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The economic contribution of wetlands to the local community and the national economy: the case of wetlands in the Lake Tana Sub-Basin, Ethiopia

Ibrahim Mohammed*[1] Ayalew Wondie[2], Minwyelet Mengist[1]

[1]*College of Agriculture and Environmental Science, Department of Fisheries and Aquatic Science, Bahir Dar University, Bahir Dar, Ethiopia*

[2]*College of Science, Department of Biology, Bahir Dar University, Bahir Dar, Ethiopia*

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Abstract

Wetlands are productive ecosystems that play a significant role in providing multiple services. However, regardless of acknowledging the benefits, this resource has got less attention in national and regional planning. Also, several people assumed wetlands as common resource and anyone could use them free of charge. Consequently, they have started to show signs of degradation and vulnerability of services. Economic valuation could address this problem and become useful in magnifying wetlands importance. Therefore, this study determined economic value, quantified resources, and contribution of wetlands to local and national economy of selected sites in the Lake Tana Sub-basin. Data were collected using questionnaires, focus group discussion, and field observation. Monetary value was estimated using market price, replacement-cost, contingent valuation, and reference method. The results indicated that wetlands provided goods and services that added 105,191,384.1 $US/yr to the country's economy. Specifically, wetlands contributed 63,636.56 $US/HH/yr, 5,303.04 $US/HH/month, and 976.61 $US per capita/month to the livelihoods of local people. Among sites, wetlands provided 8,532,749.12, 2,476,572.11, 9,956,350.98, 12,055,519.54, 24,819,848.55, and 47,350,343.77 $US/yr to the communities of Avaji, Yitamot, Dena, Wonjeta, Shesher, and Chimba, respectively. Despite this, value of food, water, raw materials, medicinal plants, habitat, and research provision was low (5.73%). Thus, in view of high value of economic benefits and to benefit more, stakeholders should recognize wetlands monetary values. This might change their attitude from wasteland to wealth land and might inspire them to develop standalone policy. Moreover, concerned bodies should take measures, especially for severely degraded wetlands and ecosystem services having low economic contribution together with awareness-creation activity.

***Corresponding Author:** Ibrahim Mohammed ✉ ibro_muhe@yahoo.com

Introduction

Globally, wetlands cover 4-7% of the earth's surface area (Lehner and Doll, 2004), of which freshwater wetlands occupy a very small part (0.3%) (Costanza *et al.,* 2014). Although wetlands cover small part of the Earth's surface, they produce 20.5% of all ecosystem goods in terms of money, which makes them the second most valuable biome on the planet (Costanza *et al.,* 2014). High level of resources provided by wetlands reflects their significant ecological importance and makes them deserving of a prior conservation target (Keddy *et al.,* 2009).

In the last century, almost half of the world's wetland areas were lost. The rate of wetland habitat loss has slowed in some regions like Europe and North America (Davidoson, 2014), but still the wetlands that remain, whether in the developed or developing world, were under increasing pressure from both direct and indirect human activities. Thus, in many countries, the wetland area and condition continue to decline (Russi *et al.,* 2013).

In Ethiopia, although wetlands provide multiple services, its conservation strategy does not consider wetlands as important ecosystems (EWNRA, 2008) and are often considered wastelands and obstacles to agricultural development and human and animal health (Taffa, 2007). Also, there was no adequate protocol for wetland assessment (Getachew *et al.*, 2012), nor any formal institution or legal framework (Hailu, 2007). Thus, a large number of wetlands are considered vulnerable and some of the most exploited ones have lost their rejuvenating capacity (Tadesse, 2006).

Among Ethiopian freshwaters, Lake Tana (studied area) is one of the largest lakes (Wondie and Mengistou, 2006), surrounded by large areas of wetlands that provide multiple services (Bijan and Shimelis, 2011). But despite the services, much of the research indicated that farming shifted towards wetlands, river banks and shorelines (Wondie, 2010). Consequently, most parts of the existing wetland area were converted to farmland (CBD, 2014). Untreated effluents were also released into the wetlands (Atnafu *et al*., 2011). The habitats are further threatened by irrigation, damming, and grazing (Aynalem and Bekele, 2008). For instance, a study between 1986 and 2013 indicated that over 52% of wetlands in the Lake Tana sub-basin were converted to other land use forms, mainly for cultivation and settlement (BNWI 2014 unpublished).

One reason for continued degradation might be a poor understanding and appreciation of the value of ecosystem services (ESs) in terms of monetary units (Lambert, 2003). Also, wetland ESs did not have a market value and most of the services, although acknowledged by most people, are unaccounted, un-priced, and remain outside the domain of the market (Kumar, 2005). Basically, ESs provided by wetlands worth many trillions of dollars annually, but most of these benefits carry no price-tag that alerts societies to minimize resource exploitation (Costanza *et al.,* 1998).

A crude estimate of the global economic value of wetlands, for instance, the value attributed solely to the physical benefits, was 70 billion dollar a year, of which 7.5% was generated in Africa (Schuyt and Brander, 2004). In Ethiopia there were a few studies carried out in wetlands; these included economic valuation of improved irrigation water in Bahir Dar Zuria Woreda (Anteneh, 2016), valuation of recreational wetland of Wondo Genet (Geremew 2010), valuing the benefits of improved quality of Lake Awassa (G/Selassie 2006) and valuation of fishery of Lake Tana (Agimass, 2009). However, to our knowledge, comprehensive studies on the valuation of the multifunction's and services of wetlands have not yet been undertaken in the country in general and the Lake Tana Sub-basin in particular.

Basically, understanding the economic values of wetlands is important for their sustainable management, as this could help to develop relevant policy (Russi *et al.,* 2013). Furthermore, it helped to recognize true economic contributions, maximize long-term benefits, and increase investment in conservation (Basnyat *et al.,* 2012). Consequently, this research was conducted with the intention of providing a recent report on the economic value, quantity of resources, and contribution of wetlands to the local and national economies of selected sites in the Lake Tana Sub-basin.

Materials and methods

Description of the study area and study sites

The study was conducted in those wetlands found in the Lake Tana Watershed. Lake Tana is one of the largest lakes in Ethiopia, located in the northern part of the Ethiopian Highlands (Goshu and Aynalem, 2017) at an elevation of 1,840 meters with a latitude of 10°58'-12°47'N and a longitude of 36°45'-38°14'E (Admas *et al.*, 2017). In the sub-basin, wetlands are distributed from the headwaters of Guna and Gishe-Abay to Fogera and Dembia, mainly around lake shores and along tributaries (Shimeles *et al.*, 2008). The total wetland area in the sub-basin was 32,157 ha (Yitaferu, 2007), which was distributed in to 29 districts and three administrative zones (BoEPLAU, 2015). Wetlands included in the study were Shesher, Avaji, Yitamot, Dena, Wonjeta, and Chimba (Fig. 1). They were selected based on their accessibility (U.S. EPA, 2002).

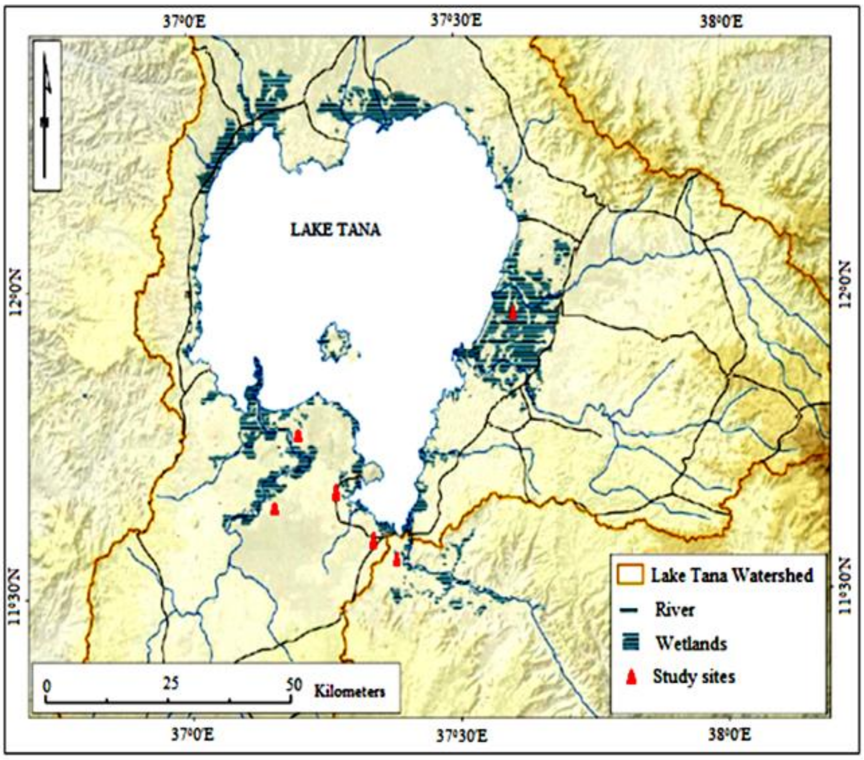

Fig. 1. The location of the study wetlands in the Lake Tana watershed (modified from ANRSBA 2013).

