysis of variance (ANOVA) showed that planting date, varieties and their interaction had no significant effect on days to 50% emergence and heading (Appendix Table 1).

Days to 90% physiological maturity

The analysis of variance (ANOVA) showed that planting date, varieties and their interaction had no significant effect on days to 90% physiological maturity (Appendix Table 1).

Table 1. Main effect of planting date and varieties on days to 50% emergence (DE), days to 50% heading (DS) and days to 90% of physiological maturity (DPM).

Treatments	DE	DH	DPM
Planting dates			
October 1st	4.11	60.56	93.78
October 15th	4.44	60.22	93.89
November 1st	4.22	60.44	94.00
LSD (0.05)	NS	NS	NS
Varieties			
Narica-1	4.11	60.44	93.22
Narica-6	4.55	60.56	94.22
Narica-14	4.11	60.22	94.22
LSD (0.05)	NS	NS	NS
CV (%)	10.2	1.7	1.2

NS = Non-significant, LSD = Least Significant Difference at 5% level of significance, CV (%) = Coefficient of variation in %; Means in column and followed by the same letters are not significantly different from each other at 5% level of significance.

Growth Parameters

Plant height (cm)

Plant height was highly significant (P<0.01) affected by the main effect of varieties, while the effect of both planting date and their interaction were not significant (Appendix Table 2).

The tallest (73.96 cm) plant was recorded at Narica-6 variety, while the shortest (56.16 cm) plant was recorded at Narica-14 variety (Table 2). This could be due to genetic difference of the varieties in adapting the environment may vary plant height. According to Sadimantara et al (2018) plant height showed significantly difference among the new plant type upland rice lines the tallest plant was GS16-2 (92.71 cm) and the shortest was GS44-1 line with 70.01 cm height.

Yield Components and Yield

Number of tillers

The analysis of variance showed that number of tillers was highly significant (P<0.01) affected by planting date, while the effect of both interaction and varieties were not significant (Table 2).

Number of tillers was influenced by various planting dates. Maximum number of tillers (5.98) was observed when crop was sown on October 1st while the crop sown on November 1st gave minimum number of tillers (5.45). This increase of number of tillers at 1st October sowing was attributed to favorable environmental conditions which enabled the plant to improve its growth and development as compared to other sowing dates. This result was supported by Madhu (2018) who reported that the highest number of total tillers hill-1 (4.89) and the highest number of effective tillers hill-1 (4.15) were found on 15 November sowing.

Number of productive tillers

Number of productive tillers was highly significant (P<0.01) affected by the main effect of planting date, while the effect of both varieties and their interaction were not significant (Table 2).

Number of productive tillers per was influenced by various planting dates. Maximum number of tillers (3.73) was observed when crop was sown on October 1st while the crop sown on November 1st gave minimum tillers (3.42) (Table 2). Among yield components, productive tillers are very important because the final yield is mainly a function of the number of panicles bearing tillers (productive tillers) per unit area. This increase of productive tillers at 1st October sowing was attributed to favorable environmental conditions which enabled the plant to improve its growth and development as compared to other sowing dates. The results are in alignment with the findings of Bashir *et al*., (2010) who reported that number of fertile tillers per m^2 was influenced by various planting dates. Maximum number of fertile tillers m^2 (335) was observed when crop was sown on 20th June while the crop sown on 20th July gave minimum tillers m-2 (200).

Table 2: Main effect of planting date and varieties on plant height (PH), number tiller per plant (NTPP) and number of productive tillers per plant (NPTPP).

Treatments	PH(cm)	NTPP	NPTPP
Planting dates			
October 1st	64.16	5.98b	3.73b
October 15th	63.89	5.66a	3.70b
November 1st	64.18	5.45a	3.42a
LSD (0.05)	NS	0.30	0.14
Varieties			
Narica-1	62.11b	5.82	3.54
Narica-6	73.96c	5.68	3.68
Narica-14	56.16a	5.60	3.62
LSD (0.05)	5.86	NS	NS
CV (%)	9.1	5.3	4.0

NS = Non-significant, LSD = Least Significant Difference at 5% level of significance, CV (%) = Coefficient of variation in %; Means in column and followed by the same letters are not significantly different from each other.

Thousand seed weight (g/ha)

Thousand seed weight was highly significant ($P<0.01$) affected by the main effect of varieties, while the effect of both planting date and their interaction were not significant (Table 3).

Thousand seed weight was significantly affected by varieties. The maximum (27.78g) thousand seed weight was recorded at Narica-14 variety which was statistically at par with Narica-1 (27.00g), while the minimum (26.11g) thousand seed weight was recorded at Narica-6 variety. This could be that genetic-make difference of the varieties which caused the weight difference. This result was supported by Altaye (2021) who reported the presence of significant varieties effects was obtained on thousand-grain weight.

Grain yield (kg/ha)

The analysis of variance showed that grain yield was highly significant ($P<0.01$) affected by planting date, while the effect of both interaction and varieties were not significant (Table 3).

The data pertaining to the grain yield as affected by different sowing dates are given in Table 3. The table indicated that all sowing dates differ significantly with respect to grain yield. October 1st sowing produced maximum grain yield (2462 kg ha-1) while the lowest grain yield (1991 kg ha-1) was observed in November 1st sowing. Grain yield decreased gradually with delay in planting time. Similarly, these findings are in agreement with the observation of Akbar (2010) who reported that grain yield was affected significantly by different sowing dates. The crop sown on 20th June (D3) produced the maximum grain yield (4468 kgha-1) followed by 10th June (D2) sowing giving 3964 kgha-1 grain yield.

Aboveground dry biomass yield (kg/ha)

Aboveground dry biomass yield was highly significant ($P<0.01$) affected by the main effect of planting date, while the effect of both varieties and their interaction were not significant (Table 3).

Aboveground dry biomass yield was significantly affected by varieties. The maximum (11,111 kg ha-1) aboveground dry biomass yield was recorded at 1st October which was statistically at par with 15th October (10700 kg ha-1), while the minimum (9259 kg ha-1) was observed in November 1st sowing (Table 3). Aboveground dry biomass yield declined as planting date was delayed. Similar result was found by Chandini (2020) who reported that dry weight per hill of different rice varieties vary significantly by dates of planting.

Table 3: Main effect of planting date and varaities on thousand seed weight, grain yeild and aboveground dry biomass yield.

Treatments	TSW(g/ha)	GY(kg/ha)	ADBY(kg/ha)
Planting dates			
October 1st	27.11	2462c	11111b
October 15th	26.89	2281b	10700b
November 1st	26.89	1991a	9259a
LSD (0.05)	NS	125.23	712.30
Varieties			
Narica-1	27.00b	2280	10494
Narica-6	26.11a	2228	10494
Narica-14	27.78b	2226	10082
LSD (0.05)	0.79	NS	NS
CV (%)	3.0	5.6	6.9

NS = Non-significant, LSD = Least Significant Difference at 5% level of significance, CV (%) = Coefficient of variation in %; Means in column and followed by the same letters are not significantly different from each other.

Conclusion

Based on the above findings the optimum date of sowing is the most crucial factor that decides the rice yield to a greater extent. Under early planting condition in Godey, when planted on October 1st out yielded other sowing dates. And as the planting gets delayed beyond the first week of October 1st the yield of rice decreases progressively. The decreasing trend in grain yield with delayed sowing date might be associated with the reported significant lower number of productive tillers, lower number of tillers and lower test weight. Also there is a consensus in the literature that the synchronization of the critical phenophases with the favorable weather regime ensures promising crop yield which is only possible by adjusting the sowing date. Therefore, it is imperative to confirm best sowing date for rice for higher yield. The recommended optimum sowing date of rice varieties is October 1st for getting maximum yield in Godey, while delay in

sowing after October 1st reduce the yield gradually. However, the result of the present study need to be evaluated and reconfirmed under different agro-climatic conditions and seasons to give a conclusive recommendation for a wide range of rice production systems.

REFERENCE

Altaye Tiruneh , Awel Beshir , Abayneh Kacharo (2021). Performance Evaluation of Upland Rice (Oryza Sativa L.) and Variability Study for Yield and Related Traits in South West Ethiopia. International Journal of Plant Breeding and Crop Science. 8(2): 1050-1054.

Bashir MU, Akbar N, Iqbal A, Zaman H. Effect of different sowing dates on yield and yield components of direct seeded coarse rice (Oryza sativa L.). Pakistan Journal of Agricultural Science, 47(4):361–365.

Bashir, M.U., N. Akber, A. Iqbal and H. Zaman (2010). Effect of different sowing dates on yield and yield components of direct seeded coarse rice (Oryza sativa L.) Pakistan Journal of Agricultural Science, 47(4): 361-365.

Chandini, Avijit Sen, VK Srivastava, Ardith Sankar and Monalisa Sahoo (2020). Effect of planting dates on dry weight, flowering and yield of different rice varieties. Journal of Pharmacognosy and Phytochemistry, 9(1): 1394-1397.

Deshmukh SP, Patel JG. Influence of Non-monetary and Low Cost Input in Sustainable Summer Pearl millet (Pennisetum Glaucum L.) Production. International Journal of Agriculture and Food Science Technology. 2013; 4(6):579-588.

Dixit AJ, Gaikwad VV, Jadhav MG, Thorat ST. Effect of sowing times on the phenology and growth of hybrid rice parents. Journal of Agrometeorology 6 (Special issue), 2004, 72-76.

Dixit, A.J., S.T. Thorat, V.V. Gaikwad and M.G. Jadhav (2004). Yield attributes and yield of parental lines of sahyadri hybrid rice as influenced by sowing dates. J. Agrometeo., 6: 95-97.

G R Sadimantara, W Nuraida, N W S Suliartini and Muhidin (2018). Evaluation of some new plant type of upland rice (Oryza sativa L.) lines derived from cross breeding for the growth and yield characteristics. IOP Conf. Ser.: Earth Environ. Sci. 157 012048.

Khalifa, A.A.B.A. (2009). Physiological evaluation of some hybrid rice varieties under different sowing dates. Australian Journal of Crop Science, 3(3): 178-183.

Lindner S, Xue W, Nay-Htoon B, Choi J, Ege Y, Lichtenwald N et al. Canopy scale CO2 exchange and productivity of transplanted grain and direct seeded rainfed rice production systems in S. Korea. Agricultural and Forest Meteorology. 2016; 228:229–38.

Madhu, U., Begum, M., Salam, A. and Sarkar, S.K. (2018). Influence of sowing date on the growth and yield performance of wheat (Triticum aestivum L.) varieties. Archives of Agriculture and Environmental Science, 3(1) 89-94 DOI: 10.26832/24566632.2018.0301014.

Nadeem Akbar , Asif Iqbal, Haroon Zaman Khan, Muhammad Kashif Hanif and Muhammad Usman Bashir (2010). Effect of different sowing dates on the yield and yield components of direct seeded fine rice (Oryza sativa L.). Journal of Plant Breeding and Crop Science. 2(10): 312-315.

Reddy, S.N. and P. Narayana (1984). Pattern of dry matter accumulation and N uptake by rice as influenced by age of seedling and date of planting. Andhra Agriculture Journal, 32:155-56. Statista, 2019. www.satatista.com.

Yoshida S, Parao FT. Climatic influence on yield and yield components of lowland rice in the tropics. Climate and rice. 1976: 20:471-494.

Performence evaluation of improved Hybrid Maize (*Zea Mays* L.) Varieties At Golohajo, Gursum Worda,Fafan,Zone,Somali Region

Abdi Husen[1], Mohamed Abdurahman[2]

Fafan agricultural research center (FARC), Fafan, Somali Region, Ethiopia.

Corresponding Author:Email: abdihussein5252@gmail.com

ABSTRACT

Maize (Zea mays, L) is one of the major cereals and chief sources of energy in the human diet. Inaccessibility is causing a significant impact on the production of maize in different parts of Ethiopia due to lack of improved varieties. Technology has not been widely addressed and adapted in the lowlands of somali region.Hence, field experiment was conducted during 2023 cropping season at Gursum woreda,SRS, Ethiopia, fafan research center to evaluate performance and yield of hybrid maize varieties in study area. Four Hybrid maize varieties (MH141, Melkassa-2, BH520, and BH549) were tested .The experiment were arranged in randomized complete block design (RCBD) with three replication. Seeds were sown on a plot size of 22.5m^2 (5m length x 4.5 width) having four rows. Data on phenological, growth, yield and yield components of crop were examined. All data were Subjected to analysis using GenStat (18th edition) software. The analysis of variance showed that there was significance difference among the varieties for all parameters except days to maturity, and number of ears per plant. According to the analysis of variance the highest days to tasseling and silking was recorded from variety BH-149, while the earliest was recorded from MH-141. The highest grain yield was noted in variety BH-520, which is 89.47Qt/ha followed by BH-549 with 62.5qt/ha. Based on this finding, it can be concluded that BH-520 variety showed in best result in terms of yield and yield components in study areas. Therefore for sustainable maize production in the study area BH-520 variety is recommended and need to be demonstrated with local varieties to users along with their improved production package.

Keywords: *Evaluation, Improved, Maize, Variety, Hybrid*

INTRODUCTION

Maize (*Zea mays* L., also commonly known as corn**)** was domesticated more than 9,000 years ago in southern Mexico/Meso America (Awika, 2011; Kennett et al., 2020), following the earlier domestication some 10,000 years ago of wheat in the Fertile Crescent of the Near East and rice in the Yangtze Valley, China (Awika, 2011). Despite maize's somewhat later domestication and relative isolation till the European settlement in the Americas, maize has quickly disseminated across the globe since then and has become the leading global staple cereal in terms of annual production exceeding 1 billion metric tons (García-Lara & Serna-Saldivar, 2019). The global maize area (for dry grain) amounts to 197 M ha, including substantive areas in sub-Saharan Africa (SSA), Asia and Latin America (FAOStat, 2021).

Maize is one of the most important cereals cultivated in Ethiopia. It ranks second after teff in area coverage and first in total production. In the year 2020/21, Agricultural Sample survey indicates that total land areas of about 12,979,459.91 hectares were covered by grain crops. Out of the total grain crop areas, 10,538,341.91 hectares was under cereals. Of this maize covered 23.97% (about 2,526,212.36 hectares) of the grain crop area (CSA, 2020/2021).

In 2020/2021 Meher season the total area cultivated maize in Somali region was 53,753.17 hectares, out of which they obtained total yield 20.17qt/ha (CSA,2020/2021).

In fafan zone the total cultivated area of maize was 24,941.68 ha (CSA,2020/2021) hectares, out of which they obtained total yield of 24.67qt/ha which is very low when compared to potential maize **production** areas, the low yield in this area is mainly attributed to lack of improved maize varieties,low level of fertilizer and recurrent drought. Hence this study was aimed at selecting and recommending maize varieties that perform better and give high yield in study area.

MATERIALS AND METHODS

Study area and experimental design

The study was conducted at Golo-hajo site, Fafan research center, Fafan zone, Somali Regional State in 2023 cropping season. Four Hybrid maize varieties (MH141, Melkassa-2, BH520, and BH549) were tested at Fafan research Center,Golohajo,Site in 2023.

The trail was carried out in Randomized Complete Block Design (RCBD) with three replications. The plot size was 11.25m^2 (3m length x 3.75 width) with inter-row and intra-row spacing's of 0.75 m and 0.25 m, respectively. Two seeds per hill were planted and later thinned to single plant per hill, at 2 leaf stage (V-2 stage) and then thinned to one plant per hill providing a uniform stand of about 53,200 plants ha-1 All recommended Agronomic practices were applied.

Data collection and analysis:

Days to maturity, Plant height, ear length, and number of ears per plant, thousand seed weight, grain yield, and biomass yield data were collected.

All data were subjected to the analysis of variance (ANOVA) appropriate to the randomized complete block design using Gen stat version 18.2. Significant difference (LSD) test at 5% level of probability was used for mean separation (Gomez and Gomez, 1984).

RESULT AND DISCUSION

The Phenological and growth parameters:

Days to Tasseling: The analysis of variance revealed that varieties had significant (<0.05) on days to Tasseling as described in (Table 1).The prolonged duration of tasselling (73.67 days) was recorded from BH-520 variety While the earliest(70.33 days) duration to tasseling was obtained from MH-141 variety , this might be duet genetic variations among different maize of varieties. In line with this result, kusa *et al. (2022).*who reported significance difference among varieties. A similar result, Hussain *et al*., (2011) reported a differential pattern of maize varieties for days to tassel.

Days to silking: The analysis of variance revealed that the main effect of variety was highly significant (<0.01) on days to silking as described in (Table 1). The highest prolonged duration to silking (78.00 days) was obtained from BH-549 variety whereas the lowest (75.00 days) duration to silking obtained from MH-141 variety. This might be duet genetic variations among different maize varieties. In line with this result, Abduselam *et al* .(2017). reported significant difference days to silking among maize varieties. A similar result, kusa *et al.(2022).*who reported significance difference among varieties.

Days to maturity: The result from analysis of variance showed that, there was non-significance difference ($p<0.05$) among varieties on Days to maturity as described in (Table 1).The highest prolonged duration of Days to maturity (125.0 days) was recorded from MH-141 variety, whereas the lowest duration of days to maturity (123.0 days) was recorded from BH-549 variety. This might be duet genetic variations among different maize varieties.

Table 1: Mean performance of Phenological and growth parameters of hybrid maize varieties

Treatments	DT	DS	PH	DM
Hybrid maize varieties				
MH-141	70.33a	75.00[a]	201.1[a]	125.0[a]
BH-520	71.67[ab]	76.00[ab]	254.2[c]	123.7[a]
Melkassa-2	72.67[b]	76.67[b]	237.7[bc]	129.0[a]
BH-549	73.67[b]	78.00[c]	225.9[ab]	123.0[a]
LSD(0.05)	2.234*	1.290**	25.25	NS
C.V(%)	3.2	2.8	4.3	2.1

CV: Coefficient of variation, DTT: Days to tassel, DS: days to silking, LSD:least significance difference, means followed by different letters with in columns are significantly different by Duncan new multiple range test(p:0.05)

Plant height (cm): The analysis of variance revealed that the main effect of variety was highly significant ($p<0.01$) on plant height (Table 1). The highest plant height was recorded from BH-520 (254.2 cm) followed by melkassa-2 (237.7 cm). Whereas the lowest plant height was recorded from MH-141(201.1 cm). This might be duet genetic variations among different maize varieties. In line with this result, kusa *et al*.(2022). who reported significance difference among varieties.

Yield and yield components parameters of hybrid maize

Ear length (cm): The analysis of variance revealed that the main effect of variety was highly significant ($p<0.01$) on ear length of maize. The longest ear length was recorded from BH-520 (32.33 cm) while the lowest was recorded from Melkass-2 (29.93 cm). This might be duet genetic variations among different maize varieties. These results agreed with Kinfe *et al*.(2016), who reported different ear length for different maize varieties might be influenced by genetic variation.

Number of ears per plant: The result from analysis of variance showed that, there was non-significance difference ($p<0.05$) among varieties on number of ears per plant. This finding is in line with Kandil *et al*.(2017) who reported non-significant difference among maize varieties.

Thousand seed weight (g): The analysis of variance revealed that the main effect of variety was highly significant ($p<0.01$) on thousand seed weight (Table 2). The highest thousand seed weight was recorded From BH-549 (340.0g). While the lowest thousand seed weight recorded from

MH-141 (293.3g). This might be duet genetic variations among different maize varieties. In line with this result, kusa *et al.(2022) and* Taye *et al (* 2016). Who assessed and reported on the different thousand kernels weight of maize varieties.

Table 2: Mean performance of yield and yield component parameters of hybrid maize

Treatments	NEPP	EL (cm)	TSW (g)	GY (qt/ha)	BMY
Maize varieties					
MH-141	1.33[a]	29.60[a]	293.3[a]	44.54[a]	192.6a
BH-520	1.400[a]	32.33[b]	326.7[b]	89.47[c]	392.6c
Melkassa-2	1.267[a]	27.93[a]	320.0[ab]	42.50[a]	224.7a
BH-549	1.333[a]	30.20[ab]	340.0[b]	62.51[b]	296.3b
LSD(0.05)	**NS**	2.232**	26.85	16.06	68.22
C.V(%)	**7.5**	**3.7**	**4.2**	**10.6**	**7.4**

CV: Coefficient of variation, NEPP: number of ears per plant, TSW:Thousand seed weight,EL: days ear length, BY:biomass yield, GY:grain yield,LSD:least significance difference, means followed by different letters with in columns are significantly different by Duncan new multiple range test(p:0.05)

Biomass yield (Qt/ha): A significance ($p<0.05$) variation was observed among hybrid maize varieties in their response to number of biomass yield. The highest biomass yield was obtained from BH-520(392.6 Qt/ha) while the lowest was obtained from MH-141(192.6 Qt/ha). This might be duet genetic variations among different maize varieties.

Grain yield (Qt/ha): The analysis of variance revealed that varieties was highly significantly ($p<0.01$) influenced the grain yield of maize (Table 2). The highest grain yield was obtained from BH-520 (89.47 Qt/ha) and the lowest grain yield was obtained from melkassa-2(42.50 Qt/ha). This might be duet genetic variations among different maize varieties. In line with this result, kusa *et al*. (2022).who reported significance difference among varieties.

CONCLUSION AND RECOMMENDATION

From the experiment conducted at golo-ajo at 2023, the variation among hybrid maize varieties for grain yield was observed. The existence of significant variation among varieties for grain yield indicated the possibility of selecting best performing varieties for the study area and similar agro ecologies. Generally the yield result indicted that hybrid maize variety BH-520 gave the

highest grain yield (89.47qt/ha) among tested varieties followed by BH-549 variety (62.51qt/ha). Therefore for sustainable maize production in the study area BH-520 and BH-549 variety is recommended and need to be demonstrated with local varieties to users along with their improved production package. On-farm demonstration should be done in fafan zone areas and similar agro-ecology. The research should be conducted across location and year.

REFERENCE

Abduselam, f., z. Lagese, s. Tegene, f.t.a. Biri and n. Siraj, 2017. Performance evaluation and adaptability of improved released maize (*zea mays* l.) varieties in the midlands of fedis district of eastern hararghe. Asian j. Plant sci. Res., 7: 10-14.

Csa (central statistical agency). 2020/2021.agricultural sample survey reports on area and production of major crops. Addis ababa, ethiopia.

Fao, ifad, unicef, wfp, who,. (2021). The state of food security and nutrition in the world 2021: Transforming food systems for

Food security, improved nutrition and affordable healthy diets forall. *Fao, rome.* Https:// doi. Org/ 10. 4060/ cb447 4en

García-lara, s., chuck-hernandez, c., & serna-saldivar, s. O. (2019).development and structure of the corn kernel. In: Serna-saldivar,s.o. (ed.), corn (third edition). Aacc international press, oxford,pp. 147–163. Https:// doi. Org/ 10. 1016/ b978-0- 12- 811971- 6. 00006-1.

Gomez a. And gomez a. 1984.statistical procedures for agricultural research. 2nd ed., willey j. And son i., new york, usa, pp: 97-107.

Hussain, n., m.y. Khan and m.s. Baloch, 2011. Screening ofmaize varieties for grain yield at dera ismail khan. J. Anim.Plant sci., 21: 626-628.

Kandil, a.a., a.e. Sharief and a.m. Abo-zaied, 2017. Maize hybrids yield as affected by inter and intra row spacing. Int. J.Environ. Agric. Biotechnol., 2: 643-652.

Kinfe h,tsehaye y, redda a, welegebriel r, yalew d, et al. (2017) evaluating adaptability and yield performance of open pollinated

Kusa, k.a., s. Alemu and g. Teshome, 2022. Evaluation of drought tolerant maize varieties (*zea mays* l.) for low land of guji zone, southern oromia, ethiopia. J. Agron., 21: 8-13.

Maize varieties in north western tigray. Adv crop sci tech 5: 316. Doi:10.4172/2329-8863.1000316.

Taye t, bekele n, shimalis y. 2016. Evaluation of highland maize at bule hora district of so

Performace Evaluation of Opv Maize (*Zea Mays* L.) Varieties At Golohajo, Gursum Worda,Fafan,Zone,Somali Region

Abdi Husen, Mohamed Abdurahman.

Fafan agricultural research center (FARC), fafan,somali region.ethiopia.

Corresponding Author:Email: abdihussein5252@gmail.com

ABSTRACT

Maize (Zea mays, L) is one of the major cereals and chief sources of energy in the human diet and its production is constrained by many challenges such as the Lack of improved maize variety is highly limited in somali region due to the Inaccessibility of production factors. Hence, A field experiment was conducted during 2023 cropping season at Gursum woreda,SRS, Ethiopia,fafan research center to evaluate the performance and yield of Opv Maize (Zea Mays L.) Varieties in study area. Three improved maize varieties were evaluated. The experiments were arranged in randomized complete block design (RCBD) with three replications. Date on phenological, growth, yield and yield components of crop, were examined. Seeds were sown on a plot size of 22.5m^2 (5m length x 4.5 width) having four rows with a spacing. The analysis of variance showed that there was significance difference among the varieties for all parameters except plant height. The earliest days to maturity,tasseling and silking was recorded from variety Afan-qalo (122.3, 62.33 and 67.33 days) respectively. While the longest days to maturity,tasseling and silking was recorded from variety Raare-1. Afan-qalo variety showed the highest number of ears per plant and longest ear length (1.333 and 30.40 cm) respectively. The highest thousand seed weight, grain yield and biomass yield was noted in variety Afan-qalo (306.7 g, 284.0 Qt/ha and 49.08 Qt/ha) respectively. Therefore, for sustainable maize production in the study area,the Afan-qalo could be recommended. Further study should be carried out with other varieties, location and seasons In order to improve maize production under study area and similar agro-ecological areas.

***Keywords**: Improved, Maize, OPV, Yield, Varieties.*

INTRODUCTION

Maize (*Zea mays* L., also commonly known as corn**)** was domesticated more than 9,000 years ago in southern Mexico/Meso America (Awika, 2011; Kennett et al., 2020), following the earlier domestication some 10,000 years ago of wheat in the Fertile Crescent of the Near East and rice in the Yangtze Valley, China (Awika, 2011). Despite maize's somewhat later domestication and relative isolation till the European settlement in the Americas, maize has quickly disseminated across the globe since then and has become the leading global staple cereal in terms of annual production exceeding 1 billion metric tons (García-Lara & Serna-Saldivar, 2019). The global maize area (for dry grain) amounts to 197 M ha, including substantive areas in sub-Saharan Africa (SSA), Asia and Latin America (FAOStat, 2021).

Maize is one of the most important cereals cultivated in Ethiopia. It ranks second after teff in area coverage and first in total production. In the year 2020/21, Agricultural Sample survey indicates that total land areas of about 12,979,459.91 hectares were covered by grain crops. Out of the total grain crop areas, 10,538,341.91 hectares was under cereals. Of this maize covered 23.97% (about 2,526,212.36 hectares) of the grain crop area (CSA, 2020/2021).

In 2020/2021 Meher season the total area cultivated maize in Somali region was 53,753.17 hectares, out of which they obtained total yield 20.17qt/ha (CSA,2020/2021).

In fafan zone the total cultivated area of maize was 24,941.68 hectares, out of which they obtained total yield of 24.67qt/ha which is very low when compared to potential maize **production** areas, the low yield in this area is mainly attributed to lack of improved maize varieties, low level of fertilizer, poor agronomic package and recurrent drought. Therefore, the objective of this study was aimed at selecting improved maize varieties that perform better and give high yield in study area.

MATERIALS AND METHODS

Study area and experimental design

The study was conducted at Golo-hajo site, Fafan research center, Fafan zone, Somali Regional State in 2023 cropping season. Three Opv maize varieties (Afan-qalo, Baate, and Raare-1) were tested at Fafan research Center, Golohajo,Site in 2023. The trail was carried out in Randomized Complete Block Design (RCBD) with three replications. The plot size was 11.25m^2 (3m length x 3.75 width) with inter-row and intra-row spacing's of 0.75 m and 0.25 m, respectively. Two seeds per hill were planted and later thinned to single plant per hill, at 2 leaf stage (V-2 stage) and then thinned to one plant per hill providing a uniform stand of about 53,200 plants ha-1 All recommended Agronomic practices were applied.

Data collection and analysis:

Days to maturity, Plant height, ear length, and number of ears per plant, thousand seed weight, grain yield, and biomass yield data were collected.

All data were subjected to the analysis of variance (ANOVA) appropriate to the randomized complete block design using Gen stat version 18.2. Significant difference (LSD) test at 5% level of probability was used for mean separation (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

Phonological and growth parameter

Days to tasseling: The analysis of variance revealed that varieties was highly significant (<0.001) on days to Tasseling as described in (Table 1).The highest the highest duration to tasseling (72.67 days) was recorded from Raare-1 variety, While the lowest (62.33days) duration to tasseling was obtained from Afanqalo variety , this might be duet genetic variations among different maize of varieties. In line with this result,Abduselam *et al*.(2017) reported significance difference in days to tasseling among the maize varieties. A similar result, Hussain *et al*., (2011) reported a differential pattern of maize varietiesfor days to tasseling.

Days to silking: the analysis of variance revealed that maize varieties had highly significant (<0.001) on days to silking (Table 1). The highest the highest duration to silking (78 days) was obtained from Raare-1 variety, While the lowest (67.33days) duration to silking was obtained from Afanqalo variety , this might be duet genetic variations among the evaluated maize of varieties. In with this result,Abduselam *et al*., (2017). reported significance difference in days to silking among the maize varieties.

Days to maturity: The result from analysis of variance showed that, there was significance difference ($p<0.05$) among varieties on Days to maturity (Table 1). The highest duration in Days to maturity (129.3 days) was recorded from Baate variety, whereas the lowest duration of days to maturity(122.3 days) was recorded from Afan qalo variety. This might be duet genetic variations among the evaluated maize varieties. This finding is in agreement with Bakala *et al*., (2017) found significant differences among genotypes in their study of Maize evaluation.

Table 1. **Mean performance Phonological and growth parameters of Opv maize varieties.**

Treatments	DTT	DS	DM	PH
Afanqalo	62.33[a]	67.33 [a]	122.3[a]	242.4
Baate	68.33[b]	73.67 [b]	124.0[a]	235.5
Raare-1	72.67[c]	78.00 [c]	129.3[b]	229.1
LSD	3.023	3.023	4.868	NS
CV(%)	2.00	1.2	1.7	2.0

CV: Coefficient of variation, DTT: Days to tassel, DS: days to silking, LSD:least significance difference, means followed by different letters with in columns are significantly different by Duncan new multiple range test(p:0.05)

Plant height (cm): The analysis of variance revealed that the main effect of variety was not significant ($p<0.05$) on plant height of maize variety (Table 1). In contrast to this finding, Kinfe *et al*., (2016) reported variation of plant height for different maize varieties tested, Abduselam *et al*., (2017) also reported different plant height for different maize varieties.

Table 2. Mean performance yield and yield components parameters of OPV maize

Treatments	NEPP	EL(cm)	TSW(g)	BY(q/ha)	GY
Afanqalo	1.333[a]	30.40[b]	306.7[a]	284.0[a]	49.08[b]
Baate	1.200[ab]	28.47[b]	273.3[b]	212.3[b]	48.00[b]
Rare-1	1.133[b]	25.27[a]	180.2[b]	180.2[b]	16.88[a]
LSD0.05	0.151 *	2.686**	50.22	50.22	11.13
C.V(%)	7.5	1.8	3.3	3.3	7.5

CV: Coefficient of variation, NEPP: number of ears per plant, TSW:Thousand seed weight,EL: days ear length, BY:biomass yield, GY:grain yield,LSD:least significance difference, means followed by different letters with in columns are significantly different by Duncan new multiple range test(p:0.05)

The yield and yield components parameters of OPV maize

Number of Ears per plant: The analysis of variances showed that, the number of ears per plant was significantly affected by maize varieties (Table 2). The highest number of ears per plant (1.333) was recorded from Afan-qalo variety while the lowest (1.133) was recorded from Rare-1 variety (Table 2). This difference among varieties could be due to their own genetically difference. This finding is in line with Kandil *et al*., (2017) who reported non- significant difference among maize varieties.

Ear length (cm): The analysis of variance revealed that the maize variety had highly significance effect on ear length of (Table 2). The longest ear length (30.40cm) was recorded from variety Afan-qalo, while the lowest (25.27cm) was recorded from rare-1 variety. This finding is in line with Kandil *et al*. (2017), who reported no significant difference among maize varieties.

Thousand seed kernel weight: The analysis of variance revealed that the main effect of variety was significant ($p<0.05$) on thousand seed weight (Table 2). The highest thousand seed weight (306.7g) was obtained from Afan-qalo variety while the lowest thousand seed weight (266.7 g)

was recorded from Rare-1 variety. The recorded significance difference among variety is duet genetically variation of maize variety. This resultis like that of Taye *et al*., (2016) and Kinfe *et al*., (2016), who evaluated and reported different thousand kernels weight of maize varieties among different tested varieties.

Biomass yield (Qt/ha): The significance ($p<0.05$) variation was observed among hybrid maize varieties in their response to number of biomass yield. The highest biomass yield was obtained from Afan qalo variety (284.0 Qt/ha), while the lowest was obtained from Rare-1(180.2 Qt/ha). In general the recorded significance difference on biomass yield was most likely due to inherent character of the varieties.

Grain yield (Qt/ha): The result from analysis of variance, varieties showed that, there was highly significance ($p<0.001$) difference on grain yield (Table 2). the highest grain yield was recorded from Afan qalo followed by baate variety which is (49.08Qt/ha) and (48.00Qt/ha) while lowest (16.88) recorded from Rare-1 variety (Table 2). This might be duet genetic variations among different maize varieties. In agreement with Taye *et al*., (2016) also reported significant yield difference among different maize genotypes.

CONCLUSION AND RECOMMENDATION

From the experiment conducted at Golo ajo on station for 2023, variation among maize varieties for grain yield, phonological traits and most of other important traits were observed. Significant variation among varieties for grain yield and other yield related traits indicated the possibility of selecting varieties for the study areas for those traits. Based on the evaluated three opv maize varieties (Afan qalo,Baate and Rare-1), Afan-qalo variety showed best performance in terms of yield and yield component followed by Baate variety, while the rare-1 variety didn't performed good as compared to other varieties. Therefore, for sustainable maize production in the study area Afan-qalo could be recommended. Further study should be carried out with other varieties, location In order to improve maize production under study area and similar agro-ecological areas.

REFERENCE

Abduselam, F., Z. Lagese, S. Tegene, F.T.A. Biri and N. Siraj, 2017. Performance evaluation and adaptability of improved released maize (*Zea mays* L.) varieties in the midlands of fedis district of Eastern Hararghe. Asian J. Plant Sci. Res., 7: 10-14.

Awika, J. (2011). Major cereal grains production and use around the world. In: Awika, J. M., Piironen, V., & Bean, S. (Eds.), *Advances in cereal science: implications to food processing and health promotion*. American Chemical Society Atlantic City,NJ, Washington DC, pp. 1–13. https:// doi. org/ 10. 1021/ bk- 2011-1089. ch001.

Bakala N, Abate B, Nigusie M. "Standard Heterosis of Maize (*Zea mays* L.) Inbred Lines for Grain Yieldand Yield Related Traits at Southern Ethiopia, Hawassa". American-Eurasian J.Agric. and Environ. Sci., 17: 2017. 257-264.

CSA (Central Statistical Agency). 2020/2021.Agricultural Sample Survey Reports on Area and Production of Major Crops. Addis Ababa, Ethiopia.

FAO, Ifad, UNICEF, WFP, WHO,. (2021). The State of Food Security and Nutrition in the World 2021: Transforming food systems for

García-Lara, S., Chuck-Hernandez, C., & Serna-Saldivar, S. O. (2019).Development and Structure of the Corn Kernel. In: Serna-Saldivar,S.O. (Ed.), Corn (Third Edition). AACC International Press, Oxford,pp. 147–163. https:// doi. org/ 10. 1016/ B978-0- 12- 811971- 6. 00006-1.

Gomez A. and Gomez A. 1984.Statistical procedures for agricultural research. 2nd ed., Willey J. and Son I., New York, USA, PP: 97-107.

Hussain, N., M.Y. Khan and M.S. Baloch, 2011. Screening of maize varieties for grain yield at Dera Ismail Khan. J. Anim.Plant Sci., 21: 626-628.

Kandil, A.A., A.E. Sharief and A.M. Abo-Zaied, 2017. Maize hybrids yield as affected by inter and intra row spacing. Int. J.Environ. Agric. Biotechnol., 2: 643-652.

Kinfe H,Tsehaye Y, Redda A, Welegebriel R, Yalew D, et al. (2017) Evaluating Adaptability and Yield Performance of Open Pollinated

Taye T, Bekele N, Shimalis Y. 2016. Evaluation of highland maize at Bule hora District of So

Adaptation Trial of Improved Dessi Chickpea (Cicerarietinum L) Varieties At Golohajo, Gursum Worda, Fafan, Zone, Somali Region

Mohamed Abdurahman, Abdi Husen meydhane

Fafan agricultural research center (FARC), Fafan, Somali Region, Ethiopia.

Corresponding Author:Email: Themaame77@gmail.com

ABSTRACT

*Chickpea (Cicerarietinum L.) is an economically important crop grown by nearly one million Ethiopian smallholder farmers. Ethiopia is the largest chickpea growing country in Africa, with a contribution of about 37% in area and 48% in production. However, scarcity of varieties that fit to the environment is one of the major constraints of production in the study area. A field experiment was conducted during 2023 cropping season at fafan zone, SRS, Ethiopia. This study is, therefore initiated with the aim of introducing and selecting high grain yielding chick pea. Six chickpea varieties(Esheter, Natoli, Hora, Koka, Dimtu and Dalota) were used. The experiments were arranged in randomized complete block design (RCBD) with three replication. The experimental plots consisted of five rows. Data on phenological, growth, yield and yield components of crop were examined. The analysis of variance (ANOVA) for total yield and other agronomic traits of six chickpea varieties evaluated revealed significant varietal. Based on the obtained result Natoli (*2027 kg/ha) *and Dimitu (*1495 kg/ha) *were highest grain yields when we compared other varieties. Therefore, these varieties are recommended for local chickpea producers. Further research should be carried out through season, location to reach solid recommendation.*

Keywords: *chickpea, improved, varieties, Yield*

INTRODUCTION

Chickpea (Cicerarietinum L.) is an important cool-season food legume grown and consumed predominantly in the arid and semiarid tropical regions of the world. It is the world's second most important food legume representing an important component of the small-scale crop production (Varshney et al., 2014). It is an excellent source of high-quality edible protein particularly for the underprivileged population (Jukanti et al., 2012). Globally, chickpea is cultivated on an area of 17.85 million ha with an annual production of over 17 Tg (FAOSTAT, 2019). Among chickpea-growing countries, India alone contributes about 70% of the world's total production (Korbu et al., 2020). Ethiopia is the leading chickpea producer in Africa, producing more than 500,000 metric tons per year from an area of ~243,000 ha of smallholder farms (CSA, 2019; FAOSTAT, 2019), accounting for over 90% of grain production in sub-Saharan Africa (Verkaart et al., 2017). Chickpea is an economically important crop in Ethiopia

grown by more than 900,000 smallholder farmers (CSA,2019).The crop is well known as one of the major food legumes having great nutritional values for millions of farming communities.

Ethiopia is the largest chickpea growing country in Africa, with a contribution of about 37% in area and 48% in production. Amhara and Oromia regions cover more than 90% of the entire chickpea area and constitute about 92% of the total chickpea production of the country (IFPRI, 2010). It is one of the major pulse crop cultivated in the country, which occupies about 233,440 hectares of land annually with estimated production of 3,120,800qt (CSA, 2010). Chick pea has one of the highest nutritional compositions of among any dry edible legume. On an average, chickpea seed contains 23% protein, 47% starch, 56% fat, 6% crude fiber, 6% soluble sugar, and 3% ash (Munyua, B, 2013). According to Gaur, P. *et al*., (2008), the Ethiopian chick pea production is predominately about 95% by desi chickpea but in recent years, the interest of farmers in producing the large seeded kabuli varieties increasing due to domestic and export market. Having high protein content, it is so rich in zinc, dietary fiber, calcium, magnesium, phosphorus, potassium, iron and vitamins (Güler*et al*., 2001).

While information about the introduction of desi chickpea in Somali region is scant or unavailable, presently the production of this crop has been expanded to dry low altitude areas. In this regard, chickpea Having high protein content, it is so rich in zinc, dietary fiber, calcium, magnesium, phosphorus, potassium, iron and vitamins, deemed a promising crop in drylands in general and Somali region in particular. However, efforts exerted so far to introduce this crop to the farming community of the region is insignificant. Therefore this study was initiated with the aim of introducing and selecting high grain yielding chick pea varieties.

MATERIAL AND METHODS.

Experimental Sites, Designs and Experimental Materials

The study was conducted at Gola-ajosite, Fafan center, Fafan zone, Somali Regional State in 2022/2023 cropping season. Six chickpea varieties (Esheter, Natoli, Hora, Koka, Dimtu and Dalota) were used as the experiment materials with one standard check. The study was conducted under rain fed condition. The experimental plots were laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental plots were consist of five rows of 3 m length, 2 m width and 0.4 m row space. The central three rows were harvested

to estimate grain yield. The spacing between adjacent replications and plots were 1 m, and 0.5 m, respectively. Agronomic data was collected on plant and plot basis from the trial.

Data collection and statistical analysis

The data on number of pods per plant, number of seeds per pod and plant height (cm) were taken and evaluated on five plants from each plot. Data like days to 50% flowering, days to maturity and seed yield (g) were collected from whole plot area. Data was analyzed using Gen STAT statistical software package and mean values was compared using Least Significant Differences (LSD) procedures of Duncan's at the 5% level of significance.

RESULT AND DISCUSSIONS

Phonological and growth parameter

Days to 50% **flowering** was found to be highly significantly (P<0.01) influenced due to the effects of variety (Table 1). The variety 'Natoli' took the lowest number of days (39.33 days) to reach 50% **flowering** while the variety 'koka' was late to reach 50% **flowering** (53.67 days). This reveals the existence of genetic differences among the varieties. In line with this result, Getachew, *et al.* (2015) also reported significance variation of days to flowering among chickpea varieties.

Days to 90% Physiological Maturity: the analysis of variance revealed that varieties had highly significant (P<0.01) effects on days to 90% physiological maturity of chickpea (Table 1). The variety 'Natoli' took the longest days maturity (123.7days) while variety 'Hora' was early (101.7 days) to reach physiological maturity. This might be due to the fact that there is a genetic difference among the varieties of chickpea. In line with this result, Getachew, *et al.* (2015),also reported the existence of significant variation for days to maturity.

Plant height (cm): the analysis of variance showed that the varieties were highly significant (P<0.01) effects on plant height (Table 1) .The tallest (42.93cm) and shortest (39.53cm) plants were recorded for Dalota and Hora respectively. This might be due to the genetic differences among the chickpea varieties Grain yield. In line with this result, Ercan *et al.* (2013), also reported highly significant variation for plant height of the chickpea evaluated.

Table 1. Mean performance phenological and growth parameters of improved chickpea varieties

Variety	DF	DM	PH(cm)
Hora	48.33c	101.7a	39.53a
Esheter	44.67b	105.0 a	42.33c
Dalota	42.67b	106.3a	42.93c
Koka	53.67d	110.0ab	41.33b
Dimtu	51.00cd	121.7bc	41.20b
Natoli	39.33 a	123.7c	42.40c
LSD $_{(0.05)}$	**3.249**	**13.03**	**0.986**
CV (%)	3.8	6.4	1.3

CV: Coefficient of variation, DF: Days to flowering, DM: days to maturity, PH: plant height, LSD:least significance difference, means followed by different letters with in columns are significantly different by Duncan new multiple range test(p:0.05)

Yield and yield components parameters

Number of pods/plant: the analysis of variance revealed that the main effect of varieties were highly significant (P<0.01) on number of pods per plant (Table 2).The highest number of pod per plant of chickpea was recorded on Natoli (40.40) while lowest number of pod per plant of chickpea was recorded from Hora (31.57). This might be duet genetic variations among different chickpea varieties. Similarly with this finding, Dan *et al.* (2016), also reported that a significance variation in number of pods per plant in chickpea variety.

Number of seeds/pods: The main effects of variety were significant (P<0.05) on number of seeds per pods (Table 2).The highest number of seeds per pod were recorded from Natoli (1.933) and lowest was recorded similarly from Hora, Esheter and koka variety (1.333). This might be due to genetically differences among the varieties. According to this finding, Getachew *et al*. (2015), also reported a significance variation in number of seeds per pod in chickpea variety.

Table 2. Mean performance of Yield and yield component parameters of chickpea varieties

Variety	NPP	NSP	TSW(g)	BY (kg ha-1)	GY (kg ha-1)
Hora	31.57	1.333[a]	0.2800[b]	4424bc	1393abc
Esheter	36.00b	1.333[a]	0.2107[a]	3909ab	1197ab
Dalota	39.33c	1.467[a]	0.3007[bc]	4414bc	1678c
Koka	36.70b	1.333[a]	0.1887a	3407a	1188a
Dimtu	35.17b	1.533[a]	0.2907bc	4690c	1495bc
Natoli	40.40c	1.933[b]	0.3513c	5426d	2027d
$LSD_{(0.05)}$	1.994	0.2629	0.06491	726.9	302.8
CV (%)	3.0	9.7	13.2	9.1	11.1

CV: Coefficient of variation, NPP: number of pods per plant, NSP: number of seeds per pod, TSW:thousand seed weight, BY: biomass yield, GY: grain yield, LSD:least significance difference,

Thousand Seed Weight: The main effects of variety had significant (P<0.05) effect on thousand seed weight (Table 2). The highest thousand seed weight (0.3513 g) was recorded from variety 'Natoli' while the lowest (0.1887 g) was obtained from the koka variety. This might be due to the fact that there is a genetic difference among the varieties. Similarly, Dan, *et al. (2016),* pointed out that there were significances in thousand seed weight for different chickpea varieties.

Biomass yield (kg ha-1): The analysis of variance showed that the main effect of varieties was significant (P < 0.05) on biomass yield. The highest biomass yield was recorded from Natoli (5426kg ha-1) variety followed by Dimtu (4690 kg ha-1) variety while the lowest was obtained from Koka (3407kg ha-1) variety. This shows the existence of genetic differences among the varieties.

Grain yield (kg ha-1): The analysis of variance indicated significant (P<0.05) effects of varieties on Grain yield of chickpea. The Variety 'Natoli' was recorded from the highest grain yield (2027kg ha-1) followed by variety Dalota (1678 kg ha-1). On the other hand, the lowest grain yield of (1188 kg ha-1) was recorded from koka variety. This is due to the existence of genetic differences among the varieties. In line with this result, Desai *et al.* (2016), also reported that significant difference on grain yield on chickpea variety.

Conclusions and recommendations

The significant difference was shown different yield related traits among varieties. Generally significant differences for a number of traits among the tested varieties were observed. Evaluation of varieties for adaptation is a fast truck strategic approach to develop and promote agricultural technology. The result of this study showed that variety Natoli and Dimitu was showed best performance in all parameters. The highest (2027 kg ha^{-1}) grain yield was recorded from Natoli variety followed by Dimitu variety (1495 kg ha^{-1}).Based on this finding Natoli and Dimitu are recommended for local chickpea producers. Further research should be carried out through season, location to reach solid recommendation.

REFERENCE

Chiulele, R., Mwangi, T., Ehlers, J., &Ndeve, A. (2011).Assessment of cowpea genotypes for variability to drought tolerance. African Crop Science Conference Proceedings, 10, 531–537.

CSA (Central Statistical Agency of Ethiopia).(2019). Agricultural sample survey 2018/19 (2011 E.C.) Report on area and production of major crops. CSA.

Dan, S. J., Kamble, M. S., Abhishek, S., and Saket, K., 2016. "Performance of chickpea (cicer arietinum l.) genotypes in kolhapur region." *International Journal of Agriculture, Environment and Biotechnology*, vol.9, pp. 283-289.

Desai, K., Tank, C. J., Gami, R. A., and Patel, A. M., 2016. "G X E Interaction and stability analysis in chickpea (Cicer arietinum L.)." *International Journal of Agriculture, Environment and Biotechnology*, vol.9, pp. 479-484.

Ercan, C., Ali, K., and Hasan, D., 2013. "Determination of some agricultural characters of chickpea (cicerarietinum l.) genotypes. World academy of science, engineering and technology." *International Journal of Agricultural and Biosystems Engineering*, vol. 7, pp. 1092-1095.

FAO. (2018). World food and agriculture: Statistical pocketbook 2018. FAO.

FAO.(2019). FAOSTAT database. Retrieved October 2021 from https://www.fao.org/faostat/en/

Fikre, A., Funga, A., Korbu, L., Eshete, M., &Girma, N. (2018). Stability analysis in chickpea genotype sets as tool for breeding germplasm structuring strategy and adaptability scoping. Ethiopian Journal of Crop Science, 6(2), 19–37.

Getachew, T., Firew, M., Asnake, F., and Million, E., 2015. "Genotype x environment interaction and stability analysis for yield and yield related traits of Kabuli-type Chickpea (Cicer arietinum L.) in Ethiopia."*African Journal of Biotechnology,* vol. 14, pp. 1564-1575.

Jukanti, A., Gaur, P., Gowda, C., &Chibbar, R. (2012). Nutritional quality and health benefits of chickpea (Cicerarietinum L): A review. British Journal of Nutrition, 108, S11–S26.https://doi.org/10.1017/ S0007114512000797

Korbu, L., Tafes, B., Kassa, G., Mola, T., &Fikre, A. (2020). Unlocking the genetic potential of chickpea through improved crop management practices in ethiopia a review. Agronomy for Sustainable Development, 40(2).https://doi.org/10.1007/s13593-020 00618-3

Kumar, P., Boora, K. S., Kumar, N., Batra, R., Goyal, M., Sharma, K. D., & RC, Y. (2018).

Traits of significance for screening of chickpea (Cicerarietinum L.) genotypes under terminal drought stress. Journal of Agrometeorology, 20(1), 40–45.

Varshney, R. K., Thudi, M., Nayak, S. N., Gaur, P. M., Kashiwagi, J., Krishnamurthy, L., Jaganathan, D., Koppolu, J., Bohra, A., Tripathi, S., Rathore, A., Jukanti, A. K., Jayalakshmi, V., Vemula, A., Singh, S. J., Yasin, M., Sheshshayee, M. S., &Viswanatha, K. P. (2014). Genetic dissection of drought tolerance in chickpea (Cicerarietinum L). Theoretical and Applied Genetics, 127, 445–462. https://doi.org/ 10.1007/s00122-013-2230-6.

Verkaart, S., Munyua, B. G., Mausch, K., &Michler, J. D. (2017). Welfare impacts of improved chickpea adoption: A pathway for rural development in Ethiopia? Food Policy, 66, 50–61. https://doi.org/10. 1016/j.foodpol.2016.11.007.

Adaptation Trial of Improved linseed (Cicerarietinum L) Varieties At Golohajo,Gursum Worda,Fafan,Zone,Somali Region

Abdi Hussen[1], Mohamed Abdirahman[2]*

Fafan Agricultural Research Center (FARC), Fafan, Somali Region, Ethiopia.
**Corresponding Author:Email: abdihussein5252@gmail.com*

ABSTRACT

Linseed (Linum usitatissimum L.) is an oil crop which belongs to Linaceae and widely distributed in temperate and subtropical areas of the world. While information about the introduction of linseed in Somali region is scant or unavailable, Hence, field experiment was conducted during 2023 cropping season at fafan zone, SRS, Ethiopia.This study was intended to select linseed varieties with best adapted and high yielding under Fafan environmental conditions. Five improved linseed varieties (Kuma,Furtu,Walin,Yaadamo and Bekojuu-14) were tested .The experiment were arranged in randomized complete block design (RCBD) with three replication .The experiment was planted in 10 rows plot of 2 m length. The spacing was 20 cm between rows and 10cm between plants. Date on phenological, growth, yield and yield components of crop, were examined. All data were Subjected to analysis using GenStat (18th edition) software. The analysis of variance showed that there was significance difference among the varieties for all parameters except plant height. The earliest days to flowering (51 days) was recorded from yadamo variety, while the longest days to flowering (56.33 days) was recorded from Bekoju-14 variety. The prolonged days to maturity (116days) was recorded from walin variety. While the earlist days to maturity (101.3days) was obtained from kuma variety. highest number of capsule per plant,thousand seed weight and grain yiled was recorded from kuma variety which is54.00,12.00gm and 2135kg/ha respectively.while the lowest number of capsule per plant,thousand seed weight and grain yield was recorded from yadamo variety. Therefore, for sustainable linseed production in study areas, kuma could be recommended. On-farm demonstration should be done in fafan areas and similar agro-ecology.

Keywords: *Adaption, Improved, Linseed, Yield, Variety.*

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is an oil crop which belongs to Linaceae and widely distributed in temperate and subtropical areas of the world (Tadesse *et al.,* 2010). The crop was originated in east of the Mediterranean region (Adugna *et al.,* 2004). Linseed is widely distributed in different countries like Canada, Argentina, China, India, U.S and Ethiopia (Madhusudhan, 2009).

In Ethiopia, linseed is the third important oil seed next to sesame and NOUG both in terms of acreage and total production. Annually, a total of 112,760 tons of linseed is harvested from about 117,000 ha of land, and as such the crop accounts for over 13% of the total cultivated area and over 15% of the total production of oilseeds in the country (CSA 2012). Linseed is the second

major oil seed crop next to NOUG in the highlands of Ethiopia (Adugna, 2000). It has traditionally been used for food and as a cash crop since ancient times. It is now grown primarily for food and to generate revenue, either in local markets or by export. For food, the seeds are usually roasted, ground, mixed with spices and water, and served with various local breads. It is also consumed in soups, with porridges and cooked potatoes, etc. Limited amounts are also pressed locally for its edible oil, which is often blended with other high quality vegetable oils. As a result, linseed is currently becoming popular worldwide for its functional food products (MOA, 1998). The usage of improved seeds is one of the most efficient ways of raising crop production, but in Ethiopia less than 10 percent of farmers use improved seeds. (FAO, 2010). Lack of access to improved varieties in western Ethiopia is the main problem that hampers production of this crop.

While information about the introduction of linseed in Somali region is scant or unavailable, presently the production of this crop has been expanded to dry low altitude areas. However, efforts exerted so far to introduce this crop to the farming community of the region is insignificant. The present study was intended to assess the adaptability of improved linseed varieties that gives best yield under rain-fed condition of Fafan.

MATERIALS AND METHODS

Five linseed varieties (Kuma,Furtu,Walin,Yaadamo and Bekojuu-14) were tested at Fafan research Center,Golohajo,Site in 2023.The treatments were laid out with a randomized completed block design with three replications. The experiment was planted in 10 rows plot of 2 m length. The spacing was 20 cm between rows and 10cm between plants. The seed was drilled during planting and later thinned at 5 cm spacing. The fertilizer and seed rate were used as per the recommendation and all other recommended agronomic management practices were applied properly. Data were collected both on plot and plant basis. The four central rows were used for data collection based on plots, such as days to flowering, days to maturity, 1000 seed weight and yield. Five plants from the central rows were randomly selected for data collection on plant basis and the averages of the five plants in each experimental plot were used for statistical analysis for traits such as plant height, number of capsule/ plants, number of seeds/plants; number of heads/plants; number of seeds/heads. All data were subjected to the analysis of variance (ANOVA) appropriate to the randomized complete block design using Gen

stat version 18.2. Significant difference (LSD) test at 5% level of probability was used for mean separation (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

Phonological and growth parameters

Days to flowering: The analysis of variance showed that linseed varieties were highly significant (P<0.01) on days to flowering (Table.1). The longest days to flowering was observed Bekoju-14 (56.33 days) variety, while the earliest days to flowering was recorded from yaadamo (51 days) variety. This might be due to genetically difference among varieties. In line with this result,Wossen et al., (2017) reported that significance difference days to flowering among linseed varieties.

Days to maturity: The analysis of variance revealed that linseed varieties was significantly affected by days to maturity (Table 1). The longest days to maturity was obtained from kuma (116 days) variety and the lowest days to maturity was recorded from walin (101.3 days) variety. The reason for this may be a genetic difference among maize varieties. In line with this result, Akbaret al. (2003), also reported that significance difference of chickpea varieties on days to maturity.

Plant height (cm): The plant height was not significantly affected by linseed varieties (Table1). The highest plant was obtained from walin (90.1cm)variety and lowest plant height was recorded from yaadamo (79.7 days) variety.

Table 1: Mean performance of Phenological and growth parameters of linseed varieties

Treatments	DF	DM	PH
linseed varieties			
Kuma	54.00[b]	116.0b	88.7a
Furtu	53.67[ab]	115.3[b]	84.7a
Walin	51.67[a]	101.3[a]	90.1[a]
Yadamo	51.00[a]	100.7[a]	79.7a
Bekoju-14	56.33b	110.7[b]	85.7a
LSD(0.05)	2.707**	8.82*	NS
C.V(%)	2.7	3.5	4.9

*Where, **= highly Significant at p ≤ 0.01, *= Significant at p ≤ 0.05, DF = Days to 50% flowering, DM = days to 90% maturity, PH = Plant Height*

The yield and yield components parameters of linseed varieties

Number of Capsule per Plant: The analysis of variance revealed that the main effect of variety was highly significant ($p<0.01$) on number of capsule per plant (Table 2). The highest number of capsule per plant (40.83) was observed from Kuma variety while the lowest (25.13) was observed from Yaadamo variety. This might be duet genetic variations among different linseed varieties. In line with this Dash et al. (2016), and Terfa and Gurmu (2020), also found significance difference in number of capsule per plant.

Thousand seed weight (g): the analysis of variance showed that the linseed variety had significant effect ($p<0.01$) on thousand seed weigh (Table 2). The highest thousand seed weight was recorded From Kuma variety (12.0 g). While the lowest thousand seed weight recorded from yaadamo (8.67 g) variety. This might be duet genetic variations among different linseed varieties. According, Akbaret al. (2003), Dash et al. (2016), and Terfa and Gurmu (2020),there significant differences in thousand seed weight between linseed varieties.

Table 2: Mean performance of yield and yield components parameters of hybrid maize

Treatments	NCPP	TSW (g)	GY(kg/ha)
linseed varieties			
Kuma	40.83c	12.00[a]	2135[a]
Furtu	33.33bc	11.33[a]	1750[b]
Walin	29.87ab	9.67[b]	1698[b]
Yadamo	25.13a	8.67[b]	1458[b]
Bekoju-14	27.40ab	11.67[a]	1677[b]
LSD(0.05)	7.51**	1.649**	331.2*
C.V(%)	12.7	7.6	5.9

*Where, **= highly Significant at $p \leq 0.01$, *= Significant at $p \leq 0.05$, NCPP = number of Capsule per Plant, TSW = Thousand seed weight and YH = Grain Yield per Hectare.*

Grain yield (kg/ha): A significance ($p<0.05$) variation was observed among improved linseed varieties in their response to number of grain yield. The highest grain yield was obtained from Kuma (2135Qt/ha) variety while the lowest was obtained from Yaadamo (1458Qt/ha) variety. This might be duet genetic variations among different linseed varieties. Sahito et al. (2022) and Lea and Belay (2021), also reported that significant variations among linseed varieties in grain yield.

CONCLUSION AND RECOMMENDATION

Linseed (*Linum usitatissimum* L.) is an oil crop which belongs to Linaceae and widely distributed in temperate and subtropical areas of the world. The results of analysis of variance showed that, all the yield and yield related parameters were significantly affected by varieties. kuma variety was superior over all varieties for all parameters. Moreover, kuma variety gave higher yield over the other varieties, indicating that, the kuma variety is stable and can provide reasonable amount of yield regularly.

Therefore, kuma could be recommended for the study area. Moreover, it can be concluded that kuma variety is recommended for further demonstration in in fafan areas and similar agro-ecologies.

REFERENCE

Adugna, W., Labuschagne, M. T. and Hugo, A. (2004). Variability in oil content and fatty acid composition of Ethiopian and introduced cultivars of linseed.Journal of the Science of Food and Agriculture, 84:601-607.

G. N. Terfa and G. N. Gurmu, "Genetic variability, heritability and genetic advance in linseed (*Linum usitatissimum* L.)Genotypes for seed yield and other agronomic traits," *Oil Crop Science*, vol. 5, no. 3, pp. 156–160, 2020.

in linseed (*Linum usitatissimum*L.) under late sown conditions in the north central plateau zone of Odisha in India introduction," *International Journal of Advanced Research*, vol. 4, no. 1, pp. 799–811, 2016.

J. Dash, B. S. Naik, and U. B. Mohapatra, "Variability, correlation and path-coeCcient analysis

M. Akbar, T. Mahmood, M. Anwar, M. Ali, M. Sha6q, and J. Salim, "Linseed improvement through genetic variability ,correlation and path coeCcient analysis," *International Journal of Agriculture and Biology*, vol. 5, no. 3, pp. 303–305, 2003, https://www.ijab.org.

M.A. Sahito, A. H. Sial, K. R. Kalwar, B. S. Mengal,F. M. Baloch, and A. L. Siyal, "Comparative evaluation oflinseed varieties under environmental conditions of tandojam Pakistan," *Pure Applied Biology*, vol. 11, no. 1, pp. 92–99, 2022.

M.D. Lea and T. Belay, "Adaptation of improved linseed (*Linum usitatissimum* L.) varieties for seed yield in kafa and benchmaji zones of South Western Ethiopia," *Asian Journal of Plant Science & Research*, vol. 11, no. 1, pp. 30–32, 2021.

Madhusudhan, B. (2009). Potential benefits of flaxseed in health and disease-A perspective. Agric Conspec Scient, 74:67-72.

Tadesse, T., Parven, A., Singh, H. and Weyessa, B. (2010). Estimates of variability and heritability in linseed germplasm. International Journal of Sustainable Crop Production**,** *5*:8-16.

Wijnands, J. H. M., Biersteker, J. and van Loo E. N.(2009). Oilseeds business opportunities in Ethiopia: Public Private Partnership on Oilseeds: the Ethiopian Ministry of Agriculture and Rural Development (MoARD). Hague, the Netherlands. p.62. https://edepot.wur.nl/14197.

Wossen,T,Anley W and Habtie F,et al.(2016) Evaluation of Improved Varieties of Linseed in Dabat District, Northwest highland of Ethiopia.Vol. 4, Issue 3, pp: (100-105), Month: July - September 2016, Available at: **www.researchpublish.com**

Identification and Assessment of wild agave plant species in some selected woredas of Somali Region state

Abdikadir shekh abdurahman[1]

Crop directorate, Somali region pastoral and agro-pastoral research institute (SoRPARI), jigjiga, ethiopia

Corresponding Author: E-mail: cabdiqadirshekh19@gmail.com

Abstract

The study was conducted in Fafen and Qoraxey Zone of somali Regional National state, to assess, identify, document and recommend for domestication of wild agave plant species. Data was collected using semi-structured interviews, observation based focus group discussions, and questionnaires with a total of 115 informants, where 15 informants were used as key informants based on their very rich experiences on using wild Agave plants and assumed to provide factual information. Descriptive methods of data analyse was employed to analyse gathered information or data on wild Agave plant species. A total of 4 wild agave plant species were identified from the study area out of which all were shrub of which Parts of wild agave species used were stalk (43.33%) and Leaf (56.67%). the reason of usage of agave plants was reported in which 7(11.67%) for fencing, 26 (43.33%) for construction material, 10(16.67%) for fiber production , while 5(8.33%) for Feed for animal at times of drought and 5(8.33%) For erosion control. the abundance of wild Agave species plants in the area 31(51.67%) of the respondent reported that abundance of wild Agave species plants in the area is as it was at the past that no change has been observed, while 10(16.66%) of the respondent reported that a decreasing of the abundance of the agave plants and also 19 (31.67%) of the respondent observed that an increasing abundance of the agave plants in the area. It was concluded that there was a need to domesticate these wild Agave plants for food security, raise public awareness in the community through information exchanges and promote sustainable utilization and conservation of wild Agave plant resource, Establishment of forest stands, protection and further research on wild Agave plants were recommended as a result of this study.

Keywords: Stalk, Domesticate, Agave, Leaves, pulp, fiber, and Wild**.**

Introduction

Agaves (genus Agave, family Asparagaceae) are a group of plants representative of Mexico that are highly valued both ecologically and economically. The genus was first described by Carl Linnaeus in 1753 (Ciaramello & De Paiva, 1975; García-Mendoza, 2007). They are part of the floristic composition of a wide variety of vegetation types, among which are included conifer forests located in mountain systems above 3500 m altitude and coastal desert scrub characteristic of arid and semiarid areas of the Baja California Peninsula at 0 m above sea level (Solís-Aguilar et al., 2001; Bautista-Justo et al., 2001). these plants have been used for 8000 - 10,000 years. Today, they are used as a source of food, traditional medicine, biofuel (bioethanol), shelter,

ornament, raw material for natural fiber articles and, in greater proportion, for alcoholic beverages.

The plants of the genus Agave are monocotyledonous, their leaves are shown in a rosette arrangement, also known as pencas, depending on the species, the edge of the pencas can be linear, spatulate, lanceolate, deltoid, oblong or ovate, they are generally rigid, in their most with lateral spines (Gentry, 1982; García-Mendoza, 2007). Its stem, depending on the species can be acaulescent or caulescent, is also called 'heart of the maguey or pineapple of maguey'. It is a hermaphrodite plant, which has an inflorescence in spike. Its flowers are greenish yellow. Its fruit is woody capsule elongated dehiscent and each capsule contains numerous flattened seeds and black testa (Esparza-Ibarra et al., 2015)

The genus Agave has been of great importance not only in economic context but also insocial aspect. The genus Agave includes 210 species widespread in the tropical and subtropical regions of the world mainly in desert, dry and semiarid environments [Gentry HS, 1982] or 166 valid species [Good-Avila SV et al., 2006]. Middle America is the center of its greatest diversity use and cultivation [Callen EO, 1965; Colunga-GarcÍa, 1993]

The agave, commonly is a plant whose leaves, stems, flowers and fruits are used to satisfy various needs as a source of food, drink, medicine, ornaments, fiber, fuel and fertilizer.In addition, the floral scape and its fibers are used for the construction of houses, as an agricultural implement and flowers are highly valued in human nutrition (García-Mendoza, 2007). In general, it offers more than 100 forms of use, among which 70 serve as employment to the people who give it some kind of use. Of these, the production of distilled beverages such as: bacanora, charanda, sotol, tequila and mezcal stands out (Esparza-Ibarra et al., 2015).

The agaves are plants that have social, economic and ecological importance, that thrive in diverse ecosystems and altitudes. Its center of origin is Mexico, although it is also distributed to the southwest of the United States, Central America, the Caribbean and northern South America (Vázquez-García et al., 2007). 211 species are recognized, of which 159 (75%) are located in Mexico and of these 119 (57%) are endemic (Garcia-Mendoza, 2012). Therefore, there is a high diversity in the Agavaceae family (García-Mendoza, 2007; Jacinto, 2013).

The high number of endemic species in Mexico suggests that the diversity of the group is due to the physiology that has allowed local adaptation in heterogeneous habitats and this process of diversification has probably been accepted by the domestication to which several species have

been subject of Agavaceae (García-Mendoza, 2007). The wide ecological tolerance, the dispersion and germination of seeds and the interaction with other organisms (pollinators), depends on the intrinsic properties of the genus such as genetic diversity (García-Mendoza, 2002).

Thus, identification of such multi-purpose plant species in the study area is very crucial from the conservation and management point of view. This is because the most valued plants species particularly should be given priority in order to conserve and manage them before extinction takes them away (Cunningham, 2001). Bayafers Tamene et al. (2000), stated that as local people and communities encounter cultural changes, unless documented and conserved, the knowledge of the people on plant resource use could vanish forever. Even though the area is rich with Agave wild plant species, no information or little information is known to agricultural research community or other stake holders about the study area.

So, this study was initiated with the objective to asses, identify, explore, document the indigenous knowledge, and Recommend the domestication and adoption of wild agave plant species of the study are for further uses.

MATERIALS AND METHODS

Methods and Research design

Data collection tools were observations, sample collection, on field morphological characterization, interview questions and questionnaires. Population size of the study were 30 informants for identification of wild agave plant species through observation, 18 dwellers to interview questions as a key informant and 60 respondents for questionnaires selected from 6 study stations. Some of the Informants were purposely selected based on their experiences and very rich in indigenous knowledge on using wild agave plants for many years according to information obtained from local authorities.

Data collection instruments

Observation

In order to asses and identify the existing wild agave plant species, checklist tables were set to list the species of wild agave plants by the guide and support of 10 indigenous elder informants whereby pictures and GPS records of each plant at wild conditions were taken at IN-SITU conditions.

On field characterization

The agave plant species were characterized on the field by measuring the plant height by cutting the stalk, leave type and size, type of flowering, color of leaves and flower, rosettes size and maturity

Interviews

Structured interviews questions were set to collect information from the selected 5 study stations. The interviewees were elders who have rich experience on wild agave plant species and assumed to provide factual information.

Questionnaires

The prepared questionnaires were distributed to 60 indigenous respondents selected from 5 study stations that all distributed questionnaires were filled at the site. the questionnaires were used to collect information on socioeconomic factors, landraces grown, source of seed, traits preference, cultural practices, post harvest handling, utilization and constraints in agave species production in the study areas.

Data collection procedures

The procedure of data collection is listed as follows.

1. Assessments and identification of wild agave plants in the selected study stations at the IN-SITU condition were applied using observations methods through 10 indigenous elder informants who have long traditional and practical experiences who travelled to the field with the researcher and assisted throughout the field works. In view of this, 10 informants (8 from each PAs) were selected to practically show and inform the species wild agave species aiding with focal group discussion. Agenda were also set to give direction for the focal group discussing.
2. For interview questions, 10 elder dwellers (3 from each PAs) were selected to discuss the structured interview questions on each wild Agave plant species.
3. Totally, 60 questionnaires were distributed to selected informants from 5 PAs (10 people per PAs) in the study station.
4. All Informants used their rich experiences, identified, showed and explained all about wild agave plants to the researcher and provided with adequate information on naming in vernaculars, utilities, parts used, seasonal availability, habits and sample collections.

Data sampling techniques and sample size

Data collection techniques and the uses of tools of the study were structured as follows.

Table 1 Data source sample size

No.	Data collection tools	Number of respondents
1	Observation based group discussion	30 informants
2	Questionnaires	60 informants
3	Interview based discussion	18 interviewees(elder) as key informants
Total		118

Data analysis

Data was analyzed using both qualitative (descriptive method) and quantitative (percentage and tabulation) methods. Close ended questions were analyzed through tables and percentage to compare the results while open ended questions like interview and observations were analyzed using descriptive methods.

Results and discussion

Socio-Demographic and Economic Characteristics of Households

In total, 60 households were interviewed, with a response rate of 100% (Table 1). However, data from one household was not included in the analysis because of an incomplete response. The respondents were Muslims. Almost all were married. All households owned agricultural land or farmland, holdings were of various sizes, and nearly all were headed by males. Mean values for the age of the household head, household size and land holding size were 37.7 ± 9.8 years, 6.9 ± 2.6 and 3.9 ± 2.1 hectares, respectively. Similar proportions of household heads had 0, 1-5 or ≥6 years of formal education. More than 80% of households had monthly incomes ≤2500 Birr.

Table 1. Socio-demographic and economic characteristics of respondents and households (n=60).

Socio-demographic and economic characteristics	Frequency	Percent
Respondents' Religion		
Muslim	60	100
Respondents' Marital status		
Married	50	83.33
Widowed	8	16.67
Household head		
Male	55	91.66
Female	5	8.34
Household Head Age		
20-30	9	15
31-40	37	61.67
≥41	14	23.33
Household head educational status		
None	3	5
1^{st}-5^{th} Grade	26	43.33
≥6^{th}Grade	31	51.67
Household Size		
1-6	19	31.67
≥7	41	68.33
Land size		
0.75-4.00 Hectare	48	80
≥4.5 Hectare	12	20

List of identified and collected wild agave species

A total of 4 wild agave plant species were identified from the study area out of which all were shrub. Concerning the uses of wild agave plant species, leaves accounted for 69.2% and stalk 30.8% The study was also founded that about 100% of the wild agave plant species are collected are available in both seasons with all the months of seasons (Table 2).

Table 2. Lists of identified living wild agave plant species in the study area

No	Vernacular names	Scientific names	Parts used	Status	Seasonal availability
1	Xig case/cade	Agave tequilana	Leaves and stalk	Shrub	Both seasons with all Months
2	Xig xabashi	Agave beauleriana	Leaves and stalk	Shrub	Both seasons with all Months
3	Xig madobe bila qodaxa/xaskul/xigaal	Agave sisalana	Leaves and stalk	Shrub	Both seasons with all months
4	Xig madobe qodaxa leh/xaskul	Agave angustifolia haw	Leaves and stalk	Shrub	Both seasons with all months

Agave sisalana (Xig madobe bila qodaxa/xaskul/xigaal)

sisal, (Agave sisalana), plant of the family Asparagaceae and its fibre, the most important of the leaf fibre group. Agave sisalana is a succulent, tall, perennial monocot native to southern Mexico.

Agave sisalana is a succulent plant that forms short-stemmed rosettes of stiff sword-shaped leaves with spinless margins and a red-brown terminal spine about 1-1.5 m tall. The stem grows up to 1m tall. Leaves are glaucous when young, later dark blue-green. They are up to 60–180cm long and 10–18 cm wide, terminating in a sharp spine. Young leaves may have a few minute teeth along their margins, but lose them as they mature. The inflorescence is a large panicle with flowers arranged on the terminal portion in dense clusters and A branched inflorescence forms atop a flower stalk 5-6 m tall. The flowers are yellowish-green with reddish filaments, with an unpleasant odour, form dense clusters at the ends of branches growing from the flower stalk, with 10-20 lateral branches. This species is monocarpic (i.e. die after fruiting). They do not produce seeds but form bulbils which are used for reproduction. The bulbils are borne in the axils of the bracteoles of the. As the flowers begin to wither, buds growing in the upper angle between the stem and flower stalk develop into small plants, or bulbils, that fall to the ground and take root. Agave sisalana reproduces vegetatively by suckers and plantlets (bulbils) on the branches of its flower clusters and and it is able to develop dense monospecific stands which may prevent the establishment of native vegetation. The picture of plant was shot at IN-SITU condition of GPS of 9’37’29N 42’45’08E, 9’26’21’N 43’02’02’E, 9’20’40N 42’35’13’E, 9’47’56’N 43’14’15’E, 6’18’47’N 44’25’41’E and 6’18’45’N 44’27’28’E”



Figure 1. The species Agave sisalana (Xig madobe bila qodaxa/xaskul/xigaal))

2. Agave beauleriana (xig xabashi)

Agave beauleriana, also known as Agave americana var. franzosinii, is an attractive large succulent that forms a usually solitary rosette of powdery, bluish-gray leaves that undulate and arch gracefully. Agave beauleriana is native to Mexico and naturalized at the study areas. The slow-growing rosette can reach up to 2.4 m in height and 3 m in diameter. The leaves can reach up to 0.8–2.0 × 0.15–0.25 m long. The leaves have large teeth along the margins and a dark brown terminal spine. Leaf margins are nearly straight to crenate, creamy white and armed with variable teeth of up to 10 mm long and 10–40 mm apart. The apices of leaves bear sharp, dark brown, conical or subulate spines of mostly 20–60 mm long. the leaves become reflexed and flop over to one side. Near the end of its life, the rosette sends up a stout flowering stalk branched near the top and up to 9-10 m tall. Flowers are yellow or greenish-yellow, up to 10 cm long, and occur in panicles at the branch ends. Rosettes die after flowering but produce offsets around the base, often forming a colony of new plants. Spreads both vegetatively and by seed. Having 10 to 15 years vegetative growth. The picture of plant was shot at IN-SITU condition of GPS of 9’37’29N 42’45’08E, 9’26’21’N 43’02’02’E, 9’20’40N 42’35’13’E and 9’47’56’N 43’14’15’E”



Figure 2. The species Agave beauleriana (xig xabashi)

3. Agave angustifolia (Xig madobe qodaxa leh/xaskul)

Agave angustifolia is a succulent plant that forms large stemless or short-stemmed rosettes of stiff, fleshy, greyish-green or bluish-grey leaves with margins armed with small brown prickly teeth and a pointed tip topped with a dark-brown apical spine of 1.5 to 3.5 cm in length. The rosettes grow up to 1 m tall and 1.5 to 2 m in diameter. Leaves are narrow, have lanceolate shape up to 80-120 long, and up to 10 cm wide. After 6 to 8 years years, the rosette blooms and dies after flowering. Flowers are greenish-yellow and appear clustered on a stem that grows up to 5 m tall. The seed capsules are dark brown or blackish, up to 5 cm long, and up to 3 cm wide. Plantlets are often also produced in clusters near the tips of the flowering branches.

Like the rest of the agaves, A. angustifolia has a long life cycle as a biological characteristic, as it usually takes about 6 to 8 years for fruits to grow with seed, although it does not always form them. It is also a plant that presents a single sexual reproductive event, at the end of which, the plant dies. The picture of plant was shot at IN-SITU condition of GPS of 9’37’29N 42’45’08E, 9’26’21’N 43’02’02’E, 9’20’40N 42’35’13’E, 9’47’56’N 43’14’15’E, 6’18’47’N 44’25’41’E and 6’18’45’N 44’27’28’E



Figure 3. The species Agave angustifolia (Xig madobe qodaxa leh/xaskul)

4. Agave tequilana (Xig case/cade/xaskul)

Agave tequilana is a fast-growing succulent that forms large rosettes of thick fleshy blue-green to silver-green leaves. The rosettes grow up to 1.8 m tall and are nearly equal in diameter. Blue-green to bluish-grey, stiff leaves are linear with a pointed apex that ends in a spine. Leaves are arranged in a rosette. Leaves are lance-shaped with have light to dark brown marginal teeth and a sharp brown terminal spine. They are up to 1.2 m long and up to 12 cm wide. After 5 years, the rosettes mature and produce an up to 5-6 m tall flower stalk with 20 to 25 branches. Flowers are green with purple stamens. The rosette dies after flowering, leaving offsets to continue the life cycle. The picture of plant was shot at IN-SITU condition of GPS of 9’37’29N 42’45’08E, 9’26’21’N 43’02’02’E, 9’20’40N 42’35’13’E and 9’47’56’N 43’14’15’E”.



Figure 4. The species Agave tequilana (Xig case/cade/xaskul)

Analysis on questionnaire distributed to respondents

According to questionnaire distributed, 60(100%) respondents agreed the presence of wild Agave species plants in their area, listed the species vernacular names and parts used in table 2. Based on this, response of respondents in table 3 on parts of wild agave species used were stalk (43.33%) and Leaf (56.67%). Majority of respondents said that, agave leaves were mostly used in the area followed by stalk and whole plant part were not used generally.

Table 3. Response of respondents to questionnaires on parts of wild agave species plants used.

Parts mostly consumed	Respondents	Percentage
Leaves	34	56.67
Stalk	26	43.33
Total	60	100

Response of respondents in table 4 shown that the reason of usage of agave plants in which 7(11.67%) of the respondent reported they use for fencing as the agave species have a good height and cover also bearing spines at the edge and tips of the plants while 26 (43.33%) of the respondent reported that they use gave stalk for construction material for tradition somali house. Moreover, 10(16.67%) of the respondent reported that they use the leaves of the agave plants For erosion control, while 5(8.33%) of the respondent reported that they use agave plants for fiber production and 5(8.33%) For Feed source. Majority of respondents responded that they use agave plants as construction material for traditional Somali house followed by fencing.

Table 4. Responses on why wild agave plants are used

Purposes of using the plants	Respondents	Percentages
For fencing	7	11.67
For construction purpose	26	43.33
For erosion control	10	16.67
For fiber production	5	8.33
Feed sources	5	8.33
Total	60	100

According to table 5, the response of respondents to abundance of wild Agave species plants in the area 31(51.67%) of the respondent reported that abundance of wild Agave species plants in the area is as it was at the past that no change has been observed, while 10(16.66%) of the respondent reported that a decreasing of the abundance of the agave plants and also 19 (31.67%) of the respondent observed that an increasing abundance of the agave plants in the area. Most of the respondents believed that, the abundance of the agave is as previous to them followed by increasing and the abundance is decreasing.

Table 5. Response of respondents on abundance of wild Agave plants

Current abundances	Respondents	Percentages
Appears as previous/ no change	31	51.67
Decreasing	10	16.66
Increasing	19	31.67
Total	60	100

According to response of respondents in table 6, the abundance is decreasing due to agriculture expensation 48 (80%). While, agave leaves and stalk is being harvested for biofuel 5(8.33%) and feed 7(11.67%) purpose. This showed the major factors for disappearing of wild agave plants were agriculture, feed and biofuel.

Table 6. Responses to the disappearances of wild agave species

Causes of disappearing of plants	Respondents	Percentages
Biofuel	5	8.33
Feed for animal	7	11.67
Agriculture	48	80
Total	60	100

According to table 7, the conservation taken to minimize challenges to wild Agave plants were reported by keeping the surviving plants from danger 32(53.33%) while, restoration collaborating with concerned body was also reported by the respondent 12(20%),

Moreover, replanting the damaged area by using indigenous knowledge from elders 11(18.33%) was also reported, some said that no measurement was taken 5(8.33%). Majority of respondents

said that they were keeping the previous existed plants from danger rather than planting new plants while some were tried to plant collaborating with concerned body.

Table 7. Responses on conservation

Restorations activities planned	Respondents	Percentages
Replanting the plant areas by traditional way using sucker	11	18.33
Keeping survived plants from danger only	4	6.67
Plants exist naturally and no need of conservation	45	75
Total	60	100

According to table 8, most of respondents responded that they were not tried to domesticate the wild Agave plants with about 53(88.33%) but some had tried 7(8.67%).

Those who were not tried to domesticate put out reasons like lack of enough farm land along with domesticated plants 12(22.64%), slow growth rate 11(20.75%), long productivity period 9(16.98%), Lack of knowledge 8(15.09%), not as much marketable 9(16.98%).

Others 4(7.55%) also pointed out fiber preparation of wild agave plants species have negative effect on the skin, some species bear spines along the edges and the tip of the leaf which pain children, no need to plant because they get freely and also they fear negative social perceptions comparing with domestic plants.

Table 8. Responses on domestication of wild agave species

Reason for not domesticating	Respondents	Percentages
Slow growth rate	11	20.75
Long productivity cycle	9	16.98
Lack of convenience to domestic plants	12	22.64
Lack of knowledge	8	15.09
Not marketable	9	16.98
Other reasons	4	7.55
Total	53	100

The analysis from group discussion and interview on positive and negative social perception of using wild agave species also summarized as followings:

Positive aspects

Using as an alternative feeds and foods for animals' wild agave plants supports to cope up with drought seasons. Agave's extensive root systems play a crucial role in soil erosion control. Planting agave in degraded or erosion-prone areas helps stabilize soil, preventing loss and promoting ecosystem restoration.

