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Full Length Research Paper

Ecological risk assessment of heavy metals and water bird distribution in rift valley lakes, Kenya

Barasa Mercy[1]*, James Mbaria[1], Gerald Muchemi[1], Francis Gakuya[2], Edward Kariuki[2] and Wanyoike Wamiti[3]

[1]Department of Public Health, Pharmacology and Toxicology, University of Nairobi, Nairobi, Kenya.
[2]Department of Veterinary and Capture Services, Kenya Wildlife Service, Kenya.
[3]Zoology Department, National Museums of Kenya, Kenya.

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The study was carried out in six Kenyan rift valley lakes, Nakuru, Magadi, Oloiden, Crater (Sonachi), Bogoria and Elementaita with the aim to determine the levels of heavy metals and other metal elements (Co, Mn, Zn, Cu, Cr, Cd, Pb, Ni, Hg and As) in water and sediment samples as well as assess its association with water bird distribution. High levels of Pb (42 ppm) above the Pb benchmark levels (36 ppm) as per EPA (2007) benchmarks were detected in Lake Oloiden sediments. Lakes Bogoria and Elementaita had high levels of Mn (3676.7 ± 6652.3 and 747.55 ± 510.95, respectively), also above the Mn benchmark levels (631 ppm), according to EPA (2007). The mean sediment concentrations for Zn, Pb, Ni, As and Hg varied significantly (P<0.05) among the six lakes. Apart from Zn, all other metals (Pb, Co, Mn, Cr, Cd, Fe and Cu) varied significantly in all water samples from the six selected lakes (P<0.05). A total of 15 water bird families were identified across the six lakes. The distribution of the families for lakes Nakuru, Magadi, Elementaita, Oloiden, Bogoria and Crater were 11, 9, 9, 7, 6 and 4, respectively. There was no association between metal elements concentration and water bird distribution in all the selected six lakes (P>0.05). It was concluded that metals concentration in Kenyan Rift Valley lakes has no significant influence on the distribution of water birds. High Mn levels in lakes Bogoria and Elementaita, and Pb in Oloiden may cause toxic effects to the aquatic life and humans as a result of bioaccumulation.

Key words: Ecotoxicology, heavy metals, water birds.

INTRODUCTION

Ecology is the scientific study of abundance, distributions and relations of organisms and their interaction with the environment (Begon et al., 2006). Heavy metals such as common toxic chemicals in the environment since they are naturally occurring and they are resistant to biodegradation (Reena et al., 2011). Trace metals like lead, mercury, chromium and cadmium are among the copper, zinc and iron play a biochemical role in the life processes of all aquatic plants and animals. They are therefore essential in trace amounts (Jakimska et al.

*Corresponding author. E-mail: mercybarasa74@outlook.com. Tel: +254716074674.

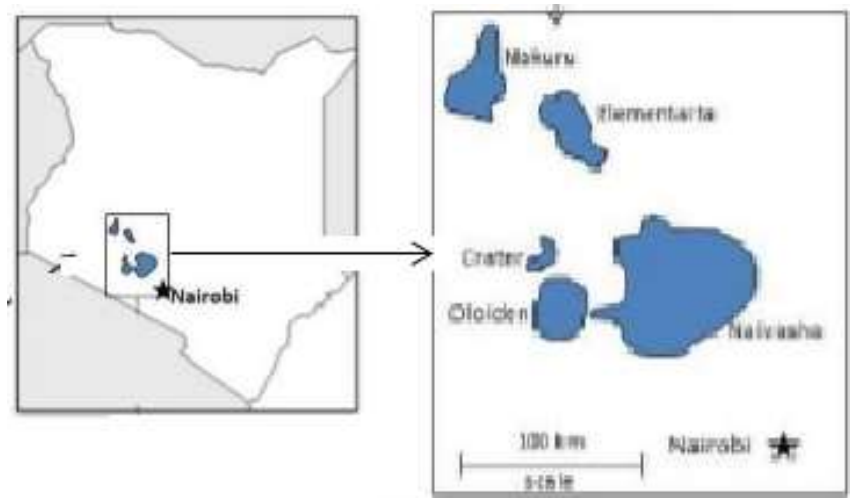

Figure 1. Map of Kenya showing rift valley lakes.

2011). However, high concentrations of these essential elements are toxic to aquatic life (Jakimska et al., 2011). The sources of metal elements in water bodies include, natural weathering, industrial wastes, sewage, surface run-off and agricultural effluents (Paul et al., 2012). Lake sediments form the final pathway of both anthropogenic and natural contaminants in the environment. Sediment quality is therefore a good indicator of pollution in the environment (Gavin and Marco, 2008; Samir and Ibrahim, 2008; Hahladakis et al., 2013).

Water birds that rely on wetlands for food, nesting and breeding can be used as environmental indicators (Ogden et al., 2014) because they are high in trophic levels, able to move in response to both opportunity and adversity, and are easy to notice and quantify in both space and time (O'Doherty and Caro, 1999).

In recent years, there has been dynamic changes in water bird number in Kenyan Rift valley lakes and pollution levels due to heavy metals is among the incriminated factors suggested to be causing the change in water bird distribution (Motelin et al., 1995; Nelson et al., 1998; Motelin et al., 2000; Guynub, 2002; Ouko et al., 2016). A study on the association between water bird distribution and heavy metal concentration in the environment is needed. In this paper, baseline data on concentrations of Mn, Zn, Cu, Cd, Cr, Co, Ni, As, Pb and Hg in surface sediments and water samples from six Kenyan Rift Valley lakes (Nakuru, Magadi, Oloiden, Crater, Bogoria and Elementaita) is reported. Data on water bird families distribution across the six lakes and their association with heavy metal concentration is also given.

MATERIALS AND METHODS

Study area and sampling

The study was carried out in six alkaline lakes in Kenya (Rift Valley): Lakes Nakuru, Magadi, Oloiden, Crater, Bogoria and Elementaita (Figure 1). The study sites were chosen based on convenience and sample size purposively determined depending on site characteristics. Water and surface sediment samples were taken from five sites (SS) in Lake Nakuru, five SS in Lake Bogoria, five SS in Lake Oloiden and six SS in Lake Magadi (Table 1). In Lakes Elementaita and Crater, five replicate subsamples were taken from one site. Surface sediment (0-2 cm layer) samples were collected in zip lock plastic bags, properly labelled and transported at 4°C in cool boxes to the laboratory awaiting analysis. Water samples were taken in plastic capped containers and transported in cool boxes at 4°C to the laboratory.

Sample preparation

Water samples were prepared in duplicates by measuring 50 ml of water into a beaker, adding 2 ml of concentrated nitric acid and heating the contents on a hot plate to reduce the volume to 10 ml. After that, the mixture was filtered into a 50 ml volumetric flask and topped to the mark with demineralized water ready for analysis. Each sediment sample was well mixed and 20 g were weighed in aluminum foil papers and dried in an oven at 60°C overnight. The sample was then ground in a pulverizer and 2.5 g weighed into a 250 ml beaker before adding 20 ml of water to make sludge. Concentrated nitric acid (20 ml) was then added to the sludge and the contents heated on a hot plate at 130°C for 1 hour without spurting to reduce the volume to 10 ml. This was then cooled and filtered into 50 ml volumetric flask, washed carefully with hot water and then topped to the mark ready for analysis. Known standards for each metal element were prepared from respective certified analytical standards at concentrations of 0.05, 0.1, 10 and 100 ppm. These known standards were read to generate calibration curves within the spectrophotometer before reading the samples. Standards were read after every reading of 5 samples to check the accuracy and precision of the machine and analytical process.

Instrumentation

Atomic absorption spectrophotometer (AAS) with an air/acetylene flame (Model SpectrAA-10) was used for analysis of Cd, Cr, Mn, Co, Zn and Cu in both water and sediment samples after preparation of appropriate calibration standards. Hg, Ni and As in

Table 1. The sites of sample collection from the six rift valley lakes.

Site	Magadi	Nakuru	Oloiden	Bogoria
1	South lagoon 1	Njoro R. Inlet	Kongoni landing bay	Wasekes R. Inlet
2	Spring area	Makalia R. Inlet	37m0195344	Chebuluny Swamp
3	South lagoon 2	WCK hostels	37m0195352	Water meter
4	Western lagoon	Sewage inlet		Flamingo area
5	Main gate barrier	After causeway	Kongoni	Hot springs
6	Factory causeway			

Table 2. Metal concentrations (ppm dry weight) in sediment samples in six Rift Valley lakes analyzed by atomic absorption spectrophotometry.

