Hindawi
International Journal of Ecology
Volume 2022, Article ID 7667611, 19 pages
https://doi.org/10.1155/2022/7667611

Research Article

Ecological Conditions and Ecosystem Services of Artificial Wetlands in Semiarid Ethiopian Highlands

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Received 7 February 2022; Revised 15 July 2022; Accepted 1 August 2022; Published 27 September 2022

Academic Editor: Daniel I. Rubenstein

The main purpose of the study was to investigate the ecological status, ecosystem services (ESs) with their relative importance, and the local communities' perception of the management of Washa and Borale artificial wetlands located in the Semiarid Ethiopian Highlands. The results revealed that many of the communities relied mainly on farming and livestock rearing with small land size (≤1 ha) and large family size. Grass harvesting, free grazing, farming, wetland conversion, and water extraction were the main anthropogenic factors causing the wetlands' ecological disturbance. The ecological status of Washa and Borale wetlands were thus moderately (67) and highly degraded (80), respectively. Yet, the various ESs categorized as provisioning, regulating, cultural, and supporting services, were still delivered from both sites. Vegetables (carrots, potatoes, garlic), crops (barley, beans), grass, water, and crafting materials were the products obtained from the wetlands. Some educational, research, and recreational services were also delivered mainly from the Washa site. Still, erosion, flooding, carbon regulation, and biota (plants, birds, fish) supporting services were provided at both sites. Yet, many of the ESs provided had low and medium importance due to the wetlands' impairedness. Yet, the water and food delivered from the wetlands had high and even higher importance than the other services due to their being designed for providing water mainly for irrigation and livestock watering. Still, Washa provided higher cultural, regulating, and supporting services than the Borale's owing to its being moderately impaired and lesser buffer and catchment area disturbance. Overall, many of the ESs delivered had low and medium importance because of the wetlands' biodiversity loss, ecological degradation, and water reduction chiefly in the dry season. Yet, the people had good perceptions of the wetlands' management. Hence, for the wetlands' restoration, urgent action is required via developing a management plan.

1. Introduction

1.1. Background of the Study. Wetlands are natural and/or man-made assets and the most productive environments. They provide several services like wildlife habitats, basic sources of food for humans, and regulating global warming and geochemical cycles; thus, they accomplish numerous functions from local to global scale [1]. The ecosystem services (ESs) provided by ecosystems lie at the heart of interactions between society and nature. The wetlands are, thus, critical for supporting human livelihoods in Africa [2]. Ethiopia, located in the Eastern Region of Africa, covers 1.13 million Km^2 and is endowed with several inland water bodies comprising mainly swamps, rivers, lakes, ponds, reservoirs, and other wetlands (bogs, marshes), which are generally termed as wetlands [3]. Such artificial wetlands are critical resources in providing paramount services including environmental, hydrological, and socioeconomic services. According to WCD [4] and Gunkel et al. [5], the main uses of the artificial wetlands/reservoirs are flood control, hydropower, and water sources for drinking of human and/or livestock, and irrigation, besides supporting biodiversity. The Ethiopian government presently highlights the development of small-scale irrigation schemes of <200 ha [6] via constructing small reservoirs like the *Washa* and *Borale* artificial wetlands. Yet, their role in safeguarding water, food, and energy security and mitigating climate change is currently threatened via their poor protection and management [7]. Additionally, since some ESs such as climate, erosion, and flooding regulating services are not easily understandable for estimating their values, their role in human well-being was overlooked in development policy [8]. Thus, the present studied *Washa* and *Borale* artificial wetlands were similarly threatened by anthropological activities. Even since the country has not yet ratified the Ramsar Convention, there is no support for it [9, 10]. Moreover, inadequate data on current ecological conditions and biodiversity of wetlands, people's perception, and wetland policy and policy interventions [3, 11] have aggravated the degradation of wetlands. Besides, the current state of the ESs of Ethiopian wetlands remains poorly understood [10, 12]. Particularly, the ecological status and delivered ESs of the Ethiopian artificial wetlands were not yet rated and investigated scientifically before this study, respectively. However, despite facing such highly critical and urgent problems, little or no study has been made so far on such artificial wetlands in Ethiopia. Therefore, the ESs also continued to be the main part of the research issue of ecological economics [13] of scholars. Thus, the main objectives of this study were to investigate (i) the anthropogenic factors and ecological status of the artificial wetlands using human disturbance gradient score (hereafter abbreviated as HDGS) and field observation, (ii) the ESs delivered by the study wetlands with their relative importance, and (iii) the perception of the local communities towards their experiences and interests in wetlands' management in the future.

2. Materials and Methods

2.1. Description of the Study Area. This study was carried out in two sites, locally called *Washa* and *Borale* artificial wetlands, which are also positioned in 01 Kebele (which is proportional to a county), but at the periphery of *Debre Berhan Town* (DBT) being bordered by Basona-Werena District of North Shewa Zone, Semi-Arid Central Ethiopian Highlands (Figure 1). The *Washa* and *Borale* sites are also far away by 10 and 15 km from the center of DBT, with altitudes of 2763 and 2832 meters above sea level, respectively (Table 1). The *Washa* site is also located at 9°39′45″ latitude and 39°32′45″ longitude, whereas the *Borale* site is situated at 9°39′62″ latitude and 39°32′36″ longitude. The temperature of DBT ranges from the mean annual minimum to maximum temperature of 2.3°C to 22°C, respectively, and its mean annual rainfall is 906 mm [14]. In 01 *Kebele*, about 690 total households were living, of whom 149 and 58 households of *Borale* and *Washa* sites, respectively, had been irrigated land downstream/around and cultivated various vegetable and cereal crops at least twice a year by extracting water directly from the reservoirs (interviews made with experts of Urban Agricultural Office of DBT). Generally, the studied artificial wetlands provided water, besides serving being biota preservation areas for fish, birds, and plants.

2.2. Study Site Selection. The *Washa* and *Borale* sites were selected due to their socioeconomic services to the localities, and the problems of conversion of the upper catchments and wetlands downstream into agricultural, settlement, and grazing lands, leading to reservoirs' water reduction and wetland degradation.

2.2.1. Washa Site. The total area of *Washa* site was 56 ha, comprising a reservoir (12 ha) and its surrounding wetlands (16 ha) and irrigated land (28 ha) (Table 1). The reservoir in this site was constructed in 1995 by a nongovernmental organization (NGO) called Lutheran with the main aim of providing water for fisheries, irrigation, and livestock watering.

The reservoir is fed by a seasonal flood and small streams drain its catchment, particularly in the rainy season, from the end of June to the beginning of September. It was designed to hold 91, 875 m^3 water with 14 m maximum depth (as reported by Zonal and urban agricultural experts). The catchment and its surrounding wetlands were characterized by farming, grass harvesting, grazing, and settlement. There was also high water extraction from the reservoir for irrigation and livestock watering, especially in the long dry season, from December to May.

2.2.2. Borale Site. The total area of *Borale* site was 154 ha, consisting of a reservoir (17 ha), surrounding wetlands (17 ha), and irrigated land mainly at downstream (120 ha) (Table 1). The reservoir was constructed in 2007 by the Bureau of Agriculture of the Amhara Region to provide water for irrigation, fishery, and livestock watering and fed by seasonal flooding and three small streams draining its catchment, particularly in the rainy season. It was designed to hold 280,000 m^3 of water to 14m depth; however, currently, its depth and amount of water are highly reduced. Grazing, grass harvesting, farming, and water extraction for irrigation were the main activities that occurred.

2.3. Study Design. Descriptive and vegetative surveys were the appropriate approach for collecting and analyzing the data of this study. A reconnaissance survey was conducted to familiarize with the landscape and hydrological situation of the study area along with development agents, and Kebele and district administrative bodies, in May and September 2020. A cross-sectional survey design was applied for collecting data using the household questionnaire, KI interview, FGD, and stakeholder survey. A vegetative systematic survey design was also made for plant specimens' collection and identification. Therefore, since the data collected were quantitative and qualitative during their formal and informal surveys, both quantitative and qualitative data analyzing approaches were employed.

