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The Effect of Smallholder Farmers' Managed Wetlands on Plants' Diversity and Soil Properties in Gedeo Zone, Gedeb wereda, Southern Ethiopia.

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Abstract

This study was conducted in southern Ethiopia to assess the impact of smallholder farmers' managed wetlands on plants diversity and soil properties. Vegetation data were collected from 60 plots having (1m x1m) quadrats laid on five transects lines along the altitudinal gradient. Vegetation data were analyzed using, descriptive statistics, Sorenson's similarity, and Shannon-Wiener diversity index and R. 2.14 software. Sixty composite soil samples were collected at depth of 0-15 and 15-30 cm to study soil texture, pH, electrical conductivity, soil organic carbon, total nitrogen and cation exchange capacity at a distance of 1m, 100 m, 200 m and 300 m from the wetland. Moreover, 60 undisturbed soil core samples were collected to examine soil bulk density. Analysis of variance ($P<0.05$) was employed to test the degree of variations. Result showed 65 plant species were identified and grouped in 21 families. Of all families, Poaceae contains 12 species. The Sorenson's similarity showed highest similarity was observed between community one and two 85% and lowest similarity were observed between community one and three 28%. The highest diversity of species was observed in community four while the highest species evenness was observed in community two. A soil bulk density ($p =0.001$) and EC significantly varied ($p<0.001$, $p = 0.041$ respectively) with distance from wetland. Similarly, variation was observed on silt, clay, soil bulk density and CEC ($p = 0.031$, $p = 0.046$, $p<0.001$ and $p<0.001$ respectively) along with the soil depth. The soil near the wetland has shown improvements relative to the distance treatments. The improvement in the soil properties near the wetland was due to higher soil organic matter (SOM) input and less soil disturbance.

Keywords: Soil properties, Plant diversity, and Smallholder farmers'

1. Introduction

Wetlands are an important resource base actively utilized by rural communities for socio-economic activities (Dube and Chitiga, 2010). The more water content in wetlands allows diverse flora and fauna life to develop and enrich species biodiversity (Berhanu, 2003). A large number of people are believed to be dependent on wetlands for their livelihood. The loss of species from wetlands has led to a decline in productivity, nutrient retention and resistance to invasion by introduced plant species (Naeem et al., 2000). Despite their importance, wetlands are being continuously altered for the agricultural purpose by human (Dube and Chitiga, 2010).

In Ethiopia, wetlands are locally known as *Chefa*, and cover about 1.14 - 2% of the country's land mass (Tariku and Abebayehu, 2003; Karlsson, 2015). Currently, studies estimated that wetland of Ethiopia exceed 2% (22,500 km2) of the country's surface area (Mengistu, 2006). The dispersed distribution of wetland has made them accessible to a high proportion of the rural population (Kassahun *et al*., 2014). The use of wetland as pasture and cultivation area has increased due to the growing rural population and economic pressures (Dioxn and Wood, 2003). As a result, wetlands cultivation is becoming a well-established tradition amongst rural farmers in Ethiopia so that their gardens provide a regular supply of crops which is especially important during drought years (Tuluab, and Destabc, 2015).

In Ethiopia shortage of agricultural land forced the surrounding communities to drain the wetland for crop cultivation, to meet the increasing food demand of household. In this regard Afwork (2001) and Berhanu (2003) reported that small landowner farmers drain wetland to keep their food security. Draining wetland for growing food crops, the appearance of invasive plant species due to mismanagement of the resources, and the introduction of eucalyptus tree into the wetland ecosystem are the major threats that are posing a danger to the country's wetlands (Zerihun and Kumlachew, 2003). Furthermore, Assefa et al. (2015) also reported that poor community plant eucalyptus tree near the wetland to generate income and for farmland expansion. Planting a eucalyptus plant harms wetland-dependent plant and soil fertility (Kassahun *et al*., 2014). Moreover, drainage and cultivation of wetland have major impact on wetland hydrology (Doxon,2002) which determine vegetation composition, diversity and soil properties(Collins, 2005) disposal of industrial waste affecting wetland plants diversity and oil properties (Bahilu and Tadesse, 2017).

The ecological value of wetland in Gedeo zone has been taken for granted because of incorrect public perceptions, poor legislation and conservation strategies that are not backed by adequate scientific research (Bogale, *et al.,* 2015). This makes it difficult to get full information about wetland flora, and soil properties to plan for wetland conservation and to integrate conservation and development goals at local level. Similar problems were observed in the study area (personal observation). In Gedeb wereda wetlands cultivation is increasingly needed due to growing population associated to shortage of agricultural land decline in crop productivity of the uplands. Furthermore, drainage of wetland for micro irrigation and temporary roads construction has impact on wetland hydrology which is one of strongest determinant for wetland vegetation composition, diversity and soil properties. Therefore, there is a need to continue research on wetland plant diversity, and soil properties, especially in view of the growing level of human impacts that are contributing to their destruction. This research is the first of its kind in the study area since there is no research carried out on plants and soil properties before. Thus, this study investigates how the exploitation of Gedeb wetland by smallholders' farmers change vegetation composition, plant diversity and soil properties.

2. Materials and Methods

2.1 Description of the study area

The study was conducted in Gedeb woreda, Gedeo zone, Southern Ethiopia (Figure 1). The wetland is found in Ginda watershed of Gedeb Woreda southern Ethiopia. The wetland is located between 5051′03″ to 5058′33″ latitude and 38012′46″ to 380 15′ 46″ longitudes covering a total area of 38.2 km2. The study was conducted in two kebele (Gedeb Gubeta and Harmufo) purposely selected among five kebeles based on the extent of wetland coverage and wetland uses by smallholder farmers. Accordingly twenty households (HHs) living around wetlands were selected by purposive sampling techniques (i.e. HHs near to the wetland were purposively selected than HHs far away from it). After selecting the respondents, a survey questionnaire was distributed to 120 respondents. Survey questionnaire was prepared in English and later it was translated in to Amharic to collect the benefits of wetland for the local community.

