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# Wetland Ecosystem: Plant Species Diversity, Services, Degradation Drivers, and Community Perception in Sinana District, Oromia Region, Southeast Ethiopia

**Kemalo Abdulmalik Boru*, Lalit Tukaram Ingale**† and Kassahun Mulatu Lemt*****
*Department of Natural Resource Management, College of Agriculture and Natural Resource, Madda Walabu University, Bale Robe, Oromia, Ethiopia
**Environmental Science Department, College of Agriculture and Natural Resource, Mizan Tepi University, Mizan, Southwest, Ethiopia
***Department of Natural Resource Management, College of Agriculture and Natural Resource, Mizan Tepi University, Mizan, Southwest, Ethiopia
†Corresponding author: Lalit Tukaram Ingale; lalit.ingale17@gmail.com

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## ABSTRACT

Wetlands are a vital source of biodiversity and ecosystem services. The study investigated the plant species diversity and assessed the perception of the ecosystem services of the area and drivers of wetland degradation in Sinana district, Southeast Ethiopia. Vegetation inventory, household surveys, focused group discussions, and key informant interviews were employed to gather information. A total of 45 sample plots laid along transacts were inventoried. A plot size of 5 m × 5 m (25 $m^2$) and 1 m × 1 m (1 $m^2$) nested within the major plot was used for shrubs and herbs, respectively. A total of 137 households were surveyed to collect socioeconomic data. The study identified 20 plant species belonging to 14 families. Family Cyperaceae was dominant within the studied wetland. The Shannon diversity (H=1.15) indicates that the wetland has low vegetation diversity with an uneven distribution (E=0.385) of vegetation. A total of 20 ecosystem services thought to be underprovisioning, regulating, and cultural services were identified. According to plaintiffs, major provision services are grazing livestock (77.4%), irrigation (76.6%), and harvesting of grass for fodder (68.6%). Important drivers of wetland degradation are a shortage of cropland (70.8%), lack of awareness (69.3%), upland land degradation (65.7%), and increasing population (62%). The main driver, a shortage of cropland, was the key driver, followed by a lack of awareness and upland land degradation. Therefore, the result heightened that the studied wetland is under serious degradation due to high human pressure associated with population growth and climate change. Thus, an appropriate wetland management strategy must be designed.

## INTRODUCTION

Wetlands are the ecosystems or units of the landscape that are found within the interface between land and water, which are either fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low water does not exceed six meters (Ramsar Convention Secretariat 2013). They are distributed everywhere around the globe and are estimated to cover approximately 6% of the worldwide land surface (Schuyt & Brander 2004), 4% of Africa (Lehner & Doll 2004, Zedler & Kercher 2005), and 2% of the total land mass of Ethiopia (Wondie 2010). The largest areas of wetlands are in Asia (32% of the worldwide area), North America (27%), Latin America, and the Caribbean (16%). Wetland areas in Europe (13%), Africa (10%), and Oceania (3%) are smaller (Davidson et al. 2018).

To date, no comprehensive documentation and studies of wetland characterizations have been made in Ethiopia. However, it is estimated that there are 58 major lakes and marshes and a total of 77 wetlands in Ethiopia, including lakes that cover a vicinity of 18,587 $km^2$, which is approximately 1.14% of the country's landmass (Karlsson 2015). Ethiopia is usually referred to as the water tower of Africa, with the whole annual volume of runoff water being approximately 110 billion cubic meters (USAID 2008). The wetlands of Ethiopia vary in attributes such as size, type, and location, and they represent a substantial microenvironment in many parts of the country (Endalew 2015). Various varieties of wetlands are found to exist in Ethiopia, including alpine formations and riverine, lacustrine, palustrine, and floodplain wetlands (Abebe & Geheb 2003), except coastal and marine-related wetlands and extensive swamp-forest complexes (Dixon & Wood 2001). Ethiopian wetlands will be broadly grouped into four major categories supported by ecological zones, hydrological functions, geomorphologic formations, and atmospheric conditions. These categories are interspersed to create four key biomes, which also designate the climate in Ethiopia. These biomes are the Afro-tropical highlands, the Somali Masai, Sudan, Guinea, and the Sahelian Transition Zone groups (Tilahun et al. 1996, Wonderfrash 2003, Bezabih & Mosissa 2017).

Ethiopia, having variable topography and altitudinal range from 126 m below sea level to 4,620 m above water level, may be a country endowed with rich wetland resources (Yimer & Mengistou 2009). In Ethiopia, the wetland ecosystem covers 58 different types of wetlands, which offer enormous socioeconomic and environmental values despite these being under severe pressure and degradation. Due to improper extraction of uses and misconceptions forwarded to wetlands, the health of the wetlands is uninterruptedly declining from time to time, and their existence is suspected within the near future (Gebresllassie et al. 2014).

## IMPORTANCE OF WETLAND ECOSYSTEMS

Ecologically, wetlands play critical ecosystem roles in biodiversity conservation, hydrological balance, and human welfare both through economic and sociocultural benefits (Ramsar 2007, Zeleke et al. 2015). The world's surface freshwater wetland is rich in species composition and is a habitat for over 40% of plant and animal species (Zedler & Kercher 2005). They are particularly important in Sub-Saharan African countries such as Ethiopia because they sustain agricultural livelihoods, mainly in areas with low or unpredictable rainfall and land scarcity where uplands have poor soil (Bezabih & Mosissa 2017, Menbere & Menbere 2018).

Wetlands offer natural resources and services to humankind. According to Hailu (2003), wetlands are used virtually by all households within the Western Wollaga and Illubabor zones in Ethiopia directly or indirectly. The most common uses are social/ceremonial reeds, medicinal plants, thatching reeds used for housing construction and granary roofing, domestic water supplies, dry season grazing land, water for livestock, and temporary crop-guarding huts of reeds, cultivation, and craft materials. The indirect uses of wetlands are because of their hydrological and ecological functions, which support various economic activities, life support systems, and human welfare. This includes groundwater recharge, flood control, nutrient cycling, erosion control, sediment traps, climate regulation, stream flow moderation, water filtration and purification, plant and fish products, biodiversity, wildlife habitat for nomadic wildlife, and pest control (Dugan 1990, McHugh et al. 2007).

