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The roles of Chemoga Wetland Plane and Determinants of Its Management Practices in Northwest Ethiopia

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Abstract

Wetlands are vital for providing essential ecosystem services and supporting biodiversity. Despite their ecological significance, they face numerous threats from human activities. Therefore, this study aimed to explore the roles of the Chemoga Wetland Plane and the determinants of its management practices in Northwest Ethiopia. Using purposive sampling, four rural kebeles: Chemboard, Enerata,Yegagina, and Yenebrna located near this wetland were selected. Subsequently, 78 households were chosen through a simple random sampling method. Data were collected through household surveys, focus group discussions, key informant interviews, and field observations. The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) version 22.0, employing descriptive statistics, Logit Model, and thematic analyses for quantitative data. The study elucidates the multifaceted relationship between households and wetlands, revealing the diverse benefits derived from wetland resources. The study result shown the Chemoga Plane Wetland provided various ecosystem services to the local community. Indigenous (Ditches or "Tekebkeb") and introduced (Terrace, Trench and Cut off drain) practices implemented by local communities are also examined, highlighting their positive impacts on wetland conservation. Logistic regression analysis identified significant determinants of wetland management adoption, including education level, family size, access to training, and proximity to wetlands ($p< 0.01$). The results were showed the critical role of education, training, and community participation for promoting sustainable wetland management. This research contributes valuable insights to inform conservation efforts and policy interventions aimed at safeguarding wetland ecosystems and enhancing their resilience in the face of ongoing environmental challenges.

Keywords: *Adoption, Ecological Function, Wetland, Wetland management*

1. Introduction

Wetlands are crucial ecosystems found worldwide, encompassing diverse habitats such as marshes, swamps, fens, and mangroves (Arya *et al*., 2020). Often called the "kidneys of the earth," they filter water, regulate flow, and provide essential ecosystem services (Sharma *et al*., 2021). As some of the most biologically diverse ecosystems, they support a vast array of species, including many that are endangered or endemic (Mengesha, 2017). Covering approximately 5.3 to 12.8 million km², wetlands are one of the most widespread ecosystem types in the world (Tan *et al*., 2020).

Ethiopia, known as the "water tower of East Africa," it has an extensive wetland system shaped by its diverse landforms and climatic conditions (Bezabih & Mosissa, 2017). According to the Ramsar definition, Ethiopia features a variety of wetlands originating from diverse sources (Mengesha, 2017). It hosts all types of wetlands except for coastal and marine-related wetlands and large swamp forest complexes (Dixon & Wood, 2007). Covering approximately 2% of Ethiopia's total landmass, these wetlands provide numerous socioeconomic benefits to local communities (Bezabih & Mosissa, 2017). They range from high-altitude mountain bogs to lowland floodplains, each with distinctive characteristics and functions, distributed across various regions (Haji, 2019). These wetlands serve as crucial sources of water, food, medicinal plants, and fish for rural communities (Atiim *et al*., 2022). Furthermore, they play vital environmental roles such as water purification, air quality improvement, soil formation and protection, pest control, and habitats for a diverse array of flora and fauna (Smith *et al*., 2019).

Moreover, wetlands provide a variety of ecosystem services (Camacho-Valdez *et al*., 2020), including regulating services such as groundwater recharge and discharge, biodiversity support, carbon sequestration, and flood mitigation (Sharma *et al*., 2021). Despite their vital roles in cultural, supporting, regulating, and provisioning services (Wondie, 2018; Assessment, 2005), wetland ecosystems are currently experiencing significant ecological challenges due to harmful human activities (Newton *et al*., 2020).

Despite providing multiple ecosystem services, wetlands are often wrongly perceived as wastelands and impediments to human development (Christine, 2014). These misconceptions stem from issues such as floods, diseases, and malaria associated with wetlands (Medlock & Vaux, 2015). Consequently, there has been extensive conversion of wetlands into other land uses (Mao et al., 2018), including agriculture, grazing, landfill, mining, and settlements (Beuel *et al*., 2016). To ensure the sustainability of wetlands for both environmental conservation and socio-economic benefits, robust planning and management systems are imperative (De Jonge *et al*., 2012). Effective utilization of wetland resources requires comprehensive assessments of their current conditions and the implementation of appropriate management strategies.

Previous studies have been conducted in Northwest Ethiopia and other regions, examining various aspects of wetland management. These investigations cover topics such as household willingness to invest in wetland rehabilitation (Asmare et al., 2022), spatiotemporal changes in wetlands (Zekarias et al., 2021; Hussien et al., 2018), and the anthropogenic impact on wetland biodiversity (Eneyew & Assefa, 2021). However, a research gap exists regarding the ecosystem services and factors determining the adoption of wetland management practices specifically in the Chemoga Plane wetland. Site-specific studies are essential for an inclusive understanding of the characteristics, functions, and values of wetlands (Kadykalo & Findlay, 2016). Therefore, the current study was aimed to assess the ecosystem services of wetlands and the determinants influencing the adoption of wetland management practices.