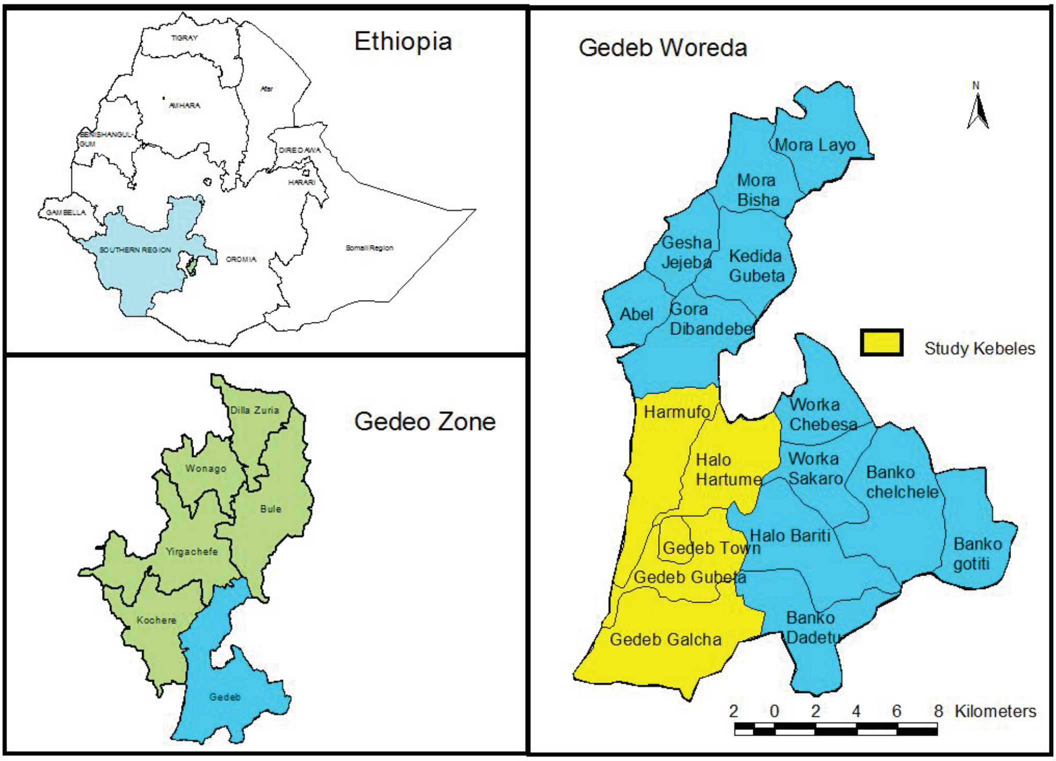

Figure 1: Location map of the study area

According to FAO's soil classification, dominant soil types of Gedeb wereda are Eutric Fluvisols, and Eutric Nitosol (Ethio-GIS, 1994). The average yearly annual rainfall is 1480 mm. the rainfall distribution is bimodal (Figure 2).The maximum and minimum temperature are 22.9^{0}c and 12.3^{0}c respectively (Figure 2). The area is densely populated with 603 persons per sq km in 2014 with high growth rate of about 3.3% per a year. With this growth rate, more agricultural land is demanded in the near future to meet the demand for agriculture production of which wetland are among the potential victims.

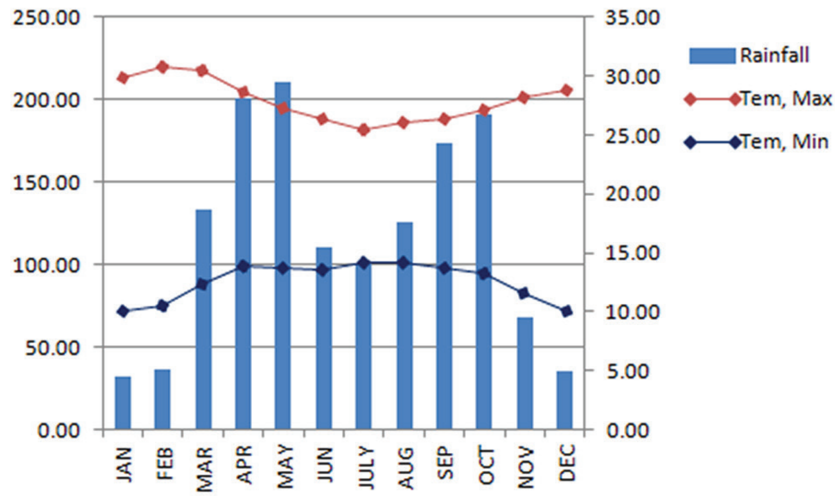

Figure 2: Mean monthly rainfall and temperature of Gedeb Wereda (2000-2009 GC)
Source: Ethiopia Meteorological Agency, Hawassa Branch, (2012).

2.2 Plant Sampling and identification

A plant sampling survey was made from June 2016 to mid- September. This period was selected because most species were expected to reach their full growing stage. Five transects lines 400 m long and 2 m wide were laid parallel to each other on the water flow. These transects were laid from the northern direction towards the south 80 m apart.10 quadrates of 100 cm x100 cm were laid systematically along each transect line. Sixty quadrates were sampled on the wetlands. In each quadrate, different plant species were recorded and identified using flora of Edwards (1989), Azene (2007), Edwards and Mesfin (1995), Sebsebe and Edwards (1997).

2.3 Diversity assessment

The Shannon diversity (H ') and evenness (E') indices were calculated as a measure to incorporate both species richness and species evenness (Magurran, 988). The Shannon diversity index (H') 1was calculated using the following formula (Helper and Soetalk, 1998).

$$H' = -\sum_{i=1}^{S} pi \ In \ pi$$

Where:

H′= Shannon-Wiener Diversity Index, S= number of plant species encountered, pi = is the proportion of individuals found in the i^{th} species, Pi = ni/N =, Ni = number of individual species, N= total number of all individual of all species.

The values of Shannon diversity index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5 (Magurran, 1988). The evenness (E) component of H' was computed

$$E = \frac{\mathrm{H}'}{\mathrm{Ln(S)}} = \frac{H'}{\mathrm{H'max}}$$

Where: E= Evenness, H`max= Ln (S), S= total number of species in sampled plots. Sorensen's similarity index was used to assess the similarity of plant species in the wetlands using the formula (Kent and Cooker, 1992). Hmax is the maximum level of diversity possible within a given population, which equals ln (number of species). Magurran (1988) explained that *E* ' ranges normally between 0 and 1, where 1 representing a situation in which all the species are equally abundant.

$$\mathrm{S} = \frac{2\mathrm{C}}{\mathrm{A+B}}$$

Where: S is Sørensen‟s similarity index, C= is the number of species common to both sites, A is the number of species present in one of the sites to be compared B is the number of species present in the other site.

2.4 Soil sampling

Soil samples were collected by soil auger measuring 5 cm in diameter and 30 cm in depth. Sixteen soil samples were collected from 60 quadrates at depth of 0-15 cm and 15-30 cm. The samples were placed into self-sealing plastic bags and stored in a cooler until laboratory analysis was carried out. The soil sampling was chosen among the plots used for plant sampling using a simple random method. Soil bulk density was determined by core method using core sampler and drying it to constant weight in an oven at a temperature of 105^{0}c for 24 hours. Soil texture was determined by hydrometer methods (FAO, 2006). Soil organic carbon was determined by Walkley method (Nelson and Sommers, 1982). Soil total nitrogen was analyzed by Kjeldahal method (Bremner and Mulvaney, 1982). Soil pH (1:2.5 soil: water) was measured by using the glasscalomel electrode whereas electric conductivity (EC) was measured by conductivity meter using suspension of 1:2.5 soil water ration. Cation exchange capacity (CEC) was determined at soil pH 7 after displacement by using 1N ammonium acetate method in which it was thereafter estimated titrimetrically by distillation of ammonium that was displaced by sodium.

2.5 Data analysis

Descriptive statistics such as frequency and percentage were used to summarize wetland vegetation and soil data collected from the fields. The results of the study were demonstrated in tables, bar graph and figures. Vegetation data were analyzed using Sorensen's similarity index, Shannon-Wiener's diversity index, and Shannon index of evenness. Multivariate analysis was carried out using R- program Version .2.14. Analysis of variance (ANOVA) was employed to test the degree of variations. Turkey's Honest Significance Difference (HSD) test was used when the mean separation showed statistically significant differences ($p < 0.05$).