2.4. Respondents' Selection and Their Sampling Techniques. Households, KIs, stakeholders, and members of FGD were the participants of this study, who, except stakeholders, represented more than 20% of the total households of

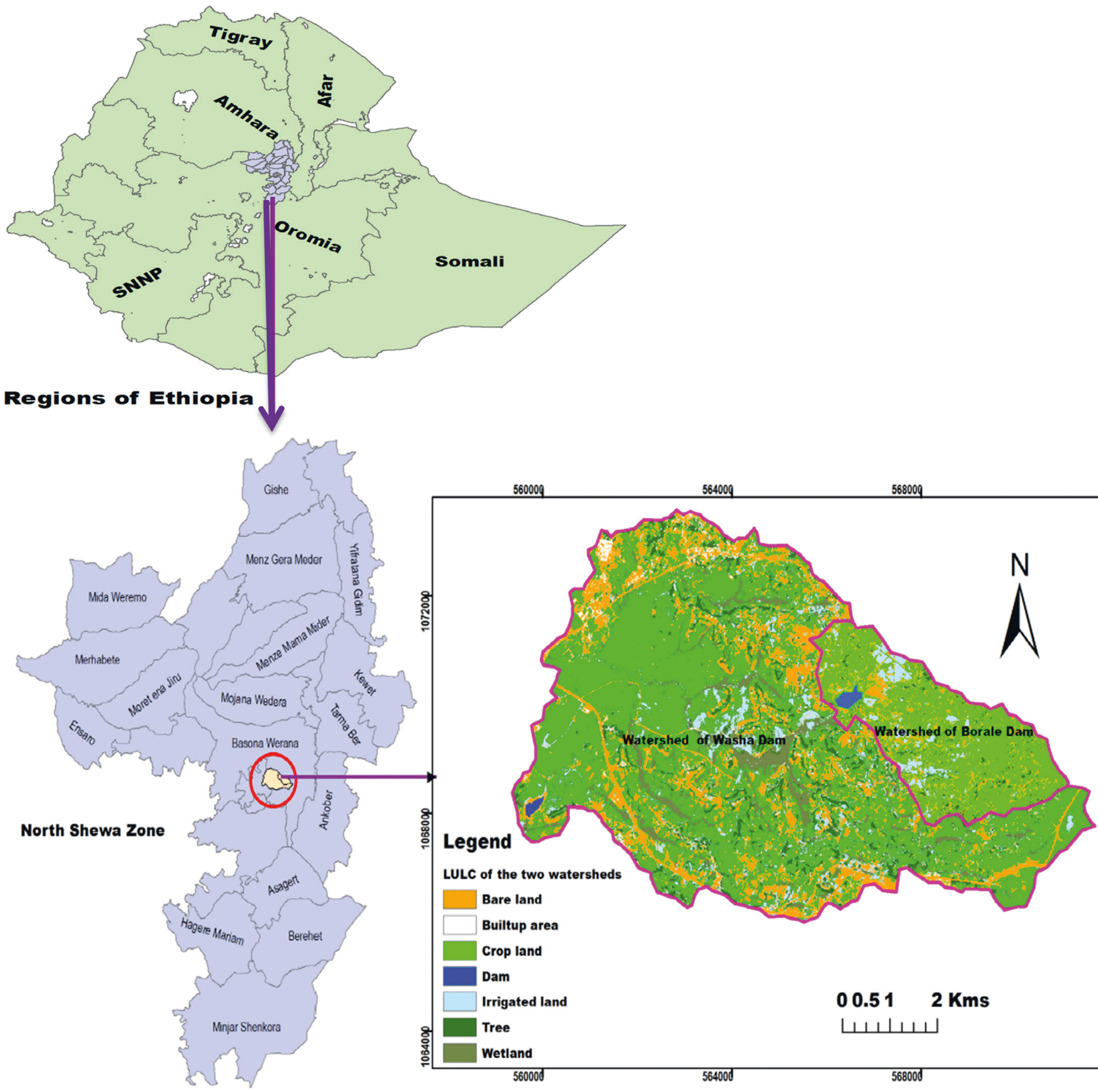


Figure 1: A map of the study area with its land use land cover (LULC) in the North Shewa zone (with its districts) of the Amhara region, Ethiopia.

Table 1: The name, location, and land size of the study area, including irrigated land.

Name of study sites	Distance from DBT	Location Latitude (N)	Location Longitude (E)	Altitude (in meter)	Depth in meter	Area size (ha) Reservoir	Area size (ha) Wetland	Area size (ha) Irrigated land
Washa	15	9°39′45″	39°32′45″	2763	14	12	16	28
Borale	10	9°39′62″	39°32′36″	2832	14	17	17	120

01Kebele (690), where the two study sites were located. Accordingly, for the household survey, a total 100 household respondents (50 households per site) living and/or having land within a 5 Km radius of *Washa* and *Borale* wetlands were selected using a clustered random sampling technique [9, 15]. This is because those people living within a 5 Km radius have direct contact and influence on wetlands in harvesting and/or grazing grasses, encroaching wetlands for farming and settlement, extracting/using water for different purposes, and even in conserving practices of the wetlands. Moreover, two groups of KIs (24), who are proposed to be more interactive and knowledgeable individuals about their Kebele from *Washa* (12) and *Borale* (12) site communities, were selected purposively through consulting development agents and Kebele administrative bodies. The other 12 respondents were purposively selected from stakeholders of the study area (8 experts from zonal and urban agricultural offices, Nongovernmental Organization (NGO), and Debre Berhan University (DBU); 2 development agents, and 2 *Kebele* administrative bodies). Additionally, 16 farmers (eight per site) for the two FGDs were randomly selected. Hence, a total of 152 respondents were participants in this study. However, since the responses of five households from both study sites were rejected for their incompleteness, the data of a total 147 participants were made ready for analysis.

2.5. Data Collection Methods

2.5.1. Household Survey, KI and Stakeholder Interviews, and FGD. Based on the perceptions of the household survey, KI and stakeholder interviews, the data collection on ESs and their relative importance and interest in wetland management were carried out. However, regulating and supporting services are somewhat challenging concepts for understanding and interacting with farmers. Thereby, the importance of wetlands relating to these services was assessed by clarifying the concepts of the terms to those household respondents. Moreover, for validating the responses of the households and getting additional information, questions relating to regulating and supporting services were asked to stakeholders and key informants. Furthermore, the relative importance of ESs was rated using 5-Likert points (not sure, very low, low, medium, and high importance). Moreover, FGD and field observations were employed for validating the data collected via household survey, besides collecting the missed data. Thus, structured and semistructured questionnaires comprising open- and close-ended items were prepared, besides checklists. Additionally, the plant specimens were collected using the quadrat method at 50-meter intervals and then pressed and taken to DBU for identification.

2.5.2. Protocols for Estimating the Ecological Status of Wetlands. The degree and severity of the ecological condition of wetlands could be estimated and determined using different ecological disturbance assessment methods. For this study, therefore, mainly the protocols of human disturbance gradient score (HDGS) of Gernes and Helgen [16] and the field observation checklist were applied. Consequently, repeated ecological assessments during the wet and dry seasons, from October 2020 to May 2021, were conducted. Accordingly, the physical buffer landscape disturbance (within 50 m radius), and further landscape disturbance up to 500m radius from the edges of the wetlands were made, where the habitat, vegetation, and hydrological alterations were assessed. Moreover, chemical pollutants such as phosphate, nitrate, dissolved oxygen (DO), and electric conductivity (EC), and biological data on the presence or absence of birds and fish were also assessed and evaluated. Repeated field visits and fish nets were also used for determining the presence of birds and capturing fish, respectively. Moreover, three bottle composite water samples (with one litter volume of each), besides *in situ* measures (for DO and EC), were taken for water chemical analysis from each referenced, mid-impacted, and high-impacted sampling sites of the study area.

Thus, to determine the HDGSs of each study wetland, various data sources were categorized into six-factor groups as follows:

(1) Factor 1: Focused on the assessment of buffer landscape disturbances within 50 m radius from the edge of the wetland, where the degree of disturbance varies from 0 to 18 points.
(2) Factor 2: Measured extent and intensity of landscape disturbance within 500 m radius from the edge of the wetland, where the degree of disturbance varies from 0 to 18 points
(3) Factor 3: Evaluated the severity and extent of habitat and vegetation alternations of the whole study wetland area, where the severity and extent of alteration range from 0 to 18 points.
(4) Factor 4: Measured degree and severity of hydrological alteration, where the alteration rate varies from 0 to 21 points.
(5) Factor 5: Assessed the extent and severity of chemical pollution using mainly phosphate, nitrate, EC, and DO, where the degree of chemical pollution ranges from 0 to 21 points.
(6) Factor 6: Focused on assessing with additional points added to the cumulative disturbance, such as the presence/absence of fish and birds in the wetlands, where the extent of presence or absence of them ranges from 0 to 4 points.

The water samples were analyzed in the laboratory of Addis Ababa University to score the extent of chemical pollution of the wetlands (Factor 5). Finally, each factor was evaluated and scored into one of the four categories ranging from best to poor, with values ranging from zero to eighteen/twenty-one, respectively. At the end, all scored values of the six factors were summed up to the study wetlands to get their total HDGSs. Based on the values, each wetland falls within the potential range of 0–100 HDGS. Those study wetlands with the values of HDGS falling in the categorical ranges of 0–33, 34–67, and 68–100 are considered the least impacted, mid-impacted, and most impacted sites [16], respectively.

2.6. Data Analysis. For framing the ESs, the conceptual model (Figure 2) of De Groot et al. [16] and Moges et al. [9] was adopted and is more appropriate to analyze the ESs by bringing various services into their limited categories: provisioning, cultural, regulating, and supporting services. Moreover, the data collected based on the protocol and field checklist were analyzed to rate the ecological status of these artificial wetlands. Furthermore, for some water quality parameter analyses, APHA [18] laboratory procedures were used.