The communities of surrounding wetlands have utilized the resources as a means of improving their livelihoods (Gordon *et al.*, 2007). Farmers benefit from the wetland in several ways; most of them were engaged in livestock grazing, small-scale irrigation, recession agriculture (in some sites), and using water for sanitation and household purposes. The wetland vegetation, including reeds, provided important fish breeding and nursery habitat, as well as made reed boats, mats and decorations for houses. They also benefited from medicinal plants and recreational services.

Avaji is a shoreline wetland that receives storm water and domestic wastewater from surrounding communities. Similarly, in Yitamot, the wetland was engaged in discharge of waste from the town, Bahir Dar University, livestock grazing, and irrigation.

In Chimba and Shesher, cultivation and grazing were common activities. On the other hand, Dena and Wonjeta were papyrus dominated are currently recognized as core zones of the Lake Tana Biosphere reserve.

Study design and methods of data collection

A cross-sectional field survey was carried out between November and June 2020. A questionnaire, focus group discussions, key informant interviews, and observations were used to collect integrated qualitative and quantitative data about the types of ecosystem services (the benefits and economic and socio-cultural values they provide to the local people), the quantity of resources collected, the frequency of collection, and people's perceptions of managing wetlands. For the questionnaire, sample size was determined using the population sampling protocol of Nyariki (2009). Accordingly, 178 households (HH) were proportionally selected from 20 districts/villages and questionnaires were administered to HH heads. Focus group discussions were held with community representatives and elderly people. Key informant interviews were held with agriculture development agents. Also, field visits were carried out to acquire additional information.

Estimation of human disturbance status of wetlands

The degree of human disturbance was assessed using the human disturbance score (HDS) protocol of Gernes and Helgen (2002). Accordingly, a field survey was conducted to collect data about the degree of human disturbance to wetlands in the landscape, including physical condition, water quality, and biological assessment. Data were then grouped into six factors; finally, to obtain HDS out of 100%, all scored values from each factor and for each wetland were summed.

If the result of the HDS value falls within the ranges of 0–33, 33–67, and 67–100, the wetland could be classified as less impacted, moderately impacted, and highly impacted, respectively.

Economic valuation of the identified goods and services

Before valuation started, the total annual quantity of harvested products, mainly for marketable goods, was calculated based on the data collected from the sampled HHs. This was determined by following the equation adapted from Adekola *et al.* (2006) (Equation 1 and 2).

$$TQH = \frac{\sum_{i=1}^{m} HCi}{n} \times PHH \qquad (1)$$

Where, TQH = total annual quantity harvested (or produced) and

HCi = quantity of product collected by HH i

PHH = percentage of HHs participating in the activity

$$PHH = \frac{m}{n} \times N \qquad (2)$$

Where, m = number of HHs in the sample participating in the activity

n = total number of sampled HHs (n=178)

N = total number of HHs in the population (N= 1653)

Then, after estimating the total annual quantity of all services, the value was determined in terms of money. The monetary values of habitat provision, water purification, and educational and research services were determined following the reference method developed by Wang (2006). Similarly, market price, contingent valuation, and replacement cost methods were employed to determine the monetary values of direct use, non-use, and water provision for livestock drinking, respectively. Then, the total economic value was calculated following the conceptual framework of Edward *et al.* (1997). For the contingent valuation, questionnaire was used to evaluate the respondents' willingness to pay (WTP) for the conservation of wetlands, then total WTP value was calculated using equation 3.

$$TWTP = Mean\ WTP * population \qquad (3)$$

Where, TWTP= total number of individual willing to pay in the community/population, Mean

WTP= mean of sample willing to pay in the community, and

Population= number of people in the community

Methods of data analysis

The identified and quantified goods and services were analyzed using SPSS version 20. The frequency, mean, and standard deviation for different attributes in the questionnaire were computed, tabulated, and graphed using MS-Excel.

Results

Household socio-demographic characteristics

In the six wetlands, a total of 20 villages and 178 HHs were included. The age of respondents ranged from 21 to

68 years, with a sex composition of 79.8% male-headed and 87.6% married. The HH size ranged from 1 to 11 and most HHs had a family size of 4 to 6. Regarding educational background, 56.7% were illiterate and 74.7% were farmers. Respondents received a mean monthly income of 93.31 $US. About 37.6% of the respondents reside within a 50 meter radius of the wetlands boundary, and data on religion showed that 100% of the respondents were Christians (Appendix 1).

Appendix 1. Socio-demographic characteristics of respondents' in those wetlands found in the Lake Tana Sub-basin.

	Respondents													
Characterstics	Chimba		Shesher		Dena		Wonjeta		Avaji		Yitamot		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Age														
21-30	15	8.4	0	0.0	0	0.0	10	5.6	13	7.3	5	2.8	43	24.2
31-40	5	2.8	0	0.0	8	4.5	4	2.2	7	3.9	0	0.0	24	13.5
41-55	7	3.9	20	11.2	26	14.6	10	5.6	7	3.9	15	8.4	85	47.8
56-65	3	1.7	5	2.8	0	0.0	3	1.7	6	3.4	5	2.8	22	12.4
+65	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	2.2	4	2.2
Marital status														
Single	2	1.1	0.0	0.0	0	0.0	6	3.4	3	1.7	2	1.1	713	7.3
Married	25	14	25	14	34	19.1	21	11.8	30	16.9	21	11.8	156	87.6
Divorce	3	1.7	0	0.0	0	0.0	0	0.0	0	0.0	6	3.4	9	5.1
Sex														
Male	24	13.5	21	11.8	29	16.3	27	15.2	24	13.5	17	9.6	142	79.8
Female	6	3.4	4	2.2	5	2.8	0	0.0	9	5.1	12	6.7	36	20.2
Education level														
Illiterate	19	10.7	23	12.9	21	11.8	10	5.6	10	5.6	18	10.1	101	56.7
1-6	11	6.2	2	1.1	9	5.1	12	6.7	7	3.9	5	2.8	46	25.8
7-12	0	0.0	0	0.0	4	2.2	5	2.8	13	7.3	6	3.4	28	15.7
12+	0	0.0	0	0.0	0	0.0	0	0.0	3	1.7	0	0.0	3	1.7
Family size														
<=3	9	5.1	2	1.1	5	2.8	9	5.1	10	5.6	8	4.5	43	24.2
4-6	16	9.0	8	4.5	12	6.7	16	9.0	7	3.9	18	10.1	77	43.3
7-9	4	2.2	10	5.6	17	9.6	0	0.0	13	7.3	3	1.7	47	26.4
+10	1	0.6	5	2.8	0	0.0	2	1.1	3	1.7	0	0.0	11	6.2
Occupation														
Farmer	28	15.7	25	14	34	19.1	27	15.2	11	6.2	8	4.5	133	74.7
Merchant	2	1.1	0	0.0	0	0.0	0	0.0	2	1.1	6	3.4	10	5.6
Gov.t employee	0	0.0	0	0.0	0	0.0	0	0.0	3	1.7	0	0.0	3	1.7
Own work	0	0.0	0	0.0	0	0.0	0	0.0	17	9.6	15	8.4	32	18.0
Income														
<=18.5	18	10.1	0	0.0	8	4.5	7	3.9	3	1.7	0	0.0	36	20.2
18.6-30.9	7	3.9	0	0.0	5	2.8	3	1.7	14	7.9	3	1.7	32	18
31.0-92.6	2	1.1	10	5.6	12	6.7	9	5.1	10	5.6	23	12.9	66	37.1
93-185.2	3	1.7	15	8.4	0	0.0	5	2.8	6	3.4	3	1.7	32	18
>185.2	0	0.0	0	0.0	9	5.1	3	1.7	0	0.0	0	0.0	12	6.7
Religion														
Orthodox	30	16.9	25	14	34	19.1	27	15.2	33	18.5	29	16.3	178	100
Other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

People's Perception towards Wetland Management

About 83.7% of the respondents were interested in conserving wetlands.

