Response of Potato to nitrogen and phosphorus fertilizer at Wag-Lasta Areas of Eastern Amhara, Ethiopia

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Abstract

Background: Production and productivity of potato in Ethiopia is far below the world average due to soil fertility problem, pest, disease, and agronomic factors. Nutrient depletion due to soil erosion is a serious problem in Ethiopian highlands. Annually, nitrogen 122 kg ha^{-1} P 13 kg ha^{-1} and K 82 kg ha^{-1} were estimated to deplete from Ethiopia (Haileslassie et al., 2005). The essential nutrients like, nitrogen and phosphorus are the most important influential nutrient for the production of potato but they are deficient in most Ethiopian soils and thus an application of these nutrients could increase significantly the crop yields. In this context, an experiment was conducted at Sekota and Lasta Lalibela districts (Woleh and Kechin Abeba irrigation command areas) of eastern Amhara to investigate the effects of nitrogen and phosphorus fertilizers for yield and yield component of potato under irrigation condition.

Methods: Four rates of nitrogen (0, 46, 92, and 138 kg N kg ha^{-1}) and four rates of phosphorus (0, 23, 46, and 69 Kg P_2O_5 kg ha^{-1}) were combined in the factorial arrangement and laid out in randomized complete block design with three replications.

Results: The result of the study revealed that nitrogen and phosphorus had a significant effect on plant height, marketable, and total yield of potato at Kechin Abeba. But phosphorus did not show a significant effect on plant height and unmarketable yield at Sekota district of Woleh irrigation command area. The highest yield 45.55 t ha^{-1} was obtained from in combined application of 138 N and 23 P_2O_5 in Lalibela and 17.12 t ha^{-1} was obtained from in combined application of 138 N kg ha^{-1} and 46 P_2O_5 kg ha^{-1} from Sekota districts of Woleh irrigation command area.

Conclusion: The application of nitrogen and phosphorous fertilizer in the study area were more efficient in terms of tuber yield in Lalibela (Kechin Abeba) than Woleh. The application of 138 kg ha^{-1} N combined with 23 kg ha^{-1} P_2O_5 is found to be the appropriate rates for optimum productivity of Potato at Lalibela (Kechin Abeba) and Sekota (Woleh) under irrigation conditions and the same agro-ecology.

Background

Potato (Solanum tuberosum L.) is one of the most important agricultural crops in the world. In the volume of production, it ranks fourth in the world after maize, rice, and wheat, with an estimated production area of 18.9 million hectares (Naz et al., 2011). Its yield in sub-Sahara Africa is below 10 t ha^{-1} while the attainable yields with good crop management are well above 30 t ha^{-1}. In Ethiopia its productivity is very low there are many reasons for this low actual yield of potato tubers (Haverkort et al., 2012). Factors like soil fertility problem, lack of good quality seed, unbalanced mineral nutrition and inadequate application of fertilizers, pests and disease, irregularity of water supply and traditional irrigation schemes and schedules are the main reason for low productivity of potato in Ethiopia (Emana and Nigussie, 2011). In addition to this continuous cropping without replacing the removal nutrient from crop biomass and another organic source is a major problem of nutrient depletion in Ethiopia. Plants