Moreover, plant identification was performed using the flora volumes of Ethiopia and Eritrea [19–23]. Finally, to analyze plant communities' similarity between the two

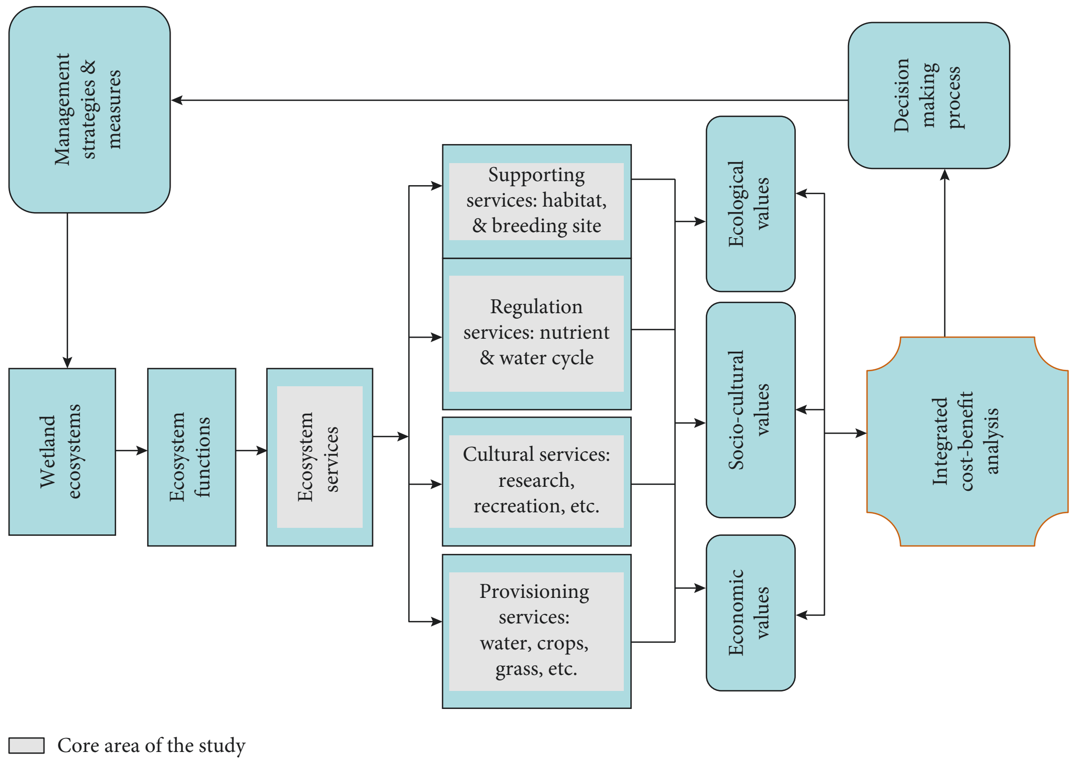


Figure 2: A conceptual model was used as a framework for the assessment and analysis of ESs [9, 17].

artificial wetlands, the Sorenson Similarity index (J) was performed using the formula:

$J = 2a/2a + b + c$, where J = Sorenson similarity Index, a = the number of species in site 1, B = the number of species in site 2, and c = the number of common species in both sites (wetlands), and where the index ranges from 0 (no similarity) to 1 (complete similarity), corresponding to 0 to 100% [24]. For all these analyses, SPSS, PAST, and Microsoft Excel 2010 soft wares were employed. Hence, besides content analysis for narrating qualitative data, descriptive and inferential statistics such as frequency, percentage, HDGS, and similarity index were made.

3. Results

3.1. Background Information of the Respondents. This background information mainly focused on the characteristics of household respondents, who were the major primary data source of this study, carried out from December 2020 to April 2021. Thus, the total household respondents were 95, drawn from *Washa* (46) and *Borale* (49) sites and comprised 13 females (~14%) and 82 males (~86%). Of the total, many respondents (~35%) had from five to six family sizes per household, followed by three to four (~30%) and seven to eight (~22%) family sizes, respectively (Table 2). The least number of households (2%, on average) had more than eight family sizes. Regarding the age categories of the households, more than half of them in this study (~55%) fell in the age group of >45–60, followed by > 30–45, with the least participants in the 20–30 age groups (~6%) (Table 2).

The educational status of the household participants included almost all individuals ranging from illiterates to higher literates. However, many of the respondents comprised individuals who completed their education from Grades 1–4 (~22%) and Grades 5–9 (~22%), who can write and read (21%), and illiterates (21%) (Table 2). Yet, the least participants were those who completed their higher education (≥diploma) (~2%).

3.2. Economic and Livelihood Conditions of the Community. Of the total, 98.9%, 62.1%, and 51.6% of the households of the study area had farmland, grazing land (noted as bare land in the LULC map (Figure 1) since found almost bare during the mapping survey) and wetland, respectively (Table 3). Contrarily, one percent of them had no land at all in the study area (from *Borale* site). Still, there were slight variations in the land use system ownership between the communities of *Washa* and *Borale* sites (Table 3). For instance, 100% and 97.9% of *Washa* and *Borale* households had farmlands, respectively (Table 3).

In the present study area, many of the households engaged in more than one activity to get additional incomes and/or diversify their income. Accordingly, the livelihoods of the local communities in the study area were dominated by farming (66.3) and livestock rearing (65.3%) (Table 4). Besides these, 22.1% and 10.5% of the households were engaged in fuel wood collection and small trade, respectively; however, very few individuals were involved in daily labor (1.0%), the least income source of the community (Table 4). While considering the two communities living

Table 2: Background information of the participants of the study.

Study site	*Family size* total 1–2		3–4		5–6		7–8		>8	
	n	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Washa	6	13.0	7	15.2	17	36.9	15	32.6	1	2.2
Borale	5	10.2	21	42.8	16	32.6	6	12.2	1	2.0
Total	11	11.6	28	29.5	33	34.7	21	22.1	2	2.1

	Age categories 20–30 *n* (%)	>30–45 *n* (%)	>45–60 *n* (%)	>60 *n* (%)	*Total* *n*	%
Washa	1 (2.2%)	6 (13%)	32 (69.5%)	7 (15.2)	46	100
Borale	5 (10.2%)	21 (42.8%)	20 (40.8%)	3 (6.1%)	46	100
Total	6 (6.3%)	27 (28.4%)	52 (54.7%)	10 (10.5%)	95	100

	Educational status Illiterate		Who can read and write		Grade 1–4		Grade 5–8		Grade 9–12		Higher education		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Washa	3	6.5	7	15.2	15	32.6	13	28.3	7	15.2	1	2.2	46	100
Borale	17	34.7	13	26.5	6	11.2	8	16.3	4	8.2	1	2.1	49	100
G. total	20	21	20	21	21	22.1	21	22.1	11	11.6	2	2.1	95	100

Table 3: Number of households who had different land use types across the study sites.

Study sites	Farmland plus irrigated land		Grazing land		Bush land		Wetland		No land at all		Total households, who have land	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Washa	46	100	20	43.5	7	15.2	16	16.8	0	0	46	100
Borale	48	97.9	39	79.6	21	42.9	33	67.3	1	2	48	97.9
Total	94	98.9	59	62.1	28	29.5	49	51.6	1	1	94	98.9

Note. **n** refers to the number of household respondents, while **%** stands for household percentage.

Table 4: Major income source diversification based on the household survey in the study area.

Study sites	Income source diversification										Total households	
	Farming		Livestock rearing		Fuel wood collection		Small trade		Daily labor			
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Washa	25	54.3	25	54.3	13	28.3	8	17.4	0	0.0	46	100
Borale	38	77.6	37	75.5	8	16.3	2	4.0	1	2.0	49	100
Total	63	66.3	62	65.3	21	22.1	10	10.5	1	1.0	95	100

around *Washa* and *Borale* wetlands, there were some variations in terms of their income sources. For instance, farming and livestock rearing were relatively larger practices in the communities surrounding the *Borale* than *Washa* wetlands, whereas small trade and fuel wood collecting activities were more practiced in vice versa (Table 4).

In the study area, roughly 1%, 71%, 37%, and 48% of them did not have their own farmland, bush land, grazing land, and wetlands, respectively (Table 5). Still, of the total households having their own farmland, bush land, grazing land, and wetland, 75.8%, 29.5%, 63.2%, and 51.6% had small landholdings with ≤1 ha, respectively (Table 5). As depicted in Table 5, except for some in farmland, the majority of the households did not have more than one ha size of the land use system. Of course, the surroundings and/or downstream wetlands of the reservoirs were privatized, whereas the reservoirs were communal; thus, the ownership of the study sites was mixed and only 51.6% of individual farmers had a wetland with ≤1 ha size per head (Table 5).

3.3. Anthropogenic Factors and Ecological Status of Wetlands

3.3.1. Anthropogenic Factors. Grass harvesting, free grazing, farming and settlement (within the catchment), livestock watering, conversion of wetlands into cultivated/irrigated land (at downstream), large water extraction for irrigation, and inappropriate soil and water conservation practices were the common anthropogenic activities observed in both wetlands (Figures 3 and 4). Yet, the severity of those activities was lesser in *Washa* (Figures 3(e)–3(f)) than *Borale* sites (Figure 4(e)) as assessed frequently by researchers using the field checklist and rated using HDGS protocol during the field survey of the study (Table 6). Especially, as developed a LULC (Figure 1) made two FGDs with discussants and observed during the field survey, almost all except a few parts of the catchment of *Borale* Wetland were converted into farmland till the margin of the wetland (Figures 1 and 4(e)), but not as such extreme in the case of *Washa* site (Figure 3(c)–3(e)).

3.3.2. Ecological Status of Wetlands. Based on the survey made using the HDGS format and field checklist, the HDGS values of each factor of *Washa* and *Borale* sites ranged from 3 to 14 and 3 to 21, respectively (Table 6). For instance, the HDGS of landscape disturbance (factor 2) were 12 and 18 for Washa and Borale sites, respectively (Table 6). Thus, the total HDGSs were 67 and 80 to *Washa* and *Borale* wetlands, which in turn are referred to as mid-impacted and most impacted wetlands, respectively (Table 6). Compared with other factors, hydrological change (Factor 4) and chemical pollution (Factor 5) were high in both wetlands, besides having very high landscape disturbance (Factor 2) in *Borale* site (Table 6).