Site	n	Mn	Co	Cu	Zn	Cd	Cr
Nakuru	5	326 ± 178.72	100.82±210.77	8.26±6.0425	57.236±42.941	ND	0.196±0.08173
Magadi	6	249.91±92.405	11.52±5.836	8.9233±3.3382	26.413±7	ND	0.15667±0.06377
Oloiden	5	65.74±14.304	11.86±7.1365	1.865±1.466	16.14±5.9053	ND	0.295±0.20936
Crater	5	185.7±60.558	27.148±13.709	9.272±2.597	22.136±6.787	ND	0.215±0.03416
Bogoria	5	3676.7±6652.3	16.725±7.7662	3.93±2.5429	54.556±42.361	ND	0.204±0.07403
Elementaita	5	747.55±510.95	15.075±6.935	7.268 ± 16.252	18.068±6.9173	ND	0.224±0.0555
Benchmark levels		631		32	121	1.0	43

Benchmark levels for sediment concentrations (EPA, 2007), bulk sediment toxicity benchmarks for benthic macroinvertebrates.

sediments were analyzed using a X-ray Fluorescence (XRF) analyzer (s1 TITAN RS 200). Pb in water samples was analyzed by AAS and Pb in sediment samples analyzed by XRF after the AAS Pb lamp becoming faulty.

Reagents

Heavy metal analytical standards were of analytical grade from Sigma - Aldrich Limited, TraceCERT® products. Water used was deionised water from ReAgent chemical suppliers, Cheshire, England, UK.

Glassware cleaning

Glass was cleaned with tap water, soap and brush, rinsed three times with 0.5 M perchloric acid before rinsing with distilled water three times. They were then dried in the oven at 60°C.

Water bird identification

Water birds along drive ways, were observed in each SS using binoculars and identified using a bird guide book (Zimmerman et al., 1999) and identified with help of an expert ornithologist from the National Museums of Kenya (NMK).

Data obtained was entered into Microsoft Excel® spreadsheet, cleaned and then exported to Stata® for analysis. The means, standard deviations, maximum and minimum levels to determine toxicant levels within the six lakes were obtained.One way Anova test was used to analyze the variation between and within the lakes Chi - square test (Appendix 4) was used to test the association between metals concentration and water bird distribution among the lakes.

RESULTS AND DISCUSSION

The mean concentrations of heavy metals Mn, Co, Cu, Zn, Cd, Cr, Pb, Hg, Ni and As analyzed in sediments and water samples from the six Rift valley lakes are showed in Tables 2, 3, 4, Appendix 1 and Appendix 2. Lake Bogoria recorded the highest Mn mean sediment concentrations of 3676 ppm; Lake Nakuru gave highest mean sediment concentrations of Co (100 ppm) and Lake Oloiden recorded highest mean concentrations of Pb (42 ppm) in sediments. The mean sediment levels of Mn in Lake Bogoria are within the ranges obtained by Ochieng et al. (2007) who obtained Mn mean sediment concentration of 3947 ± 121 ppm. The mean sediment concentrations for Cu, Zn, As and Cr were very low in all the six lakes (Table 2 to 4). Cd and Hg were not detectable in sediment samples from all the six lakes. The results on Cd concentrations in sediments differ from those obtained by Tenai (2015) who found traces of Cd (0.0004 to 0.076 ppm) in Lakes Crater, Elementaita, Nakuru and Oloiden. Ochieng et al. (2007) also obtained high levels of Cd (1.18 ppm) in sediment from Lake Elementaita. Cd was also not detectable in water samples from all the six lakes. This was in agreement with the results obtained by Tenai (2015) but contrary to those obtained by Ochieng et al. (2007) who recorded traces of Cd levels in water samples (2.0 to 5.0

Table 3. Metal concentrations (ppm dry weight) in sediment samples in six rift valley lakes analyzed by X-ray fluorescence.

Site	n	Ni	As	Hg	Pb
Nakuru	5	ND	ND	ND	16±23.022
Magadi	6	3.3333±8.165	ND	ND	6.6667±16.33
Oloiden	5	4±5.4772	4±5.4772	ND	42±27.749
Crater	5	ND	6±5.4772	ND	ND
Bogoria	5	38±38.987	2±4.4721	ND	ND
Elementaita	5	2±4.4721	2±4.4721	ND	ND
Benchmark levels		23	9.8	0.18	36

Benchmark levels for sediment concentrations (EPA, 2007), bulk sediment toxicity benchmarks for benthic macroinvertebrates; N, Number of samples.

Table 4. Dissolved metal concentrations (ppm) in water samples of the six rift valley lakes analyzed by atomic absorption spectrophotometry.

Site	Mn	Co	Cu	Zn	Cd	Cr	Pb
Nakuru	0.00433±0.00351	ND	ND	0.095±0.14256	ND	0.7958±0.0725	0.0015±0.00071
Magadi	0.00467±0.00234	2.3482±0.98588	0.04±0.01414	0.05083±0.02457	ND	1.2238±0.19708	0.0118±0.00319
Oloiden	0.0054±0.00055	ND	ND	0.0488±0.00084	ND	1.335±0.01037	ND
Crater	0.0048±0.00045	ND	ND	0.0512±0.00045	ND	1.3658±0.00694	ND
Bogoria	0.0064±0.00089	0.1742±0.04707	ND	0.1526±0.21657	ND	1.3918±0.04094	ND
Elementaita	0.0052±0.00045	ND	ND	0.0552±0.00045	ND		
Benchmark	0.12	0.023	0.003	0.036	0.000009	0.011	0.0005

Benchmark levels for sediment concentrations (EPA, 2007) bulk sediment toxicity benchmarks for benthic macroinvertebrates; ND, not detected; n, Number of samples.

µg/L) in Lake Baringo, (5.0 to 41.0 µg/L) in Lake Bogoria Bogoria (1.3918 ppm), Crater (1.3658 ppm) and Oloiden (3.0 to 43.0 µg/L) in Lake Nakuru and (3.0 to 25.1 µg/L) in Lake Elementaita. Dilution as a result of rising water levels in Kenyan Rift Valley Lakes may be responsible for undetected Cd. The mean sediment concentrations for Zn, Pb, Ni, As and Hg varied significantly ($P<0.05$) among the six lakes. Concentrations of Mn in Lake Bogoria may be attributed to natural leaching and erosion from rocks, volcanic activity and soils (Stokes et al., 1988) since the Lake is remote from anthropogenic activities. These high levels is a threat to biological lives that depend on the lake especially water birds. Elevated levels of Mn affect fetal development, causes DNA damage and chromosomal aberrations thus toxic to embryo (ATSDR, 2000). The levels of Co in Lake Nakuru may be attributed to the increased industrial activities around the lake. Spillway from fresh water Lake Naivasha is the likely source of Pb levels in Lake Oloiden since a lot of anthropogenic activities especially flower farming occur around Lake Naivasha. Surface run-offs from these farms are a good source of Pb in the lake. Birds depending on the lake are also at risk of Pb toxicity.

In water samples, high mean concentrations of Cr and Zn is above the threshold limits (0.011 and 0.036 ppm), respectively, according to EPA (2007) limit, were recorded in all the six lakes with highest Cr levels in (1.335 ppm) Table 3. These levels are much higher compared to those obtained by Ochieng et al. (2007) who obtained a maximum of 0.188 ppm in Lake Nakuru but lower than ranges (10 to 280 ppm) recorded by Nelson et al. (1998) in Lake Nakuru sediments. Highest Zn levels were recorded in Lake Bogoria (0.1526 ppm) (Table 3). Lake Magadi water samples had high levels of both Co (2.3482 ppm) and Cu (0.04 ppm) which were above the benchmark levels given by EPA (2007) limits (Table 3). Lake Bogoria also had high Co levels in water samples (0.1742 ppm). Mn levels were low in water samples from all the six lakes. Apart from Zn, all other metal elements (Pb, Co, Mn, Cr, Cd, Fe and Cu) varied significantly ($P<0.05$) in water samples among the six lakes. The noted high levels of metal elements in water columns from the lakes is a major concern since these lakes support many water birds, wild animals, fish among other biological organisms.