require a variety of elements for growth and development of which N and P are the most important of the essential nutrients to plants because they are required in large quantities. The deficiency of these elements is manifested in the detrimental effects on the growth and development of the plants (Tisdale et al., 1995). Fertilizer usage plays a major role in the universal need to increase food production to meet the demands of the growing world population. Its' application resulted in marked crop yield increases, which for most crops was more than a hundred percent (Mengel and Kirkby, 1996). Applications of nitrogen and phosphorus fertilizer have shown that good yield response for different crops including potato in the country. Research conducted by Friew et al., (2016) shows that combined application of nitrogen and phosphorus fertilizer had increases the yield of potato by 12.26 t ha^{-1} as compared to control (0 N, 0 P). Similarly, Wubengeda et al.,(2016) reported that increasing the rate of the two (N and P) nutrient increases the yield and yield components of potato. Desalegn et al., (2016) also, reported that increasing the rate of nitrogen and phosphorus increases the tuber yield by 361 and 358 % as compared with control. Generally, the above-mentioned study shows that appropriate agronomic practices including fertilizer recommendation play a significant role in potato production. However, in the study areas, farmers utilized inorganic and organic fertilizers with a blanket recommendation to increase the potato production. But, a site-specific recommendation is very vital to produce much more economic production of potato for smallholder farmers. Moreover, there was no appropriate fertilizer rate recommendation for potato in the study area. Therefore, the experiment was conducted to determine the optimum rates of nitrogen and phosphorus fertilizers for potato production at Wag-Lasta areas of the Amhara Region Ethiopia.

Materials And Methods

Description of the study area

The experiment was conducted in the 2015 and 2017 irrigation season at two sites; Sekota district (Woleh) and Lasta district Kechin Abeba. The sites are located (11^{o} 57' 31.14" and 12^{o} 31'44.57"latitude, 39^{o} 04'01.07" and 39^{o} 02'55.6" longitude and altitude of 2120 m and 2101 meter above sea level), respectively. Specifically, Woleh and Kechin Abeba irrigation command areas irrigate an area of 137.25 ha and 75 ha of land respectively. The topographical feature of the area is characterized by mountainous, plateaus, and hills. Soil erosion is a common problem in the areas. Due to this the soil fertility status is very low. Mixed agriculture is a common farming system in the study area. The major crops cultivate in the districts are cereals such as *teff (Eragrostis tef), Wheat* (*Triticumaestivum L.*), Barley (Hordeum vulgare L), and sorghum (*Sorghum bicolor*) and horticultural crops such as Mango *(Mangifera indica L*), pepper (*Capsicum species*), Tomato (*Solanum Lycopersicum L.*), Garlic (*Allium Sativa*), and onion (*Alluim Cepa* L.).

Experimental treatments, design and procedures

The experiment was conducted in the 2015 and 2017 irrigation season at Woleh and Kechin Abeba irrigation command areas. Four levels of nitrogen (0, 46, 92, 138 kg ha^{-1}) and four levels of phosphorus

(0, 23, 46, 69 kg ha^{-1}) were arranged in a factorial combination, giving a total of 16 treatments set in a Randomized Complete Block Design (RCBD) with three replications. The entire rate of P_2O_5 and the half rate of the N fertilizers were applied at the time of planting. The remaining half of N was applied 45 days after planting. Urea (46% N) and Triple Super Phosphate (46% P_2O_5) were used as fertilizer sources for N and P, respectively. Medium size and well-sprouted potato tubers were planted at a spacing of 75 cm between rows and 30 cm between plants. The total plot size was 3mx3m (9 m^2), the spacing between plots and replications were 0.5 and 1 m, respectively. Cultural practices like cultivation, weeding and ridging were practiced as per recommendation. Watering was done within 5 days interval based on the recommendation. Gera potato variety was used for the study.

Data collection and analysis

Plant height (cm), marketable tuber yields (ton), unmarketable tuber yield (ton) and total tuber yield (ton) were collected from the middle rows of the experimental plots. Data were subjected to analysis of variance using proc GLM (general linear model) procedure of SAS 9.0 software (SAS 2004). Treatments means were compared with LSD at 5% significance level. To determine the nutrient content of the soil before planting, composite soil samples were collected from 0-20 cm depth using the Edelman auger from the experimental sites. Samples were air-dried and ground to pass through a 2-mm sieve to get the fine earth fraction (<2 mm separates). Particle size distribution (sand, silt, and clay separate) was determined by the hydrometer method as outlined by Bouyoucos (1965). Soil pH was determined from the filtered suspension of 1:2.5 soils to water ratio using a glass electrode attached to a digital pH meter. Organic carbon of the soils was determined following the wet digestion method as described by Walkley and Black (1934). Total nitrogen was determined by the micro-Kjeldahl digestion, distillation and titration method (Bremner and Mulvaney, 1982). The available phosphorus was determined by the standard Olsen method (Olsen *et al.,* 1954).