3.4. ESs Provided by the Studied Artificial Wetlands. Using the model (Figure 2), each ES identified and provided by the studied wetlands, with their descriptions, indicators, and roles, were presented in this section (Table 7).

3.4.1. Provisioning Services. Based on the results of the study, the major provisioning services provided by the study sites were again classified as food and raw materials.

(1) Food Provisioning Services. Agricultural crops, vegetables, and fish are mostly considered as food provisioning services (Table 7). Accordingly, more than 86% of the households reported that vegetables such as garlic, potatoes, and carrots with sometimes cabbages and lentils were produced in the study area (Figure 5, Tables 7 and 8). While considering those products to each study site, close to 72% and 100% of the households agreed that the local communities cultivated

Table 5: Landholding size of the households across their land use types.

Land size in ha	Farm land		Bush land		Grazing land		Wetland		Other land if any	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
0 (no land)	1	1	67	70.5	35	36.8	46	48.4	95	100
≤1	72	75.8	28	29.5	60	63.2	49	51.6	0	0
1.1–2	20	21	0	0	0	0	0	0	0	0
2.1–3	1	1	0	0	0	0	0	0	0	0
3.1–4	1	1	0	0	0	0	0	0	0	0
>4	0	0	0	0	0	0	0	0	0	0
Total	95	100	95	100	95	100	0	0	95	100

Figure 3: Partial views of *Washa* site during wet (a, b, c, d) and dry (e, f) seasons with the reservoir filled fully with water (a, c, d), downstream wetlands (b), surrounding wetlands with herbaceous species and birds (c–d), and cattle watering with some birds (e) and high water reduction and silt sedimentation (f), where the photos were taken at the end of the rainy season (September 2020) and in the dry season (May 2021).

them in the surroundings and downstream irrigated land of *Washa* and *Borale* wetlands, respectively (Table 8). As also reported by key informants and observed in the field, the vegetables were cultivated in those same lands of *Washa* and *Borale* wetlands via drawing water from those reservoirs of the study sites (Figure 5).

Additionally, in the same irrigated parts of the wetlands, agricultural crops such as barley, shalom, beans, and lentils

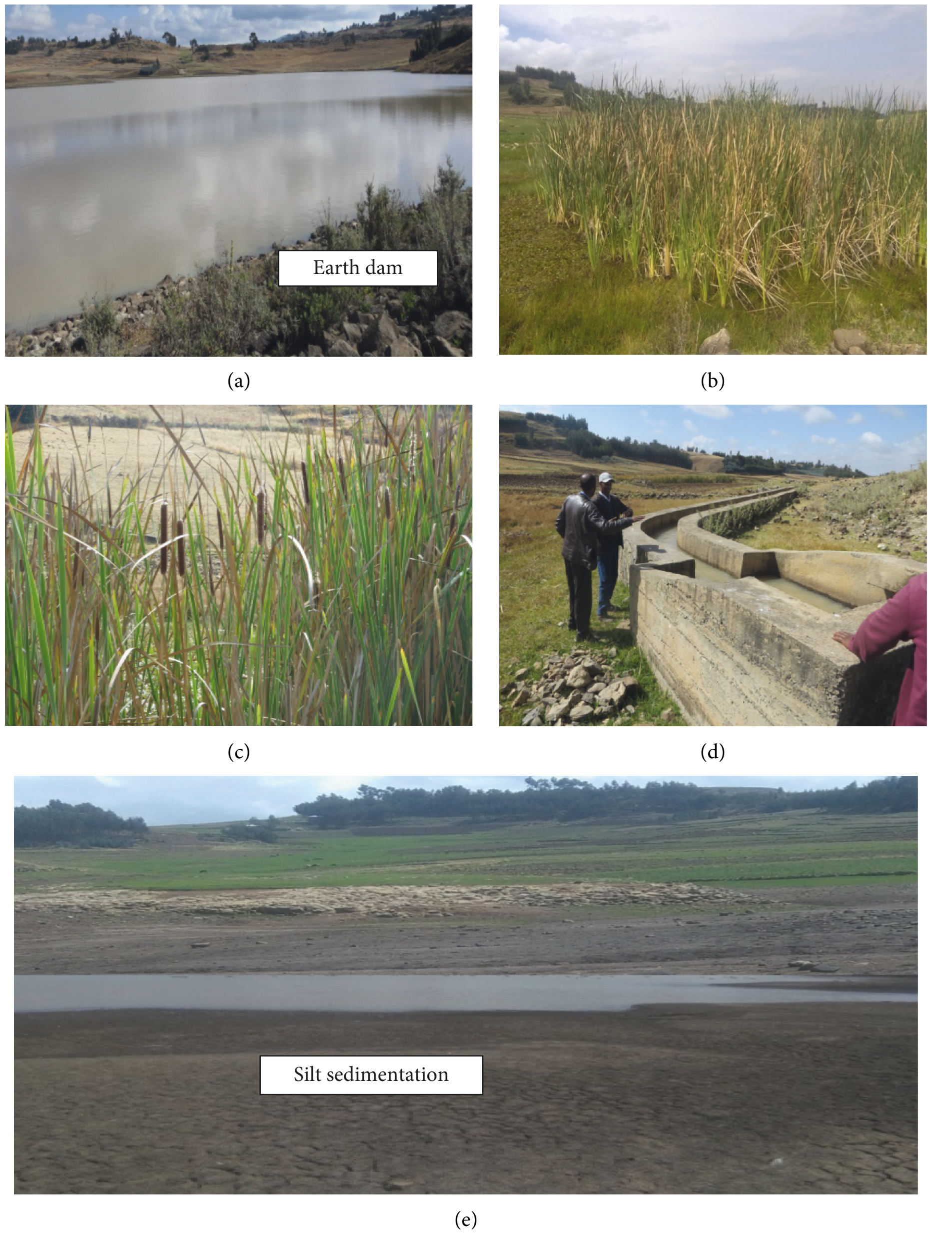


Figure 4: Partial views of *Borale* sites during the wet (a, b) and dry (c, d, e) seasons, with its reservoir and Earth dam (a), downstream wetlands covered with Typha, Cyperus, and Commelina species (b–c) and the canal (d), silt sedimentation, highly reduced water volume, catchment ploughed and covered with barely growing during a light rainy season (locally called 'Belg') from February to April and some woodlots of Eucalyptus globules nearby corrugated iron homes (e) (Photos taken from September 2020 to May 2021).

Table 6: The factors and their values, total HDGSs, and ecological status of the artificial wetlands.

Wetlands	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Total HDGS	Wetland status
Washa	12	12	12	14	14	3	67	MI
Borale	12	18	12	21	14	3	80	HI

Note. MI refers to mid-impacted; HI, high-impacted wetlands.

were cultivated during the dry season from February to May, as reported by respondents and as practically observed by the researchers in the field (Figure 6(a)–6(c)). Roughly 57% of the households answered that the communities of the study area also cultivated and harvested those crops. Of which about 39% and 74% of the households replied as the communities of *Washa* and *Borale* wetlands cultivated and harvested them, respectively (Table 8). As also reported during FGD by the local farmers, nowaday, barley, shalom, beans, and lentils were cultivated on irrigated land as crop

Table 7: The ESs delivered by the artificial wetland ecosystems and their explanations, indicators, and roles.

Categories and ESs	Explanation of ESs provided by the wetlands	Indicators for rating the relative importance	Role
Provisioning services			
a) Food (vegetables, crops, and fish)	Provision of cultivated food: vegetables (carrots, cabbage, garlic), crops (bean, barley, shalom lentils) from irrigated land, and fish from both reservoirs	Amount and number of species	Well-being, socioeconomic
b) Water supply (for irrigating, drinking, and bathing)	Provision of fresh water for irrigation, livestock, and domestic uses from both sites	Quality and volume of water	Socioeconomic, well-being
c) Animal fodder and grazing	Fodder and grazing provision from grasses including *Typha* sp., by-products of cultivated crops	Amount and number of species	Socioeconomic
d) Thatching and crafting materials	Provision of thatch grasses for house roofs and *Typha* sp., *Eleusine* sp. and *Pennisetum* sp. for making house utensils, decoration and mattresses	Amount and quality of grass types	Socio-economic, well-being
e) Construction materials and firewood	Provision of firewood and house construction materials from *Eucalyptus globules*, *Cupressus lusitanica* and *Buddleja* sp. growing in catchments	Amount and quality of wood and its products	Socioeconomic, Well-being
f) Medicinal plants	Medicinal plants such as *E. globules*, *Rumex nepalensis, Inula* sp., *Verbascum sinaiticum*, *Echinops kebeircho* for pharmaceutical and drug production	Species types and amount of medicinal parts	Health well-being
Cultural services			
a) Recreation and ecotourism	Wetlands' green sites, water, towers, and birds used for recreational activities and ecotourism opportunities	Number of visitors and visual quality of sites	Socioeconomic
b) Research services	Serving as being study area for graduate students and scholars	Researchable issues (water quality, flora fauna, ecological status)	Socioeconomic
c) Educational services	Informal and formal education/training opportunities	Number of students/trainees visited	Socioeconomic
Regulating services			
a) Water regulation	The vegetation of wetlands and reservoirs regulate the water flow, runoff, and flooding, thereby recharging ground and surface water, discharging water throughout the year (for drinking and irrigation)	Continuous water flow, low runoff/flooding downstream, water quality and quantity	Environmental conservation, well-being
b) Soil erosion regulation	Vegetation cover prevents sheet, gully, and wind erosion	Vegetation coverage	Environmental management
c) Microclimate regulation and carbon sequestration	Vegetation and water surface regulate the microclimate (rainfall and temperature) via evapotranspiration and sequestrate carbon being sunk	Less temperature fluctuation and pollution	Well-being
d) Water purification and disease control	Wetland vegetation and macro-& microorganisms use to purify waste and polluted water via digesting and absorbing them as food, thereby regulating diseases	Clean water discharging from wetlands	Well-being, environmental management
e) Sediment regulation	The vegetation and reservoirs facilitate the deposition of silts in wetlands, thereby preventing sedimentation and flooding of downstream	Silt accumulation	Environmental management
Supporting services			
a) Habitat service	Habitat for phytoplankton and zooplanktons, wild animals, mainly birds, and vascular plants	Number and volume of wild fauna and flora	Biodiversity conservation
b) Nursery service	Reproduction and growth place for wild animals, including birds, fish, and zooplanktons, and wild flora	Number and cover of young animals, seedlings	Regeneration management

rotations to increase soil fertility and minimize the disease and productivity problems of the vegetables the land owners face.