3. Result and Discussions

3.1 Benefits of wetland for smallholder framers

As it was indicated in Table 1 a large proportion of household farmers were found to be dependent on Gedeb wetland. Thus, the wetland area the local community used for cultivation accounts about 32.33% and for ching grasses 17.41% and for grazing 17.41%. This indicated that wetland is pressurized by the local community. The evidences suggested that wetland in this area serve the needs of the people in individual, family, community, and village levels. The study also revealed that the majority of households' livelihood was directly linked to the wetland. This result suggested that the wetland is the most important resource for livelihoods of the local community and the dependence of the community on wetlands resources are higher. Similarly study by Kassahun *et al*. (2014) reported that 40% of the community used wetland for cultivation while Elias *et al.* (2016) reported that about 50% people used wetlands for cultivation.

Table 1. Wetland resource uses by smallholder farmers

Uses of wetland	Respondents	
	Frequency	Percentage
Ceremonial	15	7.46
Thatching grasses	35	17.41
Dry season grazing	31	15.42
Water for livestock	30	14.92
Cultivation	65	32.33
Micro irrigation during dry season	25	12.43
Total	201	100

3.2 Species composition

A total of 65 wetland plant species representing 55 genera and 21 families were recorded from Gedeb wereda wetland (Appendix 1).The Families with the highest number of species were poaceace with 12 (18%) species followed by Asteraceae with 7(11%) and Cyperaceae with 6 (9%) species and the rest with 1 to 3 (1.5% - 4.5%) species (Table 2). The number of species in each plot varied greatly from 7 species in plot 8 to 18 species in plot 29. These findings are similar with Zerihun and Kumlachew (2003) who reported family poaceae is the dominant in wetland of southwestern Ethiopia.

Table 2. Wetland plant families, genus and species in Gedeb wereda

Family	Genus	%	Species	%	Family	Genus	%	Specieses	%
Acantha-ceae	1	1.5	1	1.5	Juncaceae	2	3	2	3
Amrantha-ceae	2	3	3	4.25	Lamiaceae	3	4.5	3	4.25
Apiaceae	3	4.5	2	3	Nymphaceae	1	1.5	1	1.5
Asteraceae	7	11	7	11	Onagraceae	1	1.5	1	1.5
Commelin-aceae	2	3	5	8	Osmundaceae	2	3	2	3
Cyperaceae	6	9	12	18	Polygonaceae	3	4.5	5	8
Dryopteri-daceae	1	1	1	1.5	Potamogetonaceae	1	1.5	1	1.5
Eriocaula-ceae	1	1.5	1	1.5	Ranunculaceae	2	3	1	3
Fabaceae	1	1.5	1	1.5	Solonaceae	1	1.5	1	1.5
Poaceae	12	18	11	20	Tiliaceae	2	3	1	1.5
Irideaceae	1	1.5	1	1.5	Total	55	83	65	100

There are about 58.46% herb and 41.43% gramminoid in the wetlands. Number and life forms of the species are indicated in appendix 1. In terms of their habitat, (37%) of the species are found in damp or wet habitats. Of the rest, 37 species (57%) grow in both wet and dry habitats. Many of these are weeds or plants of marginal habitats. Sufficient habitat information is not available for the remaining 4 species (6%). This finding is in agreement with Melaku *et al*., (2004); Rebecca (2006) who reported that most of wetland plant species is dominantly found in marshy habitat.

3.3 Sorenson's similarity for the communities

The distribution of plant species in identified plant community showed there is a dissimilarity patterns (Table 2). The overall similarity coefficient ranges from 14%-61% among all the communities. The highest similarity was observed between community one and two (85%), this may be due to the existence of quadrate id adjacent to each other. The lowest similarity was observed between community one and three (28%), and community two and four (14%). The reason is the existence of similar soil chemistry and altitudinal gradients in each habitat. Similar findings by Dube and Chitiga (2011), reported that similar soil physical and chemical properties determine the distribution and abundance of plant species.

Table 3. Sorenson's Similarity coefficient among the four communities

Community	I	II	III	IV
I	1			
II	0.61	1		
III	0.28	0.58	1	
IV	0.35	0.14	0.43	1

3.4 Species richness, diversity and similarity of the communities

The overall Shannon–Wiener diversity and evenness of the wetland were found to be H'max=2.06 and E=0.115 respectively. However, the H'max values of the four communities were different (Table 3). The Shannon–Wiener diversity (H') and Evenness (E) values of the entire wetland were less than H'max values of some communities like community 2 and 4 (Table 3) which implies that each community may show variation with total species richness and diversity indices. Study by Fungai (2006) also reported that the wetland specie's richness varied overexploitation of plant species for different purpose.

Table 4. Species richness, diversity and evenness in each community

Community types	Quadrats included in each community	No of species	H' Max	evenness (E)
Type I	34,3	2	1.9	0.11
Type II	65,62.26,60,59,58,57,56,55,54,52, 50, 49,48,47,46,45,44,43,42,40,39,38,37,33,29,28,10	28	2.25	0.14
Type III	14,9,12,1	3	1.6	0.12
Type IV	3,8,6,11,13,53,25,32,23,16,20,30,7,22,16,24,18,19,17,41,135,27,21,5,4,2, 51,31,36,15,24,63,64	33	2.49	0.09

As shown in table 3, the highest H' max were community type 4 followed by community type 2 and 1.Whereas the lowest H' max' were community type 3 (H'=1.6). Community four also consisted the highest number of species richness followed by community two and the least was at community one. The highest species richness and diversity indices were community 4 and 2. This may be due to less proximity to the residence and exposure to disturbance, like grazing, browsing and others (personal observation). Similar work by Afework 2001; Zerihun and Kumlachew (2003) reported the lowest species diversity and evenness were due to increasing anthropogenic disturbances notable through agriculture, settlement, intensive grazing, expansion of huge infrastructures and brick making. Similarly Mcune and Grace (2002) and Assefa *et al*.(2015) explained in their study that the highest species diversity and evenness were found due to low disturbance intensity while there was a drastic decrease at high disturbance intensity of wetland.

3.5 Plant Communities classification

Cluster analysis was used to identify groups of sampled vegetation that are similar in terms of their species composition. The R- program software was used to perform a hierarchical cluster dendrogram which depicted the vegetation community of wetland species. Thus, four plant community types were identified (figure 3) and the distribution of sample plot in communities were shown in Table 5.

Table 5. Plant community type and their respective species

Community type	Altitudinal ranges (m)	Number of plots	Plots in the community
Type I	2234 -2243	2	34,3
Type II	2234–2403	28	65,62.26,60,59,58,57,56,55,54,52,50,49,48,47,46,45,44,43,42,40,39,38,37,33,29,28 &10
Type III	2309- 2408	4	14,9,12&1
Type IV	2407-2460	32	3,8,6,11,13,53,25,32,23,16,20,30,7,22,16,24,18,19,17,41,135,27,21,5,4,2,51,31,36,15,24,63&64

The four plant communities are:- *Osmunda cinnamomea-Sagitaria graminea, Nymphea odonata-Carex atherodes, Amaranthus hybridus-Andropogon virginicus and Sonchus aspera-Cynodon datylon* and their descriptions are given as follows:

3.5.1 Osmunda cinnamomea-Sagitaria graminea community types

The community type distributed between altitudinal ranges of 2234 and 2243 meter above sea level. In this community, *O. cinnamomea* is the dominant species in the herb layer because of browsing resistance and more frequently found near the river bank (Cayssials, and Rodríguez, 2016) while *S. graminea is* less abundant due to less browsing resistance and most disturbed by human due to versatile uses (Keser *et al*.,2015).