Thus, understanding the standard of a wetland by measuring its biota is one of the direct tactics to preserve the biological diversity for extreme ecosystem service delivery (Fennessy et al. 2007). Information on plant species of a specific wetland is incredibly helpful for understanding wetland conditions and diagnosing the impacts of human interference on wetlands (Bijos et al. 2017, Woldemariam et al. 2018). It further helps in understanding appropriate ecological processes and developing suitable and sustainable conservation policies (Junk et al. 2013, Rosolen et al. 2015). Da Ponte et al. (2017) & Rahman et al. (2005) further stated that the community's perceptions of the importance of ecosystem services could make a valuable contribution toward successfully conserving natural resources such as wetlands protection and management.

## COMPOSITION AND DIVERSITY OF WETLAND PLANTS

Wetland disturbance reduces plant species composition and relative abundances and facilitates opportunistic plant species establishment (Zedler & Kercher 2005, Handa et al. 2012, Battisti et al. 2016). EWNRA (2008) identified 36 plant species belonging to 18 families; the Cyperaceae, Combretaceae, and Asteraceae families were the widespread families. This showed that the wetlands of the study area were rich in plant diversity; however, further management intervention was required to scale back disturbance and ensure sustainable biodiversity conservation.

Wetland vegetation varies from wetland to wetland in numerous ways. Consistent with Mulatu et al. (2014), among wetland plant species of uncultivated sites of south Bench district, 7 plant species were dominant within the plant community, with a relative abundance of over two percent. These plant species were *Leersia hexandra* (46.35%), *Cyperus latifolius* (23.79%), *Thelypteris confluens* (3.96%), *Phyllanthus boehmii* (3.73%), *Persicaria glabra* (2.71%), *Dissotis canescens* (2.58%) and *Achyranthes aspera* (2.09%). These 7 plant species accounted for 85.21% of the community, while the remaining 22 species had a relative abundance of 2%, which accounted for 14.79%. The results revealed that important species such as *Leersia hexandra* and *Cyprus latifolius* decreased significantly due to cultivation.

The dominant plant species of the Tana wetland of the Amhara region of Ethiopia were reported by Wondie (2018). In addition, it specifies that the collective plant community similarity index in the midst of wetlands was mostly low (20%). The explanations for the low average percentage similarity are due to low plant diversity in some urban and agriculture-impacted wetlands.

## DRIVERS OF WETLAND DEGRADATION

However, wetlands face a substantial threat due to human interaction, which indicates that approximately 50% of the world's wetlands have been lost since 1900 (Bezabih & Mosissa 2017, Hirpo 2018, Moges et al. 2018). Unregulated utilization of wetlands, including diversion of water for agricultural intensification, urbanization, dam construction, population pressures, food shortages, increased drainage and cultivation, and collection of sedges and reeds for roofing and housing, were identified as major drivers of wetland degradation in Ethiopia (Bezabih & Mosissa 2017, Menbere & Menbere 2018). Such drivers have resulted in wetland disturbances, degradation, and loss, which ultimately can cause the elimination of native plant species, encroachment of exotic species, and reduction of ecological and socioeconomic values of wetlands in Ethiopia (Collins 2005, Mulatu et al. 2014). Little awareness of the prominence of wetlands, or perhaps the prerequisite for their conservation and sustainable utilization, could be a delinquent in Ethiopia (Wondarfrash 2003).

The most common threats to wetlands are the results of a mixture of social, economic, and climatic factors, which have increased pressure on the natural resources in Ethiopian wetlands. Another constraint to the judicious use of African wetlands is the lack of knowledge by planners and natural resource managers of the advantages that they supply and the techniques by which they will be utilized in an exceedingly sustainable manner (Jogo & Hassan 2010). A large number of wetlands in Ethiopia are considered vulnerable zones; some are most exploited, mismanaged, and lose their regenerating capacity (Alemayehu 2006).

In 1999, the government increased its pressure on farmers to cultivate wetlands to make amends for more drought-induced food shortages (Dixon et al. 2008). Currently, wetland cultivation provides between 10 and 20% of the annual food needs of the region but will be as high as 100% during the summer months in some areas. Eucalyptus, banana, sugarcane, and Khat cultivation on the perimeters of wetlands and Teff cropping in wetlands have been identified as threats to the survival of those areas.

## CONSEQUENCES OF WETLAND DEGRADATION

The consequences of wetland loss and degradation in Ethiopia's alterations of the hydrological regime of wetlands have significant physico-chemical and biological, ecological, and socioeconomic implications at a wider scale (Roggeri 1995, OECD 1996). In Ethiopia, the implications of wetland loss and degradation are enormous as well as directly affecting the livelihood base of rural communities, decrease and extinction of wild flora and fauna, loss of natural soil nutrients and water reservoirs, and their subsequent benefits (Bezabih & Mosissa 2017, Menbere & Menbere 2018). They have affected various traditional occupations, socioeconomic conditions, and cultural activities (Kumsa 2015). The drainage of wetlands in Illubabor Zones, southwest Ethiopia, has led to a variety of ecological and economic problems (Wood 2003).

In Ethiopia, wetland management is not efficiently harmonized and lacks acceptable policy support. Due to the absence of workable institutional arrangements and wetland management policies, sustainable management of wetlands and capacity building do not seem to be strengthened. As a result, the sector suffers from a shortage of skilled manpower that is capable of disseminating the concept of wise use of wetlands (Birhan et al. 2015, Seid 2017).

Wetlands in southeastern Ethiopia, particularly in the Sinana district, are ecologically, socially, and environmentally crucial for the realm. The enormous direct and indirect consequences of wetland loss and degradation are observed in the Kedar wetland. However, empirical evidence on the plant species diversity and ecosystem services of the wetland, and therefore the drivers for wetland degradation within the region and Sinana district, is not available. Thus, the target of the study was to investigate plant species diversity and assess the perception of people on ecosystem services and drivers of wetland degradation within the Sinana District of the Bale Zone, Southeast Ethiopia. As a result, the study attempts to fill this gap by providing scientific information useful to style an efficient management plan vital for sustainable management of wetlands.

## MATERIALS AND METHODS

### Description of the Study Area

This study was conducted in Sinana district, in Bale zone Oromia regional state. It is located approximately 430 km southeast of the capital of Ethiopia (Fig.1). Geographically, the study district is identified with the placement between 6°29′ to 7°10′ N latitude and 39°28′ to 39°57′ E longitude. The full area of the district is approximately 1168 $km^2$. The district has 20 rural and 4 urban kebeles, a total of 24 kebeles.