Fish, introduced at the time of the establishment of the two wetlands, had also been found in *both* wetlands (Table 7) until the end of this study. More than 26% and 12% in *Washa* and *Borale* wetlands, respectively, and totally close to 20% of the households reported that fish was available and harvested in the study area (Table 8). All respondents, however, agreed that there was no beekeeping practiced by

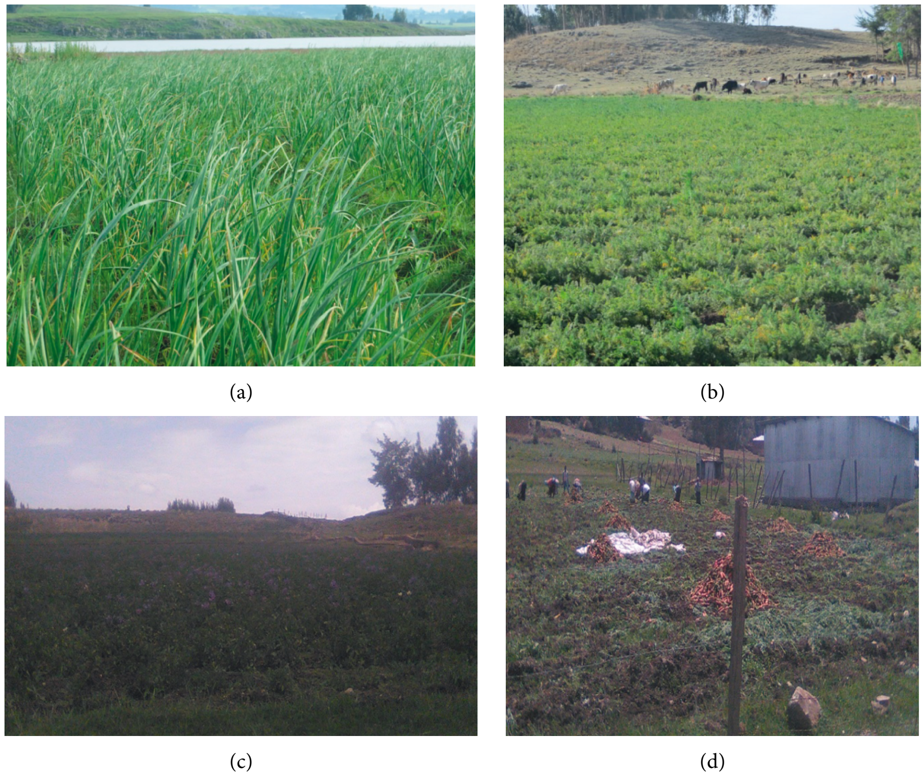


Figure 5: Photos showed garlic (a) and carrots (b, d) in the growing/flowering stage and carrot (c, e) in the harvesting stage in the irrigated lands *of Washa* (a, b) and *Borale* sites (c, d) (Photo taken in June 2021).

the locals of the study area being supported by wetland resources.

Raw materials. Water, grasses, medicinal plants, firewood, and construction materials harvested within and around the study wetlands are considered as raw materials (Tables 7 and 8). Accordingly, 100%, 86%, and 51% of the households replied that the water of the study area was used for livestock watering, irrigation, and washing/cleaning of clothes (Table 8), respectively. While considering those water services provided by the two sites independently, 100% and more than 71% and 28% of the households living around *Washa* Wetland consumed water for livestock watering, irrigation, and washing, respectively. Similarly, 100%, 100%, and >73% of the households of the *Borale* Wetland surroundings used water for livestock watering, irrigation, and cloth washing, respectively (Table 8). No report was made as honey and fruits were harvested for food, and water was used for human drink (Table 8).

About 99%, 38%, and 37% of the households reported that the various grass and other plant species growing in the present study area were used for fodder and grazing, thatching, and making domestic tools, respectively (Table 8). While examining the *Washa* and *Borale* wetland communities independently, the households, roughly 98%, 48%, and 46% of *Washa* Wetland harvested grasses for fodder and grazing, thatching, and crafting work, respectively. Likewise, 100%, and about 29% and 29% of the households living around *Borale* Wetland used grasses for fodder and grazing, thatching, and crafting work, respectively. Roughly 19% of the households used some other plant species for fuel wood; of those, more than 30% and 8% of the households in *Washa* and *Borale* wetlands were used for fuel wood (and construction) purposes, respectively. There were still other plant species used for medicinal purposes. About 32% of the households living in the surroundings of the study sites used some plant species for medicinal values (Table 8).

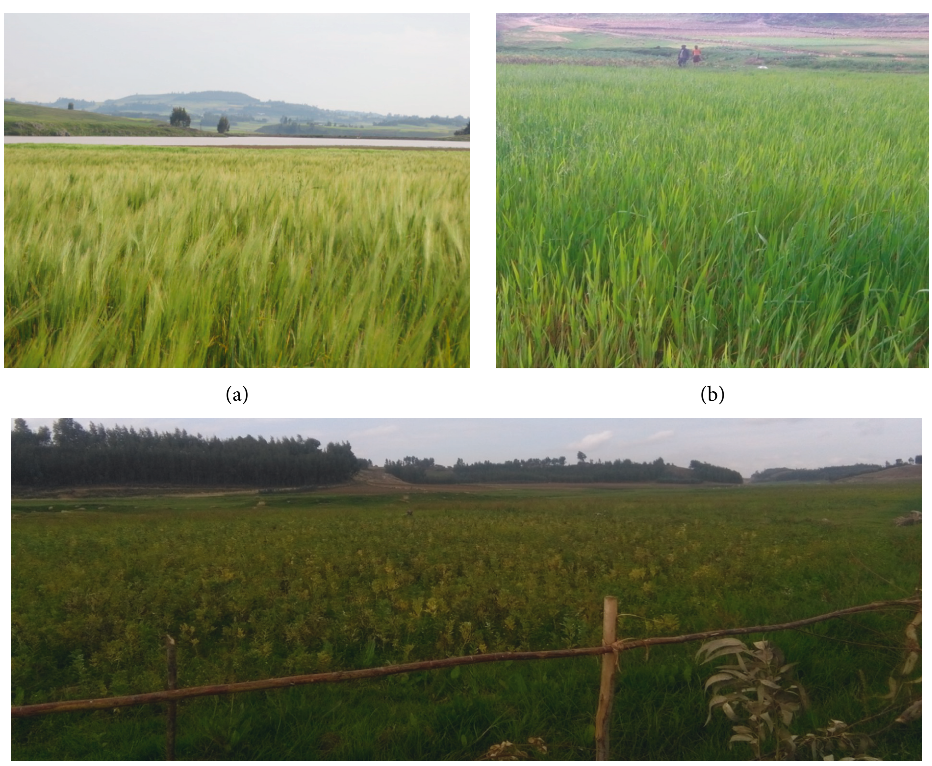
3.4.2. Cultural Services. As also reported by roughly 62%, 38%, and 34% of the households, the study area provided recreational, educational, and research services, respectively. While comparing the two studied wetlands, 97.8%, 56.5%, and 52.2% of the households replied that recreational, educational, and research services were provided by *Washa* site, respectively. Only 1% of the households reported that spiritual service was provided by *Washa*, but not from *Borale* Wetland.

3.4.3. Regulating Services. Both *Washa* and *Borale* wetlands provided regulating services, including water storing and continuous water flow, flood, sediment, and microclimate regulating (carbon sequestrating), water purification, and disease controlling services (Table 7).

3.4.4. Supporting Services. Biota conservation, namely, nursery and habitat services, were the main supporting services provided by the studied wetlands (Table 9). Plants

Table 8: Provisioning services provided by the study sites using the household survey.