Agave species are renowned for their ability to thrive in arid and semi-arid regions with minimal water requirements. This makes them suitable for cultivation in areas facing water scarcity, contributing to sustainable agriculture practices.

Agave is an excellent replacement for firewood. Dried Agave plant is fantastic material for building a fire. The papery leaves catch fire easily and burn nicely on their own, you can add dried leaves to other materials as fuel for bolstering a strong, roaring fire.

You can make rope out of it! Agave is made up of pith that's super fibrous and stringy like thread, which makes it a super useful material for making rope. The fiber is strong and can be woven into a sturdy rope of varying thickness and length. Each leaf is made up of many fibrous threads, so a small amount of Agave pith can actually yield quite a bit of rope.

Agave plants provide habitat and sustenance for various wildlife species, including insects and birds. Their role in supporting biodiversity contributes to the overall health of ecosystems in which they are found. Beside feed for animal, wild agave species are used as a building material. The Rosetta of wild agave plants stays too long in the soil and can be used as fence. Nectar of the agave flower provide tasty sweet containing fructose and the like. They are especially in great demand in erosion prone areas.

Negative aspects

The agave species are very difficult to cut or harvest as agave species bear thorns around the edge and midrib of the leaves. wild agave fiber extraction causes skin irritation (candho).

Discussion

In the study site, most of the people were using variety of agave plants from their surrounding which is yet continuing. They were using, leaves, shoots and other parts as a source of fiber, bio fuel and feed values for many years. But now day those plants are threatened comparing to the

past by many factors. Most of the informants stated the major factors for disappearing of wild agave plants were agriculture, feed, deforestation, biofuel production. Due to these reason, many wild agave plants were highly over-harvested and became scarce in the study area. This finding was in agreement with the report by Beyafers Tamene (2000) and Tigist Wondimu et al. (2006). It is also similar with results obtained in different investigation by Endashew Amenu (2007) which showed agriculture and population pressure severely threatened plant species in general. The finding of Cunningham, (1997) indicated that the harvest of leaves or young shoot part have a treat to the deterioration of wild plants since the removal of leaves or young shoot part limit the transformation of vegetative to reproduce development such as flower production and fruit/seed set, which is in its turn limit the natural/wild regeneration of plants.

This is also similar to the a report which states the most common threats reported to wild plants were agricultural expansion, deforestation and urbanization (Ensermu Kelbessa et al., 1992; Addis, 2009; Asfaw Zemede, 2009; Tilahun Teklehaymanot and Mirutse Giday, 2010). The people in the study site especially elders are rich in the indigenous knowledge concerned to wild agave plants which is not documented yet. However it is contrasted with the ideas of Fentahun Mengistu and Hager, H (2008), where children and youth are more knowledgeable than older people in case of wild food plant knowledge. This indigenous knowledge unless documented, is threatened by various factors like less contact with natural environment, influence of modern education, influence of western culture, availability of ready made products fibers in the market and various negative social perceptions.

It is also founded 2 use categories of these plant species accounting Leaves (56.67%) and stalk (43.33%). The leaves was the major part of plant widely employed by local people followed by young shoot and stalks. It was the most commonly used for fiber extraction among other parts used in the area because it used for preparation fiber and used as soon as collected. Fiber production from agave plants still remains the most important application as reported by (Embrapa, 2008; Leão et al., 2006). Extraction of fibre is done on the same day or preferably next day as early as possible as also reported by (Sarkar et al., 2010). Other important traditional uses of the fiber are in , rugs, sacks, yarns, ropes and other cordage (Müssig, 2010).

In study area, agave pulp distributed in the field is often used to feed the goats or cattle. This may lead to health problems for the animals if eaten to much because short fibers (tow) and juice that are from the pulp can cause bloat (bokhokh). this is in line with (Sindifibras, 2012).

Agave plant species is also being used as a fence and hedge. This is similarly reported by Mishra et al., (2000)

The agave plant also used for energy source (biofuel**.** Agave plants as a biofuel feedstock, reflecting the increasing need for sustainable energy sources was similarly reported by (Davis et al., 2011; Escamilla-Treviño, 2012; TerraponPfaff et al., 2012; Pérez-Pimienta et al., 2017; Niechayev et al., 2019). Agave stalks is also being used as a building material for the traditional somali houses. Similary it was reported that agave plant can be used as a building materials (CFC, 2010; Leão et al., 2006)

Identified wild agave plant species on how to use and their preference

Farmers preference on agave species

As reported by the farmers for the preference of agave species for fiber production Agave sisalana is mostly preferred for fiber production for making rope and pillow followed by Agave angustifolia haw, Agave tequilana and Agave beauleriana respectively.

Regarding feed for animal preference during sever drought seasons the farmers reported that they prefer Agave beauleriana specie due to its high water content followed by Agave angustifolia haw, Agave sisalana and Agave tequilana species respectively in which this species can only be used as a feed only when they are young except Agave beauleriana.

Furthermore, for the preference a building material preference Agave tequilana, Agave sisalana and Agave angustifolia haw are preferred for making roof purlin (shaxda iyo dhigta guriga), column (dhidibka/udub dhaxadka guriga), beam (gudub) and traditional bed making. While Agave beauleriana is preferred to have a strong column (udub).

Agave species for construction and feed purpose

For a agave plant to be used as a building material, it must be worked on to create desired shape, bend and length to be used for structural or other purposes. In the case agave plant, walls, beam, column and roof are interconnected and often rely on the other for overall stability.

The agave plant stalks are split into halves or quarter sections using an axe ideal for the job and setting them apart by a wedge. About four segments can be acquired which are used as roof purlin (shaxda aqalka), beam (gudubka aqalka), column (dhidibka aqalka) strips or battens.

Agave plant can be bent while they are freshly splitting in to halves using axe. stalk can be peeled to make strings.

The wood is very easy to work with and can even be split in halves. The quiote can also be used as a building material and it finds its greatest utility when dried. It is often used as firewood and has been used to build beds.

According to information gathered from respondents Agave plant leaves is also being used as feed for animal in the study areas during drought seasons. The leaves are being chopped into small pieces so as to make for the animal to chew. It's been reported that no more than two leaves are being feed to animal per-days because if being more than two leaves is being feed the animal will get sick with secondary bloat (bokhokh).

Wild Agave plants in the study area are declining due to agricultural expansion, overgrazing, urbanization, less conservation of forests, charcoal production, deforestation for fire wood (Table 6).

Fibre extraction method

According to the respondents the agave leaves are also being used to produce fiber for rope making. The fiber is prepared tradition by hand. The sisal fibre was extracted by one methods namely scraping. In the scraping system, the harvested leaves were split longitudinally in to 4-5 pieces and beaten with wooden stick and placed on a board held firmly by the toes. The pulp was then removed by means of a stick scrapper and the fibre was then dried in sun. The operation of fiber removal, washing and drying must be done promptly after the leave are cut, otherwise the gums in the leaves hardens, causing the pulp to adhere with the fiber and making difficulty to clean the fiber properly.

Conclusion and Recommendation

The study conducted in the study area was founded and recorded about 4 wild agave species through observation, questionnaires, interview and focal group discussion. Even though the area is rich with wild agave species, no information or little information is known to agricultural research community or other stake holders about the study area (Fafen and Qoraxey zone). Most of identified species were used for building material, feed for animal and fiber extraction. Majority of identified and assessed species were available in all months of season.

Therefore, this study have provided valuable insights into the diversity and distribution of these plants. The study has highlighted the presence of various agave species, some of which may have economic, ecological, or cultural significance. Based of the finding its recommended to Develop conservation strategies for wild agave landrace, considering their distribution patterns and

ecological requirements. To collaborate with local communities to integrate traditional knowledge into conservation initiatives. To Raise awareness among local communities about the importance of wild agave plant conservation. Involve communities in sustainable harvesting practices to ensure the long-term viability of agave landrace populations. To advocate for the incorporation of agave landrace conservation into regional and national biodiversity policies. Promote the development of regulations that support the sustainable utilization of agave genetic resources.

REFERENCE

Bautista-Justo, M., García-Oropeza, L., Barboza-Corona, J., & Parra-Negrete, L. A. (2001). El Agave tequilana Weber y la producción de tequila. Acta Universitaria, 11, 26-34. https://doi.org/10.15174/au.2001.301

Callen EO. Food habits of some pre-Columbian Mexican Indians. Econ. Bot., 1965; 19: 335–343.

CFC. (2010). Impact Evaluation of a CFC Funded Cluster of Sisal Projects. Retrieved from http://www.commonfund.org/fileadmin/user_upload/Publications/Evaluation/EVAL_FIGHF_Sisal_Cluster.pdf

Ciaramello, D., & De Paiva, G. (1975). Estudio comparativo entre especies de Agave. Bragantia, 34, 195-201. https://doi.org/10.1590/S0006-87051975000100011

Colunga-GarcÍa Marin P. F. May-Pat. Agave studies in Yucatan, Mexico. I. Past and present germplasm diversity and uses. *Econ. Bot., 1993;* 47: 312-327.

Davis, S. C., Dohleman, F. G., & long, S. P. (2011). The global potential for Agave as a biofuel feedstock. *GCB Bioenergy*, *3*(1), 68–78. https://doi.org/doi:10.1111/j.1757-1707.2010.01077.x

EndalewAmenu (2007). Use and Management of Medicinal plants by Indigenous People of Ejaji Area (ChelyaWoreda), West Shoa, Ethiopia:AnEthnobotanical Approach. M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Ensermu Kelbessa, Sebsibew Demissew, Zerihun Woldu and Edwards, S. (1992). Some threatened Endemic Plants of Ethiopia. In: The status of some plants in parts of tropical Africa (Edwards, S. and Asfaw Z. eds.). NAPRECA, No. 2. Botany 2000: East and Central Africa, pp. 35-55.

Escamilla-Treviño, L. L. (2012). Potential of Plants from the Genus Agave as Bioenergy Crops. BioEnergy Research, 5(1), 1–9. https://doi.org/10.1007/s12155-011-9159-x

Esparza-Ibarra, E. L.; Violante-González, S. J.; Monks, J. C.; Iñiguez, C.; Araujo-Andrade y Rossel-Kipping, E. D. 2015. Los agaves mezcaleros del Altiplano Potosino y Zacatecano. Estudios en Biodiversidad. University of Nebraska-Lincoln. 227-245 pp

Fentahun Mengistu and Hager, H. (2008).Wild edible fruit species cultural domain, informant species competence and preference in three Districts of Amhara Region, Ethiopia.Ethnobotany Research & Applications 6:487-502.and implications to food security. Pakistan Journal of Nutrition 10 (1): 40-50.

García-Mendoza, A. (2007). Los agaves de México. Ciencias, 87, 14-23.

García-Mendoza, A. 2002. Distribution of Agave (Agavaceae) in México. Cact. Succ. J. USA. 74(4):177-187.
Gentry HS. Agaves of continental North America. University of Arizona Press, Tucson, Arizona, USA 1982.
Gentry, H. S. 1982. Agaves of Continental North America. The University of Arizona Press, Tucson, Arizona. 670 p.
Good-Avila SV, Souza V, Gaut BS, Eguiarte LE. Timing and rate of speciation in Agave (Agavaceae). Proceedings of the National Academy of Sciences U.S.A. 2006; 103(24): 9124–9129.
Jacinto, L. A. 2013. Aspectos de la fenología, visitantes florales y polinización de Agave inaequidens Koch spp. inaequidens (Agavaceae) en el estado de Michoacán. Tesis de Licenciatura. Universidad Michoacana de San Nicolás de Hidalgo. Morelia, Michoacán, México. 100 p.
Leão, A., Sartor, S. M., & Caraschi, J. C. (2006). Natural Fibers Based Composites - Technical and Social Issues. Molecular Crystals and Liquid Crystals, 448(1), 161–177.
Müssig, J. (2010). Industrial Applications of Natural Fibres. Chichester, UK: John Wiley & Sons, Ltd
Niechayev, N. A., Jones, A. M., Rosenthal, D. M., & Davis, S. C. (2019). A model of environmental limitations on production of Agave americana L. grown as a biofuel crop in semi-arid regions. Journal of Experimental Botany, 70(22), 6549-6559. https://doi.org/10.1093/jxb/ery383
Pérez-Pimienta, J. A., López-Ortega, M. G., & Sanchez, A. (2017). Recent developments in Agave performance as a drought-tolerant biofuel feedstock: agronomics, characterization, and biorefining. In Biofuels, Bioproducts and Biorefining, 11(4). https://doi.org/10.1002/bbb.1776
Sarkar, S. and Abdullah, Sk. 2010. Weed management in primary nursery of sisal. JAF News, 8 (2): 22.
Sindifibras. (2012). Feasibility evaluation for utilization of sisal liquid waste (juice) for the production of pesticides and veterinary drugs. Amsterdam. Retrieved from http://www.commonfund.org/fileadmin/user_upload/Projects/FIGHF/FIGHF_30FT/Final_Report_2012.pdf
Solís-Aguilar, J., González-Hernández, H., Leyva-Vázquez, J., Equihua-Martínez, A., Flores-Mendoza, F., & Martínez-Garza, Á. (2001). Scyphophorus acupunctatus Gyllenhal, plaga del agave tequilero en Jalisco, México. Agrociencia, 35, 663-670.
Terrapon-Pfaff, J. C., Fischedick, M., & Monheim, H. (2012). Energy potentials and sustainability—the case of sisal residues in Tanzania. Energy for Sustainable Development, 16(3), 312–319. https://doi.org/10.1016/J.ESD.2012.06.001
TilahunTeklehaymanot and Mirutse Giday (2010).Ethnobotanical study of wild edible plants of Kara and Kewegosemipastoralist people in Lower Omo River valley, Debub Omo Zone, SNNPR, Ethiopia.Journal of Ethnobiology and Ethnomedicine 2010, 6: 23.
Vázquez-García, J. A.; Cházaro, B. M. de J.; Hernández, V. G.; Vargas-Rodríguez Y. L. y Zamora, T. Ma. del P. 2007. Taxonomía del género Agave en el Occidente de México: una panorámica preliminar. In: Vázquez-García, M. J.; Cházaro, G.; Hernández, V. E.; Flores, and Vargas-Rodríguez Y. L. (Ed.) Los Agaves del Occidente de México. (Ed.). by J. A. Universidad de Guadalajara CUCBA-CUCSH, México. 38-82 pp

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Assessment of Salinity and Drainage Problem in Small Scale Irrigation Schemes at Genale River of Somali region, Ethiopia, 2023

Somali Region pastoral and Agro-Pastoral research Institute (SoRPARI), Soil and Water Research Directorate
Dahir Yosuf Abdi[1] Tesfu Mengistu[2]
Corresponding Author: daahirtwo@gmail.com

Abstract

Soil salinity is a major concern and an environmental threat in the arid and semi-arid regions of the world. In Ethiopia, the salt problem has been aggravated by factors such as poor water quality, ineffective water management on farms, and insufficient or improper drainage systems at irrigation sites. This study aimed to assess the salinity problem of the Ganele river small scale irrigation schemes (SSIS) and to generate thematic maps using Arc GIS 10.5 (IDW) for further management recommendations. Six of the most salt affected irrigation schemes were deliberately selected for the study. A total of 43 composite surface (0-30cm) soil samples were collected from all the SSISs. Soil profile pits were also opened at a representative site of each of the SSIS and soil samples were collected depth wise for laboratory analysis of the most relevant soil properties. Likewise, irrigation water samples were taken from different spots of the Genale river for laboratory analysis. Soil analytical results indicate that the soil reactions as indicated by pH (H_2O) varied from slightly acidic in the 0-30cm depth of profile at Bur-amino to strongly alkaline in the 60-120 cm depth of profile at Hilowayn-2 and 30-120cm depth of profile at Hilowayn-3. The total soluble salts (as expressed by ECe) increased consistently with depth in all the profiles studied except for the Bur-amino irrigation scheme. The Exchangeable Sodium Percentage (ESP) values did not show a consistent relationship with depth in any of the studied sites. The soil salinity and sodicity assessment of the study area revealed that significant parts of the Ganele river smallholder irrigation schemes were affected by salinity problem. A substantial proportion of the irrigated land had been abandoned. The Spatial mapping of soil salinity/sodicity showed that about 40.9% of the total areas of the studied schemes were salt-affected, with 31.7% saline, 7.1% sodic, and 2% saline-sodic. However, the irrigation water samples had suitable pH, ECw, and SAR values for irrigation and belonged to the low salinity (C1) and low sodium hazard (S1) classes, which meant they could be safely used for irrigation of most crops on most soils. Therefore, this suggested that the likely causes of soil salinity/sodicity in the studied irrigation schemes were secondary salinization due to shallow groundwater table, poor irrigation system, and primary salinization due to the underlying rock types. Salinity and sodicity tolerant crops and forages, appropriate irrigation water management, organic and inorganic amendments, and proper agronomic practices seemed to be the possible ways to improve productivity and sustainability of the schemes.

Keywords: Salinity, Sodicity, irrigation water, GIS, IDW, Dollo Ado, Somali

INTRODUCTION

Soil salinity is a major concern in the arid and semi- arid regions of the world and considered an environmental menace (Metternicht and Zinck, 2003; Shrestha and Farshad, 2008; Kumar et al., 2018). Similarly, Soil salinization in irrigated lands is becoming an increasing problem affecting global agricultural production and sustainable utilization of land resources, especially in arid and semi-arid regions. Soil degradation due to salinity and sodicity is increasing at an alarming rate endangering the agricultural practices (Metternicht, 2003; Astaraei *et al*., 2008; Zheng *et al*., 2009; Rongjiang and Jingsong, 2010).

It is a severe environmental hazard that impacts growth of several crop varieties. Statistics on the extent of world salt affected areas vary; however, general estimates are close to one billion hectares, which represent about 7% of the earth's continental extent. More than 120 countries are confronted to a smaller or to a greater degree with the problem of soil salinity (Al-Khaier, 2003). Semi-arid regions are under high pressure to produce food for their rapidly increasing populations. The consequent changes in land-use mainly due to agricultural intensification together with harsh climatic conditions including global climate change, have accelerated land degradation process, which has already caused yield reduction in many parts of the arid world. Therefore, the need for detecting salinization and land degradation along with assessing its severity at any given time becomes vital.

According to Tamirie (1994), salt affected surfaces have increased from 6% to 16% of the total land of Ethiopia in recent years. About 9% of the population lives in the areas affected by salinity. The semi-arid and arid lowlands and valleys in Ethiopia have major problems of salinity and alkalinity. About 44 million ha in 36% of the country's total land is potentially susceptible to salinity problems. Out of the 44 million ha, 33 million ha has dominantly salinity problems, 8 million ha has combined salinity and alkalinity problems, and 3 million ha has dominantly alkalinity problems.

Salinization is a common phenomenon in irrigated agriculture, but its intensity and effects vary from area to area and from region to region. With this basic understanding, the present study aimed to investigate the extent of salinity in Ganele-Dawa small scale irrigation schemes and to

monitor changes of salinized soils based on the spatial variation of soil salinity caused by human and natural factors. The findings of this study are expected to have great significance in maintaining ecological stability and agricultural productivity, and for developing better management strategies in irrigated areas of Ganele-Dawa of Somali region. The main objective of this project was to identify, analyse and map salinity level of lower Genale river smallholder irrigation schemes (small and medium scale irrigation farmers) that were affected by environmental degradation and poor water management practices.

METHODOLOGY AND PROCEDURES

Description of the Study Area

Location

The study area covers the Dolo-Ado irrigation schemes, which are located in the Dollo Ado district of Liben Zone, Somali Regional State, Ethiopia. The district is situated 300 km east of Negelle, between 4˚24’ N latitude and 41˚38’E longitude. The altitude ranges from 200 to 1000 meters above sea level. The district borders Filtu district to the northwest, Afder Zone to the northeast, Somalia to the southeast, and Kenya to the south. The total area of the woreda is estimated about 30,5258 hectares (Degu, 2020; Wikipedia).

Climate

The climate of Dolo Ado is arid to semi-arid, with low and erratic rainfall of high annual and seasonal variability. The average annual rainfall is 270 mm/year (excluding the extreme rainfall of 1997). The rainfall pattern is bimodal, with two rainy seasons per year: the main rainy season (locally known as *Gu*) from March to June, and the short rainy season (locally known as *Deyr*) from October to December. The *Gu* rains are important for local livelihoods, as they mark the end of the long dry season (locally known as *Jilaal*), replenish river flow, initiate agricultural production, and regenerate pastures (grasslands) (Heijden et al., 2020).

Soil

According to the WRB’s soil map, there are four major soil types in Dolo Ado district: Fluvisols (deposited by seasonal streams on the floodplains along the Genale and Dawa rivers), Gypsisols (dominant in the central rangelands), Leptosols, and Solonchaks (present in the west) (Heijden *et al*., 2020).

Geology

The Genale-Dawa river basin has a unique geological setting, with a diversified lithology and structural framework, resulting from the basin's location near multiple volcanic-tectonic events (Woldemariyam and Ayenew, 2016). The basin has different types of rocks, ranging from old sedimentary formations to newer volcanic rocks. The older rocks are more porous and fractured, allowing groundwater to accumulate and flow. The newer rocks are more impermeable and prevent groundwater movement. The groundwater flow direction is mainly southeast, and the groundwater sources depend on the climate and topography of the region. The dominant rock types overlying the Genale-Dawa river basin include shale, limestone, dolomite, gypsum, anhydrite, and sandstone.

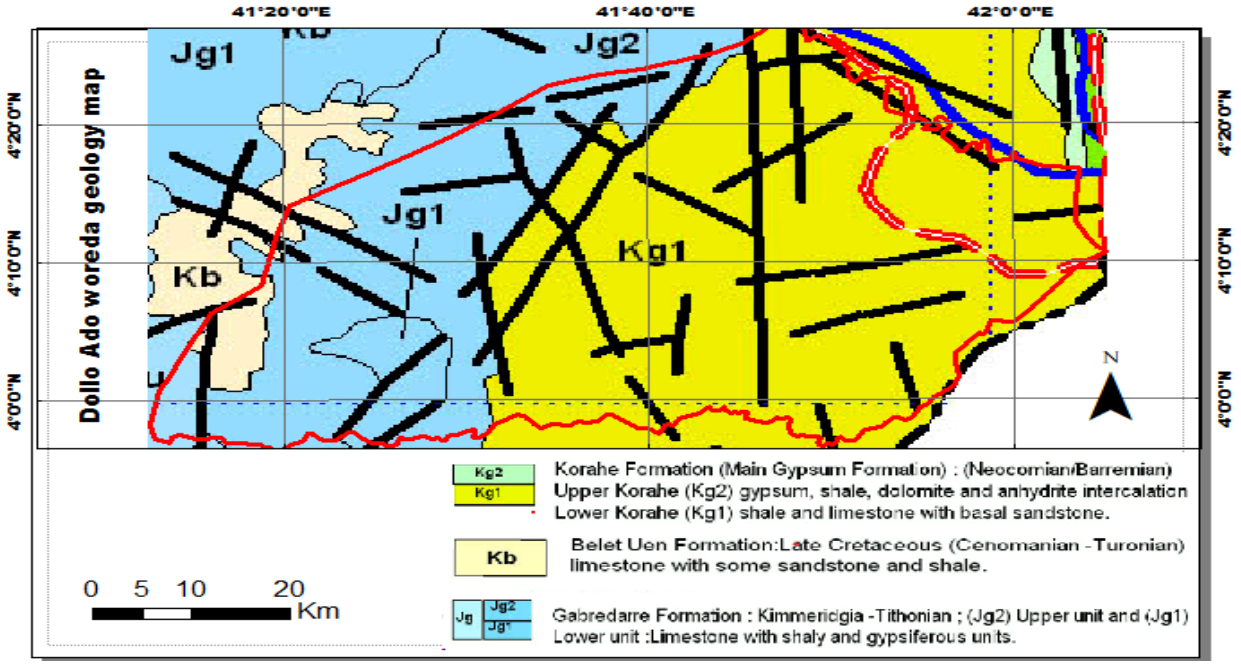


Figure 1 Geologic map of the study area

Selection of Small Scale Irrigation Schemes (SSIS)

This current study was based on the selection of suitable small scale irrigation schemes (SSIS). The SSISs were chosen intentionally, with the involvement of experts from the Dollo-Addo Agriculture and Natural Resource Office. The team also conducted a desk review to identify the potential schemes for further investigation and analysis. This desk work involved consulting with bureaus and offices that had experience in developing SSI schemes and had connections with regional and woreda level Agricultural Offices. As a result, 12 (twelve) salt-affected SSIS were

selected as the possible irrigation schemes for the study. However, due to time and budget limitations, only the six most salt affected irrigation schemes were intentionally selected from the 12 SSISs.

Soil Sampling and Analysis

Surface soil sample collection

Soil samples from the surface layer (0-30 cm) were collected along a transect line (100-250m interval) depending on the size of the command area and variability of the scheme. A total of 43 surface soil samples (0-30 cm) were taken from the schemes to prepare a spatial distribution map of the salt affected area. Coordinates of each sampling points were recorded using GPS. The coordinates were used to develop maps using GIS. The samples were taken in a horizontal and vertical transect manner (north-south and east-west direction of the scheme). After thoroughly mixing the composited samples, about 1kg soil was kept in a plastic bag, air dried and transported to Haramaya University soil laboratory for further analysis.


Soil sample transported to Lab.


Soil Sample collection

Sampling soils from profile pits

Depending on the homogeneity of the scheme, one representative profile pit was opened to a depth of 1.2 meter in each of the SSIS. These pits were sampled at depths of 0-30 cm, 30-60 cm, 60-90 cm and 90-120 cm to characterize the salinity status and dynamics along the soil profile/depth.

Soil sample preparation and analysis

Collected soil samples were air dried, ground to pass through 2 mm sieve and stored in clean sample bag for analysis (Jackson, 1973). The soil samples were analyzed for selected chemical properties [ECe, pH, CEC, Exchangeable bases (Ca, Mg, Na & K), soluble cations (Ca, Mg, and Na), ESP, and SAR] following standard test procedures. Soil pH was determined using a digital pH-meter with combined glass electrode in water(H_2O) at 1:2.5 soil: water ratio. Electrical conductivity was measured by conductivity meter from saturated soil past extracts. Exchangeable bases of the soils were extracted by excess ammonium acetate (1M NH_4OAc at pH 7) solution and exchangeable Ca and Mg were determined by atomic adsorption spectrophotometer while exchangeable Na^+ and K^+ in the extracts were measured by flame photometer (Okalebo *et al*., 2002). Cation Exchange Capacity (CEC) (cmol $_{(+)}$/kg) of the soils was determined after leaching the ammonium acetate saturated soil samples with 10% sodium chloride solution. The amount of ammonium ion in the percolate was determined using the modified Kjeldahl procedure as described by Okalebo et al. (2002) and reported as CEC. Exchangeable Sodium Percentage (ESP) was computed from exchangeable Na as percent retained by CEC of the soil as follows:

$$ESP\,(\%) = \frac{\text{Exchangeable sodium } (Na^+)}{CEC} * 100 \qquad (1)$$

Where, concentrations are in cmol $_{(+)}$/kg of soil.

Water soluble cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) were measured from the saturated soil paste extracts by atomic absorption spectrophotometer for Ca^{2+} and Mg^{2+} and by flame photometer for K^+ and Na^+ (FAO, 1984). Sodium Adsorption Ratio (SAR) of the soil solution was calculated from the concentrations of soluble Na, Ca and Mg as follows:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$



Classification method

Soil ECe and ESP values were used as the indicators of soil salinity and sodicity, respectively. Hence in order to classify the ranges of the different values recorded from the laboratory result, ECe values were classified in to six categories as: non-saline, slightly saline, moderately saline, strongly saline, very strongly saline and extremely saline. The values of ESP were classified in to five categories as: non-sodic, slightly sodic, moderately sodic, strongly sodic and very strongly sodic (Table 1). Similarly, ECw and SAR were used as indicators of salinity and sodicity of river and ground water samples. Therefore, the values of ECw and SAR were classified in to four categories as: low, medium, high and very high (Table 1) Modified USSL Staff (1954) by Shahid and Mahmoudi (2014).

Table 1 Salinity and Sodicity classification ranges classes of soil and irrigation water

Parameter	Range	Class	Source
ESP (soil)	<6	Non-sodic	Amrhein 1996
	6 to 10	Slightly sodic	
	10 to 15	Moderately sodic	
	15 to 25	Strongly sodic	
	>25	Very strongly sodic	
ECe (dSm^{-1}) (Soil)	<0.75	Non-saline	FAO, 2008
	0.75 to 2	Slightly saline	
	2 to 4	Moderately saline	
	4 to 8	Strongly saline	
	8 to 15	Very strongly saline	
	>15	Extremely saline	
SAR (water)	<10	Low	Modified USSLS (1954) by Shahid and Mahmoudi (2014).
	10-18	Medium	
	18-25	High	
	>25	Very high	
ECw (dSm-1) (water)	<0.25	Low	
	0.25 to 0.75	Medium	
	0.75 to 2.25	High	
	>2.25	Very high	

Similarly, the salt-affected soils classified into four categories: saline, saline-sodic, sodic, and non-saline non-sodic soils. Hence, the salt affected soil types were classified based on the criteria established by the US Salinity Laboratory Staff (1954) (Table 2).

Table 2 Classification of salt affected soils based on their chemical properties

Salt affected soil type	Electrical conductivity of saturation extracts (ECe) at 25 ^{o}C (ds/m)	Saturation (%) of cation exchange capacity with Na (ESP)	Reaction (pH value)
Saline	> 4	< 15	<8.5
Saline sodic	> 4	> 15	<8.5
Sodic (Alkali)	< 4	> 15	8.5-10
Non-saline non-sodic	< 4	< 15	About neutral

Irrigation Water Sampling and Analysis

Irrigation water sampling and preparation

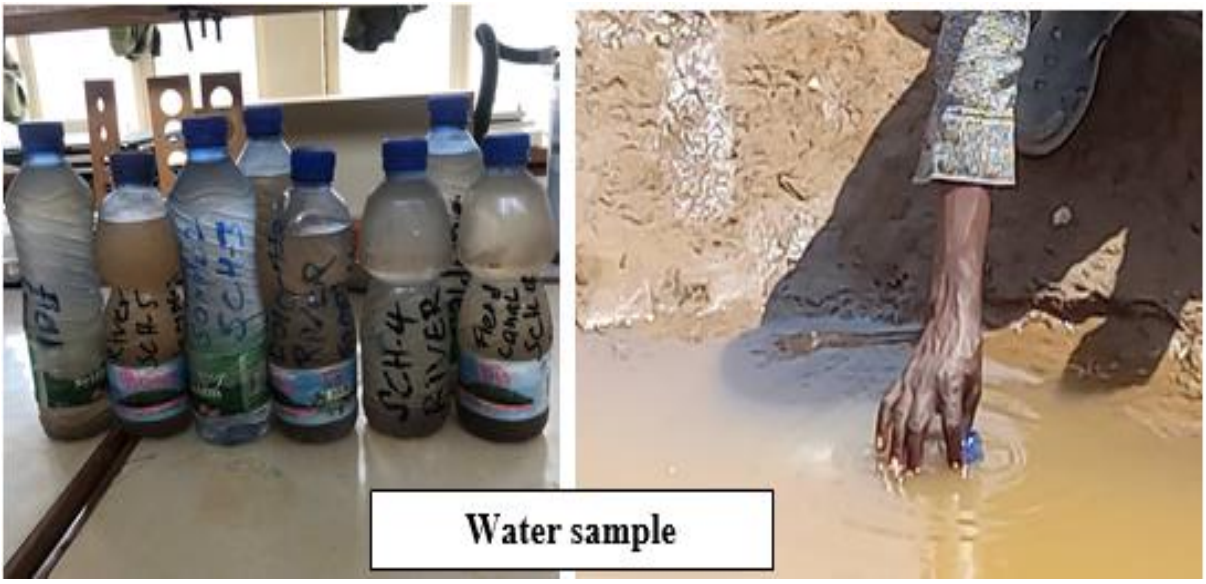
Irrigation water samples were taken from six different spots of the irrigation water sources of the schemes (Genale river).The water samples were taken during the mid of the dry season (September, 2022). Acid-washed and rinsed polyethylene bottles were used to collect irrigation water samples. The samples were properly labeled and transported to the Haramaya University laboratory and analyzed for their chemical composition immediately. Generally, the collection and handling of irrigation water samples were done in accordance with the procedure outlined by the US Salinity Laboratory Staff (1954).

Irrigation water sample analysis

The collected water samples were subjected for the analysis of pH, EC, dissolved cations (Ca, Mg, and Na) contents in the laboratory. Furthermore, SAR was estimated from the measured parameters. Finally, the quality and suitability of the water for irrigation was evaluated based on the outputs.

EC and pH of the water samples were measured in a laboratory within 24 hours using conductivity meter and a digital pH meter, respectively (Richards, 1954). Soluble Ca and Mg were measured using atomic absorption spectrophotometer, while Na was analyzed using flame photometer.

The SAR value was calculated using equation (2) with the concentrations expressed in meq/l.



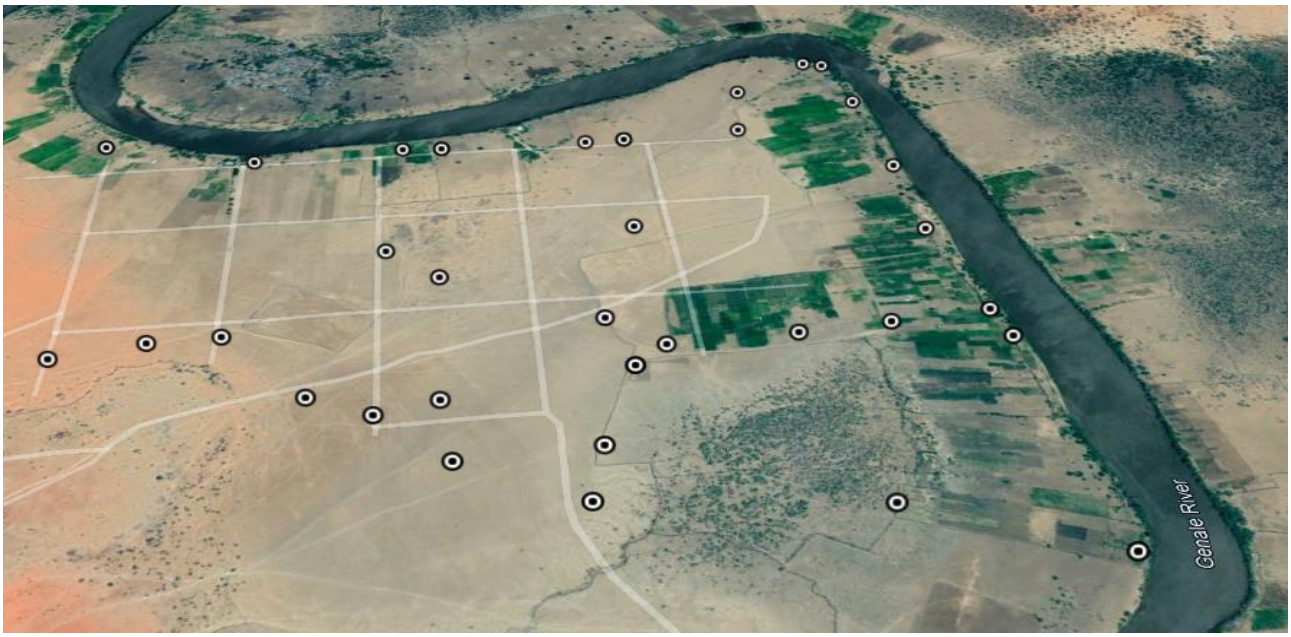
Mapping the Spatial Distribution of Salt Affected Soils Using GIS

Salinity mapping

The spatial mapping of saline soils in the study areas was carried out using GIS (ArcMap 10.8) following the interpolation techniques. Inverse Distance Weight (IDW) was employed for spatial mapping of the soil quality parameters (Megersa, 2010).

Ground truth data

Geo-referencing data using GPS is very important to map the soil salinity problem in study area. Therefore, during the soil sampling, GPS coordinates of both soil samples and scheme boundaries were recorded in order to use them later for the interpolation.



RESULTS AND DISCUSSION

Soil profile Analysis

Soil reaction (pH)

The surface layer pH values of the studied profiles varied from slightly acidic (6.09) at Bur-amino to moderately alkaline (7.91) at Sigalow. The pH values increased with depth in all sites except for Kali masago and Sigalow, which showed irregular pH patterns across the profile depths. The bottom layers (90-120cm) of Hilowayn-2 and Hilowayn-3 had strongly alkaline reactions (pH>8), while the other sites had moderately alkaline reactions (7.4-8.0) (Tekalign, 1991) at their bottom layers. Since the pH value is influenced by the presence of cations, its range varies in salt affected soils across the irrigation schemes (Table 3). Gebrejewergs *et al*. (2019) indicated that low precipitation, high value of exchangeable Ca^{+} and high evapotranspiration reduced the losses of basic cations from soil profile, resulting in high soil pH values.

Electrical Conductivity (ECe)

The distribution of the total soluble salts (as expressed by ECe) was observed to increase consistently with depth of all the profiles studied except Bur-amino irrigation scheme which showed variation of ECe along the depth. Based on the US Salinity Laboratory Staff (1954)

classification, the surface soil salinity of the studied irrigation schemes was low for Hilowayn-2, Hilowayn-3 and Kali-masago; moderate for Hilowayn-1 and Sigalow; and high for Bur-amino. . The ECe values in the surface soils showed high magnitude at Hilowayn-1 (3.5 dS/m) and Bur-amino (4.99 dS/m) irrigation schemes compared to the other schemes (Table 3). The relative increase of soluble salts within the depth of the profiles suggests that the downward movement of salts (leaching) is more dominant than upward (capillary) movement of salts as usually happens in areas with shallow ground water containing higher dissolved salts. This might also be caused by poor irrigation water management and inadequate drainage system of the irrigated fields.



Table 3 Analysis of soil profile based on pH, EC and ESP

Schemes name	Analysis soil profile/depth wise trend based on EC, ESP, and pH											
	0-30 cm			30-60 cm			60-90			90-120		
	pH	EC (dS/m)	ESP	pH	EC (dS/m)	ESP	pH	EC (dS/m)	ESP	pH	EC (dS/m)	ESP
Hilowayn-1	7.13	3.51	15.31	7.21	3.76	6.69	7.49	4.45	7.01	7.63	5.26	7.19
Hilowayn-2	7.74	1.50	15.93	7.78	1.69	13.32	8.23	2.78	8.36	8.71	2.91	11.73
Hilowayn-3	6.99	1.75	11.97	8.17	2.98	18.55	8.04	2.37	8.12	8.68	5.49	11.96
Bur-amino	6.09	4.99	15.75	7.11	2.61	16.44	7.21	3.71	9.50	7.89	4.87	9.69
Kali-masago	7.47	1.59	7.03	6.99	2.65	3.68	7.77	2.64	18.14	7.99	3.64	7.69
Sigalow	7.91	2. 49	6.70	7.68	2. 51	17.11	7.77	3.62	6.48	7.91	4.87	12.65

Exchangeable Sodium Percentage (ESP)

The ESP values throughout the profiles of all the study sites ranged from 3.68 to 18.55% and did not show a consistent relationship with depth of the profiles. Hilowayn-1, Hilowayn-2 and Bur-amino had surface layer ESP values above the lower limit (15%) for sodic soils, according to the US Salinity Laboratory Staff (1954). However, Bur-amino also had high ECe values (> 4 dS/m), which made it a saline-sodic soil. The other study sites did not qualify as sodic/saline-sodic soils, as their ESP values were below the lower limit (15%). However, Hilowayn-3 and Kali-masago had ESP values above 15% at some lower layers of their profiles, which indicated a potential risk of becoming sodic soils (Table 3).



Surface Soil Salinity Assessment and Spatial Mapping

Electrical conductivity (ECe) spatial mapping

The soils of the study areas showed a high variation in ECe values (Appendix Table 2). The map of salt affected soils derived from the Inverse Distance Weighted (IDW) model revealed four classes of salinity levels: non-saline, slightly saline, moderately saline, and strongly saline soils, with different extents of area (Fig. 2, 3 & 4). The largest area was occupied by moderately saline soils (104.15 ha), which accounted for 53.5% of the total area (Table 4). The smallest area was

covered by slightly saline soils (11.5 ha), which represented 5.9% of the total area (Table 4). Moderately saline and strongly saline soils covered 70.9% of the total area and were distributed across the sampled irrigation schemes. Moreover, the surface soil sample results showed that the EC value for the entire study sites ranged from 0.7 to 15.6 dS/m (Appendix Table 2). Furthermore, Holowayn-2, Kali-masago, and Sigalow irrigation schemes had more than 20% of their soils classified as strongly saline. However, most of the study area had salinity levels from slightly saline to strongly saline. This could limit the yields of many crops..

Table 4 Area coverage of different salinity levels in the study areas

Schemes	Total Area (ha)	Area coverage per salinity level (%)				
		Non-saline	Slightly saline	Moderately saline	Strongly saline	Very strongly saline
	FAO (2008)	**0-2**	**2 to 4**	**4 to 8**	**8 to 15**	**>16**
Hilowayn-1	53.0	5.1	17.4	58.5	19.0	
Hilowayn-2	37.84	9.9	22.8	42.9	24.4	
Hilowayn-3	52.31	4.0	21.4	65.8	8.8	
Bur-amino	15.26	8.4	36.8	48.8	6.0	
Kali-masago	12.26	3.2	28.8	38.8	29.2	
Sigalow	24.01	4.8	32.5	41.0	21.7	
Total	**194.68**	**5.85**	**19.3**	**53.5**	**17.4**	
Source: Own Survey 2023						

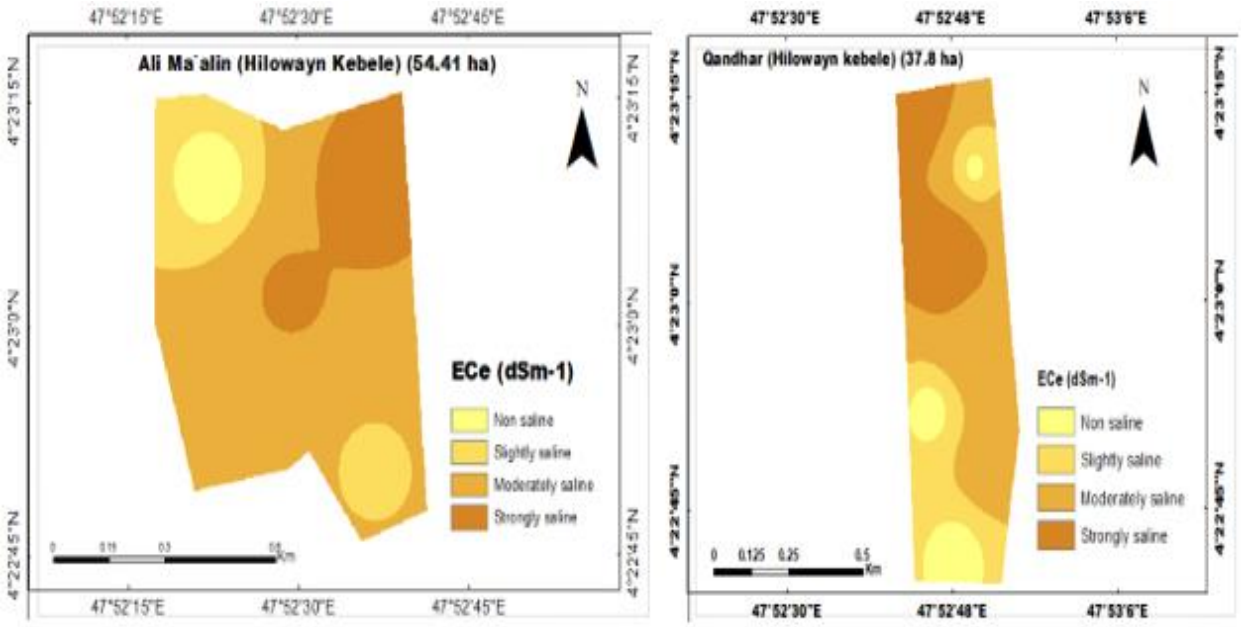


Figure 2 Spatial mapping of salinity for Ali ma`alin and Qandher irrigation schemes

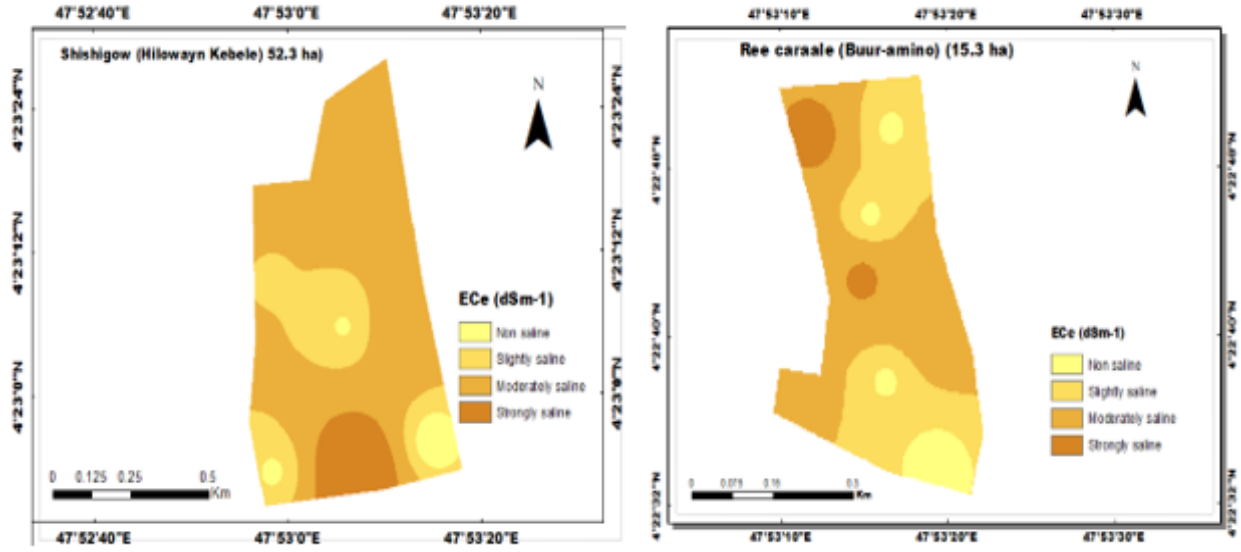


Figure 3 Spatial mapping of salinity for Shishigow and Caarele irrigation schemes

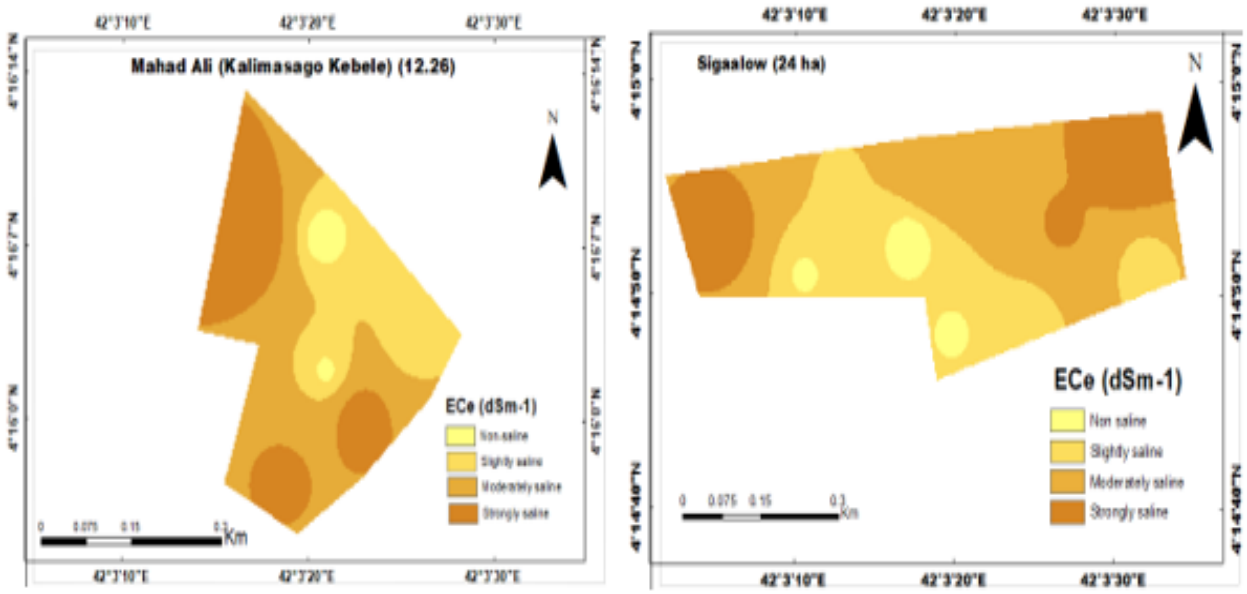


Figure 4 Spatial mapping of salinity for Mahad-Ali and Sigalow irrigation schemes

Soil Sodicity Spatial Mapping

The sodium adsorption ratio (ESP) of the soils in the irrigation schemes varied from 5.5 to 18.0% in Hilowayn-1, 3.3 to 27.2% in Hilowayn-2, 4.5 to 15.7% in Hilowayn-3, 3.2 to 13.6% in Bur-amino, 3.7 to 13.7% in Kali-masago, and 3.2 to 18.1% in Sigalow (Appendix Table 2). The highest soil sodicity problem were observed in Hilowayn-1 & 2, which had very strongly sodic character (Table 5).

According to the FAO (2008) classification, out of the 43 soil samples from the surface layer (0-30cm), 11.7% were non-sodic with ESP values of less than 6%. About 44.8% of the soils were slightly sodic with ESP values between 6 and 10%. About 33.8% of the soils were moderately sodic with ESP values between 10 and 15. The remaining 9.88% were fall under classes of strongly to very strongly sodic with ESP values of above 15 (Table 5).

Table 5 Area coverage of different sodicity levels in the study areas

Schemes	Total Area (ha)	Area coverage per sodicity level (%)				
		Non-sodic	Slightly sodic	Moderately sodic	Strongly sodic	Very strongly sodic
	FAO (2008)	<6	6 to 10	10 to 15	15 to 25	>25
Hilowayn-1	53	1.6	47.6	34.7	16.0	
Hilowayn-2	37.84	9.2	40.7	32.4	15.3	2.48
Hilowayn-3	52.31	5.2	37.1	52.4	5.3	
Bur-amino	15.26	74.0	26.0			
Kali-masago	12.26	18.1	50.4	26.4	5.1	
Sigalow	24.01	9.1	70.1	18.2	2.5	
Total	**194.68**	**11.7**	**44.8**	**33.8**	**9.4**	**0.48**

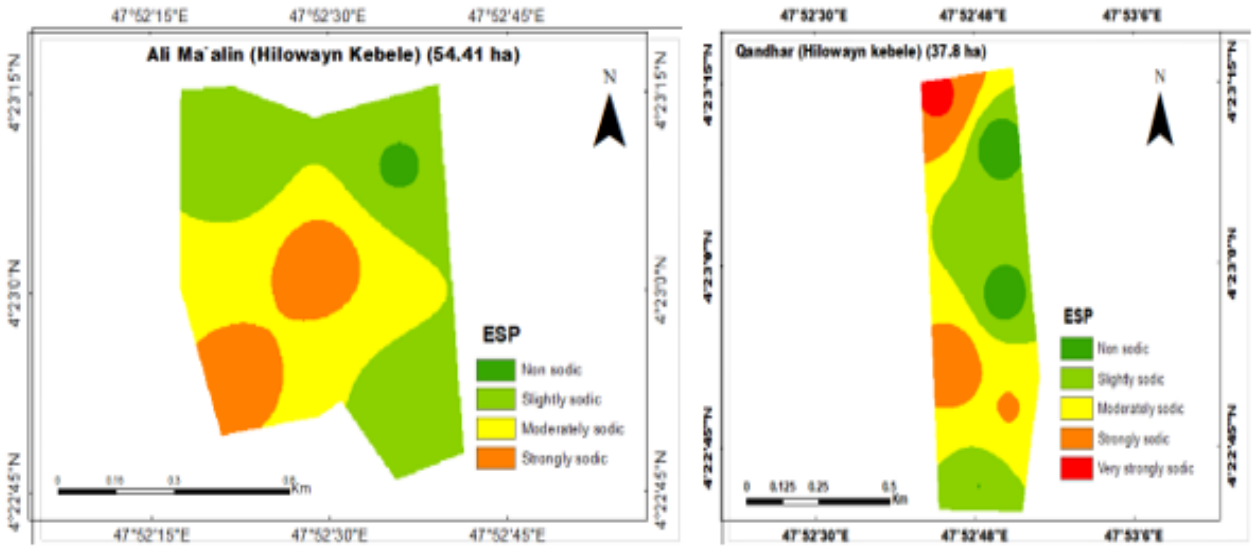


Figure 5 Spatial mapping of sodicity for Ali ma`alin and Qandher irrigation schemes

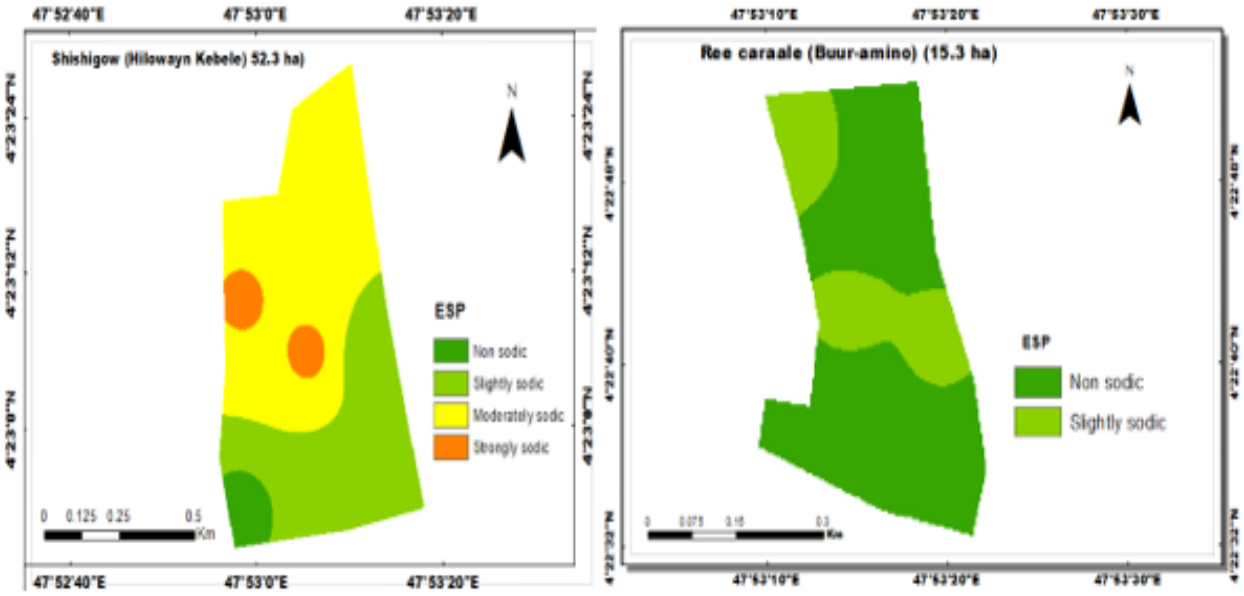


Figure 6 Spatial mapping of sodicity for Ali ma`alin and Qandher irrigation schemes

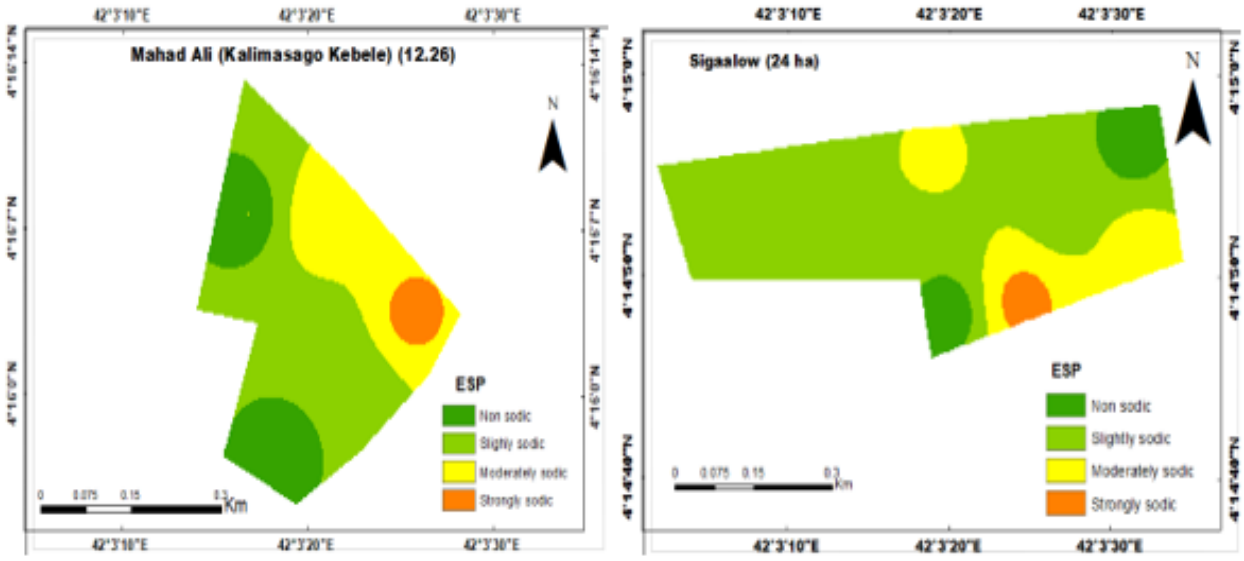


Figure 7. Spatial mapping of sodicity for Ali Mahad-Ali and Sigalow irrigation schemes

The Spatial Distribution of the Different Classes of Salt Affected Soils

The irrigation schemes were mapped separately for ECe and ESP, and then a combined analysis was done to understand their joint effect and identify areas affected by both salinity and sodicity (saline-sodic soils). According to the U.S. Salinity Laboratory Staff (1954) classification, a significant part of the Dollo-Ado irrigation schemes were classified as non-saline non-sodic soil

(59.1%) with ECe and ESP values of less than 4 dS/m and 15%, respectively. However, about 40.9% of the areas of studied schemes were salt affected, with 31.7% saline, 7.1% sodic and 2% saline-sodic (Table 6). The result indicated that no saline-sodic soils were observed in Hilowayn-3, Bur-amino, Kali-masago and Sigalow irrigation schemes. The result also revealed that saline soils covered the largest areas of Hilowayn-2 (62.3%) and Bur-amino (54.8%) irrigation schemes in Ganele river (Table 9). Hilowayn-1 (11.3%) and Hilowayn-2 (10%) irrigation schemes had the highest extent of sodic soils compared to others. Despite this fact, most of the study areas were potentially salt affected, as they have larger accumulation of soluble salts or exchangeable sodium at some part of their profile.

Table 6 Area coverage of different classes of salt affected soils in the study areas

Scheme name	Total Area (ha)	Area Coverage Per Salt Affected Soil Classes (%)			
		Non-saline Non- sodic	Saline sodic	Saline	Sodic
	USSLS (1954)	(EC: <4, ESP: <15)	(EC: >4, ESP: >15)	(EC: >4,ESP: <15)	(EC:<4, ESP: >15)
Hilowayn-1	53	22.6	3.8	62.3	11.3
Hilowayn-2	37.84	65.5	7.7	16.8	10.0
Hilowayn-3	52.31	85.9		8.8	5.3
Bur-amino	15.26	45.2		54.8	
Kali-masago	12.26	66.4		28.4	5.2
Sigalow	24.01	75.8		21.7	2.5
Total	**194.68**	**59.1**	**2.8**	**31.7**	**7.1**
Source: Own survey, 2023					

Irrigation Water Quality Analysis

pH

In this study, the pH value of water samples ranged from 7.68 to 8.11, indicating that they were suitable for irrigation (Table 7). These values were within the acceptable limits for irrigation water (6.0 – 8.5) recommended by the FAO, and therefore unlikely to cause any adverse effects on the crops in the sites. However, this data only represents one season, and irrigation water quality may vary in different seasons. Therefore, it is important to monitor the pH value of irrigation water regularly in different seasons.

Electrical conductivity (ECw)

The electrical conductivity (ECw) of water samples from Ganele river ranged from 0.11 to 0.2 ds/m, to be classified under the low salinity hazard class (C1) (US Salinity Laboratory Staff, 1954), (Table 7). According to the recommendations provided by the US Salinity Laboratory Staff (1954), waters with low salinity hazard (C1) can be used for irrigation on most crops in most soils with little likelihood that soil salinity will develop. Electrical conductivity is used for indicating overall concentration of ionized water constituents such as anions and cations (Onwughara *et al*., 2013). The increase of electrical conductivity is due to increase of ionized salts consequently affecting crop yield due to low seeds germination (Onwughara *et al*., 2013). Electrical conductivity (ECw) is the capacity of water to transmit the electric current. It is a good estimator of the total amounts of mineral salts dissolved in water (Warrence *et al*. 2003).

Sodium adsorption ratio (SAR)

The result revealed that the SAR values of water samples range from 5.30 to 6.54 which fall in to the category of low sodium hazard (S1) according to the US Salinity Laboratory Staff (1954) (Table 7). This means that this water can be used for irrigation with most crops and soils with little danger of developing harmful levels of sodium. However, it is important to note that SAR values are not the only factor that determines the suitability of water for irrigation. Other factors, such as salinity, pH, bicarbonate, and toxic elements, should also be considered when evaluating irrigation water quality.





Table 7 Chemical Analysis of Somali Region Irrigation Water

Schemes	Water source	pH H2O (1:2.5)	ECw (dS/m) (USSLS (1954)		SAR (USSLS (1954)	
		Value	Value	Classification	Value	Classification
Cali ma`alin	River	7.68	0.11	Low	5.82	low
Qandar	River	8.11	0.19	Low	4.89	low
Shishigow	River	7.98	0.18	Low	5.54	low
Qasim Abdi	River	7.99	0.16	Low	6.54	low
Mahad Ali	River	7.74	0.12	Low	5.30	low
DoPARI	River	7.83	0.17	Low	6.32	low

Even though the Genale-Dawa river water is characterized as having low salinity/sodicity hazard, soils formed along the river were observed to be salt affected. Apparently salts may originate from various sources acting either alone or in combination. The likely cause of salinity/sodicity in the Genale-Dawa river valley could be deposition of physically transported salts along with parent material and/or from in situ dissolution and deposition of endogenous (parent) minerals.

Given the arid to semi-arid climatic conditions of the area, slats released during the in-situ weathering process tend to accumulate and result in the development of salinity and/or sodicity. This process of salt and sodium accumulation due to natural causes, namely mineralogy of parent material is known as primary salination/sodification (Stavi *et al*., 2021). The low precipitation which is insufficient for removing of salts below root zones coupled with high evaporation rate might have led soluble salts as well as exchangeable Na+ accumulate over the course of years during the process of soil formation. These soils might have existed before the advent of the irrigation practices in the basin.

It is also evident that shale, limestone, dolomite, gypsum, anhydrite, and sandstone are the dominant rock types overlaying the Genale-Dawa river. Some of these rock types such as gypsum and anhydrite can dissolve easily and release salts into the soil water. Likewise, Shale, especially those of marine origin, can supply large quantities of soluble salts when traversed by

water. Moreover, carbonate rocks including limestone and dolomite, up on weathering release bicarbonate ions in to the soil water and therefore can contribute to soil salinity and sodicity (Nell and van Huyssteen, 2014). These ions can react with calcium and magnesium ions and precipitate as carbonate minerals, leaving behind sodium ions in the soil solution.

CONCLUSION AND RECOMMENDATION

Conclusion

The soil salinity and sodicity assessment of the study area revealed that significant parts of the Ganele river smallholder irrigation schemes were affected by salinity problems. A substantial proportion of the irrigated land has been abandoned or is at risk of being abandoned. The spatial mapping of soil salinity/sodicity revealed that about 40.9% of the total areas of the studied schemes were affected by salt, with 31.7% being saline, 7.1% being sodic, and 2% being saline-sodic. On the other hand, the irrigation water samples were found to belong to the low salinity (C1) and low sodium hazard (S1) classes, which mean they can be safely used for irrigation of most crops on most soils. Therefore, the likely causes of soil salinity/sodicity in the studied irrigation schemes could be secondary salinization due to shallow groundwater table, poor irrigation system, and primary salinization due to the underlying rock types that contained soluble salts.

Recommendations

- There are irrigation schemes where sign of sodicity is showing up. The sodic soil should be treated at the earliest stage before the soil structure is fully destroyed.
- High salinity was observed in large areas of Hilowayn and Sigalow irrigation schemes. Immediate remedial measures should be taken to reclaim the affected soils and prevent further degradation..
- Salinity and sodicity tolerant crops and forages should be introduced and practiced by the community to cope with the challenges of crop production.
- Community based salinity and irrigation water management awareness programs could be beneficial for the affected irrigation schemes.
- Impact on the environment and socio-economic aspect must be assessed to establish a sustainable system of agricultural production

- Large portions of the land are being abandoned; further research on other alternative management options should be done.
- Irrigation water quality of Ganele river showed no hazard to crops. However, further research on seasonal variations of irrigation water quality should be undertaken.

REFERENCES

Abraha B, Yohannes G. The role of seed priming in improving seedling growth of maize (Zea mays L.) under salt stress at field conditions. Agricultural Sciences. 2013 Dec 5;2013.

Agegnehu G, Bekele T. On-farm integrated soil fertility management in wheat on Nitisols of central Ethiopian highlands. Ethiopian Journal of Natural Resources. 2005;7(2):141-55.

Al-Khaier F. Soil salinity detection using satellite remote sensing. ITC.

Asfaw KG, Itanna F. Screening some tef [Eragrostis tef (Zucc.) Trotter] accessions/varieties for salt tolerance during germination and seedling stage. Momona Ethiopian Journal of Science. 2009;1(2).

Asfaw KG, Itanna F. Screening some tef [Eragrostis tef (Zucc.) Trotter] accessions/varieties for salt tolerance during germination and seedling stage. Momona Ethiopian Journal of Science. 2009;1(2).

Astaraei AR. Effect of organic sources as foliar spray and root media on nutrition of cowpea plant. American-Eurasian Journal of Agricultural & Environmental Science. 2008 Aug 12;3.

Ayenew T. Water management problems in the Ethiopian rift: Challenges for development. Journal of African Earth Sciences. 2007 Jun 1;48(2-3):222-36.

Behailu M, Haile M. Water harvesting in northern Ethiopia: Environmental, health and socio-economic impacts. Integrated water and land management research and capacity building priorities for Ethiopia. 2002;185.

Dubale P. Present and future trends in natural resources management in agriculture: An overview. Integrated water and land management research and capacity building priorities for Ethiopia. 2002 Dec;29.

Friedman HS, Prados MD, Wen PY, Mikkelsen T, Schiff D, Abrey LE, Yung WA, Paleologos N, Nicholas MK, Jensen R, Vredenburgh J. Bevacizumab alone and in combination with irinotecan in recurrent glioblastoma. Journal of clinical oncology. 2009 Oct 1;27(28):4733-40.

Gebrehiwot KA. A review on waterlogging, salinization and drainage in Ethiopian irrigated agriculture. Sustainable Water Resources Management. 2018 Mar;4(1):55-62.

Johannes P Nell & Cornelius W van Huyssteen (2014) Geology and groundwater regions to quantify primary salinity, sodicity and alkalinity in South African soils, South African Journal of Plant and Soil, 31:3, 127-135, DOI: 10.1080/02571862.2014.921940

Kelly WP (1951) Alkali soils—their formation, properties and reclamation. Reinhold, New York

Kumar S, Stecher G, Li M, Knyaz C, Tamura K. MEGA X: molecular evolutionary genetics analysis across computing platforms. Molecular biology and evolution. 2018 Jun;35(6):1547.

Loiskandl W, Ruffeis D, Schönerklee M, Spendlingwimmer R, Awulachew SB, Boelee E. Case study review of investigated irrigation projects in Ethiopia. 2008.

Loiskandl W, Ruffeis D, Schönerklee M, Spendlingwimmer R, Awulachew SB, Boelee E. Case study review of investigated irrigation projects in Ethiopia. 2008.

Mersha TB, Abebe T. Self-reported race/ethnicity in the age of genomic research: its potential impact on understanding health disparities. Human genomics. 2015 Dec;9(1):1-5.

Mersha TB, Abebe T. Self-reported race/ethnicity in the age of genomic research: its potential impact on understanding health disparities. Human genomics. 2015 Dec;9(1):1-5.

Metternicht GI, Zinck JA. Remote sensing of soil salinity: potentials and constraints. Remote sensing of Environment. 2003 Apr 25;85(1):1-20.

Moonjun R, Farshad A, Shrestha DP, Vaiphasa C. Application of artificial neural network and decision tree in a GIS-based predictive soil mapping in sloping areas in Thailand.

Onwughara, N.I., Ajiwe, V.I.E. and Nnabuenyi, H.O., 2013. Physicochemical studies of water from selected boreholes in Umuahia North Local Government Area. *Abia State, Nigeria. International Journal of Pure & Applied Bioscience*, *1*(3), pp.34-44.

Rongjiang Y, Jingsong Y, Xiufang Z. Three-dimensional stochastic simulation and uncertainty assessment onspatial distribution of soil salinity in coastal region. Transactions of the Chinese Society of Agricultural Engineering (Transactions of the CSAE). 2010;26(11):91-7.

Stavi, I. Thevs, N. and Priori, S.(2021). Soil Salinity and Sodicity in Drylands: A Review of Causes, Effects, Monitoring, and Restoration Measures. ***Frontier in Environmental Science***, volume 9-2021. https://doi.org/10.3389/fenvs.2021.712831

Taddese G. Land degradation: a challenge to Ethiopia. Environmental management. 2001 Jun;27(6):815-24.

Taddese S, Asres K, Gebre-Mariam T. In vitro antimicrobial activities of some selected topically applied medicinal plants of Ethiopia. Ethiop Pharm J. 2003; 21:39-46.

Tefera B. Nature and causes of land degradation in the Oromiya Region: A review.

Wichelns D, Qadir M. Achieving sustainable irrigation requires effective management of salts, soil salinity, and shallow groundwater. Agricultural Water Management. 2015 Jul 31; 157:31-8.

Wichelns D, Qadir M. Achieving sustainable irrigation requires effective management of salts, soil salinity, and shallow groundwater. Agricultural Water Management. 2015 Jul 31; 157:31-8.

Woldemariyam, F., Ayenew, T. (2016). Identification of hydrogeochemical processes in groundwater of Dawa River basin, southern Ethiopia. *Environ Monit Assess* **188**, 481 (2016). https://doi.org/10.1007/s10661-016-5480-3

Rangeland Suitability Evaluation for Livestock Production in Somali Region, Ethiopia, 2023

Somali Region pastoral and Agro-Pastoral research Institute (SoRPARI), Soil and Water Research Directorate

Mahamed Omer Yusuf[1] Abdi Abdullahi Ahmed[2]

Soil and Water Research Department[1], Livestock and Forage Research Department[2]

Abstract

The rangelands in Somali region are degraded by the combined factors of Land use land cover change, recurrent drought, irregular rainfall, and overgrazing. This study aimed to evaluate and assess the suitability of rangelands for livestock production under extensive pastoral system using GIS and remote sensing techniques. Rangeland vegetation cover, land form/slope, annual rainfall amount, temperature regime, and water source availability were the parameters used for the suitability analysis. The study revealed that the majority of the study area was more suitable for browser stocks such as camel and goat than for cattle and sheep. About 70% and 60% of the rangelands were marginally suitable or unsuitable for cattle and sheep production under free grazing condition, respectively. The major limitations for sustainable livestock production in the study area were shortage and erratic nature of rainfall, high temperature, and open shrubland dominated rangelands. Based on the identified qualities and limitations of land resources, majority of Somali region, particularly the hot arid, semi-arid, and sub-moist lowland areas have huge potential rangeland for sustainable camel and goat production under extensive pastoral system. Hence, it is recommended that there should be separate rangelands for each livestock type to improve productivity. This study can provide insights for policy and decision makers to formulate environmental and rangeland policies to identify land characteristics and separate the rangeland for each livestock category.

Keywords: Rangeland, suitability, Livestock, GIS and Remote sensing, Somali region.

Introduction

Land varies in its characteristics everywhere. This variation actually affects its use, as for each type of land there are uses that are more or less physically and economically appropriate as regards productivity and return on invested capital. The variation in land is largely systematic and is caused by known factors which means that they can be mapped, separating them into on average homogenous areas. Rangeland is a type of land characterized by non-forest and native vegetation (NRCS, 1997). Land cover types of rangelands include grasslands, shrub land, and savannas. Rangeland is an area that serves as grazing land for domestic animals and wildlife (Tongway *et al*., 2010; Yu *et al*., 2010). It has crucial value in environmental, social, and economic aspects. Besides, rangeland is very significant, particularly for pastoralists, since it is

used for forage and water for their livestock. Although rangeland has positive contributions to environmental and social aspects, it has been degraded due to land-use and land cover (LULC) change (Arjjumend *et al*., 2018). Rangeland degradation causes low livestock production and seasonal mobility.

Land evaluation may be defined as the process of assessment of land performance when used for specified purposes (FAO, 1983). As such, it attempts to predict the behaviour of each land unit for each actual and proposed land use. It is a procedure for comparing land with land use, where land refers to all the factors of the physical environment. Suitability refers to use on a sustained basis incorporating productivity, social equity and environmental concerns. Land evaluation involves comparison between the environmental requirements of the various kinds of land use, which in this case are camel, cattle & shoats, and their properties. Its main purpose is to inform the process of allocation of land uses to land areas by individuals, collectives, or governments. A complementary purpose of land evaluation is to describe the limitations to land use, and based on these, appropriate management methods.

There is now greater emphasis on environmental consequences and on wider benefits and environmental & ecosystem services (FAO, 2007). Evaluation of natural resources is necessary to obtain optimal land use and to prevent deterioration. Crucial aspects concern the determination of land utilization types and their requirements for different livestock species. Sustainability of livestock production on grasslands depends on the balance of a wide range of ecological, political, economic and social influences (Harris, 2000).

In Somali region and other lowlands of Ethiopia, limited rangeland resources and a lack of sufficient environmental policies for sustainable use of rangelands are the main problems for pastoralists. Besides, the combined factors of LULC change, frequent drought, and irregular rainfall cause rangeland depletion (Legesse and Balew, 2021). In addition, the mounting pressure on natural resources, especially the declining land and water resources, both in quality & quantity added up with the prevailing recurrent drought calls for policies and planning based on the knowledge of the available resources, demand and the interaction between the land and land use. Hence this study was aimed to evaluate and map suitable land areas for livestock production under extensive grazing system in Somali region.

METHODOLOGY AND PROCEDURES

Study location

The study was conducted throughout the Somali Regional State (SRS), the south-eastern part of Ethiopia. The Somali region shares boundaries with Oromia in the West, Afar in the North-West, Djibouti republic in the North, Kenya in the South and Somalia Republic in the South-East and North-East. The total area coverage of the region is estimated to be 374,859,96 km^2 with the population of 3.2 million in 1994 and increased to 4.4 million in 2007, while the projected population in 2017 was estimated to be 11,748,998 (CSA, 2018). The region had annual growth rate of 2.6 per cent from 1994 to 2007 (CSA, 2007).

Moreover, the region is endowed with huge livestock resources with an estimated total population of more than 40 million which is the highest owner of livestock population at national level (CSA, 2021). Livestock rearing or pastoralism is the dominant and indispensable livelihood practice followed by crop production. Crop production is also a growing sector in the region where most of the rural smallholder agro-pastoralists are involved in producing crops both for home consumption and cash income. Field crops, such as cereals, pulses and oil crops constitute the major part of crop production sector in the region. According to the Central Statistical Agency (CSA, 2021), more than a hundred thousand hectares of land were cultivated with different grain crops, yielding close to two million quintals of grains. Moreover, the region has untapped natural resources, such as ample arable land, high potential ground water, major permanent rivers (Wabi Shebelle, Dawa, and Genale), several seasonal rivers, wide area of rangeland, different forest products (Gum, Incense, and Myrrh), and fertile soil, all of which could potentially contribute to agricultural development.

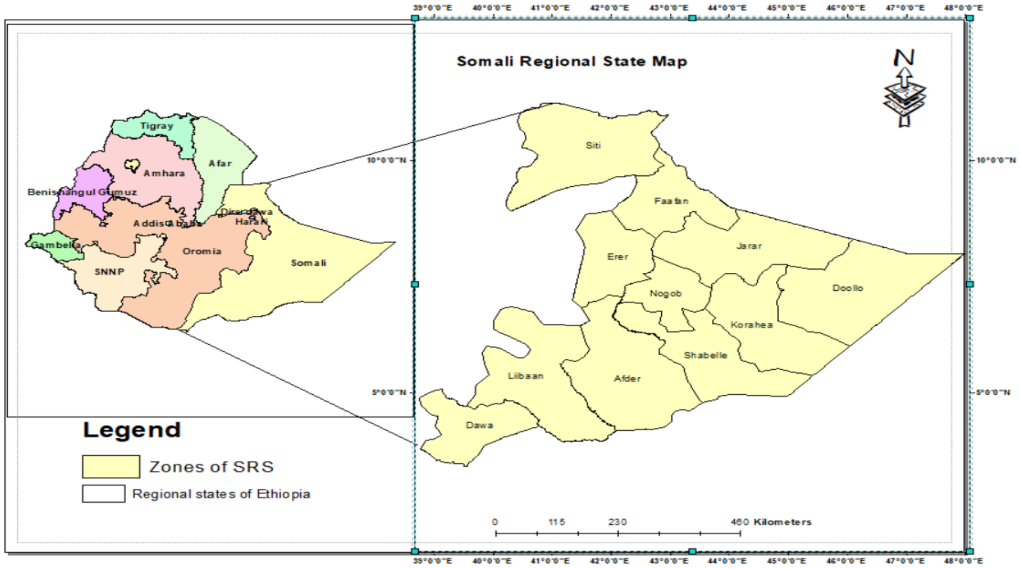


Figure 2.1 location of the study area

Climatically, the region has a bimodal rainfall pattern with two types of seasons. as the first type is the *Gu'u* rains which starts in late March and end in mid-May, and cover the whole region. The second type is the *Dayr* rains, which start in October and last until the end of November, and cover most part of the region except for the areas from the north-west to north-eastern. These areas, which include Sitti and main portion of Fafan zone, receive the *Karan* rains as their second rainy season from July to September.

Data sources and method of collection

In the present study, four environmental and one infrastructural parameter were considered viz: land-use/land cover, topography, rainfall, temperature regime, and available water sources. The data for these parameters were collected as shown in table 1.

Table 1. Data sources and methods of collection

Data type	**Data source**
vegetation cover	Landsat image (USGS) https://earthexplorer.usgs.gov/
Topography (Slope)	SRTM DEM (USGS) https://earthexplorer.usgs.gov/
Ground control points	Field survey by using Garmin GPS
Climate (precipitation and temperature)	30 years of data record from EMSA
Available water sources	SRS, Bureau of Planning
Livestock requirements	FAO (1996, 2007) guideline

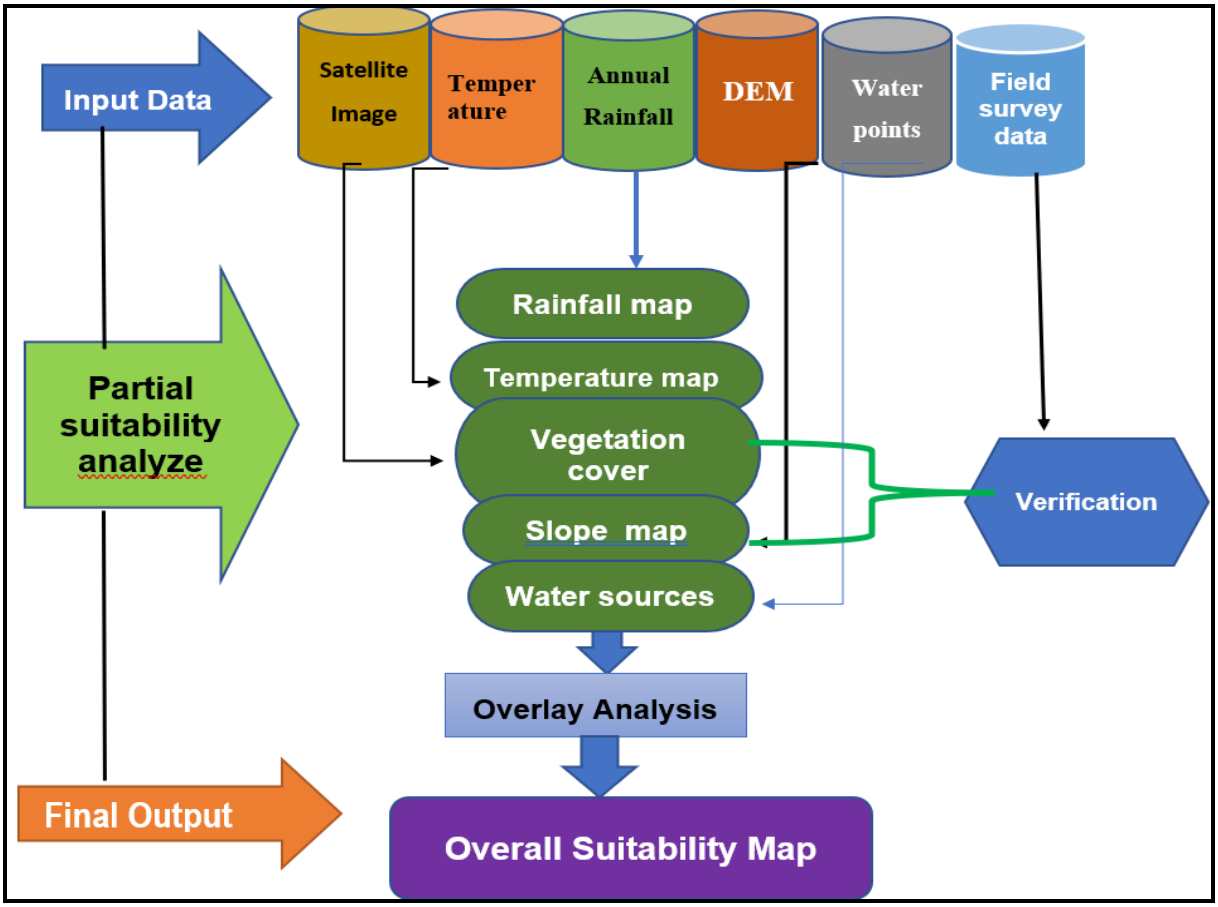


Figure 2.2. Methodological flowchart for suitability analysis in ArcGIS environment.