But when asked to pay money to protect wetlands, only 39.9% were willing.

On the other hand, regarding their interest in converting wetlands, the majority of the households (75.3%) preferred wetlands to be converted to farmlands and grazing lands (Appendix 2).

Estimated human disturbance status of wetlands

Overall, human disturbance scores ranged from 20 for the least disturbed sites to 89 for the most disturbed sites of the six selected wetlands, higher human disturbance scores were recorded in the Shesher, Avaji, and Chimba wetlands.

The HDS for the Shesher site was found to be 1.17 times higher than Chimba, about 3.4 times that of the Wonjeta site, and 4.4 times higher than Dena (Table 1).

Appendix 2. The respondents' perception regarding the importance of wetlands management.

	Chimba		Shesher		Dena		Wonjeta		Avaji		Yitamot		Total	
Responses	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Interest to manage wetlands														
Interested	22	12.4	13	7.3	34	19.1	21	11.8	30	16.9	29	16.3	149	83.7
Not interested	22	12.4	12	6.7	0	0	6	3.4	3	1.7	0	0	29	16.3
Willing to pay to protect	10	5.6	7	3.9	15	8.4	11	6.2	12	6.7	16	9.0	71	39.9
Who is responsible to manage														
Government	8	4.8	0	0	4	2.4	6	3.6	9	5.4	23	13.9	50	30.1
Local people	13	7.8	20	12	26	15.7	13	7.8	11	6.6	3	1.8	86	51.8
Govt. & local	1	7.8	0	0	4	2.4	5	3	13	7.8	3	1.8	26	15.7
Other	4	2.4	0	0	0	0	0	0	0	0	0	0	4	2.4
Wetland conversion interest														
Farm land	14	7.9	25	14	4	2.2	6	3.4	10	5.6	14	7.9	73	41
Grazing	7	3.9	0	0	8	4.5	3	1.7	00	0	3	1.7	21	11.8
Settlement	4	2.2	0	0	0	0	5	2.8	3	1.7	9	5.1	21	11.8
Recreational	0	0	0	0	0	0	0	0	9	5.1	0	0	9	5.1
Other	0	0	0	0	0	0	2	1.1	8	4.5	0	0	10	5.6
Not to be converted	5	2.8	0	0	22	12.4	11	6.2	3	1.7	3	1.7	44	24.7

Appendix 3. The quantity of goods and services obtained from wetlands in one harvest period.

Goods	Quantity of goods and services collected								
	Total No of participating HH	Frequency of harvest/yr	unit	Avaji	Yitamot	Dena	Wonjeta	Shesher	Chimba
Food									
Mimusops	177	48	kg	0	0.75	0.87	1.37	0	0.25
S. guineense	326	48	kg	1.12	0	1.75	1.5	0	0
Tomato	333.9	3	Kg	16	0	26	40	0	8000
Onion	269.4	2	kg	0	12	30	14	7	1,000
Cabbage	454.6	3	Kg	50	15	60	50	0	5,000
Peper	343.8	3	Kg	2	3	6	4	0	50
Avocado	343.9	4	Kg	50	10	30	75	0	0
Mango	205	3	Kg	13	5	18	50	0	0
Coffee	362	3	Kg	14	0	20	45	0	0
Maize	621.5	1	Kg	0	0	0	0	1,500	0
Teff	241.3	1	Kg	0	0	0	0	11,500	0
Rice	205	1	Kg	0	500	0	0	7,000	0
Vetch	380.2	1	Kg	0	0	0	0	5,000	4,000
Chickpea	259.5	1	Kg	0	0	0	0	40,000	10,000
Barley	130.6	1	Kg	0	0	0	0	35,000	0
Khat	454.5	12	kg	6.8	3.5	2.4	4.2	0	2.4
Catfish	538.9	24	kg	3	1	2	2	3	1
Tilapia	138.9	24	kg	2	1	1	1	0.5	0.5
Barbus	287.6	24	Kg	2	1	1	1	0.5	0.5
Milk	137	218.4	L	240.2	2,936.6	21.84	1,345.3	2,909.1	3,516.2
Water									
For domestic	659.5	210	L	1,600	60	600	440	0	400
For irrigation	454.6	840		17	6	8	12	0	6
For animals (no of pump)				0.49	0.3	1.17	1.8	1.38	1.06
Reed									
For animals	241.3	24	Bun	10	0	27	1	0	8
For floor décor	205	4	Bun	8.5	4	6	3	0	0
Firewood	742.2	14	Bun	0	5	12	10	0	3
Grass qty/yr			kg/yr	1,457.2	1,360.8	4,048.4	5,857.1	4,388.6	3,112.8
Medicinal plants									
O.lamiifolium	166.9	4	Hf	3	12	0	3	0	0
Z. scabra	110.7	4	Hf	0	30	0	0	0	0
Eucalyptus	56.2	4	Hf	0	3	0	3	0	0
S. indicum	15	4	Hf	0	0	0	15	0	0

Table 1. The human disturbance score results of the six wetlands.

Wetland	Contributing factors						HDS	Status
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6		
Chimba	12	18	18	14	14	0	76	HI
Shesher	18	18	18	21	14	0	89	HI
Avaji	12	18	18	14	21	1	84	HI
Yitamot	6	12	12	14	14	0	58	MI
Dena	0	6	0	14	0	0	20	LI
Wonjeta	0	6	0	14	6	0	26	LI

LI = less impacted, MI=moderately-impacted, and HI=highly impacted

The direct use values of ecosystem goods and services provided by wetlands

The economic values of wetlands in providing food

The main wild fruit foods were collected by 19.7% and 10.7% of the HH, in which they collected 156kg of *Syzygium guineense* and 210kg of *Mimusops,* respectively. A Higher amount was collected in Dena and Wonjeta. Collection took place once a week all year round, and when the quantity was valued at the market price, wild fruits contributed 261.59 $US (Table 2). On the other hand, besides wild fruit, 35.4% and 39.3% of the local people harvested different types of cultivated fruits and vegetables around the wetlands margin, respectively. So an annual quantity of 45,391.64kg of tomatoes, 376.63kg of peppers, 39,649.8kg of Cabbage, 481.98kg of Coffee, and 297.13kg of Mango were collected (Appendix 4). of the six wetlands, production was higher in Chimba and Wonjeta. When the quantity was estimated by market price, the contribution of cultivated fruit and vegetables was 41,229.20 $US (Table 2).

Concerning cereals, the main crops grown were Maize *(Zea mays)*, Vetch (*Lathyrus sativus)*, Chickpea (*Cicer arietinum)*, and Teff *(Eragrostis tef),* which were produced by 37.6%, 23.0%, 15.7%, and 14.6% of HHs, respectively. Rice (12.4%) and Barely (7.9%) were also the other crops grown by a small number of respondents. In one harvesting period, respondents' collected 1,500kg, 7,500kg, 9,000kg, 11,500kg, 35,000kg, and 50,000kg of Maize, Rice, Vetch, Teff, Barely, and Chickpea, respectively (Appendix 4). Thus, a total of 147,260.74kg/yr of cereals was obtained and in the market price, its annual contribution was 76,967.19 $US.

Table 2. The economic value of goods and services provided by wetlands.