Partial budget analysis

The partial budget analysis was carried out for every treatment based on CIMMYT (1998) to indicate the economic superiority of alternative treatments over the control treatment. The varying costs (fertilizer and labor) were estimated based on the existing rate of fertilizer purchase and daily labor cost. The average yield was adjusted downward by 10% from the exact yield to reflect the difference between the experimental yield and yield of farmers. MRR (%) was calculated as changes in net benefit divided by changes in cost.

Results And Discussion

Pre planting soil property of the study sites

Table 1: soil sample result before planting

Sites	pH	EC	OC %	TN %	Avai.P ppm	Particle size distribution			
						Sand%	Silt%	Clay%	Textural class
Woleh Kechin	7.6	0.13	0.43	0.04	15.45	32.66	33.65	33.69	Clay loam
Abeba	7.3	0.12	0.55	0.02	18.04	30	30	40	Clay loam

EC stands for electrical conductivity, OC stands for organic carbon, TN stands for total nitrogen, Avai.P stands for available phosphorous ppm stands for parts per million

Soil laboratory analysis

At Woleh, soil pH, EC and total nitrogen were numerically higher than at Kechin Abeba, but organic carbon and available phosphorus were lower at Woleh. The sites had a textural class of clay loam. The soil pH value of the surface soil at Woleh and Kechin Abeba was 7.3 and 7.6 respectively. According to Landon, (1991) soil pH rating is classified as neutral and slightly alkaline. Similarly, the electrical conductivity of the study sites soil was free from salt (Landon 1991). The organic carbon and total nitrogen content were rated at low categories. According to Olson (1951), the available phosphorous was high on both sites. This might be the area had a long history on agriculture without replacing the complete removal of cover crop and burning crop residue as fuel are the main cause for nutrient loses.

A significant interaction (N*P) was observed for plant height and marketable yield in both years but total tuber yield was interacted in the year 2015 at Lalibela Kechin Abeba irrigation command area (Table 2 and 3). But the main effect of nitrogen was significantly affected all the parameters and the main effect of phosphorous was affect the only marketable and total yield of potato in 2017. In the year 2015, the main effect of phosphorous was affected marketable, total yield and plant height. Whereas at Woleh irrigation command area except for plant height significant interaction was observed on the other stated parameter (Table 4). The main effect of nitrogen and phosphorous fertilization was significantly influenced the plant height, marketable yield, unmarketable yield and total yield of potato but, phosphorous was not affecting the plant height.

Table 2: ANOVA for the effect of N and P fertilizers on the plant height (cm), marketable yield, unmarketable yield and total yield (t ha^{-1}) of potato 2017 at Kechin Abeba

Source of variation	DF	Mean square values			
		Plant Height(cm)	Marketable yield	Unmarketable yield	Total yield
N	3	638.44*	418.95*	5.60*	451.10*
P	3	5.56^{ns}	67.91*	0.27^{ns}	65.04*
N*P	9	45.77*	69.57*	0.82^{ns}	71.06
Error	32	15.56	4.50	1.20	4.72

Table 3: ANOVA for the effect of N and P fertilizers on the plant height (cm), marketable yield, unmarketable yield and total yield (t ha^{-1}) of potato 2015

e of variation	DF	Mean square values			
		Plant Height	Marketable yield	Unmarketable yield	Total yield
N	3	518.94*	101.55*	4.14*	138.09*
P	3	92.15*	11.94*	1.11^{ns}	12.04*
N*P	9	44.91*	12.75*	0.89^{ns}	12.57*
Error	32	19.38	2.50	0.57	3.81