Land use requirements for livestock stocks

Table 2. Land use requirements of local cattle production under extensive pastoral system (low input level)

Land use requirements		**Factor rating**				
Land quality	**Land Characteristics**	**Unit**	**Highly suitable**	**Moderately suitable**	**Marginally suitable**	**Not suitable**
Moisture availability	Amount of rainfall	mm	700 – 900	450-700	300 - 450	< 300
Temperature regime	Thermal zone	^{0}C	19.1 – 25	25.1 – 27.5 & 13-19	27.6-30	>30 & <13
Topography	Slope/ land form	%	0-10	10-20	20.1 – 35	> 35
Land use and Vegetation cover			Open Grassland, Wooded Grassland	Bushland, Cropland	Open shrubland	Bare soil and exposed rock surface
Water availability	Distance	Km	< 4	4 – 6	6 – 10	> 10

Table 3. Land use requirements of local sheep production under extensive pastoral system (low input level)

Land use requirements		**Factor rating**				
Land quality	Land Characteristics	Unit	Highly suitable	Moderately suitable	Marginally suitable	Not suitable
Moisture availability	Amount of rainfall	mm	700 – 900	450-700	300 - 450	< 300
Temperature regime	Thermal zone	^{o}C	19.1 – 25	25.1 – 27.5 & 13-19	27.6-30	>30 & <13
Topography	Slope/ land form	%	< 16	16 – 30	30 – 40	> 40
Land use and Vegetation cover			Open Grassland Wooded Grassland	Bushland, Cropland	Open shrubland	Bare soil and exposed rock surface
Water availability	Distance	Km	< 4	4 – 6	6 – 10	> 10

Table 4. Land use requirements of local goat production under extensive pastoral system (low input level)

Land use requirements			Factor rating			
Land quality	Land Characteristics	Unit	Highly suitable	Moderately suitable	Marginally suitable	Not suitable
Moisture availability	Amount of rainfall	Mm	500 – 700	400-500	250 - 400 & > 700	< 250
Temperature regime	Thermal zone	0C	19.1 – 25	25.1 – 27.5 & 13-19	27.6-30	>30 & <13
Topography	Slope/ land form	%	< 16	16-35	35-45	>45
Land use and Vegetation cover			Shrubland, Wooded Grassland	Bushland, open Grassland	Cropland	Bare soil and exposed rock surface
Water availability	Distance	Km	< 4	4 – 6	6 – 10	> 10

Table 5. Land use requirements of camel production under extensive pastoral system (low level of management)

Land use requirements			Factor rating			
Land quality	Land Characteristics	Unit	Highly suitable	Moderately suitable	Marginally suitable	Not suitable
Moisture availability	Amount of rainfall	Mm	450 – 700	350- 450	200 - 350 & > 900	< 200
Temperature regime	Thermal zone	0C	20.1 - 27.5	27.6 - 35	>35 17- 20	< 17
Topography	Slope/ land form	%	< 8	8 – 16	16 – 30	> 30
Land use and Vegetation cover			Shrubland, Wooded Grassland	Bushland, open Grassland	Cropland	Bare soil and exposed rock surface
Water availability	Distance	Km	< 10	10 – 15	15 – 25	> 25

RESULTS AND DISCUSSIONS

Partial suitability analysis

This study applied five selected parameters to evaluate the suitability of rangeland resources for livestock production under extensive pastoral system in Somali region. These parameters were:

I. Rangeland vegetation cover

II. Land form/Slope

III. Annual rainfall amount

IV. Temperature regime

V. Water source availability

The suitability of these parameters for livestock production was specifically analysed in order to show the limiting factors for sustained livestock production.

Rangeland vegetation covers suitability analysis

Rangeland vegetation cover is the main controlling factor of rangeland because it is a unit of land that directly affects forage availability and production. The vegetation cover status of the study area was analysed based on its present condition and future potentiality. The majority of the Somali region is covered by bushed shrubbed grassland. The result showed that the majority of arid and semi-arid shrubbed and woody vegetation dominated rangelands are slightly suitable for grazers (cattle and sheep), whereas, these regions have the potential to be moderately to highly suitable for these species (figure 3.1 and 3.2). Currently, the rangeland productivity has declined due to recurrent droughts and the domination of invasive plant species. However, they can be productive, if any alterations against these factors are adopted. In contrary, majority of the study area was found to be moderately to highly suitable for browsers (camel and goats) both currently and in future prospects (figure 3.3 and 3.4).

Areas that are covered by bushland and shrub land were moderately suitable for cattle and sheep production. On the other hand, areas that are covered by woodland and shrub land were highly suitable for goat and camel production. Besides, the farming areas were marginally suitable for cattle, sheep, goats, and camels because they are very hard for forage production and difficult for grazing. Places that are dominated by bushland and shrub land were moderately suitable for cattle and sheep production. The study also revealed that grassland areas are highly suitable for cattle and sheep production because such land types have high grass species diversity and are very suitable for grazing. Terfa and Suryabhagavan (2015) stated that a place that is dominated by grass is highly suitable for cattle and sheep. Whereas shrub land and bushland are more suitable for goat and camel production because these animals are browsers and can easily get their food from such kind of land cover types.

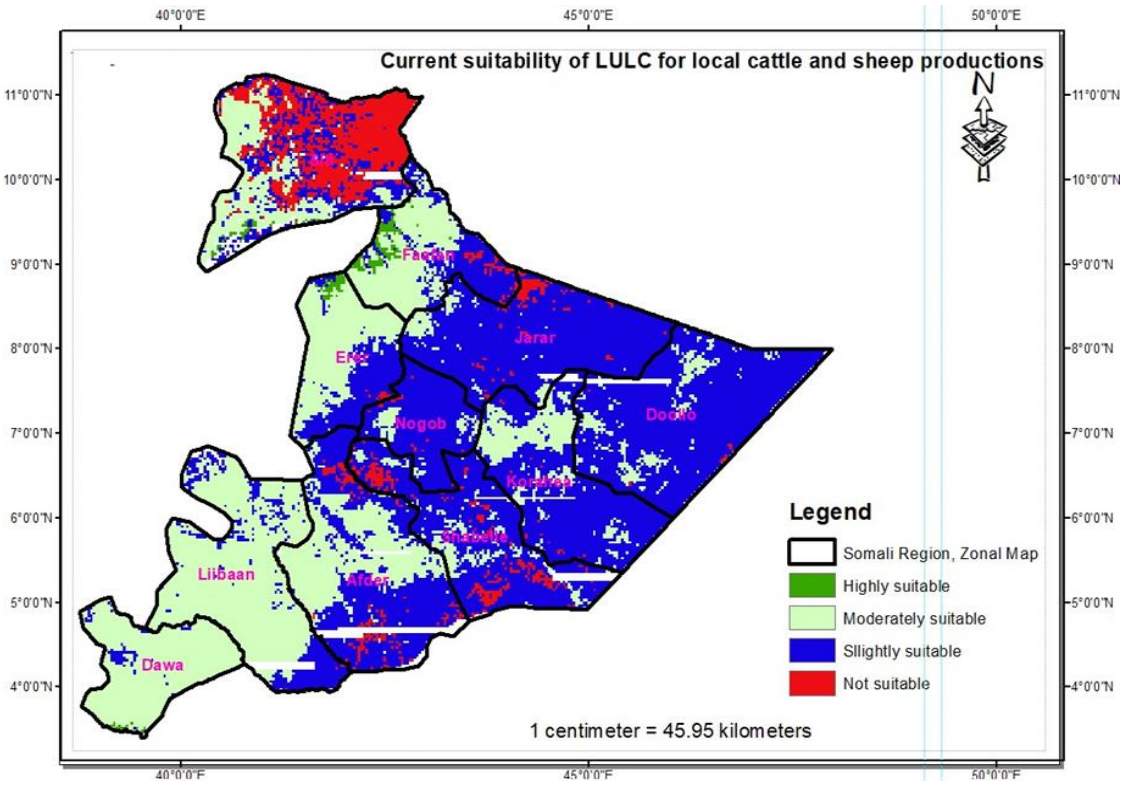


Figure 3.1 Present vegetation cover suitability for cattle and sheep

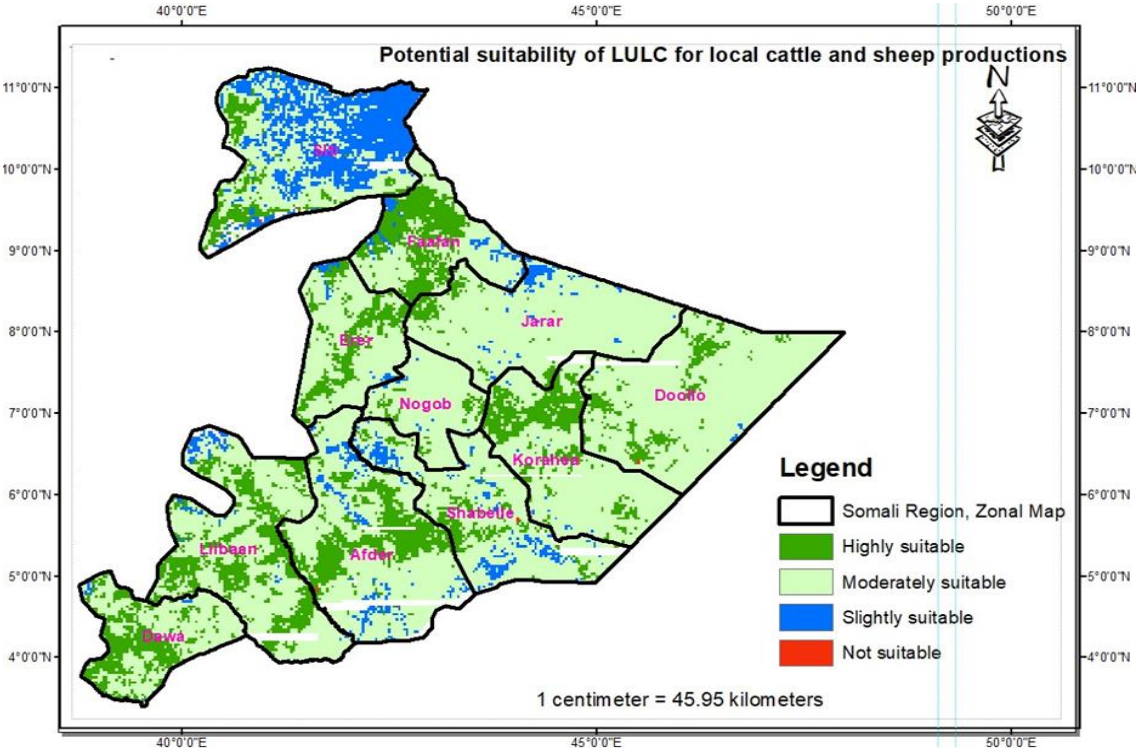


Figure 3.2 vegetation cover potential suitability for cattle and sheep

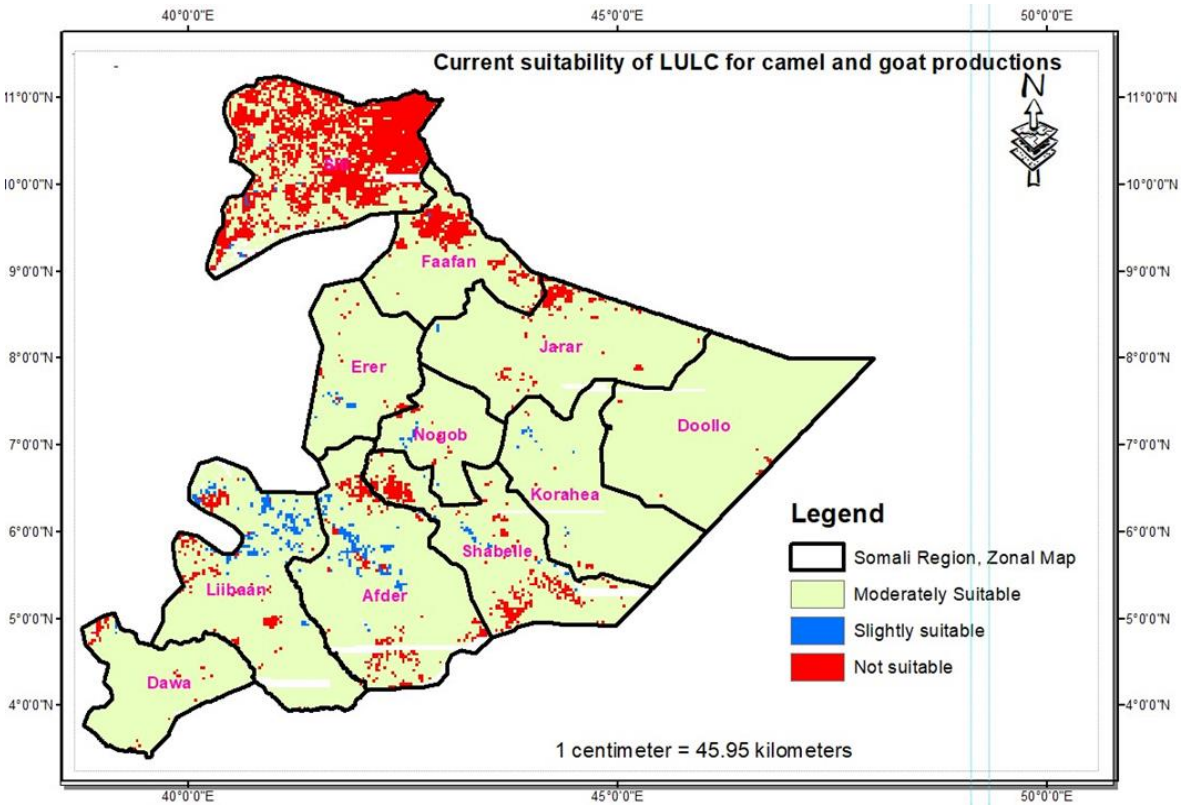


Figure 3.3 Present Vegetation cover suitability for camel and goat

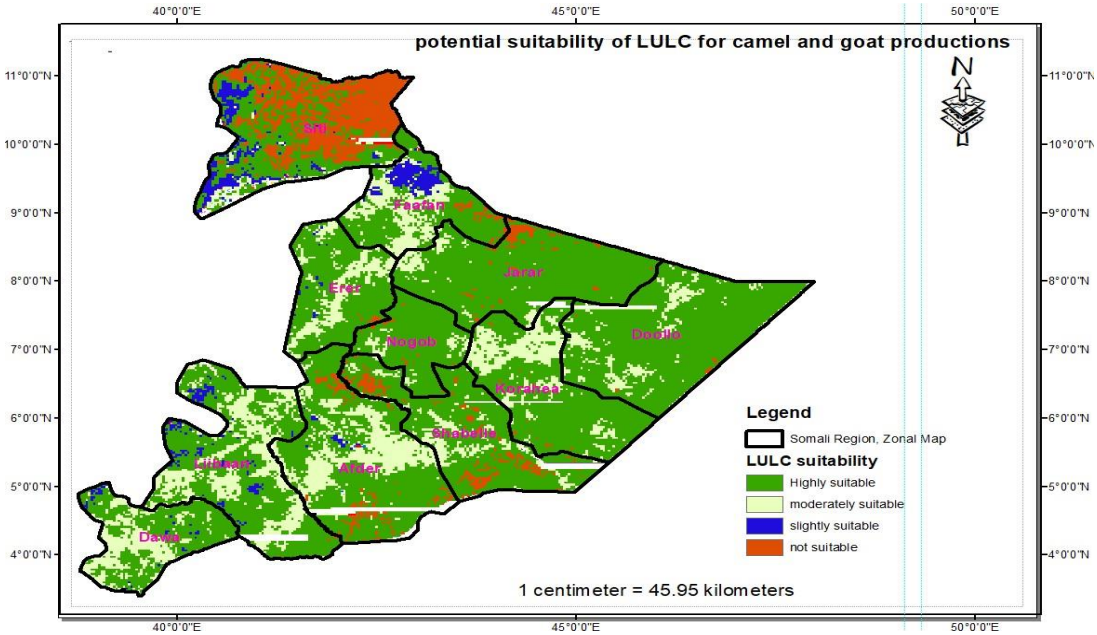


Figure 3.4 Proposed vegetation cover suitability for camel and goat

Slope suitability analysis

The majority of the study area was shown to be gently sloped flatland of < 16% and small hilly terrain, which is highly suitable for livestock production. Places with steep slopes were not suitable for cattle and sheep because they affect their access to feed and water. they also affect surface runoff and soil erosion, which reduce forage production. On the other hand, places having flat slopes were highly suitable for rangeland because they are appropriately smooth for grazing.

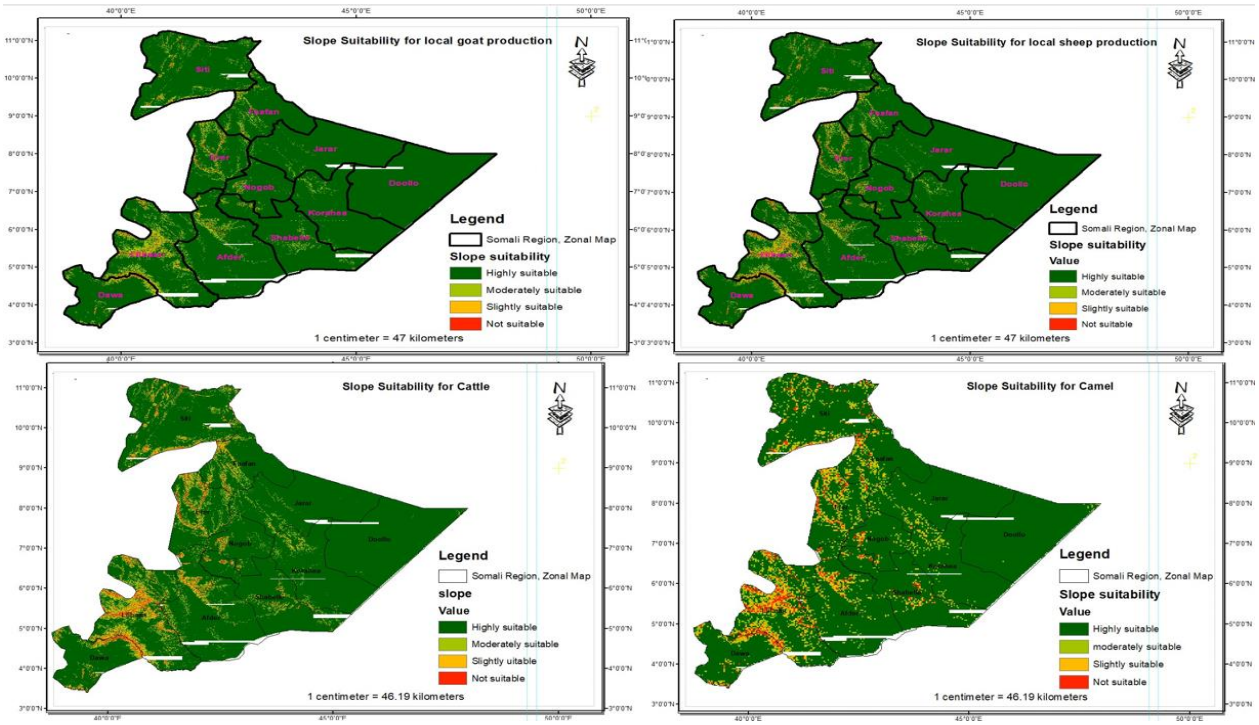


Figure 3.5 slope suitability for goat (a), sheep (b), cattle (c), and camel (d).

Temperature regime suitability analysis

According to FAO (2007), all tropical livestock except the camel have almost similar range of temperature requirements (table 2 – 4). The result showed that the majority of the region is moderately to highly suitable for all the study livestock species, except for some parts of the region in the south and south-east adjacent to the border of Somalia. In these areas the mean annual temperature is greater than 35^0 C, which is above the optimum requirement of cattle, sheep, and goat. Hence the temperature regime of these areas is slightly suitable for these species

(figure 3.6). Similarly, the temperature regime between 15 – 17.5 ^{0} C, which is characterized in Fafan mid-highland areas is slightly suitable for camel production (figure 3.6).

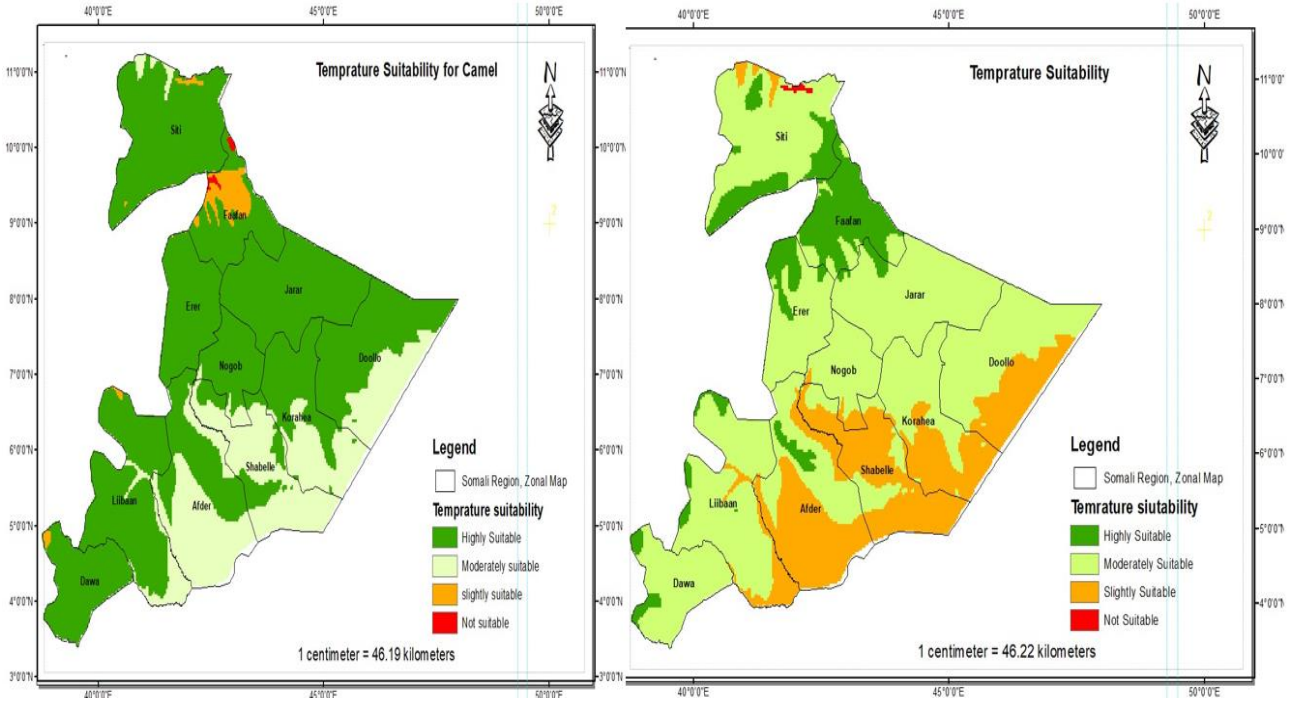


Figure 3.6 Temperature suitability for camel (a) and cattle, sheep, and goat (b).

Annual Rainfall suitability

Rainfall is also the main factor that affects rangeland suitability since it controls water availability for rangeland plant growth and their greenness. It also determines soil moisture, which in turn affects grass and other plants' growth.

The results showed that majority of arid and semi-arid lowland areas were not suitable for cattle and sheep productions (figure 3.7). However, most of the study area was found to be moderately to highly suitable for goat and camel productions (figure 3.8). On the other hand, mountainous areas and places that received high rainfall, such as the north and northwest of the region were not suitable for camels because such areas may affect their movement and consume more energy to travel. Besides, hot-arid lowland areas that receive low amount of rainfall (< 200 mm/year) in the south and eastern part of the region were slightly suitable for goat and camel production.

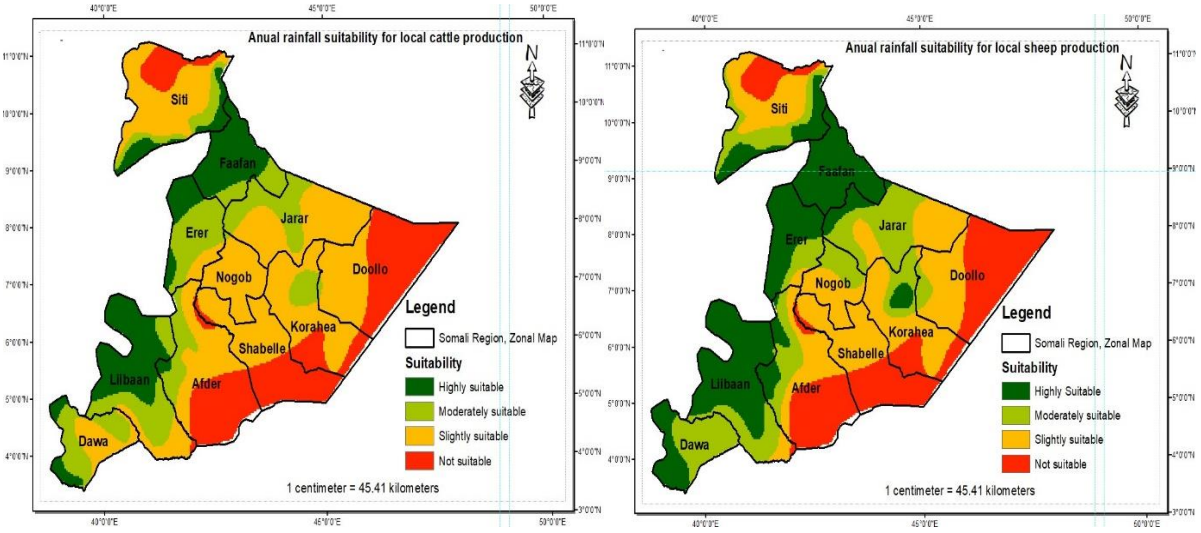


Figure 3.7 Annual rainfall suitability for cattle (a) sheep (b).

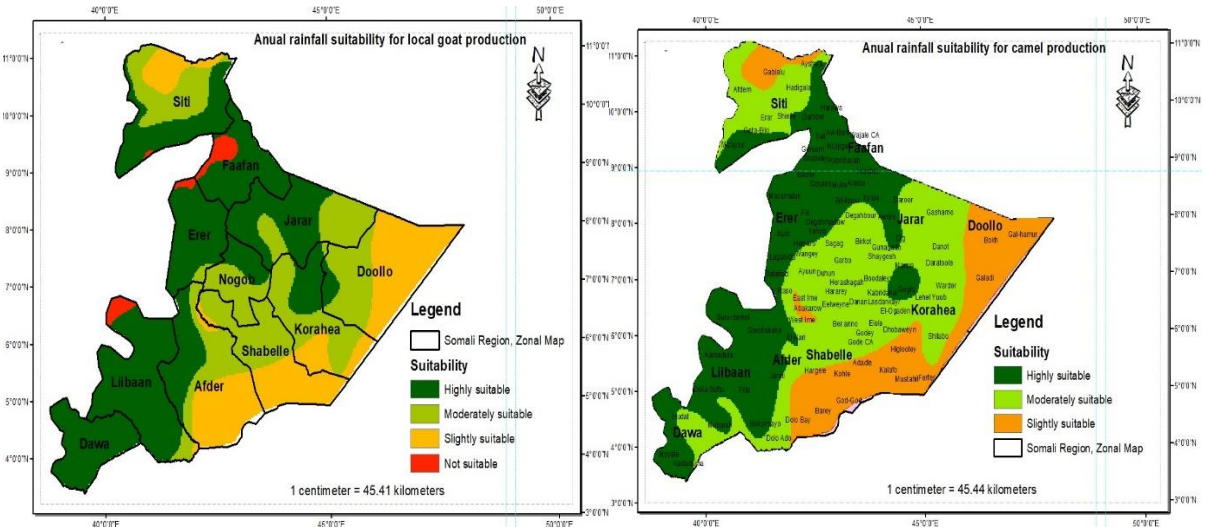


Figure 3.8 Annual rainfall suitability for goat (a) and camel (b).

Available water sources suitability analysis

Access to surface water such as springs, rivers, and streams is essential for rangeland suitability. Areas which have high access to water resources were suitable for rangeland and livestock production because they reduce the time and energy of transportation and minimize the probable risk of mobility. However, places that have low access to water resources were not suitable for livestock production since they increase the cost of mobility and causes different risks. According to Gavili *et al*. (2011) and Terfa and Suryabhagavan (2015), the water sources within a 5 km range were highly suitable for livestock production.

According to data received from Bureau of Planning and Economic Development (BPED), the available water sources in the region are moderately to highly suitable for camel production, as this species can access water from a distance below 15 km.

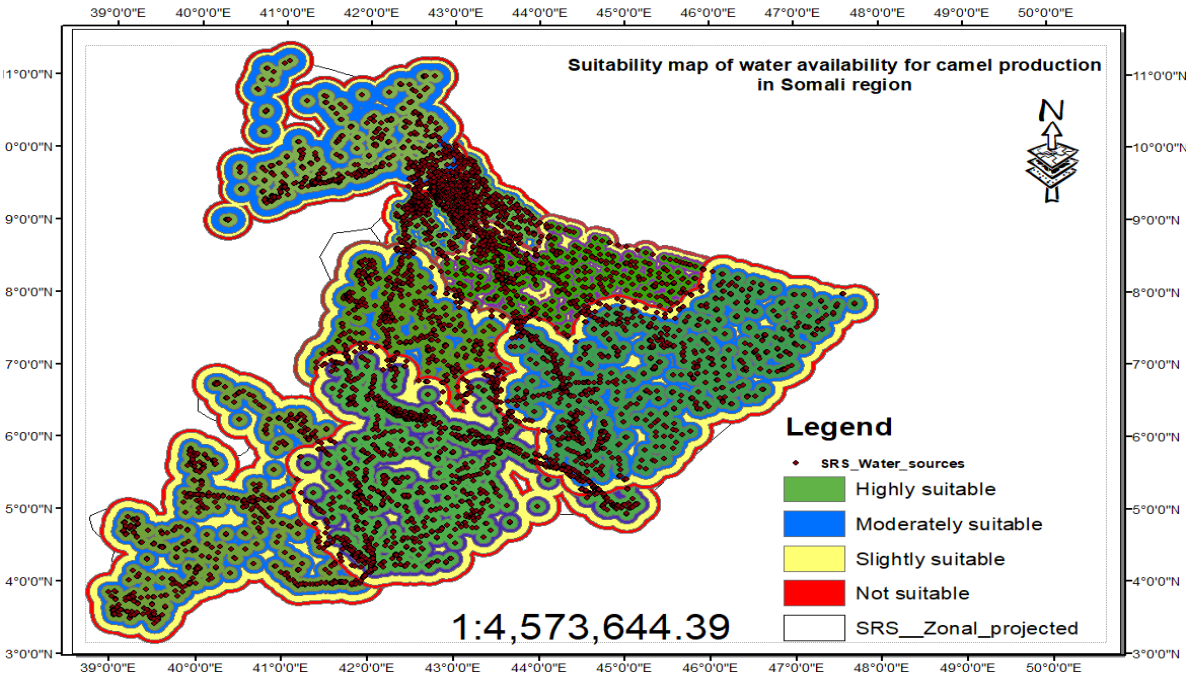


Figure 3.9 Available water sources suitability for camel production

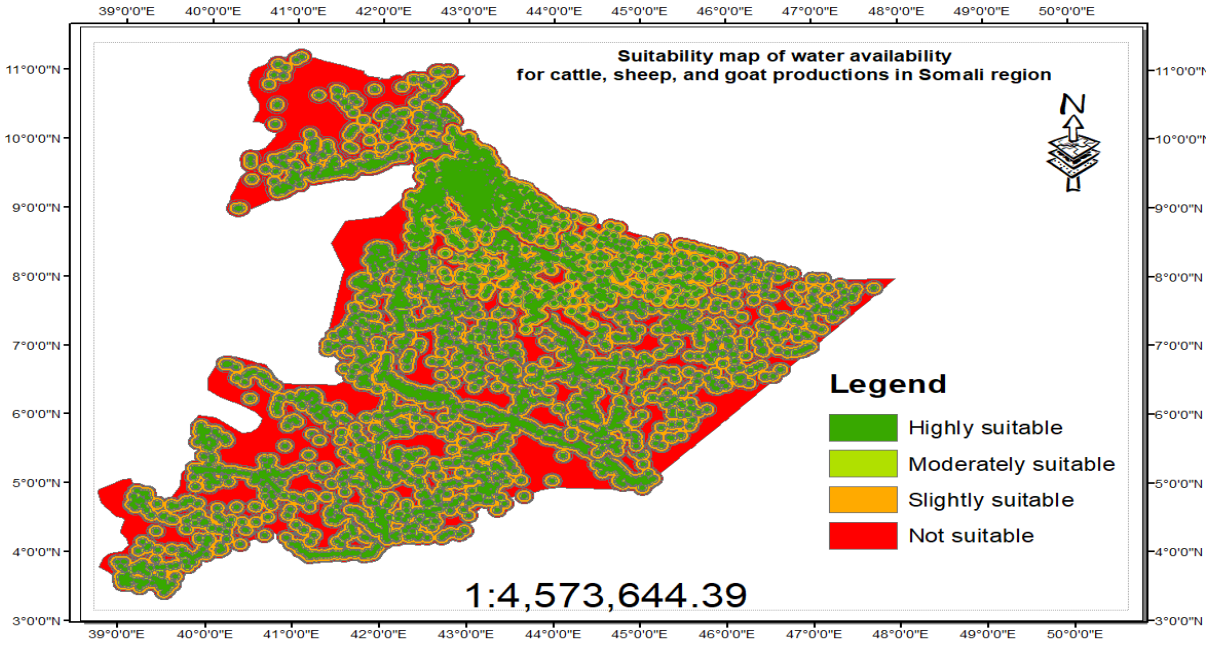


Figure. 3.10 Available water sources suitability for cattle, sheep, and goat productions

Overall suitability analysis

The partial suitability classes for each of the selected livestock species were overlaid together to generate the final overall suitability class. The results showed that, 15.3%, 51.4%, 22.7%, and 10.5% of the study area were highly, moderately, slightly, and not suitable for camel production, respectively. Hence only 10.5% of the study area was not suitable for camel production. The major limiting factor were low vegetation cover at cropland plains in Fafan Zone, and bare soil and exposed rock surface in Sitti Zone. The other limiting factors were very low rainfall (< 200 mm/year) and high temperature (> 36 ^{0} C) in the south- eastern part of the region. The result also revealed that largest portion of the study area was found to be highly (49.1%), moderately (10.4%), and slightly (30.7%) suitable for local goat production, while a small portion (9.9%) was not suitable. The major limiting factors were the same as for camel production, but the temperature threshold was lower (> 30 ^{0} C) and affected the northern part of the region as well.

Table 6. Land Suitability Evaluation Result for Livestock and their Share of area distribution (ha & %)

livestock species	**Overall suitability analysis**				
Cattle	**S1**	**S2**	**S3**	**N**	**Total**
Area in ha	99720	960601.6	1660019	1028291	3748632
%	2.7	25.6	44.3	27.4	100
Camel					
Area in ha	575016	1927698	776976.8	468702.4	3748632
%	15.3	51.4	22.7	10.5	100
Goat					
Area in ha	390259.2	1839976	1149251	369724.8	3748632
%	10.4	49.1	30.7	9.9	100
Sheep					
Area in ha	216054.4	1488899	1348614	694473.6	3748632
%	5.8	39.7	35.9	18.5	100

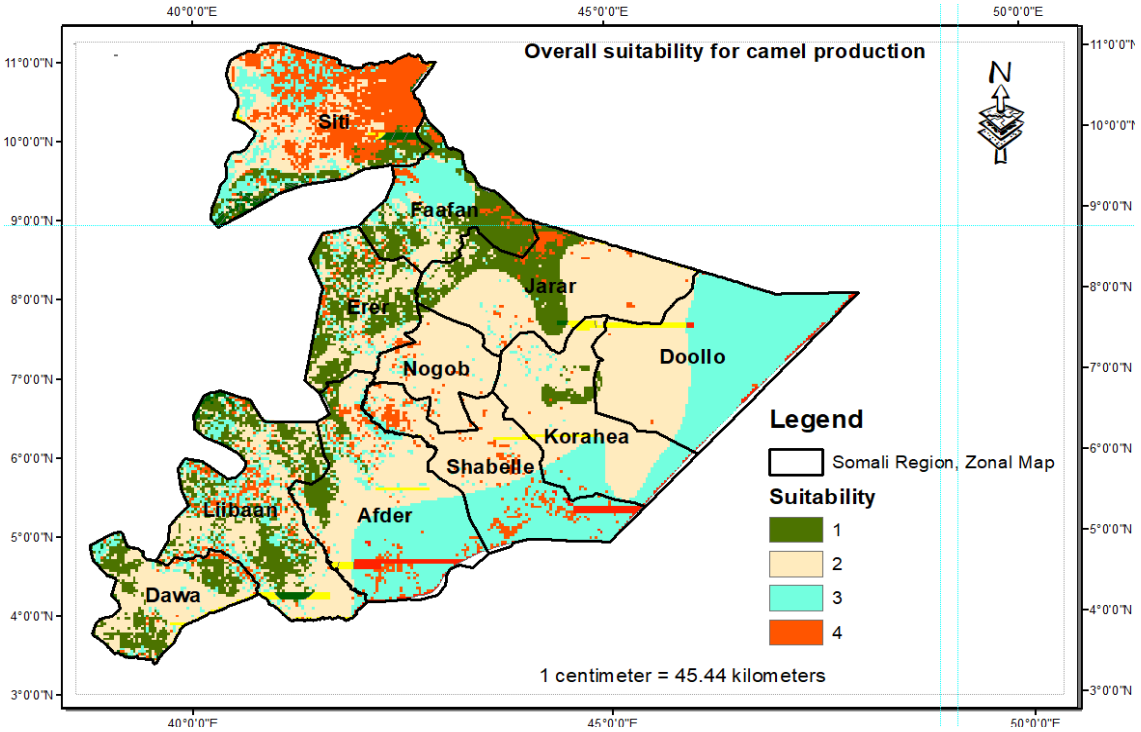


Figure 3.11 Overall suitability for camel production

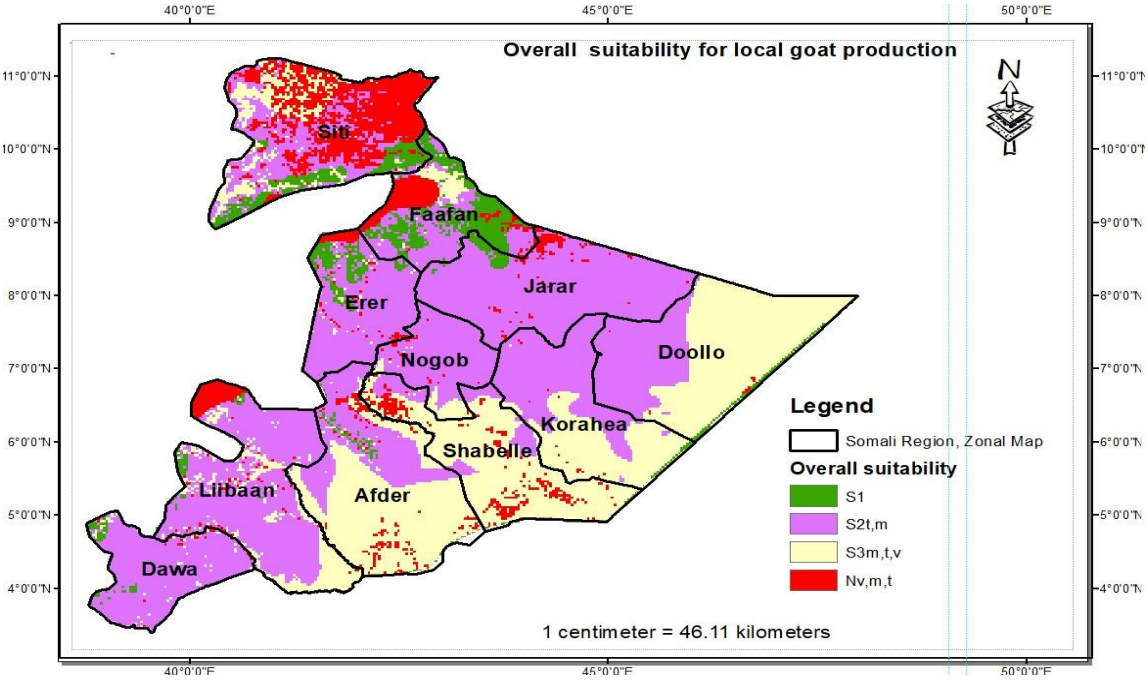


Figure 3.12. Overall suitability for goat production

The results indicated that 5.8%, 39.7%, 35.9%, and 18.5% of the study area were highly, moderately, slightly, and not suitable for local sheep production, respectively. The major limitations for the sustained production of this species were shortage of pasture due to low rainfall, bush encroachment, and exposed nature of the soil surface. In addition, high temperature (> 30 ^{0}C) in south -eastern and northern part of the region was the other limiting factor. The study also showed that 2.7%, 25.6%, and 44.3% of the study area were highly, moderately, and slightly suitable for cattle production, respectively, while 27.4% of it was not suitable. The limiting factors for cattle production were low annual rainfall, undulating landform, and high temperature regime, which were not favourable for the optimal performance of the species.

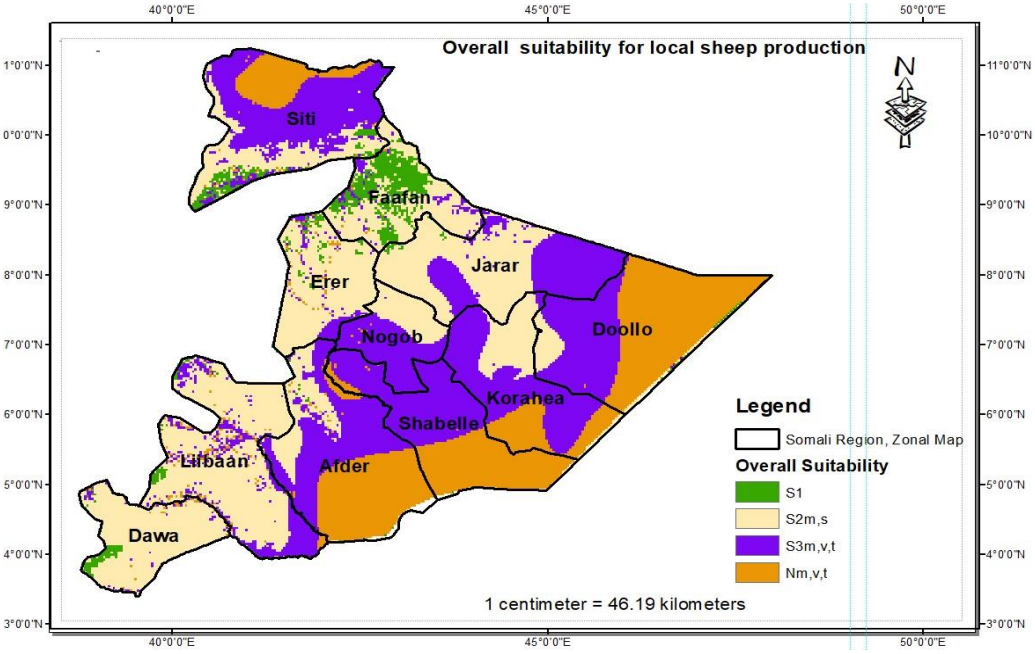


Figure 3.13. Overall suitability for sheep production

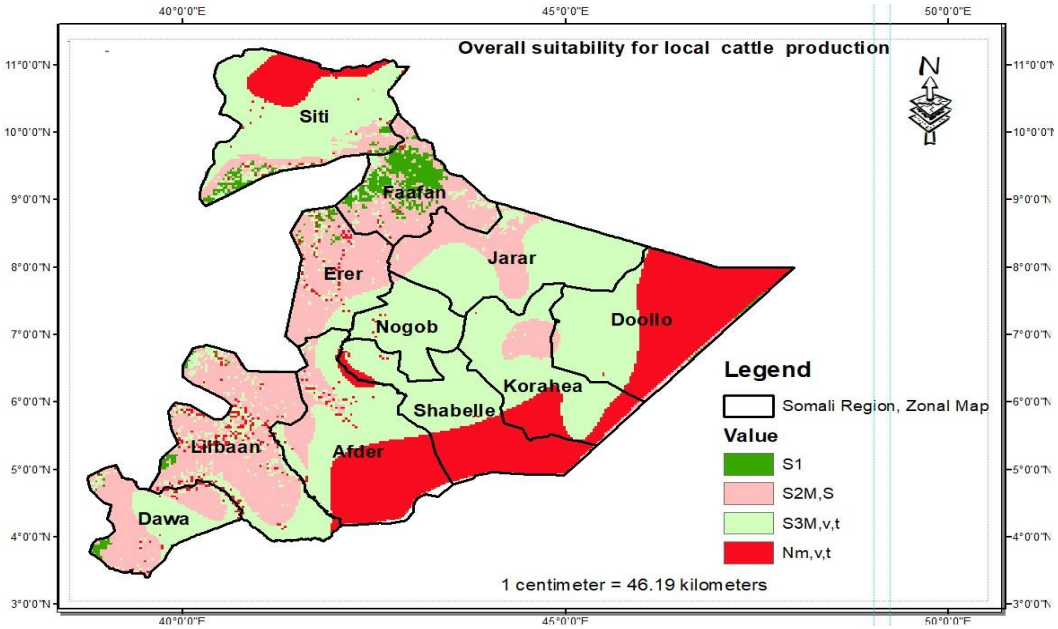


Figure 3.14. Overall suitability for cattle production

Conclusion and recommendations

The study identified the biophysical land characteristic of the study area and matched the land use requirements of four livestock species. The majority of the study area was more suitable for browser stocks, such as camel and goat, than for cattle and sheep. About 70% and 60% of the rangelands were marginally to not suitable for cattle and sheep productions under free grazing condition, respectively. The major limitations for sustained livestock production were shortage and erratic nature of rainfall, high temperature, and open shrubland dominated rangelands of the study area. Based on the identified qualities and limitations of land resources, majority of Somali region, particularly hot arid, semi-arid, and sub-moist lowland areas had a huge potential rangeland for sustained camel and goat production under extensive pastoral system. Hence, it is recommended that separate rangelands should be allocated for each livestock type to improve productivity. This study can provide insights for policy and decision makers to formulate environmental and rangeland policies to identify land characteristics and separate the rangeland for each livestock category.

References

Arjjumend, H., Shibata, S., and Fakana, S. T. (2018). Ecosystem services of forest ecosystem in Nech Sar National Park, Ethiopia: identifying the challenges and conservation measures. *Journal of Global Resources*, 4, 18–29.

Food and Agriculture Organization (FAO). (1991). Guidelines: Land evaluation for extensive grazing. Soils bulletin 58. FAO, Rome.

Gavili, H., Ghasriani, F., Arzani, H., Vahabi, M., and Amiri, F. (2011). Determine water resources accessibility for sheep grazing by GIS technology (Case study: Feraidun Shahr rangeland in Isfahan Province). *J. Appl. RS GIS Technology, Natural Resources Research*, 1, 89–99.

NRCS. (1997). *National Range and Pasture Handbook*, Create Space Independent Publishing Platform, Carolina, USA.

Legese, B., and Balew, A. (2021). Land-use and land-cover change in the lowlands of Bale zone, Ethiopia: its driving factors and impacts of rangeland dynamics in livestock mobility. Environmental Monitoring and Assessment, 193, Article 77. https://doi.org/10.1007/s10661-021-08826-0

Terfa B. K. and Suryabhagavan, K. V. (2015). Rangeland suitability evaluation for livestock production using remote sensing and GIS techniques in Dire district, southern Ethiopia," *Glob. J. Sci. Front. Res. H Environ. Earth Sci*., 15, 1-12.

Tongway, J. A. and Ludwig, J. A. (2010). Restoring Disturbed Landscapes: Putting Principles into Practice, Island Press, Washington, DC, USA.

Squires, V. R. (2010). People in Rangelands: Role and Influence on Rangeland Utilization and Sustainable Management. Range and Animal Sciences and Resources Management, vol. 1.

Yu, L. Zhou, W. Liu, W., and Zhou, H.-K. (2010). Using remote sensing and GIS technologies to estimate grass yield and livestock carrying capacity of alpine grasslands in Golog Prefecture, China. *Pedosphere,* 20(3): 342–351.

Determination Haricot Bean Water Requirement and Scheduling at Gode, Dolo-Ado, Jarati and Kalafo Districts of Somali Region, Ethiopia, 2023

Somali Region pastoral and Agro-Pastoral research Institute (SoRPARI), Soil and Water Research Directorate

Abdinasir Ismail[1], Tesfu Mingistu[1], Abdirizak Abdulahi[2], Abdi Ali[2] Ibrahim Ma`ow[2]

Abstract

Irrigation is a vital practice for enhancing crop production and food security in Ethiopia, especially in the arid and semi-arid regions. The objective of this study was to determine the water requirement and scheduling of haricot bean in four districts of the Somali Region. The experiment was conducted at four locations (Gode, Kelafo, Jarati, and Dolo Ado) using a Randomized Complete Block Design (RCBD) with three replications. The treatments consisted of five levels of soil moisture depletion (SMD) (60%, 80%, 100%, 120% and 140%). Soil samples (0-30 cm and 30-60 cm) from the experimental field were analyzed. The data on growth, yield and yield components of haricot bean were recorded. The analysis of variance revealed that the grain and total biomass yield of haricot bean were not significantly (P>0.05) influenced by the different soil moisture depletion levels. But, water productivity was found to be highly significantly (P<0.01) affected by the treatments. A significantly higher Water Productivity was recorded when the haricot bean was irrigated at 120% ASMDL. Even though statistically not significant, a relatively higher grain and Biomass yield was also obtained when the crop was irrigated at 120% ASWDL. Irrigating haricot bean at the different depletion level within +/- 40% ASMDL didn't affect all the crop characters (except water productivity) at all study locations. In general, the result showed that farmers can irrigate haricot bean at different ASMDLs without significant yield loss. However, it's better to irrigate at 120% ASMDL at large interval.

Keywords: Crop water requirements, haricot bean, Yield, ASMDL, Somali

INTRODUCTION

Irrigation is a vital practice for enhancing crop production and food security in Ethiopia, especially in the arid and semi-arid regions. However, irrigation water is often used inefficiently and unsustainably, leading to low water productivity and environmental degradation. Therefore, proper irrigation water management is essential to optimize water use and conserve water resources (Derib *et al*., 2011).

The Somali Regional State (SRS) is one of the regions in Ethiopia where irrigation has great potential to improve the livelihoods of the agro-pastoral communities. The Wabi Shebelle river basin, which covers most of the SRS, is one of the 12 major river basins in Ethiopia and has abundant water resources for

irrigation development. However, the irrigation sector in the region faces many challenges, such as lack of sufficient technical skills and knowledge among the irrigation users, lack of appropriate irrigation methods and schemes, and lack of reliable data on crop water requirements and irrigation scheduling (Mesfin et al., 2020).

The potential advantages of small-scale irrigation are well known. Irrigation can reduce crop failure and the variability of rainfall, enabling farmers to increase the quantity of their output by producing two or three harvests annually (as opposed to one), and to raise their incomes by growing high-value cash crops.

To combat excessive irrigation and solve numerous related issues, it is vital to implement appropriate irrigation water management procedures. In this context, techniques for accurately estimating irrigation water requirements are crucial to the management and conservation of water resources. Planning and management of water are crucial for agricultural practices in arid and semi-arid regions. Knowing the crop water requirement is essential for better agricultural water management and conservation(Shah, 2018).

In many ways irrigation scheduling can be regarded as a mature research field which has moved from innovative science into the realms of use, or at most the refinement, of existing practical applications. Water use efficiency (WUE) is commonly described, using a volumetric or hydrological approach, as the fraction of irrigation water that is effectively used by the plant (Koech and Langat, 2018). The water use efficiency is defined as the yield of marketable crop produced per unit of water used as evapotranspiration(Tilahun *et al.*, 2011). However, main objective of this study was to determine the water requirement and scheduling of haricot bean in four districts of the Somali Region.

MATERIALS AND METHODS

Description of the Study Areas

The experiment was conducted in four districts located in the Wabe-shebelle (Gode and Kelafo) and Genale-Dawa (Dolo-Ado and Jarati) basins of Somali region under irrigation condition.

Gode

Gode is located in the South Eastern part of the country. It is 1225 km far from Addis Ababa and 580 km from the regional capital-Jigjiga. It is one of the zones with an extensive flat to gently

sloping topography that accounts for about 94 % of the zone's total area. Gode is characterized by warm and dry climate with a relatively low and erratic rainfall. The mean maximum and minimum annual temperature is 35 and 23.6^{0}C, respectively. About seven soil types occupy the Gode Zone, but he predominant soil types are calcic Xerosols, Orthic Solonchacks (Petrogrypesic phase) and Gypsic Yermosols (Saline Phase).

Dollo Ado

Dollo Ado is one of the districts in Liben Zone, Somali Regional State, located 300 kms to the east of Negelle. It is located between 4˚24 AND latitude, 41˚38'E longitude and with altitude that ranges from 200 to 1000 meters above sea level. Dollo ado is bordered to the northwest by Filtu, on the northeast by Afder Zone, on the southeast by Somalia, and on the south by Kenya. The total area of the woreda is estimated about 30, 5258 hectares (Degu, 2020; Wikipedia).

The Climate of Dolo Ado is arid to Semi-arid, with low and erratic rainfall of high annual and seasonal variability. The average yearly rainfall is 270 mm/year (without the extreme rainfall of 1997). The rainfall pattern is bimodal experiencing two rainy seasons per year: the main rainy season-locally known as *Gu* extends from March to June and the short rain season called *Deyr*, from October to December. The Gu rains are important for local livelihoods as they mark the end of the long dry season (Jilaal) replenishing river flow, beginning of agricultural production and regeneration of pastures (grasslands) (Heijden et al., 2020)

According to the WRB's soil map, about four major soil types have been identified to occur in Dolo Ado district, these are: Fluvisols (deposited by seasonal streams on the floodplains along the river Genale and Dawa), Gypsisols (dominant in the central rangelands), Leptosols and Solonchaks (present in the west) (Heijden et al., 2020).

Jarati

Jarati is one of the woredas in the Somali Region of Ethiopia, named after its major town, Melka Jairati. Jarati is bordered on the southwest by the Ganale Dorya River which separates it from the Liben Zone, on the west by Goro Bekeksa, on the north by Elekere, on the east by Afder, and on the southeast by Dolobay. The altitude of this woreda ranges from 750 to 1700 meters above sea level. Other rivers in Jarati include the Mena and the Weyib. (https://en.wikipedia.org/wiki/Chereti_(woreda))

Kelafo

Kelafo is a district in Shebelle zone of the Somali Region of Ethiopia. The major town in the district is Kelafo, which is located on the Shebelle River. It is located between 5˚37'N latitude, and 44˚08'E longitude, with an altitude of 247 meters above sea level. The district is mostly arid and semi-arid, with low rainfall and high temperatures. The mean annual rainfall, maximum, and minimum temperatures of the area are 190mm, 32.92 ^{o}C, and 22.93 ^{o}C, respectively. The main economic activities are livestock rearing and agriculture, especially along the river banks. The district is also affected by recurrent floods, droughts, and invasive plants (https://en.wikipedia.org/wiki/Kelafo).

Experimental Design and Treatments

The experiment was conducted at four locations (Gode, Kelafo, Jarati, and Dolo ado) using a Randomized Complete Block Design (RCBD) with three replications. The treatments consisted of irrigating haricot bean at five different soil moisture depletion levels, namely 60%, 80%, 100%, 120% and 140% of the FAO recommended allowable soil moisture depletion (ASMD) for beans, which is 45% (Allen *et al*., 1998). The treatments were obtained by increasing or decreasing the ASMD by 20% and 40%. The SMD levels were randomly assigned to the experimental plots, each measuring 4 m by 2.4 m (9.6 m2). Each plot had six rows of haricot beans, spaced 40 cm apart, with 10 cm between plants within a row. The plots were separated by 1 m within a block and by 1.5 m between blocks. A predetermined amount of irrigation water was applied to each plot using a parshal flume

Table 1: Treatment combinations and description

No	Treatment Description	Code
1	60% of ASMDL (-40%)	T1
2	80% of ASMDL (-20%)	T2
3	100% of ASMDL (Control)	T3
4	120% of ASMDL (+20%)	T4
5	140% of ASMDL (+40%)	T5

*ASMDL is available soil moisture depletion level according to FAO (33)

Estimation of Crop Water Requirement

The amount of irrigation water applied was estimated using the CROPWAT model version 8.0 (FAO, 2009), which is based on the actual daily weather data collected at the nearby meteorological stations of each study location. The model uses inputs of weather, crop and soil data, as well as irrigation and rainfall data, to calculate irrigation requirements and scheduling by performing a daily water balance (Allen et al., 1998). The model also uses the FAO Penman-Montieth equation (Allen et al., 1998) to compute ETo from the daily weather data (maximum and minimum temperatures, humidity, wind speed and actual sunshine hours) and the geographical information (coordinates and altitude of the location) using equation 1

$$ETo = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad \ldots\ldots\ldots\ldots (1)$$

Where

- ETo -reference evapotranspiration (mm/day),
- Rn -net radiation at the crop surface (MJ/m2/day),
- G -soil heat flux density (MJ/m2/day),
- T -mean daily air temperature at 2 m height (^{o}C),
- u2 -wind speed at 2 m height (m/s),
- es-saturation vapour pressure (kPa),
- ea -actual vapour pressure (kPa),
- es - ea -saturation vapour pressure deficit (kPa),
- Δ -slope vapour pressure curve (kPa/^{o}C) and
- γ -psychrometric constant (kPa/^{o}C)

Crop evapotranspiration was calculated from reference evapotranspiration and crop coefficient value over a given period using equation 2. Four stages of plant growth were used in determining water requirement of the crop. The crop growth stages include initial stage, development stage, and mid-season and late season stage.

$$ETc = ETo \times Kc \quad \ldots\ldots\ldots\ldots (2)$$

Where ETc is crop evapotranspiration (mm/day), Kc is crop coefficient, and ETo is reference evapotranspiration (mm/day).

The respective depletion level of each treatment was followed to determine the amount of water applied at each irrigation interval. Based on equation 3, the net irrigation water requirement was determined based on the water holding capacity of the soil from depletion level to field capacity in the effective root depth for each treatment.

$$In = (FC-PWP)*P*\rho *Rd- Pe \quad \ldots\ldots\ldots\

Data collection

Soil sampling and analysis

Soil samples were taken from two depths of 0-30 cm and 30-60 cm along the diagonal of the experimental field to determine soil texture, pH, electrical conductivity (EC), CEC, organic carbon (OC), bulk density (BD), field capacity (FC) and permanent wilting point (PWP). The particle size distributions in the soil were determined using the hydrometric method. The pH of the soil was measured in a soil-water mixture of 1:2.5 using a pH meter. The electrical conductivity of the saturated soil paste extracts (EC_e) was determined using electric conductivity meter on the saturated soil paste extract as outlined by US Salinity Laboratory Staff (1954). Cation exchange capacity (CEC) was determined by extracting the ammonium acetate saturated soil samples by sodium chloride solution. Then the ammonium displaced from the soil exchange site was distilled and the evolved ammonia was determined by the macro-Kjeldhal method (Jackson, 1958) and its concentration was reported as CEC.

The Walkely and Black (1934) method was used to determine organic carbon content of the soils and the organic matter content was obtained by multiplying the percent organic carbon by conversion factor of 1.724.

The field capacity and the permanent wilting point of the soil were analyzed in the laboratory with a ceramic plate apparatus at a pressure of 1 bar (for field capacity) and 15 bar (for permanent wilting point). The soil was also examined for infiltration using double ring Infiltrometers. Soil bulk density was determined from undisturbed soil samples using a core sampler measuring 2.5 cm diameter and 2.5 in (12.27 cm3) high. The bulk density was then calculated as the ratio of the dry weight of the soil to the known volume of the cylindrical core sampler.

Crop data

The data on growth, yield and yield components of haricot bean were recorded from ten plants of the central rows which were selected randomly in each plot as specified in each plant characters below. However, data for days to emergence, days to flowering, days to maturity, grain and biomass yield of the crop were collected from the net plot.

- **Days to 50% flowering:** This was recorded as the number of days from sowing to the time at which 50% of the plants in a plot were flowered.

- **Days to 90% physiological maturity**: This was recorded as the number of days from sowing to the date at which 90% of the plants in a plot attained physiological maturity, the stage at which pods lose their pigmentation and begin to dry.

- **Plant height (cm)**: plant height was measured from ground level to the tip of the plant at physiological maturity from ten randomly taken plants.

- **Number of pods per plant**: Number of pods per plant was recorded by counting the total number of pods from ten plants and their average was taken as the number of pods per plant at harvest.

- **Grain yield (kg ha^{-1}):** Grain yield that was obtained from central rows of each experimental plot was converted to hectare bases after being adjusted to 10% grain moisture content.

- **Water Productivity:** Water productivity (WP) was calculated as a ratio of yield to the total ETc through the crop growing season using equation 7 (Molden *et al*., 2010).

$$WP = Ya/ET \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7$$

Where WP is water productivity (kg/m3), Ya is crop yield (kg/ha) and ETa is the seasonal crop water consumption by evapotranspiration (m3/ha).

Data Analysis

All the data collected were subjected to the analysis of variance (ANOVA) using statistical analysis system (SAS) software using the GLM procedure (SAS Institute, 1998). The significance between mean values was expressed by Least Significant difference (LSD) tests at 5% probability level.

RESULTS AND DISCUSSION

Physio-chemical properties of soils of the study areas

Table 2 shows the soil test results of the four study locations: Jarati, Kelafo, Dolo Addo, and Gode. The soils of Jarati, Dolo Addo, and Kelafo had a sandy clay loam texture, while soils of Gode had a sandy clay texture. The soil bulk density values of all the study locations were below the critical value of the respective textural classes, indicating the suitability of the soil for plant growth. Similarly, the total soil porosity of all the study locations represented ideal condition for the growth of plants. Except for Jarati which had a strongly alkaline reaction (pH >8.0), the soils of all the other study locations were rated as moderately alkaline (pH: 7.4-8.0) (Tekalign, 1991). The soils of all the study locations were non saline with EC values of less than 1ds/m. The CEC values were very high for Jarati and Dolo Addo, and high for Kelafo and Gode. The soils of all the study locations had low organic matter and available phosphorous. The total nitrogen was also low for Jarati and Dolo Addo, but very low for Gode and Kelafo, according to Tekalign's (1991) rating. The exchangeable Magnesium and Sodium were, respectively rated as very high and high for all the study location; the exchangeable K is high for Jarati and Dolo addo, but medium for Gode and Kelafo. Exchangeable calcium was very high for Jarati, Dolo-addo, and Kelafo soils, but high for Gode (FAO, 2006).

Table 2 Physico chemical properties of soils of the study areas

Soil properties	Jarati	Dolo Addo	Kelafo	Gode
Texture	SCL	SCL	SCL	SC
BD (g/cm^3)	1.101	1.106	1.136	1.121
Porosity (%)	58.467	58.274	57.121	57.697
pH (H_2O)	8.06	7.99	7.59	7.62
EC(ds/m)	0.108	0.095	0.053	0.065
TN (%)	0.126	0.118	0.092	0.098
OM (%)	1.705	1.673	1.383	1.448
Available P (ppm)	9.07	7.744	5.581	6.512
CEC ($Cmol_{(+)}/kg$)	49	48.4	37	39
Ex. K($Cmol_{(+)}/kg$)	0.883	0.605	0.58	0.454
Ex. Na($Cmol_{(+)}/kg$)	1.193	0.977	0.941	0.671
Ex. Ca($Cmol_{(+)}/kg$)	26.94	26.28	27.11	18.89
Ex. Mg($Cmol_{(+)}/kg$)	11.588	12.01	8.217	8.849

BD=Bulk Density, EC=Electrical conductivity, TN=Total Nitrogen, OM=Organic matter, CEC=Cation Exchange Capacity, Ex. =Exchangeable

Days to emergence, flowering, maturity and number of pods per plant

As indicated the table 3 the main effects of the different soil moisture depletion levels had no significant (P>0.05) effect on days to emergence, days to flowering, days to maturity and number of pods per plant. However, a highly significant variation (P < 0.01) was recorded across the study locations regarding these parameters. Haricot bean was observed to emerge early in Jarati (3.5 days) and relatively late at Dolo ado (4.4 days). The variation in soil temperature, soil aeration and depth of planting may be responsible for the differences observed in days to emergence across the study locations. The flowering and subsequent maturity of haricot bean was early at Dolo-ado and these were late at Kelafo. A significantly higher number of pods per plant (33.57) was obtained at Dolo ado, while the lowest number (3.1) was recorded at Gode.

Table 3. Days to emergence, days to flowering, days to maturity and number of pods per plant of haricot bean as affected by ASWDL & Location

Factors	DTE	DTF	DTM	NPPP
ASWDL				
60%	3.92	51.67	65.75	17.84
80%	3.92	52.58	65.92	17.72
100%	3.92	53.5	66.17	17.37
120%	3.75	52.33	65.83	17.03
140%	3.92	53.17	66.92	17.00
LSD (0.05)	NS	NS	NS	NS
Location				
Jarati	3.5c	43.87bc	57.4c	13.28c
Gode	3.6c	43.60b	69.47b	3.16d
Dolo Ado	4.4a	42.47c	56.93c	33.57a
Kelafo	4.0b	58.76a	80.67a	19.55b
LSD (0.05)	**	**	**	**
CV(%)	10.56	3.15	2.09	9.69

ASWDL=Available Soil Water Depletion Level, DTE=Days to Emergence, DTF=Days to flowering, DTM= days to maturity, NPPP= Number of pods per plant

Grain yield, total above ground Biomass yield and water productivity

The analysis of variance revealed that the grain and total biomass yield of haricot bean were not significantly (P>0.05) influenced by the different soil moisture depletion levels. However, water productivity was found to be highly significantly (P<0.01) affected by the treatments. A significantly higher Water Productivity was recorded when the haricot bean was irrigated at 120% ASMDL. Even though statistically not significant, a relatively higher grain and Biomass yield was also obtained when the crop was irrigated at 120% ASWDL. Nevertheless, location had a highly significant effect (P<0.01) on grain and biomass yield as well as water productivity of haricot bean (table 4). The highest and lowest grain yield and water productivity were respectively recorded at Jarati (1222.2kg/ha, 0.254kg/m^3) and Gode (414.18kg/ha, 0.073kg/m^3). Whereas the highest and lowest biomass yield was obtained from Gode (7258.8kg/ha) and Kelafo (2612.8kg/ha), respectively.

Table 4 Grain yield, total above ground biomass yield and water productivity of haricot bean as affected by ASWDL and Location

Factors	Grain yield (kg/ha)	Biomass yield (Kg/ha)	Water Productivity (kg/m^3)
ASWDL			
60%	703.54	5191.1	0.119c
80%	711.08	5552.8	0.127bc
100%	762.81	4566.8	0.149bc
120%	829.78	5576.5	0.183a
140%	744.41	5671.1	0.159ab
LSD (0.05)	NS	NS	**
Location			
Jarati	1222.2a	7208.3a	0.254a
Gode	414.18c	7258.8a	0.073c
Dolo Ado	909.38b	4166.7b	0.174b
Kelafo	455.51c	2612.8b	0.089c
LSD (0.05)	**	**	**
CV(%)	25.64	44.79	25.83

LSD=Least Significant Difference, CV=Coefficient of variation

The results of this study show that haricot bean yield and water productivity are influenced by both soil moisture depletion levels and location. The soil moisture depletion levels affect the water productivity more than the yield, indicating that haricot bean can adapt to different water stress conditions without compromising its productivity. However, the optimal soil moisture depletion level for maximizing water productivity was found to be 120%, which is higher than the commonly recommended level. This suggests that haricot bean can be irrigated less frequently and with less water than previously thought, which could save water resources and reduce irrigation costs.

The location effect on yield and water productivity was highly significant, reflecting the variability of soil and climatic factors among the four districts. Jarati had the highest yield and water productivity, while Gode had the lowest. This could be attributed to the differences in soil and climatic conditions. Gode had the highest biomass yield, but the lowest grain yield, indicating a low harvest index. This could be due to the high temperature and evaporation in Gode, which might have reduced the grain filling and increased the vegetative growth.

The results of this study have important implications for the sustainable management of haricot bean irrigation in the Somali Region of Ethiopia. By optimizing the irrigation schedule based on the soil moisture depletion levels and the location-specific factors, farmers can improve the water use efficiency and the profitability of haricot bean cultivation.

However, the yield obtained at all the locations was much lower than the national average, suggesting that there are other constraints or challenges that limit the productivity of haricot bean in the study areas. These factors need to be addressed in order to improve the yield potential of haricot bean.

CONCLUSION AND RECOMMENDATION

Conclusion

Irrigating haricot bean at the different depletion level within +/- 40% ASMDL didn't affect all the crop characters (except water productivity) at all study locations. However, a highly significant variation was observed among the study locations regarding all the studied characters of the crop. The highest grain yield of haricot bean (1222.2kg/ha) was recorded at Jarati which was 198% and 168% greater than at Gode and Kelafo, respectively. A significantly higher Crop Water Productivity was recorded when the crop was irrigated at 120% ASMDL. Even though statistically not significant, a relatively higher grain yield & Biomass yield was also obtained when the crop was irrigated at 120% ASWDL. In general, the result showed that farmers can irrigate haricot bean at different ASMDLs without significant yield loss. However, it's better to irrigate at 120% ASMDL at large interval. The yield obtained is much lower than the national average. This suggests that there are other constraints or challenges that limit the productivity of haricot bean in the study areas. These factors need to be addressed in order to improve the yield potential of haricot bean.

Recommendations

Based on the findings of this study, the following recommendations are made

- Researchers should conduct further experiments to identify heat tolerant, adaptable and high-yielding haricot bean varieties and then determine the optimal irrigation interval for these varieties under different locations and seasons, taking into account the variability and uncertainty of weather patterns.
- Future research should explore the reasons for the variation among locations and identify the optimal agronomic practices for each location to enhance haricot bean productivity and profitability**.**

REFERENCES

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M., 1998. Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56. FAO, Rome, 300(9), p.D05109.

Derib, Sisay Demeku, Descheemaeker, Katrien, Haileslassie, Amare, & Amede, Tilahun. (2011). Irrigation water productivity as affected by water management in a small-scale irrigation scheme in the Blue Nile basin, Ethiopia. *Experimental agriculture, 47*(S1), 39-55.

FAO (Food and Agricultural Organization) 2002. Irrigation manual: planning, development, monitoring and evaluation of irrigated agriculture with farmer's participation. 2 (7): FAO-SAFR. Harare, Zimbabwe.

FAO (Food and Agriculture Organization) (2009). CropWat for windows version 8.0. FAO, Rome, Italy.

Graham, PH, & Ranalli, P. (1997). Common bean (Phaseolus vulgaris L.). *Field Crops Research, 53*(1-3), 131-146.

Ketema Tezera, Gobena Dirirsa, Tilahun Hordofa, Tatek Wendimu, Abera Tesfaye, Gebeyehu Ashame,Tigist Worku, Aynalem Gurms.2022. Effect of Optimal Irrigation Scheduling on Yield and Water Productivity of Haricot Bean (Phaseolus vulgaris L.) at Melkassa, Central Rift Valley of Ethiopia. *Journal of Natural Sciences Research*, 13(5): 1-8.

Koech, Richard, & Langat, Philip. (2018). Improving irrigation water use efficiency: A review of advances, challenges and opportunities in the Australian context. *Water, 10*(12), 1771.

Meja, M., Bassa, M., & Mirkeno, T. (2020). Assessing the Challenges of Irrigation Development in Ethiopia: A Review. International Journal of Engineering Research & Technology, 9(1), 1-8

Molden D, Oweis T, Steduto P, Bindraban P, Hanjra MA, Kijne J (2010). Improving agricultural water productivity: Between optimism and caution. Agric. Water Manag. 97: 528–553.

Shah, Vijeta. (2018). Determination of crop water requirements and irrigation scheduling using CROPWAT: a case study of Waghodia region. *Int J Innov Res Sci Eng Technol*, *7*(2), 1137-1144.

Tekalign Tadese. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa.

Tilahun, Hordofa, Teklu, Erkossa, Michael, Menkir, Fitsum, Hagos, & Awulachew, Seleshi Bekele. (2011). Comparative performance of irrigated and rainfed agriculture in Ethiopia. *World Applied Sciences Journal, 14*(2), 235-244.

Turuko, Meseret, & Mohammed, Amin. (2014). Effect of different phosphorus fertilizer rates on growth, dry matter yield and yield components of common bean (Phaseolus vulgaris L.). *World Journal of Agricultural Research, 2*(3), 88-92.

Effect of Moisture Conservation on Yield and Yield Components of Maize (*Zea mays* L.) in Gursum (Fafan) District, Somali Region, Ethiopia

Mohamed Abdirahman[1], Abdi Husen Meydane[1], Mustafa Ismail[2]

[1]Fafan Agricultural Research Center (FARC), Fafan, Somali Region, Ethiopia

Corresponding author: Email:themaame77@gmail.com

Somali Region pastoral and Agro-Pastoral research Institute (SoRPARI), Soil and Water Research Directorate

ABSTRACT

Soil moisture and nutrients conservation are the most essential factors for plant growth. A field experiment was conducted to investigate the effects of in-situ moisture conservation methods on yield and yield components of maize at Gola-aha site, Fafan center, Fafan zone, Somali regional state in 2023 cropping season. The experiment consisted of four treatments (tied ridge with mulching, flat bed with mulching, tied ridge, and flat bed planting), arranged in a Randomized Complete Block Design with three replications. The results showed that flat bed planting had the longest duration to emergence (6.78 days), tasseling (72.87days), and silking (76.13days), while tied ridge with mulching had the longest duration to physiological maturity (122 days). Tied ridge with mulching also produced the tallest plants (175.50cm), longest ear (23.41cm), the highest number of ears per plant (1.90), and thousand kernel weight (394.4g). The highest grain yields (5842 kg ha^{-1}) and above ground biomass yield (15556 kg ha^{-1}) was also obtained from tied ridge with mulching. The study concluded that maize planted on tied ridge with mulching had the best performance and was preferable to other moisture conservation methods.

Keywords*:* maize**,** moisture conservation, mulching, tied-ridge, yield,

INTRODUCTION

Maize (*Zea mays* L.) a member of the grass family, *Poaceae* is one of the most important cereal crops in the world. It ranks third in world production after wheat and rice (FAOSTAT, 2016). Maize is originated in Central America and was introduced to West Africa in the early 1500s by the Portuguese traders. It was introduced to Ethiopia during the 1960s to 1970s. Today maize is one of the most important food crops worldwide. It is grown in most parts of the world over a wide range of environmental conditions, ranging between 50° latitude north and south of equator. It also grows from sea level to over 3000 meters above sea level (MoA, 2011). Ethiopia is the fourth largest maize producing country in Africa, and first in the East African region in terms of production (Tolessa, 1993). In view of its high demand for food grains and high yield per unit area, maize has been among the leading food grains selected to achieve food self-sufficiency in Ethiopia (Tolessa, 1993).

In Ethiopia, maize grows from moisture stress areas to high rainfall areas and from lowlands to the highlands. It is largely produced in Western, Central, Southern and Eastern parts of the country (MoA, 2015). Maize is produced mainly for food, especially, in major maize producing regions particularly for low-income groups; it is also used as staple food. Maize is consumed as "Injera", Porridge, Bread and "Nefro." It is also consumed roasted or boiled as vegetables at green stage. In addition to these, it is used to prepare local alcoholic drinks known as "Tella" and "Arekie." The leaf and stalk are used for animal feed and also dried stalk and cob are used for fuel. It is also used as industrial raw material for oil and glucose production (MoA, 2015).

The 2017/18 *Meher* season post-harvest crop production survey indicated that at the national level, about 16.79% (2,128,948.91 hectares) of the land area was covered by maize and production of grain was about 27.43% or 83,958,87.24 tons with an average yield of 3.9 t·ha^{-1} (CSA, 2018). Maize is the second important cereal crop in area coverage and production following sorghum, but first in productivity among the cereal crops in Eastern Ethiopia (CSA, 2017). Likewise, as per CSA's report, in Fafan zone of Somali region, during the 2016/17 *Meher* season maize covered an area of about 21,313.72 ha with total grain production and average productivity of 45,873.828 tons and 2.15 t· ha^{-1}, respectively (CSA, 2017). Even though maize has multiple purposes and high yielding potential, the average grain yield for Fafan zone (2.15 t·

ha^{-1}) is lower than the national (3.67 t ha^{-1}) as well as the global average (6.2 t ha^{-1}) (CSA, 2017; ATA, 2014)

Rainfall in Ethiopia is highly variable and unpredictable from year to year, which poses a challenge for crop productivity in dry lowlands. Kidane and Rezene (1989) suggested two possible ways to enhance the efficiency of rainwater use: ($_{i}$) applying agronomic techniques that increase soil moisture infiltration; and ($_{ii}$) selecting crop types and management practices that reduce drought damage throughout the growing season.

Maize is a staple crop in the Somali region, where soil moisture is a critical factor for its production. However, most smallholder farmers in this region do not have sufficient knowledge and skills on how to conserve and manage soil moisture effectively. This results in low maize yields and poor food security. Therefore, this study aimed to identify and evaluate effective and feasible soil moisture conservation methods that can improve maize productivity and resilience in water-scarce areas. The specific objective was to assess the impact of moisture conservation methods on the growth, yield, and yield components of maize.

MATERIALS AND METHODS

Description of the Study Site

The study was conducted at Gola-aha, Fafan center, Fafan zone, Somali Regional State, in the 2023 cropping season. The study area lies 563 km east of Addis Ababa and 45 km west of Jigjiga, between 9° 24’ N latitude and 42° 6’ E longitude, at an elevation of 1442 m above sea level (Degefu *et al*., 2011).

The climate is generally semiarid with an annual rainfall that varies from 500 to 600 mm and the annual average evapo-transpiration is estimated to be 1476 to 1686 mm/year (Keskes *et al*., 2013). The mean monthly minimum temperature varies from 5.8 ℃ in November to 14 ℃ from July to September and the mean monthly maximum temperature varies from 25 ℃ in July to 29 ℃ from March to April (Wudie, 2006). Like other parts of the Fafan zone, the rainy season (Gu) in Fafen Sub-Basin has three sub seasons: *Dira* (April – May), *Hagaa* (June – July) and *Karan* (August – September) all of which are equally important for cultivation of crops; availability of water and pasture for livestock. Furthermore, the dry season, *Jilaal* (October – March) is divided

into two sub seasons: *Deyr* (October – November) and *Kalil* (December – March) (Devereux, 2006). The major annual crops grown in the area include; cereals (sorghum, maize and wheat), Oil crops (Groundnuts), vegetables (onion and tomato). Maize, Sorghum, Wheat and *Chat* are the most common one (Aklilu and Mekiso, 2015). The soil is a well-drained sandy clay loam (Amare and Tamado, 2014).

Treatment and Experimental Design

The experiment consisted of four moisture conservation methods (Tied Ridge with mulch, Tied Ridge, Flat with mulch, and Flat planting). The experiment was laid out in a randomized complete block design (RCBD) with three replications. In the Tied Ridge treatments, the ridges were formed before planting along the rows, and the ties were made at 1 m intervals during planting. The ridges were 0.30 m high and 0.25 m wide.

The gross plot area was 11.25 m^2, with dimensions of 3 m by 3.75 m, and each plot had five rows. The plant spacing was 75 cm between rows and 30 cm within rows. The blocks and plots were separated by 1.5 m and 1 m, respectively. Sudan grass was used as a mulch and applied after planting.

Variety Details

MH141 is a maize variety that was developed by the Melkasa Agricultural Research Center from the International Maize and Wheat Improvement Center (CIMMYT) maize lines and released in Ethiopia in 2020. It is adapted to the lowland and mid-altitude dry regions of Ethiopia where the altitude ranges from 1000 to 1800 meters above sea level and the annual rainfall is between 500 and 1000 millimeters. It can produce 6.5 to 8.5 tons per hectare of grain under research station conditions and 4 to 5.5 tons per hectare under farmers' management practices. It has an average maturity period of 120 days.

Table 1: Description of the maize variety used in the experiment

Variable	Variety
	MH141
Year of release	2020
Area of adaptation	
Altitude (m)	1000-1800
Maturity (days)	120
Yield (t/ha)	
On research	6.5-8.5
On farm	4.0-5.5

Data Collection

Phonological Stages

Days to 50% emergence: This was determined as the number of days from planting to the date when 50% of the plants in a plot emerged.

Days to 50% tasseling: This was determined as the number of days from planting to the date when 50% of the plants in a plot started to show tassels.

Days to 50% silking: This was determined as the number of days from planting to the date when 50% of the plants in a plot produced silks.

Days to 90% physiological maturity: This was determined as the number of days from planting to the date when 90% the plants in a plot formed black layer at the base of the seed.

Growth parameters

Plant height (cm): The height of five randomly taken plants were measured after tasseling from ground level to the point where the tassel starts branching and the mean value was recorded as plant height.

Yield and yield components

Number of ears per plant: The numbers of ears were counted from five randomly taken plants from the central rows per plot at harvest and the mean value was calculated**.**

Ear length (cm): This was recorded from the measure of the ear lengths of five randomly taken plants from the central rows at harvest.

Thousand kernel weight (g): weight of 1000 kernels was recorded where the kernels were taken randomly from the net plot after grain yield was determined.

Grain yield (kg ha^{-1}): This refers to the weight of grain harvested from the central three rows of the net plot. Grain yield was adjusted to 12.5% moisture level and converted to kg ha^{-1} basis.

Aboveground biomass (kg ha^{-1}): This was measured based on central three rows of the net plot plants at harvest time after sun drying, and changed to per hectare using respective plant weight for each treatment.