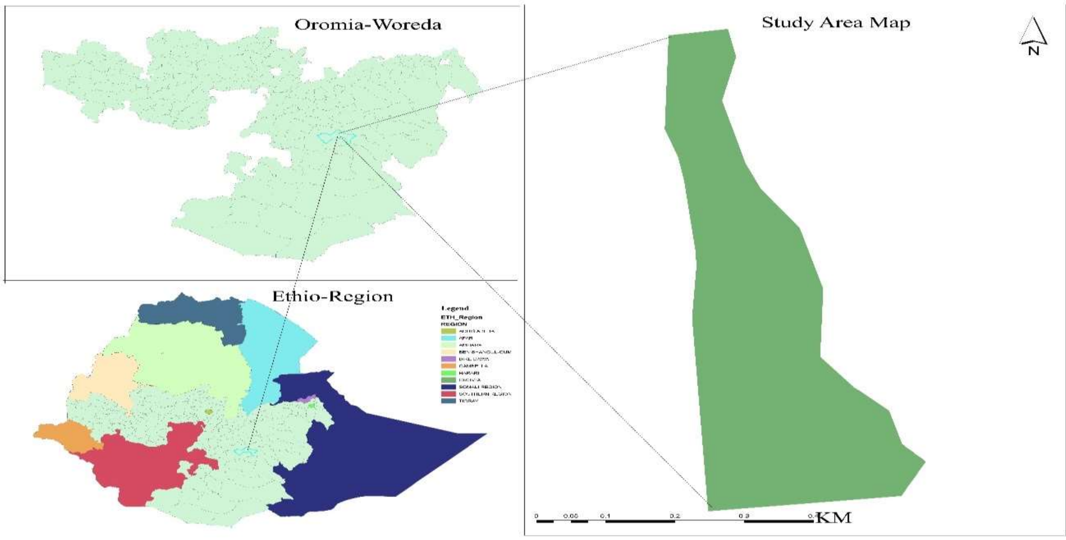


Fig. 1: Map of the study area.

The altitude of the district ranges from 1650 to 2950 m a.s.l. Of the entire area of the district, approximately 73.54% is plain land, 3.7% is hills, 9.6% is mountains, 12.3% is rugged, and 0.86% is gorge (Diriba & Kebede 2020).

The present study focused on the Kedar-Besaso wetland, which is one of the wetlands found within the Sinana district and has diverse ecological, economic, and environmental values within the area. It is located 9 km northeast of Robe town, the capital of the Bale Zone. The wetland covers approximately a region of approximately 30 ha and is found at longitudes 40°03′34″ and latitudes 07°08′24″. The elevation of the Kedar-Besaso wetland ranges from 2410 to 2420 m.a.s.l. The Kedar-Besaso wetland is an area made of land parcels owned by the community in common and individual agricultural tenure and used for grazing and drinking water by the community. The Kedar-Besaso wetland is categorized under swampy and freshwater wetlands fed by water sourced from perennial and seasonal water sources (Diriba & Kebede 2020). The annual average temperature is 16.5°C, whereas the minimum and maximum temperatures are 9°C and 23°C, respectively. The annual average rainfall is 1105mm, whereas the minimum and maximum rainfall are 1060 and 1150 mm, respectively (National Meteorological Agency of Ethiopia, 2012).

Farmers in this district experienced a mixed farming system of both livestock and major crops of wheat, barley, pulses, and oil crops. The rainfall pattern of the district is characterized by bimodal rainfall distribution. The district has two distinct seasons, i.e., autumn (belg), which extends from March to July, and summer (kiremt), which extends from August to January (Diriba & Kebede 2020). The presence of the Sinana Agricultural Research Center (SARC) and Oromia Seed Enterprise creates a decent opportunity for the farmers within the study area.

## Research Methods

**Site selection and household sample size:** Aimed at wetland vegetation inventory, Kedar-Besaso wetland was selected purposively as this wetland is incredibly large, likewise a highly threatened wetland due to high pressure associated with urban expansion, improper water diversion for irrigation from the wetland, and pressure due to agricultural use and overgrazing. In addition, supported discussions with district experts and a preliminary survey, the wetland could represent the opposite surrounding wetlands situation within the study area in terms of the amount of disturbance and diversity of wetland use. Additionally, for the wetland vegetation inventory, three kebeles (smallest administrative unit) bordering the wetlands were selected purposively to review the perception of the community on the ecosystem services of wetlands and drivers of wetland degradation. Thus, two rural (Besaso & Shalo) and one urban (Nano Robe) kebele were selected. The household heads of every kebele were 8,458 (4,144 males and 4,314 females) from Nano Robe, 5,844 (2,982 males and 2,862 females) from Besaso and

Table 1: Site selection and household sample size.

| Name of kebeles | Households (HH) | Sample size |
|---|---|---|
| Nano robe | 8458 | 63 |
| Besaso | 5844 | 43 |
| Shalo | 4114 | 31 |
| Total | 18416 | 137 |

4114 (3,754 males and 360 females) from Shalo, with a total of 18,416 household heads (Table 1).

The sample size was determined using the formula developed by Cochran (1977) at a 95% confidence interval as follows:

$$n = \frac{Nz^2pq}{d^2(N-1)+pqz^2} \quad \ldots(1)$$

$$= \frac{18{,}416(1.96)^2(0.1 * 0.9)}{0.05^2(18{,}416-1)+0.1 * 0.9(1.96)^2}$$

$$= 137$$

Where n = sample size of household, P = 0.1 (proportion of the population to be included within the sample, that is, 10%), q = is 1-P, that is, (0.9), d = is that the degree of accuracy desired (0.05), N = a total number of housing units, Z = standardized normal variable and its value that corresponds to 95% confidence interval equals 1.96.

However, the numbers of household heads from each kebele were determined proportionally and obtained 63, 43, and 31 from Nano Robe, Besaso, and Shalo, respectively. Moreover, three key informants (KI) per kebele and a joint focus group discussion (FGD) composed of 8-10 farmers per group were used for data collection.

### Data Collection

**Vegetation data collection:** A vegetation survey was conducted from August to September 2021 during the flowering season for many plants within the study area (Alemayehu & Solomon 2010). Before the vegetation inventory was conducted, wetland boundaries were delineated to the utmost extent of flooding or the sting of depressions to position transects and sampling plots. A transect-quadrant method was used to assess species composition (Shannon & Weiner 1949).