A total of 15 water bird families were identified across the six lakes (Table 5, Appendix 3). Phoenicopteridae family, which comprises flamingos, was the most abundant with an estimate of 1877 lesser flamingos (*Phoeniconias minor*), followed by Scolopacidae (862) and Recurvirstridae (453) families. The distribution of water bird families for lakes Nakuru, Magadi, Elementaita, Oloiden, Bogoria and Crater were11, 9, 9, 7, 6 and 4 respectively. African fish eagle of the family Accipitridae

Table 2. Number of water bird families identified at the six rift valley lakes.

Family	Lake Nakuru	Lake Magadi	Lake Oloiden	Crater Lake	Lake Bogoria	Lake Elementaita	Totals
Phoenicopteridae: Flamingos		476		1	1400		**1877**
Scolopacidae: Sandpipers and relatives	367	191		4	50	250	**862**
Recurvirostridae: Stilts and avocets	69	357			24	3	**453**
Anatidae: Ducks and geese	207	20			5	5	**237**
Pelecanidae: Pelicans	52		15			53	**120**
Ardeidae: Herons, Egrets and bitterns	45	8	5		1	54	**113**
Threskiornithidae: Ibises and spoonbills	24	1				78	**103**
Phalacrocoracidae: Cormorants	35		35				**70**
Laridae: Gulls, terns and skimmers	28	6	10				**44**
Ciconiidae: Storks	6	1	3			10	**20**
Charadriidae: Plovers					10	9	**19**
Accipitridae: Diurnal birds of prey other than falcons		1	2	2		6	**11**
Gruidae: Cranes	10						**10**
Podicipedidae: Grebes	2			7			**9**
Accipitridae: African fish eagles			1				**1**
Total	845	1061	71	14	1490	468	**3949**

was sighted at Lake Oloiden.

The test of association between mean heavy metal concentrations and water bird families distribution in the six lakes was performed using Chi-square test in Statistical Package for the Social Sciences (SPSS) version 24. There was no significant influence (P>0.05) (Appendix 4) of heavy metals on water bird distribution in all the lakes. This implies that other factors different from heavy metal concentrations affect the ever changing distribution of water birds in Kenya Rift Valley lakes.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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APPENDIX

Appendix 1: Metal element concentrations (ppm) in sediments from Lakes Nakuru, Bogoria, Magadi, Crater, Oloiden and Elementaita analyzed by atomic absorption spectrophotometry.

Ref. no.	Mn	Co	Cu	Zn	Cd	Cr
Naksa.c.w	175.62	8.64	2.32	32.38	ND	0.24
Naksswg	209.36	0.78	6.94	97.4	ND	0.26
Naks MKL	560.007	7.08	3.16	29.56	ND	0.26
Naks WCK	208.8	9.8	16.26	17.04	ND	0.08
Naksnjr r	477.8	477.8	12.62	109.8	ND	0.14
Mgd F.C.W	249.2	11.58	7.8	39.96	ND	0.06
Mgd SL 2	213.8	22.88	9.14	24.34	ND	0.24
Mgd M.G.B	401.8	10.86	7.06	21.28	ND	0.2
Mgd WL	117.44	8.58	6.04	21.68	ND	0.14
MgdSprn	276.2	8.5	8.1	23.72	ND	0.18
Mgd SL 1	241	6.72	15.4	27.5	ND	0.12
Oloiden 1	65.1	ND	1.58	16.12	ND	0.44
Oloiden 2	54.86	8.36	2	16.2	ND	0.18
0loiden 3	ND	13	ND	7.86	ND	ND
Oloiden 4	86.14	4.78	3.72	15.96	ND	0.5
oloiden 5	279.8	21.3	0.16	24.56	ND	0.06
Crater 1	163.4	31.94	4.8	11.62	ND	ND
Crater 5	129.3	11.3	10.42	22.68	ND	0.2
Crater 3	209.76	22.22	9.26	30.14	ND	0.18
Crater 4	146.24	47.9	10.72	25.04	ND	0.26
crater 2	180.8	22.38	11.16	21.2	ND	0.22
Bogoria 1	791.4	22.38	6.68	18.76	ND	0.3
Bogoria 2	15562	24.44	5.46	21.94	ND	0.26
Bogoria 4	1090	10.22	2.2	30.88	ND	0.18
Bogoria 3	758.6	ND	ND	104.6	ND	0.12
Bogoria 5	1480.6	9.86	1.38	96.6	ND	0.16
Elmt 1	498.4	21.22	ND	28	ND	0.3
Elmt 2	752.8	18.3	ND	11.42	ND	0.18
Elmt 3	906.2	5.28	36.34	21.78	ND	0.24
Elmt 4	99.74	ND	ND	16.84	ND	0.24
Elmt 5	37	15.5	ND	12.3	ND	0.16

Appendix 2: Metal element concentrations in water samples from Lakes Nakuru, Bogoria, Magadi, Crater, Oloiden and Elementaita analyzed by atomic absorption spectrophotometry.

Ref. No.	Mn	Co	Cu	Zn	Cd	Cr	Pb
Naksa.c.w	0.008	ND	ND	0.032	ND	0.71	0.002
Naksswg	0.004	ND	ND	0.029	ND	0.745	ND
NaksMklia	0.001	ND	ND	0.032	ND	0.798	0.001
NaksWck	ND	0.034	ND	0.032	ND	0.831	ND
NaksNjr R	ND	ND	ND	0.35	ND	0.895	ND
Mgd F.C.W	0.006	3.089	0.05	0.004	ND	0.914	0.014
Mgd SL2	0.003	3.063	ND	0.061	ND	1.048	0.014
Mgd M.G.B	0.002	1.808	ND	0.06	ND	1.29	0.01
Mgd WL	0.003	3.109	0.03	0.053	ND	1.346	0.014
MgdSpn area	0.008	2.383	ND	0.051	ND	1.329	0.007
Mgd SL1	0.006	0.637	ND	0.076	ND	1.416	ND
Oloiden 1	0.006	ND	ND	0.048	ND	1.327	ND
Oloiden 2	0.006	ND	ND	0.049	ND	1.332	ND
Oloiden 3	0.005	ND	ND	0.048	ND	1.352	ND
Oloiden 4	0.005	ND	ND	0.049	ND	1.327	ND
Oloiden 5	0.005	ND	ND	0.05	ND	1.337	ND
Crater 1	0.005	ND	ND	0.051	ND	1.364	ND
Crater 5	0.005	ND	ND	0.051	ND	1.362	ND
Crater 3	0.005	ND	ND	0.051	ND	1.364	ND
Crater 4	0.005	ND	ND	0.052	ND	1.378	ND
Crater 2	0.004	ND	ND	0.051	ND	1.361	ND
Bogoria 1	0.006	0.16	ND	0.54	ND	1.33	ND
Bogoria 2	0.006	0.178	ND	0.054	ND	1.373	ND
Bogoria 4	0.008	0.253	ND	0.057	ND	1.405	ND
Bogoria 3	0.006	0.147	ND	0.055	ND	1.419	ND
Bogoria 5	0.006	0.133	ND	0.057	ND	1.432	0.001
Elmt 1	0.005	ND	ND	0.055	ND	1.439	ND
Elmt 2	0.005	ND	ND	0.055	ND	1.426	ND
Elmt 3	0.005	ND	ND	0.055	ND	1.425	ND
Elmt 4	0.005	ND	ND	0.055	ND	1.413	ND
elmt 5	0.006	ND	ND	0.056	ND	0.413	ND

Appendix 3 : Table showing water bird families identified at the Lakes.

Family	Lake Oloiden	Crater Lake	Lake Elementaita	Lake Bogoria	Lake Nakuru	Lake Magadi	
Phoenicopteridae: flamingos		1		1400		476	1877
Scolopacidae: sandpipers and relatives		4	250	50	367	191	862
Recurvirostridae: stilts and avocets			3	24	69	357	453
Anatidae: ducks and geese			5	5	207	20	237
Pelecanidae: pelicans	15		53		52		120
Ardeidae: herons, egrets and bitterns	5		54	1	45	8	113
Threskiornithidae: ibises and spoonbills			78		24	1	103
Phalacrocoracidae: cormorants	35				35		70
Laridae: gulls, terns and skimmers	10				28	6	44
Ciconiidae: storks	3		10		6	1	20
Charadriidae: plovers			9	10			19
Accipitridae: diurnal birds of prey other than falcons	2	2	6			1	11
Gruidae: cranes					10		10
Podicipedidae: grebes		7			2		9
Accipitridae: African fish eagles	1						1
Total	71	14	468	1490	845	1061	3949

Appendix 4: Computation table for metal concentrations in six Kenyan rift valley lakes for chi-square test.