Statistical Data Analysis

The data analysis was performed using SAS computer software (SAS, 2002) following the procedures outlined by Gomez and Gomez (1984). Mean separation was computed using the Least Significant Difference (LSD) test at a 5% probability level when the ANOVA showed significant effects

RESULTS AND DISCUSSION

Phenology parameters

Days to 50% emergence

The effect of soil moisture conservation methods on days to 50% emergence was highly significant ($P<0.01$). The mean days to 50% emergence ranged from 6.0 days for tied ridge with mulching to 6.84 days for flat planting (Table 2). This result suggests that the combination of tied ridge and mulching accelerated the emergence of maize seeds, possibly because it enhanced the soil water infiltration and retention compared to flat planting.

Days to 50% tasseling

Days to 50% tasseling was highly significantly (P<0.01) affected by the moisture conservation methods. The shortest days of tasseling (61.22) was recorded for tied ridge with mulching while the longest (72.87days) was recorded for flat planting. This result indicated that mulching and tied ridge hastened tasseling; this could be due to the increased infiltration and retention of water in the soil by the tied ridge and mulching.

This result agrees with that of Madsen (1992) who reported that the number of days to tasseling and silking of maize was reduced possibly due to their earlier emergence and favorable soil temperature under water hyacinth and rice straw mulches. Similarly, Tolk *et al*. (1999) stated that mulched treatments also maintained significantly greater plant available water than the bare soil until near anthesis and after anthesis which helped earlier initiation of tassel and silk.

Days to 50% silking

Days to 50% silking was found to be highly significantly (P<0.01) influenced due to the effects of moisture conservation methods. The shortest days of silking (65.07) was recorded for tied ridge with mulching, while the longest (76.13 days) was recorded for flat planting (Table 2). This result indicates that the application of mulching and tied ridge advanced the tasseling of maize plants, which could be attributed to the increased soil water availability and temperature under these treatments. This result is consistent with Madsen (1992), who reported that water hyacinth and rice straw mulches reduced the number of days to tasseling and silking of maize by promoting earlier emergence and favorable soil temperature. Similarly, Tolk et al. (1999) stated that mulched treatments maintained significantly greater plant available water than the bare soil until near anthesis and after anthesis, which facilitated earlier initiation of tassel and silk. Furthermore, Lingduo *et al*. (2013) indicated that mulch treatments only resulted in higher soil water storage than the non-mulched crop field treatment during the limited-rainfall season, the cumulative total soil temperature (>10 $^{\circ}$C) values in the upper 5 cm (depth of seeding) soil layer were also enhanced by the gravel mulched field treatment and thus, the seedling emergence was 2 day earlier and the silking stage was 8 day earlier than the non-mulched crop.

Days to 90% physiological maturity

Highly significant (P<0.01) effects of moisture conservation methods was observed on days to 90% physiological maturity. The longest duration (122.days) to 90% physiological maturity was recorded from tied ridge with mulching treatment, while the shortest (110.5days) was recorded for flat planting (Table 2). This could be because tied ridge with mulching reduces environmental stress that might hasten maturity. The result agrees with that of Tolessa (2015) who reported that mulching applied at planting time showed noticeably prolonged days to maturity of maize

Table 2: Effect of moisture conservation methods on days to 50% emergence, tasseling, silking, and physiological maturity of maize

Treatment	Days to 50% emergence	Days to 50% tasselling	Days to 50% silking	Days to 90% maturity
Tied Ridge with mulch	6.0b	61.22c	65.07c	122.0a
Flat bed with mulch	6.10b	63.80b	69.80b	119.7a
Tied Ridge	6.14b	64.22b	66.00c	111.7b
Flat bed	6.78a	72.87a	76.13a	110.5b
LSD $_{(0.05)}$	0.26	0.796	0.881	0.981
CV (%)	4.2	1.4	1.3	1.1

Values sharing similar letters in a column do not differ significantly at p<0.05

Growth Parameters

Plant height (cm)

The effect of moisture conservation treatments on plant height was highly significant (P<0.01). The mean plant height ranged from 139.46 cm for flat bed planting to 175.50 cm for tied ridge with mulching (Table 3). This result suggests that moisture conservation methods increased plant height, possibly by improving soil water availability and temperature. This result is consistent with the findings of El-Nady *et al*. (2013), who reported that mulching condition significantly affected plant height and height growth rate of maize. Singh et al. (2016) also reported that application of rice straw mulch enhanced plant height and yield attributes. Similarly, Yaseen *et*

al. (2014) reported that maximum increase (11.39%) in plant height was recorded on mulch and higher irrigation depth treatments. Khurshid *et al.* (2006) also obtained similar results.

Ear length (cm)

The analysis of variance showed that ear length was highly significantly (P<0.01) influenced by moisture conservation methods. The shortest ear length (16.41cm) was recorded from flat bed planting, while the longest (23.41cm) was obtained from tied ridge with mulching (Table 3). This result agrees with finding of Khan and Parvej (2010) who reported that yield contributing attributes such as number of ears per plant, ear height, length and diameter of ear, tassel length, number of seeds per ear and seeds per row, 1000-grains weight and weight of rachis per ear were significantly affected by zero tillage and different mulches.

Number of ears per plant

Number of ears per plant was highly significantly (P<0.01) affected by moisture conservation methods. Highest number of ears per plant (1.90) was recorded from tied ridge with mulching while the lowest (1.24) was obtained from flat planting. The increased number of ears per plant in tied ridge with mulch resulted from the favorable effects of moisture conservation. These findings corroborate with the results reported by Khan *et al.* (2010) indicating that tied ridge with mulching practices enhanced the number of ears per plant and other yield traits.

Table 3: Effect of moisture conservation methods on growth parameters of maize at Gursum district

Treatment	Plant height (cm)	Ear length (cm)	Number of e ears per plant
Tied Ridge with mulch	175.50a	23.41a	1.90a
Flat bed with mulch	169.14b	20.92b	1.71b
Tied Ridge	141.97c	18.58c	1.40c
Flat bed	139.46c	16.41d	1.23c
LSD $_{(0.05)}$	2.837	0.631	0.0997
CV (%)	1.49	4.07	5.3

Values sharing similar letters in a column do not differ significantly at p<0.05

Yield and Yield Components

Thousand Kernel weight (g)

The analysis of variance indicated that Thousand Kernel weight was highly significantly ($P<0.01$) affected by the moisture conservation methods. The mean Thousand Kernel weight ranged from 363.5 g for flat planting to 394.4 g for tied ridge with mulching (Table 4). This result suggests that the application of mulching and tied ridge created favorable conditions in the soil that increased the weight of the kernels. This result is consistent with the findings of Girma et al. (2005), who reported that moisture conservation methods enhanced the productivity of grain yield and 1000 kernel weight by improving the growth and yield attributes of maize.

Above ground biomass yield (kg/ha)

The analysis of variance showed that aboveground biomass yield was highly significantly ($P<0.01$) affected by the moisture conservation methods. The highest aboveground biomass (15556kg ha^{-1}) was obtained from tied ridge with mulching, while the lowest (13649kg ha^{-1}) was recorded from flat planting (Table 4). This indicates that mulching and tied ridge prolonged the period of water availability which consequently supported better development of crop at later stages resulting in higher yields. These findings also corroborate with the results of Girma *et al*.(2005) who reported that combined application of ridge and furrow plus straw mulching gave more straw yield and other yield related traits than flat planting due to availability of moisture better than separate application. Similarly, these findings are in agreement with the observation of Mnotfo *et al*.(2016) who reported that tied ridges with mulch treatment yielded the highest grain and aboveground biomass.

Grain yield (kg/ha)

The effect of moisture conservation methods on grain yield was also highly significant ($P<0.01$). The mean grain yield ranged from 4173 kg ha^{-1} for flat bed planting to 5842 kg ha^{-1} for tied ridge with mulching (Table 4). This result implies that the application of mulching and tied ridge prolonged the period of water availability, which supported better development of the crop and resulted in higher yields. This result corroborates with the results of Girma et al. (2005), who reported that the combined application of ridge and furrow plus straw mulching gave more straw yield and other yield related traits than flat planting due to the better availability of moisture.

Similarly, this result agrees with the observation of Mnotfo et al. (2016), who reported that tied ridges with mulch treatment yielded the highest grain and aboveground biomass

Table 4. Effect of moisture conservation methods on Thousand Kernel weight (g), Aboveground biomass (kg/ha), and Grain yield (kg/ha) of maize

Treatment	Thousand Kernel weight (g)	Aboveground biomass (kg/ha)	Grain yield (kg/ha)
Tied Ridge with mulch	394.4a	15556a	5842a
Flat bed with mulch	383.3b	14884b	5220b
Tied Ridge	389.0ab	14316c	4701c
Flat bed	363.5c	13649d	4173d
$LSD_{(0.05)}$	18.92	165.5	270.6
CV (%)	4.3	9.1	3.8

Values sharing similar letters in a column do not differ significantly at $p<0.05$

CONCLUSIONS AND RECOMMENDATION

Conclusion

This study investigated the effects of different soil moisture conservation methods on the phenology, growth, and yield of maize in Fafan, Somali Region, Ethiopia. The experiment was conducted using a randomized complete block design with four treatments: flat planting, tied ridge, mulching, and tied ridge with mulching. The results showed that all the phenology, growth, and yield parameters were significantly affected by the moisture conservation methods. The best performance was observed for the tied ridge with mulching treatment, which enhanced the soil water infiltration and retention, and reduced the environmental stress on the crop. The study concluded that the combination of tied ridge and mulching is an effective and feasible technique for improving maize production in water-scarce areas.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are suggested for future research and practice:

- The experiment should be repeated in different locations and seasons to verify the consistency and generalizability of the results.

- The economic analysis of the moisture conservation methods should be conducted to evaluate their profitability and affordability for smallholder farmers.
- The effects of different types and rates of mulching materials on the soil properties and crop performance should be investigated to optimize the mulching practice.
- The interactions of moisture conservation methods with other agronomic practices, such as fertilizer application, weed control, and pest management, should be explored to determine the best integrated crop management system for maize

REFERENCES

Abdi Ahmed, Abdurehman Eid and Muhiyadin Mohamed, 2009.Comprehensive Registry of Research Technologies, for Somali Region and other Same Agro-Ecological Areas in Ethiopia.Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI).Jigjiga, Ethiopia.

ATA (Agricultural Transformation Agency) 2014.Annual Report.ATA, Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). 2017. Agricultural Sample Survey Reports On Area and Production of Major Crops. Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). 2018. Agricultural Sample Survey Reports on Area and Production of Major Crops. Addis Ababa, Ethiopia.

El-nady ma,Abdallh AM (2013) corn yield response to same irrigation methods and fertilization with macro and micronutrients. *Egypt J Soil Sci*., 53: 347-360.

FAOSTAT (Food and Agriculture Organization of the United Nations), 2016.Food and Agriculture Data.Https://Www.Fao.Org/Faostat/En/#Home

Girma Woldetsadik, Sombat, C., Rungsit, S., Sunanta, J. and Aphiphan, P. 2005. Nitrogen Fertilization and Moisture Conservation Practices on Maize (*Zea mays* L.) Grown Under Dryland Conditions of Ethiopia.Kasetsart. *Journal of Natural Science*, 39: 1-11

Khan, M.A.H. and Parvej, M.R. 2010. impact of conservation tillage under organic mulches on the reproductive efficacy and yield of quality protein maize. *The Journal of Agricultural Sciences*, 5(2): 52-63.

Khurshid, K., Iqbal, M., Arif, M. S., Nawaz, A. 2006. Effect of tillage and mulch on soil physical properties and growth of maize. *International journal of agricultural Biology*,8: 593–596

Madsen, M.B. 1992. Mulching of maize with plastic.Tidsskrift for plant eavl, 96 (4), 343-351.

MoA (Ministry of Agriculture). 2011. Animal and Plant Health regulatory directorate. Crop variety register, Issue NO 13. Addis Ababa, Ethiopia.

MoA (Ministry of Agriculture). 2015. Animal and Plant Health Regulatory Directorate: Crop Variety Register. Addis Ababa, Ethiopia.

MoFA (Ministry of Food and Agriculture). 2011. Agriculture in Ghana: Facts and Figures (2010). Statistics Research and Information Directorate. Accra, Ghana.

Plessis, J. 2003. Maize production hand book. Department of Agriculture Resource Centre Directorate Agricultural Information Services. Private Bag X144, Pretoria, 0001 South Africa.

Singh G, Joshi VK, Chandra S, Bhatnagar A, Dass A (2016) Spring maize (Zea mays L.) response to different crop establishment and moisture management practices in north-west plains of India. ROC 17.

Tenaw Workayehu, 2001. Development of appropriate cropping systems for various maize producing regions of Ethiopia.pp.61-63. In: Enhancing the contribution of Maize to food security in 2nd Natl. Workshop of Ethiopia.12-16 November. Addis Ababa, Ethiopia. EARO and CIMMYT,Central Press Plc.

The Federal Republic of Ethiopia central statistical agency (CSA, 2015/2016). Agricultural sample survey 2015/2016 (2008 E.C.). Volume I report on area and production of major crops.

Tolessa, B., Gobezayehu, T., Worku, M., Desalegne, Y., Mulatu, K. And Bogale, G. 1993. Genetic Improvement of Maize in Ethiopia: A Review. In: Tolessa, B. and Ransom, J.K., Eds., Proceedings of the First National Maize Workshop of Ethiopia, Addis Ababa, Ethiopia, 13 22.

TolessaTaye., NaolBekele. andYonasShimalis. 2015. Response of maize to inter row mulch application at different growth stage of maize for small scale agro-pastoralist. *Global Journal of Food science and technology*, 3(7): 204-206.

Tolk, J.A., T.A. Howell and S.R. Evett. 1999. Effect of mulch, irrigation and soil type on water use and yield of maize. *Soil and Tillage Research*, 50 (2): 137-147.

Usha, R. and Pandey, B.K. 2007.Origin and introduction of crop plants, cereals, and pulses.Department of Botany, University of Delhi, India.

Yaseen R,Shafi J,Ahmed W,Rana MS, Salim M, et al. (2014) Effect of deficit irrigation and mulch on soil physical properties, growth and yield of maize. *Environ Ecol Res* 2: 122-

Flood Risk Analysis and Its Socio-Economic Effects on Agro-Pastoralist Communities of Lower- Shebelle Basin

Mohamed Ibrahim Kadiye [1], Dahir Yusuf Abdi [2] and Mohamed Abdikadir Dies[3]
Tel - +251915191975[1], +251921648449 [2]+251916987074[3]
e-mail: Mohamedkadiye14@gmail.com[1], daahirtwo@gmail.com[2], m.abdika2@gmail.com[3]

Abstract
The study was conducted in lower shabelle basin with objective of analyzing flood risks and its socio-economic effects on agro-pastoralist communities of lower- Shebelle basin. To achieve the objective of this study mixed research design was employed. Questionnaire, key informants interview and document review were used as data collection instruments. A total of 384 respondents were taken as sample of the study population. Both quantitative and quantitative analytical techniques were applied. Quantitative data was analyzed by using descriptive statistics such as frequencies, and percentages. The finding of the study indicated that food insecurity, loss of grazing land, loss of farm land, loss of livestock, damage to houses, exposed water born diseases such as diarrhea, malaria and skin disease, displacement are major effects resulted by the recurrent flood. The result of the study also showed that early warning system of the study area is generally poor/low. Likewise, the study furthermore indicates that the public mobilization via training from the governmental institutions is also very weak. The result of the study indicated that rebuilding the flood affected houses using basic materials, social capital using collective crisis management, drawing down assets (selling productive assets), Livelihood diversification, modifying consumption pattern of the household are the major coping strategies practiced by the local communities. The study recommends that Strengthening early warning system, flood forecasting, emergency planning and situation analysis. This will help the targeted population to stay updated prior to flood hazard on their life aspects; community should make early evacuation of their productive assets from flood susceptible areas to the save area which is far from the river bank and highly elevated areas of the lower shabelle basin; and the government should think over permanent resident relocation from these flood risk areas in order to minimize property, livestock and human loss during flood incident; especially Mustahil woreda Kebeles. Furthermore, Communities in flood prone areas are need to diversify their means of livelihood specifically, the involvement non- farm activities. Likewise, community should adopt the plantation of flood resilient crops and early maturing crops.

Key words: *Flood, Risk analysis, flood effects, coping mechanism*

INTRODUCTION

It is widely recognized that environmental hazards frequently affect the livelihoods of many people around the world. The effects of these hazards cannot be expected to be similar as people and nations differ in terms of their level of development, which largely determines their response to specific disasters. Flooding is one of the most frequent and destructive environmental hazards that occur annually worldwide (UNISDR, 2015). The frequency and severity of flooding are also

increasing in many parts of the world associated with population pressure, urbanization and climate change (Hirabayashi *et al.*, 2013; Jongman *et al*., 2014). This is evident when one considers the number of people affected by flooding in recent decades. For instance, flooding the top list (the second largest natural hazard, next to drought,) of natural disasters by economic damages in 2014 (Guha *et al*, 2015)

In Ethiopia, despite being given relatively less attention as compared to drought, flooding has long been recognized as one of the major environmental hazards that often develop into a disaster affecting the lives and livelihoods of people for many years. In fact, flooding and its damages are considered as a perennial phenomenon in the highlands (DPPC, 1994). The country's proneness to non-drought disasters such as floods has been limited in the past in terms of frequency and scope (DPPC, 1997). However, the historical records on flood data suggests that Ethiopia faced 47 major floods since 1900, which affected close to 2.2 million people (You and Ringer, 2010). This coupled with climate change and variability is likely to increase flooding as one of the major extreme events in the future posing a growing threat to many livelihoods (IPCC), 2014). Flooding as a recurrent environmental hazard is particularly felt in areas where people are already vulnerable to any adverse climatic event as a result of weakened resilience. For instance, an estimated 210,600 people were affected by flooding only within three months (November, 2015– January, 2016) (UN-OCHA, 2016).

In Somali region, heavy rains of neighboring highlands caused flooding in Kalafo, Mustahil and Ber-ano woredas (Shabelle zone); Dolo Ado woreda in Liban zone and Cherati woreda in Afder zone. Flash floods also occurred in Babile (Fafan zone) and Elweyne (Nogob zone). Meanwhile, the flooding in 2020 affected 34,974 people (5,829 households), including 20,868 people displaced (3,478 households) in Kalafo, Mustahil, Ferfer and East Imay woredas of Shabelle zone. Of the total affected, 11,106 people (1,851 households) are surrounded by floodwater. At least 2,388 hectares of cropland are also inundated. Similarly, flooding in Sitti zone affected 9,000 people (1,500 households) in Erer, Gablalu and Hadagala woredas. Earlier flooding in the region had affected 404,172 people (67,362 households), including 214,968 people displaced (35,828 households) in 28 woredas across Dawa, Erer, Fafan, Liban and Shabelle zones. More

than 34,006 hectares of cropland were totally damaged, and 10,739 livestock killed (UN OCHA, 2020).

Most of the studies conducted on natural disasters and their effects on peoples' livelihoods in different parts of Ethiopia focused mainly on drought and overlooked flooding and its impacts (Woldemariam, 1986; Rahmato, 1991; Sharp *et al*., 2003; Rahmato, 2007). The few available studies on floods also focus on issues such as risk perceptions and risk management strategies (Moges, 1978; Bekele, 2003; WMO, 2003; Nederveen *et al*., 2011). Although there are recent studies that looked into resilience and vulnerability in Ethiopia, flooding and its impact on livelihoods has not been investigated (Deressa *et al*., 2008; Simane *et al*., 2014; Mengistu *et al*., 2015). This is a key gap in the existing empirical studies given that flooding is a major natural hazard that affects the livelihoods of thousands of pastoralists and agro pastoralist communities every year across the country.

Therefore, the study was focused the gap in the literature by looking into the effects of flood on the livelihood of agro-pastoralist communities and their copping strategies in lower- Shebelle basin with objectives; to assess the effects of flood on agro-pastoralist communities and to examine coping strategies developed by the local people to flood hazard.

MATERIAL AND METHOD

The Study area

The study was carried out in the lower Shebelle River sub-basin located in the South-Eastern part of Ethiopia. It lies within latitudes 4.789742˚ and 6.370002˚ N and longitudes of 42.797545˚ and 45.379227˚ E with an area of 24470 Km^2 (Fig. 1). The Shebelle is the major drainage basin in the Horn of Africa, Shebelle River has a total catchment area of approximately 307,000km^2. The total length of the river is estimated to be about1700km, slightly under half of which is in Somalia.

Sampling Techniques

Multiple-stage sampling approaches were used for this study. Firstly, two woredas namely Mustahil and Kalafo were purposively selected because of incidence and severity of flood risks

in comparison to other woradas of the Zone. In the second stage, five kebeles such as kabobe, God-arro and Kunaso from Mustahil; and Allow igarsi and Niri from Kalafo were randomly selected, and at the third stage, respondents over the age of 18 were selected for this study from each selected kebele using a probability proportional to sample size.

The sample size used by this study is 384 respondents selected from five kebeles in the Mustahil and Kalafo woradas. According to Cochran (1997) sample size determination, a sample size of about 384 is a sufficient sample size at the 95% confidence level with a 5% margin of error when the size of the population is large or infinite. The following formula given by Cochran was adopted. Cochran developed a formula to calculate a representative sample as we want the most favorable sample size for an infinite population and we shall take the value of p = 0.5 and q = 0.5. We can determine the sample size as under

Where;

n= is the sample size,

z = is the selected critical value of desired confidence level (z = 1.96 as per table of area under normal curve for the given confidence level of 95%).

p = is the estimated proportion of an attribute that is present in the population, q=p-1 and

e = marginal error ±5% ;- is the desired level of precision Assuming the maximum variability, which is equal to 50% (p = 0.5) and taking 95% confidence level with ±5% precision, the calculation for required sample size were as follows:

p = 0.5 and hence q = 1–0.5 = 0.5; e = 0.05; z = 1.96

Therefore; Sample size = ((1.96)2 *(0.5) *(0.5)) / (0.05)2 =384.

Types, Sources, Method of Data collection and Data Analysis

For this study, the study both qualitative and quantitative types of data from primary and secondary sources were gathered. The primary data was collected from agro-pastoral communities (by survey questionnaire), key informants such as local elders; regional and district level government staffs; and NGOs staffs (by using semi-structured questionnaire). With regard

to secondary data, the available documents such as books, reports, and earlier empirical studies were used.

For quantitative data analysis, descriptive statistics such as frequencies and percentages were used. The qualitative data collected through interviews was described and summarized. Thematic analysis was deployed to analyze the qualitative data.

RESULTS AND DISCUSSION

Demographic Characteristics of the Respondents

According to table 1, which indicates sex of the household heads, majority of the sampled participants about 306 (79.7%) were male headed households, whereas the remaining 78 (20.3%) were female headed households. The implication is that males are dominated in the sampled respondent. With respect to family size of the household heads of study participants, 172 (44.8%) of them have family size of 6-10 persons while 111 (28.9%) have a family size above 10 persons, and the remaining 101 (26.3%) of the sampled respondents were had 1-5 family size. Therefore, the result of the study indicates that most of the household heads (about 73.7%) who participated in this study have a large family size that ranges 6-10 persons and above.

With respect to age of the household heads, 244 (63.5%) of them have age group of 18-40 years while 92 (24%) 41-65 years, and the remaining 48 (12.5%) of the sampled respondents were above 65 years old. Therefore, the result of the study indicates that most of the household heads (about 87.5%) who participated in this study have an age range of 18-65 years old. This implies that majority of respondents were active labour force of the population who can participate in different livelihood activities.

Concerning with the marital status of the respondents, 378 (98.4%) and 6 (1.6%) were married and widow respectively. Therefore, the finding of the study indicates that majority of the respondents were married.

Table 1. Sex, Family Size, and Age of the Respondents

Variable	**Category**	**Frequency**	**Percentage**
Sex of the Respondent	Male	306	79.7
	Female	78	20.3
Family Size of the Respondents	1-5	101	26.3
	6-10	172	44.8
	above 10	111	28.9
Age of the Respondents	18-40	244	63.5
	41-65	92	24.0
	Above 65	48	12.5
Education	Illiterate	232	60.4
	Read and write	58	15.1
	Primary school	36	9.4
	Secondary school	35	9.1
	Diploma	17	4.4
	Degree	6	1.6
Marital Status of the Respondents	Married	378	98.4
	Widow	6	1.6

Source: Field Survey, 2022

As shown in table 1, 232 (60.4%) and 58 (15.1%) of the respondents were illiterate and literate (read and write) respectively. Whereas 36 (9.4%) and 35(9.1%) of the sampled households were primary school and secondary school respectively. Lastly, the remaining number of the participants which are 17(4.4%) and 6 (1.6%) were diploma and degree holders.

Hence, the above result indicates that most of the participants have low level of education which in turn can result to remain as poor information seekers or have less access to disaster risk reduction and climate adoption information and knowledge to prepare strategic response in the face of flooding hazards.

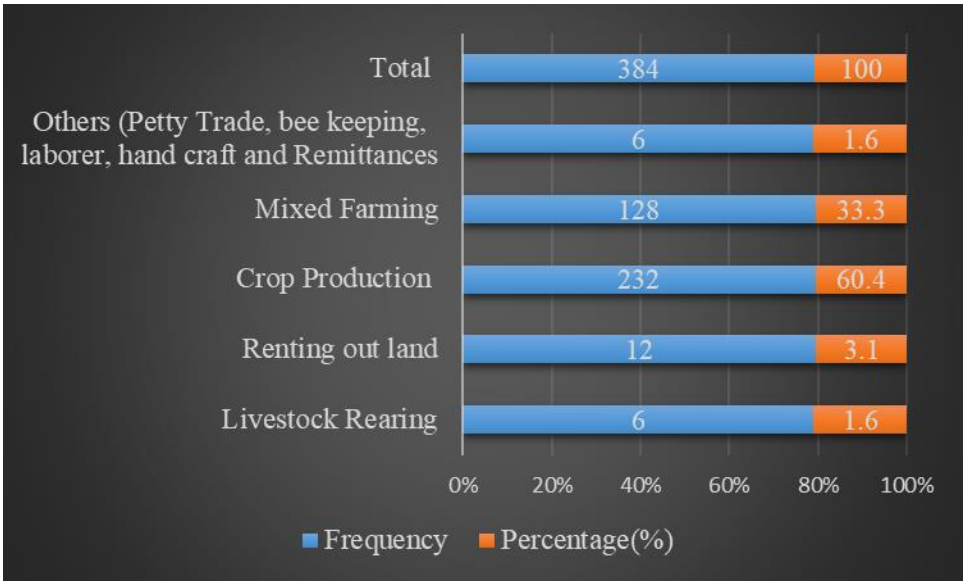


Figure 1. Means of livelihood of the Respondents

Source: Field survey, 2022.

With regard to the livelihood condition of the respondents, about 232 (60.4%) identified that they were engaged in crop production of different variates, 128 (33.3%) of them were engaging mixed farming, 12 (3.1%) of them were engaged in renting out land, and the remaining less number of the study participants were identified 6 (1.6%) and 6(1.6%) as they are engaged in livestock rearing and other means of livelihood (Petty trade, bee keeping, laborer, hand craft and remittances) respectively. This can be shows the majority of the respondents depend on agricultural and livestock as means of livelihood of their families.

Effects of flood on river bank communities of lower Shabelle basin

Table 2. Effects of flood

Effects of flood	Category	Frequency	Percentage
Death of a Household member	Yes	121	32
	No	263	68
Exposed to food insecurity	Yes	376	98
	No	8	2
Loss of grazing land	Yes	338	88
	No	46	12
Loss of farm land	Yes	361	94
	No	23	6
Loss of livestock	Yes	307	80
	No	77	20
Damage to Houses	Yes	361	94
	No	23	6
Exposed to diseases such as acute water diarrhoea, Malaria, measles	Yes	357	93
	No	27	7
Dislocated and forced to live in temporary shelters	Yes	376	98
	No	8	2
Loss of public service and infrastructure	Yes	365	95
	No	19	5

Source: Field survey, 2022

As indicated in the above table, flood resulted multi-faceted effects on the life of the agro-pastoral communities in lower shabelle basin. To begin with the human losses resulted by flood, 68% of respondents revealed that they did not suffer death for family members, while 32% of them said that they suffered death for their households' members. This indicates that although, flood is recurrent phenomena, the loss of human life is not highly common in comparison to other consequences resulted by flood. Similarly, the flooding report of the affected districts

(2019) indicated that human losses are not a prominent effect resulted by the recurrent flood tragedy. For instance in 2019 flood have only resulted death of five persons and 25 injuries.

Likewise, according to the study conducted by EM-DAT (2017), deaths directly attributable to floods have fallen dramatically over the past century, and are relatively well-understood. Therefore, the result of the study can be concluded that although flood resulted enormous losses, the losses related to human life are still very less.

With regard to food insecurity, 98% of the study participants witnessed that the community in the study area faced severe food insecurity due to flood that destroyed their crops whereas remaining 2% of them reported that there is no any exposed food insecurity caused by flood in the study areas.

Concerning the grazing land, 88% of them confirmed that the grazing land of their locality had lost because of floods , while only 12 % of them mentioned that no grazing land that lost by floods. This can be inferred that flooding have resulted the loss of grazing land. In addition to this statistical data, the district report indicated that about 10,000 ha of pasture land were inundated by water which result the former pasture land to change into degraded and water logged areas. This indicates that flooding have resulted negative effects to the grazing land by changing the former grazing land to degraded land and invaded by different invasive plants like prosopis julifora.

With regard to loss of farm land, 98% of respondents mentioned that they had lost their farmland due to floods while very insignificant number of the respondent which is 2% showed that there is no loss of farm land resulted by flood. In addition to this statistical data, the report of the flood affected districts (Kalafo and Mustahil), indicated around 9,135 ha of farm land were devastated by the recurrent flood. Similar findings were reported by Mwape (2009) in Namibia and Zerihun (2008) in Ethiopia that the flood prone communities have lost various types of crops to flooding. Hence, the effects of flooding on farmland is extremely serious and alarming agenda that need immediate solution.

In terms of the loss of livestock, 80% of the sampled respondents confirmed that they lost large number of their livestock, while the remaining 20% indicated that flood have no effects to their livestock. According to RDPFSA, (2019), livestock physical condition became poor due to scarcity of pasture (pasture land covered by flood) resulting poor livestock productivity and

deaths. As indicated in the figure 2 flood has killed 633 cattle 4,717 shoats (sheep and goats), 348 equine and 13,980 chickens. Similarly, 2019 flooding report of the flood affected districts (Mustahil and Kalafo) signposted that flooding have resulted a loss of 19,684 domestic animals.

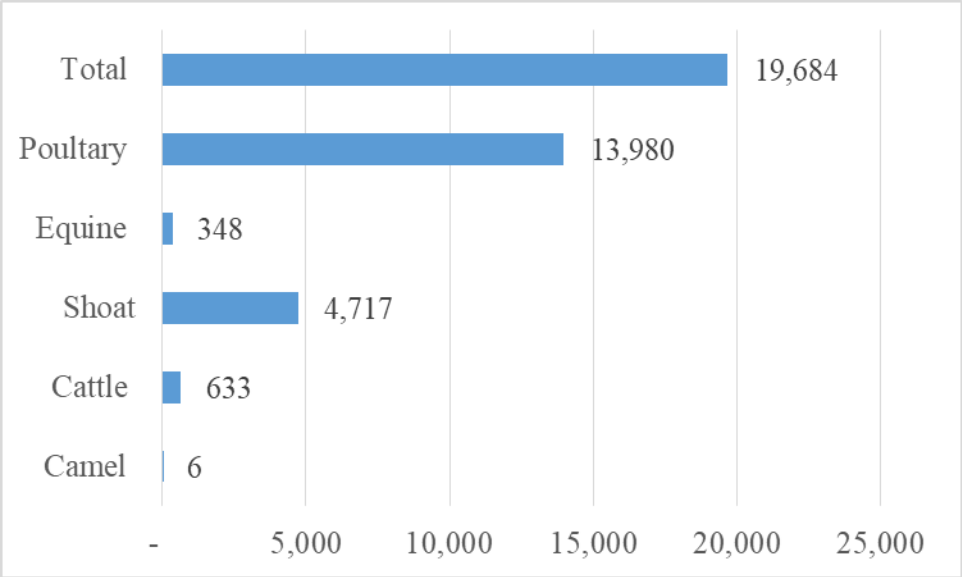


Figure 2. Summary of livestock losses resulted by flood
Source: Mustahil and Kalafo flooding Report, 2019

This quantitative result is supplemented by the interview conducted with district animal health office:

> *Apart from direct causalities resulted by flood, there is also indirect consequences of flood to livestock population. In the last flood event, many livestock died due to flood-related diseases because most of the time flood carried a large number of snails which act as an intermediate hos for fasciollosis which is fatal disease to animals. Moreover, the flood induces stress, aggravates livestock diseases, parasitic infestations, and leads to the outbreak of transboundary and vector-borne animal diseases.*
>
> *Musthahil Animal Health Worker (2022)*

For damage of houses about 94% of them clearly stated that flooding have devastated and damaged massive number of houses among agro-pastoralist communities living in the shabelle river bank, while 6% of respondents reported no effects. The report from district in 2019 stated that 1,500 houses were completely collapsed. In line with this finding, the study conducted by Christie and Hanlon in (2020) revealed flooding has serious direct effect with regard to damages

of houses and sheds as it made many villagers homeless. This findings is further supplemented by the interview conducted in parallel with the survey data. The interview can be quoted as.

> *Despite having convenient shelter is a basic need for our life, we have suffered lack of house after being hit by a heavy flooding. Home equipment and clothing were all taken away by the flooding. Nowadays, the worst issue to worry the most is fear of house destructions when floods come.*
>
> *Flood Affected Community Member (2022)*

With concern to diseases, the result of the study witnessed that almost all of the respondents (93%) agreed that there was water borne diseases like dysentery, malaria and measles resulted by floods while remaining 7% of them not mentioned any water borne diseases resulted by floods. In addition to the above survey data, the report of both districts (Kalafo and Mustahil) revealed that recurrent flood have increased the occurrence of water born diseases such as diarrhea, bilharzias (schistosomiasis), malaria and skin diseases. Similarly, Murthy (2010) indicated that flooding can increase the risk of infectious and vector-borne diseases. In addition to this, Watkins (2012), showed that outbreaks of gastrointestinal illness have been documented after flood events in the U.S. Furthermore, according to Olteanu *et al*. (2011) flooding disasters may have lasting consequences on psychological health, especially for children. The trauma resulted by the disaster could subsequently lead to reduced economic productivity.

Coming to displacement, the flood also resulted displacement of people from their origin settlement to temporary settlement. As shown in the above table 98 % of study participants witnessed that flooding resulted huge number of displacement while the very insignificant number of the respondents which only 2% stated that flooding has not resulted displacement in the study areas. Apart from the above presented statistical data, in 2019 flood report of the affected districts showed that flooding have affected a total number of 52,316 households in which 13,655 household were relocated to new settlement in temporary manner whereas the remaining 38,661 households were living their villages with very hard condition in which water besieged in every direction. The finding of the study is further supplemented by the findings of NDRM (2020), which indicates that flooding have resulted significance effects on housing by and displaced over 7000 people in the district in the study this year. Other similar results by Gizachew (1999), revealed that the inundation of water in the plain area resulted a huge numbers

of people had migrated to the neighboring villages and districts in search of shelter for existence either temporarily or permanently.

The floods destroyed tremendous quantity of irrigation infrastructure in the rural agricultural land, interrupted rural roads, communication around districts and affected public services. According to the household survey result, 95% of the study participants disclosed that flood damaged infrastructures and public service in study areas, while 5% of them said that the flood didn't cause any effects in infrastructures and public services. The reports from flood affected districts stated that flooding have severely affected the irrigation infrastructure mainly irrigation machines and public services such as health centers, animal health posts, schools, water wells and other basic services. Accordingly, a total of 512 irrigation motors were drowned and taken away by the flood water, 69 schools were seriously affected by the flood, four human health centers and five human health posts were totally collapsed, 18 human health posts were extremely damaged by the flood water and 25 water wells were drowned/ sub-merged to flood water. Similarly, Agwa (2021) revealed that the flood has affected the services delivery (mainly drinking water schemes, education, and health and transportation services) in the community severely by facts that social services delivery provision completely impossible during flooding.

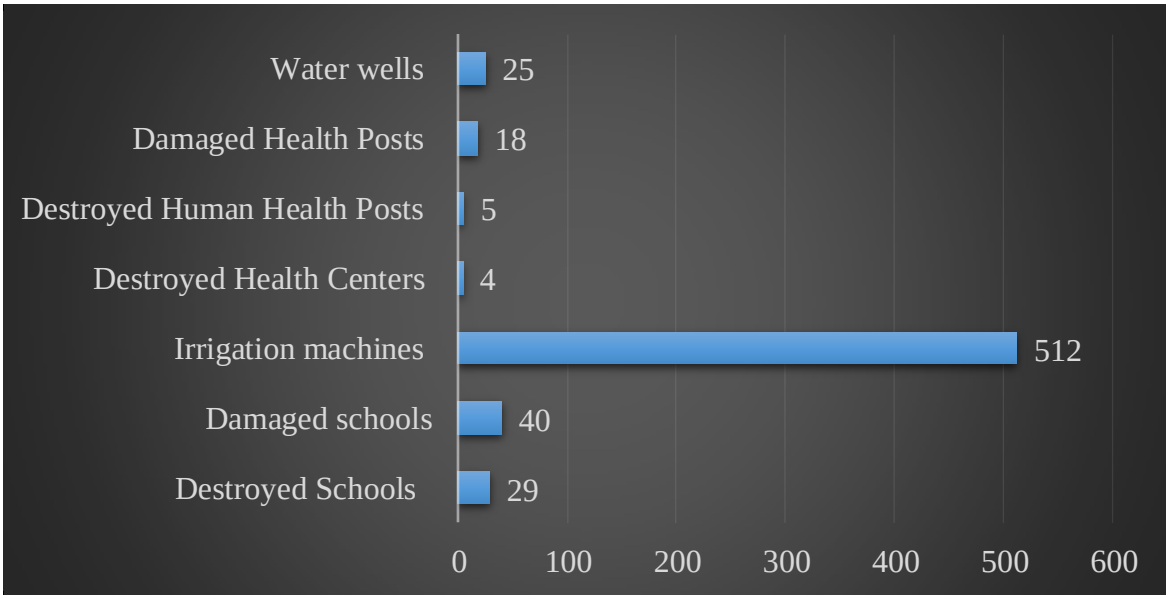


Figure 3. Infrastructure and basic Services affected by flood
Source: Kalafo and Mustahil flooding Report, 2019.

Community's based coping mechanisms.

Usually, the local communities are already undertaking various coping and adaptation mechanisms in response to the adverse impacts of environment change and variability. Among the others, pre-flood, interim and post flood are always adopted by the different actors.

Pre-disaster Coping Strategies:

Pre-disaster coping strategies is the strategy taken before the disaster occurrences. This kind of strategies are designed on the bases of past flood disaster experience, based on those experience different group of people takes the preventive strategies, as moving the valuable in safer place, early warning system, communication, shelter management, keeping the food stuff in higher elevated parts etc. The role of government, NGO/INGO is in structure development. Fencing their homes, change in the structure of the house has also seen in some households. Improving more social network and based on the household socio-economic condition they choose different option to diversify their income sources; for example in on-farm production, they have adopted different pre-coping strategies mostly after the floods of 2019 and this strategies varies from household to household based on their capacity.

Table 3. The existing prevention mechanisms in the study area

S/N	Flood prevention mechanisms	Alternatives	Frequency	Percentage
1	Receiving early warning information from government institutions	Yes	15	4
		No	369	96
2	Cultural preventive measures (Placing sandbags and stone bags in flooded areas)	Yes	346	90
		No	38	10
3	Public mobilization through training	Yes	4	1%
		No	380	99%

Source: Field survey, 2022

As indicated in the above table, 96% of the respondents revealed that early warning information from the government is not in place and the early warning system of the government is very poor while the remaining 4% of the study participants stated that there is strong early warning system in the study area. Similarly, UNOCHA (2020) reported that the district's officials and the

community know the time of flood occurrence. But, the level of preparedness for flood hazard and early warning system of the country is generally poor/low; and almost all districts in lower Shabelle basin including Kalafo and Mustahil do not have preparedness and action plan for flood.

Shemsedin and etal (2022), also shows that the awareness of flood hazards may raise the population's attention on managing flood risks. Thus, absence of an early warning system is highly contributed to the increment of the flood affected communities of the study area.

In line with this quantitative data, the interview with the wodera officials indicated the similar information.

> *The early warning system and the level of preparedness Kalafo wodera is still very low. People are not well informed and prepared to withstand with the natural disasters. Hence, more trainings are needed to prepare community on how to behave during and after a disaster and as result of this, the bureau Disaster Management in collaboration of local authorities have to play a big role in these above mentioned areas.*
>
> *Early warning officer at Kalafo District (2022)*

Therefore, the finding of the study can be generalized that early warning system of the study areas are very poor and result of this, a fast communication system with reliable and timely information which helps to circulate flood warning information is important in the area. Individual homes, communities, and organizations used various coping techniques to prevent floods or limit the effects of floods to maintain their lifestyles and recover their losses. Accordingly, about 261(90%) stated that the community practiced cultural preventive measures such as placing sandbags and stone bags in flooded areas as means of preventing the flood risks. Likewise, the finding of this study is also supported by the findings of Shemsedin *et al*. (2022), which indicates that communities of Hirna Town use different cultural preventive mechanisms such as construction of temporal drains and bridges, use of sand and stone bags, collecting and removing out water, diverting the direction of water as a major coping mechanism for flood protections. Lastly, with regard to public mobilization, 287 (99%) of the respondents reflected that there is no public mobilization via training from the governmental institutions.

Post-disaster Coping Strategies:

Post-disaster coping strategies is usually done after the flood disaster. In this context, the study show that almost all the household members were affected by the flood in most of the river banks of villages in Mushalil and Kalafo woredas. The flood affected victims, who were rescued and who were in the safer place, all return back to see their houses and other properties once the flood water recedes. Those houses that were not swept away by the flood, were found with the accumulation of large amount of sand and mud insides their houses. The first step they do is clearing the deposited sand and mud and then cleaning house and they try to maintain the dismantle houses. The details of the post-disaster strategies taken by the flood victims are as follows.

Table 4. Post-flood coping Strategies

Post flood Coping mechanism	**Category**	**Frequency**	**Percentage**
Rebuilding the flood affected houses	Yes	349	91
	No	35	9
Migration	Yes	35	9
	No	349	91
Social capital using kinship ties	Yes	292	76
	No	92	24
Drawing down assets:	Yes	353	92
	No	31	8
Livelihood diversification	Yes	326	85
	No	58	15
Modifying consumption pattern	Yes	319	83
	No	65	17

Source: Field survey, 2022

As shown in the above table, almost all of the sampled respondents about 91% indicated that after flood crises ended, the local community cannot stay in the places deployed during the flood for rescue purpose, hence they start the re-construction of flood destroyed houses by using materials available in their locality, while 9% of them showed that they did not make any attempt for rebuilding their houses.

With regard to migration as an option of flood effect remedies, majority of the study participants about 91% indicated that permanent migration not commonly practiced in the study area, while

remaining small number of the respondents about 9% showed that local community practiced migration as coping strategy to flood hazards. Although few household members migrate permanently as a viable option to flood hazards, the finding of the study can be generalized that flood affected communities in study area don't practice migration as a valid option of overcoming flood hazards and getting better livelihood in else were.

A social and kinship tie plays a crucial role in minimizing vulnerability, especially at the time of crop failure and loss of all properties. As indicated in the above table, 76 % of the study participants witnessed that they sought help from relatives, while 24% of the respondents indicated that they don't have any social capital and kinship that can support when flood swept all their properties. Therefore, a social capital and kinship ties as widely practiced coping strategy and plays great role in minimizing vulnerability, especially at the time of crop failure and loss of all properties.

Concerning the drawing down assets, about 92% of the study participants proved that they were drawing down of their assets as a coping strategy of flood risks, while the remaining 8% showed that Drawing down their assets is not as viable option to cope with risks caused by flood. Therefore, as shown in the table 4 selling productive assets such as livestock and jewelry is highly practiced as coping strategy during crisis situation.

With concern to livelihood diversification, 85% of the sampled respondents showed that the local community diversify non-farm activities such renting out land, daily labor, collecting and selling charcoal, working as house cleaners in the big urban centers, shoe shining, and other similar informal activities as coping strategy to flood crises, while the remaining 15% of the respondents stated that they don't make any change with regard to livelihood diversification. Concerning with modification of the consumption pattern of the flood affected communities, 83% of the respondents stated that flood affected the consumption habit of the communities, while 17% of them said that the consumption behavior of the community didn't change and remain as it was. Generally, the study found that the consumption habit of communities living in lower Shabelle basin have been decreased at present due to flood disaster.

External Support to flood affected population

According to data results obtained from the target population, external assistance being received by the affected community was emergency support in their characters. In another word, the

support was temporary and has no sustainability aspects. In this regards, the researcher has attempted to assess the support being provided at the grassroots level and the one at macro level which include the following assistance expected bodies: social network, Government, NGOs and Religious Organization as well.

Table 5. The sources of support for the flood affected in the study area

S/N	Sources of support	Alternative/option	frequency	Percentage
1	Social network	Yes	230	60%
		No	154	40%
2	Government	Yes	230	60%
		No	154	40%
3	Non-governmental organization (NGOs)	Yes	369	96%
		No	15	4%
4	Religious organizations	Yes	3	1%
		No	381	99%

Source: Field survey, 2022

As presented in the above in table 5, respondents about 60% reported that they receive external support in the form of social network such as relatives (within the community and from abroad) and neighborhood as well, while 40% of the study participants confirmed that they didn't receive any support from their relatives. With regard to government actors, majority of the respondents about 60% reflected that they receive emergency assistance from the government, while remaining 40% of the sampled respondents stated that they don't receive any support from the government. Most of the time community tend to rely on support from their respective social networks such as relatives and neighbors. In the year of 2019, the flood hazard in both Kalafo and Musthail districts has caught the attention of many individuals living within the country and abroad. As a result, the diaspora community have made great mobilization through social media which eventually led them to donate funding for the flood affected community.

Table 6. The types of support being provided to the flood victims in the study area

S/N	Types of support being provided	Alternative/option	frequency	Percentage
1	Shelters	Yes	96	25%
		No	288	75%
2	Financial gift	Yes	54	14%
		No	330	86%
4	Food assistance	Yes	369	96%
		No	12	4%
5	WASH materials	Yes	273	71%
		No	111	29%

Source: Field survey, 2022

Furthermore, the external assistance provided to the flood victims involves shelters, food assistance, materials and financial assistance either by the NGOs, government or by the social networks. As shown in the above table, the respondents received food assistance which accounted for 96.8%. With regard to provider of this assistant, more likely provided by the NGOs especially, aftermath of the disaster. Distribution of such emergency assistant is always matched to aftermath of the flood due to lack of all-weather road to transport food aid because the whole area was covered by flood water. On the other hand, 71% of the respondents revealed that they have receive materials assistance such as cooking utensils, sanitation equipment, water handling materials and so forth. Moreover, the surveyed households stated that they also used to receive less support for provision of shelter and financial gifts which accounted 25% and 14% respectively.

CONCLUSION AND RECOMMENDATION

Flooding have resulted food insecurity, loss of grazing land, loss of farm land, loss of livestock, damage to houses, displacement and exposing to water-borne diseases such as diarrhea, bilharzias, malaria and skin disease. Early warning system is generally poor/low and the public mobilization via training from the governmental institutions is also very weak. The flood affected houses maintenance, social capital using kinship ties, drawing down assets (selling

productive assets), livelihood diversification, modifying consumption pattern of the household are the major coping strategies practiced by the local communities

Strengthening early warning system, flood forecasting, emergency planning and situation analysis can help the targeted population to stay updated prior to flood hazard. Local community should make early evacuation of their productive assets from flood susceptible areas to the save area which is far from the river bank or keeping them at highly elevated areas. Moreover, the government should think over permanent resident relocation from these flood risk areas in order to minimize property, livestock and human loss during flood incident; especially Mustahil woreda Kebeles. Furthermore, Communities in flood prone areas have to diversify their means of livelihood specifically, the involvement non-farm activities. Likewise, community should adopt the plantation of flood resilient crops and early maturing crops. Better Watershed management practices and construction of canal should be taken into consideration to attract the extra water in the uplands of the catchment so as to alleviate future flood disasters.

REFERENCES

Bekele, L. (2003). Community perceptions and responses to Awash Floods in the Wonji environs, Ethiopia. *Ethiopian Journal of Development Research 25(2): 1–33.*

Deressa, T.T., and R. M. Hassan. (2009). Economic impact of climate change on crop production in Ethiopia: evidence from cross-section measures. *Journal of African Economies 18(4): 529–554.*

Disaster Prevention and Preparedness Commission (DPPC). (1997b). Worst case scenario for drought, flood, influx of refugees and epidemics and the present response system. June 1997: Addis Ababa: Federal Democratic Republic of Ethiopia (FDRE).

Guha-Sapir, D., P. Hoyois, and R. Below. (2015). Annual Disaster Statistical Review

Hirabayashi, Y., R. Mahendran, S. Koirala, L. Konoshima, D. Yamazaki, S. Watanabe, and S. Kanae. (2013). Global flood risk under climate change. *Nature Climate Change 3(9): 816–821.*

IPC. (2014). Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Geneva, Switzerland, 151 pp..

Jongman, B., S. Hochrainer-Stigler, L. Feyen, J.C. Aerts, R. Mechler, W.W. Botzen, and P.J. Ward. (2014). Increasing stress on disaster-risk finance due to large floods. *Nature Climate Change 4(4): 264–268.*

Mengistu, A., A. Argaw, and T. Seid.(2015). Resilience of Ecosystems to climate change. *American Journal of Environmental Protection 4(6): 325–333.*

Moges, A .(1978). Flood risks and vulnerability in different regions of Ethiopia. Disaster Preparedness Planning Program. Relief and Rehabilitation Commission. Addis Ababa: Relief and Rehabilitation Commission (RRC).

Mwape. (2009). An Impact of Floods on the Socio-Economic Livelihoods of People: A Case Study of Sikaunzwe Community in Kazungula District of Zambia. University of the Free State, Zambia.

Nederveen, S., M. Abebe, F.V. Steenbergen, A. Tena, and G. Yohannes. (2011). Flood based farming practices in Ethiopia: status and potential, Overview Paper Spate Irrigation.

Rahmato, D. (1991). Famine and survival strategies: a case study from Northeast Ethiopia. Nordic Africa Institute.

Rahmato, D. (2007). Development intervention in Wollaita, 1960s-2000s: a critical review. Forum for social studies monograph 4. Addis Ababa: Forum for Social Studies.

Simane, B., B.F. Zaitchik, and J.D. Foltz. (2014). Agroecosystem specific climate vulnerability analysis: application of the livelihood vulnerability index to a tropical highland region. *Mitigation and Adaptation Strategies for Global Change 21(1): 39–65.*

UNOCHA (United Nations Office for the Coordination of Humanitarian Affairs). (2020). Situation Report on floods in Ethiopia.

Woldemariam, M. (1986). Rural vulnerability to famine in Ethiopia, 1958–1977. New Delhi: Vikas publishing House LTD.

WMO (World Meteorological Organization). (2003). Integrated Flood Management Case Study1Ethiopia: Integrated Flood Management. In WMO/GWP Associated Program on Flood Management, Technical Report.

You, G.Y. And C. Ringler. (2010). Hydro-Economic Modeling of Climate Change Impacts in Ethiopia. IFPRI Discussion Paper No. 960. Washington DC: International Food Policy Research Institute (IFPRI).

Flood Risk Susceptibility Analysis of Lower Wabi-Shebelle River of Somali Region

Dahir Yosuf Abdi[1] Mohamed Ibrahim Kadiye[1] Ebrahim Sied[1]

1 Soil and Water Research Directorate, Somali Region Pastoral and Agro-Pastoral Research Institute, Jigjiga, Ethiopia

Abstract

Floods are the most common and costly natural disasters that affect the Somali Region of Ethiopia. The Shebelle River Basin in the southern part of the region poses a significant challenge to sustainable development due to frequent flooding. Floods have devastating social, economic and environmental impacts in the area. The main objective of this study was to analyze the flood risk in the lower-Shebelle basin. The data collected were processed using the ArcGIS software and the Analytic Hierarchy Process (AHP) to produce a flood susceptibility map. The flood hazard map was created using eight important causative factors: elevation, geology, slope, drainage density, proximity, land use and land cover, soil, and rainfall. The result showed that moderate (88.3%), high (1.0%), and very high (10.7%) flood risk zones were mapped in the lower Wabi-Shebelle of the Somali region of Ethiopia. Moreover, the analysis revealed that elevation, slope, drainage density, proximity, rainfall, geology, soil, and land use and land cover have a high influence on flood occurrence in the area. Based on the result of the study, decision and policy makers can use this map as a reference for potential preventive actions, such as better watershed management, improved land use planning, and flood risk management. Additionally, the locations classified as very high flood risk require further flood protection measures, such as relocation of the residents, reshaping of the river banks and building protective walls.

Keywords: Flood, Risk, AHP, ArcGIS, Lower Wabi-Shebelle, Somali region

Introduction

Natural disasters, like floods, are causing massive damages to natural and human resources (Du *et al*. 2013; Youssef *et al.* 2011). These natural occurrences are mostly caused by global warming, which alters the rate and intensity of rainfall, resulting in extreme rainfalls that cause dams to burst, river, lakes, streams and seas to over flow (Zereini, 2008). Consequently, they generate severe floods in a given area for a specific period of time, resulting in socio-economic losses, fatalities, and property destructions (Chen, 2025). However, an average of 140 million people is affected per year due to flooding (WHO 2003). Between 1980 and 2010, Ethiopia experienced 86 natural disasters, resulting in the loss of 313,486 human lives, the displacement of 57 million people, and an economic loss of US$ 31.7 million. Flood came in second place among natural disasters, trailing only drought (OFDA 2012). Flooding can occur in a number of different ways. River/stream overflow, heavy rainfall and rapid melting of ice in the mountains are among the most prominent.

Currently, geospatial techniques provide a wide range of data sources for the modelling of flood (Wanders et al., 2014). Analytical hierarchy process (AHP) is one of the most popular and satisfactory methods in disaster modelling like flood monitoring, mapping and analyzing complex problems (Billa et al., 2006; Yalcin, 2008; Chen et al., 2011). Multi-criteria decision support approach (MCDA), Remote Sensing (RS), and Geographic Information System (GIS) techniques are extremely useful in reliable and accurate analysis and mapping of plausible flood prone zones.

Control of a flood and prevention measures are necessary to reduce potential damages to natural resources, agriculture, infrastructure etc. (Billa et al., 2006; Huang et al., 2008). Therefore identification of flood susceptible areas is an important task for early warning system, emergency services and mitigation of the future flood episodes (Tehrany et al., 2015). In Ethiopia, most flood hazard studies have been concentrated in *Tana sub-basin* (Assefa et al., 2008; Mossie, 2008; Hagos, 2011; Wubet & Dagnachew, 2011; Zelalem, 2011; Yalelet, 2013), in Dire Dawa (Daniel, 2007) and in Middle and Upper Awash sub-basin (Alemayehu, 2007; Sifan, 2012, Yirga, 2016).

However, the available literature indicates that some areas in the country are far more frequently affected than others, to the extent of being labeled as ‘flood prone areas’ (World Meteorological

Organization (WMO), 2003; Nederveen et al., 2011; UN-OCHA, 2016). These areas include central and western zones of Tigray; North Gondar, North and South Wello, some parts of Somali region and Oromia zones of Amhara region which are often affected by flash flooding as well as those that are affected by riverine floods, which include almost all the major river basins and the Tana Basin (DPPC 1994; 1997b; Nederveen et al., 2011; UN-OCHA, 2016).

However, Somali Region particularly Shebelle River periphery districts experiences two types of floods; river and flash floods. River floods occur due to over flow or bursting river banks and inundate areas along the banks in lowland flood plains. Flash floods occur in lowland areas when excessive rain fall in adjacent highland and flows downstream with massive magnitude, speed and force. Therefore, in Somali region, heavy rains of neighboring highlands caused flooding in Mustahil, Kalafo, and Bercano woredas (Shabelle zone); Dolo Ado woreda in Liban zone and Cherati woreda in Afder zone. Flash floods also occurred in Babile (Fafan zone) and Elweyne (Nogob zone). Meanwhile, the heavy floods in 2020 affected 34,974 people (5,829 households), including 20,868 people displaced (3,478 households) in Kalafo, Mustahil, Ferfer and East Imay woredas of Shabelle zone. Of the total affected, 11,106 people (1,851 households) are surrounded by floodwater. At least 2,388 hectares of cropland are also inundated. Similarly, flooding in Siti zone affected 9,000 people (1,500 households) in Erer, Gablalu and Hadhagala woredas. Earlier flooding in the region had affected 404,172 people (67,362 households), including 214,968 people displaced (35,828 households) in 28 woredas across Dawa, Erer, Fafan, Liban and Shabelle zones. More than 34,006 hectares of cropland were totally damaged, and 10,739 livestock killed (UN OCHA, 2020). However, one of the main deficiencies in the literature of this phenomena has been the failure to identify the flood risk susceptible location. Hence this current study was aimed to identify and map flood susceptible areas in Wabe-Shebelle River basin of Somali region, using Analytical Hierarchical Process (AHP).

Material and Methods

Description of the Study area

The study was carried out in the lower Shebelle River sub-basin located in the South-Eastern part of Ethiopia. It lies within latitudes 4.789742˚ and 6.370002˚ N and longitudes of 42.797545˚ and 45.379227˚ E with an area of 24470 Km^2 (Fig. 1). The Shebelle is the major drainage basin in the

Horn of Africa, with a total catchment area of approximately 307,000km^2 , of which about 199,000km^2 (65%) lies within Ethiopia.. The total length of the river is estimated to be about1700km, slightly under half of which is in Somalia.

The study area covers the lower and arid lowland areas of the basin with elevation range between 165 m and 691 meters above sea level (m.a.s.l.). Orthic Solonchaks soil dominates the sub-basin with an aerial area of 1106906.77 ha (45.8 %), followed by Calcaric Fluvisols with 493158.83ha (20.41%), Calcaric Xerosols with 342369.12 ha (14.17%), Calcic Xerosols with 268989.07 ha (11.13%), Chromic Vertisols with 121812.59 ha (5.04%) and Eutric Nitisols covering 35537.46ha (1.47%). The study area has two agro ecological classes namely hot arid lowland plain and warm arid low land plain covering an area of 20377.67 km^2 (84.47%) and 3745.29 km^2 (15.53%) respectively. The topography of the study area is generally lowland plain, with an average elevation of 358 meter above sea level (m.a.s.l.), and a maximum elevation of 691 m.a.s.l.

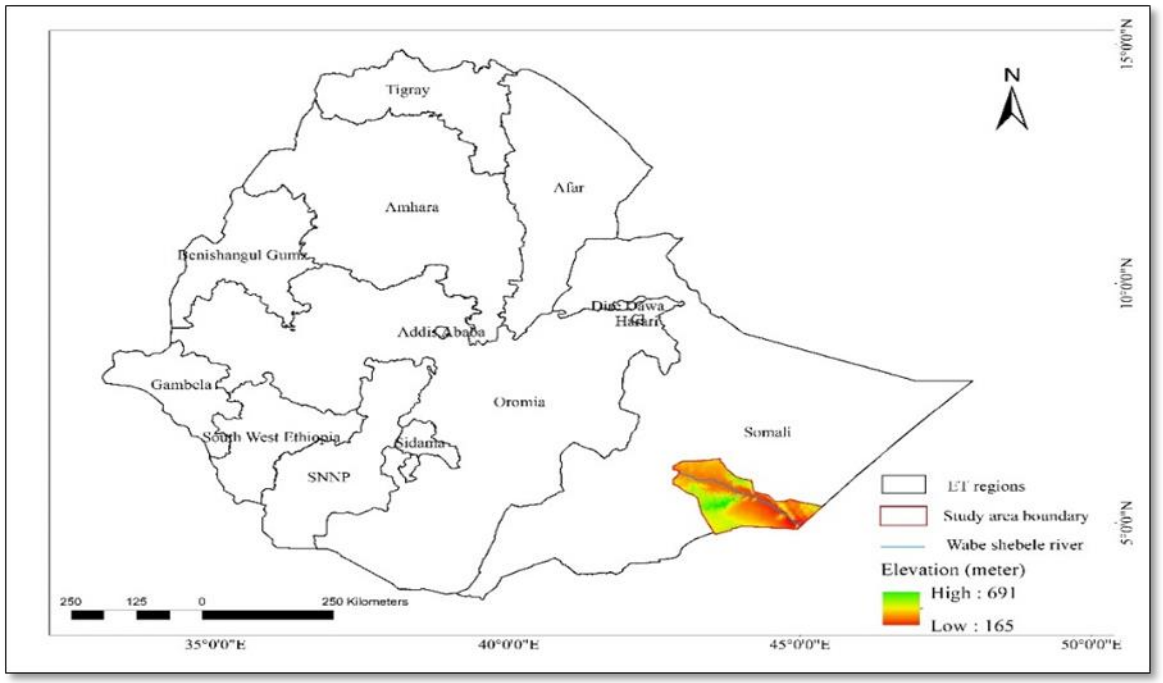


Figure 1 Geographic location of the study area

Data acquiring and preparation of thematic maps

Selection of effectual parameters is vital to produce a flood risk map in any catchment (Kia et al., 2012). Environmental variables like topography, climate, soil and land use land cover varies across the area significantly influence the magnitude and direction of flood in the area. A total of 10 (ten) causative factors having significant influence on flooding were identified through field survey, reviewing related papers and expert's opinion. Those are land use/land cover, elevation, slope, topographic wetness index (TWI), surface runoff, landform, lithology, distance from the main river, soil texture and soil drainage.

Table 1 Data sets used for flood risk analysis

No	Data description	Spatial resolution	Source
1	ASTER-DEM	30m * 30m	USGS official website
2	Slope	30m * 30m	From DEM data
3	Soil texture	---	FAO
4	LULC Classes	30m * 30m	Geospatial institute of Ethiopia
5	Geology	---	Geological survey of Ethiopia
6	Historical flood inventory database	GPS points	Field survey

Analytic hierarchy process (AHP)

The flooding susceptible areas were determined by overlaying the determinant flood contributing thematic layers in Arc GIS. In AHP, weights and thematic layers of each level (criteria classes) are assigned and their relative importance is determined using Saaty's 1–9 scale. The relevance or preference of each thematic layer relative to the other thematic layers on flood prone area delineation selection was conveyed by assigning weights. Pairwise comparison matrix were generated by utilizing related review literatures, field observation, and expert judgment.

Results and Discussion

Flood risk parameters (FHP)

The degree of flooding is subjective to a variety of factors such as elevation, geology, slope, drainage density, proximity, land use and land cover, soil, landforms and rainfall. Therefore, based on literature review and field investigation, only 8 most influencing factors that contribute

to flood extent were selected by this study to develop the flood risk map of Lower Wabi-Shebelle.

Elevation

Lowland locations are more vulnerable to flooding as water moves from higher to lower elevations (Patrikaki *et al.*, 2018). The elevation map is made possible by reclassifying the DEM. The River catchment's topographic elevation ranges from 165m and 691m. The effect of the flood was categorized into different levels based on the elevation. However, the result indicated elevation of the research area was divided into five categories based on its effect on flood hazard: very high (520–691 m), high (421–520 m), moderate (338–421 m), low (268–338 m) and very low (165–268 m). Each class covers approximately 7.65, 19.32, 22.17, 31.37 and 19.5% of the total area of watershed, respectively (Table 2).

Table 2 Elevation classes of the area

Value	Range	New values	Area coverage (ha)	Proportion (%)
Very low	165 - 268	1	476897	19.5
Low	268 - 338	2	767234.5	31.37
Moderate	338 - 421	3	542194.6	22.17
High	421 - 520	4	472634.8	19.32
Very high	520 - 691	5	187065	7.65
Total		--	**2,446,025.9**	**100**

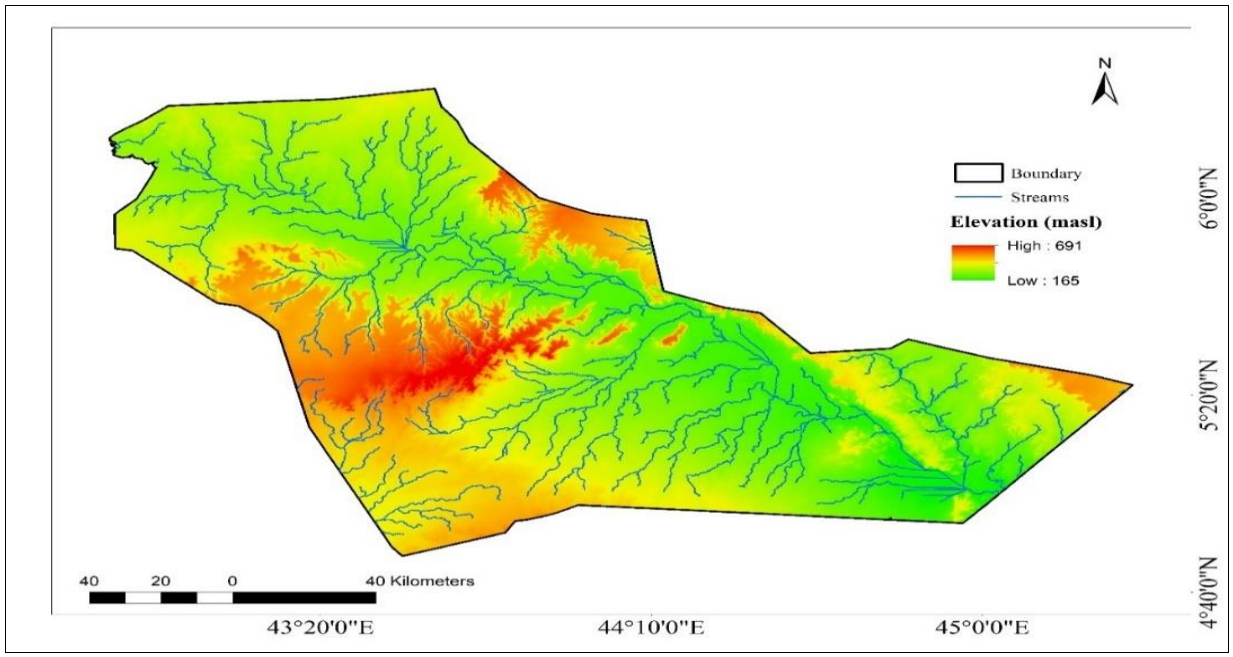


Figure 2 Elevation map of the study area

Geology

The geology of the area can have an effect on flood incidence. This is a main significant flood conditioning factor that contributes to the pace of flooding being amplified. Local geology keeps track of paleo-flood occurrences that can be used to estimate the frequency of prior flash floods (He B. et al., 2007). The infiltration phase would be accelerated by increased permeability lithological units, while the impermeable layer would amplify surface runoff, perhaps creating floods. The rate of infiltration and the permeability of rocks have a close relationship (Bonacci et al., 2006). The result of this study revealed that seven geological classes and used for the flood analysis (Table 3).

Table 3 Geological classes of the area

Geological Code	Area (ha)	Geological classes description
Kb	61393	Belet Uen Formation: Late Cretaceous (Cenomanian - Turonian) limestone with some sandstone and shale.
Kf	32439	Ferfer Formation: Albabian-Cenomanian shale, dolomite and anhydrite.
Kg2	1263496	Korahe Formation (Main Gypsum Formation):Neocomian/Barremian
Km	587895	Mustahil Formation: Aptian-Albian limestone, marl and sandstone.
P2a	34451	Ashangi Formation: Deeply weathered alkaline and transitional basalt flows with rare intercalations of tuff, often tilled (includes Akobo Basalts of SW Ethiopia).
Pi	36477	Jessoma Formation: Late Cretaceous-Paleocene sandstone
Q	429084	Alluvial and lacustrine deposits: sand, silt, clay, diatomite, limestone and beach sand.

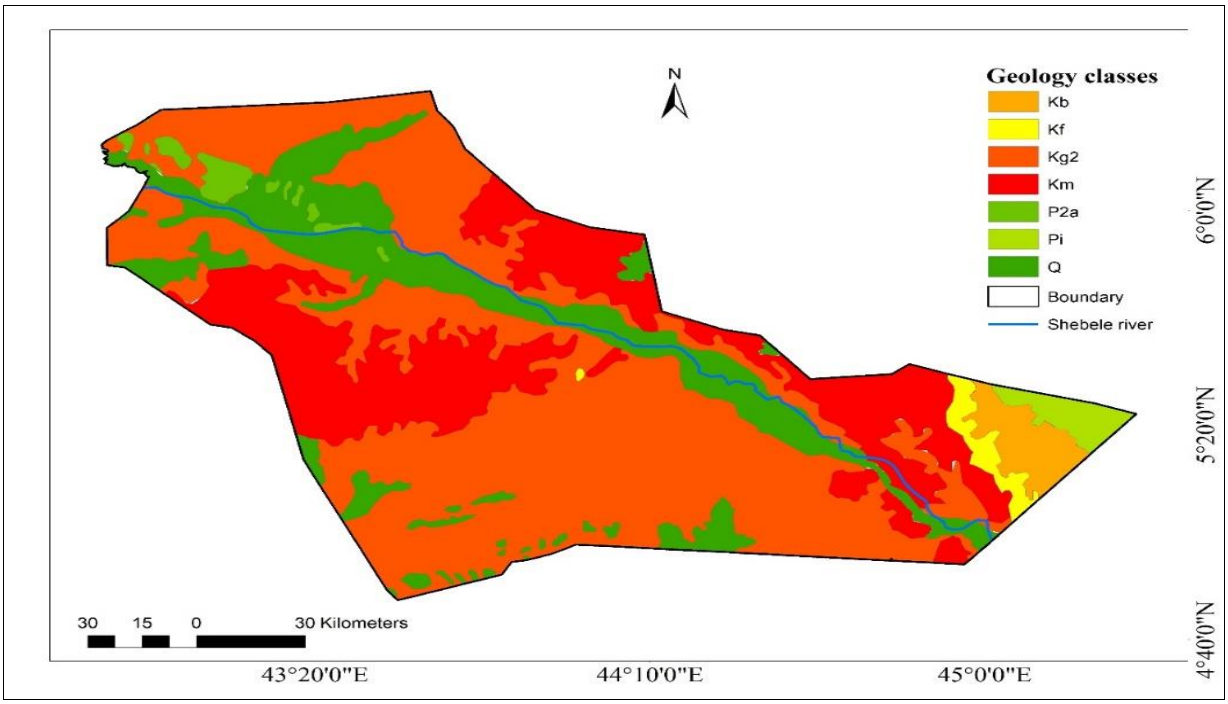


Figure 3 Geology map of the study area

Slope

Slope is an important indicator of flood-prone surface zones (Wondim, 2016) and plays a major role in flood hazard mapping (Alemayehu, 2007). It has a great influence on flood hazard assessment because it governs the amount of surface runoff produced, the precipitation rate and displacement velocity of water over the equi-potential surface. The research region's slope percentage ranges from 0 to 57.3. Lower slope values represent flatter topography that was especially vulnerable to flooding, whereas higher slope values represent steeper topography that was less vulnerable to flooding. Slopes were classified into five classes based on their impact on flood risk: extremely high (0–11), high (11–22), moderate (22–34), low (34–46) and very low (46–57.3). Each slope class accounts for about 94.002, 5.055, 0.892, 0.051 and 0.001% of the total area of the study site, respectively.

Table 4 Slope classes of the area

Value	**Range**	**Rank**	**Area coverage (ha)**	**Proportion (%)**
Very low	0 - 11	1	2297196.5	94.002
Low	11–22	2	123522.7	5.055
Moderate	22–34	3	21799.2	0.892
High	34–46	4	1234.2	0.051
Very high	46–57.3	5	22.4	0.001

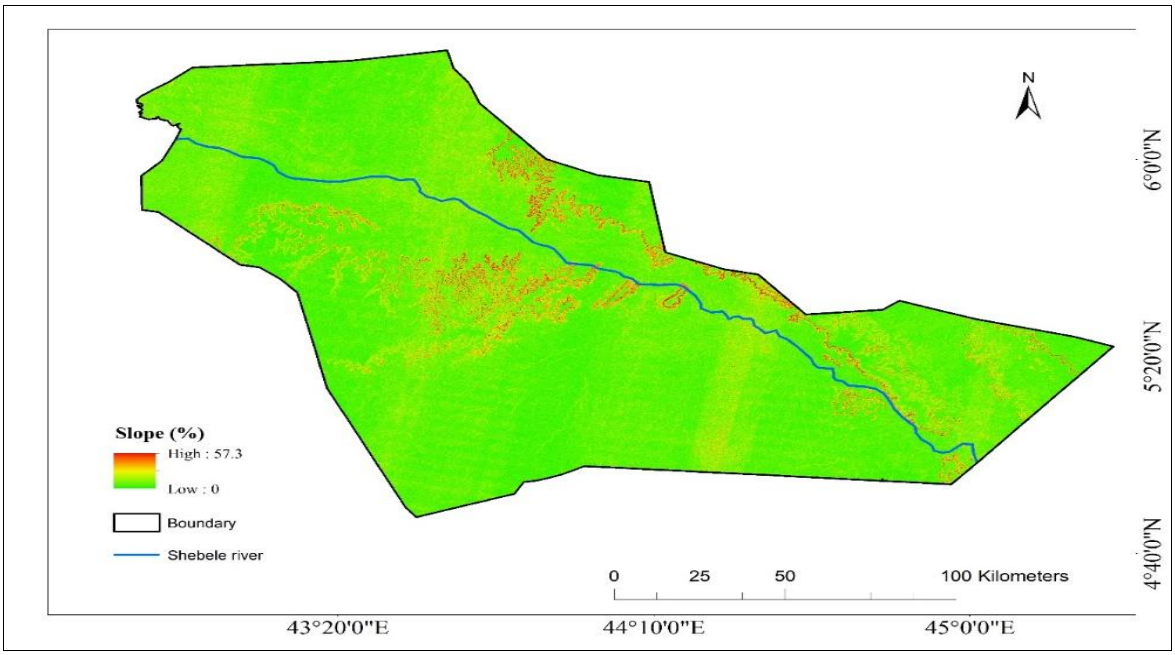


Figure 4 Slope map of the study area

Drainage density

The density of drainage is a major factor influencing flood hazard. A low permeable surface area is prone to high drainage density, and water from precipitation also leads to high runoff and vice versa. As a result, greater drainage density means that the area is less prone to flooding (Chibssa, 2007; Wondim, 2016). As a result, as drainage density increases, the rating for drainage density decreases. The technique has been proposed to extract drainage networks from DEMs with a resolution of 30 m using a spatial analysis tool in ArcGIS.

The drainage density (DD) is calculated by dividing the total length of all streams and rivers in a drainage basin by the drainage basin's total area. As shown in the equation below, drainage density is the total length of the stream segments divided by the unit area (Greenbaum 1985; Magesh et al., 2012; Ouma and Tateishi, 2014).

$$\mathrm{Dd} = \frac{\sum_{i=1}^{n} Li}{A}$$

Where $\sum_{i=1}^{n} Li$ is the total length of drainage in Km, A is total area of study site in Km^2, and n stand for number of drainage networks in the watershed.

Table 5 Drainage density classes of the area

Value	Contribution for flooding	Rank
0 - 0.071062	Very low	5
0.071062 - 0.207513	Low	4
0.207513 - 0.385409	Moderate	3
0.385409 - 0.609258	High	2
0.609258 - 1.148853	Very high	1

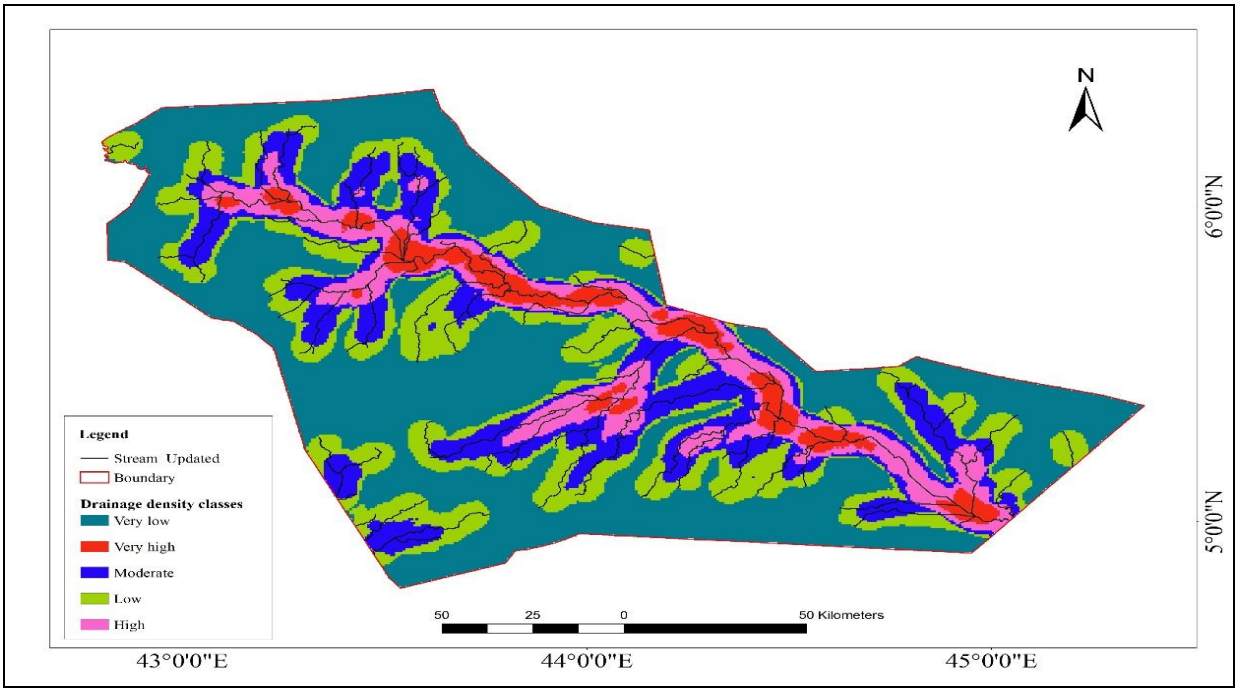


Figure 5: Drainage density map of the study area

Proximity to river

In determining the flood risk zones and the flood hazard index, the remoteness from the river network component is crucial. Flood hazard is most severe in locations near river networks, according to Fernández and Lutz (2010), whereas the effect of this parameter reduces as one advances away from the riverbed. In this study, the proximity was separated into five categories based on its effect on flood risk, namely very high (0–400 m), high (400–800 m), moderate (800–2000 m), low (2000–5500 m), and very low (5500–12599 m) which is derived from the watershed river network (Figure 6).

Table 6: River proximity classes of the area

Value	**Contribution for flooding**	Rank
0 – 400	Very high	1
400 – 800	High	2
800 – 2000	Moderate	3
2000 – 5500	Low	4
5500 – 12599	Very low	5

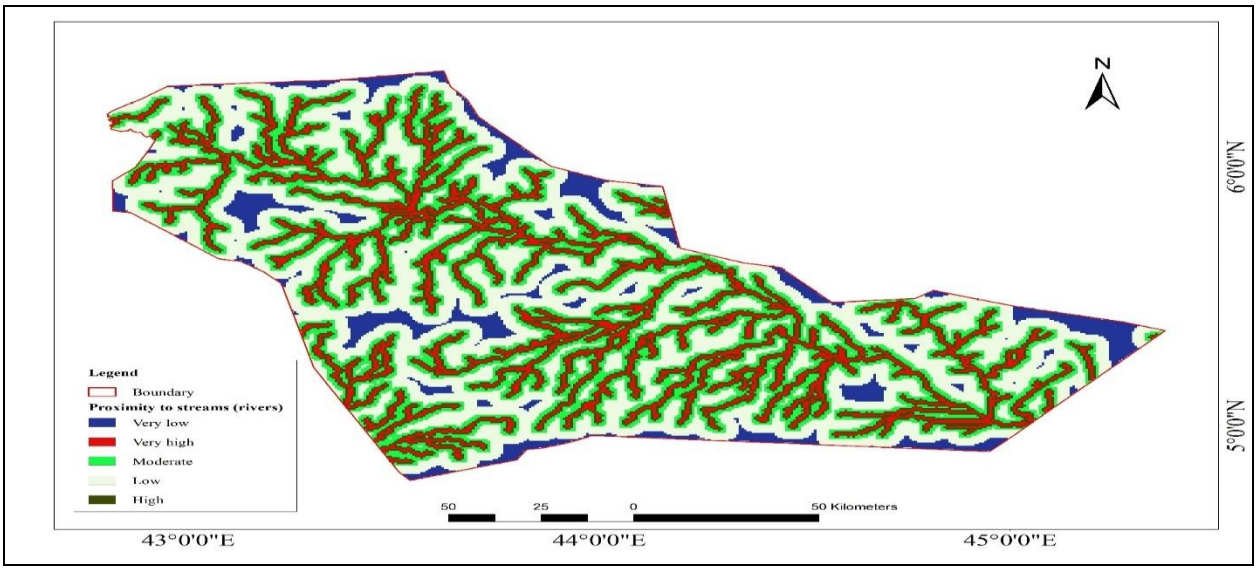


Figure 6 Proximity to streams map of the study area

Land use and land cover (LULC)

The existing relationship between the surface parameters that affect sub-surface runoff; groundwater infiltration and debris flow, the land use factors is strongly linked to the infiltration rate (RIVER 2006). Changes in rainfall, runoff characteristics of the river basin result changes in river flow regimes as a result of changes in natural land use land cover (RIVER 2006). Geospatial institute of Ethiopia revealed that Annual crop land, Settlement and Salt pan, rock out crops, Perennial crops, Open grass land, closed shrub land, Closed Grassland, Wet land, and Wood land and Dense Forest, Water body were the LULC types covered a significant portion of Wabishebelle river basin. It was assessed and ranked from very low to very high flood vulnerability using the Spatial Analyst Tool (SAT).