Table 4: Combined ANOVA for the effect of N and P fertilizers on the plant height (cm), marketable yield, unmarketable yield and total yield (t ha^{-1}) of potato at Woleh

e of variation	DF	Mean square values			
		Plant Height	Marketable yield	Unmarketable yield	Total yield
N	3	193.65*	159.35*	5.79*	233.68*
P	3	35.86^{ns}	17.02*	2.76*	30.54*
N*P	9	51.45^{ns}	221.53*	1.33*	9.44*
Error	57	34.54	3.32	0.35	3.44

Plant height

Both the main and interaction effect of nitrogen and phosphorus fertilizer application affect marketable yield and total yield significantly in the 2015 and 2017 at Kechin Abeba whereas the plant height and unmarketable yield were significantly affected by nitrogen application (Table 2 &3). The highest plant height 72.58 cm was recorded from the application of 138 N kg ha^{-1} in the 2017 irrigation season whereas the highest plant height 54.85 and 51.90 cm was a record from by application of 92 N and 69

P_2O_5 kg ha^{-1} in the year of 2015. In all parameters, the 2017 cropping season exceeded the 2015 production year. This is probably due to variation in irrigation water availability in the year between 2015 and 2017 (Table 5). That means water is essential for the germination of seeds, growth of plant roots, and nutrition, photosynthesis, transpiration, to maintain the turgidity of cell walls and multiplication of soil organisms. There was a shortage of irrigation water in the 2015 irrigation season in the command area. The increasing rate of nitrogen and phosphorus fertilizer in the irrigation season of 2015 increases plant height by 14.81 and 4.97cm whereas, in the irrigation season of 2017 application of nitrogen alone at a rate of 138 kg ha^{-1} increases plant height by 16.14 over the control treatment. The current study in line with Zelalem et al., (2009) who reported that nitrogen and phosphorus at a rate of 207 and 60 kg ha^{-1} increases plant height by 24 cm and 10.5cm respectively. Similarly, Israel et al., (2012), Alemayehu et al., (2015) and Fayera, (2017) and have found that increasing the application of nitrogen and phosphorus significantly increased plant height.

In Woleh the main effect of nitrogen fertilization was significantly influenced the plant height of potato but, their interaction exhibited a non-significant effect on the stated parameter (table 4). The highest plant height (49.82cm) was obtained from applied fertilizer rates of 138 N kg ha^{-1} at Woleh while the lowest plant height (43.15) was obtained from the control treatment (Table 5). The application of phosphorous fertilizer didn't show a significant effect on the plant height at Woleh during the study (Table 5). This might be the fact that nitrogen plays a most important role in various physiological processes. The current study inlined with Sanjana *et al.,* (2014) who reported that increasing the rate of nitrogen up to 375 kg ha^{-1} increases the plant height of potato. A study conducted in eastern Ethiopia to ascertain the effect of nitrogen and planting density on yield and yield components of potato shows that increasing the rate of nitrogen from 0 to 165 kg ha^{-1} increases the plant height of potato.

Table 5: Effect of Nitrogen and phosphorus on plant height (cm) at Kechin Abeba and Woleh sites

level kg ha^{-1}	Plant height (at Kechin Abeba)		Plant height (at Woleh)		
	2015	2017	2015	2017	Combined
0	40.05	55.86	46.63	39.66	43.15
46	46.67	61.94	48.89	41.95	45.42
92	54.85	68.14	51.13	43.65	47.39
138	52.35	72.58	53.13	46.50	49.82
LSD $_{(0.05)}$	3.24*	3.28*	3.18*	5.69*	3.39*
$_5$ level kg ha^{-1}					
0	46.93	65.34	49.28	42.07	45.67
23	49.45	63.75	50.36	40.44	45.40
46	45.65	64.66	50.64	45.59	48.11
69	51.90	64.81	49.50	43.66	46.58
$LSD_{(0.05)}$	3.24*	3.28^{ns}	ns	ns	ns
CV	9.08	6.10	7.43	15.95	12.65