	Goods	Total No of HH	Total am't harvested/ Effort	Frequency of harvest/yr	Average qty harvested/H H/yr	Total Harvested by popn./yr	Unit	Unit price ($)	Total ($)
Wild fruit	*Mimusops*	177	3.25	48	0.87	154	kg	0.5	77.07
	S. guineense	326	4.37	48	1.15	375	kg	0.5	185.51
Fruit Vegetable	Tomato	333.9	8,082	3	136.21	45,480.5	kg	0.38	17,551.9
	Onion	269.4	1,063	2	11.94	3,216.64	kg	0.55	1,787.57
	Cabbage	454.6	5,175	3	87.22	39,650.2	kg	0.46	18,362.2
	Pepper	343.8	65	3	1.09	374.74	kg	1.42	532.20
	Coffee	362	79	3	1.33	481.46	kg	3.70	1,783.73
	Avocado	343.9	165	4	3.7	1,272.43	kg	0.77	982.12
	Mango	205	86	3	1.45	297.25	kg	0.77	229.43
Cereals	Maize	621.5	1,500	1	8.43	5,239.25	kg	0.49	2,588.08
	E. tef	241.3	11,500	1	64.61	15,590.4	kg	0.92	14,440.0
	Rice	205	7,500	1	42.13	8,636.65	kg	0.74	6,399.49
	'etch	380.2	9,000	1	50.56	19,222.9	kg	0.30	5,934.82
	Chickpea	259.5	50,000	1	280.9	72,893.6	kg	0.55	40,508.9
	Barley	130.6	35,000	1	196.63	25,679.9	kg	0.27	7,095.86
	Catha edulis	454.6	19.3	12	1.3	590.85	kg	10.5	6,202.19
Fish	Catfish	538.9	12	24	1.62	871.93	kg	3.55	3,095.76
	Tilapia	138.9	6	24	0.81	112.37	kg	3.55	398.96
	Barbus	287.6	6	24	0.81	232.95	kg	3.55	827.08

am't-amount, HH-household, No-number, popn.-population, qty-quantity, yr-year

Appendix 4. Annual quantities of goods and services obtained from wetlands.

Goods	The quantity of goods collected annually								
	Total No of participating HH	Frequency of harvest/yr	unit	Avaji	Yitamot	Dena	Wonjeta	Shesher	Chimba
Food									
Mimusops	177	48	Kg	0	35.79	41.6	65.63	0	11.93
S.guineense	326	48	Kg	98.89	0	153.84	131.86	0	0
Tomato	333.9	3	Kg	0	0	146.31	225.10	0	45,020.2
Onion	269.4	2	Kg	0	36.32	90.81	42.38	21.189	3,026.97
Cabbage	454.6	3	Kg	383.09	114.92	459.71	383.09		38,308.9
Pepper	343.8	3	Kg	11.59	17.38	34.76	23.18	0	289.72
Avocado	343.9	4	Kg	386.40	77.28	231.84	579.61	0	0
Mango	205	3	Kg	44.91	17.27	62.19	172.75	0	0
Coffee	362	3	Kg	85.41	0	122.02	274.55	0	0
Maize	621.5	1	Kg	0	0	0	0	5,237.3	0
Teff	241.3	1	Kg	0	0	0	0	15,589	0
Rice	205	1	Kg	0	575.84	0	0	8,061.8	0
Vetch	380.2	1	Kg	0	0	0	0	10,679	8,543.82
Chickpea	259.5	1	Kg	0	0	0	0	58,314	14,578.6
Barley	130.6	1	Kg	0	0	0	0	25,679	0
Khat	454.5	12	Kg	208.36	107.24	73.53	128.69	0	73.54
Catfish	538.9	24	Kg	217.98	72.66	145.32	145.32	217.98	72.66
Tilapia	138.9	24	Kg	37.45	18.73	18.73	18.73	9.36	9.36
Barbus	287.6	24	Kg	77.56	38.78	38.78	38.78	19.39	19.39
Milk	137	218.4	L	240.24	2,936.64	21.84	1,345.34	2,909.1	3,516.24
Water for									
Domestic	659.5	210	L	1,244,899	46,683.7	466,837	3,423,47	0	311,224
Irrigation	370		L	13,493,958	4,762,573	6,350,098	9,525,147	0	4,762,573
Livestock (no of Pump)				0.49	0.3	1.17	1.8	1.38	1.06
Reed									
For animal		no of heads		13,013.93	0	35,137.62	1,301.39	0	10,411.15
For floor decor		no of heads		1,566.29	737.08	1,105.62	552.81	0	0
Firewood	742.2	14	Bun	0	291.87	700.5	583.75	0	175.12
Grass			kg/yr	1,457.19	1,360.8	4,048.38	5,857.11	4,388.58	3,112.83
Medicinal plant									
O.lamiifolium	166.9	4	Hf	11.25	45.01	0	11.25	0	0
Z. scabra	110.7	4	Hf	0	74.63	0	0	0	0
Eucalyptus	56.2	4	Hf	0	3.79	0	3.788	0	0
S. indicum	15	4	Hf	0	0	0	5.06	0	0
Carbon store			MgC/ha	33,400	9,519	41,750	50,100	108,550	206,144.8

Regarding Khat (*Catha edulis)* production, 27.5% of the HHs used the wetlands margin area to produce 19.3kg per month, which is equal to 591.36kg/yr. The amount was higher in Avaji and Wonjeta; when the quantity was valued in the market price, its annual provision was 6,207.55 $US (Table 2).

Additionally, the values of wetlands are extended by providing different fish species, in which 32.6%, 8.4%, and 17.4% of the respondents caught *Clarias gariepinus*, *Oreochromis niloticus*, and *Barbus spp.* fish, respectively. I think it is better if the highlighted statement is replaced by "Fish were caught once a week, primarily during the dry seasons, and each week 24 kg of fish were caught. This gives an annual total quantity of 1,217.25 kg of fish. When the quantity was estimated by market price, its annual contribution was equal to 4,320.80 $US (Table 2).

Regarding wetlands value through value addition in milk production, it was found that one milked cow provided an average amount of 1.3L of milk for a minimum of six months on a daily basis. Although previous study by Tesfaye *et al.* (2010) found a daily amount of 1.54L per cow over a lactation period of 180 days, in this study a daily amount of 1.3L and a milking period of six months were found. Accordingly, 10,969.39L of milk was collected annually, which was equal to 7,111.98 $US (Table 3).

The economic values of wetlands in providing water

For domestic purposes, wetlands served as source of water for 39.3% of the HHs. Respondents' collected an average of 3,657.3 L of water from December to June. This gives an annual amount of 2,375,784.3 L of water.

Table 3. The value of wetlands through milk production.

Variables	Chimba	Shesher	Dena	Wonjeta	Avaji	Yitamot	Overall
Total no of cow	70	149	104	205	39	37	604
No of milked cow	23	36	4	44	11	19	137
Aver. milk/cow/week (L)	9.1	9.1	9.1	9.1	9.1	9.1	9.1
Total milk /yr (L)	5,023.2	7,862.4	873.6	9,609.6	2,402.4	4,149.6	29,920.8
% attributed to wetland	70%	37%	10%	14%	10%	70%	10-70%
Milk r/d to wetland (L)	3,516.2	2,909.1	21.84	1,345.34	240.24	2,936.6	10,969.4
Price of milk/L ($US)	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Value per year ($US)	228,553.00	1,890.9	14.19	874.47	156.15	1,908.8	7,130.10

no stands for number, L-liter, r/d-related, aver-average, yr-year

When it was estimated by market price, its annual contribution was equal to 142,547.05 $US. This relieved the government allocating of 86.23 $US/HH/yr for water provision. Similarly, for livestock drinking, 69.1% of the HHs used wetlands regularly and since it was difficult to know the volume of water that had been drunk by the livestock, the value of water was estimated by replacement cost method, i.e., replacing wetlands water with a stand hand pipe. It is an alternative water source with market value and for this the cost of drilling a borehole was considered. Accordingly, the government drills a borehole with average cost of 12,500.00 $US including maintenance. A borehole could sustain 276 livestock heads (IUCN 2002) and for all 1,713 livestock 6.2 boreholes were required that costs 77,500.00 $US (Appendix 5).

Appendix 5. The monetary value of goods and services provided by wetlands.