Table 7 Land Use Land Cover classes of the area

LULC types	Rank	Contribution for flooding
Annual crop land, Settlement, Salt pan	1	Very high
Rock out crops, Lava flow	2	High
Perennial crops, open shrub land	3	Moderate
Open grass land, Closed shrub land, Closed Grassland, Wet land and Wood land	4	Low
Dense Forest, Water body	5	Very low

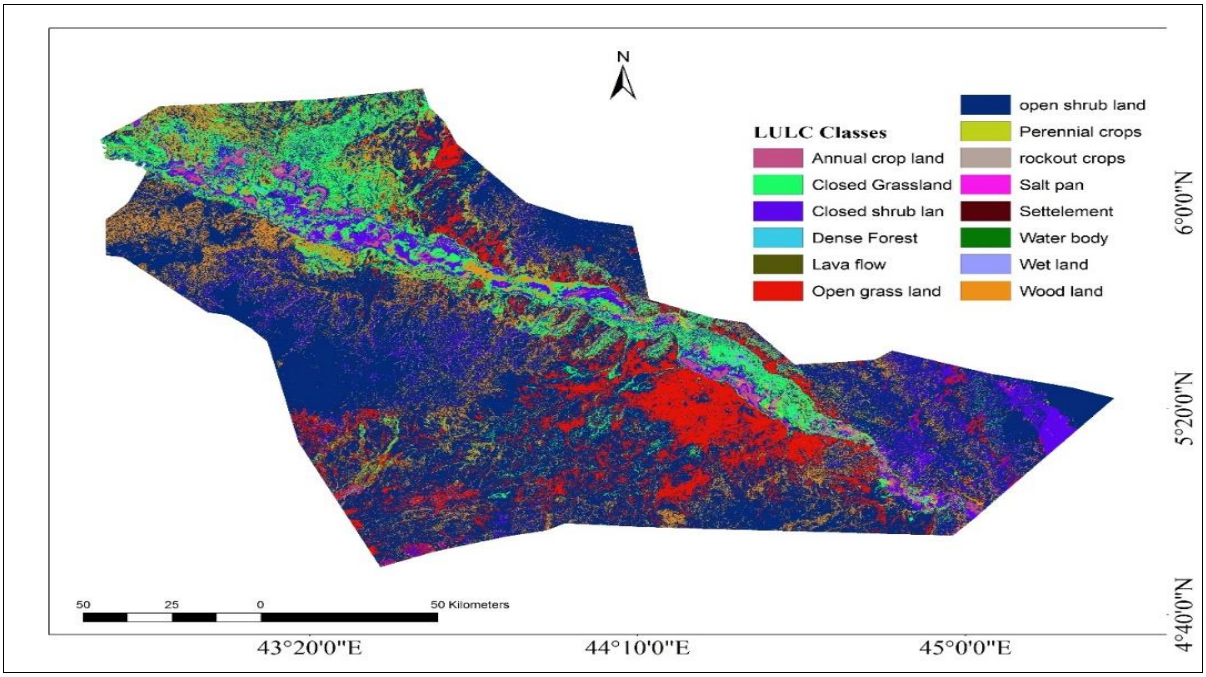


Figure 7 Land Use Land Cover map of the study area

Soil data

Understanding the many morphological and other physical aspects of the soil can be found in the soil description guideline (FAO, 2006). As shown in the figure 8, there were varied soil types in the Shebelle River Basin. In the study area 9 distinct soil types have been found (Table 8). The Arc-GIS "to Raster" conversion tool was used to convert the soil feature type to a raster layer. As a result, the reclassification into five flood hazard levels is based on the degree to which flooding

occurs. The classification of soil degree to flooding as follows; very high class scaled 1 (Fluvisols), high class scaled 2 (Vertisols), moderate class scaled 3 (Leptosols), low class scale 4 (Nitosols), very low class scaled 5 (Solonchaks).

Table 8 Soil types of the study area

No	Soil type	Area	Percent
1	Calcaric Fluvisols	493158.8	20.4
2	Calcaric Xerosols	342369.1	14.2
3	Calcic Fluvisols	7922.7	0.3
4	Calcic Xerosols	268989.1	11.1
5	Chromic Vertisols	121812.6	5.0
6	Dystric Nitisols	6235.9	0.3
7	Eutric Nitisols	35537.5	1.5
8	Leptosols	18559.5	0.8
9	Orthic Solonchaks	1106906.8	45.8

Note: Rank 1-5, 1=higher, 5=lower

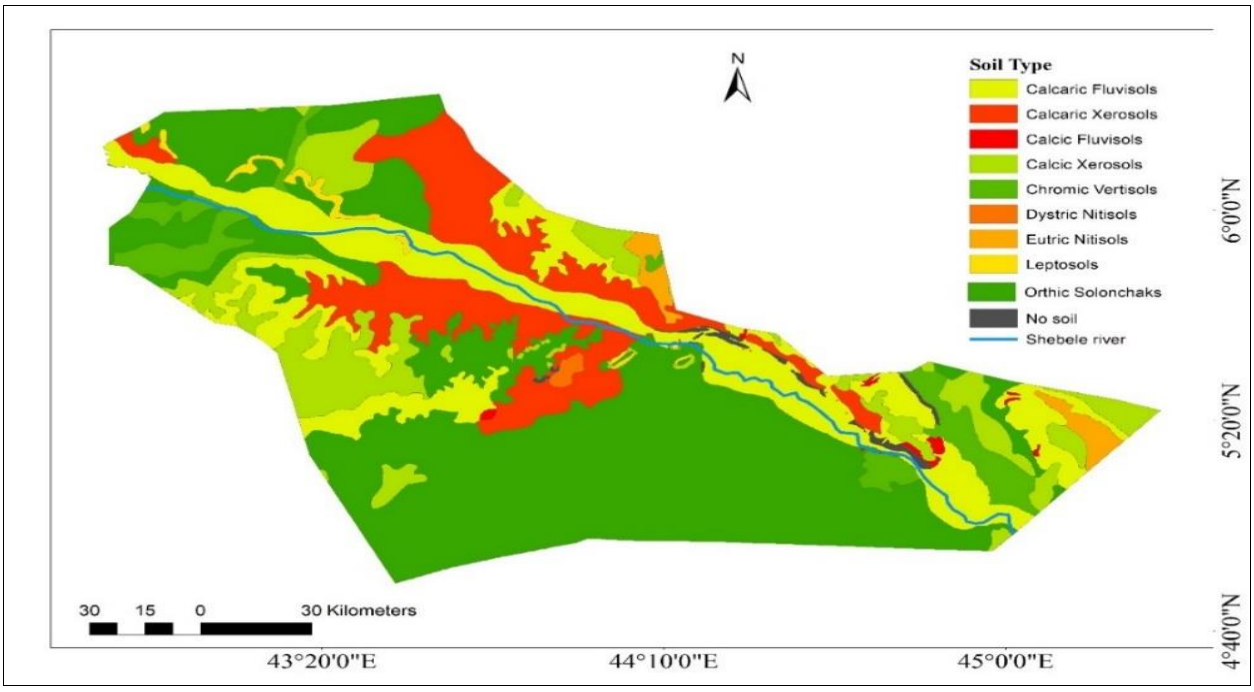


Figure 8 Soil map of the study area

Rainfall

Rainfall is a significant factor in creating a flood danger map. Due to limited meteorology station's data in the study area, the rainfall data were downloaded from WorldClim version 2 (*www.worldclim.org*). It is an average for the years 1970-2000. The area receives a minimum and maximum rainfall of 228 and 362 mm respectively. The rainfall in the research area were relatively classified into five categories based on its impact on flood risk: very low (228 – 259 mm), low (259 - 281 mm), moderate (281 - 304 mm), high (304 - 324 mm) and very high (324 - 362 mm). Each rainfall volume class covers about 5.4, 2.8, 22.6, 31.9 and 37.4% of the total area of the watershed, respectively.

Table 9 Rainfall classes of the area

Rainfall value (mm)	**Rank**	**Contribution for flooding**	**Area coverage (ha)**	**Proportion (%)**
228 – 259	5	Very low	365046.11	14.92
259 – 281	4	Low	482755.29	19.73
281 – 304	3	Moderate	466379.11	19.07
304 – 324	2	High	478216.05	19.55
324 – 362	1	Very high	653797.95	26.73

Flood risk analysis of lower Wabi-Shebelle

The slope, elevation, rainfall, land use/land cover, drainage density, proximity to river, Geology and soil types have been used to develop a flood vulnerability map by using GIS and AHP or multi-criteria decision-making techniques (Fernandez and Lutz, 2010; Karaman and Erden, 2014; Rozos et al., 2011; Peng et al., 2012; Karaman, 2015; Bathrellos et al., 2012). Besides, different researches uses only four or six components (Rahmati 2016; Choudhury 2022; Kourgialas 2011). However, using more than six (6) strata is generally suggested to decrease the hazard of overrating some aspects due to non-representative ratings controlled by a single factor (Mahmoud 2018). According to the literature, there is no collective rule for automatically identifying class limits; instead, most studies practice their own knowledge and expertise (Poddar 2023). In Shebelle river basin the food risk map was produced using GIS and AHP reclassification technique. The current research generated a flood risk map by integrating the eight flood affected

layers, similar to other flood hazard researches. However, the current result classified as very high 11%, high 88% and moderate 1% (Table 10). The areas near Shebelle river have shown the highest susceptibility for flooding (Figure 9). As indicated in figure 9, most of the very high and high flood risk zone falls in the river side areas, especially in Adadle, Kalafo, Mustahil and Ferfer woredas. Therefore, the majority of the farm land and residences surrounding the river in these woredas were affected highly by flood.

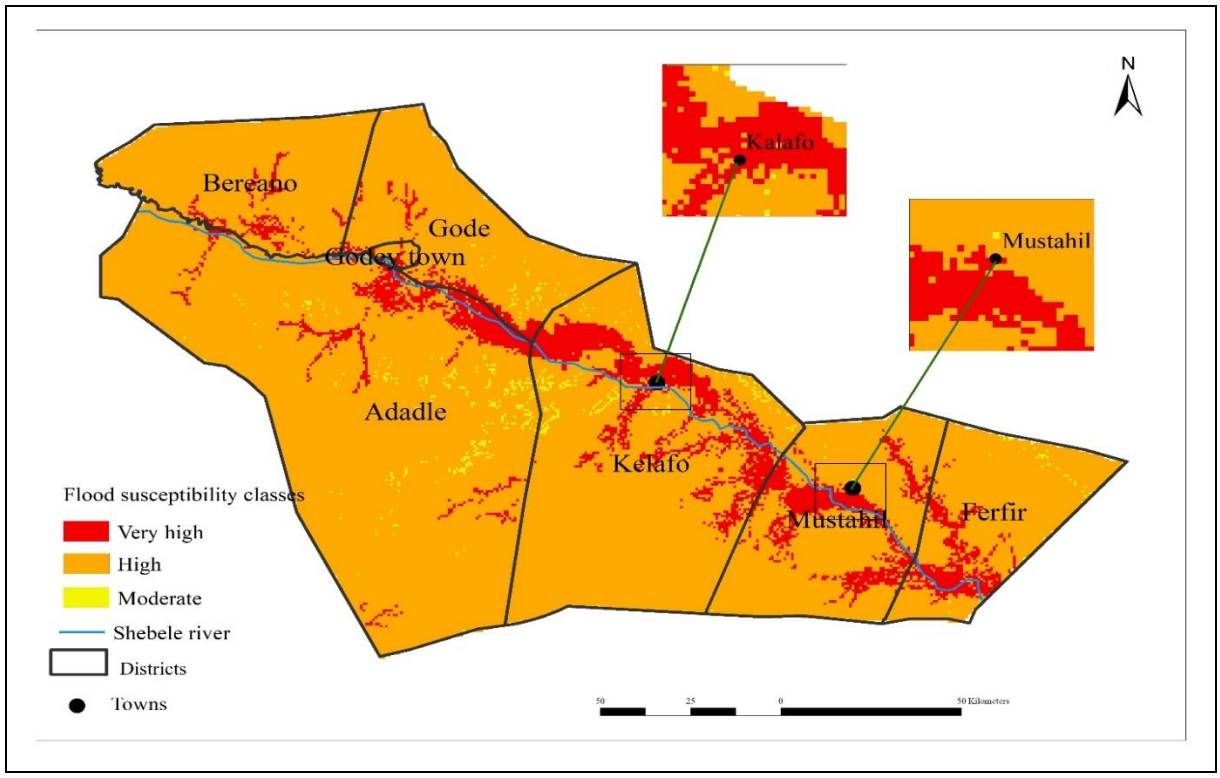


Figure 9 Flood susceptibility of lower Wabe-Shebele River

Table 10 Percentage of area covered each flood susceptibility classes

S. No	Total grids	Area (ha)	Proportion (%)	Flood susceptibility class
1	5263	257,048.80	10.7	Very high
2	483	23,590.10	1.0	High
3	43567	2,127,845.00	88.3	Moderate
Total		**2,408,483.90**	**100.0**	

Validation Process

The validation process was made by overlaying and comparing the traced peripheral of the flooded areas with the results achieved through the AHP method and sensitivity analysis method in the study area. A field visit has been made, and the peripheral of flood points have been collected for the years 2022 through Garmin hand GPS. A total of 21 flood marks were collected. Flood marks were collected for Koligee, Godaro, Busley, Gafur-danyer, Kunaso, Gabri, of Mustahil woreda and Niri, Jabole, Alow-igarsi of Kalafo woreda. Those of flood points then overlaid in the generated flood maps in ArcGIS environment (Figure 10). As shown in Figure (10) most of the flood marks laid over the high flood zone of the maps developed using AHP sensitivity analysis methods. From the total collected flood marks, 21 points (88%) laid over high flood zone, while 12 points laid over very high of the AHP flood map zones. The accuracy prediction was greater than 85%.

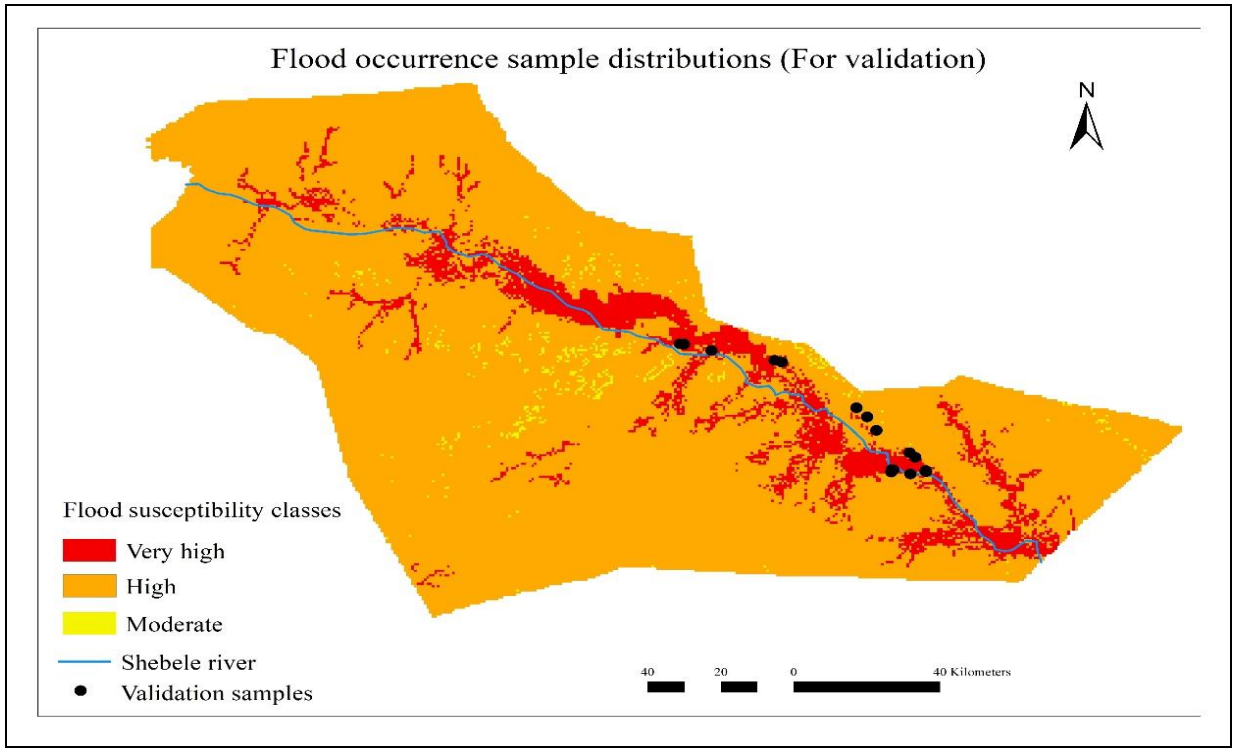


Figure 10 Flood susceptibility sample distribution

Conclusion and Recommendation

Floods have become more frequent and severe in the Wabi-Shebelle river basin, causing huge economic losses and social impacts. This is mainly due to climate change and other related factors. The aim of this study was to prepare a flood risk map for a specific part of the lower Wabi-Shebelle River Basin of the Somali region by analyzing the factors that cause floods using the GIS-based AHP method. Using the Arc GIS software, the following parameters were used to create the flood hazard map: Elevation, Slope, Soil, Geology, Distance to river, Rainfall, Drainage density and Land Use Land cover. The AHP method was used to assign weights to each parameter and generate the flood risk map. The map showed that 12% of the study area is at very high and high risk of flooding. Based on the result of the study, decision and policy makers can use this map as a reference for potential preventive actions, such as better watershed management, improved land use planning, flood hazard management and flood risk reduction. Moreover, the locations classified as very high flood risk require further flood protection measures, such as relocating the residents, reshaping the river banks and building protective walls. Furthermore, the authorities of the districts and the region (DRM Bureau) should collaborate to plan for flood protection and risk reduction in their strategic documents. They should also consider relocating the residents permanently from the flood risk areas in order to minimize the loss of property, livestock and human lives during flood events, especially in the Mustahil and Kalafo districts.

References

Alemayehu Z (2007) Modeling of Flood hazard management for forecasting and emergency response of ‘Koka’ area within Awash River basin using remote sensing and GIS method. Unpublished Msc Thesis, Addis Ababa University, Ethiopia.

Alemayehu Z., 2007.Modeling of Flood hazard management for forecasting and emergency response of ‘Koka’ area within Awash River basin using remote sensing and GIS method. Unpublished Msc Thesis, Addis Ababa University, Ethiopia.

Assefa, K., Andel, S. & Jonoski, A.W., 2008. A Warning in Lake Tana Sub Basin, Upper Blue Nile, Ethiopia.

Billa L, Shattri M, Mahmud AR, Ghazali AH (2006) Comprehensive planning and the role of SDSS in flood disaster management in Malaysia. Dis Prev Manag 15:233–240.

Bonacci O, Ljubenkov I, Roje-Bonacci T (2006) Karst fash foods: an example from the Dinaric karst (Croatia). Nat Hazards Earth Syst Sci 6(2):195–203. https://doi.org/10.5194/nhess-6-195-2006.

Chen H, Ito Y, Sawamukai M, Tokunaga T (2015) Flood hazard assessment in the Kujukuri Plain of Chiba Prefecture, Japan, based on GIS and multicriteria decision analysis. Nat Hazards 78(1):105–120. https://doi.org/10.1007/s11069-015-1699-5

Chen YR, Yeh CH, Yu B (2011) Integrated application of the analytic hierarchy process and the geographic information system for flood risk assessment and flood plain management in Taiwan. Nat Hazards 59(3):1261–1276

Chibssa AF (2007) Flood hazard assessment using GIS in Bacho Plain, Upper Awash Valley, South west of Addis Ababa. Master of Science Thesis. Addis Ababa University, Addis Ababa.

Choudhury S, Basak A, Biswas S, Das J (2022) Flash Flood susceptibility mapping using GIS-Based AHP method. In: Pradhan B, Shit PK, Bhunia GS, Adhikary PP, Pourghasemi HR (eds) Spatial modelling of Flood Risk and Flood Hazards. GIScience and Geo-environmental modelling. Springer, Cham. https://doi.org/10.1007/978-3-030-94544-2_8.

Daniel A., 2007. Assessment of flood risk in Dire Dawa town, Eastern Ethiopia, using GIS. Unpublished Msc Thesis, Addis Ababa University, Ethiopia.

Du J, Fang J, Xu W, Shi P (2013) Analysis of dry/wet conditions using the standardized precipitation index and its potential usefulness for drought/flood monitoring in Hunan Province China.

Fernández, D.S. and Lutz, M.A., 2010. Urban flood hazard zoning in Tucumán Province, Argentina, using GIS and multicriteria decision analysis. *Engineering Geology*, *111*(1-4), pp.90-98.

Hagos, B., 2011. Hydraulic Modeling and Flood Mapping of Fogera Flood Plain: A Case Study of Gumera River. Unpublished Msc Thesis, Addis Ababa University, Ethiopia.

He B, Xu YG, Huang XL, Luo ZY, Shi YR, Yang QJ, Yu SY (2007) Age and duration of the Emeishan flood volcanism, SW China: geochemistry and SHRIMP zircon U–Pb dating of silicic ignimbrites, post-volcanic Xuanwei formation and clay tuf at the Chaotian section. Earth Planet Sci Lett 255(3–4):306–323. https://doi.org/ 10.1016/j.epsl.2006.12.021.

Huang X, Tan H, Zhou J, Yang T, Benjamin A, Wen SW, Li S, Liu A, Li X, Fen S, Li X (2008) Flood hazard in Hunan province of China: an economic loss analysis. Nat Hazards 47:65-73.

Hunegnaw Desalegn and Arega Mulu (2020) Flood vulnerability assessment using GIS at Fetam watershed, upper Abbay basin, Ethiopia

Jahn R, Blume HP, Asio VB, Spaargaren O, Schad P (2006) Guidelines for soil description. FAO

Karaman, H. and Erden, T., 2014. Net earthquake hazard and elements at risk (NEaR) map creation for city of Istanbul via spatial multi-criteria decision analysis. *Natural hazards*, *73*, pp.685-709.

Kia MB, Pirasteh S, Pradhan B, Rodzi MA, Sulaiman WNA, Moradi A (2012) An artificial neural network model for flood simulation using GIS: Johor River Basin, Malaysia. Environ Earth Sci 67:251–264

Kourgialas NN, Karatzas GP (2011) Flood management and a GIS modelling method to assess flood-hazard areas a case study. Hydrol Sci J–J des Sci Hydrol 56(2):212–225. https://doi.org/10.1080/02626667.2011.555836.

Mahmoud SH, Gan TY (2018) Multi-criteria approach to develop flood susceptibility maps in arid regions of Middle East. J Clean Prod 196:216–229. https://doi.org/10.1016/j.jclepro.2018.06.047.

Mossie, T., 2008.Flood Generated from Tana Lake Basin. Unpublished Msc Thesis, Addis Ababa University, Ethiopia.

Patrikaki O, Kazakis N, Kougias I, Patsialis T, Theodossiou N, Voudouris K (2018) Assessing food hazard at river basin scale with an index-based approach: the case of Mouriki, Greece. Geosciences 8(2):50. https://doi.org/10.3390/geosciences802005

Poddar I, Alam J, Basak A, Mitra R, Das J (2023) Application of a geospatial-based subjective MCDM Method for Flood susceptibility modeling in Teesta River Basin, West Bengal, India. Monitoring and managing multi-hazards. Springer, Cham, pp 135–152. https://doi.org/10.1007/978-3-031-15377-8_10.

Rahmati O, Zeinivand H, Besharat M (2016) Flood hazard zoning in Yasooj region, Iran, using GIS and multi-criteria decision analysis. Geomatics Nat Hazards Risk 7(3):1000–1017. https://doi.org/10.1080/19475705.2015.1045043.

Sifan A., 2012.Remote Sensing Based Hydro-logical Modeling for Flood Early Warning in the upper and middle Awash River Basin. University of Twente.

Tehrany MS, Pradhan B, Jebur MN (2015) Flood susceptibility analysis and its verification using a novel ensemble support vector machine and frequency ratio method. Stoch Environ Res Risk Assess 29:1149–1165. https ://doi.org/10.1007/s0047 7-015-1021-9.

Wanders N, Karssenberg D, de Roo A, de Jong SM, Bierkens MFP (2014) the suitability of remotely sensed soil moisture for improving operational flood forecasting. Hydrol Earth Syst Sci 18:2343–2357

WHO (2003) World Health Organization. Disaster Data-key Trends and Statistics in World Disasters Report; WHO: Geneva, Switzerland. http://www.ifrc.org/PageF iles/89755 /2003/43800 -WDR20 03_En.pdf (Accessed 5 April 2017).

Wondim YK (2016) Flood hazard and risk assessment using GIS and remote sensing in lower Awash sub-basin Ethiopia. J Environ Earth Sci 6(9):69–86

Woubet G., & Dagnachew L., 2011.Flood Hazard and Risk Assessment in Fogera Woreda using GIS and Remote Sensing. *Journal of Springer Environmental Science, 2011,179-206*.

Yalcin A (2008) GIS-based landslide susceptibility mapping using analytical hierarchy process and bivariate statistics in Ardesen (Turkey): comparisons of results and confirmations.

Yalelet F., 2013. Flooding and its impact on Agriculture in Lake Tana Basin. Unpublished Msc Thesis, Bahir Dar University.

Yirga, 2016. Flood Hazard and Risk Assessment Using GIS and Remote Sensing in Lower Awash Sub-basin, Ethiopia.

Youssef AM, Pradhan B, Hassan AM (2011) Flash flood risk estimation long the St. Katherine road, southern Sinai, Egypt using GIS based morphometry and satellite imagery. Environ Earth Sci 62:611–623.

Zelalem, A., 2011.Flood Mapping and Modeling on Fogera Flood Plain, a Case Study of Ribb River.Unpublished Msc Thesis, Addis Ababa University, Ethiopia.

Zereini F (2008) In: Hötzl H (ed) Climatic changes and water resources in the Middle East and North Africa. Springer, Berlin. https://doi.org/10.1007/978-3-540-85047-2 9.

AGRICULTURAL MECHANIZATION RESEARCH DIRECTORATE

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Introduction of Improved Small Scale Post-harvest Agricultural Mechanization Tools maize Sheller and hand maize Sheller in Somali Region, Ethiopia

Kalid Hussein[1], Firew Kassahun[2]
Email: kalidxusen2015@gmail.com and firew2719@gmail.com
Somali Region Pastoral and Agro-pastoral Research Institute, Agricultural Mechanization Research Directorate, Jigjiga, Ethiopia

ABSTRACT

Assessing the performance characteristics of the developed maize shelling machine is the focus of this paper. Maize shelling machine was fabricated based on engineering design approach with the aid of software (CAD) and values, and was fabricated at in Somali region Pastoral & agro-pastoral Research institute(SoRPARI)Workshop using suitable materials after considering the factors such as Hardness, ease of machining, tensile strength, availability, durability and the cost. The machine is electrically operated by an electric motor with power rating of 2.235 kW, speed of 1430 rpm and torque of 14.92 Nm. Maize losses and damages were found insignificant. It shells 60 times as fast as hand shelling. The design presented in this paper is aided with computer software (Autodesk Inventor) to give the accurate and precise results. Maize shelling machine was developed to shell maize and separate the cob from the grains with appropriate engineering design factors. The efficiency of the machine is a benchmarked against the commercially available maize shelling machines. It has an average shelling capacity of 55 kg/hr, its shelling efficiency is 91.29 % and breakage is very insignificant, as well as losses. The machine can help to substantially reduce the human labor and stress involved in shelling maize and also reducing the time used for shelling operation on farms. There is no doubt that the machine will ease the long term problem of maize shelling especially for the rural farmers.

Keywords: *Maize, Shelling, Machine, Design, Research*

INTRODUCTION

Agriculture plays a major role in Ethiopian society. It provides a livelihood for around 80 per cent of the population and accounts for 40 per cent of total economic output (GIZ, 2018). In some areas of the country, considerable increases in production are possible, which could in turn be used to supply other parts of the country or even allow Ethiopia to become a net food exporter (Ababa et al., 2020).

The Ethiopian Government wants to adopt agricultural mechanization solutions as a way of achieving sustainable increases in smallholder productivity, therefore contributing to both higher incomes and the development of rural regions.

Mechanization covers all levels of farming and processing technologies, from simple and basic hand tools to more sophisticated and motorized equipment. It eases and reduces hard labor, relieves labor shortages, improves productivity and timeliness of agricultural operations, increases resource-use efficiency, enhances market access and contributes to mitigating climate-related hazards (EIAR, 2003). Sustainable mechanization considers technological, economic, social, environmental and cultural aspects when contributing to the sustainable development of the food and agricultural sector (Repetto, 1986).

The most common challenges to increasing smallholder access to appropriate mechanization include a mismatch between the economies of scale of machines and farm size. More than 50% of globally produced food originates from small family farms (Herrero et al., 2017), and many of these consist of separate and dispersed fields and thus are poorly suited for larger machinery (Loon et al., 2020). The other challenge for smallholder farmers is cost of machinery. In many countries, farmers cannot afford to purchase equipment and financial support through subsidies or finance schemes are limited. The financial-service sector shies away from providing credit to smallholders because of lack of eligible collateral and a perception of high risk involved with agriculture (Food and Agricultural Organization, 2016; Mottaleb et al., 2017).

Although the mechanization process had generated significant interest in recent time, there is still need to revolutionize by making quality machines with high performance considering the technicality adaptability, economic capacity and appropriate refers to user-friendly machinery tailored to smallholders' fields. Hence, this work focused on adapting and constructing small-scale agricultural mechanization tools that address smallholders/ Agro-pastoralist in Somali region, Ethiopia

MATERIALS AND METHODS

Consideration for material selection was based on availability, ease of machining, durability, strength, and cost, mechanical and chemical properties. Table 1 shows the parts of the machine as well as the material selected for each part

Table1: Parts of a developed maize shelling machine and its material

S/N	Components	Functions	Material
1.	Hopper	Serves as storage for the maize to move Into the crushing chamber.	Mild steel
2.	Crusher	To shell and give out grains.	Mild steel
3.	Shaft	It transmits torque and motion from the pulley to turn the crusher.	Mild steel
4.	Pillow Bearing	It holds the bearing into position.	Cast iron
5.	Stand	It allows the body to rest on firmly and absorbed vibration.	Angle bar Mild Steel
6.	Pulley	It transmits the torque from the electric Motor to the Shaft.	Cast iron
7.	Electric Motor	To generate a torque for the system.	2.234 kW, speed of 1430 rpm
8.	Bearing	To allow free movement of the shaft.	Cast iron
9.	V-Belt	To transmit the torque from the electric Motor to the pulley.	Fabric cord



DESIGN CALCULATION

The Power Requirement

The rating was determined by calculation results. Power transmitted by shaft, angular speed and torque was determined using equation 1, 2 and 3 respectively.

$$P = \frac{2\pi N}{60} \times T \quad (1)$$

$$\omega = \frac{2\pi N}{60} \quad (2)$$

Shaft Design

The Autodesk shaft generation software (Autodesk Inventor, 2010) was used to test the reliability of the shaft diameter under required loads condition. In this design, diameter 25 mm, length 500 mm for threshing shaft and 20 mm, length 500 mm for blower/fan were generated via the software which serves the interests of achieving the overall machine workability and also lower the costs of materials. The shaft has a key way and with the specified dimensions to firmly hold in place the pulley.

Performance Evaluation of maize shelling machine

Maize Sheller was subjected to test and it was found to shell maize very effectively. The following parameters were determined from the data collected

1. Capacity (rate of shelling)

$$\frac{mass\ shelled\ grains \times 3600 kg/hr}{time\ taken\ (s)}$$

1. Shelling Efficiency

$$= \frac{mass\ of\ shelled\ grains}{total\ mass\ of\ grains\ (shelled + unshelled)} \times 100$$

3 Grain damage = $\frac{mass\ of\ damage\ grain}{mass\ of\ shelled\ grains} \times 100$

Maize samples were taken and the average mass of maize measured is 0.250 kg. Samples were carried out in 3 trials.

Results and Discussions

Shelling of maize to remove the grain from the cob has been a time consuming, tedious and a mind cracking process especially to the many small scale farmers in the country who basically practice subsistence maize farming. However, traditional shelling methods do not support large-scale shelling of maize, especially for commercial purposes. Hand shelling takes a lot of time, even with some hand operated simple tools. Few researchers reported that tractor PTO (power take off) shaft operated are the most common mechanized Sheller that are designed for maize threshing or shelling (B. D. Agarwal and L..)

A number of engine-powered maize sheller were developed which provided the foundation for modern commercial and agricultural Sheller and a good example is the buch-2-hole antique Sheller (Kishan K. Chawla, Springer, 2009).

The shelling capacity shown in table 2 and table 3 below indicated that there is decrease in hand tool shelling which increases in electric machine shelling an advantage over the hand tool shelling in terms of shelling capacity (output).

While being done the comparison by the researcher team, the mean shelling efficiency obtained by using electrical and hand tool Sheller were 99% and 5%, with an average shelling capacity of 1146.2 kg/hr. and 24.47kg/hr respectively as shown in table 2, 3 and 4. The result obtained show that the grain damage with the use of electrical and hand tool sheller was discovered that it was so negligible with the ranging value 0.02kg to 0.026kg.

These two machines are the tool developed by SoRPARI's agricultural mechanization directorate. The research team faced difficulties to get similar projects for comparisons of the performance of these machines. Since the introduction of the modern maize Sheller in the 1800's, the basic design and function of this machine has remained the same with most modern-day maize Sheller bearing a strong resemblance to the original models(L.R. Calcote, Van Nostrand Rainfold, New York, 1969) Besides, the cost of purchasing such Sheller are high for the rural farmer and as a result of all these, it will be difficult for the rural farmers to maximize profits on their produce therefore the need for a relatively low cost maize shelling mechanism that will be affordable to the farmers not only to meet their shelling requirement but also to improve the threshing efficiency and reduce damage to the seed and as well as to deeply look the adoptability considering the design that initiated the researchers

Table 2: Shelling capacity with the use of electrical Sheller

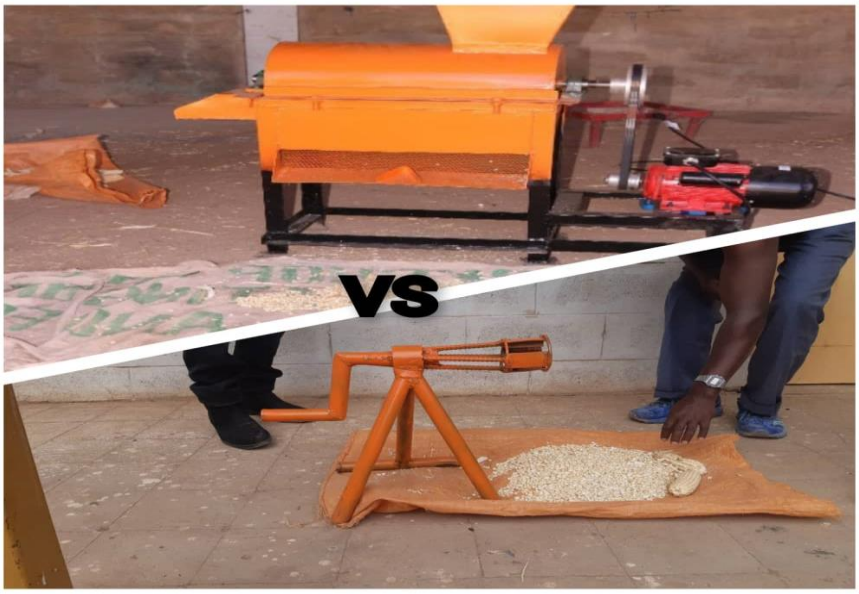
Trial	Mass of grain(kg)	Time taken(s)	Rate of shelling expression(kg/hr)	Rate of Shelling(kg/hr)
1	4.98	16	$\frac{4.98^{\times}3600}{16}$	1120.5
2	4.99	15	$\frac{4.99 \times 3600}{15}$	1197.6
3	4.98	16	$\frac{4.99 \times 3600}{16}$	1122.75

Table 3: Shelling capacity with the use of hand

Trial	Mass of grain(kg)	Time taken(s)	Rate of shelling expression(kg/hr)	Rate of Shelling(kg/hr)
1	4.8	698	$\frac{4.8 \times 3600}{698}$	24.7
2	4.85	650	$\frac{4.85 \times 3600}{650}$	26.8
3	4.9	810	$\frac{4.9 \times 3600}{810}$	21.7

Table 4: Comparison of the two shelling method

	Maize Sheller				Hand Shelling		
Trails	Time (s)	Mass of shelledgrains (kg)	Output (kg/hr)		Time (s)	Mass of shelled grains(kg)	Output (kg/hr)
1	12	0.202	60.6		460.2	0.196	1.53
2	32	0.436	49.0		800.6	0.400	1.79
3	17	0.262	55.4		512.4	0.255	1.75
Mean			55.0				1.69



The machine has a unique feature which permits the belt to be adjusted to suit to specific prerequisites or bring into a fitting connection which can prevent slacking and cutting of the belt which lessen the expenses subsequently bringing about higher productivity. The machine is also detachable so as to make assembling and dissembling easy, also to help detect faults and fix them quickly. Maintenance on the machine can be carried out easily and down time can be reduced in other to increase machine efficiency.



Figure 4 on station of electric motor operated maize Sheller and manually operated maize Sheller machines

Cost-Benefit Analysis of Maize Sheller machine

Cost-benefit analysis is an imperative part of the process for this study. In the making of any machine, the economics related to it have to be carefully considered to analyze the costs and go ahead to compute the profit.

Table 5: description cost benefit analysis maize Sheller machine

No	Variable	Cost(ETB)
1	Raw material	85,240.00
2	3Hp electric motor	36,500.00
3	Material wastage = 2.5% of 1	912.5
4	Production cost (Machine + labor)	65,000
5	Overhead 5% of 4	4,262
6	Profit 10% (1+2+3+4+5)	19,191.45
7	Sell tax 15% (1+2+3+4+5+6)	31,665.9
8	Selling Price (1+2+3+4+5+6+7)	**242,771.85**

Conclusion and Recommmedations

Conclusion

A simple, efficient, less tedious machine for shelling maize has been developed. All the materials used in fabricating the machine are affordable and locally available. Both electrical and hand tool sheller machine can shell maize with various sizes and has a shelling efficiency of 99.96 % and 5% with minimal 0.02 % -0.026grain damage with an average shelling capacity of 1146.2 kg/hr and 24.47kg/hr. respectively. The machine operates smoothly and efficiently when in operation and shelled grains flow freely through the grain outlet.

It is less bulky and the ergonomic considerations in the design would allow for its comfortable use by either male or female agro-pastoralists.

The machine can help to substantially reduce the human labor and stress involved in shelling maize at an affordable cost and also reduces the time used for shelling operation on small scale level farms.

Recommendations

From the project we come up with following recommendations;

- Wheels to enhance movement within shelling area and transportation from farms to the desired destination.
- Maize to be shelled must be properly dried for effective shelling and efficiency.
- Since achieved different maize sheller technologies, we recommended to make full package all maize sheller including manuals and guidelines and transfer stakeholders, farmers, popularize and scale up machine must consider the future de- husking maize sheller technology.
- We also recommend Cooperative office and job & skills bureau to further implement this project for cooperatives.

REFERENCES

EIAR. (2003). *The Ethiopian Institute of Agricultural Research* (Issue August).

Gittinger, J. P. (1994). Economic analysis of agricultural projects. *International Affairs*, *59*(3), 505–505. https://doi.org/10.2307/2618842

Hamzah, I. J., Al Sharifi, S. K. A., & Ghali, A. A. (2021). Requirements of maize mechanical shelling. *Agricultural Engineering International: CIGR Journal*, *23*(1), 252–256.

Langyan, S., Dar, Z. A., Chaudhary, D. P., Shekhar, J. C., Herlambang, S., Enshasy, H. El, Sayyed, R. Z., & Rakshit, S. (2021). Analysis of nutritional quality attributes and their inter-relationship in maize inbred lines for sustainable livelihood. *Sustainability (Switzerland)*, *13*(11), 1–12. https://doi.org/10.3390/su13116137

Mottalib, M. A., Hossain, M. A., Hossain, M. I., Amin, M. N., Alam, M. M., & Saha, C. K. (2019). Assessment of cost-benefit parameters of conservation agricultural machinery for custom hires entrepreneurship in the southern region of Bangladesh. *Agricultural Engineering International: CIGR Journal*, *21*(3), 94–103.

Teha, A., & Nur, J. (2020). Pre-extension Demonstration and Evaluation of Engine Maize Sheller Technology in the Selected AGP-II Districts of Harari Region and Dire Dawa Administration. *Food Science and Quality Management*, *97*, 14–18. https://doi.org/10.7176/fsqm/97-03

Win, H. H., San, M. G., & Tun, M. Y. A. (2019). Design and Structural Analysis of Shelling Shaft for Motorized Maize Shelling Machine. *Iconic Research and Engineering Journals*, *3*(2), 394–399 for Motorized Maize Shelling Machine. Iconic Research and Engineering Journals, 3(2), 394–399.

B. D. Agarwal and LAnalysis and performance of fibre Composites, J. Broutman Wiley-Interscience, New York, 1980. Analysis of Laminated Composite Structures, L.R. Calcote, Van Nostrand Rainfold, New York, 1969

Development and Evaluation of Self-Propelled Tractor-Mounted Seven-Row Precision Multi-Crop Planter in Somali Region, Ethiopia

Firew Kassahun1[1] and Kalid Hussein[2]

Email: firew2719@gmail.com and kalidxusen2015@gmail.com
Post-Harvest and Product Processing Research Program, Agricultural Mechanization Research Directorate, Somali Region Pastoral and Agro-Pastoral research Institute (SoRPARI)]

Abstract

This study was conducted in the Somali region, Ethiopia 2022-23 to develop and evaluate the performance of self-propelled tractor-mounted seven-row precision multi-crop planter which can sow different crops and fertilizer at predetermined depths and row spacing. The seed drill performances were evaluated in terms of Seed and fertilizer rate, depth of seed placement, row spacing, plant population, field capacity and field efficiency, randomized complete block design with three forward speeds, and three replications were used as experimental design. Wheat was used as a test crop for this study. There were no visible and internal seed damaged by the machine and it shows that there was no reduction in germination percentage when compared with seed supplier recommendation. The seed rate was calibrated and recorded as between 71.26 kg/ha and 102.25 kg/ha for 20 cm row spacing. The seed drill was evaluated at speed of 2, 3, 4 km/hr and hopper loading level of H_{50}, H_{75}, and H_{100}. Both the machine operational speed and hoper filling level had significant effect ($p < 0.05$) on wheat seed rate. The average field capacity, field efficiency, and fuel consumption at 2km/hr speed of operation were 0.38 ha/hr., 96.64*% and* 2.5 *l/h respectively. 379 Number of seedlings germinated per 1 m^2 area after 50 days was counted. Based on the results obtained, regarding to the performance, the seed drill machine can be recommended and efficiently to be used by the farmers and all responsible stakeholders.*

Key words: *Self-propelled, Precision multi-crop planter, Field capacity, Field efficiency*

Introduction:

Planting is the process of placing seeds in the soil to have good germination. It is one of the most important cultural practices associated with crop production. An exercise that should result in plant stands at the desired density that emerges quickly and uniformly (Alhassan et al., 2018). Among the various agronomic practices, planting technique is of considerable importance because of the optimum plant population and also proper use of the land and input resources (Afzal & Iqbal, 2016; Samoy-Pascual et al., 2021). A good seed planting gives the correct number of seed per unit area, the correct depth at which seed is placed in the soil, and the correct spacing between row-to-row and plant-to-plant (Soyoye et al., 2018; Staggenborg et al., 2004).

Seed planters are agricultural implements that can be power-driven, manually operated, and animal driven for the purpose of seed sowing in the field. A good planter should place seeds in an environment for reliable and viable germination. The main benefits were to prevent excessive time wastage, ensure even spacing with uniformity, increase agricultural output, and make crop cultivation less tedious and farming more attractive (Alhassan et al., 2018). Different planting machinery such as precision planters, grain drills, broadcasters, and vegetable planters are available (Murray et al., 2006). A precision planter helps to save seed, reduce working hours, and achieves more uniform spacing in the row and depth of planting. These help in producing crops uniform in height and strength a requisite factor for high yield (Mysara Ahmed Kheiry et al., 2017; Samoy-Pascual et al., 2021). Now a days most farmers have tractors for tillage operation but there is small or no tractor driven row planting machine due to high importing cost/ foreign currency. Although the mechanization of seeding process had generated significant interest in recent time, there is still need to revolutionize seed planting operations by making quality machines with high performance considering the technicality and economic capacity of the local farmers. Hence, this work focused on preparing on the planter manufacturing design, construction and performance evaluation of an affordable self-propelled tractor mounted multi-crop seven-row precision planter. The planter is for sowing wheat, sorghum, rice, barely and maize the major grain crops in Somali region (Ahmed et al., 2018).

Materials and Methods

Materials

Selections of proper materials used for manufacturing of various components of precision row planter was done based on components of imported row planter and locally available materials. The economic consideration and availability of materials were also taken into account.

Methodology

The prime activity of this project was preparing detail manufacturing design of the tractor mounted multi-crop seven-row precision planter all components using Solid work 2020 and AutoCAD 3D 2021 engineering software. The planter machine design by reviewing the Indian DAHRTI-seed drill model. Then a precision seven row seed planter machine constructed.

Description of the Machine Components

Th multi-crop precision 7-row planter machine have six mean parts. This includes frame, hopper, Seed and fertilizer metering mechanisms, Seed and fertilizer delivery tube, Furrow openers and Metering ground wheel.



Figure 1**:** Constructed Prototype Of Cleaning Type Wheat And Shorghem Thrasher.

Performance Evaluation of the Machine

The performance evaluation of the seed drill/planter machine was done by conducting laboratory and filed test. Before actual test was carried out in the field, the machine was tested to confirm the functionality of all the rotating parts, to check any malfunctioning parts and defects during manufacturing.

Laboratory Test

Seed mechanical damage, uniformity of seed distribution and seed emergence were determined during laboratory test.

Mechanical damage

The test for seed damage was conducted by rotating wheel 10 times with the seeder held (raised up) position at fully loaded seed hopper and the discharged seeds from each seed tube were collected and observed for any external seed damage. Any visible damaged seeds during the calibration were separately weighed and the percentage seed damage was determined as (Rangapara J., 2014).

$$\% \text{ damage} = \frac{W_s}{Wts}$$

Where, W_s = weight of damaged seed; W_{ts} = Total weight of collected seeds

Uniformity of Seed Distribution

The test for seed uniformity was carried out to identify variation between furrows in seed metering devices. To assess uniformity of seeds dropped from each seed tube, the machine was drawn by 75hp tractor at predetermined speed of operation (2, 3, and 4km/hr.) and hopper loading capacity (half, three fourth and full) on 100m length track test. During the test run, sample bags were placed under each seed tube to collect the discharged seeds. Three observations were taken for each test run over 100m distance. The collected seeds in the bags for each seed metering device after each test run were weighed and compared.

Seed Emergence Test (SE)

The seeds before and after metering mechanism test carried out for germination. Take the Petri dish and it covers with blotting paper and adds some amount of water for wetness. Take the 100 grains from seed metering mechanism and place on wetted blotting paper. After 7 days seed was germinated. The germinated seed was counted and percentage of seed germination was found out. The seed emergence was calculated using (Solomon, 2017).

$$SE = \frac{Number\ of\ Seeds\ Germenated}{Number\ of\ seeds\ Planted} \times 100$$

Field Test

Depending on the obtained parameters in laboratory test, the seed planter machine was attached to 75hp Charry tractor. Three different operating speeds were found out at different gear and throttle position. The 2 km/h, 3 km/h, and 4 km/h speed were selected for sowing operation and effect of different operating speed on seed rate, seed uniformity and seed damage were observed. The best results' giving operating speed was chosen for sowing wheat varieties.

Speed of Operation

To determine the tractor operation speed during planting operation, the time required for covering row length was recorded with digital stop watch. Five measurements will be recorded in each plot and mean values computed as km/hr. calculated.

$$\boldsymbol{Speed}\left(\frac{km}{hr}\right) = \frac{Distance\,(m)}{Time\,(s)}\ x\ 3.6 \qquad (1)$$

Theoretical field capacity

Theoretical field capacity of row planter is the rate of field coverage that would be obtained if the planter performing its function 100 % of the time at the rated forward speed and cover 100 % of its rated width. It is expressed as hectare per hour and determined as follows (Kepener, Roy Bainer, 1987).

$$\boldsymbol{TFC}\left(\frac{ha}{hr}\right) = \frac{WxS}{10} \qquad (2)$$

Where, TFC = Theoretical Field capacity, (ha/hr); W = Effective width of implement, (m); and S = Speed of operation, (km/hr).

Effective field capacity

Effective field capacity of the planter is actual rate of work covered by the planter based upon the total field time and a function of rated width of the machine actually utilized and expressed as hectare per hour (Kepener, Roy Bainer, 1987).

$$EFC\left(\frac{ha}{hr}\right) = \frac{A}{T} \qquad (3)$$

Where, EFC = Effective Field capacity, (ha/hr); A = Actual area covered, ha and T = Time required to cover the area, hr.

Field efficiency

Field efficiency is the ratio of effective field capacity to theoretical field capacity. It will be determined by the following formula:

$$FE\,(\%) = \frac{EFC}{TFC}\,x100 \qquad (4)$$

Where, FE = Field efficiency (%); EFC = Effective field capacity, (ha/hr.); and TFC=Theoretical field capacity, (ha/hr.).

Fuel consumption

The fuel consumption was measured by top-up method. The fuel tank was filled to its full capacity before and after the test run and amount of refilling after the end of test was the fuel consumption for the test.

Wheel Slip

The wheel slip was calculated by recording a total number of revolutions at no load and the total number of revolutions at load. Wheel slip represents a loss of forwarding motion of the implement and it represents the loss of power. Wheel slip for any given load is determined by the expression of (Rangapara, 2014).

Row spacing and depth of seed placement

Row to row spacing was provided by fitting furrow openers at 20cm distant to the main frame with bolt and nuts before sowing operation. While seed drill was in operation, five random measurements of actual row to row spacing were recorded by using meter tape. The depth of seed and fertilizer placement was adjusted by raising or lowering the furrow opener at desired depth of seed and fertilizer placement, then the depth of seed and fertilizer placement were measured using a metering tape and graduated ruler. Randomly selected five readings were recorded for the six furrow openers from the test plot.

Plant population and uniformity

Plant population was determined at randomly selected spots for each experimental plot per square meter areas and by counting number of seedlings emerged. Plant uniformity test was carried out by counting average number of plants in each row per meter distance and variation in between the rows was determined.

Experimental Design

The Experiments were conducted in the field had plot size of $1000m^2$ (10mx100m) and kingbirds wheat variety (K) were used as a test crop. Three forward speeds of tractor of 2km/hr., 3 km/hr. and 4 km/hr. were selected.

with plot size of 10x100with forming three treatments (Each treatment replicated three times with using Randomized Complete Block Design (RCBD) had total of 27 test runs (3x3x3 = 27). The well-prepared experimental field was divided into 9 plots each having an area of $1000m^2$ (i.e., 10 m x 100 m plot size). Various adjustments in the machine were done to get required seed depth and plant to plant distance before testing.

Statistical Analysis

The data was subjected to analysis of variances following a procedure appropriate for the design of the experiment (Gomez and Gomez, 1984) and using SPSS v15 statistical software. The treatment means that was different at 5% levels of significance was separated using least

significant difference (LSD 5%) test. The least significant difference (LSD) test was performed for the mean values of actual seed rate in relation to forward speed and hopper level of filling.

Result and Discussions

This study was conducted to evaluate the performance of seven row wheat seed drill machine capable of sowing wheat seeds and fertilizer at predetermined rates, row spacing and depths. The Performance evaluation of the planter was carried out by conducting both laboratory test and field test at SoRPARI and Fafen Agricultural Research Center.

Planter Calibration

The planter was tested for mechanical damage to seed during metering and seed rate testing. The width of 75hp tractor drawn wheat seeder was 2.05 m. The diameter of the ground wheel diameter was 45 cm. Circumference of ground wheel (π x D) =3.14 x 0.45= 1.41m. Let, the length of a strip of the plot was 180 m. The ground wheel was revolved 63 times for 100 m length i.e., X = 100/ (π × 0.2) = 63revolution for a 205m^2 (i.e., 2.05 m x 100m). The 63 revolution was given to the wheel and the seeds from all the furrow openers were collected separately. All the collected seeds were weighed separately. The total weight of the seeds collected from seven furrow openers was 1.46 kg. In one ha there are 48.78 turnings (i.e., 100m/2.05m = 48.78 turnings). Therefore, 48.78 *1.461kg=71.26kg wheat was required for one hectare. The process was repeated by suitable adjusting the speed on the tractor till we get desired seed rate recommended for a wheat variety under sowing. Three replications were carried out for calibrating the seed drill. The seed metering mechanisms used for this study had 10mm dim. The obtained seed rate result was laid on the recommended range of wheat seed rate of 70kg/ha to 100kg/ha (data gathered from the informal communication of research expert).

Average value of 71.26kg/ha was obtained which is nearest to the minimum recommended seed rate of 70kg/ha of wheat. The average seed rate for 2km/hr, 3 km/hr, and 4 km/hr speed of operation from the calibration were observed as 71.26 kg/ha, 95.58 kg/ha and 102.25 kg/ha respectively as shown in table 1. The recommended seed rate of wheat variety ranges from 70kg/ha up to 100kg/ha. Therefore, the calibrated seed rate of developed tractor drawn wheat seeder was lies in the recommended range.

Table 1. Seed rate data obtained

Speed km/h	Rep. No.	Weight of seed from each furrow opener per 63 revolutions, gm							Total seed Collected, gm	Seed rate, kg/ha
		1	2	3	4	5	6	7		
2	1	208.75	208	209.5	207.95	208.75	209.55	208.75	1461.25	71.28
	2	208	208.8	207.95	208.7	208.75	209.5	209.54	1461.24	71.28
	3	209	208.9	207.95	208.28	208	209.15	209	1460.28	71.23
	Average	208.58	208.57	208.47	208.31	208.5	209.4	209.1	1460.92	**71.26**
3	1	279	280	279.91	280.1	279.55	280.11	279.9	1958.57	95.54
	2	280.56	279.91	280.23	279.99	279.99	280.2	279	1959.88	95.61
	3	279.78	279.99	279.58	279.99	281	279.24	279.9	1959.48	95.58
	Average	279.78	279.97	279.90	280.03	280.18	279.85	279.6	1959	**95.58**
4	1	299.16	300.00	299.50	299.99	299.00	299.00	300.00	2096.65	102.27
	2	299.25	299.90	299.00	299.91	299.00	299.00	299.19	2095.25	102.21
	3	300.11	298.99	299.16	299.61	299.12	299.55	299.90	2096.44	102.26
	Average	299.51	299.63	299.22	299.84	299.04	299.18	299.70	2096.11	**102.25**



Figure 2: Planter Calibration

Mechanical Damage Test

The mechanical damage due to metering device were observed and it was found that there was no mechanical damage to the seeds at all the selected forward speeds, due to adjustable seed metering the impact and friction between fluted roller avoided.

Table 2. Mechanical damage tests

Observation	Wheat Seed Variety	Tractor Speed Km/hr.	Seed rate obtained, kg/ha	Mechanical damage, %	Germination %
1	Kingbird	2	71.26	0.0	97
2	Kingbird	3	95.58	0.0	97
3	Kingbird	4	102.25	0.0	97

Seed Uniformity Test

The result indicated that the variations in seed distribution of wheat among the rows (metering de- vice). It was observed that the entire samples collected for the similar speed of operation and hopper loding level was nearly similar and there was slight deviation among the sample i.e. (0.4 - 0.63) and coefficient of variation was in range of 0.14 - 0.30.

Effects of Seed Drill Forward Speed on Seed Rate

The analysis of variance (ANOVA) shows that the machine operational speed and hoper filling level had significant effect ($p < 0.05$) on wheat seed rate, Table 4-4 shows the effect of forward speed on wheat seed rate. Figure 4-1 shows the relationship between machine forward speed and seed rate.

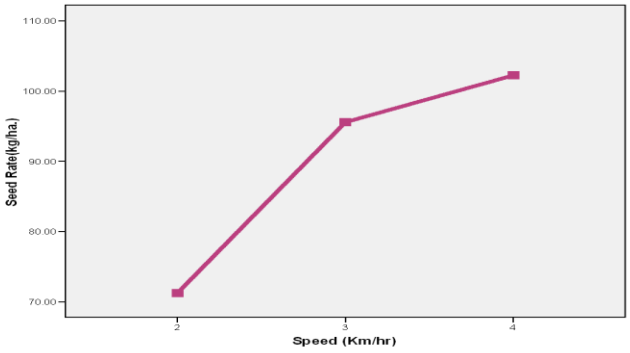


Figure 3. Effects of seed drill forward speed on wheat seed rate

Table 3. Effects of seed drill operating speed on seed rate

Parameter	Source of variation			Measure of differences	
	Speed level			LSD (5%)	SE(M)
Seed rate (Kg/ha)	2	3	4	0.20	0.026
	71.26^{a}	95.57^{b}	102.24^{c}		

Means followed by the same letter (or letters) do not have significant difference at 5% level of probability

Theoretical and effective field capacity

The result shown, the mean theoretical field capacity of the machine at 2, 3, 4 km/hr. were 0.40, 0.50, and 0.61ha/hr., respectively. The effective field capacity the machine at speed level of 2, 3, 4 km/hr. were found that 0.38, 0.43, and 0.50 ha/hr2. This indicated that both effective field capacity and theoretical field capacity of the machine increased with in- crease in operating speed as shown in figure 3.3. In general, this indicated that the seed drill can sow a hectare of land in 2.0 to 2.5 working hours based on the forward speed.

Field Efficiency

The lower field efficiency occurred at 4 km/hr was 81.97% and the higher field efficiency was obtained at 2 km/hr. was 96.64%. It can be observed that from the figure 6, field efficiency was decreased as speed in- creases. According to the finding of Rangapara J. (2014), as the size of the field was decreased; number of passes of the machine increased too, which results in increase in time losses and gave lower values of field efficiency.

Fuel Consumption

The results obtained for different forward speed indicated that the fuel consumption was in- creased with increase in speed. During test run, fuel consumption was measured as 2.5, 3.8and 4.6 l/h at the speed of 2, 3and 4km/hr., respectively.

Plant Populations and Uniformity

The plant stand count was conducted in the experimental plot after sowing kingbird wheat variety having germination potential of 97% (Ethiopian seed enterprise). Number of seedlings

germinated per 1 m^2 area after 50 days was counted and presented in table 4-6. The seed rate indicated that metering mechanism was properly metering the seeds without damage.

Table 4. Plant Populations and Uniformity

Replication	**Field germination count Per 1m^2**		
	Expected	Counted	% Germinated
1	392	379	96.68
2	392	380	96.94
3	392	379	96.68
Average	392	379	96.68



Figure 4: Plant Populations and Uniformity

Cost Analysis of the Machine

The cost of the machine includes raw material cost and production (machine and labor) cost only. Materials wastage and overhead costs are estimated from raw material and production costs.

Table 5 The summarized cost of the Seed Drill machine

No.	Variable	Cost (ETB)
		Market
1	Raw material	155,505.00
2	Seed metering	98,250.00
3	Materials Wastage = 2.5% of 1 and 2	6343.87
4	Production (machine +labor)	148,220.00
5	Overhead = 5% of 3	7,411
6	Profit = 10 % of (1+2+3+4+5)	41,572.99
7	Sell tax =15% of (1+2+3+4+5+6)	68595.43
8	Selling price = (1+2+3+4+5+6+7)	525,898.29

Conclusions and Recommendations

Conclusions

The field testing of self-propelled tractor-mounted seven-row precision multi-crop planter was carried out at the field of SoRPARI-Fafen center with plots size of 10 m × 100 m were selected for a field test. From the results obtained, it can be noted that the wheat seed drill machine performance in terms of seed and fertilizer rate, depth of seed and fertilizer placement, plant population, field capacity, field efficiency, labour cost and operating the machine is acceptable. Thus, it can be concluded that the developed seed drill can be efficiently and economically used by the majority of Ethiopian farmers.

However, the speed of operation of the seed drill should not be less than 2 km/hr and not exceed 4 km/hr. in order to have optimum plant population. From this research finding, it can be concluded that 3 km/hr. operating speed was the point where seed drill performs better in terms of optimum seed and fertilizer rate of application.

Recommendations

In general, the performance evaluations made shows that the machine can be used successfully on sowing operation. Though, the following issue must be addressed to make the seed drill more adaptable, popular, and usable among the farmers.

- Number of rows for developed tractor drawn wheat seed drill might be increased to improve field capacity and field efficiency.
- The seed drill should be tested for different cereal crops with replaceable metering device for further design refinements
- To minimize the working load from the operating tractor and to make easy the sowing operation transportation wheel should be attached on the seed drill machine.

References

Afzal, S., & Iqbal, M. A. (2016). Growth , Kernel Quality and Yield Assessment of Aerobic Aromatic Rice (Oryza sativa L .) Under Different Mulching Types and Spatial Arrangements. 12(January), 84–90.

Ahmed, A., Dechassa, N., Gebeyehu, S., & Alemayehu, Y. (2018). Characterization of soil of Jijiga plain in the Somali regional state of Ethiopia. East African Journal of Sciences, 12(1), 1–10.

Alhassan, E. A., Adewumi, A. D., & Okpodjah, B. (2018). Development of a self-propelled multi-crop two rows precision planter: A new design concept for the metering mechanism. International Journal of Mechanical Engineering and Technology, 9(10), 349–358.

Kepener, Roy Bainer, and R. L. B. (1987). PRINCIPLES OF FARM MACHINERY. In CBS Publishers & Distributors Pvt. Ltd (Vol. 1999, Issue December).

Murray, J. R., Tullberg, J. N., & Basnet, B. B. (2006). Planters and their components. Types, attributes, functional requirements, classification and description. Australian Centre for International Agricultural Research, ACIAR Monograph No. 121.

Mysara Ahmed Kheiry, Abdalla N. O. Rahma, Abbas E. Yousif, & and Husam Aldeen Babiker. (2017). Performance evaluation of two planter makes as affected by forward speeds. Journal of Agricultural Science and Practice, 2(1), 16–22.

Samoy-Pascual, K., Rafael, M. L., Remocal, A. T., Jose, M., & Regalado, C. (2021). Development and evaluation of four-wheel tractor-attached multi-crop planter for mechanized seeding of maize in the Philippines. 23(3), 143. http://www.cigrjournal.org

Solomon, A. (2017). Performance Evaluation of Walking Tractor Drawn Wheat Planter. Ethiopia. Acad. Res. J. Agri. Sci. Res, 5(7), 529–538.

Soyoye, B. O., Ademosun, O. C., & Agbetoye, L. A. S. (2018). Determination of some physical and mechanical properties of soybean and maize in relation to planter design. Agricultural Engineering International: CIGR Journal, 20(1), 81–89.

Staggenborg, S. A., Taylor, R. K., & Maddux, L. D. (2004). EFFECT OF PLANTER SPEED AND SEED FIRMERS ON CORN STAND ESTABLISHMENT. 20(1996), 573–580.

Adaptation and Construction of Cleaning Type Multi-crop Thrasher in Somali Region, Ethiopia

Firew Kassahun1[1] and Kalid Hussein[2]

Email: firew2719@gmail.com and kalidxusen2015@gmail.com
Post-Harvest and Product Processing Research Program, Agricultural Mechanization Research Directorate, Somali Region Pastoral and Agro-Pastoral research Institute (SoRPARI)]

Abstract

This study was conducted in the Somali region, Ethiopia 2022-23. Cleaning type wheat and sorghum thrasher was developed through modification of IITA multi-crop thresher, and assessment of Melkassa thrasher. The machine consisted mainly of a frame, pig type threshing drum, mechanical cleaning unit (sieve), air supplier blower, concave, feeding table. The performance of the machine was evaluated in terms of threshing capacity (kg/h), threshing efficiency (%), cleaning efficiency (%) and percent damage (%) at three levels of drum speed of 500, 600 and 700 rpm by adjusting the position of fuel control throttle of the engine and 11-13% mean grain moisture content were used. The results indicated that the threshing capacity and percentage of mechanical damage increased with an increase in drum speed. From the result obtained cleaning efficiency and percentage of loss has inverse relationship with drum speed. The highest capacity was recorded at a drum speed of 700rpm (i.e., 1461.67 Kg/hr.). The percentage of mechanical damage and loss at this operation is 0.22 and 0.1%, respectively. Cleaning Type wheat and sorghum thrasher was found superior to all others in most of the performance parameters. Its output is two times that of the Melkassa thrasher. Based on the results obtained, regarding performance indices, it can be concluded that the machine can solve the current problem of the farmers on wheat thrashing.

Key words: *Adaptation, Construction, Cleaning type, Wheat, Sorghum Thrasher*

Introduction:

In the agricultural production process mainly practiced by small-scale farmers, are threshing by either beating with a stick or treading with animals, or sometimes riding tractors over a platform. (EIAR, 2003). Threshing, the first major post-harvest operation, involves the application of mechanical forces to detach grains from straws. The applied forces fall on the straws at random, breaking the straws stochastically, to free the enclosed grains. Some physical phenomena involved in threshing crops are breakage of the grain pod which is dependent on the intensity of force, the orientation of the pod and moisture content; freedom of the grain from the straw, and the passage of them through the concave (Bekele et al., 2020). The threshing remains mostly done by animal trampling and human labor, which leave up to 30% of the crop on the ground and contaminates the remainder with urine and feces that could reduce the market value

(Wondmagn, 2020). Traditional threshing of crops like wheat, barley, and sorghum is one of the time-consuming, laborious, and in which grain loss occurs (EIAR, 2003). This is a major area where innovations might be possible to improve grain recovery and reduce grain loss. It is the need of the hour to mechanize wheat threshing operations to recover better yield completing the operation timely (Biggs & Justice, 2015). To address the threshing problem of small-scale agriculture, many efforts have been made by different governmental and non-governmental organizations to replace traditional threshing with the introduction of improved mobile threshers that can be locally developed or adopted (Bekele et al., 2020). The problem with this thresher is low threshing capacity, high seed breakage, and poor cleaning system (Bekele et al., 2020). Therefore, the aim of initiating this activity is to adopt, construct and evaluate the performance mainly the thrashing capacity and grain cleaning system of cleaning type of wheat and sorghum thrasher. The development of mechanical threshers for the purpose has an edge over conventional methods and has reduced the drudgery of work to a great extent. The use of these stationary threshing machines is based on the quick process, level of performance, and economy.

Materials and Methods

Materials

Mild steel sheet metal, angle iron, corrugated bar, metal rods, flat iron, bearings, belts, 9hp engine and square pipe were used to develop the thresher.

Methodology

The first phase of this activity was, recent information regarding farmers' practice in threshing was collected. In this study two widely used thresher prototypes Melkassa type, and IITA multi-crop thresher were considered. The problems of the collected information and practice were further identified and quantified. The problem with this thresher is low threshing capacity, high seed breakage, and poor cleaning system similarly reported by Bekele, Woyessa, and Tafa, 2020. Then as per the problem observed on listed prototype, detailed manufacturing design was prepared and fabrication of the cleaning type thrasher was completed.

Design Considerations

The following assumptions were considered in the modification of the machine; ability to thresh the selected crops without high damage, the machine must ensure high cleaning efficiency, ease of operation, reduction of the drudgery involved in the traditional methods of threshing, economy to make the machine affordable.

Description of the Machine Components

The main components of the cleaning type thresher include feeding inlet, threshing unit, cleaning unit, grain outlet and straw outlet1&2 (Figure below).



Figure 1**:** Constructed Prototype Of Cleaning Type Wheat And Shorghem Thrasher.

Performance of the Cleaning Type Wheat and Sorghum Thrasher

The performance of the machine was evaluated in terms of threshing capacity/ Throughput Capacity (Qu/h), threshing efficiency (%), cleaning efficiency (%), and percentage of damage (%) using the following equations;

A. Threshing Capacity/Throughput Capacity

The threshing capacity is measured based on the sample's input weight divided by its thrashing time in (Qt/hr). The results are expressed as Replication 1 and Replication 2. The mean values of the two measurements were also computed.

$$\text{Threshing capacity (Kg/h)} = \frac{Qt}{Tm}$$

Where: Qt–Mass of threshed grain at grain outlet (kg); Tm– time of threshing operation (h).

B. Cleaning Efficiency

The cleaning efficiency will be measure based on the weight of the total output divided by its input weight multiplied by 100. The results express as Replication 1 and Replication 2. The mean values of the two measurements also compute.

$$\text{Cleaning efficiency} = \frac{Wt-Wc}{Wt} x100$$

Where: Wt = Weight of total mixture of grain and chaff received at the grain outlet (kg), Wc = Weight of chaff at the main outlet of the thresher (kg)

C. Percent Loss/Grain brakeage

Percent loss compute based on the ratio if the difference of input weight and the accepted output weight divided by the input weight expressed in percent. The results express as Replication 1 and Replication 2. The mean values of the two measurements also compute.

$$\text{Percent loss (\%)} = \frac{Lg}{Qs+Lg} x100$$

Where: Qs= quantity of grain sample (kg); Lg–Mass of loss grain (kg)

D. **Mechanical damage**

Percent loss (%) = $\frac{Qd}{Qud - Qd} x100$

Where: Q_{ud} - quantity of undamaged grain (kg); Q_d - quantity of damaged grain (kg)

E. Machine Efficiency

Thrashing efficiency compute based on the ratio of the accepted output and input. The results express in percent.

Machine Efficiency (%) = $\frac{Qt}{Qus + Qt} x100$

Where: Qt-Mass of threshed grain at grain outlet (kg),

Qus–quantity of unthreshed (kg).

Statical Analysis

Three levels of drum speed 500, 600, and 700rpm (Ahmed et al., 2017; EIAR, 2003), were used to evaluate the performance of the machine by adjusting the position of the fuel control throttle of the engine. Wheat was used as experimental crop for this study. The full feeding rate (the batch that can fill the inlet area) makes it easy while using the machine.

The following data were collected during the performance evaluation of the machine

1. Threshed grain was collected at the grain outlet, weighed, and recorded as Q_t in kg;
2. Damaged grains, grains with visible damages, at the grain outlet were manually picked, weighed and recorded as Qd in kg;
3. Chaffs that went out with grains through the grain outlet and chaff outlet were manually collected, weighed and recorded as Wt. in kg;
4. Winnowed chaffs that were separated and discharged through the husk outlet were collected, weighed and recorded as Wc in kg; and
5. Grains that discharge with chaff were collected, weighed and recorded as Lg in kg

Data was subjected to analysis of variance using one-way ANOVA (no blocking).

Result and Discussions

The Performance evaluation of the machine was evaluated interims of threshing capacity /Throughput Capacity, Cleaning Efficiency, Percent Loss/Grain brakeage, Mechanical damage and Machine Efficiency at moisture content of 11-13% that is close to the recommended to be threshed (Ahmed et al., 2017; EIAR, 2003) were used.

Effect of Drum Speed on Threshing Capacity

From ANOVA table the threshing capacity of the machine is highly significant with drum speed. The thresher capacity varied from 1194.33kg/hr. to 1461.6667kg/hr. at different dram speed. The highest capacity was recorded at a drum speed of 700rpm (i.e., 1461.67 Kg/hr.). The results indicated that the capacity increased with an increase in drum speed. As indicated in the figure 3-3 the higher the speed, the higher is the capacity.

Table 1: ANOVA Analysis (Tukey HSD) of Threshing Capacity (Kg/hr.)

	N	Subset for alpha = .05		
Speed (RPM)	1	2	3	1
500.00	3	1194.3333		
600.00	3		1318.3333	
700.00	3			1461.6667
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 3.000.

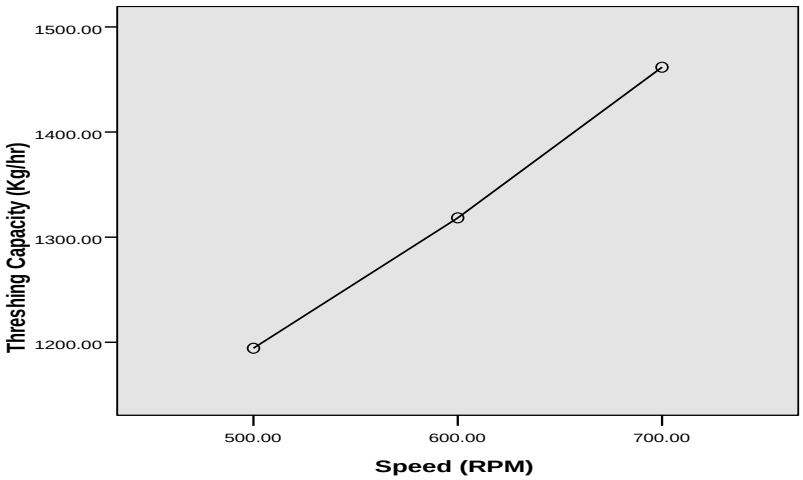


Figure 2: Effect of drum speed on capacity

Effect of Drum Speed on Threshing Efficiency

The threshing efficiency of the machine is 99.9% at all drum speeds. These results were due to low pod cohesion at the range of wheat moisture content tested. This finding is agreed with that of EIAR, (2003), Kibe, (2007) and Ahmed et al., (2017). They obtained 99.9% threshing efficiency.

Effect of drum speed on cleaning efficiency

From the result obtained cleaning efficiency has inverse relationship with drum speed. Increasing drum speed from 500 to 700 rpm, decreases cleaning efficiency from 99.95% to 95.08. This is because of the cleaning unit of the machine is only mechanical, while the drum speed is increasing the straw is highly broken due the applied impact load and increase the vibration of the sieve. To overcome the problem on the cleaning part of the machine the research group decide to modify the machine by adding a suction air mechanism on the outlet of the sieve. The result obtained after adding the suction air presented in the figure below.

Table 2: ANOVA Analysis (Tukey HSD) of Cleaning Efficiency w/t air suction

	N	Subset for alpha = .05		
Speed (RPM)	1	2	3	1
700.00	3	95.0833		
600.00	3		95.9200	
500.00	3			99.9533
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table 3: ANOVA Analysis (Tukey HSD) of Cleaning Efficiency with air suction

	N	Subset for alpha = .05	
Speed (RPM)	1	2	1
600.00	3	98.9200	
700.00	3		99.7933
500.00	3		99.9533
Sig.		1.000	.340

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

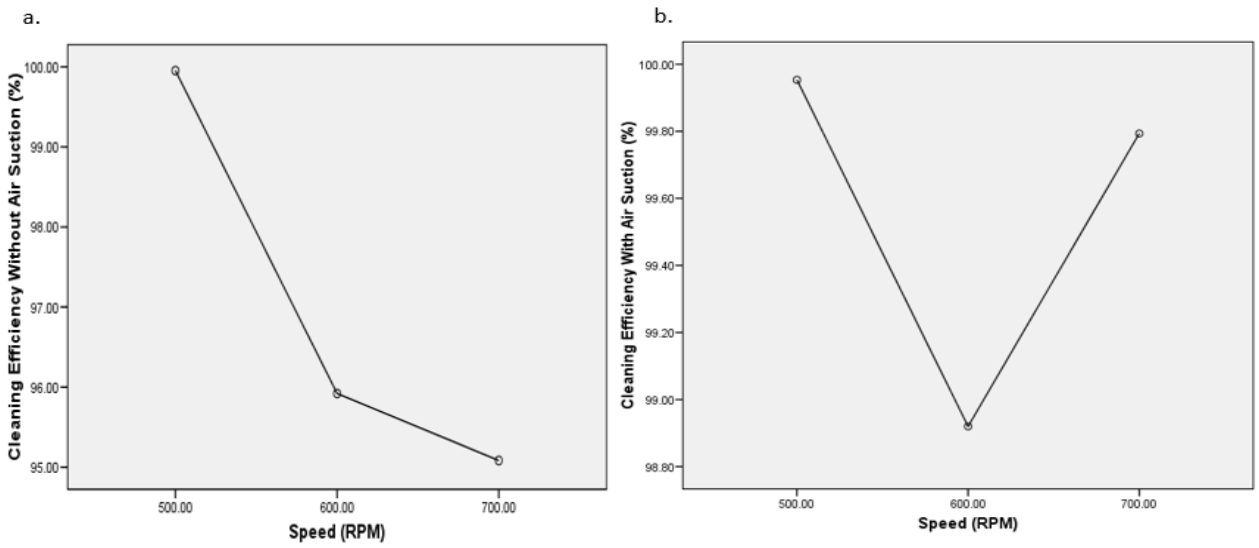


Figure 3. a. Effect of drum speed on cleaning efficiency w/t air suction and b. with air suction

Effect of Drum Speed on Percentage of Mechanical Damage

The result showed that, grain mechanical damage had a direct relationship with the drum speed. This result compares well with the findings reported by Kibe, (2007) for wheat thrasher. The maximum percentage of grain damage of 0.22% was recorded at the 700-rpm drum speed and the minimum 0.12% was recorded at 500 rpm drum speed.

Table 4: ANOVA Analysis (Tukey HSD) of Percentage of Mechanical Damage

Speed (RPM)	N	Subset for alpha = .05	
	1	2	1
500.00	3	.1033	
600.00	3	.1733	.1733
700.00	3		.2200
Sig.		.064	.081

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Effect of Drum Speed on Percentage of Grain Loss

The result in the ANOVA analysis maximum percentage of loss of 0.66% was recorded at the 500-rpm drum speed and the minimum 0.10% was recorded at 700 rpm drum speed. This percentage of grain loss not includes grain damage.

Table 5: ANOVA Analysis (Tukey HSD) of Percentage of grain loss

	N	Subset for alpha = .05	
Speed (RPM)	1	2	1
700.00	3	.1033	
600.00	3	.2167	
500.00	3		.6600
Sig.		.302	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

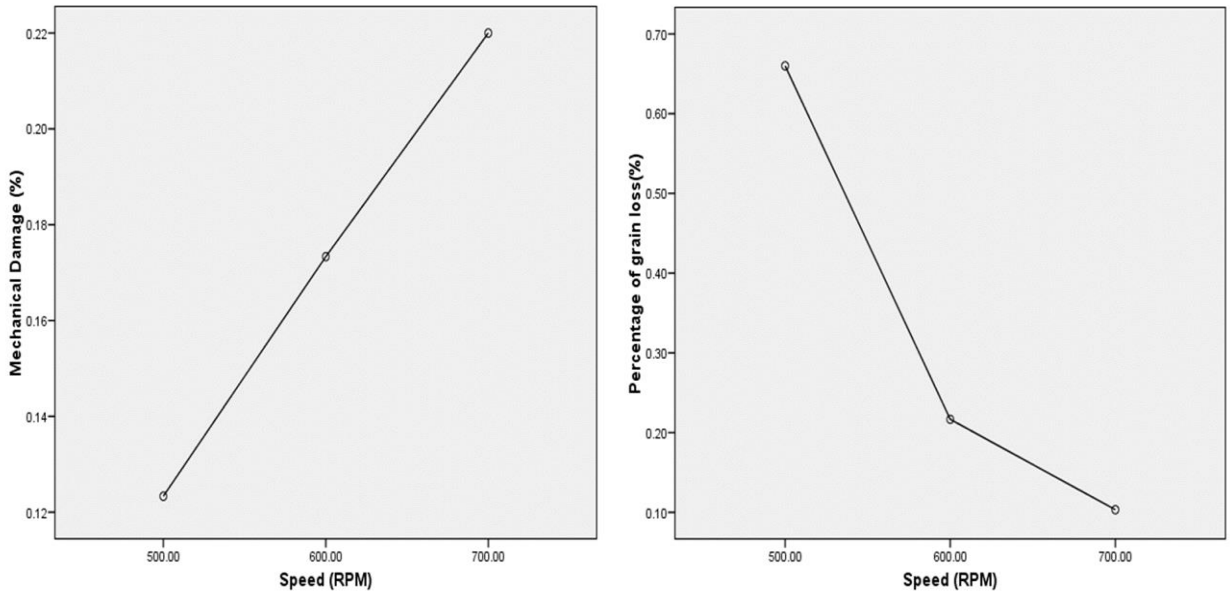


Figure 4. a. Effect of Drum Speed on Mechanical Damage and Percentage of grain loss

Finally, a comparison test has made based on the performance indicator of the three-thresher type which are; Cleaning type Wheat thrasher, Melkassa develop/IITA multi-crop thresher and Selam develop thrasher. The results are shown in the table 6. Cleaning Type wheat Thrasher was found superior to all others in most of the performance parameters. Its output is two times that of the Melkassa develop thrasher and almost three times of the Selam thresher.

The cleaning Efficiency of the cleaning type thrasher was high (99.99%) compared to other type of thrasher. The percentage of grain damage and grain loss was minimal to the required level of 0.1.

Table 6: Test results of newly developed cleaning type wheat thresher over other existing thrasher type.

S/No	Parameters	Cleaning Type Thrasher	Melkassa Develop Thresher	IITA multi-crop thresher
1.	Overall Dimension (mm)			
	• Length	1450	1350	1300
	• Width	1000	900	900
	• Height	1650	1500	1350
2.	Net Weight (Kg)	298	200	150
3.	Transport method	Mounted on wheels	By Lauber	By Labor
5.	Fuel Consumption (Lit/hr.)	1.21	1.86	2.55
6.	Drum Type	Peg	Peg	Peg
7.	Blower Type	Centrifugal	Centrifugal	No
8	Cleaning Method	Vibrating Sive	Fixed Sive	Fixed Sive
8.	Output Capacity (Qu/hr.)	14.61	6.5-7	3.5-4.5
9	Threshing Efficiency (%)	> 99.99%	95.99%	89%
10	Cleaning Efficiency (%)	>99.95%	68.45%	<50%
11	Mechanical Grain Damage (%)	0.12	4.8	6.43
12	Grain Loss (%)	0.1	2.5	2.8

Cost Analysis of the Machine

The cost of the machine includes raw material cost and production (machine and labor) cost only. Materials wastage and overhead costs are estimated from raw material and production costs.

Table 7. The summarized cost of the cleaning machine

No.	Variable	Cost (ETB)
		Market
1	Raw material	225,265.00
2	Materials Wastage = 2.5% of 1	5881.63
3	Production (machine +labor)	125,420
4	Overhead = 5% of 3	6271
5	Profit = 10 % of (1+2+3+4)	37283.76
6	Sell tax =15% of (1+2+3+4+5)	61518.20813
7	Selling price = (1+2+3+4+5+6)	471,639.60

Conclusion and Recommendation

Conclusion

The cleaning-type wheat threshing machine was developed and tested with high efficiency. The analysis data from the observation of the study led to the following conclusions: -

The cleaning wheat thrasher was found superior to all other two thresher types in most of the performance parameters. Minimum total grain losses of 0.1% were obtained at a drum speed of 700 rpm and maximum total grain losses of 0.66% were recorded at a drum speed of 500 rpm. While the threshing and cleaning efficiencies of 99.99 and 99.95% were obtained respectively at a drum speed of 700 rpm. The maximum and minimum grain damage was obtained at drum speeds of 700 and 500 which are 0.22% and 0.1% respectively. The threshing capacity/output of the machine is good at 700 rpm at which value of 1461.6kg/hr. The optimum drum speed for threshing wheat was determined to be between 650 rpm and 700 rpm. Finally, based on the results obtained, regarding performance indices, it can be concluded that the machine can solve the current problem of the farmer's wheat thrashing activity.