Marketable yield

Both the main and interaction effect of nitrogen and phosphorus fertilizer application were affect the marketable yield significantly at Kechin Abeba and Woleh. The increasing rate of nitrogen and phosphorus significantly increases the marketable yield of potato in both sites. In Kechin Abeba marketable yield was increased with the increasing rate of nitrogen and phosphorus. The highest marketable yield (45.55 t ha^{-1}) was recorded from 138 kg ha^{-1} nitrogen is combined with phosphorus at a rate of 23 kg ha^{-1} in 2017 and 19.57 t ha^{-1} was recorded from 138 nitrogen is combined with phosphorus at a rate of 23 kg ha^{-1} in 2015 (Table 6) whereas the lowest marketable yield (17.71 t ha^{-1}) and (8.1 t ha^{-1}) was recorded from treatment (0, 69 NP) in 2017 and 2015 respectively. The marketable yield of potato gained in the year of 2017 irrigation season was exceeded the irrigation season of 2015. This is probably due to irrigation water availability in the year between 2015 and 2017. There was irrigation water scarcity in the year of 2015. In case of Woleh the highest marketable yield (17. 12 t ha^{-1}) was recorded from 138 kg ha^{-1} nitrogen in combined with phosphorus at a rate of 46 kg ha^{-1} whereas the lowest marketable yield (8.16 t ha^{-1}) was recorded from the control treatment (0, 0 NP kg ha^{-1}) (Table 7). There was tuber yield reduction in Woleh and Kechin Abeba in 2015 by half as compared to tuber yield gained in 2017 Kechin Abeba. This was attributed to the fact that water is the most important limiting factor for potato production and it's possible to increase production levels by well-scheduled irrigation programs throughout the growing season (Liu et al., 2006). Similarly, (Demile, 2012) observed that 4.09 t ha^{-1} (64%) and 39% tuber yield reduction were recorded from the application of 25%, and 50% (deficit) of the total crop water requirement at all stages, respectively. However, the marketable yield was increased by 24.95 t ha^{-1} and 8.96 t ha^{-1} over control treatment at Kechin Abeba and Woleh respectively. This might be the fact that nitrogen is part of the chlorophyll molecule, which gives plants their green color and is involved in creating food for the plant through photosynthesis and phosphorus is involved in the metabolic

processes responsible for transferring energy from one point to another in the plant. It's also critical in root development and flowering. The current study is in agreement with previous study Zelalem et al., (2009), Israel et al., (2012), Gebremariam, (2014), and Alemayehu et al.,(2015), who reported that increasing rate of nitrogen increases marketable tuber yield significantly. Similarly, Desalegn et al., (2016) observed an increment of potato marketable yield with increasing of NP fertilizer in southern Ethiopia.

Table 6: Effect of nitrogen and phosphorus on tuber marketable yield of potato t ha^{-1} at Kechin Abeba 2015 and 2017

	2015				2017			
	P_2O_5 kg ha^{-1}				P_2O_5 kg ha^{-1}			
N kgha^{-1}	0	23	46	69	0	23	46	69
0	11.26	11.66	11.87	8.10	20.60	21.89	23.66	17.71
46	16.76	17.91	17.56	12.96	23.82	28.53	28.93	27.24
92	15.01	15.68	19.23	14.29	26.54	19.67	29.23	33.52
138	14.95	19.57	17.02	16.77	14.95	45.55	37.70	29.35
$LSD_{(0.05)}$	2.63*				3.53**			
CV	10.52				7.58			

Table 7: Combined analysis of potato marketable yield t ha^{-1} at Woleh

	P_2O_5 kg ha^{-1}			
N kg ha^{-1}	0	23	46	69
0	8.16	11.00	10.77	11.76
46	13.66	13.49	14.28	13.61
92	12.04	15.23	14.58	14.15
138	15.99	16.99	17.12	16.76
$LSD_{(0.05)}$	3.15*			
CV	14.55			