Ref. no.	Mn	Co	Cu	Zn	Cd	Cr	
Naks a.c.w	175.62	8.64	2.32	32.38	ND	0.24	
Naks swg	209.36	0.78	6.94	97.4	ND	0.26	
Naks MKL	560.007	7.08	3.16	29.56	ND	0.26	
Naks WCK	208.8	9.8	16.26	17.04	ND	0.08	
Naks njr r	477.8	477.8	12.62	109.8	ND	0.14	
Nakuru	**1631.587**	**504.1**	**41.3**	**286.18**		**0.98**	
Mgd F.C.W	249.2	11.58	7.8	39.96	ND	0.06	
Mgd SL 2	213.8	22.88	9.14	24.34	ND	0.24	
Mgd M.G.B	401.8	10.86	7.06	21.28	ND	0.2	
Mgd WL	117.44	8.58	6.04	21.68	ND	0.14	
Mgd Sprn	276.2	8.5	8.1	23.72	ND	0.18	
Mgd SL 1	241	6.72	15.4	27.5	ND	0.12	
Magadi	**1499.44**	**69.12**	**53.54**	**158.48**		**0.94**	
Oloiden 1	65.1	ND	1.58	16.12	ND	0.44	
Oloiden 2	54.86	8.36	2	16.2	ND	0.18	
0loiden 3	ND	13	ND	7.86	ND	ND	
Oloiden 4	86.14	4.78	3.72	15.96	ND	0.5	
Oloiden 5	279.8	21.3	0.16	24.56	ND	0.06	
Oloiden	**485.9**	**47.44**	**7.46**	**80.7**		**1.18**	
Crater 1	163.4	31.94	4.8	11.62	ND	ND	
Crater 5	129.3	11.3	10.42	22.68	ND	0.2	
Crater 3	209.76	22.22	9.26	30.14	ND	0.18	
Crater 4	146.24	47.9	10.72	25.04	ND	0.26	
Crater 2	180.8	22.38	11.16	21.2	ND	0.22	
Crater	**829.5**	**135.74**	**46.36**	**110.68**		**0.86**	
Bogoria 1	791.4	22.38	6.68	18.76	ND	0.3	
Bogoria 2	15562	24.44	5.46	21.94	ND	0.26	
Bogoria 4	1090	10.22	2.2	30.88	ND	0.18	
Bogoria 3	758.6	ND	ND	104.6	ND	0.12	
Bogoria 5	1480.6	9.86	1.38	96.6	ND	0.16	
Bogoria	**19682.6**	**66.9**	**15.72**	**272.78**		**1.02**	
Elmt 1	498.4	21.22	ND	28	ND	0.3	
Elmt 2	752.8	18.3	ND	11.42	ND	0.18	
Elmt 3	906.2	5.28	36.34	21.78	ND	0.24	
Elmt 4	99.74	ND	ND	16.84	ND	0.24	
Elmt 5	37	15.5	ND	12.3	ND	0.16	
Elementaita	**2294.14**	**60.3**	**36.34**	**90.34**		**1.12**	
Ref. No.	Mn	Co	Cu	Zn	Cd	Cr	
Nakuru	1631.587	504.1	41.3	286.18		0.98	
Magadi	1499.44	69.12	53.54	158.48		0.94	
Oloiden	485.9	47.44	7.46	80.7		1.18	
Crater	829.5	135.74	46.36	110.68		0.86	
Bogoria	19682.6	66.9	15.72	272.78		1.02	
Elementaita	2294.14	60.3	36.34	90.34		1.12	
Ref. No.	**Mn**	**Co**	**Cu**	**Zn**	**Cd**	**Cr**	**Pb**
Naks A.C.W	0.008	ND	ND	0.032	ND	0.71	0.002
Naks Swg	0.004	ND	ND	0.029	ND	0.745	ND
Naks Mklia	0.001	ND	ND	0.032	ND	0.798	0.001
Naks Wck	ND	0.034	ND	0.032	ND	0.831	ND
Naks Njr R	ND	ND	ND	0.35	ND	0.895	ND
Nakuru	**0.013**	**0.034**	**0**	**0.475**	**0**	**3.979**	**0.003**

Appendix 4: Contd.

Mgd F.C.W	0.006	3.089	0.05	0.004	ND	0.914	0.014
Mgd SL2	0.003	3.063	ND	0.061	ND	1.048	0.014
Mgd M.G.B	0.002	1.808	ND	0.06	ND	1.29	0.01
Mgd WL	0.003	3.109	0.03	0.053	ND	1.346	0.014
Mgd Spn Area	0.008	2.383	ND	0.051	ND	1.329	0.007
Mgd SL1	0.006	0.637	ND	0.076	ND	1.416	ND
Magadi	**0.028**	**14.089**	**0.08**	**0.305**	**0**	**7.343**	**0.059**
Oloiden 1	0.006	ND	ND	0.048	ND	1.327	ND
Oloiden 2	0.006	ND	ND	0.049	ND	1.332	ND
Oloiden 3	0.005	ND	ND	0.048	ND	1.352	ND
Oloiden 4	0.005	ND	ND	0.049	ND	1.327	ND
Oloiden 5	0.005	ND	ND	0.05	ND	1.337	ND
Oloiden	**0.027**	**0**	**0**	**0.244**	**0**	**6.675**	**0**
Crater 1	0.005	ND	ND	0.051	ND	1.364	ND
Crater 5	0.005	ND	ND	0.051	ND	1.362	ND
Crater 3	0.005	ND	ND	0.051	ND	1.364	ND
Crater 4	0.005	ND	ND	0.052	ND	1.378	ND
Crater 2	0.004	ND	ND	0.051	ND	1.361	ND
Crater	**0.024**	**0**	**0**	**0.256**	**0**	**6.829**	**0**
Bogoria 1	0.006	0.16	ND	0.54	ND	1.33	ND
Bogoria 2	0.006	0.178	ND	0.054	ND	1.373	ND
Bogoria 4	0.008	0.253	ND	0.057	ND	1.405	ND
Bogoria 3	0.006	0.147	ND	0.055	ND	1.419	ND
Bogoria 5	0.006	0.133	ND	0.057	ND	1.432	0.001
Bogoria	**0.032**	**0.871**	**0**	**0.763**	**0**	**6.959**	**0.001**
Elmt 1	0.005	ND	ND	0.055	ND	1.439	ND
Elmt 2	0.005	ND	ND	0.055	ND	1.426	ND
Elmt 3	0.005	ND	ND	0.055	ND	1.425	ND
Elmt 4	0.005	ND	ND	0.055	ND	1.413	ND
Elmt 5	0.006	ND	ND	0.056	ND	0.413	ND
Elementaita	**0.026**	**0**	**0**	**0.276**	**0**	**6.116**	**0**

Chi-square tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-square	12.000[a]	10	0.285
Likelihood ratio	10.411	10	0.405
Linear-by-linear association	0.585	1	0.444
N of valid cases	6		

[a]18 cells (100.0%) have expected count less than 5. The minimum expected count is 0.17.

Metal element concentrations in water samples from lakes Nakuru, Bogoria, Magadi, Crater, Oloiden and Elementaita analyzed by atomic absorption spectrophotometry

Association between Mn in water samples and bird families identified at the Lakes.

Family	Asymp. Sig. (2-sided)	Likelihood ratio	Linear by linear association
Phoenicopteridae: Flamingos	0.263	0.458	0.169
Scolopacidae: Sandpipers and relatives	0.224	0.664	0.135
Recurvirostridae: Stilts and avocets	0.242	0.540	0.838
Anatidae: Ducks and geese	0.263	0.385	0.045
Pelecanidae: Pelicans	0.263	0.458	0.147
Ardeidae: herons, Egrets and bitterns	0.224	0.664	0.200
Threskiornithidae: Ibises and spoonbills	0.263	0.458	0.646
Phalacrocoracidae: Cormorants	0.306	0.177	0.179
Laridae: Gulls, terns and skimmers	0.263	0.458	0.059
Ciconiidae: Storks	0.242	0.540	0.356
Charadriidae: Plovers	0.285	0.405	0.265
Accipitridae: Diurnal birds of prey other than falcons	0.263	0.385	0.732
Gruidae: Cranes	0.306	0.368	0.042
Podicipedidae: Grebes	0.285	0.408	0.444
Accipitridae: African fish eagles			

Association between Co in water samples and bird families identified at the Lakes.