3.5.2 *Nymphea odonata-Carex atherodes* community types

In this community *Nymphea odonata* is the most frequently occurring species followed by *Carex atherodes.*This community is comprised of 15 plots and 25 species and distributed in the altitudinal range of 2234–2403 meter above sea level. *N. odonata and C. atherodes* is the herbaceous layer while *Carex lacustris, Carex michauxiana* and *Carex Vulpinoidea* are the graminoid layer that makes the community.

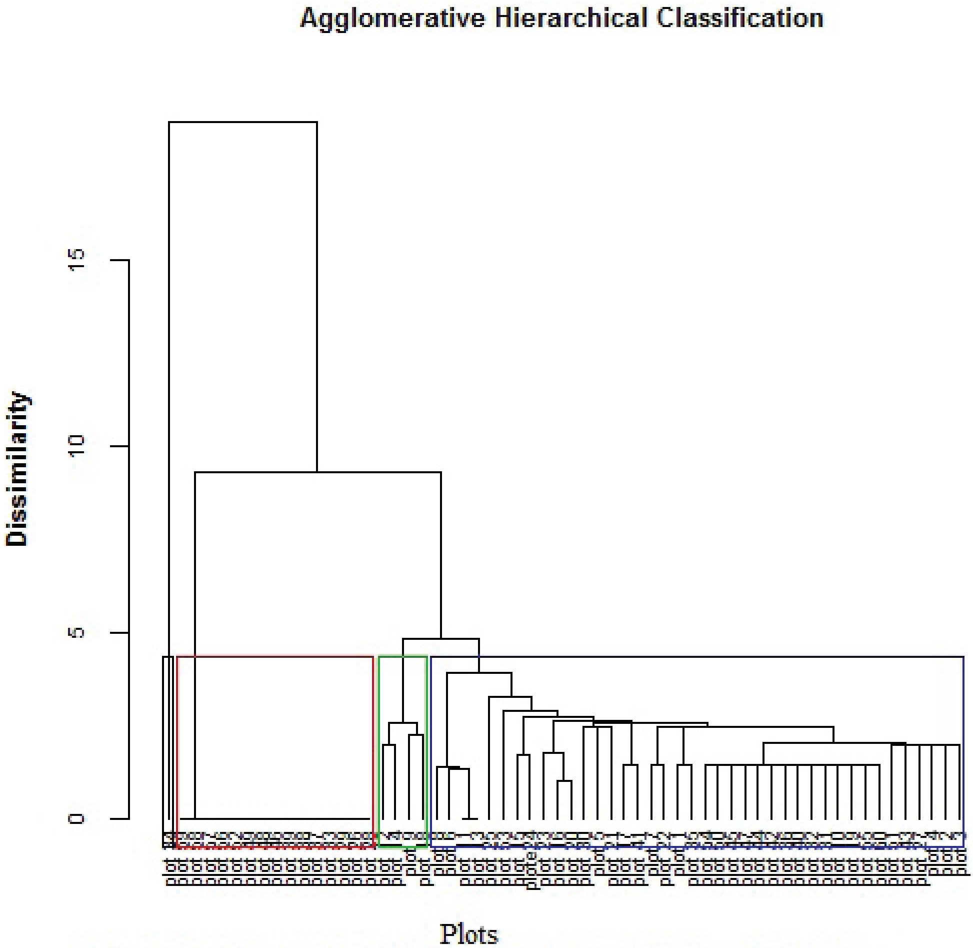

Figure 3 Dendrogram output of the cluster analysis showing the four communities and respective plots

3.5.3 Amaranthus hybridus- Andropogon virginicus community types

This community is found between 2309 and 2408 meter above sea level. They are distributed in 3 plots and comprise 3 species which make the community. In this community *Amaranthus hybridus, and Andropogon virginicus* are the dominant graminoid layer while *Oenanthe* sp. are the herbaceous layer.

3.5.4 Sonchus aspera- Cynodon datylon community types

This community is distributed between the altitudinal ranges of 2407 and 2460 meter above sea level. It comprised 15 plots and 30 species. In this community

S. aspera and C. datylon is the dominant graminod layer while *Eriocaulon abyssinicum*, *Hydrocotyle umbellate* and *Hygrophila* auriculata are the dominant herbaceous layer.

3.6 Soil Physical Properties

3.6.1 Soil Textural Fraction and Bulk Density

Soil textural fractions of sand, silt and clay content of soil samples did not show statistically significant mean difference with distance from the river bank. However, the overall mean values of sand and silt decreased while clay increased from the river bank (Table 7). On the other hand, the overall mean values of silt ($p = 0.031$,) and clay ($p = 0.046$) had shown statistically significant variation with soil depth (Table 6). Higher overall mean value of silt and clay were observed on the top soil (0-15cm, 28.4±1.24) and lower soil depth (15-30cm, 53.87±1.99) respectively. The decreasing sand and silt fractions with respect to horizontal distance from the river bank might be due to long term soil pulverization that converted sand and silt into crumb. On the other hand, the decrease of clay soil fractions near the river bank might be due to selective removal of clay through translocation favoring sand and silt to increase. The tendency of decrease in clay fractions near the wetland could also be related with the high abundance of plant root channels (macrospores) favoring the migration of fine clay fractions into the lower soil layers below 15 cm. This finding is in concurrent with Mosaddeghi *et al*. (2000) and Fenthun (2008) that reported clay fraction decreased due to selective removal from the mass of the soil. Moreover, the concave shape of the local area landscape position also contributed for the removal of clay by leaching.

Table 6. Soil textural fraction (clay, silt and sand), and soil chemistry (pH, EC, SOC (%), TN (%) and CEC).

Source of Variation	df	Soil Parameters																	
		Sand		Silt		Clay		BD		pH		EC		SOC		TN		CEC	
		MS	P	MS	P	MS	P	MS	P	MS	P	MS	P	MS	P	MS	P	MS	P
DISTA	3	31.8	0.826	8.3	0.836	67.49	0.697	3.3	p<0.001	0.17	0.513	0.007	0.041	0.359	0.637	0.045	0.181	1.883	0.813
SDEP	1	190.2	0.187	142.3	0.031	587.2	0.046	3.51	p<0.001	0.003	0.914	0.011	0.290	1.4	0.141	0.001	0.846	431.9	P<0.001
DISTA*SDEP	3	67.1	0.599	67.4	0.086	60.4	0.732	0.091	0.011	0.125	0.63	0.003	0.353	0.119	0.903	0.044	0.195	0.404	0.977
ERROR	52	106.43		29.03		140.4		0.022		0.215		0.002		0.629		0.027		6.011	
TOTAL	**60**																		

DISTA = Distance, SDEP = Soil depth, MS = Mean square, p = p-value, BD = Soil bulk density, EC = Soil Electrical conductivity, SOC = Soil organic carbon, TN = Total Nitrogen, CEC = Cation exchange capacity.