Goods	The monetary value of goods and services when extrapolated ($US)						
	Avaji	Yitamot	Dena	Wonjeta	Shesher	Chimba	Total
Food							
Mimusops	00.0	17.89	20.8	32.81	0.00	5.96	77.07
S. guineense	49.44	0.00	76.92	65.93	0.00	0.00	185.51
Tomato	0.00	00.0	55.59	85.53	0.00	17,107.68	17,551.9
Onion	0.00	19.97	49.94	23.30	11.65	1,664.83	1,787.57
Cabbage	176.22	52.86	211.46	176.22	0.00	17,622.14	18,362.24
Pepper	16.45	24.67	49.35	32.91	0.00	411.40	532.20
Avocado	297.52	59.50	178.51	446.29	0.00	0.00	982.12
Mango	34.58	13.29	47.88	133.01	0.00	0.00	229.43
Coffee	316.01	00.0	451.47	1,015.83	0.00	0.00	1,783.73
Maize	0.00	00.0	0.00	0.00	2,566.30	0.00	2,588.08
Teff	0.00	0.00	0.00	0.00	14,342.44	0.00	14,440.01
Rice	0.00	426.12	0.00	0.00	5,965.73	0.00	6,399.49
Vetch	0.00	0.00	0.00	0.00	3,203.93	2,563.14	5,934.82
Chickpea	0.00	0.00	0.00	0.00	32,073.04	8,018.25	40,508.95
Barley	0.00	0.00	0.00	0.00	6,933.54	0.00	7,095.86
Khat	2,185.69	1,124.94	771.32	1,349.95	0.00	771.43	6,202.19
Catfish	773.82	257.94	515.88	515.86	773.82	257.94	3,095.76
Tilapia	132.94	66.49	66.49	66.49	33.22	33.22	398.96
Barbus	275.33	137.66	137.66	137.66	68.83	68.83	827.08
Milk	156.15	1,908.81	14.19	874.47	1,890.90	2,285.55	7,130.10
Water							
For domestic	74,693.94	2,801.02	28,010.23	20,540.83	0.00	18,673.48	142,547.05
For irrigation	809,637.50	285,754.40	381,005.90	571,508.82	0.00	28,5754.4	2,333,661
For livestock	6,125.00	3,750.00	14,625.00	22,500.00	17,250.00	13,250.00	77,500.00
Reeds							
For animals	1,952.09	0.00	5,270.64	195.20	0.00	1,561.67	2,244.90
For floor décor	234.94	110.56	165.84	82.92	0.00	0.00	148.50
Firewood	0.00	901.87	2,164.54	1,803.78	0.00	541.12	5,412.44
Grass	102.00	95.25	283.38	409.99	307.20	217.89	1,278.79
Medicinal plants							
O.lamiifolium	17.32	69.31	0.00	17.32	0.00	0.00	102.87
Z. scabra	0.00	114.93	0.00	0.00	0.00	0.00	114.27
Eucalyptus	0.00	5.83	0.00	5.83	0.00	0.00	11.24
S. indicum	0.00	0.00	0.00	7.79	0.00	0.00	7.78
Regulating services							
Carbon store	6,699,038.00	1,909,226.00	8,373,798.00	10,048,557.00	21,771,874.00	41,346,463.00	90,148,922.45
Water purify	669,840.00	190,904.40	837,300.00	1,004,760.00	2,176,980.00	4,134,252.48	9,014,036.88
Research	174,200.00	49,647.00	217,750.00	261,300.00	566,150.00	1,075,162.04	2,344,209.04
Habitat	67,140.00	19,134.90	83,925.00	100,710.00	218,205.00	414,388.08	903,502.98
Biodiversity	1,219.49	1,625.99	1,524.37	1,117.87	508.12	1,016.24	7012.10
Total	8,532,739.02	2,476,564.40	9,956,323.42	12,055,475.17	24,819,818.64	47,350,322.69	105,191,243.30

Regarding the value of wetlands for irrigation, due to the difficulty of determining the quantity of water used by canal irrigation, only the volume of water extracted by pump was calculated. Accordingly, the value of water was captured by calculating volume of water pumped per minute multiplied by total time required to water farmland. In the six wetlands, 27.5% HHs used pump irrigation from December to June once a week for thirty minutes.

Thus, HHs extracted water for 105,119.86 min/yr. for different types of water pumps, the volume of water pumped varies from 240 to 500L/min and for the calculation, an average value of 370 L/min was used. Accordingly, for the total annual 105,119.86 min watering time, 38,894,350 L of water was drawn (Appendix 4). When the quantity was estimated by the market price, its annual contribution was equal to 2,333,661.00 $US (Appendix 5).

The economic values of wetlands in providing raw materials

Concerning grass provision, its quantity was estimated from the total number of grazing livestock and their daily requirements for seven months. Different types of animals had different daily feed demands, so animal unit value revealed by the Society for Range Management (2017) was considered. Additionally, in the calculation, for cow, sheep, goat, and horse, the value of animal unit reported by Larry *et al.* (2003) and for mule and donkey, the value reported by GOL (1980) was used. These values were then multiplied by the average number of each livestock type to find annual consumption. The price of grass straw varies from place to place, but for the calculation 0.07 $US/kg of grass was employed (Adamu and Chairatanayuth, 2007). Accordingly, wetlands provided 1,278.79 $US (Table 4).

Table 4. The quantity and monetary value of grass harvested from wetlands.

Livestock	Cow	Ox	Sheep	Goat	Horse	Mule	Donkey
No of animals	604	361	413	108	6	104	117
Average	3.39	2.02	2.32	0.61	0.03	0.58	0.66
Daily forage (kg)	12	12	2.4	1.8	15	13.5	10.8
Annual forage (kg/yr)	8,542.8	5,090.4	1,169.2	230.6	94.5	1,644.3	1,496.88
Price perkg ($US)	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Sub-total ($US)	597.99	356.33	81.84	16.14	6.61	115.10	104.78
Grand total ($US)				1,278.79			

Kg-killogram, yr-year

Regarding the value of reeds, residents' collected it for different purposes. As animal food, 14.6% of the HHs collected an average of 6.2 bundles of reed/HH and each bundle contained an average of 40 papyrus heads. Therefore, 59,864 papyrus heads were collected annually. On the other hand, as a floor décor, 12.4% HHs harvested an average of 0.48 bundles/HH during holidays and in the four holidays celebrated by Christians, since 100% of the respondents were followers of Orthodox Christianity, 3,960 papyrus heads were collected. Thus, a total of 63,824 papyrus heads were used which gives 2,393.40 $US in market price (Table 5).

Concerning the value of firewood, a total of 44.9% of the HHs were involved in collecting fire wood from wetlands. Respondents' collected an average amount of 2.36 bundles of firewood from December to June, once every two weeks. This gives an annual amount of 1,751.59 bundles collected and in the market price its value was 5,412.44 $US. On the other hand, with regard to medicinal plants, 10.1%, 6.7%, 3.4%, and 1.7% of the HHs collected *Ocimum Lamiifolium, Zehneria scabra, Eucalyptus spp.,* and *Solanum indicum,* respectively. The quantity of herbs collected was described in handful (HF) and a total of 154.77 HF were harvested annually. When the quantity was estimated by the market price, its contribution to the total economic value was equal to 236.16 $US (Table 5).

The indirect use economic value provided by wetlands

Concerning the value of wetlands through carbon sequestration, the amount of stored carbon was calculated following the equation developed by Merriman and Murata (2016).

Table 5. The value of raw materials and medicinal plants provided by wetlands.

Goods	Total No of HH	Total am't harvested/ Effort	Frequency of harvest/yr	Average qty harvested /HH/yr	Total Harvested by popn./yr	Unit	Unit price ($US)	Total price ($US)
Reeds								
For animal	241.3	46	24	6.2	14,966	Bun	0.15	2,244.90
Floor decor	205	21.5	4	0.48	990	Bun	0.15	148.50
Firewood	742.2	30	14	2.36	1,751.6	Bun	3.09	5,412.44
Medicinal plant								
O. lamiifolium	166.9	18	4	0.4	66.8	Hf	1.54	102.87
Z. scabra	110.7	30	4	0.67	74.2	Hf	1.54	114.27
Eucalyptus	56.2	6	4	0.13	7.3	Hf	1.54	11.24
S. indicum	28.1	15	4	0.33	5.05	Hf	1.54	7.78

am't-amount, Bun=bundle, HF=hand full, HH-household, No-number, popn.-population, qty-quantity, yr-year

To use the equation, the amount of carbon stored, habitat size, and prices of carbon were required. So, for the calculation, the carbon-storing capacity of tropical wetlands was used, i.e., 167 MgC/ha (IPCC, 2013). Also, since there was no fixed carbon price globally, the value reported by Wang *et al.* (2019) was employed. Accordingly, wetlands earn an annual value of 90,148,954.37 $US (Table 6).

Table 6. The amount of carbon stored and its economic value wetlands.