A vegetation inventory was conducted from the sampling plots lying along transects that were placed in the lower part of the wetland along the direction of water flow within the wetland. Sample plots of size five, 5 m × 5 m (25 $m^2$), and 1 m × 1 m (1 $m^2$) placed one in the middle, and four at each corner of the plot were used for shrubs/seedlings/sapling and herbaceous plants, respectively. Additionally, GPS readings and levels of disturbance were recorded for every main plot. A total of 45 sample plots lay along the transact and were inventoried. The gap between the transect line was 250 m, and between sampling, the plot was placed systematically at 100 m. Vegetation identification matching herbarium specimens and/or keying was completed using relevant flora identification texts, such as the Flora of Ethiopia and Eritrea (Hedberg et al. 2006). Vegetation samples were collected, pressed, and sent to the national capital, the University Herbarium, for added plant species identification, and further data were analyzed.

**Socioeconomic data collection:** The reconnaissance survey was dispensed to determine the practice of wetland resource use and other relevant information for designing data collection procedures.

**Household survey:** A household survey was carried out by employing a semi-structured questionnaire. The questionnaire was used to collect information on the background of respondents, the particular and potential use of wetlands, and drivers of wetland degradation. This household survey was conducted on 137 sample households permanently living within the area. The number of persons interviewed was 63, 43, and 31 in Nano robe, Besaso, and Shalo kebeles, respectively. We conducted the household interviews within the common language Afan Oromo, by translating the prepared questionnaire. An interview focused on each household's demographic and socioeconomic characteristics, perception of ecosystem services, and drivers of wetland degradation. Data were collected through questionnaires, and oral interviews were administered in August 2021 by three enumerators. The enumerators were knowledgeable and could speak, write, and browse both native and English languages. Additionally, the principal investigator provided the orientation and relevant information on a way to collect data and interrogate during the interviews.

**Focus group discussion (FGD):** The focus group discussion was steered in each kebele with a community representative consisting of 8-10 participants in each group. FGD was carried out to triangulate the information collected during the household survey and gain additional information, such as perceptions of respondents with reference to ecosystem service and drivers of change of the wetland, employing a guiding checklist.

**Key informant interviews:** The key informants consisted of representatives of relevant managers and agricultural extension of the village and natural resources management experts of the district. They were selected based on their knowledge of the wetland resources and people's dependency on and involvement in the management of the wetland. They were consulted to identify ecosystem services of the wetland, drivers of wetland degradation, and the history of wetland use and degradation. The key questions that were asked during interviews focused on the community's perceptions of ecosystem service and drivers of change within the wetland.

### Data Analysis

**Vegetation data analysis:** Vegetation data were analyzed and summarized using diversity indices such as species richness, Shannon and Wiener diversity (H'), and evenness (E). Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they consider the relative abundances of various species and supply important information about the rarity and commonness of species in a community (Mueller-Dombis & Ellenberg 1974).

**Shannon and Wiener diversity index (H'):** Shannon & Wiener's (1949) index of species diversity was applied to quantify species diversity and richness. It is one of the foremost widely used methods in measuring the diversity of species and richness. The Shannon diversity index (H') was used to determine species diversity (Kent & Coker 1992) as follows:

$$H' = -\sum_{i=1}^{s} P_i \ln P_i \qquad \ldots(2)$$

Where H' is the Shannon and Wiener diversity index, S = total number of species within the sample, $P_i$ = is the proportion of individuals of species, i = the proportion of total cover within the sample, and Ln = natural logarithm.

**Evenness (E):** Evenness or equitability was accustomed to quantifying the unique representation of a given species against a hypothetical community within which all species are equally common. The value of the evenness index falls between 0 and 1. The upper value of the evenness index indicates that the species were more evenly distributed within the given area of the study (Kent & Coker 1992). The evenness index was calculated using the formula:

$$J = \frac{H'}{\ln S} \qquad \ldots(3)$$

Where J = evenness, H' = Shannon-Wiener diversity index, S = total number of species within the sample, and ln = natural logarithm

**Socioeconomic data analysis:** Quantitative data obtained from interviews of households were first coded, categorized, and analyzed using descriptive analysis such as frequency analysis with Statistical Package for Social Sciences (SPSS) version 25 software. Data from the FGD and key informant interviews were summarized in narrative form. Ranking the drivers of wetland degradation perceived by respondents was computed with the principle of weighted average using the ranking index adopted by the previous researcher (Musa et al. 2006, Solomon et al. 2018) as follows:

$$\text{Index} = \frac{R_n C_1 + R_{n-1} C_2 + \cdots + R_1 C_n}{\sum (R_n C_1 + R_{n-1} C_2 + \cdots + R_1 C_n)} \qquad \ldots(4)$$

Where: $R_n$ = value given for the least ranked level (for example, if the least rank is $5^{th}$, then $R_n = 5$, $R_{n-1} = 4$, $R_1 = 1$, $C_n$ = counts of the least ranked level (in the above example, the count of the $5^{th}$ rank = Cn, and the count of the $1^{st}$ rank = $C_1$. In addition, ranking methods were used to identify the dependence of households on wetland ecosystem services.

## RESULTS

### Vegetation Composition of the Wetland

A total of 20 herbaceous and grass plant species belonging to 14 families were identified in the studied wetland (Table 2). From a study site, the family Polygonaceae consists of three species, contributing 15%, followed by Cyperaceae, Apiaceae, Commelinaceae, and Asteraceae, each consisting of 2 species and comprising 40% of the study area plant species, while the remaining nine families, each had only 1 species each and covered 45% of the species composition.

### Diversity of the Vegetation

The overall Shannon diversity (H') of the wetland was 1.15. According to Giliba et al. (2011), a diversity index value below 1.5 is low. Analysis was conducted by counting the abundance of every species. Thus, the studied wetland had low species diversity. This might have resulted from the high impact on the wetland due to agricultural expansion, overgrazing, irrigation water use, and urban waste disposal.