Provisioning services	*Washa*		*Borale*		Total	
	n	%	*n*	%	*n*	%
Food provisioning services						
Vegetables	33	71.7	49	100	82	86.3
(i) Garlic	15	32.6	20	40.8	35	36.8
(ii) Potatoes	6	13	10	20.4	26	27.4
(iii) Carrots	10	21.7	15	30.6	25	26.3
(iv) Cabbage	2	4.3	4	8.2	6	6.3
Crops	18	39.1	36	73.5	54	56.8
(i) Bean	8	17.4	20	40.8	28	29.5
(ii) Barely	6	13	6	12.2	12	12.6
(iii) Shalom	2	4.3	3	6.1	5	5.3
(iv) Lentils (misir in local language)	2	4.3	7	14.3	9	9,5
Fruit	0	0	0	0	0	0
Fish	12	26.1	6	12.2	18	18.9
Honey harvesting (bee keeping)	0	0	0	0	0	0
Raw material provision						
Water for						
(i) Livestock drinking	46	100	49	100	95	100
(ii) Irrigation	33	71.7	49	100	82	86.3
(iii) Washing/cleaning	13	28.3	36	73.5	49	51.6
(iv) Human drinking	0	0	0	0	0	0
Grass for:						
(i) Fodder and grazing	45	97.8	49	100	94	98.9
(ii) Thatching	22	47.8	14	28.6	36	37.9
(iii) Crafting (house utensils, mattresses)	21	45.6	14	28.6	35	36.8
Fuel wood and construction materials	14	30.4	4	8.2	18	18.9
Medicinal plants	18	39.1	12	24.5	30	31.6



(a) (b) (c)

Figure 6: The crops, barley in *Washa* (a), and shalom and beans in *Borale* (b, c) under cultivation (Photos taken in May 2020).

Table 9: The relative importance of ESs provided by wetlands using the perception of all participants.

Main ESs provided by:	*Washa*	*Borale*
Provisioning services		
Food (crop, vegetation)	****	****
Fish	*	*
Water for livestock drinking	****	****
Water for irrigation	****	****
Water for domestic use (washing, cleansing)	**	**
Medicinal resources	***	***
Crafting materials	**	*
Honey and fruits	Nil	Nil
Fodder/grass provision	***	***
Grazing services	***	***
Regulating services		
Flood regulating	***	**
Maintaining water flow	***	**
Climate regulation	***	**
Water purification	***	**
Disease control	***	**
Pollution regulation	***	**
Cultural services		
Spiritual celebration	*	Nil
Recreation center	***	*
Educational visit	***	**
Research center	***	Nil
Supporting services		
Nursery site for plants and animals	***	**
Habitat for plants and animals	***	**

Note. nil refers to 'not sure', '*', very low, '**', low, '***', medium and '****', high importance.

like *Cyperus* species, *C. dactylon*, *M. repens*, and *A. abyssinica* were found in *Washa* Wetland (Figures 3(b)–3(d)). Likewise, *Cyperus* sp, *C. dactylon*, *M. repens*, *A. abyssinica, L. tomentosa,* and *A. Mexican*, besides wild animals (fish and many birds), were available in and around *Borale* wetland but less abundant, as assessed during the field survey and KI interviews. Moreover, *Cyperus elegantulus* Steud, *Cyperus brevifolius* (Rottb.) Hasskn, *Eleocharis marginulata* Hochst. ex Steud, *Commelina diffusa* Burm f., *Cyperus esculantus* L., *Eleusine floccifolia* (Forssk.) Sprimg, *Geranium dissectum* L. *Cynodon dactylon* L. Pres, and *Adropogon abyssinica* Fresen were common plants identified and conserved, among others, in the wetlands. Based on the calculation made using Sorenson Similarity index (J), the two wetlands were, therefore, similar by 0.71 or 71% in their plant composition.

3.5. The Relative Importance of ESs Provided. The provisioning of agricultural crops and vegetables and water for irrigation and cattle watering had higher importance than the other provisioning services provided by both wetlands. Still, these services mentioned here above had higher importance than the other ESs provided at the two sites (Table 9). Otherwise, almost all other provisioning services provided by both *Washa* and *Borale* wetlands had proportional/equal, ranging from very low (e.g., fish) to medium (e.g., fodder provision) importance. Yet, there was no fruit and honey production in both wetland sites (Table 9).

However, while comparing the regulating and cultural services between *Wash* and *Borale* wetlands, *Washa* mostly provided better (medium) regulating and cultural services than that of Borale's (Table 9). Even though the Borale Wetland had no importance in providing spiritual and research center services, *Washa* site had a very low service importance (Table 9).

3.6. The Perception of Local People and Stakeholders towards the Management of Wetlands. Regarding the experiences of the local people on SWC activities for the past 10 years, the households were asked as follows: "Was there an experience of SWC activities in the catchments of the artificial wetlands for restoring them?" The majority of them (67.4%) said 'Yes', while the remaining ones (32.6%) said 'No'. Almost all stakeholders were also reported as they were many experiences of SWC activities at catchment level for restoring of wetlands, despite not yet successful.

Moreover, concerning the future fate of the wetlands, approximately 74% and 90% of the households of *Washa* and *Borale* wetlands were interested in the artificial wetlands to be as they are "wetlands," respectively (Table 10). Still, about 22% and six percent of the households from *Washa* and *Borale* sites' communities were interested in them being "recreational center" and "forest land", respectively. However, about 2% and 2% of the households of *Washa* community preferred the wetlands to be "forest" and "grazing land", respectively. In the case of *Borale* Wetland, approximately 4% and 0% of the community preferred the artificial wetlands to be recreation centers and communal grazing land, respectively (Table 10).

Finally, the households and other respondents were also asked about their interest in restoring the artificial wetlands and/or their catchments in the future. The majority of them (on average, 87%) agreed to conserve them. Yet, some of the households did not have an interest in protecting the wetlands. Similarly, all KIs, stakeholders, and discussants of the FGD reported as they were interested in protecting/conserving them.

4. Discussion

4.1. Socioeconomic Condition of the Study Area. Of the total respondents for this study, the majority of them were males, which might be due to that males are mainly responsible for those activities done outside the home based on the culture of Ethiopian society. The average family size of the community of the study area, which was extended from one to nine per family, was 5.5. This family size is proportional to 4–6 family members of Amhara Regional State [10], resulting in high population growth. This population growth, in turn, could create high pressure on natural resources, i.e., intensive water consumption and encroachments towards wetlands for getting new settlements, farms, and grazing lands with their environmental unfriendly practices. Concerning age-wise, more than half (~55%) of

Table 10: What was your preference for the artificial wetlands to be in the future?

Alternative response	*Washa*		*Borale*		Total	
	n	%	n	%	n	%
To be forest land	1	2.2	3	6.1	4	4.2
To be grazing land	1	2.2	0	0	1	1.0
As they are (wetlands)	34	73.9	44	89.8	78	82.1
To be a recreational center	10	21.7	2	4.1	12	12.6
Total	46	100	49	100	95	100

the respondents were under the age category of 45–60 years old, followed by 30–45 years old, who are considered as active participants in the economy of the study area. The educational status of the respondents was also ranging from illiterate to grades 9–12, with those few holding their diplomas/degrees, of which the total literate group covered about 69%. This means the majority of the households could well write and read so that it could be simple to provide extension services of agriculture and health in the study area to improve their agricultural productivity and health standards.

Concerning the economic condition of the local people, almost all (~99%) had farmland, followed by grazing land (62.1%) and wetlands (51.6). This shows that farmland, grazing, and wetlands are the main natural properties of the study area communities. That is why the income sources (livelihoods) of the local communities in the study area were dominated by farming (66.3%) and livestock rearing (65.3%), i.e., mixed agriculture. This agricultural economic background was also found similar in the rural areas of sub-Saharan African countries, including Ethiopia. Besides this mixed agricultural income source, fuel wood collection (22.1%) and small trade (10.5%) were additional income source activities for the communities. This implies that the main livelihoods of the communities were aided by additional income source activities to support their subsistence life. This is because both farming and livestock rearing practices are traditional and so do not productive compared to the modern ones. This report agrees with the findings of Moges et al. [9] from southern Ethiopia and of Wondie [10] from northern Ethiopia, where the local people were also engaged in additional activities like pottery making, sand, and wetland grass retailing, and daily labor. As also evidenced by many articles, agriculture is the backbone of the Ethiopian economy, contributes 47.40% to the GDP [26], and shares 83% of employment [27].

Regarding the landholding size of the communities in the study area, about 76% of them had *small landholdings with ≤1 ha*; 21%, from 1.1 to 2 ha, and 1%, from 2.1–3 to 3.1–4 ha per head. These all show that although 99% of the households had farmland, the majority of them had very small land size (≤1 ha per family), resulting in less income. The current report is almost similar to the report of Di Falcon and Veronesi [7], and Moges et al. [9] about land size per family of Ethiopian farmers. Similarly, only 63.2% of the total households had grazing land of ≤1 ha size per head. Likewise, close to 52% of households had their own wetlands, but with the land size still ≤1 ha. These wetlands were, therefore, pressurized by the local communities through harvesting wetland plants for fodder, thatching, and crafting materials, and using them as grazing sites during the dry season, which all led to wetland degradation. The most horrible thing is also that 71%, 37%, 48%, and 1% of the households did not have any bushland, grazing land, wetlands, and farmland at all, respectively. This smallness of the land size and the absence of land at all enforce the local farmers for encroaching wetlands and/or bushland for getting additional farmland and grazing land (or for reducing their livestock number), despite illegal. Moreover, besides these human activities, the majority of the households had a large family size (5.5, on average), resulting in increasing the total population size. Thus, the land holding and population sizes are the major factors determining the agricultural sector's productivity and food security of the people.