Recommendations

From the analysis and discussions of the performance result of the test on the cleaning type wheat thresher and to improve on the performance, the following recommendations should be considered;

- As a recommendation, as far as the appearance of the machine seems very huge due to the inclusion of the step sieves which take up large space, which opens the way for improvement or modification to the downsizing of the machine.
- A drum speed of more than 700 rpm is not recommended to thresh wheat crops because it can cause great machine vibration that can damage parts, and also high grain separation losses and grain straw under sizing.
- The research findings recommend that to increase the cleaning efficiency of the machine air suction mechanism should be made on the cleaning unit of the thresher.
- The engine seat is flexible and needs further modification to manage the vibration on the thresher

- The thresher should be extensively tested at on-farm labels for different crops and machine conditions to compare its performance.

References

Ahmed, K., Tsegaye, A., Nur, J., & Kibi, G. (2017). *Regional Review Workshop on Completed Research Activities*.

Bekele, G., Woyessa, D., & Tafa, W. (2020). Improvement of Asella Wheat and Barley Thresher. International Journal of Scientific and Research Publications (IJSRP), 10(10), 487–495. https://doi.org/10.29322/ijsrp.10.10.2020.p10666

Biggs, S., & Justice, S. (2015). Rural and Agricultural Mechanization: A History of the Spread of Small Engines in Selected Asian Countries. IFPRI Discussion Paper, 01443, 1–44. http://csisa.org/wp-content/uploads/sites/2/2014/06/BiggsJusticeIFPRI_DP_01443.pdf

EIAR. (2003). The Ethiopian Institute of Agricultural Research (Issue August).

Kibe, G. (2007). Design of wheat threshing machine 2007 E.C. 1–9.

Wondmagn, W. (2020). Adaptation , Design and Fabrication of Multipurpose Threshing Machine. DSpace Institution DSpace, Manufacturing Engineering Http://Dspace.Org.

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Proximate Anaylysis of Different Haricot Bean Varieties Adapted under Sorpari's Different Research Centers

Abdulkarim Mohammed Ali[1], Mohammed Dol Ateye[2], Hoodo Mohamed Jama[2],

1. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***adnanbdu302@gmail.com***
2. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***Ateye069@gmail.com*, *hoodoqali042@gmail.com***

Abstract

Haricot bean one the legume crop that is widely consumed in Somali community. The study was conducted in Somali Regional State with objective to analyze macronutrient, micronutrient/minerals, antinutritional content, functional and physical of different haricot bean varieties adapted by Somali Region Pastoral and Agro-Pastoral Research Institute. Six different types of haricot bean samples such as Awash mittin, Awash 2, Seri 119, Seri 125, Adi and D Control as control with total of fifteen (15) samples were collected from three different research center namely Dolo-Ado, Fafan and Kelafo. The collected haricot samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, total energy, different minerals like Calcium, Iron, Zinc and Potassium were determined by AOAC. The Anti-Nutritional content such as tannins and phytate were also determined by different standard procedures. Based on the result obtained the moisture, ash, crude fiber, protein and fat are in the range of 7.915 (K-Seri 119) -11.533% (F-Adi), 4.218 (F-Awash-2) -5.606% (K-Seri 125), 2.230 (F-Seri 125) -4.480% (F-Awash - 2), 16.210 (K-Seri 125) -22.180% (D-Awash mittin) and 0.540 (D.Seri 125) – 2.250% (D-Awash -2) respectively and most of them are statistically different at $P<0.05$. The minerals content were also in the range of 65.96 (F-Adi) – 108.07mg/100g (D-control), 126.0 (D-Seri 119) – 152.0mg/100g (K-Seri 125), 3.092 (K-Awash 2) – 4.798mg/100g (D-Awash 2) and 4.306 (K-Seri 119)-6.571mg/100g (D-control) for calcium, potassium, zinc and iron respectively and more or less they were statistically different at $P<0.05$. Regarding the anti-nutritional content, the tannins and phytate content is in the range of 0.30 (F-Adi and F-Awash 2) - 34.95mg/g (D-Seri 119) and 2.193 (K-Seri 119) – 4.05mg/g (D-Seri 119) for tannins and phytate respectively and statistically different for tannins content at $P<0.05$. Overall, from the finding we conclude that, adapted haricot bean varieties have better in nutritional content especially ash, fiber and protein content especially varieties with D-Awash mittin. Varietal difference, agro-ecology, nature of soil, farming management and some other reasons might be the factor for their difference in their nutritional content. Haricot bean is reached in protein, minerals and other important nutrient and therefore, we recommend that, it can be used either alone or mix with those staple cereals as part of fighting against malnutrition and in the preparation of different recipe.

Key words: Haricot bean, macro-nutrient, minerals content, Anti-nutritional content, Functional Properties, Physical property

INTRODUCTION

Grain legumes occupy an important place in human nutrition, especially in the dietary pattern of low-income groups of people in developing countries. Legumes, considered as poor man's meat, are generally good sources of nutrients [1]. They are an important and inexpensive source of protein, dietary fiber and starch for a large part of the world's population, mainly in developing countries [2]. Among the commonly consumed food legumes, haricot beans (Phaseolus vulgaris L.) occupy an important place in human nutrition in East and Great Lakes regions of Africa [3]. Beans are also one of the best non-meat sources of iron, providing 23–30% of daily recommended levels from a single serving [4].

Ethiopia is one of the poorest countries in the world with 85% of its population living in the rural parts of the country and employed in agriculture sector. The agriculture sector is very important in the Ethiopian economy that it accounts for roughly 46% of the country's Gross Domestic Product (GDP) and 90% of exports [5]. Agriculture is the core component and driver for Ethiopia's growth and long-term food security. Agriculture directly employs 80 percent of the total population, 43 percent of gross domestic product (GDP), and over 70 percent of export value [6]. Despite the considerable progress made in the sector, ensuring commercialized production remains one of the major challenges facing millions of people.

Haricot bean (Phaseolus vulgaris L.) has been an export pulse crop for Ethiopia for more than 50 years and probably been grown as food crop for a much longer period in the low and mid land altitude areas of the country [7]. The crop is widely grown in areas between 1400-2000 m.a.s.l. The main production areas include the East Hararghe, West Wellega, East shewa, West Arsi, Sidama, Wolayita, Wollo and East Gojam [8]. The crop is grown either as a sole crop and/or intercropped with either cereal or perennial crops [9]. There are a wide range of haricot bean types grown in Ethiopia, including the mottled, red, white and black varieties. The leading white bean varieties are the Awash 1, Awash melka and Mexican 142 varieties. The pure red and pure white colored beans are the most common commercial varieties [7]. Haricot bean is ranked as the second largest pulse crop in the country in terms of production with a share of 17 percent, next to Faba

beans [10]. CSA 2014/15 report also shows that the production share of haricot bean has consistently been 19 percent of all the pulses for the last two years.

Haricot beans are a grain crop mainly produced in Ethiopia for home consumption and export purpose. It grows in most of the agro-ecology zones of low and mid altitude areas of the country. A market demand for the haricot beans both in the export market has become the main instrument for the growing trends in volume of production [11]. Haricot beans are among the most important grain legumes produced by small-scale farmers for both subsistence and cash, mainly in the lowlands and in the rift valley areas of Ethiopia. They are high in starch, protein, and dietary fiber, and are an excellent source of minerals and vitamins.

According to [12] world market prices for agricultural goods have been increasing. The reason for the increasing trend of agricultural world market prices is that global demand growth exceeds the growth in global supply, and this trend will continue in the foreseeable future. The global demand for food will continue to grow mainly for two reasons. One is the continued growth in world population; the other is the sustained growth in per capital incomes in developing and newly industrialized countries, with corresponding increase of per capital food consumption. This fact in turn has a positive impact on the home consumption and export of high value agricultural commodities and creates international market opportunity. Shortage in one end of the world becomes an opportunity in the other end of the world, this leads to increase the production of agricultural commodities in the potential production areas. Consequently, this might accelerate economic growth. Therefore, the competitiveness of agricultural commodities in global market is imperative for exportable products.

As indicated above, now a day SoRPARI adapted releasing the common beans specially haricot bean. Different research centers under Somali region pastoral and Agro-pastoral research institute have been working on the haricot bean varieties. So, we believe that based on literature and how haricot beans are important in terms of macro, micro-nutrient and anti-nutrient content, its mandatory to investigate its quality before home consumption and export purpose. Therefore, the aim of the present study was to analyze the nutritional value, anti-nutritional value, mineral contents, functional and physical properties of haricot bean varieties adapted and released by SoRPARI.

MATERIALS AND METHOD

Six different haricot bean varieties produced/adapted under SoRPARI were collected and with one variety as a control was purchased from the local market. A total of 15 samples with six varieties produced or adapted under SoRPARI that were used for this study includes Awash 2, Awash mittin, Seri 119, Seri 125, Adi and one control sample whereas the control haricot bean is the one with most likely used by local community. Haricot bean samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. The proximate composition of haricot bean flours was determined using the standard AOAC methods (AOAC, 2000). Gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories (AOAC, 2000). The mineral contents were determined by the procedure of AOAC (2000). All the analysis were performed in duplicate and presented as mean ± standard deviation. Statistical significance of the data obtained were analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using GenStat version 17.0. The level of significance was considered at $P < 0.05$.

RESULT

Macronutrient content of different haricot bean varieties

Table 1 shows proximate composition of different haricot bean varieties. The moisture content is the range of 7.915% (K-Ser 119) to 11.533% (F-Ada) variety. Overall, there is no significance difference in moisture content of different haricot bean varieties collected both from Dolo-Ado and Kelafo research center at $P<0.05$. When it comes to ash content, F-Awash 2 has the lowest (4.218%) and K-Seri 125 with highest (5.606%) ash content. Significant difference was observed between 15 different samples of haricot bean at $P<0.05$ while in between some samples there is no significant difference at $P<0.05$.

Table 1: Proximate composition of different haricot bean varieties

Haricot bean Varieties	Results in (%) (100g)						
	Moisture	**Ash**	**C.Fiber**	**C.Protein**	**C.Fat**	**CHO**	**Energy**
DAwash2	8.095±0.5^{a}	5.500±0.2^{gh}	3.160±0.2^{f}	18.96±0.6^{i}	2.250±0.09^{k}	62.03±1.81^{b}	344.2±2.51^{fg}
D Awash – Mittin	8.141±0.3^{a}	5.473±0.2^{fgh}	3.230±0.2^{g}	22.18±0.8^{m}	1.620±0.07^{g}	59.36±1.22^{a}	340.7±3.01^{def}
D Control	8.395±0.6^{ab}	5.060±0.3^{def}	3.410±0.2^{hi}	17.25±0.5^{d}	1.740±0.07^{h}	64.15±2.11^{de}	341.2±3.12^{def}
D-Seri 119	8.782±0.7^{abc}	4.835±0.1^{bcd}	3.280±0.2^{g}	20.14±0.7^{k}	1.440±0.06^{f}	61.52±1.75^{b}	339.6±2.98^{de}
D-Seri125	8.584±0.5^{ab}	4.966±0.2^{cde}	3.350±0.3^{h}	18.77±0.6^{h}	0.540±0.02^{a}	63.79±2.08^{d}	335.1±2.87^{bc}
F-Adi	11.553±0.8^{e}	4.614±0.2^{abc}	2.760±0.1^{c}	19.63±0.7^{j}	1.400±0.06^{f}	60.04±1.32^{a}	331.3±2.68^{ab}
F-Awash 2	9.203±0.9^{bc}	4.218±0.1^{a}	4.480±0.3^{l}	18.02±0.6^{g}	0.790±0.03^{b}	63.29±1.90^{cd}	331.3±2.69^{ab}
F-Awash Mittin	10.954±0.8^{de}	4.516±0.2^{ab}	3.430±0.2^{i}	17.59±0.5^{e}	1.160±0.05^{d}	62.35±1.95^{bc}	330.2±2.56^{a}
F-Seri 119	10.613±0.7^{d}	4.296±0.1^{a}	3.620±0.2^{k}	16.75±0.4^{b}	1.070±0.04^{c}	63.65±2.06^{d}	331.2±2.68^{ab}
F-Seri 125	9.530±0.6^{c}	4.535±0.2^{ab}	2.230±0.1^{a}	20.29±0.8^{l}	1.310±0.05^{e}	62.10±1.98^{b}	341.4±3.03^{def}
K-Adi	8.689±0.5^{abc}	5.112±0.3^{defg}	2.400±0.1^{b}	17.88±0.5^{f}	1.740±0.07^{h}	64.18±2.32^{de}	343.9±3.56^{efg}
K-awash 2	8.678±0.6^{abc}	5.304±0.3^{efgh}	3.040±0.2^{e}	18.99±0.6^{i}	1.570±0.06^{g}	62.42±1.98^{bc}	339.8±3.04^{de}
K-awash Mittin	8.319±0.6^{ab}	5.284±0.3^{efgh}	3.230±0.2^{g}	17.59±0.5^{e}	1.910±0.08^{i}	63.67±2.21^{d}	342.2±3.23^{def}
K-Seri 119	7.915±0.3^{a}	5.160±0.2^{defg}	2.930±0.2^{d}	16.93±0.4^{c}	2.130±0.09^{j}	64.93±2.34^{e}	346.6±3.95^{g}
K-Seri 125	8.137±0.4^{a}	5.606±0.3^{h}	3.530±0.3^{j}	16.21±0.4^{a}	1.460±0.06^{f}	65.06±2.51^{e}	338.2±3.86^{cd}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$

D: Dolo-Ado, F: Fafan, K: Kelafo Research center and Sub-centers. CHO: Carbohydrate,

Energy: Energy in Calory unit obtained from consuming 100g of these haricot bean varieties

With respect to crude fiber content, sample with F-Seri 125 has lowest in crude fiber content while sample with F-Awash 2 has highest in crude fiber content as indicated in table above. When it comes to comparison among different samples collected from different research centers, those samples collected from Fafan research center have highest crude fiber followed by Dolo-Ado and Kelafo research center respectively. K-Seri 125 has lowest in crude protein content (16.21%) while D-Awash mittin has the highest in crude protein content (22.18%). There is no significant difference at $P<0.05$ between samples with code K-Awash mittin and F-Awash mittin. Except these two samples, the crude protein content is significantly different in between al samples at $P<0.05$. In general, the data shows, haricot bean is good source of crude protein.

D-Seri 125 has lowest in crude fat content (0.54%) while D-Awash-2 has the highest in crude fat content (2.25%). There is no significant difference in between (K-Seri 125 & F-Adi), (D-Awash mittin & K-Awash 2) and (D-Control & K-Adi) at $P<0.05$. Except these mentioned samples, the crude fat content is significantly different in between others haricot bean samples at $P<0.05$. When it comes to carbohydrate content, K-Seri 125 has the highest in carbohydrate content (65.06%) while D-Awash mittin has the lowest in carbohydrate content which is 59.36. Lastly the energy, sample code with F-Awash mittin has the lowest in energy obtained (330.2Kcal/100g) while K-Seri 119 has the highest in energy content which is 346.6Kcal/100g. Except few samples, the energy obtained is not significantly different at $P<0.05$.

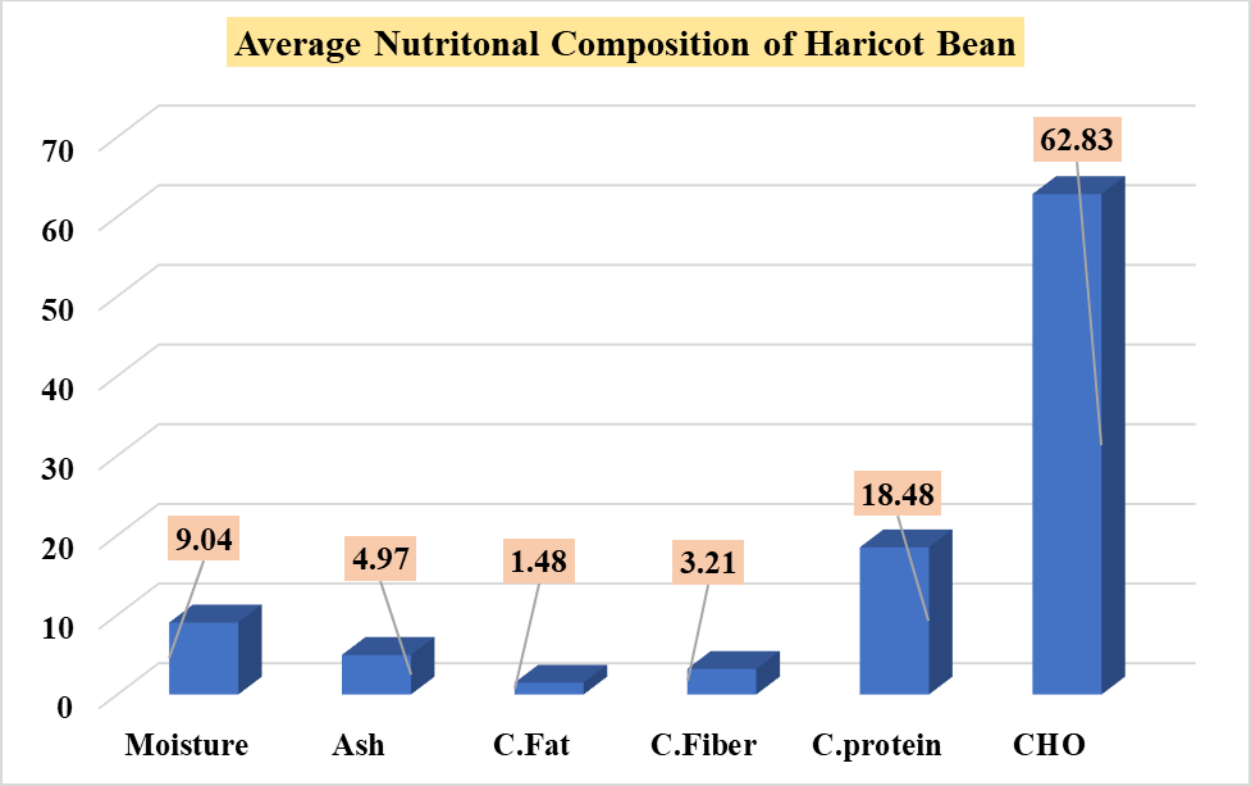


Figure 1: Average nutritional composition of haricot bean

Key: C-Crude, CHO-Carbohydrate

The general nutritional content indicated in figure 1 above. The figure indicates that, the average nutritional composition of 1.48%, 3.21%, 4.97%, 9.04%, 18.48% and 62.83% for crude fat, crude fiber, ash (Inorganic component), moisture, crude protein and carbohydrate in their order of increasing respectively.

The minerals content of different haricot bean varieties

The mineral content of different haricot bean varieties has indicated in table 2 below. The calcium content is in the range of 65.96mg/100g for sample code F-Adi while the highest amount of calcium is registered for sample with code D-Control which is 108.07g/100g. Except few samples, significant difference was observed for calcium in most of the sample in a one-to-one comparison at $P<0.05$. Sample with code K-Awash-2 has the lowest in zinc content (3.092mg/100g) while D-Awash 2 has the highest in zinc content which is (4.798mg/100g). Except few samples, there is no significant difference in zinc content if one-to-one and general comparison is considered at $P<0.05$.

Table 2. Minerals content of different haricot bean varieties

Haricot bean Varieties	Results in (mg/100g)			
	Calcium	Zinc	Iron (Fe)	Potassium (K)
DAwash2	83.04±1.50^{fg}	4.798±0.98^{f}	5.227±0.99^{ab}	150.3±1.89^{e}
D Awash -Mittin	79.96±1.35^{defg}	4.152±0.82^{cdef}	4.543±0.79^{a}	147.8±1.79^{de}
D Control	108.07±1.85^{i}	3.739±0.79^{abcd}	6.571±1.04^{b}	145.1±1.71^{cde}
D-Seri 119	68.19±1.25^{ab}	4.422±0.92^{def}	5.666±0.99^{ab}	126.0±1.21^{a}
D-Seri125	65.96±1.21^{a}	4.106±0.80^{cdef}	5.219±0.99^{ab}	138.1±1.34^{bc}
F-Adi	85.32±1.62^{g}	3.780±0.78^{abcd}	4.534±0.75^{a}	135.6±1.32^{b}
F-Awash 2	80.93±1.42^{efg}	4.025±0.78^{cde}	4.538±0.81^{a}	133.3±1.31^{ab}
F-Awash Mittin	92.49±1.48^{h}	3.541±0.65^{abc}	5.671±0.97^{ab}	133.3±1.31^{ab}
F-Seri 119	72.79±1.29^{bc}	3.706±0.69^{abcd}	4.995±0.91^{ab}	131.0±1.30^{ab}
F-Seri 125	78.32±1.35^{def}	3.457±0.59^{abc}	6.343±1.02^{b}	140.3±1.61^{bcd}
K-Adi	83.01±1.50^{fg}	3.860±0.72^{bcde}	4.988±0.94^{ab}	145.0±1.71^{cde}
K-awash 2	83.42±1.52^{fg}	3.092±0.52^{a}	5.433±0.93^{ab}	147.5±1.76^{de}
K-awash Mittin	77.09±1.29^{cde}	3.256±0.58^{ab}	5.665±1.01^{ab}	145.1±1.72^{cde}
K-Seri 119	75.14±1.19^{cd}	3.941±0.76^{bcde}	4.306±0.71^{a}	147.5±1.78^{de}
K-Seri 125	84.55±1.42^{g}	4.582±0.91^{ef}	5.663±1.02^{ab}	152.1±1.95^{e}

When it comes to iron content, sample with K-Seri 119 has lowest in iron content (4.306mg/100g) while sample with code D-control has the highest in iron content which is 6.571mg/100g. Almost all no significant difference was observed in between most of the haricot sample when it comes to iron content at $P<0.05$. Lastly, the potassium content of different haricot bean samples in the range of 126.0mg/100g for sample with code D-Seri 119 and 152mg/100g for sample with code K-Seri 125. Except few samples, there is no significant difference in potassium content if one-to-one and general comparison is considered at $P<0.05$. Relatively minor difference was observed in potassium content for same sample but collected from different sources or area.

Anti-Nutritional factors of different haricot bean varieties

Table 3 Anti-Nutritional factors of different haricot bean varieties

Haricot bean Varieties	Results (mg/g)	
	Tannins	**Phytate**
DAwash2	0.66±0.08[a]	2.663±0.28[a]
D Awash –Mittin	0.86±0.94[a]	3.594±0.36[a]
D Control	13.65±1.26[b]	2.539±0.26[a]
D-Seri 119	34.95±1.93[e]	4.050±0.43[a]
D-Seri125	28.60±1.87[d]	2.319±0.23[a]
F-Adi	0.30±0.05[a]	2.657±0.28[a]
F-Awash 2	0.30±0.05[a]	2.317±0.24[a]
F-Awash Mittin	0.52±0.07[a]	2.658±0.28[a]
F-Seri 119	22.22±1.57[c]	2.315±0.22[a]
F-Seri 125	26.31±1.51[cd]	2.310±0.21[a]
K-Adi	0.44±0.06[a]	2.309±0.20[a]
K-awash 2	1.91±0.09[a]	3.009±0.31[a]
K-awash Mittin	0.77±0.09[a]	2.662±0.29[a]
K-Seri 119	28.85±1.68[d]	2.193±0.21[a]
K-Seri 125	30.61±1.86[d]	2.784±0.30[a]

Key: Same letter in the same column is not significantly different from each other at $p<0.05$

D: Dolo-Ado, F: Fafan, K: Kelafo Research center and Sub-centers.

The anti-nutritional content (Tannins and phytate) of different haricot bean varieties has been indicated in table 3. Regarding tannins content, Sample with code F-Adi and F-Awash-2 has the lowest in tannins content (0.30mg/g) while D-Seri 119 has the highest in tannins content which is 34.95mg/g. in addition to this, high level of tannin were obtained on sample code with K-Seri 125, K-Seri 119, D-Seri 125, F-Seri 125, F-Seri 119 and D-Control sample with values of 30.61mg/g, 28.85mg/g, 28.60mg/g, 26.31mg/g, 22.22mg/g and 13.65mg/g respectively. Except few samples, there is no significant difference in tannins content if one-to-one and general comparison is considered at $P<0.05$. When it comes to the phytate content, D-Seri 119 has the highest in phytate content (4.050mg/g) while k-Seri 119 has the lowest in phytate content which is 2.193mg/g. There is no significant difference between all haricot sample collected form all centers at $p<0.05$.

DISCUSSION

Proximate Composition of Different Haricot Bean Varieties

Table 1 shows proximate composition of different haricot bean varieties. The moisture content is the range of 7.915% (K-Ser 119) to 11.533% (F-Adi) variety. When it comes those verities collected from Fafan research center, the moisture content F-Ada & F-Awash mittin are significantly different as compared to F-Awash 2, F-Ser 119 and F-Ser 125 at $P<0.05$. This might be due to difference in maturity during harvest, storage condition. According to the report of research done by Demirew Abera et.al., [13] and Shimelis and Rakshit [14], Moisture content concentration varied from 9.33 to 10.62 g/100g (DM) and 9.08 to 11.01g/100g (DM) respectively. Ash is a part of the proximate composition and is related to mineral residue. The level of ash content represents total inorganic matters that are located in food ingredients. F-Awash 2 has the lowest (4.218%) and K-Seri 125 with highest (5.606%) ash content. This value is much higher with one reported by Demirew Abera et.al.,[13]. The difference might be due the fact that, agro-ecological difference, farming system or management difference, nature of soil and some others.

The percentage of the crude fiber suggested that diet prepared with common beans could help to ensure good gut movement of food through the gut to provide energy and ensure break down of the food. Moreover crude fiber is known to influence production of high butyrate levels and butyrate has been linked to lower risks for cancer [15]. Except few haricot bean samples under study (D-Seri 125 and D-Control samples), the crude fiber content of most samples is significantly different at $P<0.05$. The crude fiber content is significantly different at $P<0.05$, in some of the same sample but collected from different research centers. The crude fiber content of those fifteen haricot bean varieties were relatively lower than the one reported by Derese [16], Shimelis [14] and Demirew Abera et.al [13] were ranged from 4.86g/100g to 7.01g/100(DM), 4.66 to 5.95 g/100g (DM) and 4.40% to 8.89% respectively. This might be due difference in other content of the bean, agro-ecological difference, farm management and this result indicates that proximate composition varied from variety to variety.

Protein is another part of proximate composition which is the second dominant in percentage after carbohydrate that help in physical and mental growth and development as earlier reported by [17, 18]. There is no significant difference at $P>0.05$ between samples with code K-Awash mittin and F-Awash mittin. Except these two samples, the crude protein content is significantly different in

between all samples at P<0.05. Even there is significant different in between same sample but collected from different research centers at P<0.05. In general, the data shows, haricot bean is good source of crude protein. The total mean protein content of Fifteen samples were lower than the research done by Demirew Abera et.al [13] on improved and released common bean varieties that were in the range of 18.62% -25.98% But comparable with [14] which was in the range of 17.96g/100g to 22.07g/100g for the improved Ethiopian beans.

Mineral content of different haricot bean varieties

Except few samples, significant difference was observed for calcium in most of the sample in a one-to-one comparison at P<0.05. When it comes to the potassium content except few samples, there is no significant difference in potassium content if one-to-one and general comparison is considered at P>0.05. Relatively minor difference was observed in calcium and potassium content for same sample but collected from different sources or area. Range of calcium content was from 4.84-44.51mg/100g, 731.93 to 1629.77mg/kg (73.19-162.97mg/100g) according research report by Demirew Abera et.al [13], Shimelis and Rakshit [14] respectively and potassium content from 186.81-423.84mg/100g, according research report by Demirew Abera et.al [13].

Sample with code K-Awash-2 has the lowest in zinc content (3.092mg/100g) while D-Awash 2 has the highest in zinc content which is (4.798mg/100g) (table 4.2). Except few samples, there is no significant difference in zinc content if one-to-one and general comparison is considered at P>0.05. When it comes to iron content, sample with K-Seri 119 has lowest in iron content (4.306mg/100g) while sample with code D-control has the highest in iron content which is 6.571mg/100g (table 4.2). Range of Iron content was from ND-8.58mg/100g, 61.81 to 83.99mg/kg (6.181-8.399mg/100g) and zinc content from 0.05-1.4mg/100g, 15.36 to 28.22mg/kg (1.536-2.822mg/100g) according research report by Demirew Abera et.al [13], Shimelis and Rakshit [14]. Similarly the ranges of these results were also reported by Derese and shimelis [16] from 46.80 to 72.40mg/kg and from 14.30 (4.680mg/100g) to 22.90mg/kg (2.290mg/100g) for iron and Zinc content respectively.

Anti-Nutritional content of different haricot bean varieties

Regarding tannins, except few samples, there is no significant difference in tannins content if one-to-one and general comparison is considered at P<0.05. Relatively minor difference was observed in tannins content for same sample but collected from different sources or area except some

samples. The tannins content of those Seri 119 and Seri 125 are significantly different as compared with other haricot bean varieties at $P<0.05$. The research done on different varieties of haricot bean indicate that, the tannins content is the range of 0.82 - 3.49mg/100g [19]. When it comes to the phytate content, there is no significant difference between all haricot sample collected form all centers at $p<0.05$. The phytate content was in contradict with that of Phytate from 124.63- 217.44mg/100g, specifically that of Seri 119 and Seri 125 were 124.63 and 146.26mg/100g respectively, according to the research report by Demirew Abera et.al [13]. On the other hand, the research done on different varieites of haricor bean indicate that, the phytate content is the range of 122.26- 143.21mg/100g [19] .

Conclusion

The research was done on six haricot bean varieties with fifteen total samples collected from three research centers under Somali Region Pastoral and Agro-Pastoral research institute (SoRPARI). From the data obtained we conclude that, the ash content of all sorghum varieties is high which an indication for their high mineral content. The moisture content of all varieties was below 12% which is an indication for their better shelf stability. The fiber, and carbohydrate is also up to the standard which indicates that, haricot bean is good sources these components. The protein content of all haricot bean varieties is very high which indicate haricot bean is the good source protein which in turn helps in fighting against protein energy malnutrition. But fat content of all haricot bean varieties is very low. When it comes to minerals content, all varieties of haricot bean have high amount calcium, iron, zinc and potassium. Regarding the anti-nutritional content of haricot bean, especially sample with varieties name Seri 119 and Seri 125 is high both tannins and phytate content. Generally, haricot bean with variety name Awash mittin is good in almost all parameter such as protein, ash, fiber, mineral and anti-nutritional content. Significant different were observed in all varieties for both macronutrient, micronutrients and Anti nutritional content of different haricot bean varieties where agro-ecology, varietal difference, soil nature, farming management are the main expected factors for their difference.

Recommendation

Based on the data obtained from this research we forward the following recommendation;

- The data shows that, all haricot bean varieties have high amount of protein, ash and fiber, therefore, we recommend possibility of using haricot bean by mixing with other staple cereals such maize, sorghum in the preparation meal so that the nutritional content can be enhanced.

- ❖ We specifically recommend, haricot bean with varieties name *Awash mittin* to be used in the preparation different food product such as complementary food, weaning food as it has high amount of protein, ash, minerals and less amount of anti-nutritional factors.
- ❖ Further research should be done by including more nutritional parameters such as more minerals, vitamins and also to see the impact of soil nature on haricot bean mineral and other nutritional content.
- ❖ Further research and then technologies should be introduced on mean to minimize anti-nutritional content especially when it comes to haricot bean with *Seri 119* and *Seri 125* varieties.
- ❖ Government and other actors on haricot bean and other different grain should do more on the promotion of haricot bean

References

1. Tharanathan R, Mahadevamma S. Grain legumes—a boon to human nutrition. Trends in Food Science & Technology 2003; 14: 507-518.
2. Osorio-Díaz P, Bello-Pérez LA, Sáyago-Ayerdi SG et al. Effect of processing and storage time on in vitro digestibility and resistant starch content of two bean (Phaseolus vulgaris L) varieties. Journal of the Science of Food and Agriculture 2003; 83: 1283-1288.
3. Doughty J, Walker A. Etude FAO: alimentation et nutrition. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy 1982.
4. Pachico D. The demand for bean technology. Working document (CIAT) 1993.
5. Croppenstedt A, Muller C. The impact of farmers' health and nutritional status on their productivity and efficiency: Evidence from Ethiopia. Economic Development and Cultural Change 2000; 48: 475-502.
6. Cochrane L, Bekele YW. Contextualizing narratives of economic growth and navigating problematic data: Economic trends in Ethiopia (1999–2017). Economies 2018; 6: 64.
7. Ferris S, Kaganzi E. Evaluating marketing opportunities for haricot beans in Ethiopia. IPMS Working Paper 2008.
8. Ayana G, Abdo A, Merine Y et al. Plant variety release. Protection and Seed Quality Control Directorate. In. Ministry Of Agriculture And Natural Resources 2016.
9. Abayneh Y, Tefera T. Factors influencing market participation decision and extent of participation of haricot bean farmers in Meskan District, Ethiopia. International journal of management and development studies 2013; 2: 17-26.
10. Negash R. Determinants of adoption of improved haricot bean production package in Alaba special woreda, southern Ethiopia. In. Haramaya University 2007.
11. Mulugeta F. Profile of Haricot bean production, supply, demand and marketing issues in Ethiopia. Ethiopian Commodity Exchange Authority, Addis Ababa 2010.
12. Kelemework G. White pea bean (Phaseolus vulgaris L.) value chain analysis: The case of Adami Tulu Jido Kombolcha district, Eastern Shewa Zone, Oromia National Regional State, Ethiopia. In. MSc Thesis. Haramaya University, Haramaya, Ethiopia 2015.

13. Ketema DA, Gebeyehu HR, Gebreyes BG. Evaluation of Proximate, Mineral and Anti-nutritional composition of improved and released Common bean varieties in Ethiopia. Int. J. Novel Res. Life Sci 2019; 6: 13-27.
14. Shimelis EA, Rakshit SK. Proximate composition and physico-chemical properties of improved dry bean (Phaseolus vulgaris L.) varieties grown in Ethiopia. LWT-Food Science and Technology 2005; 38: 331-338.
15. Le Leu RK, Brown IL, Hu Y et al. Effect of dietary resistant starch and protein on colonic fermentation and intestinal tumourigenesis in rats. Carcinogenesis 2007; 28: 240-245.
16. Teshome DM, Emire SA. Canning quality evaluation of common bean (Phaseolus vulgaris L.) varieties grown in the central rift valley of Ethiopia. East African Journal of Sciences 2012; 6: 65-78.
17. Messina MJ. Legumes and soybeans: overview of their nutritional profiles and health effects. The American journal of clinical nutrition 1999; 70: 439s-450s.
18. Aremu M, Olayioye Y, Ikokoh P. Effects of processing on nutritional quality of Kersting's groundnut (Kerstingiella geocarpa L.) seed flours. Journal of Chemical Society of Nigeria 2009; 34: 140-149.
19. Wodajo D, Emire SA. Haricot beans (Phaseolus vulgaris L.) flour: Effect of varieties and processing methods to favor the utilization of underconsumed common beans. International Journal of Food Properties 2022; 25: 1186-1202.

Proximate Composition, Anti-nutritional, Functional and Physical Properties of Different Soya bean Varieties

Mohammed Dol Ateye1, Abdulkarim Mohammed Ali[2], Hoodo Mohamed Jama[2],

3. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***Ateye069@gmail.com***
4. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***adnanbdu302@gmail.com*, *hoodoqali042@gmail.com***

P.O.Box 138, Jigjiga, Ethiopia

ABSTRACT

Soybean is the major source of high-quality protein and oil legumes and is important for human consumption, which can prevent malnutrition for vulnerable groups in general. The objective of this study was to investigate the proximate composition, physicochemical, functional and ant-nutritional properties of some new varieties of soya bean adopted by the SoRPARI research center Kelafo and Dolo-ado. Five different varieties with two different locations, D-Gezale, D-Gizo, D-Pawa 1, D-Pawa 2, and D-Pawa 3 from the Dolo-ado center and K-Gezale, K-Gizo, K-Pawa 1, K-Pawa 2, and K-Pawa 3 from the Kelafo center, L-Gode from Gode and L-Jigjiga from Jigjiga, were collected. The grains of 12 varieties of soybean were analyzed for moisture, 100 seed weight, bulk density, water absorption capacity, oil absorption capacity, ash, fat, protein and crude fiber and minerals. These soybean varieties contained 4.78-7.34% moisture, 7.0-15.755%, 100 seed weight, 0.68-0.78% bulk density, 1.51-2.67% water absorption capacity, 0.86-1.49% oil absorption capacity, 3.82-6.30% ash, 5.37-21.61% fat, 19.65-30.35% protein and 3.75-6.29% crude fiber and minerals. The total calcium, iron, magnesium and zinc contents ranged between 48.9-157.2, 5.37-12.06, 658.50-2429.10, and 3.79-6.45 mg/100g, respectively. The results indicated that K-Pawa 1, K-Pawa 3, D-Pawa 3, and D-Gezale contained high protein, crude fat, and carbohydrate contents. The fiber content was low but can still be useful for helping our body prevent or release constipation and correcting some of the problems that many people are facing, such as diabetes and obesity. Additionally, the ash content was high in some of the soybean varieties, which indicated that they are important sources of minerals such as magnesium, calcium, zinc, and iron.

Keywords: *Soya bean, Proximate composition, Functional properties, Physical properties.*

INTRODUCTION

Soya bean, botanically called Glycine max (L.) originated from Eastern Asia, probably in northern and central China. Mature soybean seeds contain approximately 40% protein, 20% oil, and 10% water-soluble carbohydrates (Byth, 1968). Glycine max is an important legume increasingly consumed for both its nutritional and economic value (Bayero et al., 2019). High-quality protein and oil are of paramount importance to human beings. One primary source of high-quality protein and oil is the soya bean (Medic et al., 2014). The quality of soya beans is usually determined by seed protein, oil, fatty acid, and mineral contents, as such, its quality is key to improving human and animal nutrition. This importance is probably related to the fact that soybean products are

excellent sources of proteins, minerals, phosphorus, and vitamins at a very low cost (Wang et al., 2003). On the other hand, soybean products are largely known to play an important role in health and healthy living. Soya bean intake is reported to prevent heart disease, obesity, hypercholesterolemia, cancer, diabetes, kidney disease, and osteoporosis, and it is also suitable for people with allergic reactions caused by animal milk (Friedman & Brandon, 2001). Glycine max has the highest protein content (40%) among cereals and other legumes. Other legumes have a protein content of between 20 and 30%, while cereals have a protein content in the range of 8-15% (Yohannes et al., 2020).

Soya beans' protein content (40%) is higher and more economical than that of beef (19%), chicken (20%), fish (18%), and groundnut (23%) (IITA 1990). Soya bean is also of particular interest as a vegetable protein source because of its cholesterol-lowering abilities in patients with type II hyperlipoproteinemia (Sridhar & Bhat, 2007). Soybean also contains approximately 20% oil, the second highest content among all food legumes, with the highest oil content found in peanuts, which is approximately 48% on a dry matter basis, while the third-highest oil content is chickpea, which is approximately 5% (Liu, 1997). Soya bean is also rich in minerals and vitamins such as iron, zinc, copper, thiamine, riboflavin, niacin, and pantothenic acid, as well as phospholipids (Bourre, 2006). Most of these vitamins and minerals are well known to be hematinic and are essential in the formation of red blood cells (Joel & U, 2011). Soya bean is reported to contain flavonoids, especially isoflavones, which is why they are regarded as having a powerful ability to fight and prevent cancers in humans, as well as other diseases (Messina et al., 1994).

Different research centers under the Somali region pastoral and Agro-pastoral research institute have been working on the Soya bean varieties, and possibly this was released and proximate analysis must check its quality. Therefore, the aim of the present study will be to profile the nutritional value, antinutritional value, mineral contents, and functional and physical properties of soybean varieties adapted and released by Somali Regional Pastoral and Agro-pastoral Research Institute (SoRPARI). Knowing the nutritional diversity of soya beans would have a direct impact on the improvement of soya beans for quality breeding and food product development to reduce the prevalence of food insecurity, malnutrition, and mineral deficiency, especially for low-income

communities. Therefore, the objective of the study was to analyze the proximate composition and physicochemical, functional, and antinutritional properties of soybean.

Material and Methods

Sample collection, preparation and data analysis

Mature soybean seeds were obtained from Kelafo, Dolo-Ado Research Center, and two local varieties were purchased from the local market of Gode city and Jigjiga city in the Somali Regional State, Ethiopia. Then, seeds were cleaned from any foreign material, and any damaged or insect-infested seeds were removed and washed with tap water. Then, the seeds were sundried for 8 hours to remove any moisture absorption during washing, milled into flour powder, packed in airtight polyethylene plastic bags and stored at 4°C for further analysis. The proximate compositions of the soybean varieties were determined using standard analytical methods. All measurements were performed in duplicate, and values are presented as percentages. All analyses were performed in duplicate (unless stated otherwise) and presented as the mean ± standard deviation. The statistical significance of the data obtained by analyzing Gestate ver.15. The level of significance of study ($p<0.05$).

RESULTS

Proximate composition of soybean varieties

The samples of the soybean varieties were analyzed for different proximate compositions, including ash content, moisture content, crude fat content, crude fiber content, crude protein content, carbohydrate content, and energy content, using different standard techniques, and the results are presented in Table 1. K-Pawa 1 had the highest moisture content of all other varieties, but it was not significantly different from K-Pawa 2, whereas the lowest moisture content was in L-Jigjiga, but it was also significantly different from L-Gode. Variety D-Pawa 1 had the highest ash content compared to the other varieties; however, except for the K-Gezale and Local varieties, there was no significant difference between the other varieties. Table 1 shows that D-Gezale has the highest crude fat content compared to other varieties; however, variety K-Pawa 3 indicated no significant difference from G-Gezale, but local varieties indicated the lowest crude fat content. The results indicated that the local varieties had more fiber than the other varieties. As seen in the results, D-Pawa 3 contained a significantly higher amount of protein, and the lowest protein content was observed in local varieties. The carbohydrate content was higher in the local varieties,

and there was a significant difference among the local varieties, whereas K-Pawa 1 had the lowest carbohydrate content. Regarding the energy content, D-Gezale showed the highest significant amount compared to varieties, and there was no significant difference between varieties D-Pawa 1, D-Pawa 2, K-Gizo, K-Pawa 1, K-Pawa 2, and K-Pawa 3.

Table 1. Proximate Composition of Different Soybean Varieties

Varieties	Parameters						
	Moisture (%)	Ash (%)	Crude Fat (%)	Crude Protein (%)	Crude Fiber (%)	Carbohydrate (%)	Energy (%)
D-Gezale	5.09±0.04^{c}	5.62±0.07^{ab}	21.61±0.03^{a}	28.92±0.03^{c}	3.75± 0.13^{d}	35.01±0.18^{ef}	450.21±0.32^{a}
D-Gizo	5.51±0.02^{abc}	5.76±0.03^{ab}	13.04±0.02^{h}	28.68±0.03^{d}	5.04± 0.03^{b}	41.97±0.04^{c}	399.96±0.23^{e}
D-Pawa 1	5.53±0.03^{abc}	6.30±0.48^{a}	21.47±0.01^{b}	28.73±0.02^{d}	4.45± 0.09^{bc}	45.35±0.05^{efg}	489.5±0.39^{b}
D-Pawa 2	5.17±0.01^{bc}	5.75±0.19^{ab}	20.83±0.01^{e}	27.96±0.02^{f}	4.14± 0.05^{cd}	47.07±0.00^{d}	487.6±0.26^{b}
D-Pawa 3	5.81±0.11^{abc}	5.77±0.08^{ab}	20.02±0.00^{f}	30.35±0.02^{a}	4.57± 0.05^{bc}	45.06±0.52^{fg}	481.8±2.00^{c}
K-Gezale	6.25±0.02^{abc}	5.22±0.07^{b}	16.56±0.01^{g}	26.35±03^{g}	4.32± 0.24^{bcd}	52.77±0.22^{c}	465.6±0.88^{d}
K-Gizo	6.52±1.68^{abc}	5.34±0.09^{ab}	21.27±0.00^{c}	26.35±0.03^{g}	4.92± 0.30^{b}	35.60±0.32^{d}	439.23±1.26^{b}
K-Pawa 1	7.34±0.61^{a}	5.64±0.55^{ab}	21.13±0.05^{d}	29.52±0.02^{b}	4.62± 0.02^{bc}	44.73±0.06^{g}	487.2±0.17^{b}
K-Pawa 2	7.17±0.42^{a}	5.84±0.50^{ab}	21.12±0.00^{d}	28.49±0.01^{e}	4.36± 0.20^{bcd}	46.03±0.01^{e}	488.2±0.09^{b}
K-Pawa 3	7.12±0.02^{ab}	5.61±0.27^{ab}	21.60±0.00^{a}	27.94±0.02^{f}	4.63±0.03^{bc}	31.1±0.00^{e}	430.56±0.08^{b}
L-Gode	4.79±0.70^{c}	4.27±0.38^{c}	5.37±0.02^{j}	19.86±0.02^{h}	5.94±0.30^{a}	59.77±0.29^{a}	366.85±1.32^{f}
L-Jigjiga	4.78±0.08^{c}	3.82±0.12^{c}	6.34±0.02^{i}	19.65±0.04^{i}	6.29±0.08^{a}	59.12±0.02^{b}	372.14±0.43^{g}
G. Mean	**6.59**	**5.43**	**17.53**	**26.9**	**4.75**	**50.82**	**468.64**
CV (%)	**11.6**	**7.8**	**0.2**	**0.1**	**6.2**	**0.6**	**0.3**
LSD (%)	**1.66**	**0.658**	**0.071**	**0.076**	**0.644**	**0.664**	**2.63**

All values are the means expressed on a dry matter basis ± standard error.
Means with the same superscripts do not differ significantly (P<0.05) G=grand D=Dolo-Ado, K=Kelafo, L-local CV=Coefficient of Variation, LSD=Least Significance Difference.

Mineral contents and antinutritional factors of different soybean varieties

The results of the analysis of some mineral elements, including calcium, iron, magnesium, and zinc, are presented in Table 2. The results showed a mineral concentration of mg/100 g of the soybean flour. Variety K-Pawa 3 had the highest calcium content, followed by D-Pawa 3 and D-Gizo, but there was no significant difference between D-Pawa 3 and D-Gizo. Additionally, variety K-Pawa 3 had the highest iron content compared to the other varieties, and the poorest mineral content was in local varieties. The magnesium content was highest in variety K-Pawa 2, and the next highest magnesium content was found in variety K-Pawa 3, which indicated that K-Pawa 3 was significantly higher in all mineral contents than the other varieties. The lowest value of zinc content was on L-Jigjiga.

The antinutritional contents of soybean varieties are presented in Table 2. It was observed that the antinutritional content of tannins was significantly higher in the local varieties, whereas the adopted varieties had lower concentrations. On the other hand, the adopted varieties of the SoRPARI Center indicated that D-Pawa 2 had more antinutritional compounds. D-Gizo had the lowest concentration of polyphenols, but there was no significant difference from K-Pawa 2. Additionally, local varieties had significant differences among the phytate contents.

Table 2. Total mineral contents and antinutritional factors of different soybean varieties

Varieties	Parameters (mg/100 g)					
	Calcium %	Iron %	Magnesium %	Zinc %	Tannins (%)	Phytates (%)
D-Gezale	130.8± 0.19^{d}	9.570± 36.07^{bcd}	930.9±36.07^{e}	6.040±0.01^{abc}	0.148 ± 0.01^{d}	3.348 ± 0.13^{bc}
D-Gizo	143.0± 2.10^{b}	9.765± 111.75^{bcd}	1144.1±111.75^{cd}	6.030±0.09^{abc}	0.228 ± 0.04^{cd}	2.317 ± 0.0.23^{d}
D-Pawa 1	137.9± 1.47^{c}	8.105± 67.80^{de}	1073.5±67.80^{cde}	6.000±^{abc}	0.180 ± 0.04^{d}	3.236 ± 0.00b^{cd}
D-Pawa 2	135.4± 1.57^{c}	9.990± 2.87^{bc}	1231.8±2.86^{bc}	6.075±0.19^{abc}	0.121 ± 0.03^{d}	4.861 ± 0.22^{a}
D-Pawa 3	143.7± 1.32^{b}	10.815± 16.23^{ab}	1140.0±`6.23^{cd}	5.680±0.19^{cd}	0.169 ± 0.01^{d}	4.045 ± 0.13^{ab}
K-Gezale	137.9± 1.34^{c}	9.165± 11.90^{bcde}	978.1±11.90^{de}	6.450±0.00^{a}	0.260 ± 0.13^{cd}	2.659 ± 0.35^{cd}
K-Gizo	138.1± 1.21^{c}	9.355± 0.13^{bcde}	1117.3±0.13^{cde}	6.275±0.30^{ab}	0.285± 0.04^{cd}	3.463 ± 0.01^{bc}
K-Pawa 1	130.2± 0.81^{d}	8.715± 61.65^{cde}	1095.1±61.64^{cde}	6.385±0.03^{ab}	0.398 ± 0.09^{c}	3.353 ± 0.10^{bc}
K-Pawa 2	127.1± 1.74^{d}	8.110± 1.07^{de}	2429.1±1.07^{a}	6.120±0.07^{abc}	0.164 ± 0.03^{d}	2.777 ± 0.24^{cd}
K-Pawa 3	157.2± 0.74^{a}	12.060± 9.51^{a}	1378.2±9.51^{b}	5.960±0.08^{bc}	0.239 ± 0.04^{cd}	4.279 ± 0.82^{ab}
L-Gode	55.4± 1.10^{e}	7.705± 1.20^{e}	658.5±1.12^{f}	5.275±0.03^{d}	4.179 ± 0.11^{b}	3.468 ± 0.23^{bc}
L-Jigjiga	48.9± 1.38^{f}	5.375± 123.48^{f}	945.3±123.48^{e}	3.790±0.16^{e}	6.660 ± 0.02^{a}	3.931 ± 0.23^{ab}
G. Mean	**123.79**	**9.06**	**1177.0**	**5.840**	**1.086**	**3.478**
CV (%)	**1.5**	**7.6**	**6.8**	**3.3**	**8.1**	**12.3**
LSD (%)	**4.11**	**1.49**	**173.3**	**0.41**	**0.19**	**0.93**

All values are the means expressed on a dry matter basis ± standard error.
Means with the same superscripts do not differ significantly (P<0.05) G=grand D=Dolo-Ado, K=Kelafo, L-local CV=Coefficient of Variation, LSD=Least Significance Difference.

Functional and Physical Properties of Soya bean

Table 3 shows the various functional properties of soybean varieties. The water absorption capacity (WAC) and oil absorption capacity (OAC) of six varieties of soybean flour ranged between 2.532-1.507 and 1.495-0.870, respectively. Regarding the WAC, K-Gizo showed the highest water absorption capacity, and K-Pawa 2 indicated the lowest water absorption capacity. Similarly, K-Gizo and K-Pawa 2 had the highest oil absorption capacity; however, there was no significant difference between all the varieties. As shown in Table 3, the results indicated that the hundred seed weight and bulk density of the soybean varieties ranged from 16.50-7.00 and 0.766-0.683% and 0.766-0.682 ml, respectively. D-Pawa 2 had a significantly higher seed weight than the other seed varieties, and L-Gode had the lowest seed weight. From the bulk density, L-Gode indicated the highest volume of the soybean varieties, whereas D-Pawa 1 showed the lowest volume compared to the other varieties.

Table 3. Functional and physical properties of soya bean

Varieties	Parameters			
	WAC (%)	**AOC (%)**	**Seed Weight %**	**Bulk density %**
D-Gezale	1.670 ± 0.10^{cd}	1.038 ± 0.18^{a}	15.75 ± 0.24^{a}	0.7635 ± 0.00^{a}
D-Gizo	2.350 ± 0.19^{abc}	1.183 ± 0.00^{a}	10.75 ± 0.25^{bc}	0.7115 ± 0.00^{cd}
D-Pawa 1	2.077 ± 0.16^{abcd}	1.438 ± 0.06^{a}	14.50 ± 0.22^{a}	0.6825 ± 0.03^{f}
D-Pawa 2	1.700 ± 0.04^{cd}	1.093 ± 0.17^{a}	16.50 ± 0.23^{a}	0.7195 ± 0.01^{bcd}
D-Pawa 3	1.638 ± 0.06^{cd}	1.008 ± 0.02^{a}	11.50 ± 0.25^{b}	0.7170 ± 0.20^{bcd}
K-Gezale	2.077 ± 0.00^{abcd}	1.060 ± 0.08^{a}	10.50 ± 0.05^{bc}	0.7255 ± 0.01^{bc}
K-Gizo	2.532 ± 0.05^{ab}	1.495 ± 0.03^{a}	11.50 ± 0.21^{b}	0.7020 ± 0.10^{de}
K-Pawa 1	1.998 ± 0.06^{abcd}	1.245 ± 0.31^{a}	11.00 ± 0.20^{b}	0.7345 ± 0.00^{b}
K-Pawa 2	1.507 ± 0.42^{d}	0.863 ± 0.26^{a}	11.75 ± 0.02^{b}	0.7145 ± 0.01^{cd}
K-Pawa 3	2.675 ± 0.23^{a}	1.085 ± 0.26^{a}	8.28 ± 0.01^{cd}	0.7170 ± 0.01^{bcd}
L-Gode	1.585 ± 0.13^{d}	0.870 ± 0.08^{a}	$7.00 \pm 0.03d$	0.763 ± 0.01^{a}
L-Jigjiga	1.890 ± 0.50^{bcd}	1.390 ± 0.31^{a}	$7.50 \pm 0.03d$	0.7660 ± 0.00^{a}
G. Mean	1.975	1.147	11.38	0.719
CV (%)	15.7	22.5	5.1	0.6
LSD (%)	0.68	0.26	1.25	0.01

All values are the means expressed on a dry matter basis ± standard error. Means with the same superscripts do not differ significantly (P<0.05) G=grand D=Dolo-Ado, K=Kelafo, L-local CV=Coefficient of Variation, LSD=Least Significance Difference.

Discussion

Proximate Composition of Soya Bean

The results of the study indicated that soybean has a low moisture content ranging from 4.78-7.34%. This result implies that it can be stored for a very long time since moisture is an important

medium for the multiplication of microorganisms. Additionally, this study is in line with a study that was conducted in Nigeria, and the results show that soybean has a lower moisture content and can be stored for a long time and that microorganisms cannot grow easily (6.12%) (NWOSU et al., 2019). On the other hand, the ash content of the soya bean is significantly higher and ranged between 3.82-6.30%, which implies that the higher the ash content is, the higher the importance in mineral sources. The study is an inline study that was conducted in Nigeria, and the results indicated that the ash content of 4.29% is indicative that the flour sample could be an important source of minerals (Etiosa et al., 2017).

The soya bean protein content ranges from 19.65-30.35%, which indicates a higher concentration of protein compounds, and these results can be used for solving many malnutrition problems, especially protein-energy malnutrition cases such as marasmus and kwashiorkor. Compared to other literature, the crude fat content ranged from 5.37-21.61%, which is a lower content, but some of the varieties, such as D-Gezale and K-Pawa 1, indicated promising results of 21.61% and 21.60%, respectively. Additionally, the results of this study were in agreement with (Etiosa et al., 2017). The fiber content of this study was found to be between 3.75% and 6.29% of D-Gezale and L-Jigjiga, respectively. Fiber has many benefits for humans and can prevent constipation as well as reduce the risk of colon cancer. This finding agreed with the reported results by (Bayero et al., 2019), who revealed a fiber content of 6.84%.

The results of the study indicated significantly higher carbohydrate content, ranging between 44.75-68.82%. These can be promising results that can be used for managing protein energy malnutrition because of higher carbohydrate content the body can manage protein, fat, and mineral substance to use for bodybuilding, repairing damaged tissues rather than using them as a source of energy. This study is in line with the reported results by (Eshun, 2012), who showed that high carbohydrate content ranges between 34.97-39.86%. The energy content (kcal/100 g) ranged from 403.1-450.21%, and this study is in line with research conducted in Ghana. The results revealed that the energy content ranged from 458.58-473.62% (Eshun, 2012).

Mineral Concentrations of Soya Bean

The findings of the study indicated that the calcium contents ranged from 48.9-157.21%, and these results can be developed for many products, such as complementary foods for infants, because calcium helps to build the bones and teeth of infants since calcium is one of the main components

of teeth and bones. This study is in line with the research results of (Eshun, 2012), which indicated that calcium is responsible for tooth and bone formation.

The iron content of soya beans in this study was significantly higher, and iron contents ranged between 5.37-12.06% K-Pawa 3, indicating a superior result. This can be used for better management of iron deficiency in vulnerable groups such as lactating mothers, young children, and adolescent girls, which also agreed with (Mehas, 2001), who indicated that iron plays a vital role in red blood cells that carry and release oxygen.

Magnesium indicated significantly higher content, and magnesium helps our body enable protein formation and plays a role in holding calcium content to the teeth as well as helping to release energy. The results of the study indicated that zinc content ranges from 3.79-6.45% according to the different literature, and zinc has many health benefits. This research is in line with research that indicated magnesium helps protein-making and energy release and zinc helps the immune system fight off invading bacteria and viruses (Eshun, 2012).

Conclusion

The results of this study indicated that soybean varieties that were grown in Kelafo and Dolo-Ado centers are promising results. From the key findings of this study, K-Pawa 1, K-Pawa 3, D-Pawa 3, and D-Gezale contained high protein, crude fat, and carbohydrate contents. It is also an inexpressive source of macronutrients, which is good for developing many food products and intervention programs that can alleviate protein energy malnutrition. The fiber content was low but can still be useful for helping our body prevent or release constipation and correcting some of the problems that many people are facing, such as diabetes and obesity. Additionally, the ash content was high in some of the soybean varieties, which indicated that they are important sources of minerals such as magnesium, calcium, zinc, and iron.

Recommendations

According to the results of the study, the authors is suggesting some recommendations about the benefits of the soya bean

- K-Pawa 1, K-Pawa 3, D-Pawa 3, and D-Gezale are highly promotable for developing many food products like weaning foods for infants and solving PEM
- It’s very important for preparing one extra meal for lactating mothers

- Product development with enriching cereals with low protein, fat, and minerals contents

References

Bayero, A., et al. (2019). Proximate composition and the mineral contents of soya beans (Glycine max) available in Kano State, Nigeria. *ChemSearch Journal*, *10*(2), 62-65.

Bourre, J.-M. (2006). Effects of nutrients (in food) on the structure and function of the nervous system: update on dietary requirements for brain. Part 1: micronutrients. *Journal of nutrition health and aging*, *10*(5), 377.

Byth, D. (1968). Comparative photoperiodic responses for several soya bean varieties of tropical and temperate origin. *Australian Journal of Agricultural Research*, *19*(6), 879-890.

Eshun, G. (2012). Nutrient composition and functional properties of bean flours of three soya bean varieties from Ghana. *African Journal of Food Science and Technology*, *3*(8), 176-181.

Etiosa, O. R., et al. (2017). Mineral and proximate composition of soya bean. *Asian Journal of Physical and Chemical Sciences*, *4*(3), 1-6.

Friedman, M., et al. (2001). Nutritional and health benefits of soy proteins. *Journal of Agricultural and Food Chemistry*, *49*(3), 1069-1086.

Joel, N., et al. (2011). Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soya bean flour blends. *African Journal of Food Science*, *5*(8), 466-472.

Liu, K. (1997). Chemistry and nutritional value of soybean components. In *Soybeans* (pp. 25-113). Springer.

Medic, J., et al. (2014). Current knowledge in soybean composition. *Journal of the American oil chemists' society*, *91*(3), 363-384.

Mehas, K. Y. (2001). *Food science: The biochemistry of food and nutrition*. McGraw-Hill Education.

Messina, M. J., et al. (1994). Soy intake and cancer risk: a review of the in vitro and in vivo data. *Nutrition and cancer*, *21*(2), 113-131.

NWOSU, D. J., et al. (2019). Proximate and mineral composition of selected soybean genotypes in Nigeria. *Journal of Plant Development*, *26*, 67.

Sridhar, K., et al. (2007). Agrobotanical, nutritional and bioactive potential of unconventional legume–Mucuna. *Livestock Research for Rural Development*, *19*(9), 126-130.

Wang, T. L., et al. (2003). Can we improve the nutritional quality of legume seeds? *Plant Physiology*, *131*(3), 886-891.

Yohannes, T. G., et al. (2020). Developing and nutritional quality evaluation of complementary diets produced from selected cereals and legumes cultivated in Gondar province, Ethiopia. *Current Research in Nutrition and Food Science Journal*, *8*(1), 291-302.

Proximate and Anti-Nutritional Content of Different Wheat Varieties Produced/Adapted Under SoRPARI and Marketed/Locals in Somali Regional State

Hoodo Mohamed Jama[1], Abdulkarim Mohammed Ali[2], Mohammed Dol Ateye[2].

5. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***hoodoqali042@gmail.com***
6. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***adnanbdu302@gmail.com*** ***Ateye069@gmail.com***

Abstract

Wheat is one of staple crop that is widely consumed by the community. The study was conducted in Somali Regional state with objective to analyze the proximate and anti-nutritional of different wheat varieties adapted in the region. Nine different types of samples such as fantail, jay, nasired, Qunfo, shid, xiryane, Local and control as control sample were collected from Kelafo research sub-center and other areas like Tulli, and Lafa-ise of Fafan Zone. The collected wheat samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, total energy, different minerals like Calcium, Iron, Zinc, Magnesium, and Potassium were determined by AOAC. The anti-nutritional content such as phytate & tannins were also determined by different standard procedure. Based on the result obtained the moisture, ash, crude fiber, protein and fat are in the range of 11.21 (bardheer) -7.71% (fantail), 2.64% (fantail) -0.67% (jay), 2.51%(xiryane) 1.46% (jay), 13.23% (Qunfo) 6.36% (fantail) and 1.10% (local) 1.75% (control) respectively and most of them are statistically different at $P<0.05$. The minerals content is also in the range of 55.77 (fantail) – 35 mg/100g (bardheer), 7.47% (fantail) 3.24 mg/100g (local), 406.8 (fantail) – 204.3mg/100g (Qunfo) and 6.950 (fantail)-2.53mg/100g (local) for calcium, potassium, zinc and iron respectively and more or less they were statistically different at $P<0.05$. Regarding the anti-nutritional content, the tannins and phytate content is in the range of 6.381% fantail and xiryane) 3.481% (control) 0.077% and (xiryane) 0.035% (control) - (xiryane) respectively and statistically different for tannins content at $P<0.05$. Overall, from the finding we conclude that, adapted wheat varieties have better in nutritional content especially, ash and fiber and protein content especially varieties with Qunfo. Varietal difference, agro-ecology, nature of soil, farming management and some other reasons might be the factor for their different in their nutritional content. Wheat is reached in protein, minerals and other important nutrient and therefore, we recommend that, it can be used either alone or mix with those staple legumes as part of fighting against malnutrition and in the preparation of different recipe.

Key words: *Wheat, Varieties, Proximate analysis, Anti-nutritional factors, functional properties.*

INTRODUCTION

Wheat (Triticumaestivum) is one of the world's most important cereal crops produced and consumed around the world [1] Wheat is the grass widely cultivated for its seed a cereal grain which is worldwide staple food. The many species of wheat together make up the genus wheat is grown on more land area than any other food crops largest producer of wheat contributing 3.17 percent of the total world wheat production [2]. It contributes 13.8 percent to the value addition in agriculture grain hardness being the most important.

Wheat quality is dependent upon soil composition and environmental factors including temperature, rainfall, Humidity etc. [3]. Variation in quality parameters like physic-chemical, rheological and functional characteristics of wheat varieties suitable for chapatti making is due to the differences in soil, environmental conditions and agronomic practices [4].

Africa produces more than 25 million tons of wheat on10mha while sub-Sahara Africa (SSA) produce at total of 7.5MT on a total area of 2.9mha accounting for 40 and 1.4 percent of the wheat production in Africa and global level respectively [5]. The wheat which on the account for 95 percent of the wheat production at the global level is also dominant types produce in SSA from 1970 to 2014. The most important wheat producing countries in SSA are; Ethiopia, South Africa, South Sudan, Kenya, Tanzania, Nigeria, Zimbabwe, and Zambia. Ethiopia account for the largest production area (1.7mh) followed by South Africa. Wheat consumption in Africa has been rising faster than in any other region around the world. The population of the Sab-Sahara Africa was 50 percent greater than it had been 14 years prior and the last year Sub-Sahara Africans were consumed one-third more wheat [5].

Wheat (Triticum aestivum L.) is a major crop grown in many countries. It is predominantly used for the production of products, such as bread, pasta, cereals and cakes, which are consumed on a regular basis Thus; wheat has the potential to contribute to the reduction of malnutrition and deficiency-related ailments by contributing to food security and the daily required intake of essential macro- and micro-nutrients in individual. Nutritional quality is a collective term that refers to the bioavailability or concentration of desirable nutritional components for human health such as iron (Fe), zinc (Zn), vitamins and selected phenolic acids found in the wheat grain. These key nutritional components are found in different wheat grain compartments at varying

concentrations [6]. The wheat germ and bran region contain the highest levels of these nutritional components [7].

Micronutrient deficiencies, especially those arising from Fe, Zn and vitamins pose a serious threat to human health as they affect more than 2 billion people worldwide especially women and children under the age of 5 years [8]. Cardiovascular diseases, diabetes, cancer and malnutrition are among the most dreadful diseases. These diseases could be prevented through regular consumption of selected nutritionally important components, such as wholegrain products and antioxidants, which are acquired as phenolic acids from various foods including the wheat grain [9].

Human health through ensuring that the required dietary intake of essential nutrients can reach poor individuals in a more sustainable and cost-effective manner. Bio fortification is a process of enhancing the dietary bioavailability or concentration of desirable nutritional components in plants genetically [10]. This process has been used to successfully improve the bioavailability or levels of β-carotene in rice, Zn and Fe in wheat grain as well as levels of other nutrients in other crops [8]. As a result, a number of strategies have been deployed to improve nutritional quality in wheat, such as conventional, technological and transgenic approaches that were undertaken in efforts to improve the levels and bioavailability of micronutrients and phenolic acids, mainly through the bio fortification route [6]. This includes several efforts that managed to successfully increase the total grain nutrient content and bioavailability of some micronutrients through genetic bio fortification, agronomic bio fortification, the use of bioavailable.

Wheat is a strategic food security commodity in Ethiopia, and its production has effected significant change in the livelihoods of farmers and has well for a large number of people across different areas of the country. In the Somali region, the production of wheat plays an important role in abating the problem of food insecurity in the farming community. Enriching Livelihoods and increasing the quality and nutritional analysis of wheat production in the Somali region is mandatory. Therefore, this is research is aimed at helping by evidence or data on all efforts made on mass production of this strategic crop through analysis nutritional content of different wheat varieties.

METHOD AND MATERIAL

Materials and Equipment Used

Nine sample of wheat including those adapted under s Somali Region were collected. Two wheat varieties produced or adapted under Somali Region was collected from Qalafo center and the other samples from Tulli a & Lafcise and another three wheat samples were purchased from each respective centers/area market as a control for comparison purpose. Only wheat without any physical damage or insect infestation was selected for analysis. All equipment used in sample preparation was obtained from laboratories and missed equipment was used from local institutes further, after bringing to the laboratory, wheat samples was individually ground to a find powder (30 mesh size), packed in air tight polyethylene plastic bags and was stored at 4°C until further analysis

The proximate composition of rice flours was determined using the standard AOAC methods (AOAC, 2000). Gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories (AOAC, 2000). The mineral contents were determined by the procedure of AOAC (2000). All the analysis were performed in duplicate and presented as mean ± standard deviation. Statistical significance of the data obtained were analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using GenStat version 17.0. The level of significance was considered at $P < 0.05$.

RESULT AND DISCUSSION

RESULT

Macronutrient contents of different Wheat varieties

The proximate composition/macro-nutrient contents of different wheat varieties are indicated in table 1 below. The moisture content of K-Fantale was found the lowest 7.71% while the T-Bardheer has the highest moisture content was found 11.21%. The moisture were statistically different among T-bardheer (11.211), T-Qunfo (7.968), T-jay (9.609) at $p<0.05$. The moisture content is also significantly different in between T-Jay (9.609) and k-fantail &t-xiryane respectively at $P<0.05$. On the other hand, there is no significant difference in moisture content

among T-shid (8.370), T-local (8.315) control (8.841), L-Nasired (8.886) Qunfo (7.968)) at P <.0.05.

Ash content of nine varieties under study were in the of range of 0.673 to 2.643. The T- jay" has the lowest while the fantail has highest. The ash content is significant different among the Bardheer (0.948), T- Fantail (k) (2.643), T-jay (0.673) at p<0.05. The Ash is also significantly different in between T-Jay (0.673) and k-fantail & Nasired respectively at P<0.05. On the other hand, the Ash content is not significantly different among Bardheer (0.948) T-local (1.049), control (1.072), Qunfo (1.073) Xiryane (1 2.509)) at P<0.05.

The crude fat content T-Jay has the lowest (1.46 %) while Xiryane varieties has highest (2.51%). The crude fat for all wheat varieties were significantly different at p<0.05. When it comes to protein content, it ranges from 6.36% to 13.23%. Fantail has the lowest in protein while Qunfo has the highest protein and all sample were significantly different at p<0.05. T- local has the lowest (1.10%) the crude fiber content while the control has highest (1.75) and there are no significant different in between most of the varieties. With carbohydrate content K-fantail has the highest in carbohydrate (79.41) while Xiryane has the lowest 73.76. The carbohydrate for all varieties are not significantly different except two varieties which are T-local (76.50) Fantail (k) (79.41), at p<0.05. Finally, when it comes to energy obtained from 100g of wheat varieties it is in the range of 350.47(Xiryane) to 368.8 kcal (Qunfo). There is no significant different in energy in between most of the samples. But the energy is significantly different in between Bardheer (352.58) and Qunfo (368.8) & Jay (352.51) respectively at P<0.05.

Table 1: Macronutrient contents of different wheat varieties.

Varieties	Parameters						
	Moisture %	**Ash %**	**C .fat %**	**C. protein %**	**C. Fiber %**	**CHO %**	**Energy %**
Bardheer	11.21 ±0.0^{d}	0.95±0.10 ^{ab}	1.62±0.01^{bc}	10.55±0.20^{b}	1.72±0.005^{c}	73.95±0.10^{a}	352.58 ±0.5 ^{a}
Fantail(k)	7.71±0.35 ^{a}	2.64±0.30^{c}	2.26±0.02^{f}	6.36±0.14 ^{a}	1.62±0.01 ^{c}	79.41±0.48^{c}	362.34 ±2.7 ^{bc}
Jay (t)	9.61±0.1^{cd}	0.67±0.12 ^{a}	1.46±0.02 ^{a}	12.34±0.5^{e}	1.64±0.005^{c}	74.28±0.18^{a}	352.51±0.08 ^{b}
Nasired	8.89±0.52^{abc}	1.32±0.02 ^{b}	1.80±0.04^{d}	12.41±0.28^{e}	1.38±0.17^{b}	74.20 ± 0.5^{a}	362.64±1.47^{bc}
Qunfo	7.97± 0.55^{b}	1.07±0.03 ^{ab}	1.88±0.03^{e}	13.23±0.1 ^{f}	1.11±0.003^{a}	74.74 ± 0.7^{a}	368.8±2.3^{c}
Shiidit(t)	8.37±1.01^{abc}	1.25±0.100^{b}	2.32±0.03^{g}	11.67±0.257^{d}	1.64±0.018^{c}	74.75±0.83^{a}	365.75±4.3^{bc}
Xiryane	9.79±0.37 ^{cd}	1.27±0.05^{b}	2.51±0.02 ^{h}	11.00±0.07^{bc}	1.67±0.007^{c}	73.76±0.32^{a}	350.47±1.57^{bc}
Local(t)	8.31±0.02^{abc}	1.05±0.05^{ab}	1.67 ±0.04 ^{c}	11.37±0.16^{cd}	1.10±0.028^{a}	76.50 ± 0.8^{b}	360.93±0.25^{bc}
Control	8.84±0.547^{abc}	1.07±0.02 ^{ab}	1.61 ±0.03 ^{b}	11.42±0.175^{cd}	1.75±0.019^{c}	75.31±0.36^{ab}	361.41±2.29^{bc}
CV %	7.7	13.5	1.2	2.3	5.6	0.9	0.8
LSD %	1.567	0.3845	0.05017	0.5879	0.1915	1.588	0.7806

Mineral contents content of different Wheat varieties

The mineral content of the wheat varieties is indicated in table 2 below. Regarding the calcium content, bardheer has the lowest 35.71mg/100g while fantail varieties has highest 55.77mg/100g in calcium content. Except the bardheer and fantail varieties which is significantly different as compared to the other varieties under study, there is no significantly different in calcium content among the other seven varieties at $p<0.05$. When it comes to Iron content, it ranges 3.245mg/100g up for 7.474mg/100g. J-local has the lowest iron while fantail has the highest in iron content and the iron content is statistical different among fantail (7.474), nasired (4.489) and T- local (3.245) at $p<0.05$ On the other hand, the Iron is not significantly different among Bardheer (3.494) control (3.996), Jay (3.491), shid (3.989) Xiryane (3.991) at $P<0.05$. With respect to potassium**,** the "fantail" varieties has the highest (406mg/100g) while the "Qunfo"

sample has the lowest which is 204mg/100g. There is significant difference in potassium content among Fantail, Qunfo, and control varieties at P<0.05. But there is no significant difference in potassium content in between “Nasired”, “Bardheer” and “Jay” varieties at P<0.05.

When it comes to Zinc content, the Jay variety has the highest (6.95mg/100g) while the T-local variety has the lowest (2.53mg/100g). There is significant difference in Zinc content among” Jay”, “Qunfo”, and “local” at P<0.05. On the other hand no significant difference in Zinc content among “Bardheer,” “Fantail”, “Nasired,”” Xiryane” and control varieties at P<0.05. Lastly, regarding magnesium content, fantail has highest (193mg/100g) while the jay has lowest (62.18mg/100g). There is significant difference in magnesium content among “Fantail”, “Bardheer,” “Nasired,” “Qunfo” and” control” at P<0.05. But other is no significant in magnesium among Xiryane, local, and Shiidit at P<0.05.

Table 2: The mineral content of different wheat varieties

Varieties	Parameters minerals in mg/100 gm				
	Calcium	**Iron (Fe)**	**Potassium**	**Magnesium**	**Zinc**
Bardheer	35.71±0.322^{a}	3.494±0.006 ^{ab}	236.5±14.46^{ab}	63.98±0.55 ^{a}	2.979± 0.03 ^{bc}
Fantail(k)	55.77±0.63^{c}	7.474 ± 0.0074^{d}	406.8±41.65^{c}	193.16±2.83 ^{e}	2.933±2.05^{abc}
Jay (t)	45.74 ±0.03 ^{b}	3.491 ± 0.003^{ab}	221.5±0.22^{ab}	62.18± 2.79^{a}	6.958±0.033^{d}
Nasired	45.74 ± 2.30^{b}	4.489±0.044 ^{c}	241.3±0.103^{ab}	104.36±8.57 ^{d}	2.775±0.04^{abc}
Qunfo	45.74±1.29 ^{b}	4.492±0.0056 ^{c}	204.3±12.14 ^{a}	79.24±2.22 ^{b}	3.059±0.16 ^{c}
Shiidit(t)	45.74 0.79 ^{b}	3.989 ±1.414 ^{bc}	256.1±9.71 ^{ab}	87.62±2.020^{bc}	3.096±0.203 ^{c}
Xiryane	45.74 ± 1.70^{b}	3.991±0.0027^{bc}	268.6±2.68 ^{b}	82.06±1.56^{bc}	2.615±0.00 ^{ab}
Local(T)	45.74 ± 0.17^{b}	3.245 ± 0.248 ^{a}	276.3±5.096^{b}	84.02 ±1.56^{bc}	2.536± 0.04 ^{a}
Control	45.74 ±0.55^{b}	3.996 ±2.826 ^{bc}	276.3±2.59 ^{b}	92.20±4.44 ^{c}	2.981± 0.001^{bc}
CV %	1.5	6.1	8.5	5.5	5.2
LSD %	3.045	0.5969	50.31	11.84	0.3886

The Anti-Nutritional Content of different Wheat varieties

The anti-nutritional content of the wheat varieties is indicated in table 3 below. The Phytate of Bardheer and Xiryane was the same and found the lowest 3.481mg/g while the K-Fantail has the highest Phytate content was found 6.381mg/g. There is no significant different among varieties like bardheer, xiryane at $p<0.05$. On the other hand, the Phytate is significantly different among K-Fantail (6.381 %) Nasired (4.40%), Bardheer (3.481%), T- Jay (3.597), Qunfo (3.713) at $P<0.05$. When it comes to Tannin content range 0.0355% up for 0.0775% Xiryane has the lowest Tannin while L- Local has the highest and no significant different among all varieties at $p<0.05$.

Table 3: Anti nutritional of different wheat varieties

Varieties	Parameters	
	Phytate %	**Tannin %**
Bardheer	3.481± 0.002[a]	0.03903 ± 0.01 [a]
Fantail(k)	6.381 ±0.116[c]	0.04754 ± 0.004[a]
Jay (t)	3.597 ±0.116[a]	0.04902 ± 0.01[a]
Nasired	4.409 ±0.464[b]	0.07454 ± 0.01[a]
Qunfo	3.713 ±0.003[a]	0.06704 ± 0.003[a]
Shiidit(t)	3.945 ±0.002[ab]	0.05904 ± 0.01[a]
Xiryane	3.481 ± 0.003 [a]	0.03552 ± 0.023[a]
Local(J)	3.597 ± 0.116[a]	0.04854 ± 0.03[a]
Control	3.713 ± 0.002 [a]	0.07752 ± 0.006[a]
Grand Mean	4.035	0.055
CV %	5.9	30.5
LSD %	0.5393	0.0382

DISCUSSION

The Macronutrient content of different wheat varieties

Table 1 indicates the macro nutrient content of different wheat varieties. Regarding the moisture contents, Bardheer variety which is significantly different as compared to the other varieties under study and there is no significant difference in moisture content among the other varieties $P<0.05$. The highest level of moisture is present in L-Bardheer T- Xiryane and T-Jay with values of (11.21%), - (9.79%) and (9.61%) respectively. Our value is higher than moisture contents of wheat varieties determined 9.67%. (14) which was conducted in Pakistan. The results show that

wheat has a lower amount of moisture content can be stored for a long time and micro-organisms can't grow easily (9.67%) [11].

On the other hand, the ash content of the wheat is significantly higher and ranged between 0.673 - 2.643 which implies that higher ash content the higher important in mineral sources also, the study is in line with study that was conducted in Pakistan [12]. The result indicated that the ash content of 2.16% is indicative that the flour sample could be important sources of minerals.

The fat content is in the range of 1.46 -2.51% as indicated in table 1. The fat content is significantly different among all wheat varieties under study at $P<0.05$. The difference may be due to the fact that being different in variety types, origin of the seed, farm management and some other reasons. The result obtained for fat content is in line with the research done by [12] for the wheat grown in Pakistan. The wheat protein content is ranged from 13.23% - 6.36% % which indicates a higher concentration of protein compounds and these results can be used for solving many malnutrition problems, especially protein-energy malnutrition cases such as marasmus and kwashiorkor.

The fiber content of this study was found between 1.10% and 1.75% of T- Jay and T- Shid respectively. Fiber has many benefits for humans and can prevent constipation as well as can cut the risk of chronic disease such as cancer also this finding agreed with the reported results by [13] and the authors revealed 1.85% of fiber content.

Results of the study indicated significantly higher carbohydrate content of range between 79.41-73.76 percent. These can be promising results that can be used for managing protein energy malnutrition because of higher carbohydrate content the body can manage protein, fat, and mineral substance to use for bodybuilding, repairing damaged tissues rather than using them as a source of energy. This study is in line with the reported results by [14] and he showed that high carbohydrate content ranges between 73.74-71.61percent.

Energy is calculated with standard factors designed for carbohydrate, fat and protein. The energy was calculated in calorie unit and is in the range of 368.8 - to 350. 47. Significance difference was observed in energy content among some of the wheat varieties in this research at $P<0.05$. This difference come as result of being different in macro component (Protein, fat and CHO) which in turn due to being different in variety and some other reasons.

Mineral Content of wheat

The mineral contents of different wheat indicated in table 2. The calcium content in Fantail and Nasired wheat were 55.77and 45.74 mg/100 g, respectively. The results are greater than 36.2mg/100 g and 35.8 mg/100 g of the wheat reported by [12]. These results can be developed for many products like complementary foods for infants and pregnant women because calcium helps to build strong bones and teeth of infants and pregnant women since calcium is one of the main components of teeth and bones. This study is in line with the research result of [12] which indicated that calcium is responsible for teeth and bone formation.

The results indicated the highest iron content (7.47%) and the lowest indicates (3.24%) from Fantail and J- Local respectively. According to the finding a promising results were obtained when compared to study that was conducted by [15] and results shows that the highest (4.45%) and lowest (3.82) from RSP-561 and PBW-396 respectively. K- Fantail indicating a superior result this can be used for better management of Iron deficiency in vulnerable groups like lactating mothers, young children, and adolescent girls also this agreed with [15] which indicates that iron plays a vital role for red blood cells that carry on and release oxygen.

When it comes to potassium, the result indicated the highest potassium content (406.8%) and the lowest (204.3%) from Fantail and Qunfo respectively. According to the finding, the data indicates a promising results compared to study that was conducted by [12] and results shows that the highest (503.4%) and lowest (395%) from Ogolcho and kingbird respectively. K- Fantail indicating a superior result this can be used for better management potassium content helps to maintain body weight and regulate water and electrolyte balance in the blood.

Magnesium indicated significantly higher content and magnesium helps our body for enabling protein formation and plays a role in holding calcium content to the teeth as well as helping to release energy. The results of study indicated that zinc content the range from (6.95%- 2.53%) for jay and J- Local respectively. According to the different literature zinc has many health benefits and this research is in line with research that indicated magnesium helps protein-making and energy releasing and zinc helps the immune system fight off invading bacteria and viruses [12].