Family	Asymp. Sig. (2-sided)	Likelihood ratio	Linear by linear association
Phoenicopteridae: Flamingos	0.178	0.270	0.653
Scolopacidae: Sandpipers and relatives	0.263	0.4580.	0.756
Recurvirostridae: Stilts and avocets	0.116	0.246	0.028
Anatidae: Ducks and geese	0.122	0.206	0.775
Pelecanidae: Pelicans	0.469	0.502	0.364
Ardeidae: Herons, egrets and bitterns	0.263	0.458	0.585
Threskiornithidae: Ibises and spoonbills	0.178	0.270	0.542
Phalacrocoracidae: Cormorants	0.392	0.282	0.450
Laridae: Gulls, terns and skimmers	0.178	0.270	0.860
Ciconiidae: Storks	0.301	0.435	0.481
Charadriidae: Plovers	0.321	0.360	0.535
Accipitridae: Diurnal birds of prey other than falcons	0.213	0.206	0.636
Gruidae: Cranes	0.112	0.144	0.635
Podicipedidae: Grebes	0.321	0.360	0.531
Accipitridae: African fish eagles			

Association between Cu in water samples and bird families identified at the lakes.

Family	Asymp. Sig. (2-sided)	Likelihood ratio	Linear by linear association
Phoenicopteridae: flamingos	0.112	0.144	0.752
Scolopacidae: sandpipers and relatives	0.306	0.368	0.729
Recurvirostridae: stilts and avocets	0.199	0.248	0.0.028
Anatidae: ducks and geese	0.112	0.144	0.795
Pelecanidae: pelicans	0.753	0.662	0.396
Ardeidae: herons, egrets and bitterns	0.306	0.368	0.622
Threskiornithidae: ibises and spoonbills	0.112	0.144	0.571
Phalacrocoracidae: cormorants	0.439	0.341	0.480
Laridae: gulls, terns and skimmers	0.112	0.144	0.894
Ciconiidae: storks	0.199	0.248	0.521
Charadriidae: plovers	0.741	0.635	0.480
Accipitridae: diurnal birds of prey other than falcons	0.112	0.144	0.682
Gruidae: cranes	0.624	0.526	0.655
Podicipedidae: grebes	0.741	0.635	0.559
Accipitridae: African fish eagles			

Association between Zn in water samples and bird families identified at the lakes.

Family	Asymp. Sig. (2-sided)	Likelihood ratio	Linear by linear association
Phoenicopteridae: Flamingos	0.263	0.458	0.057
Scolopacidae: Sandpipers and relatives	0.224	0.664	0.911
Recurvirostridae: Stilts and avocets	0.242	0.540	0.823
Anatidae: Ducks and geese	0.263	0.385	0.630
Pelecanidae: Pelicans	0.263	0.458	0.772
Ardeidae: Herons, egrets and bitterns	0.224	0.664	0.786
Threskiornithidae: Ibises and spoonbills	0.263	0.458	0.643
Phalacrocoracidae: Cormorants	0.306	0.177	0.818
Laridae: Gulls, terns and skimmers	0.263	0.458	0.909
Ciconiidae: Storks	0.242	0.540	0.549
Charadriidae: Plovers	0.285	0.405	0.214
Accipitridae: Diurnal birds of prey other than falcons	0.263	0.385	0.202
Gruidae: Cranes	0.306	0.368	0.633
Podicipedidae: Grebes	0.285	0.405	0.564
Accipitridae: African fish eagles			

Metal element concentrations (ppm) in sediments from lakes Nakuru, Bogoria, Magadi, Crater, Oloiden and Elementaita analyzed by atomic absorption spectrophotometry

Association between Mn concentrations (PPM) in sediments and bird families identified at the lakes.

Family	Asymp. Sig. (2-sided)	Likelihood ratio	Linear by linear association
Phoenicopteridae: Flamingos	0.263	0.458	0.035
Scolopacidae: Sandpipers and relatives	0.224	0.664	0.592
Recurvirostridae: Stilts and avocets	0.242	0.540	0.713
Anatidae: Ducks and geese	0.263	0.385	0.682
Pelecanidae: Pelicans	0.263	0.458	0.468
Ardeidae: Herons, egrets and bitterns	0.224	0.664	0.511
Threskiornithidae: Ibises and spoonbills	0.263	0.458	0.656
Phalacrocoracidae: Cormorants	0.306	0.177	0.441
Laridae: Gulls, terns and skimmers	0.263	0.458	0.465
Ciconiidae: Storks	0.242	0.540	0.434
Charadriidae: Plovers	0.285	0.405	0.105
Accipitridae: Diurnal birds of prey other than falcons	0.263	0.385	0.414
Gruidae: Cranes	0.306	0.368	0.686
Podicipedidae: Grebes	0.285	0.405	0.517
Accipitridae: African fish eagles			

Association between Co concentrations (PPM) in sediments and bird families identified at the lakes.

Family	Asymp0. Sig0. (2-sided)	Likelihood ratio	Linear by linear association
Phoenicopteridae: Flamingos	0.263	0.458	0.505
Scolopacidae: Sandpipers and relatives	0.224	0.664	0.129
Recurvirostridae: Stilts and avocets	0.242	0.540	0.922
Anatidae: Ducks and geese	0.263	0.385	0.029
Pelecanidae: Pelicans	0.263	0.458	0.225
Ardeidae: Herons, egrets and bitterns	0.224	0.664	0.288
Threskiornithidae: Ibises and spoonbills	0.263	0.458	0.891
Phalacrocoracidae: Cormorants	0.306	0.177	0.210
Laridae: Gulls, terns and skimmers	0.263	0.458	0.049
Ciconiidae: Storks	0.242	0.540	0.572
Charadriidae: Plovers	0.285	0.405	0.416
Accipitridae: Diurnal birds of prey other than falcons	0.263	0.385	0.352
Gruidae: Cranes	0.306	0.368	0.028
Podicipedidae: Grebes	0.285	0.405	0.570
Accipitridae: African fish eagles			

Association between Cu concentrations (PPM) in sediments and bird families identified at the lakes.

Family	**Asymp. Sig. (2-sided)**	**Likelihood ratio**	**Linear by linear association**
Phoenicopteridae: Flamingos	.263	.458	504
Scolopacidae: Sandpipers and relatives	.224	.664	275
Recurvirostridae: Stilts and avocets	.242	.540	198
Anatidae: Ducks and geese	.263	.385	.557
Pelecanidae: Pelicans	.263	.458	.870
Ardeidae: Herons, egrets and bitterns	.224	.664	.592
Threskiornithidae: Ibises and spoonbills	.263	.458	.731
Phalacrocoracidae: Cormorants	.306	.177	.384
Laridae: Gulls, terns and skimmers	.263	.458	.856
Ciconiidae: Storks	.242	.540	.911
Charadriidae: Plovers	.285	.405	.446
Accipitridae: Diurnal birds of prey other than falcons	.263	.385	.901
Gruidae: Cranes	.306	.368	.634
Podicipedidae: Grebes	.285	.405	.350
Accipitridae: African fish eagles			

Association between Zn concentrations (PPM) in sediments and bird families identified at the lakes.

Family	**Asymp. Sig. (2-sided)**	**Likelihood ratio**	**Linear by linear association**
Phoenicopteridae: Flamingos	0.263	0.458	0.211
Scolopacidae: Sandpipers and relatives	0.224	0.664	0.355
Recurvirostridae: Stilts and avocets	0.242	0.540	0.789
Anatidae: Ducks and geese	0.263	0.385	0.142
Pelecanidae: Pelicans	0.263	0.458	0.865
Ardeidae: Herons, egrets and bitterns	0.224	0.664	0.858
Threskiornithidae: Ibises and spoonbills	0.263	0.458	0.631
Phalacrocoracidae: Cormorants	0.306	0.177	0.749
Laridae: Gulls, terns and skimmers	0.263	0.458	0.275
Ciconiidae: Storks	0.242	0.540	0.704
Charadriidae: Plovers	0.285	0.405	0.708
Accipitridae: Diurnal birds of prey other than falcons	0.263	0.385	0.101
Gruidae: Cranes	0.306	0.368	0.152
Podicipedidae: Grebes	0.285	0.405	0.792
Accipitridae: African fish eagles			

Association between Cr concentrations (PPM) in sediments and bird families identified at the lakes.