Unmarketable and total yield of potato

Both the main and interaction effect of nitrogen and phosphorus fertilizer application were affected the unmarketable and total yield of potato significantly at Woleh but, at Kechin Abeba only the application of nitrogen was affected significantly the unmarketable and total yield of potato (Table 2, 3, and 5). The

highest unmarketable yield (2.88 & 4.06 t ha^{-1}) was recorded at a rate of 92 kg ha^{-1} N in the year 2015 and 2017 respectively at Kechin Abeba (Table 8). Phosphorus fertilizer application did not significantly affect the total yield of potato in the year of 2017 but, in the year of 2015, the highest yield was recorded at an application rate of 23 kg ha^{-1} P_2O_5. The highest total yield (25.39 and 38.82 t ha^{-1}) was recorded at a rate of 138 kg ha^{-1} N. In the case of Woleh the highest total yield (19.39 t ha^{-1} & 16.84 t ha^{-1}) was obtained from the application of 138 kg ha^{-1} N and 46 kg ha^{-1} P_2O_5 and the lowest (11.80 & 14.21 t ha^{-1}) were obtained from the unfertilized treatment. Similarly highest unmarketable yield was obtained from the application of N 138 and P_2O_5 46 kg ha^{-1} (Table 8).

Table 8: Effect of nitrogen and phosphorus on unmarketable and total yield (t ha^{-1}) of potato at Woleh

	Kechin Abeba				Woleh					
evel ha^{-1}	Unmarketable yield		Total yield		Unmarketable yield			Total yield		
	2015	2017	2015	2017	2015	2017	Combined	2015	2017	Combined
0	1.45	2.87	12.18	23.88	1.32	1.65	1.48	12.76	10.84	11.80
46	2.14	2.47	18.44	30.29	2.41	1.96	2.18	18.83	12.45	15.64
92	2.88	4.06	20.94	31.68	2.34	1.89	2.11	18.04	14.66	16.35
38	2.31	3.36	25.39	38.82	3.19	2.17	2.68	20.60	18.18	19.39
SD .05)	0.58*	0.91*	1.01*	1.80*	0.41*	0.39*	0.34*	1.11*	1.41*	1.07*
$_2O_5$ evel /ha										
0	2.37	3.14	16.87	34.53	19.45	1.71	1.83	15.52	12.90	14.21
23	2.40	3.23	18.61	30.85	20.83	1.91	2.00	18.99	13.51	16.25
46	1.75	3.38	17.23	29.31	33.88	1.83	2.61	18.69	15.00	16.84
69	2.26	3.02	16.24	29.98	18.38	2.22	2.03	17.03	14.71	15.87
$_{(0.05)}$	0.58*	Ns	1.01*	2.54*	4.13*	0.39*	0.34*	1.11*	1.41*	1.07*
CV	34.51	34.35	11.33	6.96	20.82	24.87	28.08	7.41	12.10	11.75

Partial budget analysis

The application of nitrogen at a rate of 138 kg ha^{-1} with 23 kg ha^{-1} phosphorus had the highest marketable yield (15.29 t ha^{-1}) and net benefit (164597 Ethiopian Birr) in Woleh irrigation command area (Table 9). The MRR (1606.90 %) was gained from the treatment of 138 N and 23 P_2O_5 kg ha^{-1}, this implies that for each Birr that invested in the new technology, the

producer can receive to recover the one Birr invested plus an additional return of 16.06 Ethiopian birr.