CONCLUSION

The study was conducted with aim of analyzing the macro and micronutrient content of the different wheat varieties grown in Somali Region especially Fafan zone. The protein, fat, fiber, moisture carbohydrate content were analyzed in this study. The moisture content is in the range of 7.71-11.21% and this indicated for shelf stability of the wheat while the ash and the fiber of content of wheat under study were too low which is an indicated for its lower minerals content. The protein content of the wheat are in the range of 6.36-13.23% which make more or less better in protein content for same kind of varieties the energy in caloric unit is up the standard as most part of cereals. Generally, wheat with variety name K-fantail and Qunfo is good in almost all parameter such as fat protein carbohydrate ash moisture minerals

RECOMMENDATION

Based on the result of the study on the finding and identified gaps, the following points are recommended;

- Further research should be done by expanding the area coverage and adding more samples from different areas of the region including the control samples.
- Fantail, Qunfo, are highly promotable for developing many food products like bread, flour, past, for people and solved food and nutrition insecurity
- Further study is also required to see the agro-ecology effect on nutritional composition of wheat.

REFERENCES

1. Safdar MN, Khalid N, Muhammad A et al. Physicochemical quality assessment of wheat grown in different regions of Punjab. Pakistan Journal of Agricultural Research 2009; 22: 18-23.
2. Shuaib M, Zeb A, Ali Z et al. Characterization of wheat varieties by seed storageprotein electrophoresis. African journal of Biotechnology 2007; 6.
3. Zeb A, Zahir A, Ahmad T, Abdumanon A. Physiochemical characteristics of wheat varieties growing in the same and different ecological regions of Pakistan. Pak. J. Biol. Sci 2006; 9: 1823-1828.
4. Rahman S, Morell M, Appels R et al. A complex arrangement of genes at a starch branching enzyme I locus in the D-genome donor of wheat. Genome 1997; 40: 465-474.
5. Noorka IR, Rehman S, Haidry JR et al. Effect of water stress on physico-chemical properties of wheat (Triticum aestivum L.). Pak. J. Bot 2009; 41: 2917-2924.

6. Borrill P, Connorton JM, Balk J et al. Biofortification of wheat grain with iron and zinc: integrating novel genomic resources and knowledge from model crops. Frontiers in plant science 2014; 5: 53.
7. Russell B, Guzman C, Mohammadi M. Cultivar, trait and management system selection to improve soft-red winter wheat productivity in the Eastern United States. Frontiers in plant science 2020; 11: 335.
8. Mulualem T. Application of bio-fortification through plant breeding to improve the value of staple crops. Biomedicine and Biotechnology 2015; 3: 11-19.
9. Anderson JW. Whole grains and coronary heart disease: the whole kernel of truth. In. Oxford University Press 2004; 1459-1460.
10. Bouis HE, Welch RM. Biofortification—a sustainable agricultural strategy for reducing micronutrient malnutrition in the global south. Crop science 2010; 50: S-20-S-32.
11. NWOSU DJ, OLUBIYI MR, ALADELE SE et al. Proximate and mineral composition of selected soybean genotypes in Nigeria. Journal of Plant Development 2019; 26: 67.
12. Ikhtiar K, Alam Z. Nutritional composition of Pakistani wheat varieties. Journal of Zhejiang University Science B 2007; 8: 555-559.
13. Bayero A, Datti Y, Abdulhadi M et al. Proximate composition and the mineral contents of soya beans (Glycine max) available in Kano State, Nigeria. ChemSearch Journal 2019; 10: 62-65.
14. Eshun G. Nutrient composition and functional properties of bean flours of three soya bean varieties from Ghana. African Journal of Food Science and Technology 2012; 3: 176-181.
15. Mallick S, Azaz K, Gupta M et al. Characterization of grain nutritional quality in wheat. Indian journal of plant physiology 2013; 18: 183-186.

Proximate and Minerals Content Anaysis of Different Meat Sources in Jigjiga City

Abdulkarim Mohammed Ali[1], Mohammed Dol Ateye[2], Hoodo Mohamed Jama[2],

1. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***adnanbdu302@gmail.com***
2. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***Ateye069@gmail.com*, *hoodoqali042@gmail.com***

Abstract

Meat is a good source of protein and different micronutrient that widely consumed by Somali community. The study was conducted in Jigjiga City Somali Regional state with objective to analyze macronutrient and micronutrient/minerals of different meat sources in different part of the city. Four different types of meat samples from camel, cattle, goat and sheep with total of eight (8) samples were collected from different part of Jigjiga city. The collected meat samples were individually grounded packed in air tight polyethylene plastic bags and were stored at -15°C until further analysis. Proximate composition such as crude Protein, crude Fat, moisture content, different minerals like Calcium, Iron, Zinc, sodium, magnesium and Potassium were determined by AOAC. Based on the result obtained the moisture, ash, protein and fat are in the range of 71.97% (SheMH02) -75.94% (GoaMH), 0.99 %(CamM01) -1.57% (CatM02), 19.12% (CamMH) -23.32% (SheMH02) and 3.01% (GoaMH) -5.25% (CatM01) respectively and most of them are statistically different at P<0.05. The minerals content is also in the range of 18.20 (CatM02) – 33.33mg/100g (CamM01), 15.78 (GoaMSH) – 59.16mg/100g (CamM01), 8.97 (CatM01) – 21.84mg/100g (CamM01), 30.59 (CamM01)-31.40mg/100g (GoaMSH), 660.93 (CamM01) – 992.32mg/100g (SheMH02) and 59.59 (CatM02) – 198.43mg/100g (Ca,M01) for calcium, iron, zinc, magnesium, potassium and sodium respectively and more or less they were statistically different at P<0.05. Overall, from the finding we conclude that, sheep is better in protein content followed by cattle, goat and camel. Species difference, breed difference, livestock management, pre and post slaughter handling practice and some other reasons might be the factors for their different in their nutritional content.

Key words: Meat, camel, cattle, goat, sheep, Nutrition, minerals.

INTRODUCTION

The general increasing human population in the world leads to the movement of people from rural areas to urban. This will increase the demand for food of livestock origin [1]. Human beings consume protein-rich foods to fulfill their nutritional requirements, mainly of animal origin, such as meat (cattle, camel, sheep, goat, poultry, pig, fish, and seafood/shellfish), milk, and eggs [2]. Meat and meat products are most valuable livestock products and sources of high-quality protein due to their amino acid composition. They are also the major source of iron and some vitamins in the B group. So, meat consumption can alleviate several nutritional deficiencies [3].

Consumers often consider meat quality based on organoleptic properties and microbiological quality. However, meat quality can be evaluated in a more unbiased way by evaluating its chemical composition and physical proprieties. Livestock meat applies a crucial role in human nutrition. Besides, it represents an important constituent of a balanced and healthy diet due to its essential components such as amino acids, long-chain n-3 polyunsaturated fatty acids, and microelements, namely, iron, selenium, zinc, and copper different quality traits of red meat are influenced by several factors, that is, genetic, environmental and management factors. meat composition varies from breeds, from animals, and from one muscle to another in the same animal [4].

Meat is the best source of animal proteins, micronutrients, and B-complex vitamins in the human diet. The chemical composition of meat is an important factor determining both its nutritional value and its suitability for processing meat products [5]. The amount of fat in beef is the source of juiciness and marbling which are some of basic parameter that determines the eating qualities of meat.

The chemical composition and physical properties of meat determined the quality of meat (pH, color, water holding capacity, hardness, thermal treatment losses, nutritional value of meat proteins, digestibility, etc.). These characteristics are influenced by animal species, breed, individual characteristics, sex, age, rearing technologies, and fattening, as well as other factors such as meat production procedure (feeding, transporting, and slaughtering condition) and processing (storage time or temperature condition) [6]. Composition, texture of the muscle, and

some biochemical processes that take place during slaughtering, fabricating, and storing carcasses essentially affect tenderness, while the flavor, which is influenced by the fat content, can be manipulated by genetic methods, growth performance control, and dietary supplementation [7].

There are no any studies that were conducted to evaluate nutritional qualities of meat in Somali region and people uses different mythologies to slaughter animals and local traders are selling in different areas and not protecting sunlight, and mostly its open areas, also the hygiene of the meat looks poor. However, the qualities of these meats were not examined or investigated. The minerals composition and profile on the quality of meat and a healthy diet are not well documented. Food security is more critical than food safety among both rural and urban poor [8]. The lack of vigorous surveillance of food pathogens in Somali region meat and meat products presents a challenge for food hygiene trainers, as it becomes difficult to demonstrate the magnitude of contamination with these pathogens. Therefore, the aim of this study was analyze the macro and micro-nutrient content of different meat sources in Jigjiga City.

MATERIALS AND METHOD

Materials and Equipment

Meat samples from different livestock sources were collected from the different establishments in Jigjiga city. The meat sources were camel, cattle, goat and sheep. Two samples were collected from each source of meat which makes the total samples 8. All necessary precaution was taken to ensure hygienic and sanitation during sample collection and on the occasion of storage. Further, after bringing to the laboratory, meat samples were size reduced until it suitable for utility, packed in airtight polyethylene plastic bags and were stored at -15°C until further analysis.

Determination of Proximate Composition

Samples from L. dorsi muscle were thawed for 24 - 48 hours at 4˚C - 8˚C. All exterior muscles, connective tissue and external fat was removed leaving only the Longissimus thoracis muscle. Samples were cubed, submerged in liquid nitrogen for rapid freezing, placed in a blender (VITA-MIX Corp, Cleveland, OH; model # VM0100A) and ground to form beef homogenates. Grinded/powdered samples were double packed in VWR sample bags (BPR-4590 VW1, Radnor,

Pennsylvania) and stored at −40˚C for subsequent analysis [9]. For each parameter approximately 5 g of lean meat was taken from Longissimus dorsi muscle (eye rib area).

Fat content

Soxhlet method of solvent extraction of fat was determined according to AOAC standard procedure [10]. About 2 g milled samples were measured into an extraction thimble lined with fat free cotton. Then the thimbles with the samples were attached to the extraction apparatus. The aluminum cup with a boiling cheap was placed in the oven at 100˚C for 30 minutes and cooled to room temperature in the desiccators for 30 minutes then the cup weight was measured using a digital balance and recorded as W1 (weight of cup), then 50 ml of diethyl ether was added into each cup, after which set up of the extraction apparatus was done.

The samples contained in the thimbles were soaked for about 1 hour by lifting the thimble down into the cup, started from the apparatus hot plate temperature reached 55˚C, after soaking the thimbles will be lifted up and the extraction process takes place for 5 hours. Then the recycling process made by the diethyl-ether was stopped to let the solvent evaporate from the aluminum cup with the extract, in the process the evaporated solvent was recovered in the apparatus. Then aluminum cup and the content were dried in the oven for 30 minutes at 100˚C to evaporate the remaining solvent in the cup. After drying, it was removed from the oven and cooled in the desiccators for 30 minutes then weighed and recorded as W2 (cup + fat).

The percentage of fat will be calculated using the following formula

$$\text{Fat\%} = \frac{(W2-W1)*100}{\text{Sample weight}}$$

Moisture Content

The chemical composition was performed by employing the classical procedures of the Association of Analytical Chemists [11]. For moisture content, the samples were dehydrated in a hot air oven at 125°C until obtaining two successive.

Ash

Ash was determined according to the AOAC standard procedure [10]. Two-gram ground meat sample will be placed into a dried crucible with known weight. The crucible was placed inside a muffle furnace at 150˚C. Temperature will be increased gradually till it reached 600˚C and

heated at that temperature for 3 hrs. Then the crucible will be taken out, cooled into a desiccator and weighed. The ash percentage was calculated as

$$\text{Ash \%} = \frac{\text{(Crucible weight containing incinerated meat- Empty crucible weight) *100}}{\text{Meat sample weight before incineration}}$$

Crude protein

For determination of crude protein Kjeldhal method of AOAC standard procedure [10], Crude protein was obtained by multiplying the amount of nitrogen by 6.25. The sample was weighed in a Kjeldhal flask. Half a tablet of catalyst mixture (10 parts) of K2SO4 to 1 part of CuSO4 was added (10 ml). 25 ml Concentrated H_2SO4 was added. The content of the flask was digested under boiling at maximum heat for 2 hours. The flask was cooled and transferred to the distillation unit. The sample was distilled using 40% NaOH solution and received in 4% Boric acid. The content was titrated against 0.1 M HCl.

$$\text{\%Crude protein} = \frac{\text{(mlHCL for sample-mlHCLfor blank)*0.1*14*100}}{\text{Weight of sample}}$$

Mineral analysis

A total of 5 gm of the well-mixed sample was introduced inside porcelain crucibles, then ashing of the sample by using muffle furnace. The obtained ash was dissolved in 1.5% nitric acid and then completed with distilled water up to 100 ml. The sample was filtrated and the trace elements were determined using a spectrophotometer (Unico-UV-2100 spectrophotometer, USA), and the wavelength was 623, 630, 578, 560, 578, and 630 nm for iron, magnesium, calcium, zinc, potassium, and sodium, respectively [12]

Statistical analysis

All the analysis will be performed in duplicate (unless stated otherwise) and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using Genstat version 18.0. The level of significance will be considered at $P < 0.05$.

RESULT

Macro-nutrient content different meat sources

Table 1: Proximate composition of different Meat sources

Sample Code	Moisture	Ash	C.Protein	C.Fat
CamM01	75.14±0.74^{e}	0.99±0.01^{a}	20.55±0.24^{d}	3.32±0.08^{b}
CamMH	75.37±0.78^{f}	1.5±0.02^{ab}	19.12±0.17^{a}	4.01±0.12^{d}
GoaMH	75.94±0.81^{g}	1.31±0.02^{bc}	19.74±0.21^{b}	3.01±0.05^{a}
GoaMSH	74.97±0.67^{d}	1.42±0.02^{c}	20.06±0.22^{c}	3.55±0.09^{c}
CatM01	73.25±0.54^{c}	1.06±0.03^{c}	20.44±0.24^{d}	5.25±0.15^{f}
CatM02	73.26±0.55^{c}	1.57±0.04^{c}	20.48±0.24^{d}	4.69±0.14^{e}
SheM01	72.91±0.46^{b}	1.4±0.03^{c}	21.74±0.29^{e}	3.95±0.11^{d}
SheMH02	71.97±0.41^{a}	1.57±0.05^{c}	23.32±0.34^{f}	3.14±0.06^{a}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
Cam: Camel, Goa: Goat, Cat: Cattle and She: Sheep

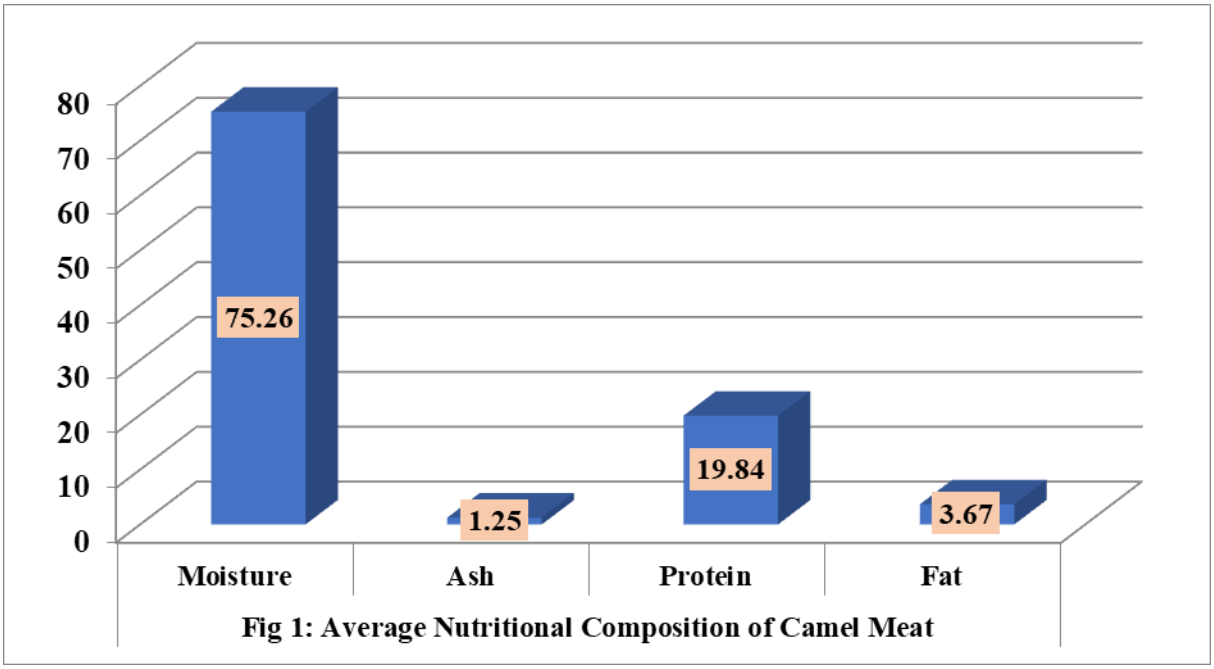


Fig 1: Average Nutritional Composition of Camel Meat

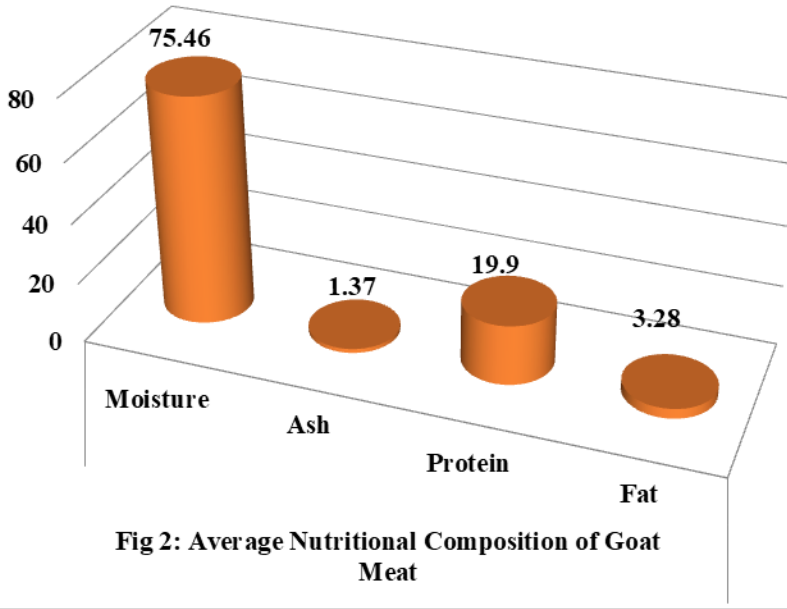


Fig 2: Average Nutritional Composition of Goat Meat

The proximate composition of different meat of camel, cattle, goat and sheep are indicated in table 1. The moisture content is in the range of 71.97% (for SheH02) to 75.94% (for GoaMH). Statistically significant different were observed at $p<0.05$ in moisture content of different meat sources. Significant differences were also observed within same species of meat sources. This is also true for the cattle where there is no difference in moisture content as shown in table 1 above which is 73.25% and 73.26% for Cat01 and Cat02 respectively.

When it comes to ash content, CamM01 has the lowest while CatM02 (0.99) & and SheMH have the highest which 1.57%. CamM01 ash content is significantly different from all others samples such as GoaMH, GoaMSH, CatM01, CatM02, SHeM01 and SheMH02 which were 1.31%, 1.42%, 1.06%, 1.57%, 1.40% and 1.57% respectively. On the other hand, the ash content is not statistically different among GoaMH, GoaMSH, CatM01, CatM02, SHeM01 and SheMH02 which were 1.31%, 1.42%, 1.06%, 1.57%, 1.40% and 1.57% respectively.

CamMH has the lowest in protein content (19.12%) while SheMH02 has the highest in protein content which is 23.32%. Statistically there is no significant different in protein content among CamM01 (20.55%), CatM01 (20.44%) and CatM02 (20.48%). The protein content is significantly different among CamMH, GoaMH, GoaMSH, SheM01 and SheMH02 which are 19.12%, 19.74%, 20.06%, 21.74% and 23.32% respectively. These samples' protein content are

significantly different with that of the above mentioned samples protein content which are CamM01 (20.55%), CatM01 (20.44%) and CatM02 (20.48%).

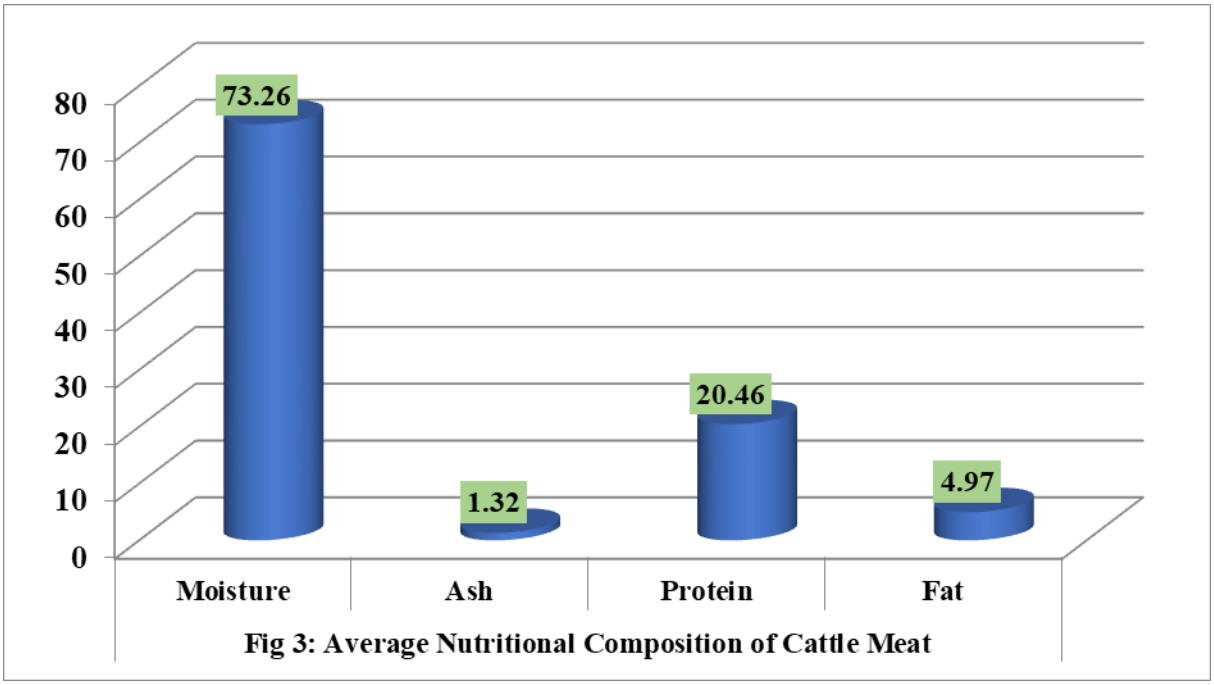


Fig 3: Average Nutritional Composition of Cattle Meat

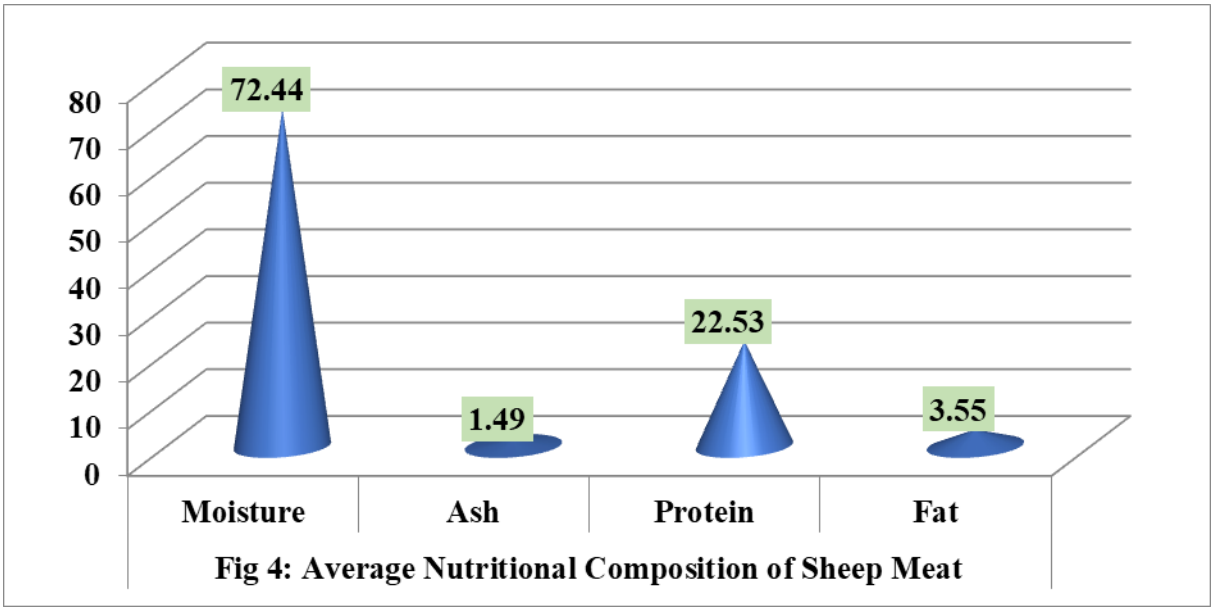


Fig 4: Average Nutritional Composition of Sheep Meat

When it comes of fat content, it is in the range of 3.14% (SheMH02) and 5.25% (CatM01). No significant difference were observed among SheMH02 (3.14%) & GoaMH (3.01%) and also among SheM01 (3.95%) and CamMH (4.01%). The fat content is statistical difference among CamM01, GoaMSH, CatM01, CatM02 which are 3.32%, 3.55%, 5.25% and 4.69% respectively. The average macronutrient composition also indicated in fig 1, 2,3 and 4 for each commodities.

Micro-nutrient content different meat sources

Table 2. Mineral's content of different Meat Sources

Sample Code	Result in (mg/100g)					
	Calcium (Ca)	Iron (Fe)	Zinc (Zn)	Magnesium (Mg)	Potassium (K)	Sodium (Na)
CamM01	33.33±0.32^{f}	59.16±0.55^{e}	21.84±0.21^{e}	30.59±0.32^{a}	660.93±0.69^{a}	198.43±0.98^{c}
CamMH	21.20±0.21^{c}	42.73±0.42^{d}	15.56±0.15^{d}	30.83±0.26^{d}	818.75±0.81^{cd}	72.78±0.74^{a}
GoaMH	22.20±0.22^{c}	16.98±0.14^{a}	13.84±0.13^{c}	31.16±0.29^{b}	703.07±0.71^{ab}	77.86±0.77^{a}
GoaMSH	23.80±0.28^{d}	15.78±0.12^{a}	14.98±0.34^{d}	31.40±0.30^{cd}	777.44±0.79^{bc}	80.99±0.81^{ab}
CatM01	25.23±0.25^{e}	18.96±0.18^{ab}	8.97±0.09^{a}	31.13±0.28^{b}	756.54±0.76^{bc}	76.12±0.76^{a}
CatM02	18.20±0.18^{a}	22.46±0.22^{b}	11.33±0.11^{b}	31.35±0.30^{bc}	900.61±0.91^{d}	59.59±0.61^{a}
SheM01	19.40±0.15^{bc}	16.45±0.13^{a}	11.86±0.12^{b}	31.23±0.31^{bc}	850.69±0.86^{cd}	95.88±0.93^{ab}
SheMH02	17.37±0.17^{ab}	34.40±0.32^{c}	12.84±0.32^{b}	31.20±0.27^{bc}	992.32±1.99^{e}	112.49±0.99^{b}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
Cam: Camel, Goa: Goat, Cat: Cattle and She: Sheep

Tables 2 indicate the minerals content different meat sources. Six different minerals were considered in this study. CatM02 has the lowest in calcium content while CamM01 has the highest in calcium content. There is no significant difference in the calcium content among CamMH, GoaMH and SheM01 which are 21.20mg/100g, 22.20mg/100g and 19.40mg/100g respectively at $P>0.05$. The same true when it comes to the calcium content for CatM02 and SheMH02 which are 18.20mg/100g and 17.37mg/100g respectively. Statistically significant

difference were observed among CamM01, GoaMSH, CatM01 at P<0.05 which are also true with the above mentioned samples calcium content.

Iron is also the 2nd minerals considered in this study. No significant differences were observed among SheM01 (16.45mg/100g), GoaMSH (15.78mg/100g), GoaMH (16.98mg/1006) and CatM01 (18.96mg/100g) at P>0.05. Statistically significant difference were observed among meat samples of SheMH02, CamMH and CamM01 which are 34.40mg/100g, 42.73mg/100g and 59.16mg/100g respectively which are also significantly different from the above mentioned samples at P<0.05.

The zinc content of different meat samples are indicated in the table 2 above. It is in the range of 21.84mg/100g for CamM01 and 8.97mg/100g for CatM01. No significant difference were observed for the samples SheMH02 (12.84mg/100g), SheM01 (11.86mg/100g) and CatM02 (11.33mg/100g) at P>0.05. The same is true for samples GoaMSH and CamMH which are 14.98mg/100g and 15.56mg/100g respectively at P>0.05. But statistically significant difference were observed in meat samples CatM01, GoaMH and CamM01 which are 8.97mg/100g, 13.84mg/100g and 21.84mg/100g respectively at P<0.05 which are also significantly different with the above mention meat samples.

CamM01 has the lowest in magnesium content (30.59mg/100g) while CamMH has the highest in magnesium content (30.83mg/100g) as shown in table above. Except these samples of the same species, no significant difference were observed among all samples when it comes to magnesium contents of the different meat samples at P>0.05.

When it comes to potassium content, it is in the range of 992.32mg/100g for SheMH02 and 660.93mg/100g as shown in table 4.2. No significant difference were observed among CatM01, GoaMSH, GoaMH and SheM01 which are 756.54mg/100g, 777.44mg/100g, 703.07mg/100g and 850.69mg/100g respectively at P>0.05. The same is true for meat samples SheM01 and CamMH which are 850.69mg/100g and 818.75mg/100g respectively at P>0.05. But statistically significant difference were observed among CamM01, CatM02 and SheMH02 which are 660.93mg/100g, 900.61mg/100g and 992.32mg/100g respectively at P<0.05.

Lastly, the sodium content of different meat samples was indicated in table 2. The sodium content of different samples are in the range of 59.59mg/100g (CatM02) to 198.43mg/100g (CamM01).Statistically, significant difference were observed among CamM01 samples which

are 198.43mg/100g with the rests of the other meat samples in one way other at P<0.05. But, significant difference were observed among CamMH, GoaMH, CatM01, CatM02, GoaMSH, SheM01 and SheMH02 which are 72.78mg/100g, 77.78mg/100g, 76.12mg/100g, 59.59mg/100g, 80.99mg/100g, 95.88mg/100g and 112.49mg/100gm respectively at P>0.05.

DISCUSSION

Macronutrients

The amount of ash, crude fat (CF) and crude protein (CP) were significantly different between breeds. Similarly, a study had reported the presence of significant difference in protein, fat, ash and moisture content of beef across the breeds [13].The moisture content of the different meat sources are in the range of 71.97-75.94% as shown in table 1. The difference in moisture content might be due to species difference, breed difference, handling practice before and after slaughter and some other reasons. The moisture content obtained in agreement with Ante Kasap, et.al. [14]. This result is also in agreement with a Spanish study on three lamb genotypes [15] where breed did not show a significant effect on dry matter ($p > 0.05$). Our results were higher than those reported by Liu et al. [16] and Berrighi et al. [17], respectively, for Chinese (23–25%) and Algeria lambs (18%).

The protein content of different meat sources are in the range of 19.12%-23.32% as indicated in table 1. The result obtained for protein analysis is comparable with study done on cattle breed based on their age in Ethiopia [18].The result of the present study in respect to CP implied that sheep are better for red meat production as the percentage protein decreased with advance in age. The obtained results were comparable to those reported by Addis et al. [19] for Agnello di Sardegna lambs, while they were lower than those reported by Liu et al. [16][25] for Oula lambs. The difference in crude protein content among these meat samples is due to species difference, breed difference, management of those species before slaughter, handling practice after slaughter and some other reasons.

The fat content of different meat sources are from 3.14 to 5.25% as shown in table 1. The result obtained for fat analysis is lower than with study done on cattle breed based on their age in Ethiopia [18] but higher than the study done by [14]. The CF content of beef of all the breeds under the study can

be considered as a good contributor to palatability of the beef as minimum of 3% fat is suggested to ensure acceptable palatability of beef [20]

Micronutrient

After protein and fat, meat is an essential source of several other nutrients, such as minerals [21]. It is defined as poor food in calcium and rich in potassium (K), phosphorus (P), iron (Fe), sodium (Na), and zinc (Zn) [22]. Its consumption can respond qualitatively or quantitatively to the human needs for mineral elements. Fe and Zn were most abundant microelements which much higher than the result obtained by some other research [14, 23]. The Zn content is the range of 8.97-21.84mg/100g as indicated in table 4.2. Meat is a major source of total iron (Fe) and heme iron [24] and thus might help reduce major public health problem worldwide [22]. The iron content depends on the breed, muscle, and animal's age [25][24]. Under this study, the iron content of the meat is in the range of 16.45 to 59.16mg/100g.

When it comes to other minerals, Potassium is the most abundant one followed by sodium, magnesium and calcium. The potassium content is in the range of 660.93-992.32mg/100g. The obtained results were higher than those reported by Osorio et al. [26] in suckling lambs of Churra breed and by Polidori et al. [27] for Fabrianese breed meat. In comparison with the literature, the tested meats presented a high content of major mineral elements [14, 26, 27]. The natural feeding condition-based pasture in phosphocalcic soils rich in phosphorus, sodium, magnesium, and calcium could explain the high levels recorded in the studied meats [28]. The magnesium and calcium contents of the meat sources are in the range of 30.59 to 31.40mg/100g and 18.20 to 33.33mg/100g respectively. The result might be influenced by bread type, nature of pasture livestock used, handling management of the livestock and some other reasons. In general, all meat types have good sources of both micro-minerals and macro minerals.

CONCLUSION

Eight different samples of meat were used for this study. The meats were collected from camel, cattle, goat and sheep from different place in Jigjiga city. Based on the laboratory analysis, the moisture content is in the range 71.97-75.94% which makes sheet meat to be lowest in moisture content while camel to be the highest averagely. Meat from camel has lowest in protein content (19.12%) while meat from sheep has highest in protein content (23.32%). When it comes to fat content, meat from cattle has highest in fat content (5.25%) while meat from goat has lowest in

fat content which is 3.01%. six types of minerals were considered in this study. All meat sources are highest in minerals content. Based on their order, potassium, sodium, magnesium, calcium, iron and zinc considered to be from highest to lowest level.

RECOMMENDATIONS

Based on the data available and identified gaps, the following recommendations are forwarded;

1. Further research should be done for some missed parameters such as type of fatty acid or fatty acid characterization.
2. Special research should be done under control condition to further analyze the effect of different factors on meat nutritional quality.
3. Research should also be done on the effect of post slaughter process/factors on meat nutritional quality.

REFERENCES

1. Catches F. FAO STATISTICS.
2. Lozano MC, Trujillo M. Chemical residues in animal food products: an issue of public health. Public Health–Methodology, Environmental and Systems Issues 2012.
3. T Kadim I. Chemical Contaminates of Meat and Meat Products which Threaten Human Health. 2016.
4. Sadaka C. Composition chimique et intérêt nutritionnel de la viande de bœufa partir de l'analyse des données INRA 2007 pour le Centre d'Informations des Viandes, in Sciences et techniques du vivant. Conservatoire national des arts et metiers 2011; 179.
5. Litwińczuk Z, Domaradzki P. Chemical composition, fatty acid profile, including health indices of intramuscular fat, and technological suitability of the meat of young bulls of three breeds included in a genetic resources conservation programme fattened within a low-input system. Animal Science Papers & Reports 2016; 34.
6. Liu M, Wei Y, Li X et al. Quantitative phosphoproteomic analysis of caprine muscle with high and low meat quality. Meat Science 2018; 141: 103-111.
7. Thu DTN. Meat quality: understanding of meat tenderness and influence of fat content on meat flavor. VNUHCM Journal of Science and Technology Development 2006; 9: 65-70.
8. Vipham JL, Amenu K, Alonso S et al. No food security without food safety: lessons from livestock related research. Global Food Security 2020; 26: 100382.
9. Horwitz W. Official methods of analysis of AOAC International. Volume I, agricultural chemicals, contaminants, drugs/edited by William Horwitz. Gaithersburg (Maryland): AOAC International, 1997. 2010.
10. International A. Official methods of analysis of the Association of Official Analytical Chemists. Association of official analytical chemists 1970.
11. Maky MA, Sadek M, Shanab O et al. Nutritional characterization of various classes of Egyptian beef luncheon. Journal of advanced veterinary and animal research 2020; 7: 299.
12. Andrade Korn MDG, da Boa Morte ES, Batista dos Santos DCM et al. Sample preparation for the determination of metals in food samples using spectroanalytical methods—a review. Applied Spectroscopy Reviews 2008; 43: 67-92.

13. Bures D, Barton L, Zahrádková R et al. Chemical composition, sensory characteristics, and fatty acid profile of muscle from Aberdeen Angus, Charolais, Simmental, and Hereford bulls. Czech Journal of Animal Science 2006; 51: 279.
14. Kasap A, Kaić A, Širić I et al. Proximate and mineral composition of M. longissimus thoracis et lumborum of suckling lambs from three Croatian indigenous breeds reared in outdoor conditions. Italian Journal of Animal Science 2018; 17: 274-278.
15. Hwang Y-H, Joo S-T. Fatty acid profiles, meat quality, and sensory palatability of grain-fed and grass-fed beef from Hanwoo, American, and Australian crossbred cattle. Korean journal for food science of animal resources 2017; 37: 153.
16. Liu J-b, Guo J, Wang F et al. Carcass and meat quality characteristics of Oula lambs in China. Small Ruminant Research 2015; 123: 251-259.
17. Berrighi N, Belkacemi L, Bouderoua K et al. Fatty acids composition and sensory properties of lamb meat fed on steppe and highland pastures. Asian Journal of Animal Sciences 2017; 11: 88-95.
18. Dagne T, Mummed YY, Kurtu MY et al. Proximate Composition and Fatty Acid Profile of Beef from Arsi, Borana and Harar Cattle Breeds in Oromia National Regional State, Ethiopia. Open Journal of Animal Sciences 2021; 11: 139.
19. Tansawat R, Maughan CA, Ward RE et al. Chemical characterisation of pasture-and grain-fed beef related to meat quality and flavour attributes. International journal of food science & technology 2013; 48: 484-495.
20. Savell J, Cross H. The role of fat in the palatability of beef, pork, and lamb. Designing foods: Animal product options in the marketplace 1988; 345.
21. Ramos A, Cabrera M, Saadoun A. Bioaccessibility of Se, Cu, Zn, Mn and Fe, and heme iron content in unaged and aged meat of Hereford and Braford steers fed pasture. Meat Science 2012; 91: 116-124.
22. Cabrera M, Saadoun A. An overview of the nutritional value of beef and lamb meat from South America. Meat science 2014; 98: 435-444.
23. Belhaj K, Mansouri F, Sindic M et al. Proximate composition, amino acid profile, and mineral content of four sheep meats reared extensively in Morocco: A comparative study. The Scientific World Journal 2021; 2021.
24. Cabrera M, Ramos A, Saadoun A. Selenium, zinc, copper and manganese in fresh Angus steers meat from pastures to concentrated-based feeding systems in Uruguay. Annals of Nutrition & Metabolism 2013; 63: 1528.
25. Martínez-Cerezo S, Sañudo C, Panea B et al. Breed, slaughter weight and ageing time effects on physico-chemical characteristics of lamb meat. Meat Science 2005; 69: 325-333.
26. Osorio MT, Zumalacárregui JM, Bermejo B et al. Effect of ewe's milk versus milk-replacer rearing on mineral composition of suckling lamb meat and liver. Small Ruminant Research 2007; 68: 296-302.
27. Polidori P, Pucciarelli S, Cammertoni N et al. The effects of slaughter age on carcass and meat quality of Fabrianese lambs. Small Ruminant Research 2017; 155: 12-15.
28. Ruellan A. Les sols a profil calcaire différencié des plaines de la basse Moulouya-Maroc Oriental-. Contrib. a la connaissance des sols des Régions Méditerranéennes. ORSTOM 1971.

Evaluation of proximate composition and mineral contents of Sorghum Blended with Peanut

Mahammed Dol[1], Abdulkarim Mohammed[2], Hodo Mohamed[2]

1. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***Ateye069@gmail.com***
2. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***adnanbdu302@gmail.com*, *hoodoqali042@gmail.com***

P.O.Box 398, Jigjiga, Ethiopia

ABSTRACT

Improving the nutritional status of infants requires the optimum use of available food. The objective of this study was to develop a Product and Evaluate its Proximate Composition and mineral contents of Sorghum Blended with Peanut (SBP) For Nutritional Improvement of Sorghum Foods. Seven formulations of composites flours composed of 100% of sorghum flour and 0% of peanut flour, 92.5% of sorghum flour and 7.5% of peanut flour, 85% of sorghum flour and 15% of peanut flour, 77.5% of sorghum flour and 22.5% of peanut flour, and 70% of sorghum flour and 30% of peanut flour were produced. The technological properties and the nutritional characteristics of the composite flours were determined using AOAC methods. The moisture content of the SBP sample flour ranged between 5.34 to 6.35%. Also, the mixture proportion of 70 grams of sorghum and 30 grams of peanut had the highest moisture contents compared to the other ratios of the mixture and these results indicated that increasing the peanut ratio increases the moisture content of the sample flours of the mixtures. From the crude protein content of the SBP samples ranged between 12.53 to 17.38% of protein concentration. the highest protein (17.38%) content was observed from the ratio of 70 grams of sorghum and 30 grams of peanut flour which is assumed to be promising potential as a good source of plant protein. The crude fat content of sorghum and peanut flour recorded in this study was found in between the values of 4.40-15.61%. The total carbohydrate content ranged from 54.08% to 75.33% for all the formulations. According to the finding of the study sorghum with zero peanut ration indicated the highest carbohydrate contents and the lowest carbohydrate contents was seen with a peanut ration of 30 grams. The total energy content of SBP sample flours varied from 388.86% to 423.80 kcal/100g. Finally the result of this study indicates that it can be used as complementary food according daily energy requirements of infants aged between 06-12 months of ages.

Keywords: *SBP product, Proximate composition, complementary food, sorghum, Peanut.*

INTRODUCTION

Food crops have continued to be an important source of human nutrition as they are the major sources of nutrients, proteins, and calories for populations, especially in developing nations. Sorghum (Sorghum bicolor) is one of the oldest known cereal grains and ranked fifth in the world after wheat, rice, maize, and barley in terms of production (Espitia-Hernández et al., 2022). Sorghum (Sorghum bicolor L.) as a potential source of bioactive substances and their biological Critical Reviews in Food Science and Nutrition. It constitutes the main food grain for over 750 million people who live in the semi-arid tropics of Africa, Asia, and Latin America. The largest group of producers is small-scale subsistence farmers with minimal access to

production inputs such as fertilizers, pesticides, improved seeds (hybrids or varieties), good soil and water, and improved credit facilities for their production (Jiru & Usmane, 2021). The most important producers are the United States, Nigeria, Sudan, Mexico, China, India, Ethiopia, Argentina, Burkina Faso, Brazil, and Australia. Burkina Faso is the world leader in sorghum production and consumption per inhabitant (Dicko et al., 2006).

This crop sustains the lives of the poorest, rural people. Availability, storage, utilization, and consumption of their food crop will significantly contribute to household food security and nutrition of the inhabitants of this area. Sorghum while playing a crucial role in food security in Africa, it's also a source of income for households (Tadele, 2019). Sorghums are rich sources of micronutrients (minerals and vitamins) and macronutrients (carbohydrates, proteins, and fat). Sorghum-based foods have continued to be nutritionally deficient and organoleptically inferior. Also, Sorghum has health benefits such as inhibiting cancer tumor growth, protecting against diabetes and insulin resistance, being safe for people with celiac disease, and helping manage cholesterol, antioxidants in sorghum are high relative to other grains, and fruits, and also sorghum may help treat human melanoma.

Peanut (Arachis hypogeae L), is an important energy-dense source of plant protein usually consumed after roasting and typically processed into different forms such as peanut butter, sweets, chocolate, cakes, and other peanut butter and jam sandwiches are very popular with raw roasted, shelled or unshelled corms of peanut being available throughout the year (Singh et al., 2021). Peanut (Khalid et al., 2022), also known as groundnut, is one of the most important sources of vegetable oil and protein. Peanuts are believed to have originated in the Central American region where they spread to other parts of the world.

Peanuts are often enriched with health-benefiting nutrients that are essential to human health. They are actually legumes but are the most frequently eaten nut and more than 300 different varieties of peanut are grown worldwide (Sobowale et al., 2019). In Ethiopia Sorghum is processed at a household level using traditional means, such as small grain mills. So, to improve the nutritional quality of cereal-based traditional diets in Ethiopia, the use of peanut flour as a protein supplement has often been suggestible. For that reason, sorghum, and peanut could be exploited since they are easy to access in the region. Therefore, the aim of this study was the influence of different composites of sorghum and peanut flour on proximate composition and

functional characteristics, after which the composites were developed into sorghum blended with peanut flour and their sensory characteristics were evaluated.

MATERIALS AND METHOD

Raw Materials and sample preparation, Blending Ratio based complementary food

The experimental materials were obtained from the local market in Jigjiga city. About 5kg of the samples sorghum grains and peanuts were collected. The preparation of sorghum flour was done according to the method developed by (Almeida-Dominguez et al., 1993) and The preparation of peanut flour was done according to the method developed by (Arab et al., 2010). Sorghum grains were cleaned, and sorted, small, broken and immature grains, dust, sand, stones, and other foreign materials were removed. The cleaned sorghum was washed with tape water and milled by a portable hand machine after that it was packed in airtight polythene plastic bags and stored at room temperature in a dry place.

This study was carried out to find the appropriate ratio of sorghum, and peanut in composite flours for complementary foods. D-optimal mixture design with a total formulation of seven , which was obtained by inserting a range of sorghum 70-100g, and 0-30g was used to set up the experiment.

Proximate Composition Analysis

The proximate composition (Protein, fat, fiber, moisture content, ash and moisture content) of sorghum and peanut flour and their mix flours was determined using the standard AOAC methods (AOAC, 2000). Gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories (AOAC, 2000). The mineral contents were determined by the procedure of AOAC (2000). All the analysis were performed in duplicate and presented as mean ± standard deviation.

Data analysis and Optimization

All the analyses were performed in duplicates (unless stated otherwise) and presented as mean. The statistical significance of the data obtained will be analyzed and modeled using Design Expert ® version 13. The level of significance was accepted at probability ($p \leq 0.01$ and $p \leq 0.05$).

RESULTS AND DISCUSSION

Proximate composition and energy content of SBP flour

Table 1 indicates the proximate composition of porridge flour from the local ingredients of sorghum and peanut. The results of the chemical composition analysis of the raw materials of sorghum and peanut were presented in Table 1. Components other than moisture contents are expressed on a dry basis. There was a significant ($P<0.01$) difference between the difference in the values of moisture, protein, fat, ash, fiber, carbohydrate and energy contents.

Table 1. Proximate composition of SBP flour samples

Std	Run	Block	SBP		Proximate composition						
			A:	B:							
			Sorghum (g)	Peanut (g)	M.C (%)	C.P (%)	C.fat (%)	C.Fib (%)	Ash (%)	CHO (%)	Energy (kcal/100g)
7	1	Block 1	70	30	6.35	17.38	14.60	3.61	3.98	54.08	417.27
3	4	Block 1	85	15	5.75	14.70	10.52	2.84	1.98	64.21	410.32
6	3	Block 1	100	0	5.34	12.53	4.40	1.05	1.34	75.33	391.09
2	2	Block 1	70	30	6.23	16.46	15.61	3.53	3.8	54.37	423.80
5	5	Block 1	77.5	22.5	6.09	15.65	12.50	2.97	2.61	60.17	415.83
1	6	Block 1	100	0	5.41	12.43	4.42	1.59	1.32	74.83	388.86
4	7	Block 1	92.5	7.5	5.67	13.66	7.71	2.73	1.45	68.78	399.14

SBP= Sorghum Blended peanut, A= Sorghum, B= Peanut, MC=Moisture Content, CP=Crude Protein, C.Fib= Crude fiber, CHO=Carbohydrate, kcal=kilo calorie.

Moisture content

As indicated in Table 1, the finding of the study from the mixture proportion of the sorghum and peanut flour have strong linear significance at a 1% probability level or ($P\leq 0.01$) on the moisture content of SBP flour. The moisture content of the SBP sample flour ranged between 5.34 to 6.35%. Also, the mixture proportion of 70 grams of sorghum and 30 grams of peanut had the highest moisture contents compared to the other ratios of the mixture and these results indicated that increasing the peanut ratio increases the moisture content of the sample flours of the mixtures. According to the FAO/WHO recommendation on the safety limit of the microbial prevention of soft products like porridge, the results of this study indicate that the SBP product has a desirable moisture content of 6.35% the highest compared to the FAO/WHO recommended safe limit below (<10%). High moisture content in foods has been shown to encourage microbial growth (Temple et al., 1996). This is an important consideration in local feeding methods in developing countries because most mothers often prepare large quantities of dry infant foods and

keep them in containers, to avoid frequent processing to have spare time and energy for other domestic activities (Makinde & Lapido, 2012). The regression model for moisture was shown by (Eq. 20) indicating in quadratic model with two variables

$$Y = 5.39_{x_1} + 6.29_{x_2} - 0.05_{x_1x_2} \ldots\ldots\ldots\

$$Y = 12.50_{x_1} + 16.89_{x_2} - 0.11_{x_1x_2} \ldots\ldots\ldots\

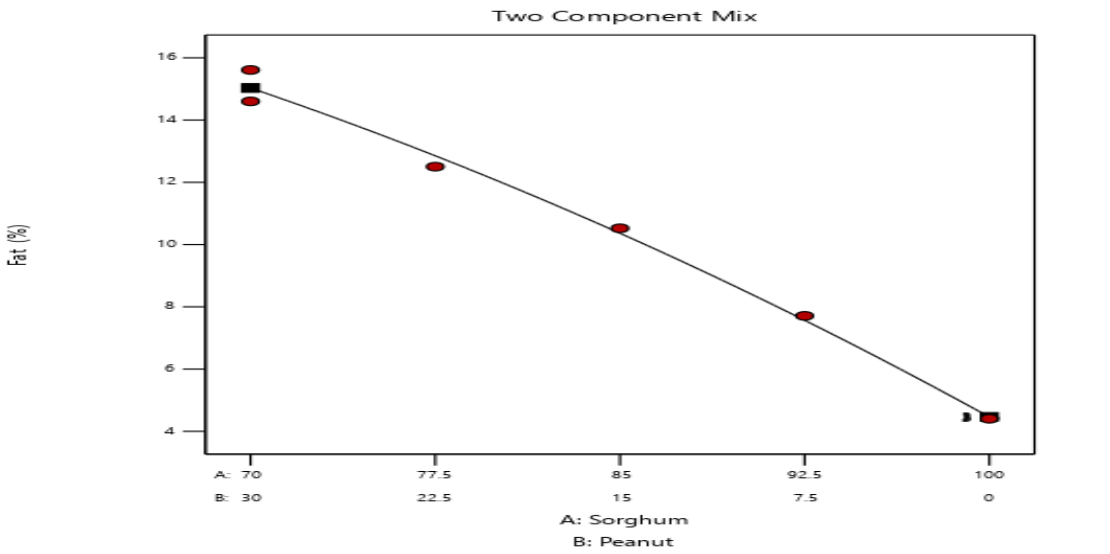


Figure 3. The contour line shows the Fat content while the black points show the treatment formulations of the SBP flour

Crude fiber contents

Table 1 shows that the linear mixture of sorghum and peanut flour has a strong linear significance (P≤ 0.01) effect on the crude fiber content of the SBP sample flours. The fiber content of SBP samples from seven different formulations varied between 1.05 to 3.61%. There was a statistically significant difference (P≤0.01) between different composite SBP sample flours. The higher fiber content was observed in SBP samples prepared from 70 grams of sorghum and 30 grams of peanut flour. The results also indicated that the fiber contents of the SBP samples showed an increasing trend with a parallel increase in the proportion of the peanut flours. This result was in agreement with the finding (Teshome, 2014), The fiber content ranged between (1.31-2.29%),(1.28-2. 18%) and (2.28 %) for sorghum peanut, sorghum-soya bean and the control samples respectively.

The acceptable fiber content of weaning foods should not exceed 5% according to the Protein Advisory Group Recommendations (1972). When the fiber content is high it decreases the digestibility of the particular food. The crude fiber contents of the sorghum-peanut were within an acceptable range. The amount of fiber content was shown in the mixture contour graph (Figure 8) and the regression model for crude fat was shown (Eq. 23) indicating a quadratic model with two variables.

$$Y = 1.42_{x_1} + 3.48_{x_2} + 1.87_{x_1x_2} \ldots\ldots\ldots\

Where Y= Crude fiber content, X_1= Sorghum, X_2=Peanut, X_1X_2=Sorghum and Peanut

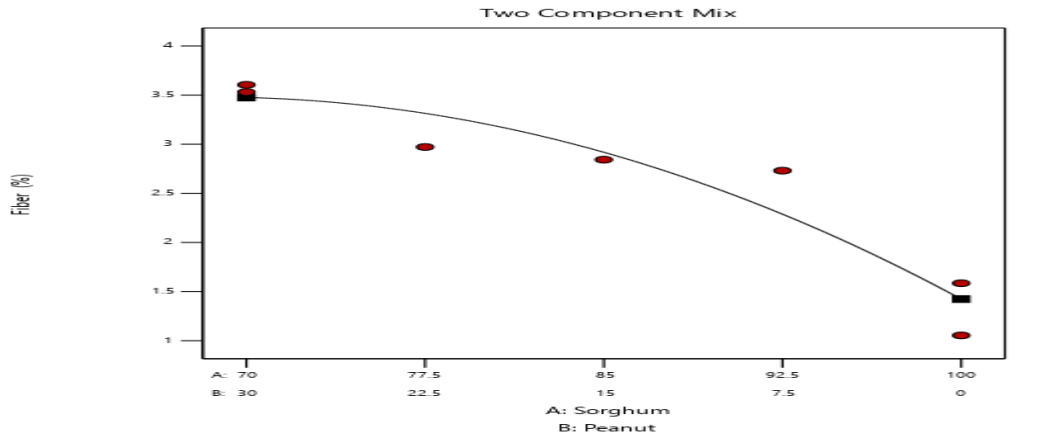


Figure 4. The contour line shows the fiber content while the black points show the treatment formulations of the SBP flour.

Total ash contents

Table 1 shows that the linear mixture of sorghum and peanut flour has a strong linear significance ($P \leq 0.01$) effect on the total ash content of the SBP sample flours. The ash contents result of the SBP blends of sorghum-peanut samples shown in (Table 1) were ranged between 1.32 to 3.98%. This result agrees with the study report by (Teshome, 2014), The ash contents result of the porridge blends from sorghum-peanut, sorghum-soya bean and the control samples ranged between(1.33- 1.91%), (1.87-3. 19%) and (1.10%) respectively.

$$Y = 1.42_{x_1} + 3.48_{x_2} + 1.87_{x_1x_2} \ldots\ldots\ldots\

The acceptable ash content of weaning foods given by the Protein Advisory Group recommendations (1972) should not exceed 5%. The result of sorghum ash content was similar to the report by(Makinde & Lapido, 2012) in their study of the physicochemical properties of sorghum-based complementary food. Formulated foods studied in the current study were within this limit as well (Munasinghe et al., 2013). The highest value of ash content recorded indicates that SBP flour has a good potential to prepare a CF that supports the mineral requirement of the infants' complementary feeding period. The regression model for crude fat content was shown by (Eq. 24) indicating in quadratic model with two variables.

Total Carbohydrate content

As shown in Table 1 the linear terms of the mixture from the sorghum and peanut flour have a strong significance (P≤0.01)on the total carbohydrate content. The total carbohydrate content ranged from 54.08% to 75.33% for all the formulations. According to the finding of the study sorghum with zero peanut ration indicated with the highest carbohydrate contents and the lowest carbohydrate contents was seen with a peanut ration of 30 grams. As the number of peanuts in the formulation increased, the carbohydrate content of the raw blends reduced significantly ($p<0.05$ due to the peanut's lower carbohydrate content. This decrease in the lower total carbohydrate content could be attributed to the lower carbohydrate content in peanut flour. This study is also in line with the study reported by (Teshome, 2014), the total carbohydrate content decreases due to the lower content of carbohydrates in peanuts and soybean. According to the protein advisory group (1972), sorghum was used as the main carbohydrate supplier which help to maintain 65% of the carbohydrate contents. The regression model for crude fat content was shown by (Eq. 25) indicating in quadratic model with two variables.

$$Y = 74.89_{x_1} + 54.44_{x_2} - 1.38_{x_1x_2} \ldots\ldots\ldots\

Figure 6. The contour line shows the total carbohydrate content while the black points show the treatment formulations of the SBP flour.

As indicated in figure 10, the curve of the graph shows that the carbohydrate content increases the as the peanut ratio decreases. The carbohydrate content of sorghum flour obtained in this study was comparable with the reported 74.68% (Mohammed et al., 2011). While lower than the value of 76.94 % reported by (Shimelis & Rakshit, 2005). This variation may be due to the germination time and variety of different experimental conditions respectively.

Total Energy content

As indicated in Table 1, the linear model of the mixture from the sorghum and peanut flour has a strong significance ($P \leq 0.01$) on the gross energy content. The total energy content of sorghum flour and peanut flour was shown in. The total energy content of SBP sample flours varied from 388.86% to 423.80 kcal/100g. The higher total energy content was observed in the SBP sample prepared from a formula sorghum 70 grams, and peanut 30 grams and the lower energy content was observed in the SBP sample prepared from a formula sorghum 100 grams. As a result, this result suggested that the high protein and fat content of peanuts may be responsible for the SBP samples' high-calorie content when they are made using a large amount of peanut flour. The study on complementary food characteristics found that the high-fat content of legumes and oil crop flour further boosted the energy density of the products prepared from various formulas (Onabanjo et al., 2009). The regression model for total energy content was shown by (Eq.26) as indicated in the quadratic model with two variables.

$$Y = 389.73_{x_1} + 420.60_{x_2} + 16.27_{x_1x_2} \ldots\ldots\ldots\

Figure 7. The contour line shows the total energy content while the black points show the treatment formulations of the SBP flour.

The current total energy requirement estimated for healthy breastfed infants is of approximately 615 kcal/day from 6 to 8 months of life, 686 kcal/day from 9 to 11 months and 894 kcal/day from 12 to 23 months (Dewey & Brown, 2003). Around 156-237 g per day of the complementary porridges would be required to meet the required energy for infants depending on their age. Adding foods containing more lipids to the porridges would be beneficial to increase energy density and provide needed nutrients (Dewey & Brown, 2003). As indicated the Figure 11, the curve indicated that the energy contents of SBP samples decrease as the peanut ratio decreases.

Table 2. Regression coefficient of a quadratic polynomial, R2, and lack of fit for proximate composition of SBP flour

Source	*MC*	*C.Protein*	*C.Fat*	*C.Fib*	*C.Ash*	*ToC*	*EK*	*PC*	*TaC*
Model	0.93**	21.67**	126.14**	5.01**	7.82**	387.95**	1670.94**	2162.10**	0.0562**
LM	0.93**	21.66**	125.67**	4.74**	7.22**	386.99**	1666.46**	2161.58**	0.0558**
A	5.39**	12.50**	4.46**	1.42**	1.34	75.23**	391.09**	144.36**	0.4364**
B	6.29**	16.89**	15.03**	3.48**	3.87	56.68**	429.58**	100.52**	0.2137**
AB	-0.05	-0.13	2.48	1.87	-2.79**	-3.54*	7.63	2.61	-0.0713
Adj. R^2	0.97	0.97	0.99	0.86	0.9936	0.99	0.98	0.9635	0.9052
Lack of fit	0.45	0.95	0.74	0.28	0.49	0.1113	0.80	0.0928	0.0142
Std.Dev.	0.07	0.34	0.42	0.35	0.0915	0.57	2.52	3.67	0.0308
C.V. %	1.25	2.28	4.17	13.53	3.89	0.87	0.61	2.99	9.66
Mean	5.83	14.69	9.97	2.62	2.35	65.64	411.01	122.67	0.3187

*A= Sorghum, B= Peanut, LM=Linear mixture, Std.Dev=standard deviation, MC=Moisture Content, P=Protein, Crude Fib= fiber, ToC=Total carbohydrate, EK=Energy Kcal/100g PC=Phytate contents, TaC=Tannin contents *Significant at P≤ 0.05 level, **Significant at P≤ 0.01*

Mineral contents of SBP flour

Table 3 displays the mineral composition of all samples and components of SBP samples. At the 1% probability level (P≤0.01), models that were fitted for the contents of all minerals showed that the lack-of-fit p-values were not significantly different. A normality plot of the residuals, one of the diagnostic techniques, showed that the residuals of all the response variables are normally distributed.

Table 3. The mineral content of SBP flour samples

Std	Run	Block	SBP		Mineral contents				
			A:	B:					
			Sorghum (g)	Peanut (g)	Calcium Mg/100g	Iron Mg/100g	Zinc Mg/100g	Potassium Mg/100g	Magnesium Mg/100g
7	1	Block 1	70	30	59.90	10.07	5.17	585.49	167.10
3	2	Block 1	85	15	23.84	4.16	3.42	441.56	130.43
6	3	Block 1	100	0	5.07	1.99	2.85	320.16	105.87
2	4	Block 1	70	30	58.95	10.95s	5.41	549.95	166.60
5	5	Block 1	77.5	22.5	38.68	7.65	3.91	492.34	148.73
1	6	Block 1	100	0	5.06	1.98	2.72	324.86	103.90
4	7	Block 1	92.5	7.5	10.61	2.54	3.00	397.96	122.07

SBP= Sorghum Blended peanut, A= Sorghum, B= Peanut,

Calcium content

Table 3, shows that the linear model of the sorghum blended with peanut flour had a strong linear significance ($P \leq 0.01$) and a significant strong interaction effect ($P \leq 0.01$) on the calcium content. The calcium content of 70 grams of raw sorghum and 30 gram of peanut was 59.90 mg/100g while the lowest calcium content of 100:0 ratio of raw sorghum and peanut was 5.07 mg/100g respectively. As seen from Table 3, the results indicated that the control group of the study has the lowest calcium contents and sorghum is commonly not a good source of calcium as seen from different literature. According to the finding of the study, the results was shown that calcium concentration increased sharply as increased the peanut ratios, about the ratio of 70:30 gram of sorghum and peanut gives 59.90 mg/100g of calcium and the ratio of 77.5:22.5-gram sorghum and peanut gives 38.68 mg/100g respectively, this result is inline the RDA for the infants. The RDA for 6 to 12 months was 270 mg per day (Trumbo et al., 2002). The current blended product was meet the RDA for the life stage of an infant, which is 22.18% for the highest blend formulation ratio. The regression model for calcium content was shown by (Eq.27) as indicated in the quadratic model with two variables

$$Y = 4.89_{x_1} + 59.44_{x_2} - 36.92_{x_1 x_2} \ldots\ldots\ldots\

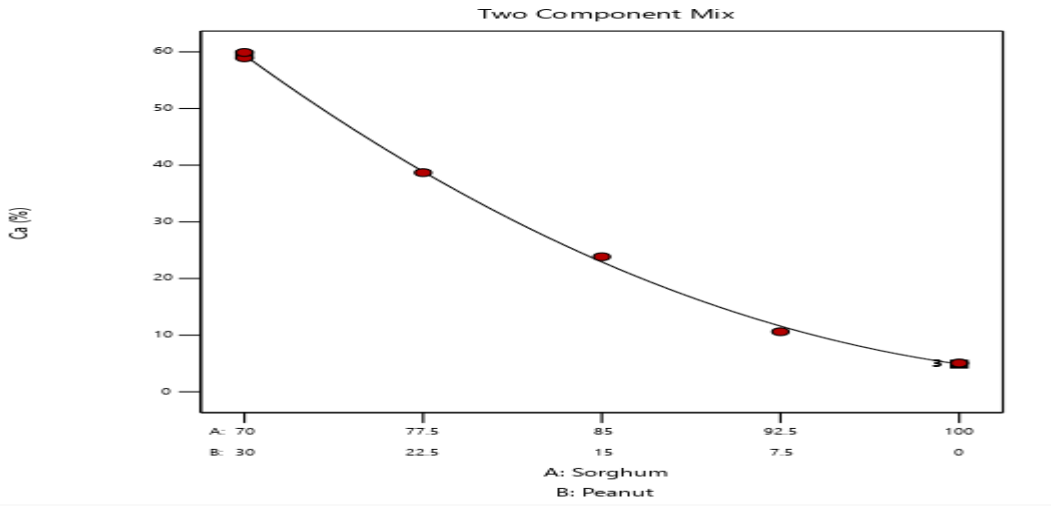


Figure 8. The contour line shows the calcium content while the black points show the treatment formulations of the SBP flour.

Iron content

As seen in Table 3, the linear model of the sorghum blended with peanut flour had a strong linear significance (P≤0.01), and a significant strong interaction effect (P≤0.05) on the iron content. The iron content of all the formulations ranged from 1.98 mg/100g to 10.95 mg/100g (Table 3). The amounts of iron in the product were within the recommended level (9mg/1000kcal) for local diets formulated for malnourished children (Golden, 2009). Due to the higher amount of peanut flour, the iron content of the sorghum that has been enhanced with peanuts increased. According to the finding of the study, results were within recommendations and there is a reasonable result that agrees with the RDA of infants and children.

Also, this result is in line with other studies, the level of iron in sorghum-based complementary food observed in this study was comparable (5.56-6.21 mg/100 g) with those reported by (Mosha et al., 2000). The iron content of the current study ranged from 3.89 to 21.95 mg/100g whereas the RDA for 6-to-12-month life stage infants is 11 mg/ day and 7 mg/day for 13 to 36 months life stage children respectively. The blended product was meet 18.09 to 99.54 % of the RDA for 6-to-12-month life stage infants and 28.28 to 100% for 13 to 36 months life stage children in lower and higher values respectively. The regression model for iron content was shown by (Eq.28) as indicated in the quadratic model with two variables.

$$Y = 1.92_{x_1} + 10.63_{x_2} - 7.63_{x_1x_2} \ldots\ldots\ldots\

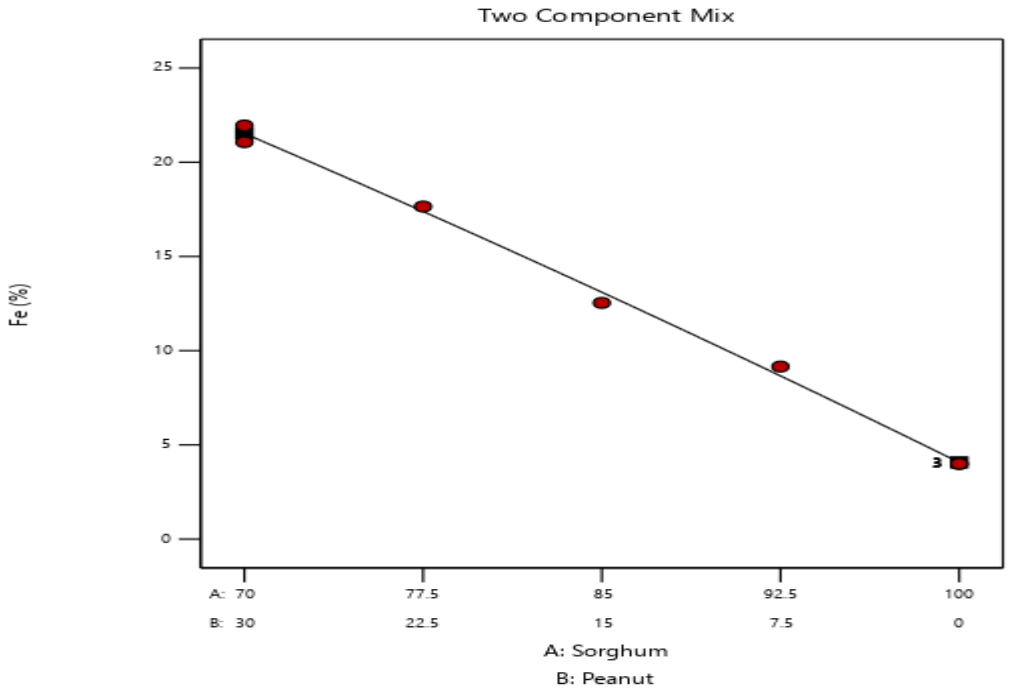


Figure 9. The contour line shows the iron content while the black points show the treatment formulations of the SBP flour

Zinc content

Table 3, it indicated that the linear model of the sorghum blended with peanut flour had a strong linear significance ($P \leq 0.01$), and a significant strong interaction effect ($P \leq 0.05$) on the iron content. The zinc content of sorghum, and peanut flour samples were represented in Table 3. The zinc content of SBP samples flour was ranged from 2.72 to 5.17 mg/100g, this finding agrees with similar reports by (Rasmata et al., 2023), the study indicated that nutritional and organoleptic characteristics of six formulated sorghum-based complementary foods, the zinc content ranged between 2.01 to 3.7 mg/100g.

According to the finding of this study, it agrees with RDA of the infants and children. The RDA for both 6-to-12-month, 13 to 36 months' life stage infant and children are 3 mg/ day. The blended product was meet 90.67 to 100 % of the RDA for both 6-to-12-month and 13 to 36 months life stage infants and children in lower and higher value respectively. According to the existing literature zinc is one of the most essential minerals for infants and it helps with brain growth. As indicated in Figure 14, the zinc content decreased as the peanut ratio decreases. The regression model for iron content was shown by (Eq.29) as indicated in the quadratic model with two variables.

$$Y = 2.82_{x_1} + 5.24_{x_2} - 2.79_{x_1x_2} \ldots\ldots\ldots\

2002). The blended product was meet 37.23 to 68.08 % of the RDA for 6-to-12-month life stage infants and 16.01 to 29.27 % of the RDA for 13 to 36 months life stage children in lower and higher values respectively. The regression model for potassium content was shown by (Eq.30) as indicated in the quadratic model with two variables.

$$Y = 325.80_{x_1} + 564.74_{x_2} - 7.34_{x_1x_2} \ldots\ldots\ldots\

Where Y= Magnesium content, X_1= Sorghum, X_2=Peanut, X_1X_2=Sorghum and Peanut

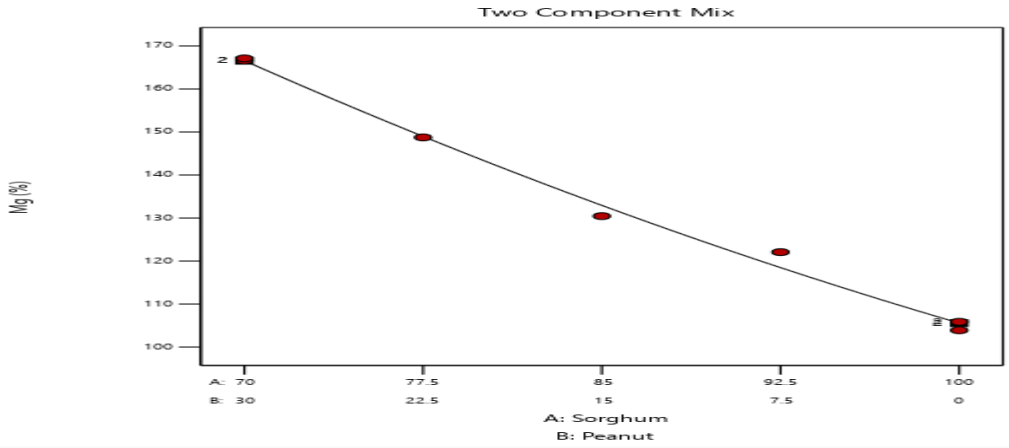


Figure 12. The contour line shows the magnesium content while the black points show the treatment formulations of the SBP flour

Table 4. Regression coefficients of a quadratic polynomial or linear model, R2, and lack of fit for the selective mineral of SBP flour samples

Source	*Calcium Mg/100g*	*Iron Mg/100g*	*Zinc Mg/100g*	*Potassium Mg/100g*	*Magnesium Mg/100g*
Model	3452.83**	89.38**	7.24**	64231.38**	4199.20**
Linear mixture	3347.84**	85.24**	6.64**	64227.23**	4187.11**
A	4.89**	1.92**	2.82**	325.80**	105.57**
B	59.44**	10.63**	5.24**	564.74**	166.58**
AB	-36.92**	-7.33*	-2.79*	-7.34	-12.53
Adj. R^2	0.9990	0.98	0.9791	0.9769	0.9920
Lack of fit	0.1924	0.45	0.3594	0.6405	0.0919
Std. Dev.	0.7666	0.47	0.1599	15.84	2.37
C.V. %	2.66	8.34	4.23	3.56	1.75
Mean	28.87	5.62	3.78	444.62	134.96

A= Sorghum, B= Peanut, *Significant at P≤ 0.05 level, **Significant at P≤ 0.01

Optimum blending ratio of SBP Product

The Optimization was carried out by setting criteria for each response to obtain the optimum levels of the responses in the experiment. The optimization was to get the maximum puffing scale, rollability scale, crude protein, crude fat, crude fiber, total ash, total carbohydrate, total energy, calcium, iron, zinc, and overall acceptability. The goal of the current research was to establish the ideal ratio for blending each ingredient to create porridge with the desired nutritious contents and sensory appeal. The carbohydrate content of the optimized sorghum flour was 74.90 grams and peanut flour was 25.10 grams. The acceptability of the overall optimum value for Moisture, protein, fat, fiber, ash, carbohydrate, energy, Mg, Ca, Fe, K, Zn, were varied between

16.16%, 13.65%, 6.14%, 3.08%, 3.40%, 57.59%, 417.79 Kcal/100g, 154.91, mg/100g 45.50 mg/100g, 18.85 mg/100g, 525.09 mg/100g, and 4.47 mg/100g respectively.

Table 5. Response optimization for proximate, physicochemical, and anti-nutritional contents of SBP flour

Name	**Unit**	**Lower Limit**	**Upper Limit**	**The optimum value**
A: Sorghum	G	70	100	74.90
B: Peanut	G	0	30	25.10
Moisture	%	12.43	17.38	16.16
Protein	%	4.40	15.61	13.65
Fat	%	5.34	6.35	6.14
Fiber	%	1.32	3.98	3.08
Ash	%	1.05	3.61	3.40
Carbohydrate	%	54.08	75.33	57.59
Energy	Kcal/100g	388.86	423.81	417.79
Mg	mg/100g	103.90	167.10	154.91
Ca	mg/100g	5.06	59.90	45.50
Fe	mg/100g	3.99	21.95	18.85
K	mg/100g	320.16	585.49	525.09
Zn	mg/100g	2.72	5.41	4.47
Overall acceptability	Scale	4.501	4.861	4.81
Desirability	--	--	--	0.68

CONCLUSION

The findings of this study showed that adding a maximum of 30% of peanut flour to the composite flour formula greatly enhanced the product's macronutrient profile (protein, fat, carbohydrate, and energy content). Additionally, the product's level of micronutrients including calcium, iron, zinc, magnesium, and potassium dramatically rose as the quantity of peanut flour increased. As the amount of peanut flour grows to 30%, the concentration of anti-nutritional elements such as phytate and tannin in the SBP product falls. To improve proximate composition and mineral concentration the composition of SBP sample flours was numerically optimized. The formulation condition of 74.90% sorghum flour and 25.10% peanut flour was determined to be the best for all the tested parameters.

REFERENCE

Almeida-Dominguez, H., et al. (1993). Production and nutritional value of weaning foods from mixtures of pearl millet and cowpeas. *Cereal Chemistry*, *70*(1), 14-18.

Arab, E. A., et al. (2010). Nutritional evaluation and functional properties of chickpea (Cicer arietinum L.) flour and the improvement of spaghetti produced from its. *Journal of American Science*, *6*(10), 1055-1072.

Dewey, K. G., et al. (2003). Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food and nutrition bulletin*, *24*(1), 5-28.

Dicko, M. H., et al. (2006). Sorghum grain as human food in Africa: relevance of content of starch and amylase activities. *African journal of biotechnology*, *5*(5), 384-395.

Espitia-Hernández, P., et al. (2022). Sorghum (Sorghum bicolor L.) as a potential source of bioactive substances and their biological properties. *Critical Reviews in Food Science and Nutrition*, *62*(8), 2269-2280.

Golden, M. H. (2009). Proposed recommended nutrient densities for moderately malnourished children. *Food and nutrition bulletin*, *30*(3_suppl3), S267-S342.

Jiru, T. U., et al. (2021). Development and evaluation of hand operated seed cleaner for small-holder farmers in East Hararghe, Oromia. *Journal of Civil Engineering and Environmental Sciences*, *7*(1), 018-024.

Khalid, W., et al. (2022). Nutrients and bioactive compounds of Sorghum bicolor L. used to prepare functional foods: a review on the efficacy against different chronic disorders. *International Journal of Food Properties*, *25*(1), 1045-1062.

Makinde, F., et al. (2012). Physico-chemical and microbial quality of sorghum–based complementary food enriched with soybean (Glycine max) and sesame (Sesamum indicum). *Journal of Agricultural Research and Development*, *11*(1), 200-206.

Mohammed, N. A., et al. (2011). Nutritional evaluation of sorghum flour (Sorghum bicolor L. Moench) during processing of injera. *World Academy of Science, Engineering and Technology*, *51*, 72-76.

Mosha, T., et al. (2000). Nutritional composition and micronutrient status of home made and commercial weaning foods consumed in Tanzania. *Plant Foods for Human Nutrition*, *55*, 185-205.

Munasinghe, M. D., et al. (2013). Development of yoghurt-based weaning foods for 1-3 years old toddlers by incorporation of mung bean (Vigna radiata), soybean (Glycine max) and brown rice (Oryza sativa) for the Sri Lankan market.

Onabanjo, O. O., et al. (2009). Characteristics of complementary foods produced from sorghum, sesame, carrot and crayfish. *J. Nat. Sci. Engr. Tech*, *8*(1), 71-83.

Rasmata, D., et al. (2023). Technological, Nutritional and Organoleptic Characteristics of Six Formulations of Composite Flours Based on Sorghum Added or Not With Moringa Leaves Powder. *International Journal of Nutrition and Food Sciences*, *12*(2), 56.

SESSION, R. D. L. Q.-S., et al. (2015). PROGRAMME MIXTE FAO/OMS SUR LES NORMES ALIMENTAIRES COMMISSION DU CODEX ALIMENTARIUS Trente-huitième session CICG, Genève, Suisse.

Shimelis, E. A., et al. (2005). Proximate composition and physico-chemical properties of improved dry bean (Phaseolus vulgaris L.) varieties grown in Ethiopia. *Lwt - Food Science and Technology*, *38*, 331-338.

Singh, A., et al. (2021). Functional uses of peanut (Arachis hypogaea L.) seed storage proteins. *Grain and Seed Proteins Functionality*.

Sobowale, S. S., et al. (2019). Production of extrudate pasta from optimal sorghum–peanut flour blend and influence of composite flours on some quality characteristics and sorption isotherms. *Transactions of the Royal Society of South Africa*, *74*(3), 268-275.

Tadele, Z. (2019). Orphan crops: their importance and the urgency of improvement. *Planta*, *250*(3), 677-694.

Temple, V., et al. (1996). Proximate chemical composition of three locally formulated complementary foods. *West Afr. J. Biol. Sci*, *5*(2), 134-143.

Teshome, B. (2014). Nutritional quality and acceptability of extruded weaning foods based on peanut, low-tannin sorghum and soybeans. *http://etd.aau.edu.et/handle/123456789/30994*.

Trumbo, P., et al. (2002). Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids.(Commentary). *Journal of the american dietetic association*, *102*(11), 1621-1631.

Evaluation of functional, anti-nutritional, and Sensory Properties of Sorghum blended with peanut

Mahammed Dol[1], Abdulkarim Mohammed[2], Hodo Mohamed[2]

1. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. **Ateye069@gmail.com**
2. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. **adnanbdu302@gmail.com, hoodoqali042@gmail.com**

P.O.Box 398, Jigjiga, Ethiopia

Abstract

Proper nourishment is critical for children's healthy growth and brain development, especially during their first five years of life, to reach their full potential. This study aimed to evaluate the functional, anti-nutritional and sensory properties of sorghum blended with peanut. Sources of materials sorghum , and Peanut were bought from the local Market, Jigjiga, Somali region, Ethiopia. About 5kg of the samples peanuts and sorghum were collected and then the raw materials were cleaned and dehulled before being milled. From the results, the water absorption capacity of the present study, the composite flour varied between 128.15-133.96%. The results show that the mixture proportions of sorghum and peanut have a strong linear significance (P≤ 0.01) effect on the water absorption capacity. According to the average sensory assessments of the SBP product's color, scent, taste, mouth feel, and overall acceptability, the inclusion of peanut flours significantly changed the product's sensory attributes.

Keywords: *Anti-Nutritional properties, Functional properties, Sensory properties, sorghum, Peanut.*

INTRODUCTION

Adequate nutrition is essential for healthy growth and brain development of children, particularly within the first 5 years of life for them to attain full potential (Motuma et al. 2016). Ironically, in developing countries including Ethiopia, many underprivileged nursing mothers or caregivers as a result of poverty and lack of nutrition knowledge to utilize locally available food materials to formulate infant foods (Samuel et al. 2021) are unable to provide adequate nutrients to their children. Hence, there is a high prevalence of moderate and severe acute malnutrition with consequences of high morbidity, mortality, and hospital admission among young children (Michaelsen et al. 2009).

Recently, epidemiological studies have implicated traditional complementary foods in developing countries as one of the main causes of growth faltering and poor brain development among children (Adesanmi et al. 2020). Complementary food is usually introduced to infants

between the ages of 6 months to 2 years when breast milk alone is no longer adequate to meet the nutritional needs of the infant (Taha et al. 2020). In developing countries, the cost of fortified, nutritious, and proprietary complementary foods is always unaffordable to less privileged families. Groundnut (Arachis hypogaea L.) also known as peanut is a legume, and widely cultivated in Ethiopia. Nutritionally, groundnut kernel contains appreciable amounts of essential oil, protein, essential amino acids, fatty acids, and micronutrients (Adlak et al. 2021). Groundnut kernel is usually consumed as snacks or used in food preparation to increase protein content, and flavor enhancer (Rossi-Márquez et al. 2021).

The purpose and type of processing applied in preparing complementary foods for infants should be for separation and purification of the edible parts of raw material and most importantly it should also improve the nutritional qualities by enrichment and inactivation of the anti-nutritional factors. The low socio-economic status mothers are not adequately knowledgeable about the available nutrients and the anti-nutritional factors in the raw materials (Oluwajuyitan, T. D et al; 2020).