Family	Asymp. Sig. (2-sided)	Likelihood ratio	Linear by linear association
Phoenicopteridae: Flamingos	.263	.458	.830
Scolopacidae: Sandpipers and relatives	.224	.664	.945
Recurvirostridae: Stilts and avocets	.242	.540	.424
Anatidae: Ducks and geese	.263	.385	.692
Pelecanidae: Pelicans	.263	.458	.376
Ardeidae: Herons, egrets and bitterns	.224	.664	.514
Threskiornithidae: Ibises and spoonbills	.263	.458	.388
Phalacrocoracidae: Cormorants	.306	.177	.351
Laridae: Gulls, terns and skimmers	.263	.458	.959
Ciconiidae: Storks	.242	.540	.242
Charadriidae: Plovers	.285	.405	.456
Accipitridae: Diurnal birds of prey other than falcons	.263	.385	.342
Gruidae: Cranes	.306	.368	.733
Podicipedidae: Grebes	.285	.405	.113
Accipitridae: African fish eagles			

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Assessment of farmers' perception towards soil and water conservation in Obi Koji Peasant Association, Woliso District, South West Shewa Ethiopia

Gebeyanesh Worku Zerssa[1*], Bahilu Bezabih[1] and Birhanu Dinkecha[2]

[1]Department of Natural Resources Management, College of Agriculture and Veterinary Medicine, Jimma University, P. O. Box 307, Jimma Ethiopia.
[2]Office Manager in Woliso Woreda, Ethiopia.

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The severity of erosion is one of the major factors which calls for various efforts to reduce unsustainable agricultural productivity. But the efforts were fails because of some factors like need of incentives, technology that needs too much labor, reduction of farm size and lack of awareness. The main purpose of this research was to determine the factors affecting farmer's perception to make decision on soil and water conservation practices on their farm land. A total of 36 (20 male and 16 female) household samples from three zones of Obi Koji, West Ethiopia were selected proportionally to the population size, respectively. Data was being collected in the form of interview, questioner and field observations and secondary data from documented files. Direct household survey and formal interview method were used to take sampling. The study was focused on the determinant factors which affect the decision of farmers to adopt soil and water conservation practices in their local conditions. Majority of the farmers have awareness about the introduced soil and water conservation (SWC) and few of them implements it. The rest uses cultural practices such as diversion ditch and water ways. Nonetheless, the sustainability of the implemented structures was unlikely. The study concluded that many of those problems were related lack of real participation of farmers in planning of conservation effort. Lastly, the carefully pursue of a farmer participatory approach especially on planning and fair distribution of training among the zone of Kebeles is a core issue.

Key words: Conservation practices, farmer's perception, soil and water conservation.

INTRODUCTION

The problem of soil erosion in Ethiopia is well known. Increased pressure on land use of the hill slopes since the 1970s has resulted in soil losses in the highlands of Ethiopia (Simeneh, 2015). A large number of studies in

*Corresponding author. E-mail: workgb2010@gmail.com.

the highlands of Ethiopia have been carried out on the causes of soil erosion and technical remedial actions have been proposed (Gizaw et al., 2009; Abiy et al., 2015). Soil erosion in association with inappropriate land management practices is one of the main factors causing land degradation. Poor land and water management practices and lack of effective planning and implementation approaches for soil conservation are responsible for strong environmental impact and major economic losses from decreased agricultural production and from off-site effects on infrastructures and water quality by sedimentation process (Yihenew et al., 2012; Pravat et al., 2015).

Soil erosion creates several limitations to sustainable agricultural land use as it reduces on farm soil productivity and cause food insecurity (Tegegne, 2014; Simeneh, 2015). To address this problem, considerable efforts have been made since that time to rehabilitate degraded environments and stop further degradation by the government of Ethiopia (Amsalu and Garf, 2004). By this action huge areas were covered with terraces and millions of trees were planted (Gizaw et al., 2009; Yeshambel, 2013; Tegegne, 2014). Various soil conservation practices applied by farmers on their own farm plots are critical components of natural resource management when the aim is to achieve sustainable agricultural acceptable ecosystem integrity (Tegegne, 2014; Tesfaye and Kasahun, 2015). Soil erosion problem is also common in the Woliso district associated with topography and other determinate factors. Hence, the rate of severity varies from Kebele (ward) to Kebele (ward). Thus, in Obi Koji Kebele (ward) topography of the land, inadequate soil water conservation practice and land use problem is the main prioritized one which accelerates soil erosion (Data of the Kebele extension document un published). Additionally, farmers frequently reject newly introduced soil water conservation practices even when they are aware of the fact that measure protects and improves productivity of the lands. Therefore, assessing the factors which affect the attitude of the farmers towards soil water conservation in Obi Koji Woliso district is necessary.

Statement of the problem

There are significant problems that were observed in the Kebele as a result of lack of farmer's attitude towards soil and water conservation practice such as: inadequate soil and water conservation practice; indicators of serious soil erosion; and decrease in productivity of land.

Objective of the study

The general objective of the study was to identify factors affecting farmer's perception to make decision on soil and water conservation practices on their farm land. The specific objectives were to evaluate local farmers perception of soil and water conservation practice and to assess the impact of incentive for adoption of SWC measures.

Significance of study

The result of this study was certainly being important both for farmers and the government. On this, it (1) helps farmers to identify the area of the problem and to minimize it, (2) enables the farmers to understand the problem of SWC and to discuss on it, (3) helps the farmers to know the factors that affect their perception towards SWC, and (4) enables the expert to know the attitude of the farmers towards SWC practice.

MATERIALS AND METHODS

Description of the study area

The study was conducted during the month of May to December 2015 in the Obi Koji Kebele peasant association (Figure 1). Kebele is located at 115 km from Addis Ababa capital city of Ethiopia and 235 km from Jimma town. The elevation ranges between 2100 and 2600 m.a.s.l. Thus, the area experience subtropical zone (90%) and cool zone (10%) climate with rainfall ranges from 1500 to 2250 mm with temperature minimum 15 to maximum 25, the dominant soil types of the Kebele is 35% Vertisols and 65% clay soil (Kebele Extension Worker Data, unpublished). Agriculture of the area is in rain fed with a subsistence mixed farming system. The major crop grown in Kebele are wheat (*Triticum*), barely (*Hordeum vulgare*), bean (*Phaseolus lunatus*), pea (*Pisum sativum*), teff (*Eragrostis tef*) and lentil (*Lens culinaris*).

The total area of the Kebele is 2100 hectare. There are three zones identified by the Kebele based on the sub watershed, named as Zone I (Obi Osole), Zone II (Balchi) and Zone III (Obi Koji). The total numbers of household are 427, of which 51 are women, 376 are male headed household and it has 2514 people of which 1333 are women and 1181 are male in the Kebele. The major edible food is locally named as "Injera and Dabo (Kebele Extension Worker, unpublished).

Data source and analysis

The data required for the study was generated through formal house hold survey and interviewed with individual farmers and extension workers called development agent (DA), working in the Kebele. The assessment was undertaken between May to December 2015. For the interviewed household survey sample of 36 farmers households from three zones of Kebele were randomly selected and interviewed, of which 16 were female headed. The stratification of sample was depending on the level of farmer's willingness to adopt the introduced SWC technologies. Fast, medium and laggard adopters were taken into consideration. The lists of these farmers were availed by the Kebele (DA), administration of the Kebele and elder group of the three zones.