Table 2: Complete list of all identified plant species from the Kedar wetland.

| Family Name | Name of species | Number of species | % Total |
|---|---|---|---|
| Polygonaceae | *Persicaria decipiens*<br>*Persicaria glabra*<br>*Rumex nepalensis* | 3 | 15 |
| Caryophyllaceae | *Drymaria cordata* | 1 | 5 |
| Apiaceae | *Cenetella asiatica*<br>*Oenanthe palustris* | 2 | 10 |
| Commelinaceae | *Commelina forskalaei*<br>*Commelina latifolia* | 2 | 10 |
| Asteraceae | *Galinsoga quadriradiata*<br>*Ageratum conyzoides* | 2 | 10 |
| Convolvulaceae | *Ipomoea cordofana* | 1 | 5 |
| Cyperaceae | *Cyperus flavescent*<br>*Cyperus aterrimu* | 2 | 10 |
| Labiatae | *Ajuga decumbence* | 1 | 5 |
| Poaceae | *Cynodon dactylon* | 1 | 5 |
| Onagraceae | *Ludwigia abyssinica* | 1 | 5 |
| Araliaceae | *Hydrocotyle umbellata* | 1 | 5 |
| Typhaceae | *Typha latifolia* | 1 | 5 |
| Araceae | *Colocasia esculenta* | 1 | 5 |
| Linderniaceae | *Lindernia rotundata* | 1 | 5 |
| Total | | 20 | 100% |

The most frequent plant species within the studied wetland were *Typha latifolia*, *Commelina forsicalia*, *Cyperus aterrimu*, *Cyperus flavescent*, and *Colocasia esculenta*. Of the 48 plant species, 13 species, *Commelina forskalaei* (15.6%), *Leersia hexandra* (12.96%), *Digitaria sanguinalis* (12%), *Oplismenus spp*. (9.71%), *Digitaria temate* (8.02%), *Cyperus assimilis* (3.54%), *Phyllantus boehmii* (3.3%), *Rumex abyssinicus* (2.89%), *Cenetella asiatica* (2.6%), *Eragrostis ciliaris* (2.59%), *Achyranthes aspera* (2.44%), *Snowdenia polystachya* (2.16%) and *Polygala petitiana* (2.11%) with relative abundances over 2% accounted for 79.92% of the plant community in cultivated sites, of which 56.61% were upland plant species. On the other hand, wetland plant species such as *Thelypteris confluence*, *Cyperus mundtii*, *Leucas deflexa*, *Cyperus flavescens*, *Cyperus elegantulus*, *Sesbania dummeri*, *Fimbristylis dichotoma*, *Plectranthus argentatus*, *Aeschynomene schimperi*, *Sacciolepis rigens,* and *Triumfetta rhomboidea* species were not observed in the cultivated site.

Table 3: Characteristics of the respondents.

| Variable | Category | Response rate | |
|---|---|---|---|
| | | Number | Percentage [%] |
| Sex | Male | 91 | 66.4 |
| | Female | 46 | 33.6 |
| Age | 20-29 | 38 | 27.7 |
| | 30-39 | 35 | 25.5 |
| | 40-49 | 33 | 24.1 |
| | 50-59 | 18 | 13.1 |
| | Above 60 | 13 | 9.5 |
| Marital status | Single | 34 | 24.8 |
| | Married | 103 | 75.2 |
| Level of education | None | 6 | 4.4 |
| | Primary | 70 | 51.1 |
| | Secondary | 42 | 30.7 |
| | Tertiary & Higher | 19 | 13.9 |
| Religion | Islamic | 90 | 65.7 |
| | Christian | 47 | 34.3 |
| Occupation | Government employed | 25 | 18.2 |
| | Farmers | 74 | 54 |
| | Merchants | 38 | 27.7 |
| Number of cattle | <5 cattle's | 30 | 21.9 |
| | 5-10 cattle | 42 | 30.7 |
| | >10 cattle's | 65 | 47.4 |
| Size of farmland | <0.05 hectares | 63 | 46 |
| | <1hectares | 50 | 36.5 |
| | >2 hectares | 24 | 17.5 |
| Residence year | <5 years | 14 | 10.2 |
| | 5-10 years | 53 | 38.7 |
| | >10 years | 70 | 51.1 |

## Community Perception of Ecosystem Services of the Wetland

**Characteristics of the respondents:** The results from Table 3 revealed that the majority (66.4%) of the respondents were male, and the remaining respondents were female. Regarding the age group, 27.7% of the respondents were aged between 20-29, followed by 30-39 (25.5%) and 40-49 (24.1%). The farmland size indicated that 46% had less than 0.05 ha of farm size, while 36.5% had less than 1 ha, and 17.5% had greater than 2 ha.

**Perception of ecosystem services of the wetland:** The study assessed the ecosystem services of a wetland, considering the actual and potential benefits through household surveys, FGDs, and key informant interviews. A total of 21 key ecosystem services categorized into provisioning, regulating, and cultural services were identified for the study area.

**Provisioning service of the wetland:** The most important provisioning services of the wetland are grazing, food through agriculture, fodder, and grass for various services, and water. The results also showed that the majority (77.4%) of the community used wetlands for grazing, followed by irrigation (76.6%), grasses for fodder (68.6%), and water for drinking livestock (48.2%) (Fig. 2). Communities produce different crops, vegetables, and fruits within the wetland and the surrounding upland during the dry season using water from wetlands as small-scale irrigation to secure household food needs and generate income.

*Cyperus* spp., locally called *Cheffe* (Afan Oromo), is usually used for roofing or thatching and adornment during holiday celebrations and regular coffee ceremonies. Approximately 56.2% of the households reported that they used *Cheffe* to form ornamental crafts, and 48.9% of them used a variety of wetland plant species as traditional medicines. FGD and key informants identified the foremost commonly used medicinal plants, including *Commelina latifolia*, *Ageratum conyzoides*, *Persicaria decipiens*, *Ludwigia abyssinica*, *Colocasia esculenta*, *Vernonia sp*., *Oenanthe palustris*, and *Lindernia rotundata*. For example, many sedges or *Cyperus* species are utilized in traditional medicines for the treatment of various diseases, e.g., stomach ache and bowel disorders, amenorrhea, bronchitis, tumors, communicable disease, pain and fever, diabetes, skin diseases, problems concerning the circulation of blood and reproductive organs (Mueller-Dombis & Ellenberg 1974).