So porridge prepared from cereals has high viscosity and low energy density; therefore, they are not potentially nutritious enough to be used as complementary foods. It is therefore desirable to propose a processing method in which cereals and peanuts can be jointly processed to reduce labor, cost, energy, and loss of nutrients that could arise from separate processing of cereals and peanuts. Therefore, the aim of this study was the functional, anti-nutritional, and sensory properties of sorghum blended with peanuts.

MATERIALS AND METHOD

Raw Materials and sample preparation, Blending Ratio based complementary food

Sources of materials sorghum , and Peanut were bought from the local Market, Jigjiga, Somali region, Ethiopia. About 5kg of the samples peanuts and sorghum were collected. The preparation of sorghum flour was done according to the method developed by (Almeida-Dominguez et al., 1993) and The preparation of peanut flour was done according to the method developed by (Arab et al., 2010).D-optimal mixture design with a total formulation of seven , which was obtained by inserting a range of sorghum 70-100g, and 0-30g was used to set up the experiment.

Functional Properties

Water absorption capacity

The WAC was determined according to the method described by Akubor (2005). One-gram sample was mixed with 10-mL distilled water (specific gravity 0.904 kg/m3) and allowed to stand at ambient temperature (31 ± 2^{o}C) for 30 min and then centrifuged at 3,000 rpm for 30 min using centrifuge model 800-1D. WAC was determined by the following formula:

$$\text{WAC} = \frac{\text{Weight of water bound}}{\text{Weight of sample (dry basis)}} \text{x}100\% \qquad (1)$$

Water absorption index

Water Absorption Index (WAI) was assessed as described by Anderson et al. (1969). Each flour sample of 3 g was suspended in 30 mL of distilled water in a tared 60-mL centrifuge tube. The slurry was stirred with a glass rod for 1 min at room temperature (25oC) and centrifuged (3000 × g, for 10 min). The supernatant was eliminated. WAI was calculated from the weight of the remaining gel and expressed as g gel/g dry flour.

$$\text{WAI} = \frac{\text{weight of sediment (g)}}{\text{weight of the sample (g)}} \qquad (2)$$

Determination of anti-nutrient properties of SBP flour

Tannins

Tannin content was determined according to the method described by Maxson and Rooney (1972), about 1.000g of the sample were weighed and mixed with 10 ml of 1% HCl solution in methanol in a screw cap test tube. Then the tube shaken were kept for 24 hr at room temperature on a mechanical shaker. The solution centrifuged was at 3000 rpm for 30 minutes. One ml of supernatant was transferred to another test tube and mixed with 5 ml of vanillin-HCl reagent (prepared by combining the equal volume of 8% concentrated HCl in methanol and 4% vanillin in methanol). Catechin standards at different concentrations (0.5-12 mg /100 ml) were used for the construction of the calibration curve. A standard curve (R^2 =0.993) will make from absorbance versus concentration, and the slope and intercept were used for calculation. The condensed tannin content was calculated by using the following formula:

$$\text{Tannin in mg/100g} = \frac{\text{Absorbance} - \text{Intercept}}{\text{Slope x Density x weight of the sample}} \qquad (3)$$

Phytate content

Determination of the phytate content was done by using the method described by Vantraub and Lapteva (1988). About 0.5 g of samples were extracted from 10 ml of 2.4% HCl in a mechanical shaker (Eberbach) for 1 hour at room temperature. The clear supernatant was used for phytate estimation. 1 ml of Wade reagent (containing 0.03% solution of $FeCl_3.6H_2O$ and 0.3% of sulfosalicylic acid in water) was added to 3 ml of the sample solution (supernatant). The mixture was in a vortex for 5 seconds to absorb the sample solutions at 500 nm using a UV-VIS spectrophotometer (Beckman DU-64- spectrophotometer, USA). A standard curve was made from absorbance versus concentration, and the slope and intercept were used for calculation. Using the sodium salt of phytic acid as a standard for the construction of the calibration curve. Phytate content was calculated by using the following formula:

$$\text{Phytate in mg/100g} = \frac{\text{Absorbance} - \text{Intercept}}{\text{Slope x Density x weight of the sample}} \qquad (4)$$

Sensory analysis of sorghum blended with peanut flour

Sensory evaluation of the sorghum blended with peanut (SBP) formulated from sorghum and peanut flour blended was carried out using 10 untrained panelists. The selection and screening of the panelists were based on the participant's interest to participate and evaluate the SBP. The participants were pre-informed about the evaluation and the purpose of assessing the sensory of the product. The sensory evaluation was done in a room with less noise and no other fragrance to avoid panelist disturbance and evaluated daylight brightness. Panelists were requested to test the SBP samples in appearance, aroma, taste, texture, and overall acceptance using a five-point hedonic scale. After evaluating each sample test panelist rinse their mouths with water in between two tests. Samples were evaluated based on five Point hedonic scales (1, dislike very much; 5, like very much) for one attribute.

Data analysis

All the analyses were performed in duplicates (unless stated otherwise) and presented as mean. The statistical significance of the data obtained will be analyzed and modeled using Design Expert ® version 13. The level of significance was accepted at probability ($p \leq 0.01$ and $p \leq 0.05$).

RESULTS AND DISCUSSION

Functional properties of SBP flour

The functional properties (bulk density, water absorption capacity, and oil absorption capacity) of composite flour with the individual ingredients were summarized in Table 1. Analysis of variance results is also summarized in Table 1. Models for functional properties were fitted indicating that the lack-of-fit p-values were not significantly different at a 5% probability level or ($P<0.05$). Diagnostic tools like normality plots of residuals indicated that the residuals of all the response variables are normally distributed.

Table1. Functional properties of SBP flour samples

Std	Run	Block	SBP		Functional properties		
			A:	B:			
			Sorghum (g)	Peanut (g)	Bulk Density (g/ml)	Water Absorption Capacity (%)	Water Absorption Index (g)
7	1	Block 1	70	30	0.68	133.95	3.71
3	4	Block 1	85	15	0.62	131.17	3.68
6	3	Block 1	100	0	0.59	128.46	3.63
2	2	Block 1	70	30	0.67	133.96	3.72
5	5	Block 1	77.5	22.5	0.63	132.99	3.70
1	6	Block 1	100	0	0.60	128.15	3.62
4	7	Block 1	92.5	7.5	0.61	129.97	3.65

SBP= Sorghum Blended peanut, A= Sorghum, B= Peanut

Bulk Density

Table 1 indicates that the sorghum blended with peanut flour has a highly significant effect ($P\leq0.01$) on the bulk density. The functional properties of the bulk density ranged between 0.59 to 0.68 g/ml. The bulk density found in this study was lower than the results reported by(Alemayehu, 2014), who reported a bulk density of between 0.81-0.84 g/ml. As seen in figure 1, the bulk density of SBP flour samples showed an increasing trend with the increment of the proportion of sorghum and peanut flour. This result agrees with Masood and (Butt & Rizwana, 2010) indicated that the bulk density was increased in the composite flour with soybean protein content. Similar results were reported by (Malomo et al., 2011) who indicated that the bulk

density of composite flour of yam with soybean increased as the amount of soybean increased. High-energy foods have low density and high-density foods have low energy, and the results of this study may be observed due to the protein and fat content found in peanut flour being higher compared to sorghum ration. The low bulk density of the blends is an advantage in the formulation of complementary foods (Akubor & Ukwuru, 2003). The regression model for bulk density was shown by (Eq. 1) indicating in quadratic model with two variables.

$$Y = 0.67_{x_1} + 0.59_{x_2} - 0.06_{x_1x_2} \ldots\ldots\ldots\

Water absorption capacity

Water absorption capacity is a measure of how much water is needed to create gruel that is the right consistency for feeding newborns. Water absorption capacity is determined by the availability of hydrophilic groups to bind water molecules and the ability of macromolecules to form gels (Onweluzo & Nwabugwu, 2009). Water absorption capacity indicates the amount of water available for gelatinization. The water absorption capacity(WAC) of the present study, the composite flour varied between 128.15-133.96% (Table 1). As indicated in (Table 2), the results show that the mixture proportions of the sorghum and peanut have a strong linear significance ($P \leq 0.01$) effect on the water absorption capacity. The highest WAC of the sorghum in enriched with peanut flour was 133.96% at 70 grams of sorghum with 30 grams of peanut flour while the lowest percent recorded was 128.15% at 100 grams of sorghum with 0 grams of peanut flour. As indicated in Figure 2, the trend increases WAC in the blended formulations, and this might be due to the higher protein content in peanut flour. Low water absorption values show mostly intact starch granules, but high values are attributed to protein denaturation, starch gelatinization, and crude fiber swelling. Damaged/transformed starches have a high-water absorption capacity and can produce paste at room temperature via the gelatinization mechanism (Nwabueze, 2006). The regression model for WAC was shown by (Eq. 2) indicating in quadratic model with two variables.

$$Y = 128.30_{x_1} + 134.01_{x_2} + 0.94_{x_1x_2} \ldots\ldots\ldots\

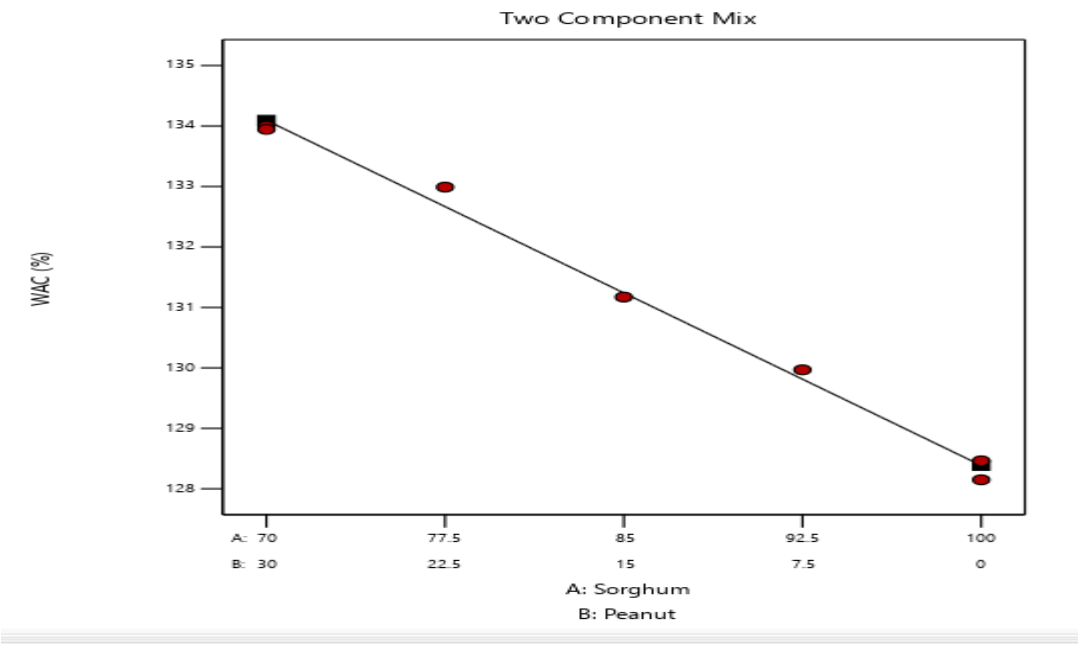


Figure 2. The contour line shows the water absorption capacity while the black points show the treatment formulations of the SBP flour

Water absorption Index

As indicated in Table 2, the mixture proportion of the sorghum and peanut flour has strong linear significance (P≤ 0.01) on the water absorption index (WAI). The WAI measures the volume occupied by a substance after swelling in excess of water. Table 1 shows that the WAI of the SBP sample flour, increases the proportion of the peanut and increases the WAI of sorghum. The highest WAI was seen in run-1, and run-2, 70g of sorghum with 30g of peanut respectively. Also, the lowest WAI was seen in the run- 3 and run-6, 100 grams of sorghum with 0 grams of peanut respectively.

The WAI of this study has similar results to previous studies on extruded sorghum and legumes (Pelembe et al., 2002). This increase was probably due to some gelatinization of the starches which would increase the availability of hydrophilic groups in the food system and due to the increased gel-forming capacities of other macromolecules, such as dietary fiber and proteins (Andersson & Hedlund, 1990). From Figure 2, the curve line indicates that WAI increased as the peanut flour increased. The regression model for WAI was shown by (Eq. 3) indicating in quadratic model with two variables

$$Y = 3.62_{x_1} + 3.72_{x_2} + 0.02_{x_1x_2} \ldots\ldots\ldots\

Where Y= Water absorption index, X_1= Sorghum, X_2=Peanut, X_1X_2=Sorghum and Peanut

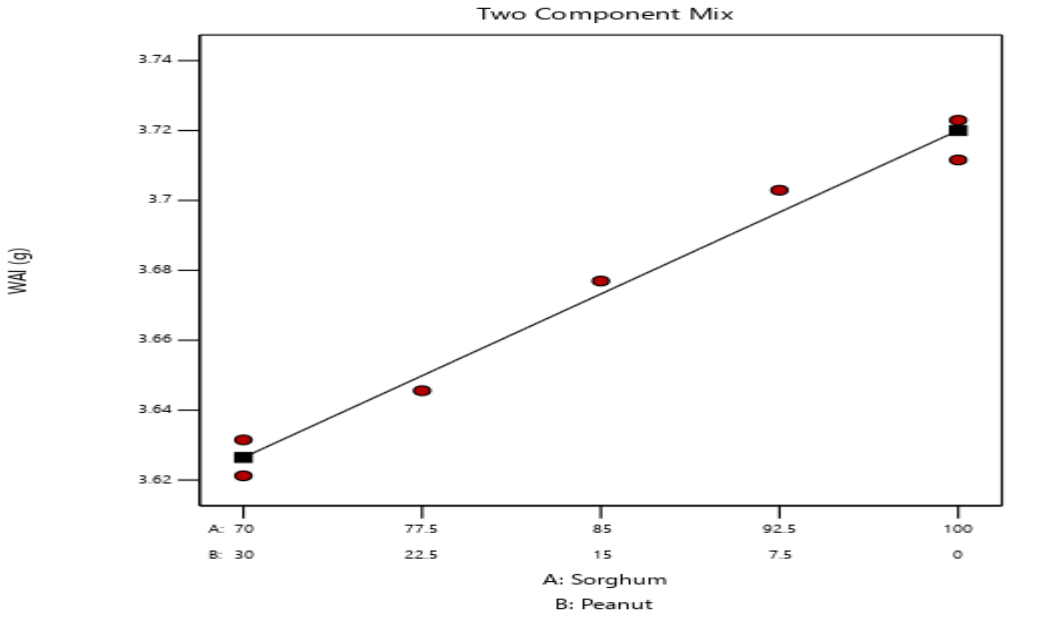


Figure 3. The contour line shows the water absorption index while the black points show the treatment formulations of the SBP flour

Table 2. Regression coefficient of a quadratic polynomial, R2, and lack of fit for functional properties of SBP flour

Source	*Bulk Density (%)*	*Water Absorption Capacity (%)*	*Water Absorption Index (g)*
Model	0.93*	36.71**	0.01**
Linear mixture	0.93**	36.65**	0.01**
A	5.39*	128.30	3.62**
B	6.29*	134.01	3.72**
AB	-0.05	0.94	0.02
Adj. R^2	0.97	0.99	0.97
Lack of fit	0.45	0.32	0.64
Std. Dev.	0.07	0.20	0.01
C.V. %	1.25	0.15	0.18
Mean	5.83	131.24	3.67

*A= Sorghum, B= Peanut, *Significant at P≤ 0.05 level, **Significant at P≤ 0.01*

Major anti-nutritional contents

The analysis of the anti-nutritional components (tannin and phytate) in the ingredients and composite flour SBP samples produced the results shown in (Table 3). At the 5% probability level (P≤0.05), models for anti-nutritional factors that were fitted showed that the lack-of-fit p-values were not significantly different. A normality plot of the residuals, one of the diagnostic techniques, showed that the residuals of all the response variables are normally distributed.

Table 3. Major anti-nutritional contents of porridge and ingredients flour samples

Std	Run	Block	SBP		Anti-nutritional	
			A:	B:		
			Sorghum (g)	Peanut (g)	Phytate (%)	Tannin (%)
7	1	Block 1	70	30	98.84	0.20
2	2	Block 1	85	15	122.45	0.31
6	3	Block 1	100	0	143.95	0.45
3	4	Block 1	70	30	99.79	0.21
5	5	Block 1	77.5	22.5	117.03	0.30
1	6	Block 1	100	0	146.97	0.45
4	7	Block 1	92.5	7.5	129.70	0.33

Std= Standard, SBP= Sorghum Blended peanut, A= Sorghum, B= Peanut

Phytate contents

As indicated in Table 3, it indicated that the linear model of the sorghum blended with peanut flour had a strong linear significance (P≤0.01). According to the finding the phytates of SBP sample flour ranged between 98.84 to 146.03%, these results indicated that the anti-nutritional factors of the SBP sample flour increased as the peanut ration decreases and indicates that the sorghum has higher anti-nutritional factors compared to the peanut ration on other hand its good ideas increasing the peanut ratio to minimize the phytates. The effect of the blending ratio on phytate content was shown in the mixture contour graph (Figure 4) and the regression model was shown (Eq. 4) as indicated in a quadratic model with two variables.

$$Y = 144.36_{x_1} + 100.52_{x_2} + 2.61_{x_1x_2} \ldots\ldots\ldots\

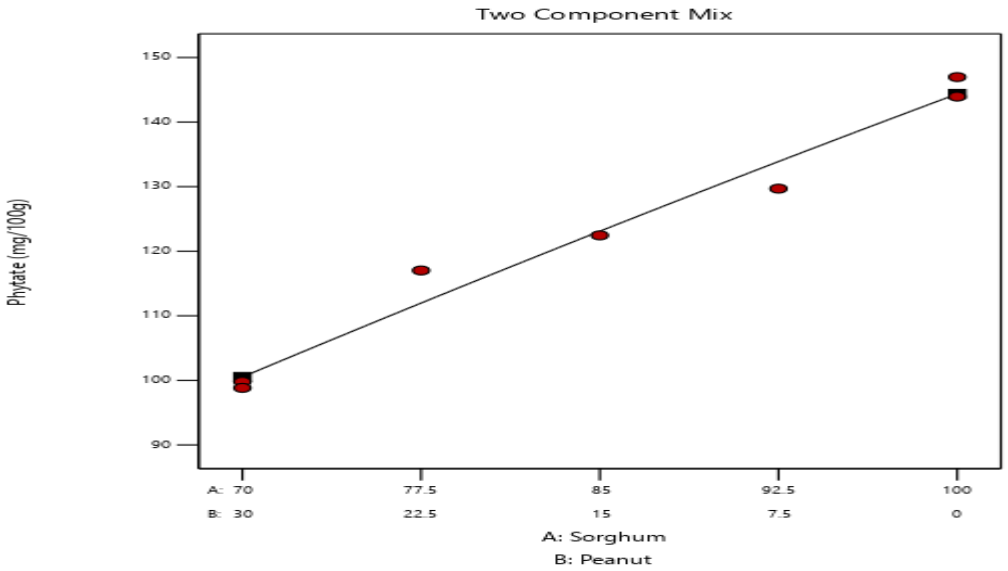


Figure 4. The contour line shows the phytate content while the black points show the treatment formulations of the SBP flour

This study also agrees with research conducted by (Alemayehu, 2014), the result indicated that the phytate content increased from 95.94 to 115.13mg/100g as sorghum flour proportion increased in the composite flour from (40-55%). As shown in the curve line in Figure 4, the results indicated that the effect of the blending ratio of the phytates from the sorghum and lowest phytate was observed on the blending ratio of 70:30 grams of sorghum and peanut respectively.

Tannin contents

As indicated in Table 3 the tannin content indicated that the linear model of the sorghum blended with peanut flour had a strong linear significance ($P \leq 0.01$). The results showed that the tannin factors of the SBP sample flour increased as the peanut ration decreased and that the sorghum has higher tannin factors compared to the peanut ration; however, it is wise to increase the peanut ratio to reduce the phytates. The tannin of the SBP sample flour ranged from 0.20 to 0.45%. The difference in tannin content may be explained by the increased tannin content of sorghum in comparison to peanuts. Also study is in line with reports of, Local red sorghum has a greater tannin concentration than Meko sorghum (1.29 mg/100g; 3946.94 mg/100g). The tannin level of Meko sorghum flour was found to be 1.29 mg/100g, while (Shimelis & Rakshit, 2005) claimed that the tannin content in the meko variety of sorghum flour was below the detection limit in his study on the improvement of energy and nutrients density of sorghum-based

complementary meal. The regression model for tannin content was shown by (Eq.5) as indicated in the quadratic model with two variables.

$$Y = 0.44_{x_1} + 0.22_{x_2} - 0.07_{x_1x_2} \ldots\ldots\ldots\

Table 4. Sensory mean scores for SBP sample evaluated by untrained panels

Std	Run	Block	SBP		Sensory Properties				
			A:	B:					
			Sorghum (g)	Peanut (g)	Color	Aroma	Taste	MF	OA
7	1	Block 1	70	30	4.71^{a}	4.70^{a}	4.84^{b}	4.80^{b}	4.83^{b}
2	2	Block 1	85	15	4.27^{d}	4.27^{d}	4.65^{d}	4.69^{d}	4.73^{d}
6	3	Block 1	100	0	3.40^{g}	3.40^{g}	4.15^{g}	4.43^{f}	4.50^{g}
3	4	Block 1	70	30	4.63^{b}	4.63^{b}	4.88^{a}	4.87^{a}	4.86^{a}
5	5	Block 1	77.5	22.5	4.47^{c}	4.47^{c}	4.71^{c}	4.72^{c}	4.75^{c}
1	6	Block 1	100	0	3.55^{f}	3.551^{f}	4.16^{f}	4.34^{g}	4.59^{f}
4	7	Block 1	92.5	7.5	4.20^{e}	4.20^{e}	4.57^{e}	4.46^{e}	4.70^{e}

Means with the same superscript letters are not significantly different ($p<0.05$). MF = Mouth feel, OA= Over all acceptability. The values indicated that 1. Dislike Very Much, 2. Dislike, 3. Neither Like or Dislike 4. Like 5. Like Very Much

Conclusion

This study analysis the functional, anti-nutritional and sensory properties of sorghum blended with peanut and the results indicated that sorghum blended with peanut flour has a highly significant effect ($P\leq0.01$) on the bulk density. The highest water absorption capacity of the study was 70 grams of sorghum with 30 grams of peanut flour while the lowest percent recorded was 100 grams of sorghum with 0 grams of peanut flour. Also, the results shown that when the peanut ration increases the the anti-nutritional elements decreases and this can enhance nutrition quality of the products. According to the findings of the SBP products' overall sensory acceptability test, the color, scent, taste, and mouth feel of the goods considerably changed when the amount of peanut flour was increased. This boosted the products' overall acceptability. To improve physicochemical attributes, and sensory acceptance, the composition of SBP sample flours was numerically optimized.

Reference

Adlak, T., Tiwari, S., Gupta, N., Tripathi, M. K., Sikarwar, R. S., Sastya, R., & Gupta, V. (2021). Assessment for yield and nutritional profiling of groundnut with the help of allele specificmarkers for desirable fatty acids. International Journal of Current Microbiology & Applied
Science, 10(02), 1625–1637.

Akubor, P., et al. (2003). Functional properties and biscuit making potential of soybean and cassava flour blends. Plant Foods for Human Nutrition, 58, 1-12.

Alemayehu, E. (2014). Complementary food product development from sorghum enriched with chickpea and orange fleshed sweet potato: the case of dawuro zone, south western ethiopia. https://repository.ju.edu.et/handle/123456789/2292.

Adesanmi, A. R., Malomo, S. A., & Fagbemi, T. N. (2020). Nutritional quality of formulated complementary diet from defatted almond seed, yellow maize and quality protein maize flours. Food Production, Processing and Nutrition, 2(1), 1–12

Andersson, Y., et al. (1990). Extruded wheat flour: correlation between processing and product quality parameters. Food quality and preference, 2(4), 201-216.

Butt, M. S., et al. (2010). Nutritional and functional properties of some promising legumes protein isolates. Pakistan Journal of Nutrition, 9(4), 373-379.

Isah, A. P., et al. (2013). Proximate composition and some functional properties of flour from the kernel of African star apple (Chrysophyllual albidum). Int J Agric Pol Res, 1, 62-66.

Karim, O., et al. (2014). Physicochemical properties of yellow maize-peanut fortified tortillas.

Malomo, S., et al. (2011). Chemical composition, rheological properties and bread making potentials of composite flours from breadfruit, breadnut and wheat. African Journal of Food Science, 5(7), 400- 410.

Mbata, T., et al. (2009). Evaluation of mineral content and functional properties of fermented maize (Generic and specific) flour blended with bambara groundnut (Vigna subterranean L). African Journal of Food Science, 3(4), 107-112.

Michaelsen, K. F., Hoppe, C., Roos, N., Kaestel, P., Stougaard, M., Lauritzen, L., Friis, H. (2009). Choice of foods and ingredients for moderately malnourished children 6 months to 5 years of age. Food and Nutrition Bulletin, 30(3), S343–S404.

Motuma, A., Azeb, L., & Bekeso, G. (2016). Complementary feeding: Review of recommendations, feeding practices, and adequacy of homemade complementary food preparations in developing countries-Lessons from Ethiopia. Frontiers in Nutrition, 3–41. https://doi.org/10.3389/fnut. 2016.00041.

Moskowitz, H. (1994). Product optimization: approaches and applications. In Measurement of food preferences (pp. 97-136). Springer.

Nwabueze, T. (2006). Water/oil absorption and solubility indices of extruded African breadfruit (Treculia africana) blends. Journal of food Technology, 4(1), 64-69.

Oluwajuyitan, T. D., Ijarotimi, O. S., & Fagbemi, T. N. (2020). Nutritional, biochemical and organoleptic properties of high protein-fibre functional foods developed from plantain, defatted soybean, ricebran and oat-bran flour. Nutrition and Food Science, 50(6), 1–32. https://doi.org/10.1108/ NFS- 06-2020-0225

Onweluzo, J., et al. (2009). Development and evaluation of weaning foods from pigeon pea and millet. Pakistan Journal of Nutrition, 8(6), 725-730. Pelembe, L., et al. (2002). Development of a protein-rich composite sorghum–cowpea instant porridge by extrusion cooking process. LWT-Food Science and Technology, 35(2), 120-127.

Rossi-Márquez, G., Helguera, M., Briones, M., Dávalos-Saucedo, C. A., & Di Pierro, P. (2021). Edible coating from enzymatically reticulated whey proteinpectin to improve shelf life on roasted peanuts. Coatings, 11(3), 329.

Samuel, F. O., Akintayo, B., & Eyinla, T. E. (2021). Complementary feeding knowledge and practices of caregivers in orphanages improved after nutrition education intervention in Ibadan, Nigeria. Open Journal of Nursing, 11(7).

Shimelis, E. A., et al. (2005). Proximate composition and physico-chemical properties of improved dry bean (Phaseolus vulgaris L.) varieties grown in Ethiopia. Lwt - Food Science and Technology, 38, 331- 338.

Taha, Z., Garemo, M., & Nanda, J. (2020). Complementary feeding practices among infants and young children in Abu Dhabi, United Arab Emirates. BMC Public Health, 20, 1308. https://doi.org/10.1186/s12889-020-09393-y

SEED RESEARCH AND TECHNOLOGY MULTIPILICATION RESEARCH DIRECTORATE

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Collection of Sorghum (*Sorghum bicolor* (L.) Moench) Landraces with Preferences of Agro-pastoralist in the Arid and Semi-arid Areas of the Somali Regional State, Eastern Ethiopia

Muhyedin Mohamud[1],Mohamed Sharif Ali[2],Abdurrahman Osman[3]

Technology Multiplication and Seed Research Directorate, Somali Region Pastoral and Agro-Pastoral Research Institute, Jigjiga, Ethiopia

Abstract

*Sorghum landraces are a valuable source of genetic diversity for crop improvement and conservation. Ethiopia, especially the Somali region, has a rich and diverse sorghum gene pool that has not been fully explored. This study aimed to collect and document sorghum accessions from six zones of the Somali region, where sorghum is a major staple crop. The specific objectives of the study were: to assess farmers' selection criteria and preferences for sorghum landraces and their special uses; to evaluate the physical and physiological seed quality of sorghum landraces to facilitate their maintenance and conservation; and to collect and preserve sorghum landraces for developing potential sorghum varieties from the superior ones. A combination of primary and secondary data sources, including semi-structured questionnaires, passport data, agro-morphological traits, and seed quality parameters were used for the study. The GLM procedure of SAS software was used to analyze the data and test the effects of different variables on the sorghum landraces. The study registered 56 sorghum accessions across 11 woredas. However, only 28 of them were available and collected for further analysis. The study identified four different collective folk names for sorghum in Somali region: Hadhuudh, Yar-yare, Garow and Masango. These names are based on the general characteristics of the crop, such as the panicle and grain features, and the flour quality. The study found that the agro-pastoralists use various criteria to select and rank the sorghum landraces according to their needs and preferences. The study listed six landraces that were identified as threatened, namely Guud-cad, Dacar, Mukre, Ejjaa, Dangaashaa, and Kufa-kaas. The main reasons for their loss or replacement were bird attack, weed and drought, poor taste, low market value, long maturity period, and low biomass production. The study evaluated the seed quality of the sorghum landraces based on five parameters: physiological purity, 100 seed weight, moisture content, germination, and seed viability. The results showed that there was variability in the physiological purity and 100 seed weight of the collected sorghum landraces, ranging from 65% to 99% and from 1.5 g to 3.31 g, respectively. The study also showed that more than 75% of the sorghum seeds collected met the national standard for physiological purity (85%), while only 25% of the sorghum seeds collected met the national standard for 100 seed weight (3 g). Likewise, in terms of germination, only 67% of the samples met the national standard for sorghum seed quality, which is 85% germinatio*n *Thus, it can be concluded that the sorghum landraces in Somali region have a rich diversity and adaptation to the local conditions, but also face a serious threat of loss of biodiversity due to various biophysical, socio-economic, and cultural factors. The study recommended that more efforts should be made to collect, conserve,*

and document the sorghum landraces in the region, to understand the factors affecting their selection and utilization by the agro-pastoralists, and to improve their seed quality and availability.
Keywords: Generic resource. Sorghum landraces, Collection, Seed quality, Somali Regional State

INTRODUCTION

Landraces constitute the basic material for developing any variety with a high capacity to tolerate biotic and a biotic stress, resulting in high yield stability and an intermediate yield level under a low input agricultural system (FAO. 2014). Sorghum is one of the most important cereal crops grown in arid and semi-arid parts of the world. In Eastern Africa, more than 70% of sorghum is cultivated in the dry and hot lowlands, where water deficit is among the major production constraints (Mukuru, 1993). Ethiopia is recognized as a center of origin and diversity and has immensely contributed to the global sorghum genetic pool (Girma et al., 2019). In the lowland areas characterized by moisture stress and marginal soil, sorghum is well adapted to drought conditions and considered as a model crop (Kidanemaryam, 2019). The Ethiopian national average yield accounts for up to 2000 kg/ha (EIAR, 2014).

Crop genetic diversity is a resource that has local, national, and global significance. For many generations, farmers have drawn on hundreds of different plant genetic resources for food and agriculture to breed the major crops that feed the world today, such as sorghum. The further development of agriculture and the world's continued food security will depend on farmers and breeders having access to the plant genetic resources necessary to face new environmental and agricultural challenges.

There is a diverse gene pool for sorghum in Ethiopia in general and in the Somali region in particular. Although some collections have been done by Jigjiga University, not all the existing gene pool has been exploited from the sorghum niche of the Somali region. Of the 11 administrative zones of the region, six zones are known to be rich in sorghum landraces. Therefore, it is of paramount importance to collect the sorghum accessions from these sorghum belts of the region. This will be used for further variety development programs, such as characterization and evaluation, to identify the promising ones from the collected landraces.

The main objectives of the present study were: (1) assess farmers' selection criteria, preferred sorghum landraces, and collect information and documentation of special purposes of landraces; (2) evaluate sorghum landraces for physical and physiological quality of seeds to facilitate maintenance and conservation of farmers' preferred landraces; and (3) collect landraces to develop potential sorghum varieties from the superior landraces

MATERIALS AND METHODS

Description of the Study Area

The study area covers six zones of the Somali region in Ethiopia, where sorghum is a major crop. The study area is characterized by arid and semi-arid climatic conditions, low soil fertility, and frequent droughts. Table 1 shows the geographical characteristics of the sorghum landrace collection sites, such as longitude, latitude, and altitude. The table also indicates the zones, woredas, and kebeles where the landraces were collected. The study area ranges from 283.6 m to 1600 m in altitude, from 42° 11' 45.60" E to 44° 27' 26.28" E in longitude, and from 5° 54' 33.84" N to 9° 30' 51.01" N in latitude. The study area covers a large and diverse region of the Somali region, which is expected to have a rich and varied sorghum gene pool.

Table 1: Geographical characteristics of sorghum landrace collection sites

No.	Zones	Woredas	Kebeles	Longitude (E)	Latitude (N)	Altitude (m)
1.	Fafen	Gursum	Adade	42.5076	9.2976	1600
		Awbare	Gobyarey	43.1922	9.51417	1,000
2.	Jarer	Degahbour	Hodaale	43.6470	7.9379	919.6
		Birqod	Baka	43.7241	7.7630	820.1
3.	Korahey	Sheygoosh	Wuchiwachi	44.1014	7.2306	683.7.
		Qabridahar	Maraacato	44.4573	6.5263	706
4.	Nogob	Garbo	Ceelnuujis	42.5459	7.3'59	879
		Sagag	Har-hawd	42.7239	7.6972	693.7.
5.	Shabelle	Danan	Burqayar	43.3994	5.9346	285.7
		Cadcaadle	Biyow	43.3999	5.9094	283.6
6.	Erer	Qubi	Nasiye	42.1960	8.0960	1035

Research Methodology

This section describes the methods used to collect and analyze data on sorghum landraces in Somali region.

Data collection

The data collection was based on both primary and secondary sources. The primary data were obtained from semi-structured questionnaires administered to selected agro-pastoralists who grow sorghum landraces in different zones of the region. The questionnaires included specific standard descriptor lists developed by BPGR and ICRISAT (1993) and passport data for each landrace sample. The secondary data were derived from available guidelines, published and unpublished documents related to the subject matter of the study.

Sampling techniques

A purposive random sampling procedure was followed to select the potential areas of sorghum production in Somali region. A four-stage sampling procedure was used as follows:

- Stage 1: Six sorghum producing zones were selected based on their productivity and diversity of landraces.
- Stage 2: Eleven woredas were selected from the six zones based on the same criteria as stage 1.
- Stage 3: Thirty-three kebeles were selected from the eleven woredas based on the same criteria as stage 1 and 2.
- Stage 4: Three to five agro-pastoralists were selected from each kebele based on their experience and willingness to participate in the study.

Sorghum landrace collection

The sorghum landrace samples were collected from the selected agro-pastoralists following the baseline rules of Cuevas and Prom (2013). The seed samples were collected from three sources: farm fields, threshing grounds and farm stores, and local seed markets. The sources were chosen based on the availability and accessibility of the landraces. The samples were labeled and packed in paper bags for further analysis.

Farmers' preference for landrace selection

During each collection, the agro-pastoralists were asked the reasons why they grew each of the different landraces, the selection criteria they used, and the field size they allocated for each landrace.

Seed treatment

The seed samples were treated for physical and physiological quality parameters. The 500 g portions of seed were submitted to Somali Region Seed and Forage Enterprise Laboratory for physical and physiological evaluation. The following tests were performed:

- **Physical purity test:** The percentage composition of the seed lot was calculated based on the weight of each component. The formula used was:

$$\text{Purity (\%)} = \frac{\text{Weight of pure seed (g)}}{\text{Total weight of sample (g)}} \times 100$$

- **Hundred seed weight test**: The weight of 100 seeds was measured in grams using a digital balance.
- **Moisture content test**: The moisture content of the seed samples was determined using the oven method. The formula used was:

$$\text{Moisture content (\%)} = \frac{\text{Initial weight of sample (g)}}{\text{Weight loss after drying (g)}} \times 100$$

- **Germination test**: The germination test was conducted using the paper towel method. Seeds were placed in Petri dishes lined with moist paper towels and kept at room temperature. First and final counts were made on 5 and 9 days after planting. The formula used was:

$$\text{Germination (\%)} = \frac{\text{Number of seeds on tray}}{\text{Number of seeds germinated}} \times 100$$

- **Viability test**: Seed viability is the ability of seeds to germinate and produce healthy seedlings under favorable conditions

Statistical analysis

The data were analyzed using the GLM procedure of SAS software (SAS, 1996). The Pearson‟s correlation coefficients (r) were calculated to describe the relationship between the selection criteria of agro-pastoralists and evaluation results of sorghum landraces for yield and seed quality parameters.

RESULTS AND DISCUSSION

Indicators of passport data

The passport data of the sorghum landraces collected from the selected agro-pastoralists included the following indicators: indigenous folk names, origin, source, location, altitude, latitude, longitude, and date of collection. The passport data were used to identify and characterize the landraces and to trace their distribution and diversity in the region.

Indigenous folk names associated with sorghum seed selection

The agro-pastoralists in Somali region use four different collective folk names to refer to sorghum: *Hadhuudh, Yar-yare, Garow and Masango*. These names are based on the general characteristics of the crop, such as the shape and size of the panicle, the color and texture of the grain, and the taste and quality of the flour. Within these four groups, the agro-pastoralists have identified 56 distinct sorghum landraces that are predominantly produced in the region (Table 3). Each landrace has its own specific varietal name that helps the agro-pastoralists to describe, identify and distinguish it from others. The varietal names are derived from various sources, such as:

- Morphological attributes, such as *Car-i-Liq* (meaning “red ear”), which has a red-colored panicle.
- Agronomic attributes, such as *Adan-gaab* (meaning “tall”), which has a high plant height, and *Dhow-dhow* (meaning “early”), which has a short maturity period.
- Seed color, such as *Hadhuudh cad* (meaning “white sorghum”), *Hadhuudh cas* (meaning “black sorghum”), and *Guud-cad* (meaning “gray sorghum”).
- Taste, such as *Dacar* (meaning “sweet”), which has a sweet flavor.
- Name of the model agro-pastoralist who introduced the landrace to the particular location, such as *Ahmedcumer, Ahmednasir, Axmadsay, Faaraxgasle*, and *Cabdidayr.*
- Panicle type, such as *Kor-u-seydhe* (meaning “spike-like”), which has a compact and cylindrical panicle.
- Original source of the material, such as *Mansugi* (meaning “from Sudan”), *Fandishe* (meaning “from Ethiopia”), *Maamo-ture* (meaning “from Somalia”), and *Dangaashaa* (meaning “from Kenya”).

The folk names of the sorghum landraces reflect the rich knowledge and experience of the agro-pastoralists in selecting and managing the crop. They also indicate the diversity and adaptation of the landraces to the environmental conditions and cultural preferences of the region.

Agro-pastoralist landrace selection criteria

The agro-pastoralists use various criteria to select and rank the sorghum landraces according to their needs and preferences. The selection criteria reflect the range of cultural and agronomic practices, ecological, biological and dietary needs each agro-pastoralist desire to obtain from available resources. The selection criteria include broad generalists and specialist sorghum types endowed with desirable attributes, such as:

- ✓ Seed size, which affects the yield and quality of the grain and flour.
- ✓ Seed color, which influences the aesthetic and nutritional value of the product.
- ✓ Taste, which affects the palatability and acceptability of the food.
- ✓ Grain yield, which affects the food security and income of the household.
- ✓ Resistance/ Susceptibility to bird attack, which affects the crop protection and loss.
- ✓ Stalk quality, which affects the sugar content and the use of the stalk as animal feed or food for human.
- ✓ Biomass production, which affects the availability of fodder for livestock.
- ✓ Threshability, which affects the ease and cost of post-harvest processing.
- ✓ Medicinal value, which affects the health and well-being of the family and community.
- ✓ Maturity period, which affects the cropping system and the intercropping options.
- ✓ Market value, which affects the demand and price of the product.
- ✓ Milling quality, which affects the extraction and recovery of the flour.

Table 2: Recorded agro-pastoralist selection criteria for sorghum landraces

No.	**No. of accessions**	**Agro-pastoralist preference**					
		Seed size	**Seed color**	**Maturity (M)**	**Taste**	**Yield (Qt)**	**Others**
1.	SoRPARI/SrL/N/2/3/18th	2	4	5	2	18	High yielder but

							susceptible to bird attack
2.	SoRPARI/SrL/SH/3/4/19th	1	5	6	2	18	Sweet stalk and high yielder
3.	SoRPARI/SrL/SH/4/5/20th	3	4	4	1	18	Low yield and bird susceptible
4.	SoRPARI/SrL/SH/4/5/21th	3	2	6	5	22	Biomass production and threshability
5.	SoRPARI/SrL/Q/5/6/22th	1	1	7	1	18	Medicinal value and livestock feed
6.	SoRPARI/SrL/Q/6/7/23th	1	4	6	1	18	High yielder and bird resistance
7.	SoRPARI/SrL/J/7/8/24th	1	1	3	1	18	Early mature but susceptible to bird attack
8.	SoRPARI/SrL/J/7/8/25th	2	4	4	2	20	High yielder and bird resistance
9.	SoRPARI/SrL/J/8/9/26th	3	2	6	5	18	Biomass production and livestock feed
10.	SoRPARI/SrL/J/8/9/27th	1	3	5	1	22	Medicinal value and Biomass production
11.	SoRPARI/SrL/F/0/1/1st	1	3	5	1	25	Milling quality

12.	SoRPARI/SrL/F/0/1/2nd	2	3	7	1	20	Biomass production
13.	SoRPARI/SrL/F/0/1/3rd	1	5	7	1	21	High yielder and bird resistance
14.	SoRPARI/SrL/F/0/1/4th	1	1	7	1	24	Biomass production and threshability
15.	SoRPARI/SrL/F/0/1/5th	2	3	5	1	20	Market value Medicinal value
16.	SoRPARI/SrL/F/0/1/6th	2	3	5	1	22	Market value Medicinal value
17.	SoRPARI/SrL/F/0/1/7th	3	2	7	5	23	Biomass production
18.	SoRPARI/SrL/F/0/1/8th	2	2	6	5	20	Biomass production for livestock feed
19.	SoRPARI/SrL/F/0/1/9th	2	4	5	5	22	Bird resistance
20.	SoRPARI/SrL/F/0/1/10th	1	1	4	2	22	Market value and Medicinal value
21.	SoRPARI/SrL/F/0/1/11th	1	4	5	1	18	Market value and Medicinal value
22.	SoRPARI/SrL/F/0/1/12th	2	1	5	5	20	Low resistance
23.	SoRPARI/SrL/F/0/1/13th	1	1	5	1	18	Market value and Medicinal value
24.	SoRPARI/SrL/F/0/1/14th	2	4	3	1	20	Early maturity
25.	SoRPARI/SrL/F/0/1/15th	2	4	3	1	20	Early maturity
26.	SoRPARI/SrL/F/0/1/16th	2	4	3	1	20	Early maturity
27.	SoRPARI/SrL/F/0/1/17th	2	4	3	1	18	Early maturity

The selection criteria were recorded using a scoring system, where the taste was recorded 1 = very good, 2 = good, 3 = average, 4 = poor, and 5 = very poor. The seed size was recorded as 1 = big, 2 = medium, and 3 = small. The seed color was recorded as 1 = good, 2 = black, 3 = brown, 4 = red, and 5 = gray.

The scoring results show that the agro-pastoralists have different preferences and priorities for the sorghum landraces. Some landraces are preferred for their high yield and bird resistance, such as SoRPARI/SrL/N/1/2/17th and SoRPARI/SrL/Q/6/7/23th. Some landraces are preferred for their sweet stalk and high biomass production, such as SoRPARI/SrL/SH/3/4/19th and SoRPARI/SrL/J/8/9/26th. Some landraces are preferred for their medicinal value and high biomass production, such as SoRPARI/SrL/Q/5/6/22th and SoRPARI/SrL/J/8/9/27th. Some landraces are preferred for their early maturity and milling quality, such as SoRPARI/SrL/J/7/8/24th and SoRPARI/SrL/F/0/1/1st. The agro-pastoralists also consider the seed size, seed color, maturity, and taste of the landraces as important factors for their selection. The diversity of the selection criteria reflects the diversity of the sorghum landraces and the diversity of the agro-pastoralists' needs and preferences.

Sorghum landrace diversity

This section presents the results of the sorghum landrace diversity assessment in different woredas of Somali region, Ethiopia. The assessment was based on passport data, agro-morphological traits, and seed quality parameters.

Landrace richness and distribution

The passport data of the sorghum landraces collected from the selected agro-pastoralists included the following indicators: indigenous folk names, origin, source, location, altitude, latitude, longitude, and date of collection. The passport data were used to identify and characterize the landraces and to trace their distribution and diversity in the region.

Table 3 shows the landrace richness at each woreda, based on the number of recorded and collected landraces. A total of 56 sorghum accessions were registered across the 11 woredas, belonging to the *Guinea, Bicolor, Caudatum, Kafir and Durra* races. However, only 28 of them were available and collected for further analysis. The highest number of recorded landraces (21) was found in Gursum woreda, followed by Awbare woreda of Fafen zone (7), and Qubi woreda of Erer zone (4). The rest eight woredas recorded 3 landraces each. The highest number of collected landraces (17) was also found in Gursum woreda, followed by Cadaadle woreda (2), Birqod (2), and Dagahbour (2). No landraces were collected from Awbare and Qubi woredas.

Table 3: Landrace richness at each Woredas

No.	Name of zones	Name of woredas	Code of collection sites	Number of Recorded	Local names of of landraces	Collected landrace
1.	Fafen	Gursum	Adade	21	Bullo, Mansugi, Cilmijaamac, Casse, Wagare, Axmadsay, Kufaa-kaas,Guud-cad, Car-i-Liq, Dhowdhow, Faaraxgasle, Dhaga-Adag, Fandishe, Cabdidayr, Eles. Maalmo-raag(Soole) (Maamo-ture), Dacar, Kor-u-seydh (Shaqqee), Mukre, Ejjaa and Dangaashaa,	17
		Awbare	Gobyarey	7	Adangaab; Mukre; Cilmijaamac; Caqlibadan; Guudcad, Case and Kor u saydhe	0
2.	Jarer	Dagahbour	Hodaale	3	Hadhuudhcas, Hadhuudh cad and Kufa-kaas	2
		Birqod	Baka	3	Hadhuudhcas, Hadhuudh cad and Kufa-kaas	2
3.	Korahey	Sheygoosh	Wuchiwachi	3	Hadhuudhcas, Hadhuudh cad and Kufa-kaas	1
		Qabridahar	Maraacato	3	Hadhuudhcas, Hadhuudh cad and Kufa-kaas	1
4.	Nogob	Garbo	Ceelnuujis	3	Hadhuudhcas, Hadhuudh cad and Kufa-kaas	1
		Sagag	Har-hawd	3	Hadhuudhcas, Hadhuudh cad and Kufa-kaas	1
5.	Shabelle	Danan	Burqayar	3	Hadhuudhcas, Hadhuudh cad and Kufa-kaas	1
		Cadaadle	Biyolow	3	Hadhuudhcas, Hadhuudh cad and Kufa-kaas	2
6.	Erer	Qubi	Nasiye	4	Hadhuudhcas, Hadhuudh cad, HadhudhandKufa-kaas	0
7.	**Total**			**56**		**28**

The variability in the types of sorghum grown by agro-pastoralists both within and between the woredas indicates the diversity and adaptation of the landraces to the local conditions. However, the low availability and collection of some landraces also suggests the risk of loss of genetic

diversity due to various factors, such as environmental and demographic stochasticity, genetic drift and inbreeding (Caughey 1994).

Loss of biodiversity

The loss of biodiversity of sorghum landraces is a serious threat to the food security and livelihoods of the agro-pastoralists in the region. The loss of biodiversity can be caused by various factors, such as:

- Biophysical factors, such as drought, pests, diseases, and weeds, which can reduce the yield and quality of the crop and increase the cost of production and protection.
- Socio-economic factors, such as market demand, price, and policy, which can influence the preference and profitability of the crop and affect the seed supply and distribution systems.
- Cultural factors, such as taste, tradition, and knowledge, which can affect the acceptance and utilization of the crop and its products and influence the seed selection and management practices.

Table 4 shows the list of threatened landrace sorghum and the reason for their loss or replacement by other crops. Six landraces were identified as threatened, namely *Guud-cad, Dacar, Mukre, Ejjaa, Dangaashaa, and Kufa-kaas.* The main reasons for their loss or replacement were:

- Susceptibility to bird attack, which makes the crop susceptible to damage and loss by birds, especially during the ripening stage.
- Weed and drought, which compete with the crop for water and nutrients and reduce the yield and quality of the crop.
- Poor taste for food, which affects the palatability and acceptability of the crop and its products by the consumers.
- Low market value, which affects the demand and price of the crop and its products and reduces the income and incentive of the producers.
- Long maturity period, which prolongs the cropping cycle and increases the risk of drought and pests.
- Low biomass production for livestock feed, which reduces the availability and quality of animal feed and affects the productivity and profitability of the livestock sector.

The agro-pastoralists' choice of sorghum landrace and the probable cause for their loss or replacement by other crops are influenced by the ecological and socio-economic factors that affect the performance and value of the crop. Ecological theories with regard to the risk of extinction, either locally or totally, have been constructed primarily in the context of wild populations. However, the same principles can be applied to the cultivated populations, as the preference of individual agro-pastoralists and how these interests can be expected to influence the risk of loss of specific landraces.

Table 4: Threatened landrace sorghum and reason for accession lost

No	**Threatened accessions**	**Reasons of loss**	**Remark**
1.	Guud-cad,	Susceptible to bird attack, low tolerance to weed and drought	Not under production
2.	Dacar	Poor taste	Not under production
3.	Mukre	Poor taste and low market value	Not under production
4.	Ejjaa	Poor taste and susceptible to bird attack	Not under production
5.	Dangaashaa	Long maturity period and poor taste	Not under production
6.	Kufa-kaas	Susceptible to bird attack, low biomass yield for livestock, low tolerance to weed and drought	Not under production

The agro-pastoralists' choice of sorghum landrace and the probable cause for their loss or replacement by other crops are influenced by the ecological and socio-economic factors that affect the performance and value of the crop. Ecological theories with regard to the risk of extinction, either locally or totally, have been constructed primarily in the context of wild populations. However, the same principles can be applied to the cultivated populations, as the preference of individual agro-pastoralists and how these interests can be expected to influence the risk of loss of specific landraces.

Seed Quality

The seed quality of the sorghum landraces collected from the agro-pastoralists was evaluated based on five parameters: Germination, viability, moisture content, physiological purity and 100

seed weight. These parameters are important for the seed production, storage and distribution systems, as they affect the seedling establishment, crop growth and yield.

Germination, Viability and Moisture content

The results indicate that there is a wide variation in seed quality among the samples. The highest germination and viability were observed in SoRPARI/SrL/J/7/8/24th and SoRPARI/SrL/J/7/8/25th, both with 98% germination and 86% and 89% viability, respectively. The lowest germination and viability were observed in SoRPARI/SrL/F/0/1/17th, with 45% germination and 33% viability. The moisture content ranged from 9.5% to 14%, with most samples having around 11% to 13%.

The result reveals that some of the samples did not meet the national standard for sorghum seed quality in Ethiopia, which is 75% germination. Only 23 out of 28 samples (85%) met this standard. The low germination and viability of some samples could be due to various factors, such as poor harvesting, handling, storage, or pest infestation. Low seed quality could pose a threat to food security in the region, as it could affect the yield and quality of the crop. It is also important to note that not all seeds with high viability are equally good, as some may have deteriorated over time and may not perform well in the field.

Table-5: Germination, Viability and grain moisture content of sorghum landrace samples collected from agro-pastoralist

S/N	No. of accessions	Germination (%)	Viability (%)	Moisture content (%)
1	SoRPARI/SrL/N/1/2/17th	65%	57	10.0%
	SoRPARI/SrL/N/2/3/18th	88%	79	11.4%
2	SoRPARI/SrL/SH/3/4/19th	68%	68	10.6%
	SoRPARI/SrL/SH/4/5/20th	85%	76	11.7%
	SoRPARI/SrL/SH/4/5/21th	85%	73	10.5%
3	SoRPARI/SrL/Q/5/6/22th	84%	76	11.6%
	SoRPARI/SrL/Q/6/7/23th	94%	84	11.5%
4	SoRPARI/SrL/J/7/8/24th	98%	86	11.5%
	SoRPARI/SrL/J/7/8/25th	98%	89	10.9%
	SoRPARI/SrL/J/8/9/26th	78%	70	10.3%
	SoRPARI/SrL/J/8/9/27th	68%	65	10.1%
	SoRPARI/SrL/F/0/1/1st	86%	75	14%
	SoRPARI/SrL/F/0/1/2nd	85%	75	13.2%
	SoRPARI/SrL/F/0/1/3rd	75%	76	11%
	SoRPARI/SrL/F/0/1/4th	80%	69	12.9%
	SoRPARI/SrL/F/0/1/5th	86%	73	13%
	SoRPARI/SrL/F/0/1/6th	92%	75	14%
	SoRPARI/SrL/F/0/1/7th	95%	74	13.9%
	SoRPARI/SrL/F/0/1/8th	95%	72	13.6%
	SoRPARI/SrL/F/0/1/9th	95%	76	12.9%
	SoRPARI/SrL/F/0/1/10th	99%	77	13%
	SoRPARI/SrL/F/0/1/11th	96%	76	12.5%
	SoRPARI/SrL/F/0/1/12th	85%	76	12.2%
	SoRPARI/SrL/F/0/1/13th	89%	76	12.5%
	SoRPARI/SrL/F/0/1/14th	85%	76	11.5%
	SoRPARI/SrL/F/0/1/15th	61%	53	12.3%
	SoRPARI/SrL/F/0/1/16th	97%	73	13.5%
	SoRPARI/SrL/F/0/1/17th	45%	33	9.5%

Physiological purity and 100 seed weight

Table 6 shows the results of the physiological purity and 100 seed weight tests of the sorghum landrace seed samples obtained from the agro-pastoralists. The physiological purity test measures the percentage of pure seeds in a seed lot, excluding any inert matter, weed seeds, or other crop seeds. The 100 seed weight test measures the weight of 100 seeds in grams, which reflects the size and quality of the seeds.

The results showed that there was variability in the physiological purity and 100 seed weight of the collected sorghum landraces. The physiological purity ranged from 65% to 99%, with a mean of 88%. The 100 seed weight ranged from 1.5 g to 3.31 g, with a mean of 2.41 g. The lowest physiological purity and 100 seed weight were observed in SoRPARI/SrL/F/0/1/17th, while the highest physiological purity and 100 seed weight were observed in SoRPARI/SrL/F/0/1/10th.

The physical purity analysis indicated that the major impurity observed in the collected samples was the contamination with panicle residue and other crop seeds. The results of the seed quality test revealed that more than 75% of the sorghum seeds collected met the national standard for physiological purity (85%), while only 25% of the sorghum seeds collected met the national standard for 100 seed weight (3 g). This proportion of seed with inadequate quality can lead to poor crop stand and generation of inferior seed quality.

Table-6: Physical purity and 100 seed weight of sorghum landrace seed samples obtained from agro-pastoralist

S/N	No. of accessions	Physiological purity (%)	100 Seed Weight (g)
1.	SoRPARI/SrL/N/1/2/17th	89%	2.45
2.	SoRPARI/SrL/N/2/3/18th	98%	2.85
3.	SoRPARI/SrL/SH/3/4/19th	75%	2.62
4.	SoRPARI/SrL/SH/4/5/20th	82%	2.94
5.	SoRPARI/SrL/SH/4/5/21th	98%	2.35
6.	SoRPARI/SrL/Q/5/6/22th	94%	2.62
7.	SoRPARI/SrL/Q/6/7/23th	88%	2.71
8.	SoRPARI/SrL/J/7/8/24th	72%	2.62
9.	SoRPARI/SrL/J/7/8/25th	98%	2.9
10.	SoRPARI/SrL/J/8/9/26th	97%	2.85
11.	SoRPARI/SrL/J/8/9/27th	58%	2.43
12.	SoRPARI/SrL/F/0/1/1st	96%	3.11
13.	SoRPARI/SrL/F/0/1/2nd	85%	2.89
14.	SoRPARI/SrL/F/0/1/3rd	75%	2.45
15.	SoRPARI/SrL/F/0/1/4th	80%	2.9
16.	SoRPARI/SrL/F/0/1/5th	86%	2.75
17.	SoRPARI/SrL/F/0/1/6th	92%	2.86
18.	SoRPARI/SrL/F/0/1/7th	95%	2.75
19.	SoRPARI/SrL/F/0/1/8th	95%	2.82
20.	SoRPARI/SrL/F/0/1/9th	95%	3.12
21.	SoRPARI/SrL/F/0/1/10th	99%	3.31
22.	SoRPARI/SrL/F/0/1/11th	96%	2.95
23.	SoRPARI/SrL/F/0/1/12th	93%	2.78
24.	SoRPARI/SrL/F/0/1/13th	99%	2.74
25.	SoRPARI/SrL/F/0/1/14th	75%	2.89
26.	SoRPARI/SrL/F/0/1/15th	98%	2.65
27.	SoRPARI/SrL/F/0/1/16th	89%	2.4
28.	SoRPARI/SrL/F/0/1/17th	65%	1.5

Correlation Analysis

Correlation is used to find degree and direction of relationship between two or more variables. The table below (Table 7) shows the Pearson correlation coefficients between six variables related to the yield and seed quality of sorghum landraces: yield, seeds viability, hundred seeds weight, seeds germination, seed moisture content, and physical purity of seeds. Based on the table, we can infer that some variables are more important than others for the yield and seed quality of sorghum landraces. Yield has a significant negative correlation with physical purity of seeds ($r = -0.429$, $p < 0.05$). This means that as the yield increases, the physical purity of seeds

tends to decrease. This could be due to the fact that higher yield may result from higher plant density, which may increase the chances of contamination by weeds or other plants. Seed viability has a very strong and significant positive correlation with seeds germination ($r = 0.802$, $p < 0.01$). This means that as the seeds viability increases, the seeds germination also tends to increase. This is expected; as seeds viability is a measure of how likely the seeds are to germinate under optimal conditions. This also indicates that these two traits are highly related and can be used as indicators of seed quality.

Hundred seeds weight has a moderate and significant positive correlation with seed germination ($r = 0.449$, $p < 0.05$) and seed moisture content ($r = 0.489$, $p < 0.01$). This means that as the hundred seeds weight increases, the seeds germination and seed moisture content also tend to increase. This could be due to the fact that larger seeds have more reserves of energy and water, which may enhance their germination performance. Seeds germination has a strong and significant positive correlation with Seed moisture content ($r = 0.517$, $p < 0.01$). This means that as the seeds moisture content increases, the seed germination also tends to increase. This is logical, as seeds germination requires a certain amount of water to activate the metabolic processes of the seeds.

Table-7: Association (Pearson correlation) of the selection criteria of agro-pastoralists and evaluation results of sorghum landraces for yield and seed quality parameters

	Yield (qt)	SV (%)	100SW (g)	SG (%)	SMC (%)	SPP (%)
Yield (qt)	**1**	-0.157	0.008	-0.181	0.091	-.429*
SV (%)		**1**	0.322	.802**	0.121	0.072
100SW (g)			**1**	.449*	.489**	0.385
SG (%)				**1**	.517**	0.395
GMC (%)					**1**	.408*
SPP (%)						**1**

*and ** significant at the 0.05 and 0.01 levels, respectively, in two tailed correlation. Yield (qt) = Grain yield in quintal, SV (%) = Percentage of seeds viability, 100SW (g) = Hundred seeds weight in gram, SG (%) = Percentage of seeds germination, SMC= Seed moisture content (%), and SPP (%) = Percentage of physical purity of seeds.

CONCLUSION AND RECOMMENDATIONS

This study examined the diversity and quality of sorghum landraces in Somali region, Ethiopia, and the factors influencing their conservation and use. The study collected and analyzed data from various sources, such as questionnaires, passport data, agro-morphological traits, and seed quality parameters. The study found 56 sorghum accessions across 11 woredas, but only 28 were available and collected for further analysis. The study also identified four collective folk names and 56 distinct varietal names for sorghum in the region, based on different characteristics of the crop. The study revealed that the agro-pastoralists have diverse criteria and preferences for selecting and ranking the sorghum landraces, such as yield, bird resistance, stalk quality, biomass production, threshability, medicinal value, maturity period, market value, and milling quality. The study listed six landraces that were threatened by various biophysical, socio-economic, and cultural factors, such as bird attack, weed and drought, poor taste, low market value, long maturity period, and low biomass production. The study assessed the seed quality of the sorghum landraces using five parameters: physiological purity, 100 seed weight, moisture content, germination, and viability. The study showed that there was variability in the seed quality of the sorghum landraces, and that some of them did not meet the national standards. The study suggested that the low seed quality was due to poor seed production, storage, and distribution practices, and that it could affect the seedling quality and the landrace characterization and evaluation.

Based on the findings, the following recommendations are made for future research and practice:

- More efforts should be made to collect, conserve, and document the sorghum landraces in Somali region, especially those that are threatened or rare.
- More studies should be conducted to understand the factors affecting the selection and utilization of the sorghum landraces by the agro-pastoralists in Somali region.
- More interventions should be implemented to improve the seed quality and availability of the sorghum landraces in Somali region.
- further research should be conducted to identify the agronomic and adaptive traits of the landraces, as well as their potential for developing new sorghum varieties

REFERENCES

Bahmankar, M., Raij, M.R., Seloki, A.R. and Shirkool, K., 2014. Assessment of broad sense heritability and genetic advance in safflower. Int. J. of Biosciences, 4(8), pp.131-135.

BPGR, I., 1993. Descriptors for sorghum [Sorghum bicolor (L.) Moench]. International Board for Plant Genetic Resources, Rome, Italy, p.432.

Central Statistical Agency (CSA) (2018) The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey. Report on Area and Production of Crops. Statistical Bulletin No. 586. Addis Abeba, Ethiopia.

Cuevas, H.E. and Prom, L.K., 2013. Assessment of molecular diversity and population structure of the Ethiopian sorghum [Sorghum bicolor (L.) Moench] germplasm collection maintained by the USDA–ARS National Plant Germplasm System using SSR markers. Genetic Resources and Crop Evolution, 60, pp.1817-1830.

De Wet JMJ, Harlan J 1971. The origin and domestication of Sorghum bicolor. Economic Botany 25: 128135.

Demissie, A., Engels, J.M.M., Hawkes, J.G. and Worede, M., 1991. A decade of germplasm exploration and collecting activities by the Plant Genetic Resources Centre/Ethiopia. Plant genetic resources of Ethiopia, p.202.

EIAR (2014). Ethiopia Strategy for Sorghum. Retrieved from https://www.kstate.edu/smil/docs/country_resources/Ethiopian%20Strategy%20for %20Sorghum.pdf.

FAO, 2014. Genebank Standards for Plant Genetic Resources for Food and Agriculture. Rev. ed. FAO, Rome.

Girma G, Nida H, Seyoum A, Mekonen M, Nega A, Lule D, Dessalegn K, Bekele A, Gebreyohannes A, Adeyanju A, Tirfessa A, Ayana G, Taddese T, Mekbib F, Belete K, Tesso T, Ejeta G and Mengiste T (2019a). A Large-Scale Genome-Wide Association Analyses of Ethiopian Sorghum Landrace Collection Reveal Loci Associated with Important Traits. Frontiers in Plant Science 10:691.

Kidanemaryam W (2019). Review on Mechanisms of Drought Tolerance in Sorghum (Sorghum bicolor (L.) Moench) Basis and Breeding Methods. Academic Research Journal of Agricultural Science Research 7(2):87-99.

McGuire JS (2008). Securing Access to Seed: Social Relations and Sorghum Seed Exchange in Eastern Ethiopia. Hum. Ecol. 36:217229.

Mekbib F, Bjornstad A, Sperling L, Synnevag G (2009). Factors shaping on-farm genetic resources of sorghum (Sorghum bicolor (L.) Moench) in the centre of diversity, Ethiopia. International Journal of Biodiversity and Conservation 1(2):45-59

Mukuru, S.Z., 1993. Sorghum and millet in Eastern Africa. Sorghum and Millets Commodities and Research Environment.(Byth, DE, ed.). Patancheru, 502(324), pp.55-62.

Semahegn, Z. and Teressa, T., 2021. Review of highland sorghum improvement research in Ethiopia. International Journal of Agricultural Science and Food Technology, 7(3), pp.335-340.

Shiferaw, W. and Yoseph, T., 2014. Collection, characterization and evaluation of sorghum (Sorghum bicolor (L.) Moench) landraces from South Omo and Segen people's zone of South Nation Nationality Peoples Region, Ethiopia. International Research Journal of Agricultural Science and Soil Science, 4(4), pp.76-84.

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Collective Actions in Agro-pastoral Communities of Shabelley Woreda, Somali Region

Mahdi Egie

Tel: +251915 751574, e-mail: mahdiege@gmail.com

Research Extension and Communication Directorate

Somali Region Pastoral and Agro-pastoral Research Institute

Abstract

Collective action is organized when greater benefits are expected through joining a group than acting individually. Collective action enables to achieve goals that individuals could not meet in isolation. This study is conducted to identify type's collective actions practiced by agro-pastoral communities and to explore management of collective actions in Shabelley woreda. The selection of Shebelly woreda and agro-pastoralists who took part in the focus group discussions was done purposively. From shabelley Wereda six Kebeles were selected randomly. Data were collected through focus group discussions and data were analysed through narration. Five types of collective actions were identified. These include construction and management of ponds and water wells, collective herding, labor sharing groups (guus), milk collection and marketing groups, and mag-paying groups (a collective responsibility for paying blood compensation). Each of the collective actions consists of joint decisions, designing management rules and setting rules of conduct of group members. Whenever, agro-pastoral communities establish informal organization in a group, they establish institutions and the institutions are enforced by elders. The government need to support collective actions and their institutions, since the collective actions has a great role in development and conflict resolution.

Key words: agro-pastoral, collective actions, institutions, elders

INTRODUCTION

Collective action can be defined as voluntary action taken by a group to achieve common interests. Members can act directly on their own (internally initiated) or through an organization (externally initiated) (DiGregorio *et al.,* 2008). Moreover, collective action requires the involvement of a group of people, shared interest within the group and it involves some kinds of common action which works in pursuit of that shared interest. Further, the action should be voluntary which distinguishes collective action from hired labor. Collective action is organized

when greater benefits are expected through joining a group than acting individually. collective action enables to achieve goals that individuals could not meet in isolation. This implies a conscious working together, such as in investing in a resource or excluding outsiders from using it. Collective action might differ depending on the specific objective of collective action. In the literature, collective action has been described as taking various forms including the development of institutions, resource mobilization, coordination activities and information sharing, collective decision-making, setting rules of conduct of a group and designing management rules, implementing decision, and monitoring adherence to rules (Meinzen-Dick *et al.,* 2004). Collective action and networks among community members can facilitate access to information and even allow farmers to participate in technology development (Ostrom, 2004).

Collective action is fundamental to the advancement of the welfare and rights of smallholder farmers. There are many different types of groups: producer organizations, self-help groups, cooperatives, marketing associations, etc. They may be loose and informal (e.g., for extension or information dissemination) or formal, with specific rules, regulations and structures. They may have single functions (such as sharing information or marketing produce) or many (purchasing inputs, organizing production, managing equipment, savings and loans, etc.). Collective action networks and associations can also help mitigate the effects of shocks that affect households, such as illness (Bernier and Meinzen-Dick 2014). For smallholders and other marginalized groups in rural areas, collective action can secure more equitable access to labour, land, commodity and financial markets, and stimulate the development of more responsive and accountable state institutions (OECD 2012). Collective action provides platforms for farmers to discuss issues, set priorities, make decisions, organize activities and develop leadership skills. When farmers are organized in groups, it is easier for capacity-building initiatives to target them rather than approaching them as individuals. Training can be better targeted by involving the group to identify its own needs, and more effective because of the mutual learning and reinforcement among members. When it comes to marketing groups, by pooling their produce and selling in bulk, members can get the volumes needed to attract buyers, sell to new markets, and negotiate for higher prices. Groups can also be eligible to apply for loans, buy bulk inputs, and get other business services that are not open to individuals (KIT, Agri-ProFocus and IIRR. 2012).

In Ethiopia, farm households conduct their day-to-day activities individually and in groups in a synchronized manner. Labor demanding activities such as ploughing, and harvesting are usually undertaken in informal but well-structured groups. In addition to agriculture, saving and credit, marketing, funerals, and festivals do involve gatherings of selected group of people with favors reciprocated more often than not. Farm households in rural Ethiopia have rich experience with group efforts including cooperatives, iddir, senbete, wonfel, debo, and equb. These formal and informal institutions can all be considered as collective actions although in some cases these institutions are imposed upon the communities (Girma et al., 2020).

Collective action activities are a common feature in rural areas of the Somali Regional State. Some of the widely practiced collective actions include construction and management of ponds and water wells, collective herding, labor sharing groups (*guus*), funeral associations, and *mag*-paying groups (a collective responsibility for paying blood compensation). Each of the collective actions consists of joint decisions, designing management rules and setting rules of conduct of group members (Mahdi, 2011). Therefore, this study is conducted to identify types collective actions practiced by agro-pastoral communities and to explore management of collective actions in Shabelley *woreda*.

RESEARCH METHODOLOGY

The study area

Shabelley woreda is one of the woredas in the Fafen Zone of Somali Regional State. Shabelley is bordered on the south by Kebri Beyah, on the southwest by Gursum, on the northwest by the Tuli Guled, and on the north by Harorays. The climate is semi-arid type which is characterized by high temperature. The mean annual rainfall in the area ranges from 600 to 700 mm. Agro-pastoralism is the dominant production system (raising both crops and livestock). Agro-pastoralists mainly produce sorghum, maize and chat. Sorghum is the main staple food of rural people. *Guus* is the principal labor arrangement used to ensure all farmers are able to plough and cultivate their land. They rear camel, cattle and shoats. The major feed sources for the livestock are communal and private pasture, and crop residue. Income is mainly from crop and livestock production. Households rely on different markets for the sale and purchase of

specific items. The potential market area is Jigjiga town where households sale crops and livestock, charcoal and some labor; and buy improved seeds, fertilizers and farm implements. Small ruminants (sheep and goats) are sold to meet immediate cash need whereas milk is consumed by the household. The surplus milk is sold or converted to butter. Camels, Oxen (Bulls) and donkeys are used as a draft power.

Sampling, data collection and data analysis

This study was entirely qualitative research. The selection of *woreda* and agro-pastoralists who took part in the focus group discussions was done purposively. From shabelley *Wereda* six *Kebeles* such as *Hadew, Shebelley, Amadle, Hodley, Yoosle, and Dumduma-as* were selected randomly. In each of these *Kebeles*, three to four focus group discussions were held with nine members in each group at a time (in the entire data collection period 160 persons were participated in focus group discussions). Snowball sampling technique was also used while conducting key informant interviews. The qualitative data were analyzed using narrative and ethnographic analysis. This was done through engagement of the researcher in the fieldwork and in the various data collection techniques.

RESULTS AND DISCUSSION

Collective action activities are a common feature in rural areas of the Shebelley woreda. Five types of collective actions are widely practiced. These include construction and management of ponds and water wells, collective herding, labor sharing groups (*guus*), milk collection and marketing groups, and *mag*-paying groups (a collective responsibility for paying blood compensation). Each of the collective actions consists of joint decisions, designing management rules and setting rules of conduct of group members, which are discussed in detail below.

Constructing and Managing Ponds and Water Wells

In the study area, there was no potable water for human consumption, and hence rural people depend on shallow water sources. So, people living this area used to harvest water by digging shallow wells near seasonal rivers for the consumption of both human and livestock. Moreover,

where adequate groundwater is available, communities dig deep wells. This practice was a persisted activity of the people for generations. Members of the community employ collective labor to construct and maintain communal ponds and engaged in such activities like silt removal, channel cleaning and fencing (to prevent their use by unauthorized strangers). In case of water wells, they dig in depth and cover the wall by wood to prevent the collapse of the well, cover the top of the well with strong materials such as logs/bricks to prevent silt and sands entering into it during rainy seasons, and assign well monitors. Under effective management, ponds can retain water both for human and livestock use for about eight months after the heavy rainy season while water wells can sustain water for years.

In the course of constructing and maintaining ponds, the cooperation of all the able-bodied men of the settlements who use them is required. Days are planned for the work and men of the local settlements are called to assist. Men provide labor and women prepare meals and drinks for working men. A failure to assist without a reasonable cause will result in verbal warning and in payment of fines is in the form of live-animals. Warning follows a day absence from group work, but if a member is repeatedly absent, other members impose fines. Then, the absentee is forced to provide a live-animal, which is slaughtered and eaten by all members who have been working on construction of the pond. The sanction of slaughtering an animal from a man's herds for his non-cooperation is usually called *yakays*. Similarly, a household that fails to contribute to the construction of common-pool of pond, which the laborers share at mid-day are liable to punishment.

Once the construction of pond or water well is finalized and water is accumulated, every member of the community has the right to water. Members practice much in encouraging for contribution rather than excluding from utilization. For watering animals, usually a rule is developed by community elders. Mostly the common rule in prioritizing the watering is based on first-come-first-served. Similar result is obtained by Fekadu and Korf (2008). These arrangements are locally known as *Kaalaysi*. Such schedules are strictly followed by herders and any one violating it is punished. The punishment is usually in the form of temporary suspension of use rights. In case of members of another clan, other than the owners, come in search of water, they are given precedence in reciprocal arrangement established with their clan. Anyone refusing to give

precedence for the guests will face social exclusion from his clan members, branded as "ridiculous" and receive stiff punishments.

Collective Herding

Collecting herding is the formation of herd tending group in which a group of herders keep its livestock jointly to graze on the pastures, to prevent animals from predators attack and matching of available pasture resources at a particular site with animals. Collective herding is also serves for confronting and addressing security risks related to theft and conflict over resources. Naess (2021) reported similar result. Thus, movement of animals is a classic strategy to exploit the special and temporal variation in resource availability resulting from uneven distribution of rainfall. When herds are moved opportunistically to follow the rains, they gain access to a more balanced pasture supply than if they were kept in one area. Collective tracking with livestock to feed and water is less costly than bringing feed and water to livestock, because of lower labor demand. Members share labor and the formed group moves with herd distant from the residence to graze livestock, sometimes move beyond their own grazing territory. The formation of the group creates the feeling of being secured.

Before going for collective herding, the herd is divided into two: the lactating and the non-lactating or dry animals. The lactating animals and young stock are left for the family under the supervision of female and young children, while the management of the remaining livestock is taken by young men i.e. the herding group and move to where good pasture is available. This strategy allows the seasonal resting of dry-season pastures around the permanent residence. In case the household does not have a young man who joins the herding group, the responsibility of managing the herd is given to a hired herder. This procedure is known as *xidhaale*. A hired herder receives full package of clothing (*arad bax*) consisting of a pair of shoes, shirts, and a sheet, which he uses for the period of herding in group.

Labor Sharing Group

The main task of men, in crop production, is ploughing, weeding and harvesting, and leading the daily activities of the household. Women do household activities like cooking and

rearing children and help husbands in fields, especially in weeding and transporting grain from the farm field. Boys over 15 years old plough with their fathers and those who below often herd livestock. Hence, labor is provided by the household members but there are still traditional labor-sharing practices (*Guus*), which is established to help each other accomplish crop production and other activities.

Guus (a labor-sharing arrangement) is an informal network, which involves a group of people, usually neighboring households, who are organized for a particular agricultural task like ox-ploughing, weeding, harvesting, threshing, and transporting grain from the farm field. A group of people pools their labor resources and/or material resources (oxen, hand plough tools, sickles etc.) to help fellow neighbors. Even though a farm household is usually framed around a nuclear family, its relationship with the extended family remains strong; this favors the formation of labor sharing group. Similar result is presented by Girma et al. (2020).

Household head, wife, and young men and girls will participate in the group productive activities including ploughing, weeding and harvesting according to their ability. Women, in the household that is calling and receiving the assistance, have also the duty to prepare meals and drinks for the working group. The assisted household is expected to provide labor for the households that have participated in the arrangement at some time in the next activity of the other group members, meaning group members pay for the labor they receive with their own personal labor. Member household, that has temporary difficulties because of illness or the need to care for the sick, is also assisted by the other group members through performing any agricultural activity on its land.

The other form of *guus* is labor sharing for house (hut) construction and dismantling, which is performed only by women group. It is established voluntarily and on mutual understanding to help each other through mobilizing labor to accomplish house construction during settling, and house dismantling during migration or shifting settlement. All households settling or migrating together have the responsibility to participate in the operations. The house is usually made of grass mats tied together and placed over a wooden frame structure. During the construction of new house, the women gather special grass from the woodland for weaving mats. The men

usually gather the wood from the trees (*Galool, Dhumay* etc.) and then the women get to construction of the house. But practice is diminishing, because rural people started constructing corrugated iron houses.

Milk collection and Marketing groups

Milk and milk product marketing is entirely done by the women groups. Not only milk and milk product marketing but also management of these products at home is exclusively the responsibility of women. Men pastoralists revealed that it is even taboo for a man to ask how his partner allocates milk and milk product in the household. How much to use at home and to sell out and for what purpose to use the proceedings from milk and milk product is the sole responsibility of the women. Mostly the morning milk marketed and the evening milk is often used for home consumption.

Women in the same locality form milk-selling group during peak production periods. Milk marketing groups is a self-organized group, which involve women who have milking cows and/or camels. The number of women that participate in milk marketing group depends on the number of neighborhoods. Members are organized on the basis of selling whole fresh cow and/or camel milk. Milk marketing group members contribute an agreed amount of milk on a weekly basis and this is allocated to an individual woman on a shift basis. The woman sells the milk and the daily income belongs to her. The cycle continues until every member gets her share of the milk income. Similar result is reported by Hussen (2007).

***Mag*-paying Group**

The use of natural resources is susceptible to conflict particularly when the resources are scarce. Conflicts over natural resources have many negative impacts among this loss of human life is included. When a conflict occurs, the traditional mechanism of resolving it is through agreements made between conflicting clan elders and paying compensation for the lives lost (i.e. conflict resolution on the bases of blood compensation). To pay this compensation, Somali people commonly established collective blood compensation group known as *mag*-paying group. The *mag*-paying group is defined as a corporate agnatic group (*Jilib/Bah*) whose members are united in joint responsibility to collectively safeguard all matters of common interest. The *mag*-

paying group is the most stable unit with a membership of groups of families ranging from a few hundred to more than a thousand.

The *mag*-paying group is collectively responsible for the payment of compensation in the event of the death or injury of a member of another group at the hands of one of its members. While members of the same *mag*-paying lineage group may live in different locations. Alene *et al.* (2023) reported similar results. It is also collectively entitled to the receipt of compensation in the event of the death or injury of one of its members at the hands of a member of another group. Moreover, the administration of *mag*-paying group has adopted the practice of electing an individual (*aaqil*) to represent them with power and influence.

The process of negotiation is taken place through all elders in a *mag*-paying group gathering in an assembly (*shir*) under a tree and taking, democratically, on important decision of common interest to them. Arbitrating panels vary in size. Often four or five elders are considered sufficient, but where *mag*-paying group elders hear the case themselves concerning members of their own group, many men may take part as judges. Between *mag*-paying groups, the court's size tends often to vary with the magnitude of the case and the structural distance of the parties to the dispute.

CONCLUSION AND RECOMMENDATION

Collective actions consist of joint decisions, designing management rules and setting rules of conduct of group members. Whenever, agro-pastoral communities establish informal organization in a group, they establish institutions and the institutions are enforced by elders. The government need to support collective actions and their institutions, since the collective actions has a great role in development and conflict resolution.

Agro-pastoralists have long experience of working in group and help each other at time of crisis. But, the collective actions such as milk marketing, and mutual aid and social insurance (*idir*) were not so strong. Therefore, there is a need to creating awareness about collective marketing and importance of cooperative organization and the mechanics of establishing and managing it.

REFERENCES

Alene, G. D., J. Duncan, and H. V. Dijk. 2023. Government through clanship: Governing Ethiopia's Somali pastoralists through a community-based social protection program. *Critical Social Policy, Volume 43, Issue 1, Pages 157-177.*

Bernier, Q. and Meinzen-Dick, E. 2014. Networks for resilience: the role of social capital. Food policy peport. IFPRI. Washington, D.C.

DiGregorio, M. D., K. Hagedorn, M. Kirk, B. Korf, N. McCarthy, R. Meinzen-Dick, and B. Swallow. 2008. Property Rights, Collective Action, and Poverty: The Role of Institutions for Poverty Reduction. CAPRi Working Paper No. 81. International Food Policy Research Institute, Washington, D.C.

Fekadu B. and B. Korf. 2008. Unmaking the Commons: Collective Action, Property Rights, and Resource Appropriation among Agro–Pastoralists in Eastern Ethiopia. CAPRi Working Paper No. 88. International Food Policy Research Institute, Washington, D.C.

Girma T. Kassie, Woinishet Asnake, Aynalem Haile, Tesfaye Getachew, and Jane Wamatu. 2020. Collective action for agricultural marketing: Training manual. International Center for Agricultural Research in the Dry Areas (ICARDA), Addis Ababa.

Hussen, K. 2007. Characterization of milk production system and opportunity for market orientation: a case study of Mieso District, Oromia Region, Ethiopia. MSc thesis (Animal Production). Haramaya University.

KIT, Agri-ProFocus and IIRR. 2012. Challenging chains to change: Gender equity in agricultural value chain development. KIT Publishers, Royal Tropical Institute, Amsterdam.

Mahdi E. M. 2011. Collective Actions and Local Institutions in Managing Rangeland Resources in Somali Region, Ethiopia. PhD Dissertation, Kasetsart University, Bangkok.

Meinzen-Dick, R., M. DiGregorio, and N. McCarthy. 2004. "Methods for Studying Collective Action in Rural Development." Agricultural Systems 82: 197-214.

Naess, M.W. 2021. Collaborative foundations of herding: The formation of cooperative groups among Tibetan pastoralists. Journal of Arid Environments, Volume 186.

OECD. 2012. Policy guidance note: the role of empowerment for poverty reduction and growth. OECD, Paris.

Ostrom, E. 2004. Understanding Collective Action. In: Meinzen-Dick, R., M. DiGregorio (eds). Collective Action and Property Rights for Sustainable Development: Policy Brief No. 2. International Food Policy Research Institute, Washington, D.C.

Rural Development Report. 2016. Fostering inclusive rural transformation. IFAD, Rome.

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