Table 7: *Soil textural fractions (Sand, Silt and Clay, %) and Bulk density (g cm-3) in relation to distance from the Wetland (Mean ± SE).*

Soil Param-eters	Soil Depth (cm)	Distance from Wetland				Overall
		1m	100m	200m	300m	
Sand	0-15	24.78±3.37	27.5±4.94	23.29±3.64	21.0±3.79	24.4±1.96[a]
	15-30	22.33±3.62	19.25±3.30	17.57±2.98	23.00±3.79	20.53±1.69[a]
	Overall	23.56±2.41[a]	23.38±3.06[a]	20.43±2.39[a]	22.0±2.58[a]	
Silt	0-15	31.44±2.97	25.0±2.17	29.00±2.23	27.67±1.23	28.4±1.24[a]
	15-30	23.89±1.41	27.00±0.75	24.43±1.84	25.33±1.08	25.13±0.68[b]
	Overall	27.67±1.84[a]	26.00±1.14[a]	26.27±1.52[a]	26.50±0.86[a]	
Clay	0-15	43.78±4.84	47.5±4.45	47.71±4.30	51.33±3.92	47.2±2.21[a]
	15-30	52.22±3.99	53.75±3.73	58.01±4.32	51.67±4.27	53.87±1.99[b]
	Overall	48.0±3.21[a]	50.63±2.91[a]	52.86±3.26[a]	51.5±2.76[a]	
Bulk Density	0-15	0.33±0.03	0.8±0.05	1.02±0.05	1.34±0.11	0.87±0.03[a]
	15-30	0.79±0.05	1.08±0.04	1.6±0.07	1.97±0.01	1.36±0.1[b]
	Overall	0.56±0.02[a]	0.94±0.05[b]	1.31±0.4[c]	1.66±0.11[d]	

Means followed by the same letter(s) across columns and row did not show statistically significant difference along with soil depth and distance from the wetland ($p = 0.05$).

On such a typical hill-slope, the quantity of water stored in the soils increases with proximity to the base of the hill-slope in response to the accumulation of surface and subsurface flow from upslope positions which cause the migration of clay fractions from the surface. Considering soil depth, the overall mean values of sand and silt soil fraction have decreased while clay fraction increases along the soil depth. Soil bulk density showed significant variation with distance from the river bank ($p < 0.001$,) and soil depth ($p < 0.001$) (Table 6). The combined effect of horizontal distance and soil depth had also shown a significant interaction effect on soil bulk density ($p = 0.011$) (Table 6). The overall mean value of bulk density was increased along horizontal distance from wetland and higher value was observed at 300m. This was due to lack of organic matter and higher soil compaction at a distance from the wetland. With respect to soil depth, the presence of less soil aggregation for lower SOC content and the pressure exerted by overlying soil layer caused higher bulk density in the 15–30 cm soil depth Similar results were reported by Mosaddeghi *et al*., 2000; Mulugeta and shemelse 2004).

3.7 Soil Chemical Properties

3.7.1 Soil Organic Carbon (SOC) and Total Nitrogen (TN)

SOC and TN did not vary significantly with horizontal distance and soil depth (Table 7). The interaction effects of horizontal distance from the river bank and soil depth were also not significant on both SOC and TN (Table 7, Figure 4a &4b). The overall mean value of SOC was higher in the first treatment (1m from the river bank) and the value decreased and becomes lower at a distance of 300m. Even though the overall mean values of both SOC (%) and TN (%) didn't show statistical significance along horizontal distance and soil depth, variations were observed between treatments (1m, 100m, 200m and 300m) and soil depth (0-15 cm and 15-30 cm)(Table 7) . With this in mind, the overall mean values of SOC in the first treatment (1m) were higher than treatment two, three and four by 11.32%, 14.56% and 16.26% respectively.

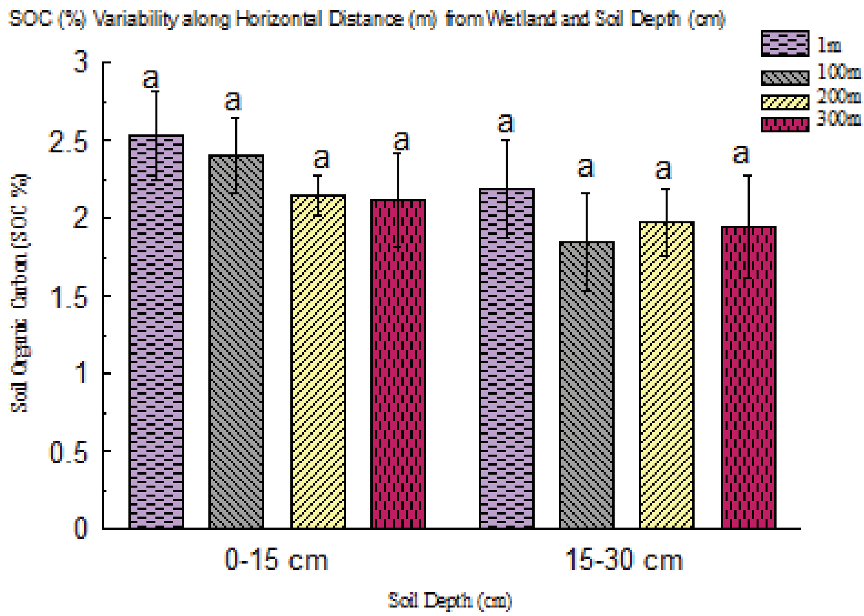

Figure 3a: SOC variation along horizontal distance (m) from the river bank and soil depth (cm).

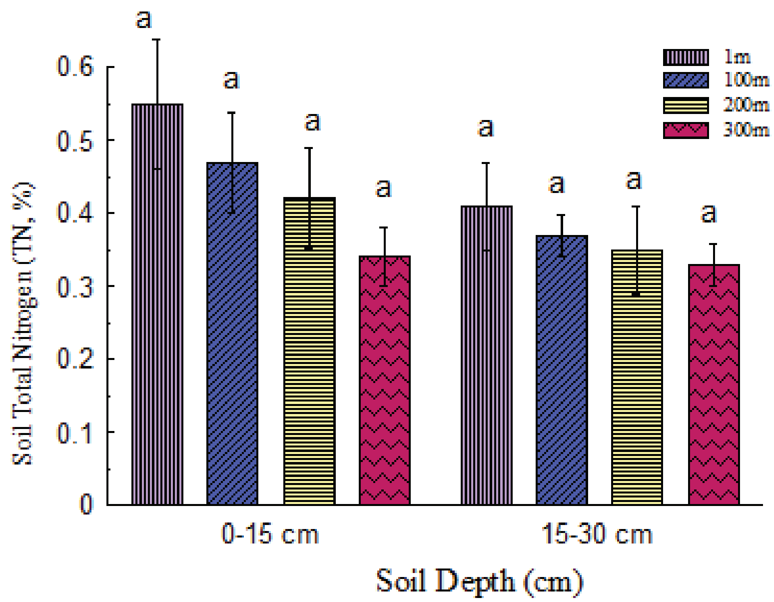

Figure 3b: TN variation along horizontal distance (m) from the river bank and soil depth (cm).

Table 8: Soil pH (1:2.5), EC, SOC (%), SOC (%), TN (%), and CEC in relation to Distance from the river bank and soil depth (Mean ± SE).