Table 9: partial budget analysis at Woleh

$_2O_5$	Unadjusted yield(t ha^{-1})	Adjusted(t ha^{-1})	Gross benefit (Ethiopian Birr)	Costs that varies (Ethiopian Birr)	Net benefit (Ethiopian Birr)	MRR%
0	9.86	8.874	97614	0	97614	
23	11	9.9	108900	580	108320	1845.86
0	11.66	10.49	115434	1008	114426	1426.64
46	10.77	9.69	106623	1160	105463	D
23	13.49	12.14	133551	1588	131963	3023.62
69	11.76	10.58	116424	1740	114684	D
0	12.04	10.83	119196	2016	117180	D
46	14.28	12.85	141372	2168	139204	1248.45
23	15.23	13.70	150777	2596	148181	2097.43
69	13.61	12.24	134739	2748	131991	D
0	15.99	14.39	158301	3024	155277	1657.94
46	14.58	13.12	144342	3176	141166	D
23	16.99	15.29	168201	3604	164597	1606.90
69	14.15	12.73	140085	3756	136329	D
46	17.12	15.40	169 488	4184	165304	121.90
69	16.76	15.08	165924	4764	161160	D

D stands for dominated treatment

Conclusion and recommendation

The current investigation showed that both nitrogen and phosphorus rates had a high significant effect on the tuber yield of potato. This study confirmed that nitrogen and phosphorus rates and their interaction have a sound and promising impact on marketable and total tuber yield of potato. However, the cost benefits analysis indicated that the application of 138 kg N ha^{-1} and 23 kg ha^{-1} P_2O_5 had a yield advantage of 86.64% or 7.13 t ha^{-1} over the control treatment at Woleh irrigation command area. Similarly, at Kechin Abeba application of 138 kg ha^{-1} nitrogen fertilizer and 23 t ha^{-1} phosphorus fertilizers resulted in the highest yield (45.55 t ha^{-1}) of potato tuber which exceeds by 121.11% or 24.95 t ha^{-1} from the control. Hence the application of nitrogen 138 and 23 P_2O_5 kg ha^{-1} is the optimum rate for potato at Woleh and Kechin Abeba irrigation command areas. Therefore, the application of 138 kg N and 23 kg P ha^{-1} is the appropriate rate for optimum productivity of Potato for Woleh and Kechin Abeba under irrigation and the same agro-ecologies.

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Competing interests

The authors declare no conflict of interest.

Availability of data and materials

The data used to support the findings of this study can be accessed from the corresponding author upon request.

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Authors' contributions

WS and MM conceptualized this study, WS and TE collects necessary data, analyzed, interpreted the data, and wrote the manuscript. All authors read and approved the final manuscript.

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Figures

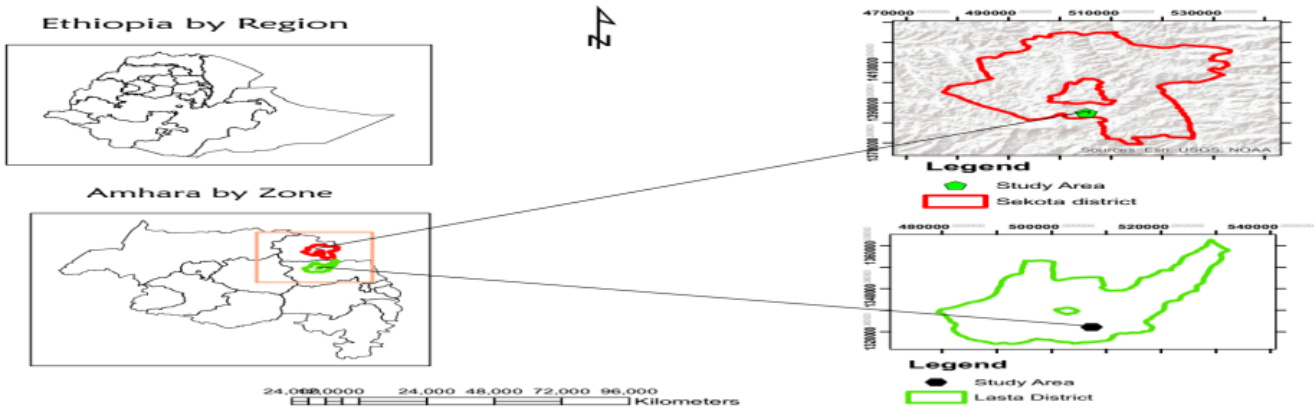

Figure 1

Description of the study area