**Regulation service of the wetland:** Regulating services were also important services perceived by respondents.

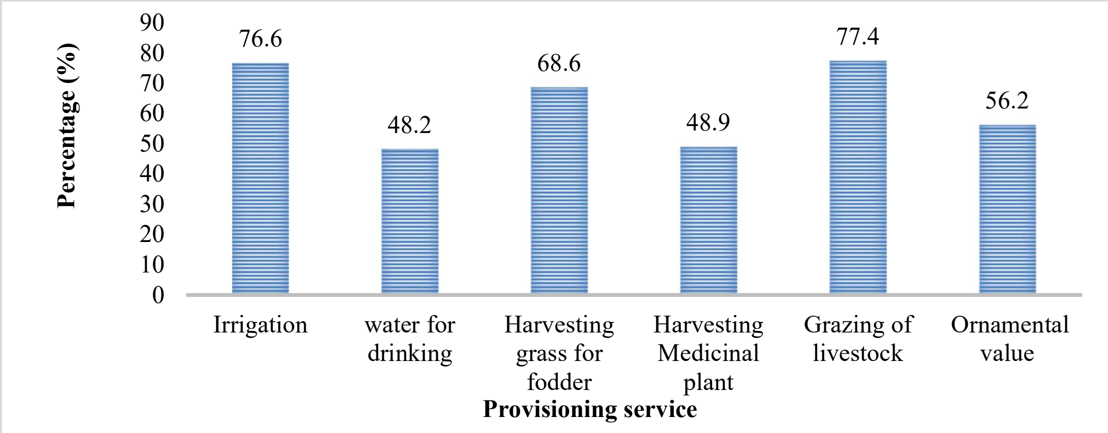


Fig. 2: Provisioning service within the studied wetland.

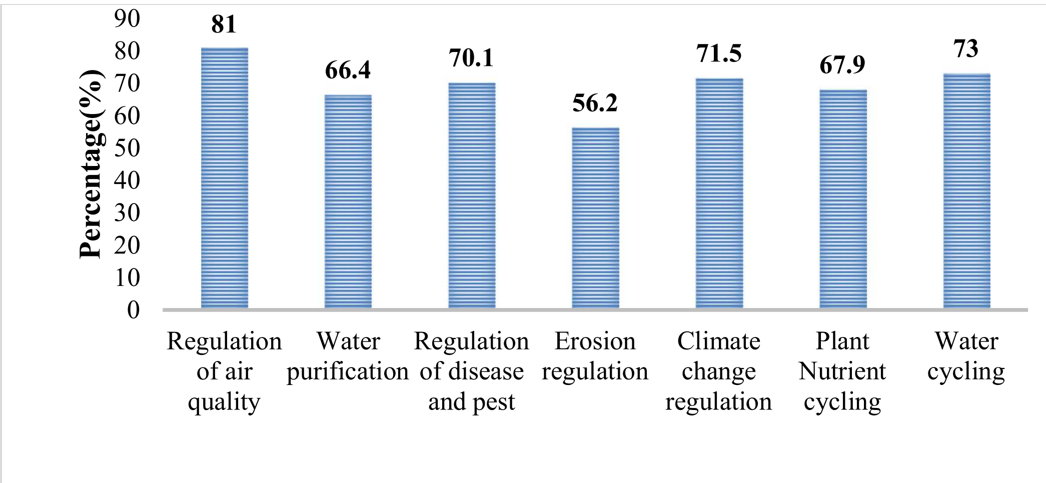


Fig. 3: Perception of the regulation services of the wetland.

Of the overall respondents, 81% believe that wetlands are important to controlling the air quality and condition of the encompassing area (Fig. 3). Seventy-three percent of them also believe that wetlands provide water cycling services, and 71.5% of them believe in climate change regulation. From households, 70.1% revealed that wetlands had served as a regulation of disease and pests.

The study respondents (66%) also believed that wetlands provide important regulation services in purifying water, followed by regulating soil erosion by 56%. Approximately 71% of households believed that wetlands could control the microclimate of the encircling area.

**Cultural service of the wetland:** Among the identified cultural ecosystem services, the aesthetic value was perceived by 81% of the households, followed by a sense of places and education and knowledge (77.4%) (Fig. 4). Educational and scientific value is also gained by appreciating natural biological processes in unimpacted environments. They also identified recreational values (76%), followed by cultural practice (74.5%). According to KIs Oromo, people had the tradition of celebrating *Erecha* within this wetland. Approximately 72% believed wetlands are the cultural heritage of their ancestors. During the FGD, they explained that cultural services, especially those associated with traditional ceremonies, were more important than other services.

**Perceptions of drivers of wetland degradation:** The respondents identify five important drivers of wetland degradation within the studied area: agricultural activity, shortage of cropland, lack of awareness, climate change, upland land degradation, and increasing population number. Among the identified drivers, shortage of cropland (70.8%)

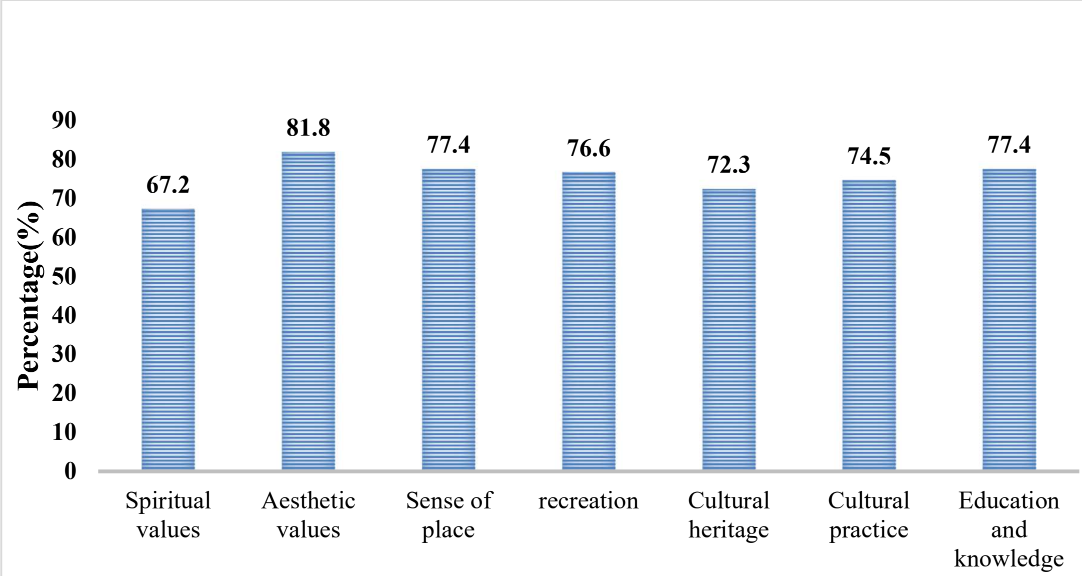


Fig. 4: Cultural service of the wetland.