As also reported during the FGD and KI interviews, smaller landholding situations were found to expose those small landholdings to repeated and intensive tillage, which resulted in depletion of nutrients, totally called land degradation. As a result, there was less agricultural production in amount and type, which aggravated the food insecurity of the communities. However, the agricultural sector is still playing a central role in poverty reduction and employment in Ethiopia [25, 27]. Thus, the need to improve the productivity of the agricultural sector is indisputable.

4.2. Anthropogenic Factors and Ecological Status of the Study Area. Based on the findings of the study, the two sites had almost similar artificial geographical and altitudinal settings. Additionally, human activities such as free grazing, grass harvesting, and farming within their catchments, wetland conversion, water extraction, and improper SWC activities were widely practiced in the present study area. These all are important factors leading to wetland degradation. Yet, the two wetlands were unlike in their severity of land degradation and adjacent urbanization. For instance, in *Washa* site, there was a buffer zone covered with grasses/vegetation up to 50 m radius, despite farming scarcely in between (Supplementary file 1e). Some parts of the catchment of this wetland were also left nontilled land. Yet, due to cattle intrusion for drinking and grazing in the catchment and buffer zone of *Washa* (Figure 3(e)), the water quality of *Washa*'s site was relatively poor than the *Borale*'s (Supplementary file 2). Contrarily, the farming activity in the catchment of *Borale* was intensive and extended to margins of the wetland, except being covered by small grazing and plantation parts in the north-east and south-east directions of the Wetland. Following this, there could be more silt loaded in *Borale* than *Washa* reservoirs. Moreover, there was more extensive wetland conversion into irrigated land at downstream of *Borale* (120 ha) than *Wahsa* (28 ha) wetlands. As a result, there was also more water extraction for irrigation from *Borale* than *Washa* wetlands. Those all, in turn, led to more degradation of the *Borale* Wetland, and its upper catchment, besides the higher water volume reduction in *Borale* than *Washa* wetlands. Many authors [9, 12], from Ethiopia and [5], from Brazil, also reported that the major factors speeding up the ecological changes in wetlands are anthropogenic activities that are continuously changing the land use in and around wetlands. Hence, the two study sites were different depending on the extent and severity of their habitat, vegetation, hydrological alterations; buffer and upper catchment landscapes; chemical stressors (Supplementary file 2). According to Campbell [28], the change of shape (landscape) and land sizes of wetlands are indicators of ecological degradation.

Accordingly, the total values of HDGSs of *Washa* and *Borale* sites were 67 and 80, which felled in the categories of mid- and most impacted wetlands, respectively. Similarly, many authors [9, 27, 29] also reported that overgrazing, agriculture, mining in and around agricultural impaired wetlands, and extraction of water for agricultural and domestic uses were the major threats to wetland degradation. According to Acreman et al. [30] and Campbell [28], changes in hydrology are the leading causes of wetland degradation. Thus, carrying out wetland inventories and assessing their extent of degradation [16] and ESs can be used to establish local or national priorities for restoration [1, 31].

4.3. The Main ESs. As revealed in the results of the study, the ESs provided by the study area were displayed and grouped into four categories as bolded hereunder.

4.3.1. Provisioning Services. The majority of the households (>86%) reported that carrots, potatoes, and garlic were the most vital agricultural vegetables produced from the irrigated land of the study sites. Thus, the farmers supplied and sold these vegetables to DBT community, thereby increasing their income for supporting their subsistence livelihoods. Besides, as reported during the FGD, when the productivity of vegetables in the irrigated land was reduced, the farmers began cultivating agricultural crops (or used crop rotation) to increase the soil fertility (locally called '*Meker*') and minimize the diseases damaging the vegetables, which could be made to grow in the next round of cultivation. Thus, roughly 57% of the households reported that agricultural crops such as beans, barley, and shalom were cultivated in the irrigated land of *Washa* and *Borale* sites (Figure 5). Moges and his colleagues [9] also reported as crops and vegetables were provided from wetlands. Remarkably, such crop rotation practices are commonly done by Ethiopian farmers in rural areas to restore the fertility of their farmlands and diminish the diseases found in the soil. Hence, wetlands largely contribute to the livelihoods of adjacent communities and can provide incentives for their engagement in wetlands conservation [32]. Regarding fish, it was rarely harvested and used by communities, although fishery was one of the main purposes of establishing those reservoirs. That is why only <20% of the households reported as fish was found and harvested in the study area: more fish (*Oreochromis niloticus* and *Labeobarbus Spp*) was harvested from *Washa* (26%) than *Borale* (12%) wetlands (*O. niloticus* sp.). As also made dialogues with focus group discussants and key informants, fish was seldom harvested and used by locals due to their being very small and quantity and lack of attention for fishery management from both the local people and government sides. Similar reports were made by Estifanos [33] and Moges et al. [9] from the southern lowlands and southwestern highlands of Ethiopia, respectively. However, the use of reservoirs for aquaculture is a common practice in many countries (e.g., [5], from Brazil; [6, 29], from Ethiopia). This is because fish is the main source of protein for over a billion people globally, and 80% of the global fishery production occurs in developing countries [1]. Concerning honey and fruits, all respondents reported that there were no honey and fruit harvesting done by local communities being supported by the studied wetland resources, which might be due to the absence of suitable trees used for hanging beehives, and fruit trees and the lack of attention of the local people towards these activities. Yet, despite minor apiculture and fruits are reported from other Ethiopian wetlands [9, 10, 33].

As the results revealed, more than 50% of the households reported that water was used for livestock watering, irrigation, and cleaning of clothes. As also reported during KI interviews, FGD, and field survey, water was one of the most raw materials provided from both wetlands and was mainly used for irrigation, livestock watering, and washing. This report also agrees with the findings of Gunkel et al. [5], who reported that the water delivered from the Itaparica reservoir in Brazil is abstracted mainly for irrigation (>50% of the total usage). According to Alexander and McInnes [1], wetlands play a vital role in the delivery of water resources to human populations, including irrigation, mining, and industry. However, for drinking, the local communities did not directly use water from the reservoirs; rather, there were small groundwater hand pumps and springs developed within and/or in the peripheries of the wetlands. That is why, no households reported the importance of water for human drink. These all imply that despite understanding the limitations of the local people, those wetlands are also the main sources of domestic water use at both household and community levels. Even for domestic uses, the whole community of DBT has obtained water from large groundwater reservoirs drawn from the surrounding wetlands of DBT. Kakuru and his colleagues [32] also reported as wetlands are the main sources of natural wells, springs, artificial dams, boreholes, and shallow wells, from which local communities draw water for their domestic use.

Different grass and other plant species growing in the studied wetlands were used for fodder and grazing, thatching, and making domestic tools, as reported by households. This finding is in line with Estifanos [33]. *Andropogen abyssinica* Steud, *Pennisetum thunbergii* Kunth, *Pennisetun sphacelatum* (Nees) Th. Dur. and Schinz, *E. floccifolia*, and *Medicago lupulina* L. were the plant species identified and mainly grown in both wetlands and mostly used for fodder and grazing purposes. There was also a report from Itaparica reservoir of Brazil [5] and from natural wetlands of Ethiopia [9, 10] that the use of plants for domestic use and animal feeding are possible. Some of the grasses such as *T. latifolia*, *E. floccifolia,* and *P. sphacelatum* were still used for crafting, i.e., making different house utensils such as locally called "*Sefed*", "*Agelgil*", and "*Lemat*" in Amharic, and other small materials used for house decoration, besides mattresses made from *T. latifolia*. Additionally, some plant species such as *Eucalyptus globules* Labill, *Juniperus procera* Hockst. ex Endl, and *Cupressus lustanica* Mill were grown in the catchments of the study area and were used for house construction, fuel wood, and farm tools, as reported during FGD.

Similarly, close to 32% of the households living nearby the study sites used some plant species for their medicinal value. This report agrees with Estifanos [33], Moges et al. [9], and Wondie [10]. As reported during FGD, KI interviews, household, and field surveys, commonly used medicinal plants included *Thymus schimperi* Ronniger, *Hagenia abyssinica* (Bruce) J.F. Gmel., *E. globules*, *Rumex nepalensis* Spreng, *Inula confertiflora* A. Rich., *Verbascum sinaiticum* Benth, *Vernonia amygdalina* Del., *Laggera tomentosa*, *Urtica simensis* Stedel., and *Echinops kebeircho*. Thus, local healers have used these medicinal plants for several years to treat various human and/or livestock diseases.

4.3.2. Cultural Services. As also reported by households, the study area provided recreational, educational, and research services. Other Ethiopian wetlands also provide such services despite varying in the extent of services provided [10, 33], while comparing the two study wetlands, the recreational, educational, and research services provided by *Washa* site were more than *Borale* Wetland's. However, little spiritual service was provided by *Washa, but not by Borale* Wetland. Surprisingly, the majority of the households (65.3%) living nearby *Borale* Wetland did not even recognize the cultural services being provided by *Borale* Wetland. As seen during the field survey, local young individuals and students from DBU visited the *Washa* Wetland in their weekends, particularly on Sundays (Supplementary file 1). Thus, *Washa* Wetland exceptionally provided recreational services to the surrounding communities.