Soil Parameters	Soil Depth (cm)	Distance from the river bank				Overall
		1m	100m	200m	300m	
pH	0-15	4.86±0.1	4.68±0.13	4.81±0.12	5.0±0.29	4.82±0.08[a]
	15-30	4.68±0.24	4.9±0.16	4.71±0.13	5.0±0.06	4.81±0.09[a]
	Overall	4.77±0.13[a]	4.79±0.104[a]	4.76±0.09[a]	5.0±0.14[a]	
EC	0-15	0.11±0.02	0.12±0.02	0.09±0.03	0.061±0.01	0.1±0.01[a]
	15-30	0.103±0.02	0.06±0.01	0.061±0.01	0.05±0.01	0.07±0.01[a]
	Overall	0.11±0.01[a]	0.091±0.013[ab]	0.08±0.014[ab]	0.05±0.01[b]	
SOC	0-15	2.53±0.28	2.4±0.24	2.15±0.13	2.11±0.3	2.29±0.13[a]
	15-30	2.19±0.31	1.84±0.32	1.97±0.21	1.95±0.33	1.99±0.15[a]
	Overall	2.36±0.21[a]	2.12±0.21[a]	2.06±0.12[a]	2.03±0.22[a]	
TN	0-15	0.55±0.09	0.47±0.07	0.42±0.07	0.34±0.04	0.45±0.03[a]
	15-30	0.41±0.06	0.37±0.03	0.35±0.06	0.33±0.03	0.37±0.03[a]
	Overall	0.48±0.06[a]	0.42±0.05[a]	0.39±0.04[a]	0.34±0.02[a]	
CEC	0-15	37.74±0.77	37.58±0.42	36.74±1.03	37.42±0.9	37.4±0.38[a]
	15-30	32.04±0.96	31.86±0.67	31.51±0.96	32.36±1.39	31.93±0.47[b]
	Overall	34.89±0.91[a]	34.72±0.83[a]	34.13±0.99[a]	34.89±1.1[a]	

Means followed by the same letter(s) across columns and row were not significantly different along soil depth and distance from the wetland ($p = 0.05$).

The higher amount of SOC (%) near the river bank (1m treatment) was due to the influence of water availability together with dense vegetation cover (Table 8). These findings concur with (Dube and Chitiga, 2011). Furthermore Taruvinga and Mushunje (2010) also reported that wetland accumulate more organic matters near the river bank. However, at a distant away from the river bank, less SOC was recorded due to the presence of soil disturbance compared to the first treatment. This finding is in agreement with Tekalign (1991) who reported that SOC is higher near to the riverbank due to less oxidation reaction takes place compared to soil far away from the wetland.

Despite the non-significant difference observed between soils layers, SOC (%) appeared to differ slightly within the vertical distribution following the soil depth. Irrespective of distance from the bank, the top surface soils (0–15cm) showed relatively higher SOC content compared to the 15–30 cm depth layer. The decrease in SOC with depth was more at treatment three (200m) and four (300m) as compared to treatment one (1m). Hiederer (2009) reported similar results of a decrease in SOC with soil depth, a result of corresponding decrease of organic matter storage via root biomass and litter decomposition, which are the main pathways of organic carbon inputs.

Similarly, TN (%) didn't show significance variation between treatments and soil depth. Like that of SOC, the first treatment (1m) had higher TN (%) than the rest treatments (Table 8, figure 5). For instance, treatment one (1m) had 14.29%, 23.08% and 41.18% higher TN (%) than treatment two, three and four. The higher amount of TN near the wetland might be due to the presence of higher addition of nitrogen containing organic matters in the area. Wetlands play a vital role in maintaining SOC & TN within it for long period of time. Currently, the wetland that is found in the study area has been suffering from anthropogenic effects and as a result the size of the wetland is shrinking from time to time. As the wetland shrinks, the existing organic matter combine with oxygen and yielded lower amount of SOC & TN at a distant area from the wetland.

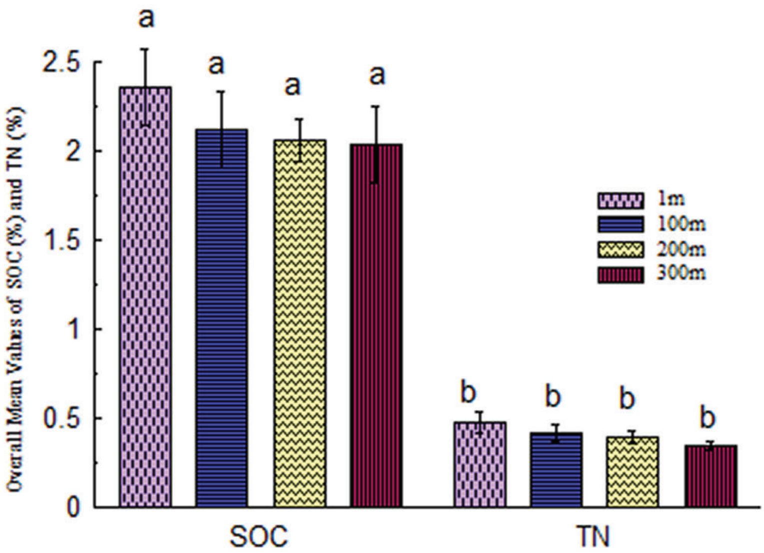

Figure 5: Soil organic carbon and Total Nitrogen content of the soil

Considering the vertical distribution of TN, higher amount was found at the first soil layer (i.e. 0-15 cm). The higher amount was due to higher addition of organic materials near the surface of the soil.

3.7.2 Soil reaction (pH-H_2O, 1:2.5), Electrical Conductivity (EC, ds m^{-1}) and CEC

Soil pH value did not show statistically significant variation among horizontal distance (treatment) from the wetland (Table 6). Relatively higher soil pH values were recorded under treatment four (300m away from the bank)(Table 8). Since the study area is categorized under highland agro-ecology, it is believed that the soil becomes highly susceptible for soil acidity. Even if there was no significant difference between treatments (1m, 100m, 200m and 300m), slight difference in overall mean pH value was seen between treatments. The higher soil pH value under treatment four was probably due to the presence of higher values of soil acidity forming nutrients. Exchangeable bases like Ca2+ and Mg2+ could be accumulated due to animal manures since the area is also used as a grazing land. Misra et al.(1993) reported that animal manure provides considerable amount of Ca2+, Mg2+ and K+ and enhances the pH values of the soil. The lowest value of pH near the bank (treatment one) as compared to treatment four (300m) (4.6% reduced, Table 8) might be due to depletion of basic cations due to leaching either by over saturation of the wetland or by the annual rainfall amount that could allow the precipitation of Al and Fe in the soil.

Soil Electrical Conductivity (EC ds/m) significantly varied along treatments ($p = 0.041$, Table 6). Higher overall mean value of EC was observed near the wetland under treatment one (1m). However, soil EC didn't show any significant difference among soil depths (Table 6). Though soil EC was not significantly affected by soil depth, its distribution was not uniform along soil depth. The overall mean value of EC decreased along the soil depth. Soil electrical conductivity (EC) has generally been associated with determining soil salinity; however, EC also can serve as a measure of soluble nutrients (Smith and Doran, 1996) for both cations and anions and is useful in monitoring the mineralization of organic matter in soil (Deneve *et al.,* 2000). The higher EC on the top soil layer (0-15 cm) near the wetland (treatment one) was attributed from higher nutrients that are emanating from accumulation and decomposition of soil organic matter.

Cation exchange capacity (CEC) has shown a significant variation along the soil depth ($p < 0.001$) and not along the treatment (Table 6). Considering soil depth, relatively higher (17.13%) CEC values (Table 8) was recorded on 0-15 cm soil layer. This is due to the presence of higher addition of soil organic carbon on the top soil surface and the presences of high clay fraction that contributes for the presence of higher CEC in the soil. Similar works by Chapman (1965). Alemayehu and Sheleme (2013) and Tilahun (2007) reported that clay absorb and hold positively charged ions and provides protection against depletion of nutrients through its colloidal particles.