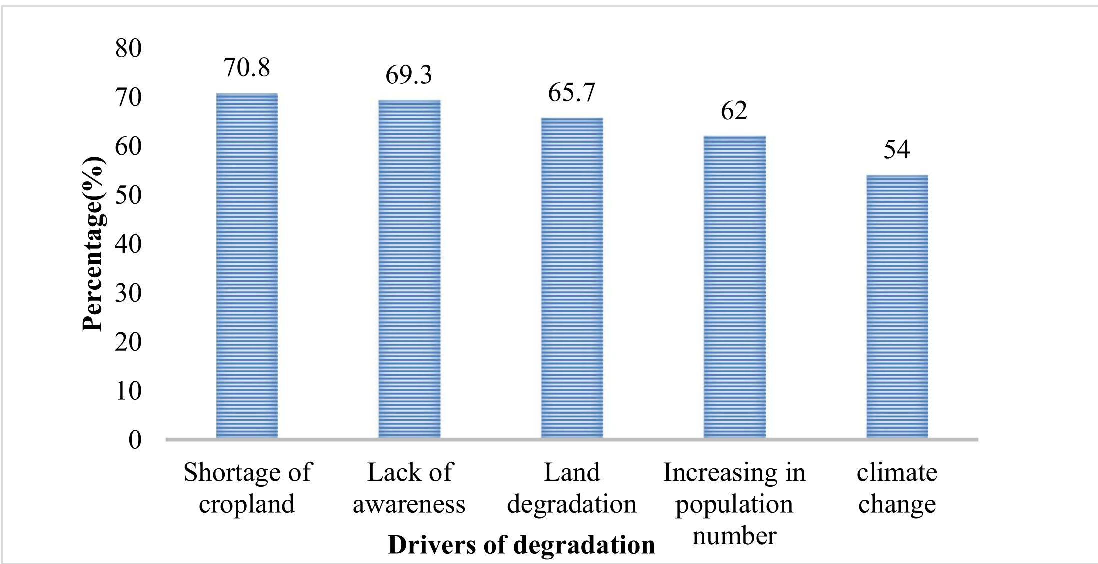


Fig. 5: Community perceptions of drivers of wetland degradation.

and lack of awareness (69.3%) were recognized as the major causes of wetland degradation, followed by upland land degradation (65.7%), increasing population (62%) and temperature change as causes of wetland degradation were perceived by 54% of the respondents (Fig. 5).

Lack of awareness that contributes to its share of wetland degradation within the study area: 69% of respondents believed it was a vital cause of wetland degradation. During the FGD and KI interviews, they mentioned that wetland management strategies practiced to date were not participatory and not integrated with awareness creation. Wetlands are taken as protected areas instead of using wetlands in a sustainable way (wise use strategy); therefore, the approach was not a win-win. Key informants also mentioned that the lack of a clear policy on wetlands is a crucial factor in wetland degradation. In some parts, wetlands are considered common land where no clear ownership is set; thus, their use is uncontrollable.

The present study respondents (62%) perceived that population growth is additionally a very important driver of

Table 4: Ranking of drivers of wetland degradation.

| Drivers | Rank | | | | | Weight | Percent | Rank |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | |
| Shortage of cropland | 75 | 20 | 15 | 0 | 1 | 501 | 18.5 | 1 |
| Lack of awareness | 70 | 26 | 10 | 1 | 1 | 487 | 18.0 | 2 |
| Land degradation | 35 | 40 | 0 | 2 | 0 | 339 | 12.5 | 5 |
| Population growth | 64 | 12 | 9 | 15 | 2 | 427 | 15.7 | 3 |
| Climate change | 52 | 8 | 11 | 9 | 3 | 346 | 12.8 | 4 |

wetland degradation. According to the FGD, a shortage of lands for cultivation and grazing resulting from population growth directly increases the encroachment of the wetlands within the study area. They also mentioned that the conversion of grazing land-associated populations pushed them to search out grazing land within the wetlands. Restless upland cultivation to secure food for growing people and its cultivation without proper soil and water conservation increased soil erosion and siltation in wetlands, thereby endangering their ecological processes.

In the study area, 54% of households perceived global climate change as the driver of wetland degradation. The FGD identified that climate effects such as a shortage of rainfall, drought, changes within the length of the wet season, and lengthening within the dry period pushed the use of wetlands to avoid crop failure and death of cattle and their products. They also explained that they were captivated by the irrigation activity of crop production in wetlands during drought years.

Farmers also ranked the drivers of wetlands. The results from Table 4 revealed that a shortage of cropland is ranked first, followed by a lack of awareness. Both drivers are interlinked so that a farmer living around the studied wetland, as well as the neighboring areas, is forced to degrade the wetland to obtain additional croplands, generate income, and maintain their livelihoods.

## DISCUSSION

In the present study, the plant families described from the studied wetland conform to the general pattern discussed for wetlands in other wetland areas in Ethiopia (EWNRA 2008). This finding agrees with Unbushe (2013), who described that the bulk of plant species within the wetlands of the Dabush swamp and other areas comprise Cyperaceae, Asteraceae, Onagraceae, Fabaceae, and Poaceae. However, in terms of dominancy, our results are different from those of Unbushe (2013), who found the highest number of species in the Poaceae family, while the findings of our study showed the highest number of species recorded within the family Polygonaceae. The variation is also because of the effect of agroecological differences and the level of wetland disturbance and degradation of vegetation. The findings during this work also showed that 55% of plant species were herbaceous, identical to the findings of Unbushe (2013), who found the dominance of herbaceous plants in wetlands.

Contrary to the present study, a study conducted by Mulatu et al. (2014) indicated that wetlands fraught with cultivation had more diversity than uncultivated (undisturbed) wetlands. Thus, the cause for low species diversity can be both the agroecological and wetland disturbance effects. The value of evenness (J) within the study area was 0.385. This implies that the distribution of wetland plant species was uneven because there was the dominance of some species within the studied wetland. This indicated that the wetlands were poor in plant diversity.