4.3.3. Regulating Services. It was supposed that many households faced the problem of understanding the regulating and supporting services. Constanz et al. [8] also reported as it was difficult to perceive regulating services by individuals. Hence, the KIs and stakeholders were invited to respond to those services coupled with field visits. Hence, they reported that both wetlands provided water purification, carbon sequestration, pollination, flood, sediment, erosion, and disease regulating services (Supplementary file 3). Similar findings were also reported by many authors [10, 34, 36]. Despite supposing their limitations, it was amazing about the households' understanding relating to the regulating services of the wetlands since they faced practically the problems of flooding, continuous water flow, sedimentation, and drought before the creation of the wetlands. However, now they could minimize those challenges due to the presence of these artificial wetlands.

4.3.4. Supporting Services. The supporting services maintain the conditions for life on Earth [37] and are the basis for the production of all other ESs. Yet, the household respondents mainly focused on wetlands' breeding and habitat services. Consequently, they reported that plants such as *C. dactylon*, *M. repens*, *Cyperus* species, *A. abyssinica,* and others were found in both *Washa* and *Borale* wetlands with less coverage in *Borale* Wetland. This was because almost all the area of *Borale* Wetland's catchment (Figure 6) was totally converted into farmland. However, the downstream wetland of *Borale* site supported different aquatic plants such as *T. latifolia* and *Cyperus* species. Moreover, wild animals such as fish (*Oreochromis niloticus* and *Labeobarbus* sp.), macro-invertebrates, and various birds Blue winged goose, Egyptian goose, Spot breasted lapwing, White-collared pigeon, Wattled ibis, and White-collared pigeon) were found within and the buffer zone of *Washa* and *Borale* Wetlands (Supplementary file 1). That is why this category of supporting services was replaced by refugia or habitat ones to emphasize the importance of the ecosystem in providing habitat for fauna such as migratory birds [8 and flora as well. Thus, assessing wetland vegetation is a good indicator of ecological status [38]. As the results revealed, the commonly growing plant species in both artificial wetlands were dominant, and the Sorenson's similarity index was, therefore, high (71%). This might be due to the similarity of the wetlands in terms of their altitudinal and climatic conditions. Yet, in the reports made by Mulatu et al. [39] and Moges et al. [39] in the south and southwestern Ethiopia, the results of the similarity index among natural wetlands were very low or dissimilar.

4.4. The Relative Importance of the ESs. The relative importance of ESs was rated using repeated field visits, households, KIs, FGD, and stakeholders' perceptions after adopting the matrix of MA [34] and Moges et al. [9]. The relative importance of the ESs provided by the study wetlands varies depending upon the extent of the ecosystem degradation: the more the ecological degradation, the less the ESs provided. Hence, the provisioning of water for irrigation and livestock drinking, vegetables, and crops had high and even higher importance than the other provisioning services provided by the two sites, which might be due to the moisture guaranteed even during the dry season. Kakuru et al. [32] from Ugandan wetlands also reported that the yields from wetland crop farming were higher. Moreover, Das et al. [40] reported that the provisioning ESs was of the highest importance, followed by regulating ESs for Tribal communities of the Barind Region in India. Different kinds of vegetables were cultivated in the two irrigated sites, especially in the dry season, via drawing water from the artificial wetlands; thereby, they provided these vegetables to the urban people of DBT. The provisioning services of the study wetlands were the sources of medicinal plants, and fodder grasses, and the grazing area had medium and even proportional importance between the two sites. This might be because of the impairedness (devegetated) of the two sites. Contrarily, the fish, honey, and fruit provisions in the study area had very low and zero importance, respectively, which might be due to the smallness of the fish size and amount, lack of fish variety, absence of fruit and other trees used for beekeeping and lack of awareness and giving less attention from both the local people and government sides. The regulating services provided by *Washa* and *Borale* wetlands had medium and low importance, respectively, which might be related to the variation of the extent of the two wetlands' degradation. Similarly, the cultural services, namely, recreation, research, and educational services provided by *Washa* site, had *medium level* importance, whereas those same services provided by *Borale* site had at low, very low, and even at zero level importance. Still, no spiritual service was provided at all by *Borale*, except very low by *Washa*. This is because the *Washa* Wetland is endowed with a variety of natural attractions and is preferred by endemic birds [14], whereas the *Borale* site was highly impaired and less accessible. However, tourism benefits from such wetlands (1) if they get attention. Generally, in Ethiopia, there are no adequate cultural services, despite using wetlands for ecotourism activities [41]. Concerning supporting services, *Washa* Wetland provided better biota conservation services than *Borale* Wetland. This might be because *Washa* Wetland was relatively less impacted due to having a better buffer zone than *Borale* Wetland. This finding is in line with Moges et al. [9] and Wondie [10] from Ethiopia. Overall, based on the findings of the study, except for water and food provisioning services, many of the ESs provided at *Washa* and *Borale* sites were of medium and low level importance, respectively, due to their extent of variation of ecological disturbance. Beddoe and his colleagues [42] also confirmed as there have been losses of ESs due to their rapid natural ecosystem degradation since the second half of 20^{th} C.

4.5. The Respondents' Perceptions of the Management of Wetlands. Concerning the SWC activities, the majority of the households (67.4%) had an experience of SWC for the past 10 years in the study area. This indicates that the local communities of the study area had been performing the SWC activities in the catchments of the two wetlands. Besides observing in the field, the KIs, stakeholders, and members of FGD all agreed that there were various SWC activities done in the catchments such as soil and/or stone bunds, check dams, and tree plantings such as *S. susban*, *J. procera*, *C. lusitanica,* and *E. globules*. However, they reported that there were no maintenance and quality of these physical and biological activities implemented in their catchments. Thus, dismantled/damaged stone bunds and remnants of plants were observed in their catchment during our field visits.

Relating to the wetlands' future fate, while summing up, 82.1% of the total households of the two study sites had an interest in using them as they are "wetlands," followed by "recreation center" (12.6%). Similar interest was heard during the interview from stakeholders. Lastly, the majority of the households and other respondents agreed to restore the artificial wetlands and/or their catchments in the future. As observed during field visits and interviews, particularly the present irrigation users were highly interested in engaging themselves in protecting the study sites because the sites provided water and livestock drinking and fodder/grazing services, besides cultivating vegetables and crops using irrigation during the dry season. The present finding agrees with Wondie's [10] finding, who reported from the northwestern part of Ethiopia that many households are interested in participating in wetland conservation; however, Moges and his colleagues [9] from southwestern Ethiopia reported the reverse, as the community did not have an interest in conserving wetlands. This might be owing to a better awareness of the people living in the northern and central than the southern parts of the country in conserving wetlands, which in turn is due to the problem of shortage of rainfall (water) in the North and central parts of Ethiopia. This might also be due to the active involvement of NGOs and government's experts in training local people in the North and central parts of the country, despite the similarity in the scarcity of land with large family size at country level.

5. Conclusions

To sum up, the local communities of the studied *Washa* and *Borale* artificial wetlands relied mainly on mixed farming with small land size (≤1 ha) versus large family size, which led to sustenance livelihoods and scarcity of land. Those study sites were impaired at moderately and highly, respectively, mainly due to agricultural encroachment, overgrazing, seasonality, and water abstraction. The study sites delivered different ESs. Vegetables like carrots, potatoes, and garlic and crops like beans, barley, and shalom were cultivated in the irrigated land of the study sites as food provisioning services. Of the raw materials delivered, water was the most important one provided by those two wetlands and mostly used for irrigation and livestock watering. Moreover, grasses and other species like *T. latifolia*, *E. floccifolia,* and *P. sphacelatum* were harvested and used for fodder, thatching, and making house utensils locally called *Ageligil*, *Sefed* and *Lemat,* and mattress. Additionally, the wetlands provided recreational, educational, and research cultural services, despite minor. Furthermore, they provided water purification, carbon sequestration, pollination, flood, sediment, erosion, and disease regulating services. Additionally, they served as nursery and shelter sites for all fauna, including birds and other macroinvertebrates and flora. While comparing ESs, the provisioning services (food and water) were better than the other services provided by the study area. However, the overall ESs delivered by the study sites were less, even though it was much less and/or absent in the case of fish, apiculture, and highland fruit trees. This was because both study sites were impaired, resulting in a serious reduction of water volume, loss of biodiversity, and ecological degradation/water pollution due mainly to human factors. The respondents, however, had a positive interest in conserving wetlands in the future. The implication of all these, despite having good respondents' perception towards conserving the study sites, the present study wetlands, especially *Borale*, would totally disappear after some years unless an urgent management action is taken. Therefore, for restoring the studied wetlands, *in-situ* and *ex-situ* conservation approaches are recommended.

Data Availability

The data are included in supplementary files and the result section as well.

Disclosure

Finally, a preprint has been previously published [43].

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

The authors would like to thank Debre Berhan University for funding this research work. Furthermore, they extend their great appreciation to those who provided data being respondents for the study area. This study was funded by Debre Berhan University (Grant no. 386-03-01).

Supplementary Materials

Supplementary file 1: Photos illustrating weekend recreation (a, b), Earth dam dismantled, tower ruined (b), a preliminary survey made in September 2020 (c), fish taken out from the reservoir (d), and birds in and around *Washa*, and *Cyperus* sp, woodlot consisting of *Eucalyptus* and *Cupressus* trees and new settlement in the catchment (*e*) of *Washa* as well as common birds living in both *Washa* and *Borale* wetlands (f). Supplementary 2. Supplementary file 2: The average water quality parameters of the study area. Supplementary 3. Supplementary file 3: The main ESs delivered by the study wetlands. (*Supplementary Materials*)

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