4. Conclusions

The present study revealed that large proportions of household farmers were found to be dependent on wetland since the wetland vegetations have many benefits for the local community. Thus, wetland plant species diversity and evenness were not even because of the wetlands are severely affected by human as well as natural factors. Similarly low similarity index of species composition were observed among the community because of variation of both physical and chemical soil properties. In addition use of wetland for cultivation and drainage of the water have negative impact on soil physical and chemical properties such as soil texture, bulk density, soil organic carbon, electric conductivity, pH, total nitrogen and electric conductivity. The overall mean value of sand and silt particles were not changed as we move away from the river bank while the clay fraction increased due to deposition from upland. Considering soil depth, the overall mean values of sand and silt soil fraction decreased while clay fraction increased along the soil depth due to deposition of clay by translocation process. Soil bulk density showed significant variation with horizontal distance from the bank of the river and soil depth. The overall mean value of SOC and Total nitrogen were higher at 1m from the bank and the value decreased and became lower at a distance of 300m from the bank. Soil pH value did not show statistically significant variation among horizontal distance (treatment) from the wetland of water flow. Soil Electrical Conductivity (EC ds/m) significantly varied along but didn't show any significant difference among soil depths. Therefore proper utilization of wetland resources are urgent agenda to conserve plant diversity and soil physical and chemical properties of the Gedeb wetland.

5. Acknowledgements

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Conflict of interest

The authors declare that there is no conflict of interest.

References

Abebayehu Aticho, Eyasu Elias and Jan, D. (2011). Comparative analysis of soil nutrient balance at farm level: a case study in Jimma Zone, Ethiopia. Int. J. Soil Sci., ISSN 181679/DOI:10.3923/ijss.

Afework Hailu (2001). Ethiopian Wetlands Distribution, Benefit & Threat', Wetland Awareness Creation Workshop in Amhara Region, Bahir Dar, & Ethiopia unpublished pp 6.

Assefa Addisu, Girma Mengesha, Anteneh Shimelis , Yosef Mamo (2015). Livestock grazing in afromontane grasslands in the Northern bale mountains, Ethiopia: Implications for bird conservation Science, Technology and Arts Research Journal, 4 (2015), pp. 112-121

Azene Bekele (2007). Useful Trees and Shrubs for Ethiopia: Identification, Propagation and Management for Agricultural and Pastoral Communities. Regional Soil Conservation Unit SIDA, RSCU, Nairobi, Kenya.

Bahilu Bezabih and Tadesse Mosissa (2017). Review on distribution, importance, threats and consequences of wetland degradation in Ethiopia. *International Journal of Water Resources and Environmental Engineering*. Vol. 9(3), pp. 64-71, DOI: 10.5897/IJWREE2016.0697

Berhanu Tekaligne (2003). Environmental impact assessment and the wise use of wetlands in: Yilma Deressa, Abebe and Kim Geheb

(Eds) (2003) Wetlands of Ethiopia: Proceedings of a seminar on the resources and status of Ethiopia's wetlands. IUCN, Gland, Switzerland

Bogale Teferi,Tariku Berihun and Fekadu Gemechu (2015). Assessment of Ecological Diversity in the wetlands of Ginda watershed, Gedeb Woreda, Southern Ethiopia. proceedings of the 5th Annual Research Review Conference of Dilla university, Ethiopia, December 24-25,2015

Bremner JM, Mulvaney, C. (1982).Total Nitrogen in Page *et al*.(ed.) Methods of soil analysis. chemical and microbiological properties SSSA, Madison, Wisconsin 2: 595-642

Cayssials ,Valerie, Rodríguez, Claudia (2018). The adaptive value of grass traits in response to grazing, *Journal of Plant Ecology, Volume 11, Issue 2,, Pages 248–255,*

Chapman, H. (1965). Cation Exchange Capacity. In: C.A. Black, (Eds.), and Methods of Soil Analysis. Agronomy, Am. Soc. Agro. Inc., Madison, Wisconsin, pp: 891-901.

CSA (Central Statistical Agency), (2007. Population and Housing Census of Ethiopia.

Dixon AB, Wood AP (2002). Wetland cultivation and hydrological management in East Africa: matching community and hydrological needs through sustainable wetland use. Nat. Res. For. 27(2):117– 129

Dixon, A. Wood, A. (2003). Wetland Cultivation and Hydrological Management in eastern Africa: Matching community and Hydrological needs through Sustainable Wetland use. Nat. Res. Forum 27(2): 117-129. http://dx.doi.org/10.1111/1477-8947.00047

Dube, T., Chitigu, M. (2010). Human impact on macrophysics diversity water quality and some soil properties in the Madikane and Dufuya wetlands of lower Gueru. Zimbabwe. Appl. Ecol Environ. Res. 9(1):85-99http//:dx.doi.org/10.15666/ aeer/0901-085099.

Edwards, S., Sebsebe Demissew (1997). Flora of Ethiopia and Eritrea, Volume 6: Hydrocharitaceae to Arecaceae. Addis Ababa, Ethiopia, Uppsala, Sweden.

Edwards, S.,Mesfin Tadesse (1995). Flora of Ethiopia and Eritrea: Canellaceae to Euphorbiaceae.Addis Ababa, Ethiopia and Uppsala, Sweden.

Elias Jigar, Shibabaw Gebru, and Amare Ayalew (2016). Socio-economic values, threats and legal protection aspects of wetland ecosystem in Afar region, Ethiopia

Ethio GIS (1994). Ethiopian Geographic System Spatial data.

FAO (2006). Plant nutrition for food security: A guide for integrated nutrient management. FAO, fertilizer and plant nutrition Bulletin 16.FAO, Rome.

Fentahun yimer (2007). Changes in Soil Organic Carbon and Total Nitrogen Contents in Three Adjacent Land Use Types in the Bale Mountains, South-eastern Highlands of Ethiopia. Journal of Forest Ecology and Management 242(2-3):337-342

Fungai, M. (2006). Impact of cultivation on soil and species composition of Mobavale Vlei, Harare. A thesis submitted to department of biological science school of Graduate studies Haramaya university.

Helper, H., and Soetalk, PMJ. (1998). Indices of diversity and evenness oceanis 24(4):61-87

Hiederer ,H.(2009). Distribution of soil organic carbon in soil profile. Journal

Karlsson J (2015). Scoping study of water resource management in the textile industry in Ethiopia. Stockholm International Water Institute (SIWI), Stockholm pp. 1-39

Kassahun Mulatu Debela Hunde, Endalkachew Kissi (2014).The impact of wetland cultivation on plant diversity and soil fertility in south Bench-District Southwest Ethiopia. *Afr.J.Agr.Res*.9(39):2936-2947

Kent, M. and Coker, P. (1992). Vegetation Description and Analysis: A Practical Approach. John Wiley and Sons Ltd

Keser LH, Visser EJW, Dawson W, Song Y-B, Yu F-H, Fischer M, Dong M and van Kleunen M. (2015) (2015). Herbaceous plant species invading natural areas tend to have stronger adaptive root foraging than other naturalized species. Front. Plant Sci. 6:273. doi: 10.3389/fpls.2015.0027

Magurran, E. (1988). Ecological diversity and its measurement. Chapman and Hall, London.

Matiza, T. (1994). Wetlands in Zimbabwe: an Overview in: Matiza, T., Crafter, S.A. (eds) Wetlands Ecology and Priorities for Conservation in Zimbabwe. Proceedings of a Seminar on Wetlands Ecology and Priorities for Conservation in Zimbabwe. Kentucky

Mcune, B., and Grace, JB. (2002). Analysis of Ecological Communities. MjM Software

Melaku Getachew, Argaw Ambelu, Seid Tiku, Worku Legesse, Aynalem Adugna, Helmut Kloos (2012).