The species *Ageratum conyzoides*, *Commelina forsicalia*, and *Galinsoga* are typical upland weed species (Alvarez et al. 2012) that are present within the studied wetland, indicating that the wetland is changing its nature or degrading. A study conducted by Alvarez et al. (2012) and Mulatu et al. (2014) found that wetland drainage for the cultivation of wetlands promoted the invasion of upland weed species. Additionally, the species *Cyperus flavescent*, *Cyperus atterrimus*, and *Ludwigia abyssinica* were invasive, representing good indicators of impaired wetlands, and are common upland weeds in Eastern Africa (Alvarez et al. 2012). The presence of native wetland plant species such as *Cyperus flavescent*, *Cyperus atterrimus*, and *Ludwigia abyssinica* within the undisturbed part of the studied wetland indicated that part is under good wetland conditions (Gichuki et al. 2001, Mulatu et al. 2014).

Provisioning services are material benefits such as food, water, and other goods people directly obtain from the ecosystem (Millennium Ecosystem Assessment-MEA 2005). The dependence of humans on provisioning services is widely acknowledged, especially in developing countries, as people are highly dependent on natural resources (Bhatta et al. 2015, Oort et al. 2015). Communities produce different crops, vegetables, and fruits within the wetland and the surrounding upland during the dry season using water from wetlands as small-scale irrigation to secure household food needs and generate income. Similar results were reported that rural communities in different parts of Ethiopia (Mulatu et al. 2014) and other parts of the planet (Hartel et al. 2014) used wetlands for dry-season agriculture.

Other studies revealed that wetlands have provided various services for several Ethiopian communities for hundreds of years. As an example, farmers in wetland areas drain wetlands for agricultural purposes, including the growth of crops, vegetables, and fruits (Hailu 2007, Mulatu et al. 2014). Such practices are common in many parts of the globe because wetlands with extensive agriculture but without fertilizer, herbicide, or pesticide application often provide additional services to food production, such as flood regulation and maintenance of water quality or biodiversity (Verhoeven & Setter 2009). Educational and scientific value is also gained by appreciating natural biological processes in unimpacted environments (Turpie et al. 2010).

The International Water Management Institute (2006) also reported that over 65% of residents within the Bumbwisudi wetland in Zanzibar used wetlands for irrigation for agriculture to support their livelihoods. The government of Ethiopia emphasizes small-scale irrigation practices to reinforce food security within the country (Awulachew et al. 2007). Experts from the Sinana district agriculture office also reported that the authorities were encouraging the cultivation of wetlands to fulfill food self-sufficiency targets. This can be similar to other Eastern African countries such as Rwanda (Gowa 2009) and Kenya (Gichuki et al. 2001), where the governments of the countries supported the transformation of wetlands for food production to mitigate food insecurity and improve the livelihoods of rural communities. Approximately 71% of households believed that wetlands could control the microclimate of the encircling area. The Ramsar Convention Secretariat (2006, 2007) also stated that wetlands could stabilize the climate, particularly patterns of temperature and rainfall, which are the first components of global climate change. Some studies (Hailu 2003, Hailu 2007, Ambelu et al. 2013) also supported the result by reporting that rural communities perceived appreciation for cultural services and regulating and supporting ecosystem services. This might be because regulating and supporting services seem to be more abstract and intangible than cultural services.

During the FGD, they explained that cultural services, especially those associated with traditional ceremonies, were more important than other services. A similar finding supported this result that wetlands are important in providing cultural services, including spiritual and aesthetic value to people (Turpie et al. 2010). A study conducted by Kindu et al. (2015) supported this, reporting that population growth, agricultural activity, shortage of cropland, and lack of awareness were the highest significant drivers of land degradation of wetlands within the Munessa-Shashemene, south-central highlands of Ethiopia.

Similarly, the expansion of crop production based on irrigation in and around the wetlands was a serious threat to the wetlands within the basin of Hawassa & Ziway wetlands through the employment of varied agrochemicals (pesticides, herbicides, fungicides, and fertilizers) to the nearby wetlands and terrestrial areas, which might be easily drained to wetlands and degrade the wetland (Hengsdijk et al. 2008).

Similar results were reported by Noriko et al. (2012), indicating that a shortage of cropland alone caused 73% of all wetland degradation in developing countries. Jogo & Hassan (2010) also suggested that improper use and waste discharge could potentially degrade wetlands and undermine their capacity to supply services in the future. In Ethiopia, the lack of a comprehensive wetlands policy and implementing the law, plus the absence of an establishment duly empowered to issue and implement wetland laws and coordinate management activities, is the underlying reason for the deterioration of the wetlands (Gebresllassie et al. 2014).

Rapid population growth is the fundamental cause of increased pressure on wetlands through on-site and off-site effects (Mequanent & Sisay 2015). Such impacts were serious in densely populated highlands of Ethiopia, such as around the shores of Lake Tana and a few of the valleys (Mequanent & Sisay 2015). Previous studies in other parts of the country also reported that population pressure is the major driver of wetland degradation (Hurni et al. 2005, Dessie & Kleman 2007, Kidane et al. 2012). This can be a typical survival strategy of rural populations during the events of degradation, drought, and rainfall variability across Africa (Campbell 1990).

## CONCLUSIONS

Wetlands are a very important source of biodiversity and ecosystem services. The study identifies 20 plant species belonging to 14 families. Family Cyperaceae was dominant within the studied wetland. The overall Shannon diversity (H=1.15) indicates that the wetland has low vegetation diversity with an uneven distribution (E=0.385). The cause for the low diversity of vegetation is also the disturbances within the wetland and, thus, the agroecological effect within the world.

A total of 20 ecosystem services categorized under-provisioning, regulating, and cultural were identified. Among those major services are grazing livestock (77.4%), regulation of air quality (81%), and aesthetic value (81.8%) near the wetland. The important drivers of the wetlands are a shortage of cropland (70.8%), lack of awareness (69.3%), upland land degradation (65.7%), and increasing population (62%). Among the foremost important drivers, the shortage of cropland was a key driver, followed by an absence of awareness and upland land degradation.

Therefore, the results illustrate that the studied wetland is degraded due to high human pressure associated with growth and global climate change. An appropriate wetland management strategy must be designed with awareness creation on wetland use, and community participation in wetland management should be implemented. Increasing the productivity of upland cropland through different mechanisms should be implemented to reduce the pressure on wetlands. Wetlands should be restored and rehabilitated whenever possible and can be conserved by ensuring their wise use. Further study on the impacts of wetland degradation is significant to supply scientific information for the conservation and sustainable use of wetland resources.

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## ORCID DETAILS OF THE AUTHORS

Lalit Tukaram Ingale: https://orcid.org/0000-0003-0407-6064