From the interviewed farmers, 51% were those who adopt the introduced soil and water conservation structure on their farm lands. The survey questionnaires comprised both closed and open

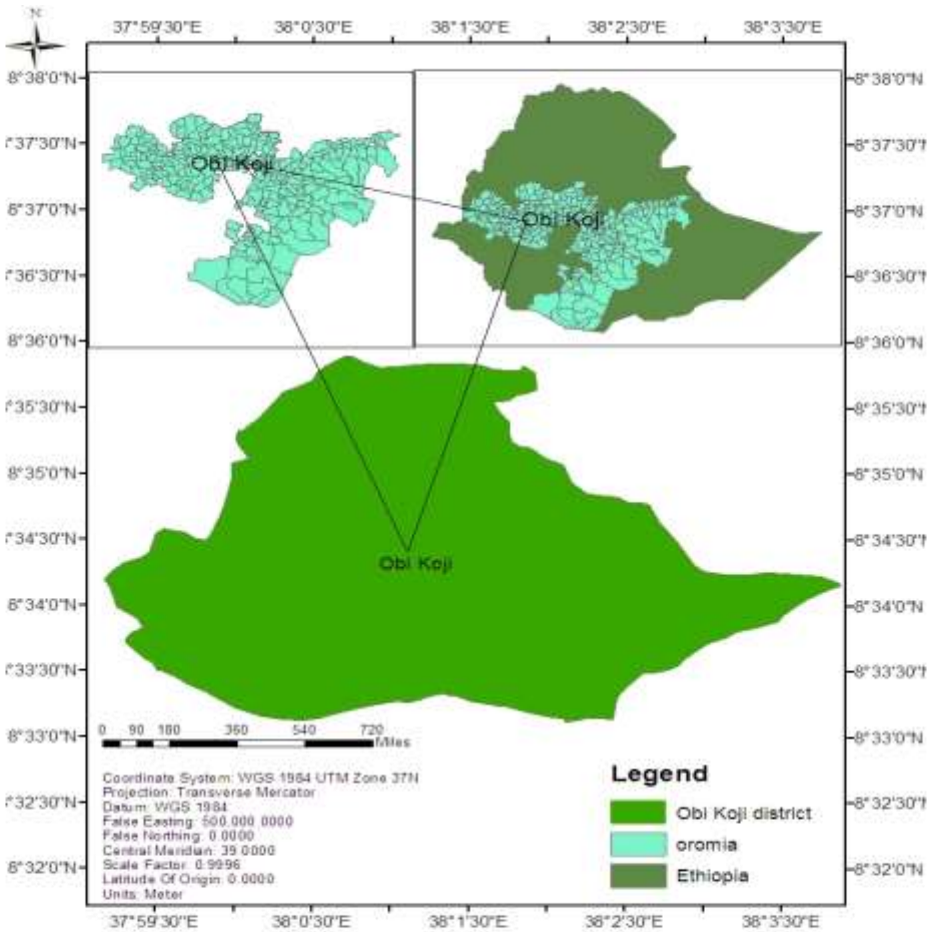

Figure 1. Map of the study area.

ended types of questions. The questionnaires generated information on the extent of farmer acceptance and adoption of the introduced conservation technologies. In reference to their awareness and perception of erosion hazards, labor supply, effectiveness of the technology in controlling soil erosion and improving land productivity, land tenure system and others. Each respondent was informed about the purpose of survey before starting the interview. Thus, they have developed trust to answer the question. Documentary materials available with the DA were also consulted to obtain information on types of the SWC technologies under implementation. Descriptive analysis has been employed in the analysis. Finally, the data generated by the questionnaires were presented by using percentage.

RESULTS AND DISCUSSION

Household farm characteristics

As described in Table 1, the total households in Obi Koji Kebele were 427 of which 376 were headed by males and 51 by females. The total population of these household were 2514 people and 1333 are women and 1181 are male in the Kebele. There were 197 people in the 36 surveyed households. The average family size is five persons (Table 1). The average age of sampled farmer was 48 with a minimum age of 33 and maximum of 63 of the total respondents (44%) were females. Half of the respondents (47%) were illiterates, while the rest are reading and writing through basic education and religious schools. All of the interviewed farmers owned land. The mean holding farm size is about 1.5 ha. The significances variation in the size of land holding among sampled households. The majority of farmer (47%) possessed less than 2 ha of lands where 36% have more than 3.5 ha. During interview, the respondents reported that one household possessed up to six plots of farm lands within the small total farm size or cropland which were rented especially for temporary cultivated without any conservation structures except some traditional ditches. As farmers said, their lands were fast losing their productivity due to lack of attention given by the owner or the one who rent the land.

In rainy season (kiremt), the livestock was dependent on

Table 1. Characteristic of total households and their livestock in the three zones.

Characteristics	Kebele			Total
	Zone-1	Zone-2	Zone-3	
Total house hold	132	124	171	427
Family size	837	787	890	2514
Sample house hold	12	12	12	36

Table 2. Farmers response to the cause of erosion, fertility and product.

Farmer'	Option	Percentage (n=36)
Cause of soil erosion	Lack of conservation structure	51
	Steep land without conservation structure	3
	Damaged conservation structure	31
	Lack of diversion ditch	11
	Other	4

Table 3. Farmer's conservation practice in Obi Koji Kebele.

Management option	Percentage (n=36)
Contour plowing	5
Cultural ditch	31
Soil bunds	39
Stone bund	12
Grass strips	0
Water ways	10
Others	2

heavily degraded (overgrazed) communal land. Some edible weed species from the field were also important source of livestock's feed during the dry season (bega), crop residue (mainly barley and wheat straw) were the main feed. During this season, crop lands as serve as grazing lands. Finally, the respondent said currently fodder availably became a critical factor determining livestock productivity.

Causes of soil erosion, soil fertility and productivity decline

As indicated in Table 2, the major causes of soil erosion in the area mentioned by farmers were steep slope, without conservation structures, lack of conservation structure, damaged conservation structure and others like deforestation, free grazing and lack of income to construct SWC structure. Minor of the farmer said that lack of diversion ditch also contributed to the cause of soil erosion.

Almost all of the farmers interviewed said that the cause of soil erosion of their farm land was lack of conservation structure. Damaged conservation structure was also other major cause of soil erosion, as mentioned by 31% of the respondents. Additionally, other reasons gave little contribution for soil erosion and fertility decline was lack of diversion ditch, cultivating steep land without conservation structure.

As reported by Adimassu (2017) most interviewed farmers believed that, productivity and their land declined because of soil erosion. As mentioned by respondents' soil, erosion was the main cause of fertility decline. On the other hand, repeated cultivation had its own effects on fertility and productivity decline. No respondents said that rainfall shortage is a problem (Table 2). In general, almost all the respondents have a good knowledge of the cause of soil erosion, fertility and productivity decline.

Farmer's conservation practice in Obi Koji Kebele

All the respondents answered that soil and water conservation measures were very helpful for erosion control and better to improve soil productivity. Farmers used terraces, cultural drainage ditch, soil bund, water way and others to control their farm land from erosion.

Traditional ditches locally called "Dandii lolaa" were indigenously practiced by 33% of the interviewed farmers for control soil erosion (Table 3). It is used to drain out excess water from their cultivated lands. The farmers also believed that these ditches were effective especially one cropping season to conserve soil against erosion. They emphasized that "ditches" need less labor, low cost and short time construction as compared to other conservation structure. However, they concluded that ditches have little importance for sustainable land management as compared to other improved soil water conservation technologies. This shows that farmers have a good knowledge's about introduced SWC technologies. Gizaw et al. (2009), also emphasized similar results that is important for effectiveness to implement SWC measure depends upon knowledge and information of farmers. From interviewed farmer, soil bund and stone bund were practiced by 51% for mean of conservation. However, from field observation bund were poorly maintenance specially those who rented land from land holder, farmers does not give attention for maintenance of already constructed bunds due to need of immediate return and they believe that bunds can decrease their farm size. Even long term returns of soil bund were other problems for adopting SWC technologies.

A waterway which is locally constructed alongside of cultivated field was used by 10% respondents. This water way are more wider and deeper than cultural contour plowing also practiced in the Kebele as suggested by 5% of respondent. This measure was practiced culturally. For decrease of traction of animals during plowing on steep as respondent mentioned contour plowing were not efficient alone to control erosion. Furthermore, during interview, crop rotation and planting trees was also mentioned as important mechanisms to control erosion.

Farmer’s perception, acceptance and adoption of SWC measures

Since the 1990, implementation of soil and water conservation measured has been taken as part of agricultural extension package of the present government (Bewket, 2003). However, the practice has largely delivery oriented in which the farmer forces to the implemented conservation measures designed for them by technical expert (Simeneh, 2015). All of the respondents believed that the new soil and water conservation technologies have the potential to improve land productivity. The farmers who tried to implement some conservation measures in their plots were interviewed on how they measure the effectiveness of soil and water conservation technologies. They had already observed a better growth and development of crops particularly along the structures felt sediments were trapped. They also evaluated that if that conservation structure were not built, during data collection, participant who treated their land by some conservation structures gave wittiness for us that technology have improved their land productivity.