Wetlands	Area (ha)	C-storing capacity (MgC)	Total C-stored (MgC/ha)	Price ($US/MgC)	Total ($US)
Shesher	650	167	108,550	200.57	21,771,873.50
Chimba	1,234.4	167	206,144.8	200.57	41,346,462.54
Avaji	200	167	33,400	200.57	6,699,038.00
Yitamot	57	167	9519	200.57	1,909,225.83
Dena	250	167	41,750	200.57	8,373,797.50
Wonjeta	300	167	50,100	200.57	10,048,557.00
Total	2,691.4	167	449,463.8	200.57	90,148,954.37

C- Carbon, ha-hectar, MgC- Mega gram of carbon or tone

Regarding water purification value, the reference method developed by Wang (2006) was employed. To use the method, the average of unit value of pollutant degradation of global wetland ecosystems, i.e., 4,177.00 $US/ha, and the unit value revealed by Xie et al. (2001), i.e., 2,521.40 $US, was taken as a reference; thus, the average (reference) value was equal to 3,349.20 $US/ha.

Then, using the formula, the wetlands water purification function provided an annual amount of 9,014,036.88 $US. Similarly, to determine the value of education and research services, the reference method was applied. Accordingly, using 871 $US/ha as unit value, the contribution of wetlands was found to be 2,344,209.04 $US/yr (Table 7).

Table 7. Value of water purification research & education & habitat providing services.

Wetland	Area (ha)	Water purification ($US)	Education and research ($US)	Habitat provision ($US)
Shesher	650	2,176,980.00	566,150.00	218,205.00
Chimba	1,234.4	4,134,252.48	1,075,162.04	414,388.08
Avaji	200	669,840.00	174,200.00	67,140.00
Yitamot	57	190,904.40	49,647.00	19,134.90
Dena	250	837,300.00	217,750.00	83,925.00
Wonjeta	300	1,004,760.00	261,300.00	100,710.00
Total	2,691.4	9,014,036.88	2,344,209.04	903,502.98

ha-hectar

The non-use economic value of provided by wetlands

To determine the value of habitat provision services, the reference method was used. For this, the mean of two figures was used as a reference: the habitat value per unit area, i.e., 304 $US/ha (Costanza *et al.*, 1998), which was combined with the study result of Xie *et al.* (2001), i.e., 367.40 $US/ha, yielding the average value of 335.7 $US/ha. Then, following the formula, the species habitat provision value was found to be 903,502.98 $US/yr (Table 7).

The economic costs of managing wetlands in the Lake Tana Sub-basin

The monetary value of biodiversity conservation was estimated by contingent valuation method. Accordingly, 39.9% HH were willing to contribute 0 to 4.63 $US and an average of 0.35 $US/HH/month. When the value was extrapolated to the total HHs, the projected average willingness to pay by all users was 584.34 $US/month and 7,012.11 $US/yr.

The relative monetary contribution of ecosystem services

Of the different values, indirect use value took the first rank and contributed more than half of the total economic value (97.2%), which was followed by direct use value (2.8%). On the other hand, the non-use value was lower than the rest of the services (0.006%) (Table 8).

Table 8. The total economic values of goods and services provided by wetlands.

Value	Goods and services	Value ($US)	Proportion (%)	Value ($US)/HH/yr
Direct use value	Food provision	136,075.18	0.13	82.32
	Water provision	2,628,061.39	2.49	1,589.87
	Raw materials	9,324.86	0.008	5.64
	Medicinal plant	238.92	0.0002	0.14
Sub-total		2,773,559.62	2.63	1,677.98
Indirect use value				
	Climate regulation	90,148,922.45	85.56	54,536.55
	Water purification	9,014,037.04	8.6	5,453.14
	Education and research	2,344,209.40	2.22	1,418.15
	Habitat provision	903,502.73	0.86	546.58
Sub-total		102,410,671.60	97.2	61,954.43
Non use value	Biodiversity conservation	7,012.11	0.006	4.24
Sub-total		7,012.11	0.006	4.24
Grand total		105,191,384.1	100	63,737.73

HH-household, yr-year

Regarding the relative monetary contribution of the four categories of ESs, the value provided by regulating service was higher, followed by provisioning and cultural services, whereas supporting services contributed the least (Table 9). Specifically, of all the services, the value of climate regulation took the first rank and contributed more than half of the value, followed by water purification service (Table 9). Among sites, the value of goods and services that contributed to the total economic value was highest in Chimba, which was followed by Shesher and Wonjeta, where as its contribution was lowest in Yitamot (Fig. 2).

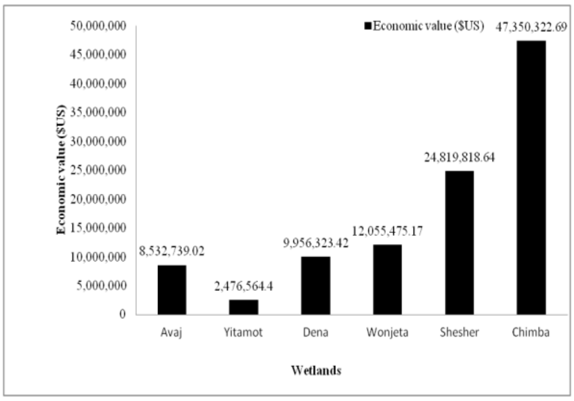

Fig. 2. The total economic values of all ecosystem services provided by wetlands.

Table 9. The relative economic values of the four categories of ecosystem goods and services.

Ecosystem services	Value ($)	Proportion (%)
Provisioning	2,773,559.63	2.64
Regulating	99,162,959.49	94.27
Cultural	2,344,209.40	2.23
Supporting	910,514.84	0.86
Total	105,191,243.30	100

Related to the provision of food, the economic value was higher in Shesher, followed by Chimba wetland, whereas its contribution was lowest in Yitamot. The food provision in Shesher contributed about 48% of the total food provision value. Similarly, water provision was the other ecosystem service that contributed to the livelihoods of the local people. Of the six sites, the economic value was higher in Avaji, followed by Wonjeta sites (Fig. 3).

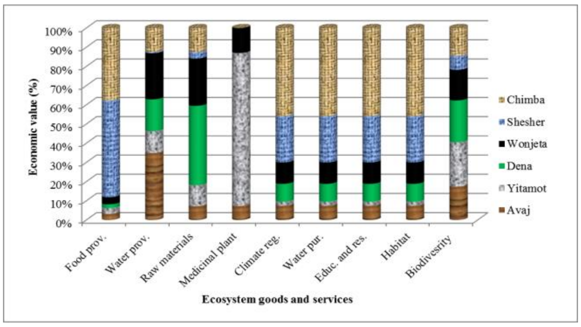

Fig. 3. The percentage contribution of ecosystem goods and services in terms of money.

Regarding the provision of raw materials, except for Chimba and Shesher, the monetary value of others was relatively higher. Specifically, a higher quantity of firewood, reeds and grass were collected in Dena, Dena, and Wonjeta, respectively. Concerning the medicinal value, quantitatively, a total of 154.77 HF of herbs were collected from all sites. From all the herbs, most HH used higher amount of *Z. scabra* (74.2 HF) and *Ocimum lamiifolium* (66.8 HF) and about 76% of the total medicinal plants were utilized in Yitamot (Appendix 4).

The value of climate regulation, water purification, habitat provisioning, and education and research services was higher in Chimba in that it contributed about 48% of the total regulating and supporting services, it was lowest in Yitamot site (Fig. 3).

The contribution of wetlands for the local and national economy

The total economic contribution of the six wetlands was estimated to be 105,191,384.1 $US/yr to the national economy. Assuming benefit is shared equally among all HHs (1,653), the average wetland's contribution amounts 63,636.56 $US/HH/yr. This translated to 5,303.04 $US/HH/month and 976.61 $US/capita/month/average HH size (5.43) for the local people (Table 10).

Table 10. The contribution of wetlands for the local and national economy.