Ecological assessment of Cheffa Wetland in the Borkena Valley, northeast Ethiopia: Macro-invertebrate and bird communities

Mengistou S (2006). Status and challenges of aquatic invertebrate research in Ethiopia: A review. Ethiopian Journal of Biological Sciences 5(1):75-115

Mosaddegh, M. Abbas, H. Mohammad, AH. and Afyuni H.(2000). Soil compactibility as affected by soil water content and farmyard manure in central Iran. *J. Soil and Tillage Research* 55(1):87-97

Mulugeta Demiss and Sheleme Beyene, 2004. Characterization and classification of soils along the toposequence of Kindo Koye watershed in southern Ethiopia. MoA. Addis Ababa, Ethiopia. East Africa Journal of Science. 4 (2):65-77.

Naeem, S., Knops, J.M.H., Tilman, D., Howe, K.M., Kennedy, T., Gale, S. (2000). Plant diversity increases resistance to invasion in the absence of covering factors. – Oikos 91: 97-108.

Nelson, D. W., Sommers, L. (1982): Total carbon, organic matter and carbon, in Page, A. L., Miller, R. H., Keeney, D. R. (eds.): Method of Soil Analysis, Part 2—Chemical and Microbial Properties, 2nd Ed. ASA, SSSA, Madison, WI, USA, pp. 539–577

Shannon, C.E., Wienner, W. (1963). The Mathematical Theory of Communication, USA

Sorensen, T. (1948). A method of establishing groups of equal amplitude in plant sociology

Tariku Mekonnen and Abebayehu Aticho (2011).The driving forces of Boye wetland degradation and its bird species composition, Jimma, Southwestern, Ethiopia

Taruvinga, M., Mushunje, A. (2010). Socio-economic factors that influence households` participation In wetland cultivation, Conference, Cape Town, South Africa

Tuluab, MA Destabc MA (2015). Human development and Wetland Conservation Policy. International Journal of Environmental Sciences 4(3):126-138.

Whitlow, J.R.(1985). Research on dambos Zimbabwe Agricultural Journal 82: 29-66.

Zerihun Woldu, Yeshtila Kumlachew (2003). Wetland Plants in Ethiopia. In: proceeding of a seminar on the resources and status of Ethiopia's wetlands. IUCN. The World Conservation Union Nairobi, Kenya

6. Appendix 1

List of identified wetland plant species from Gedeb wereda wetland

No	Botanical name	Family	Habit
1	Hygrophila auriculata Schumanch	Achanthaceae	Herb
2	Sagittaria graminea Michx	Alismataceae	Graminoid
3	Amaranthus hybridus L	Amaranthaceae	Herb
4	Oenanthe sp.	Apiaceae	Herb
5	Hydrocotyle umbellate L.	Araliaceae	Herb
6	Bidens frondosa L	Asteraceae	Herb
7	Eclipta prostrate (L.)	Asteraceae	Herb
8	Eupatorium maculatum (L)	Asteraceae	Herb
9	Guizotia scabra Vis.(Chiov.)	Asteraceae	Graminoid
10	Saphaeranthus suaveolens (Forssk) DC	Asteraceae	Herb
11	Sonchus asper (L)	Asteraceae	Herb
12	Sphaeranthus sp.	Astreaceae	Herb
13	Ceratophyllum demersum L.	Ceratophyllaceae	Herb
14	Commelina benghalensis L.	Commelinaceae	Herb
15	Commelina diffusa Burm f	Commelinaceae	Herb
16	Commelina forskalae Vahi	Commelinaceae	Herb
17	Ipomoea fragrans(Bojer	convolvulaceae	Herb
18	Mukia maderaspatana (L) M.J. Roem.	Cucurbitaceae	Climber
19	Carex atherodes Sperng	Cyperacae	Graminoid
20	Carex vulpinoidea Lam	Cyperacae	Graminoid
21	Carex lacustris Willd.	Cyperaceae	Graminoid
22	Carex scoparia Schkuhr ex.wild	cyperaceae	Herb
23	Carex stricata wahlenb	cyperaceae	Herb
24	Cyperus assimilis Steud	Cyperaceae	hHrb

25	Cyperus bipartitus Torr.	cyperaceae	Herb
26	Cyperus esculentus L.	Cyperaceae	Graminoid
27	Cyperus longus Varbadius	cyperaceae	Herb
28	Eleocharis sp.	Cyperaceae	Graminoid
29	Fimbristylis ferruginea (L) Vahl. ssp. Sieberiana	Cyperaceae	Graminoid
30	Juncus roemerians Schele	cyperaceae	Herb
31	Lipocarpha chinensis (Osb.) Kern.	Cyperaceae	Graminoid
32	Rhynchospora subquadrata Cherm.	Cyperaceae	Graminoid
33	Schoenoplectus corymbosus var brachyceras	Cyperaceae	Graminoid
34	Scirpus acutus L.var	Cyperaceae	Graminoid
35	Scirpus americanus (Pers.) Volkart ex	Cyperaceae	Herb
36	Scirpus cyperinus (L.) Kunth	cyperaceae	Herb
37	Scirpus littoralis L.	Cyperaceae	Herb
38	polystichum acrostichoides L	Dryopteridaceae	Herb
39	Eriocaulon abyssinicum Hochst.	Eriocaulaceae	Graminoid
40	Iris missouriensis Nutt	irideaceae	Herb
41	Juncus effuses L	Juncaceae	Herb
42	Juncus spp	Juncaceae	Graminoid
43	Leucas deflexa Hook.f	Lamiaceae	Herb
44	Platostoma rotundifolium (Briq.) A. J. Paton	Lamiaceae	Graminoid
45	Trifolium acaule A.Rich	leguminaceae	Herb
46	Nymphaea odorata Aiton	Nymphaceae	Herb
47	Nephrolepis undulate (Sw.) J. Sm.fern	Oleandraceae	Graminoid
48	Ludwigia repens J.R forst	Onagraceae	Herb
49	Osmunda cinnamomea (L) C. Presl	Osmundaceae	Herb
50	Eleusine indica (L) Gaertn	poacae	Graminoid
51	Agrostis capillaries L.	Poaceae	Graminoide
52	Andropogon virginicus L.	Poaceae	Graminoid

53	Carex michauxiana Doll &Asch	Poaceae	Graminoid
54	Cynodon dactylon (L)	poaceae	Graminoid
55	Digitaria ciliaris (L)	Poaceae	Graminoid
56	Digitaria longiflora Pers	poaceae	Graminoid
57	Leersia hexandra Sw	Poaceae	Herb
58	Panicum anceps Michx	Poaceae	Graminoid
59	Stenotaphrum secundatum (Walter) Kuntze	Poaceae	Graminoid
60	Zinaniopsis miliacea (Michx.) Döll & Asch	Poaceae	Graminoid
61	Pericaria setosula A. Rich	Polygonaceae	Herb
62	Polygonum barbatum L.	polygonaceae	Herb
63	Polygonum hydropiperoides Michx	Polygonaceae	Herb
64	Polygonum senegalense Meisn.	Polygonaceae	Herb
65	Potamogeton natans L.	Potamogetonaceae	Herb