The farmers were interviewed also what their intensions were regarded using the introduced soil and water conservation technology in the future (Table 4); majority of the respondents expressed their commitment to continue maintaining the established structures. In addition to this form, the interviewed whether they would like to apply the soil and water conservation technologies in the rest of their farm fields (pilots that were not treated by that time); most of the respondents expressed that they had plan to implement SWC measures. However, they intentionally need availability of incentive to implement SWC measures in their land.

According to Mebrahten (2014) and Simeneh (2015), the use of incentives in promoting adoption of soil and water conservation measures under the condition of the Ethiopia high land was necessary. Farmers are unlikely to expect that the introduction of new conservations measures will improve their immediate well beings. They suggested the use of incentives such as food for work and creditors’ fertilizers are interring linkage mechanism and adopting soil and water conservation measures. Similarly, the assessed result indicates their attitude towards support need from government or other body, they were asked whether they should be paid for constructing and maintaining soil and water conservation structure in their farm. The minority (44%) responded “no” while majority (56%) answered “yes”; especially materials and money incentives. This shows farmers had an intention for incentives to adopt conservation measures from government and concerned body.

Factors affecting farm level adoption of the SWC technologies

The following section presents details of some factors that influence the farmer’s decision with regards to utilization of the technologies as part of their regular land use and agricultural production activities.

Perception of erosion as a problem

Perception of soil erosion as a hazard soil productivity and sustainable agriculture was the most important determinant of effort of conservation measures. On the other hand, when farmers do not accept soil erosion as a problem, they cannot expect benefits from controlling the erosion process and it is highly that they will be by the side against adopting any conservation technologies.

As shown in Table 5, the results support the findings of Biratu and Asmamaw (2016), all the interviewed farmers perceived soil erosion as a problem on their own farm that constraining soil productivity. They said that the most important top soil for crop production activity was deteriorating over time due to erosion processes. Hence, they observed frequently how they lose soil from cultivated fields has been reducing the depth of the top soil throughout the time. Moreover, soil depth decrease or the unproductive soil (stone which is very compacted) will be left. The majority of the respondents reported that the occurrence of rill erosion is dominant erosion feature for all on their farm lands. While gully and sheet erosion is moderate.

From all respondents, almost half of the farmers rated the extent of the problem as sever and some respondents mentioned that the rate of soil erosion has been increasing over the time while small number of respondents believed that the extents of erosion were minor (Table 5). Almost all respondents answered that erosion can be controlled while very small number of respondents believed that erosion was not controlled totally, but it can decrease some degree of its severity.

Farmers were asked to respond on how they knew about soil erosion which occurs on their land in open-ended question part. Some of the respondents said, there was over flow of constructed ditches and it damages their

Table 4. Indicators of acceptance and adoption of SWC technologies.

Farmers response to	Option	Yes (%)	No (%)
Indicators of acceptance	Their knowledge of SWC measures	100	-
	Effectiveness of SWC in arresting soil erosion	100	-
	SWC have a potential to improve land productivity	100	-
Indicators of adoption	Plan to implement the new SWC tech;	72	28
	Plan to maintain the constructed structured	56	44
	Farmers should be paid for constructing and maintain SWC in their farm	56	44

Table 5. Farmer's perception of respondents for soil erosion as a problem.

Farmer's response to	Option	Percentage (N=36)
Occurrence of soil erosion	Yes	100
	No	0
Prevailing from of erosion	Sheet erosion	3
	Rill erosion	85
	Gully erosion	12
Extent of soil erosion (The degree of the extent damage)	Sevier	43
	Moderate	49
	minor	8
The rate of erosion over time	Increasing	53
	Same	0
	Decreasing	47
Can soil erosion be controlled	Yes	86
	No	14

crops when there was siltation in and out of their field mostly at the lower field border. Rills appeared on their field, when the color of soil in the upper part of the field goes to red and compacted stone than lower field. From these responses, it can be concluded that farmers have good perception of erosion as a problem that limits their soil productivity. Hence, there is lack of interest to adapt the technology which cannot be concluded by lack of awareness about erosion as a problem. Bewket (2003) also report similar result from his study that the majority of the farmers had indicated soil erosion as a key agricultural problem yet most of them were not willing to participate in construction of SWC structure. Thus, this implies the perception of erosion as a problem which may be necessary, but not always sufficient condition for adoption of SWC structure on farm level.

As sited by Rehema (2014), property rights claimed to affect adoption of SWC practices at the farm level. This means owner operators have a high tendency to adopt soil conservation practices than individuals who are not land owners driven by short term profit maximization. All (100%) interview respondents answered that land security was not a problem to adopt soil and water conservation practices on their farm land (Table 6). In Kebele, the newly introduced soil and water conservation measures are not a vital problem of awareness, most farmers showed unwillingness to adopt the newly introduced soil and water conservation structures. Most of the interviewed farmers said that some conservation measures like terraces and soil bund were land consuming and labor demanding for construction (Table 6). The other issue that affected their conservation practices was age, lack of income and family size to construct bunds and terraces.

In the data assessment and formal interviews, lack of drained water away from land of each other was the big

Table 6. Farmers reasons for not adopting the newly introduces SWC measures.

Options	Percentage (n=36)
Requires too much labor to implement	34
Land insecurity	4
Decrease farm size and difficult to plow	32
Lack of knowledge	23
Note considering erosion as a problem	0
Other (lack income , age, family size	7

problem raised by the participants. For example, farmers wanted to construct terraces by his/her indigenous knowledge, and if his/her neighbor does not, the runoff will not drain out. As the owner of the down slope fields does not permit to receive the run off since he/she did not construct some conservation measures like the one who did. Based on the above idea the interviewer raised the issue raised to Kebele development agent. They also understood/accept the raised idea was a problem of Kebele. Therefore, they have a future plan to implement soil and water conservation adoption in organized group to enhance the effectiveness of new technology.

Finally, farmers during personal interview were asked to recommend what should be done to improve effectiveness of soil and water conservation measures.

They suggested

(1) Most farmers do not have materials to construct terraces and bunds. Therefore, the concerned body like governments should support in this regards.
(2) Technical support from expert (DA) to design soil and water conservation measures is necessary.
(3) Even though some farmers have awareness to soil erosion problem, continues training and experience sharing and incentives should be given for the community for more understanding and implement the new soil and water conservation measures.
(4) Once conservation structured is constructed, it should be maintained whenever necessary.
(5) Efforts should be taken until farmers show willingness or adopt the technology
(6) If there is accessibility of grass and trees seedling, they have dual purposes for forage and soil conservation measures.

CONCLUSION AND RECOMMENDATION

Generally, from the research conducted, it was concluded that soil and water conservation were not sufficiently implemented as compared to erosion hazards of Kebele. The conservation undertaken in Kebele does not fairly distributed to the three zones of Kebele equally. The effectiveness in controlling depends on perception of farmers rather than using other different approaches to accept farmers. Even though, the farmers of Kebele have a good perception, they consider the structure can consume more land and need labor. The farmer suggested the use of incentives such as food for work and creditors' fertilizers are interring linkage mechanism and adopting soil and water conservation measures. Almost all the farmers have a good perception about erosion hazards, but their willingness to adopt SWC measures depend intentionally on incentives. Almost half of the farmers within the Kebele also practice the local diversion ditch as a means of conservation measures which is believed to be simple, not need too much labor, do not decrease farm size. Land tenure affects farmer's perception to adopt SWC technology. Based on the research, the following future lines of work are forwarded:

(1) Fairly distribution of technical support, training and application of improved SWC technology is necessary across three zones.
(2) Real farmers participatory approach necessary in planning and implementing of SWC to increase their preferences for adopting SWC technology.
(3) Avoiding dependences on incentives by cooperating farmers to implement SWC technology.
(4) Improving market accessibility and exporting potential for local products.
(5) Maintaining and stabilizing constructed SWC technology continuously.
(6) Training should be taken until farmers show willingness/adopt the technology.
(7) Facilitate zero grazing.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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