Goods & services	Chimba ($US)/yr	Shesher ($US)/yr	Dena ($US)/yr	Wonjeta ($US)/yr	Avaji ($US)/yr	Yitamot ($US)/yr	Value ($US)/capita/month	Value ($US)/HH/month	Value ($)/ HH/yr	Value ($US)/yr
Food provision	51,366.2	68,573.96	2,651.06	4,959.42	4,417.2	4,107.28	1.26	6.86	82.32	136,075.2
Water provision	326,544.1	17,250.0	435,553.	631,792.6	916,211.	300,709.	24.40	132.49	1,589.	2,628,061.
Raw materials	1,166.39	315.69	3,852.64	2,295.15	667.51	1,027.46	0.08	0.46	5.56	9,184.13
Medicinal plant	0	0	0	31.02	17.37	190.53	0.002	0.01	0.14	238.92
Climate regulate	41,346,448	21,771,866	837,3794	10,048,553	6,699,035	1,909,225	836.96	4,544.71	54,536	90,148,922
Water purify	4,134,252.6	2,176,980.0	837,300.0	1,004,760.0	669,840.0	190,904.4	83.68	454.42	5,453.1	9,014,037.0
Educ. & research	1,075,162.	566,150.0	217,750.	261,300.0	174,200.	49,647.0	21.76	118.18	1,418.	2,344,209.
Habitat provision	414,387.9	218,204.94	83,924.9	100,709.9	67,139.9	19,134.8	8.39	45.55	546.58	903,502.73
Biodiv. conserve.	1,016.24	508.12	1,524.37	1,117.87	1,219.49	1,626.0	0.06	0.35	4.24	7,012.11
Total	47,350,343	24,819,848	9,956,350	12,055,519	8,532,749	2,476,572	976.61	5,303.04	63,636	105,191,384

HH-household, yr-year, biodiv. conserve.-biodiversity conservation, educ-education

Discussion

Estimated human disturbance status results of the six wetlands

Of the six wetlands, higher human disturbance scores were recorded in Shesher, followed by Avaji and Chimba. Shesher and Chimba were highly affected by cultivation and open grazing. These could be factors contributed significantly to the higher HDS result. In these areas, the buffer zones as well as catchments were highly degraded by open grazing and recession agriculture, particularly during dry season. Shesher was totally devoid of buffer vegetation, sometimes losing the entirety of its water for about two months (Wondie, 2018). When wetlands were exposed to extensive agriculture and open grazing, the decline in vegetation and increase in bare were attributed to them, and according to Rivers-Moore and Cowden (2012), the presence of bare land is an indicator of wetland degradation.

At the Chimba and Yitamot sites, open grazing might be one of the factors contributed significantly to the higher HDS result. Because the pressure from grazing has resulted in changes in the wetland characteristics (Mckee, 2007), uncontrolled livestock grazing alters the hydrology and drainage pathways at a site by compacting topsoil, which in turn decreases the infiltration capacity of the soil (Gathumbi *et al.*, 2004) and, consequently, led to increase in the release of nutrients and sediments by erosion (Kurz *et al.*, 2005). In addition, grazing might lead to alteration in wetland plant composition, which is able to intercept sediments and nutrients (Gathumbi *et al.*, 2004). Deposition of dung and urine during grazing is also one source of nitrogen and phosphorous for surface water (Edwards *et al.*, 2000).

In Avaji and to some extent Yitamot the wetlands buffer and catchment area was occupied by residence. This could be another factor contributed significantly to the higher HDS result. This result concurs with Rivers-Moore and Cowden (2012), who predicted that wetlands located close to main roads/settlements are more likely to be degraded than those away from such infrastructure.

Another threat was pollution. In Avaji and Yitamot sites, waste disposal from Bahir Dar town, leather tanning, and waste from Bahir Dar University (in Yitamot only) might be the other factors for higher HDS value. Basically, it is not only in Avaji and Yitamot, but practically in most countries, all city sewage lines end up into the lake and wetlands. The other source of pollution was the dumping of domestic and industrial wastes and garbage, primarily in urban wetlands (Beyene et al., 2009), which added nutrients via runoff. Nutrient enrichment then produces algal blooms and increases aquatic weed growth, which reduces water clarity and dissolved oxygen concentration (Chen *et al.*, 2002).

In all wetlands, water abstraction for small-scale irrigation, animal drink, and domestic use were common practices, so all were characterized by currently active and major disturbances to the natural hydrology. This is because expansion of irrigation in and around wetlands depletes dissolved oxygen and causes toxic gas secretion, mainly by decomposition (Hailemicael and Raju, 2011). Similarly, population growth may be another driving force because it necessitates more land, damages frosts in the catchment, and overconsumes water for irrigation. Furthermore, shortage of land has forced farmers to cultivate steep-slopes and shallow soils that are vulnerable to degradation and have led to altered water cycles. A similar result was found by Gell *et al.* (2013).

The direct use values of ecosystem goods and services provided by wetlands

Wild fruit was one of the ecosystem goods contributed to the livelihoods of local people. In the six wetlands, the values of wild fruits were higher in Wonjeta and Dena. The reason might be the presence of different types of trees that bear edible fruits around wetlands periphery. Dena and Wonjeta were relatively forested and currently recognized as core zones of the Lake Tana Biosphere reserve (zur Heide, 2012). This indicated that wild fruits are available more in forested wetlands.

Similarly, besides wild fruits, cultivating fruits and vegetables were observed in many Ethiopian wetlands (Tadesse and Addisu, 2014), including the study area. This was due to the fertile soils and abundant soil moisture in wetlands that supported crop farming almost throughout the year (Turyahabwe *et al.,* 2013) and this indirectly provided subsistence income for the poor (Kakuru *et al.,* 2013). In the six wetlands, the value of cultivated fruits and vegetables was higher in Wonjeta and Chimba, respectively. The reason for higher productivity of vegetables in Chimba might be due to the dependency of some of the community on wetland products, so they considered wetlands as a major economic source, thus practice recessive agriculture. On the other hand, regarding fruits, in Wonjeta the surrounding communities cultivated fruits by abstracting water for irrigation, so the production was relatively higher. Basically, irrigation has been used to produce subsistence food crops in Ethiopia since ancient times (Awulachew *et al.,* 2007).

The wetlands also played vital role in the cultivation of cereals. From all sites, wetlands added 46.56 $US/HH by cultivating waterlogged areas for cereals. In support of the argument, wetland adjacent communities noted that, yields from wetland crop farming were higher owing to the moisture guaranteed even during the dry seasons. In the six wetlands, higher amount of cereals were collected in Shesher. The reason might be the communities' intensive cultivation activities due to the growing human population, since many crops that improve food security or generate income grow best in moist soils, thus practicing recessive agriculture. For instance, Vijverberg *et al.* (2009) reported that 55% of the people in Shesher were benefiting from the wetland and the communities produced 120,635 quintals in the 2009/10 cropping season from recession agriculture.

Regarding fish catch, the economic value of wetlands through fish production was enormous. It was reported as a less expensive type of food when compared to other sources of meat. But its contribution was lower when compared with wetland fishing reported in Zegie area, 109.60 i.e., $US/fisherman/yr (Yiganda wetland management plan 2014 unpublished). The reason for the decrease in the quantity of fish caught in the studied area might be due to the reason that over 1,800 species of fish, worldwide, were resident for all or part of their life cycles in wetlands (Akwetaireho, 2009). But in the Lake Tana Sub-basin, despite its role, untreated effluents were released into the wetlands (Wondie, 2010) leading to a reduction in the amount of oxygen and cause changes to water temperatures (Jackson, 2011). This in turn might lead to a decline in the water quality and biodiversity in wetlands (Porte and Gupta, 2017) including fish. Similarly, concerning Khat production, in the Lake Tana Sub-basin, it was the main commercial crop that the local people cultivate extensively as source of income (Wondie, 2018). Accordingly, Khat contributed 3.75 $US/HH/yr, which was comparable with Lamsal *et al.* (2015).

Wetlands also provided food for the livestock not only to provide meat, but also products such as milk. Through the provision of forage and water, the studied wetlands supported the sustenance of animals, which in turn enabled them to provide milk that costs 7,111.98 $US/yr. In support of the result, Kakuru (2013) noted that pastures from wetlands provided not only fodder, but also enhance milk production, thus contributing to food security. Moreover, the contribution of wetlands was more considerable due to the fact that alternative livestock feed is expensive and may not be easily met by most farmers (Musamba *et al.,* 2011).

In general, from all the value of wetlands in providing food, the economic value was higher in Shesher than in others. The reason for the higher economic value of Shesher wetland might be due to the occurrence of year-round extended wetland agriculture, so HHs produce higher amount of cereals like Teff, Barely, Chickpea, Rice, etc, but the contribution of fruits and vegetables was negligible. Similarly, previous study revealed the occurrence of intensive cultivation activities in Shesher wetland (BoEPLAU, 2015). Hence, its food provisioning service was relatively higher.

Water is another wetland resource used for drinking, cooking, washing, and irrigation. Regarding the use of water for domestic purposes respondents indicated that, even though the water needed for drinking was obtained mainly from nearby boreholes and stand pipes, wetlands still served as important sources of water especially during dry season. In support of the argument, Dixon and Wood (2007) noted that, in Ethiopia water from wetlands and peripheral springs guarantees the local communities year-round access for domestic use both at HHs and community levels. Regarding water provision for livestock drinking, for most cattle posting grazing areas, wetlands were the main source of water and although the monetary value was good, in the present study, its contribution was low when compared with other African wetlands like Nyando, Kenya (Raburu, 2012). Similarly, with regard to wetlands value for irrigation, obviously availability of irrigation water enabled farmers to produce crops during dry seasons. For this surface and groundwater are important water sources and are vital parts of the strategy to overcome food scarcity in developing countries including Ethiopia (Tadesse *et al.,* 2009).

In general, of all the values of wetlands in providing water, the economic value was higher in Avaji wetland. The reason for the higher economic value of water might be the occurrence of Khat plantation that need continuous water supply and for this irrigation accounted for 81.86% of the total value of wetlands in providing water. Basically, the negative impact of water extraction was observed and reported in the Lake Tana Sub-basin (Aynalem and Bekele, 2008), but still HH extracted large amount of water for irrigation (13,493,958.2 L/yr). Hence, its economic value was relatively higher.

Concerning grass provision, the scarcity of high quality forage was one of the greatest limiting factors affecting livestock production in Africa (Lukuyu *et al.,* 2011), but in the Lake Tana Sub-basin wetlands were important for livestock grazing particularly during dry seasons and in the present study the annual amount of forage consumed was 20,253.24kg/yr. This value was significant due to the reason that during dry seasons alternative livestock feed was expensive and was not easily met by most farmers in the study area. The argument was supported by Musamba *et al.* (2011).

Wetlands also provided firewood mainly for cooking and although wetlands supported human wellbeing by offering firewood (Tadesse and Addisu, 2014), in the six wetlands large amount of firewood was collected in the margin area of Dena and Wonjeta. The reason might be due to presence of shrubs and trees around wetlands margin that could be cut easily and used as firewood (Wondie, 2018).

In general, of all the values of wetlands in providing raw materials, the economic value was relatively higher in all wetlands except Chimba and Shesher. The reason for the reduction in the value of firewood in Chimba and Shesher might be the lack of forest, grass, and reeds due to the degradation of the area with agriculture and grazing. In support of this argument, McCartney and Houghton-Carr (2009) reported that increasing the use of wetlands for agriculture reduces their natural status and the range of ESs they could provide, including firewood, grass, and reeds. For instance, papyrus plant for various purposes and animal fodder were common in forested sites (Wondie, 2018), contrary to Chimba and Shesher.

In the Lake Tana Sub-basin, the economic contribution of wetlands in the form of medicinal plant provision was reported by Wondie (2018), and in the six sites, a higher amount of money was earned from *O. lamiifolium* and *Z. scabra*. Basically, wetlands medicinal plant provision was reported in many countries, but the value obtained in the present study was lower when compared with other wetlands like Cambodia (Emerton, 2005) and Malaysia (IWMI, 2006).

The indirect use economic value of wetlands

The other role of wetlands was in the regulation of global climate change through sequestering carbon. Anthropogenically caused climate change induced by the use of fossil fuels draws special attention on wetlands carbon sequestration to safeguard the future. For instance, peat lands cover small area (3-4%) of the world's land area, but are estimated to hold 540 giga tons of carbon, representing 1.5% of the global carbon storage (MEA, 2005). In this study, the amount of carbon stored was higher than previous studies reported in Ethiopian and other African wetlands like Tekuma Wetland (Yohannes, 2015) and Lake Navishia, Kenya (Saunders *et al.,* 2007).

Concerning the value of water purification service, aquatic systems can break down, remove, and recycle waste (de Groot *et al.,* 2002). This service, in the study area, costs 9,014,037.04 $US/yr. In support of the result, Gustafson *et al.* (2000) noted that wetlands were the most cost effective and sustainable providers of water purification services. For instance, in Canada, boreal wetlands provided an estimated 39 billion dollar/yr in water filtration (Anielski and Wilson, 2005).

With regard to the education and scientific research value, wetlands act as source of information about aquatic organisms, their habitats, ecosystem functions, natural biological processes and relationships between them (Turpie *et al.,* 2010). Moreover, wetlands provided almost unlimited opportunities for nature studies and environmental education through excursions and functioned as field laboratories for scientific research.

The non-use economic value of wetlands provided in the Lake Tana Sub-basin

Wetlands served as a source of biological diversity by hosting diverse fish, wildlife, and plants. Habitat services, like nursery service and gene pool protection were necessary for sustaining vital ecosystem functions and the provision of all other ESs. So, the economic contribution of this service found in this study was supported by Awoke (2017) and Anteneh *et al.* (2012).

Similarly, wetlands are crucial in the maintenance of life-support systems and ecological processes. So, for the conservation of wetlands, average HH willingness to pay was far lower than other similar studies. The HHs lower willingness to pay in the study sites were mainly because of prioritizing to fulfill their basic needs rather than conserving wetlands (Kassa, 2012). Most of them need to convert it to either settlement or farm land. Even currently, many governments in Africa give priority to food security rather than biodiversity conservation (Wood *et al.,* 2013a).

The relative economic contribution of ecosystem services

The relative monetary value of the four types of ESs was different, in which the economic value provided by the regulating service was ranked first, followed by provisioning. This might be due to the higher economic value of carbon-storing ability of wetlands. Because the global cost of carbon was very high and this high value contributed significantly to increase the overall economic value of regulating services than others. In the present study, among the regulating services, the monetary contribution of climate regulation was the highest (85.6%). The result is consistent with Martin-Lopez *et al.* (2014).

The contribution of wetlands to the local and national economy

Globally, wetlands provide goods and services to millions of people (McCartney *et al.,* 2010). In the present study, the monetary value of goods and services identified in the six wetlands contributed significantly to HHs economy of the local people, because wetlands provided 63,636.56 $US/HH/yr, 5,303.04 $US/HH/month, and 976.61 $US per capita/month to the local people. Basically, the role of wetlands in the livelihoods of the poor was revealed not only in the present study, but there was stronger evidence about the role of wetlands in some developing countries economies. For instance, in Uganda, Pece Wetland provided more than 50% of the monthly income of the dependent population (Opio *et al.,* 2011). Similarly, in India, 90% of the East Godavari Delta population depends completely on mangrove wetland products (Dahdouh-Guebas *et al.,* 2006).

Conclusion

Wetlands provide multiple services and products that contribute to income and food security. But regardless of acknowledging the benefits, several people assumed wetlands were a common resource and everybody was entitled to use them free of charge. Consequently, they have started to show signs of degradation and vulnerability in their services and products. Economic valuation could address this problem and become useful in magnifying the importance of wetlands. For instance, the present study indicated that wetlands provided goods and services that added 105,191,384.1 $US/yr to the country's economy. Specifically, wetlands contributed 63,636.56 $US/HH/yr, 5,303.04 $US/HH/month, and 976.61 $US per capita/month to the livelihoods of the local people.

In particular, wetlands contributed 8,532,749.12, 2,476,572.11, 9,956,350.98, 12,055,519.54, 24,819,848.55, and 47,350,343.77 $US/yr to the livelihoods of the communities of Avaji, Yitamot, Dena, Wonjeta, Shesher, and Chimba. Despite this, the value of food, water, raw materials, medicinal plants, habitat, and education research provision was relatively low.

Thus, in view of the high value of economic benefits and to benefit more, all stakeholders should recognize the monetary value of wetlands. Monetary valuation aided in the recognition of true economic contribution, the maximization of long-term benefits, and the increase in conservation investment (Basnyat et al., 2012). It might change the stakeholders' negative attitude, i.e., from wasteland to wealth land. Additionally, it might alert societies to minimize resource exploitation (Costanza *et al.,* 1998) or alert them to develop standalone policy and use resources sustainably. Moreover, the concerned body should take immediate measures, especially for the severely degraded wetlands and ecosystem services having low economic contribution together with awareness-creation activity.

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