2. Materials and Methods

2.1.Description of the Study Area

The study was conducted in the Chemoga Plane Wetland, located in the Gozamin district of the East Gojjam Administrative Zone, Northwest Ethiopia. The wetland is situated between latitudes 10° 20' 48" and 10° 26' 03" N, and longitudes 37° 44' 35" and 37° 49' 05" E (Figure 1). The district experiences an average annual rainfall of 1380 mm and an average temperature of 18°C (Demlew *et al*, 2019). This site covered 4955.81 ha, the area includes 931.4 ha of farmland, 824.34 ha of settlement/homestead trees, 1373.74 ha of grassland, 1787.72 ha of marshland and 38.61 ha of open water or ponds According to the 2023 projections by the Central Statistical Agency of Ethiopia (CSA), the district has a total population of 163,386, with 81,074 men and 82,312 women. Agriculture in the area is predominantly small-scale and subsistence-based, featuring mixed farming systems that encompass both crop cultivation and livestock production. The primary crops grown include cereals (maize, barley, wheat, and *teff*), pulses (beans and peas), and root crops (potatoes) (GWAO, 2015). Additionally, some farmers cultivate vegetables like cabbage and tomatoes, typically in homestead gardens or near water sources using irrigation.

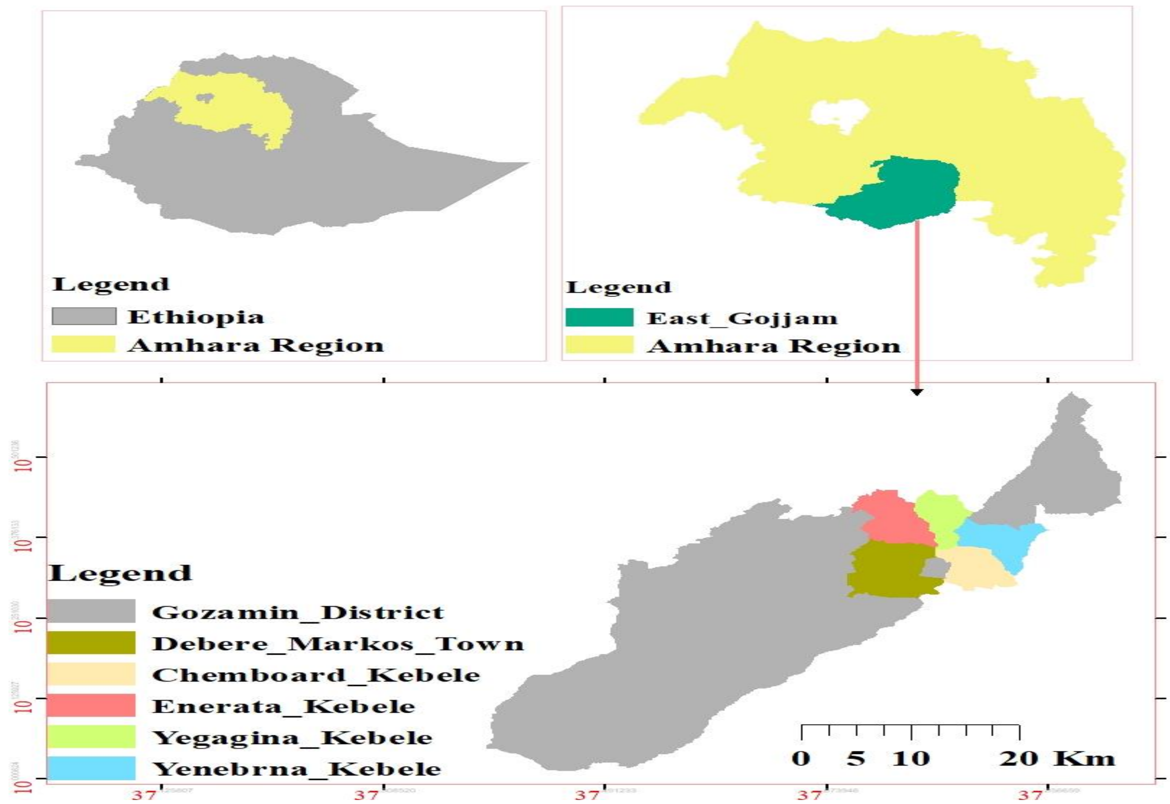

Figure 1**.** Location map of Gozamin District, East Gojjam, Amhara Region, Ethiopia

2.2.Sampling Design and Sample Size Determination

This study utilized both probability (random sampling) and non-probability (purposive) sampling techniques. Purposive sampling was employed to select the Chemoga Plane Wetland in the Gozamin district, bounded by four rural *kebele* administrations (RKA): *Chemboard, Enerata, Yegagina, and Yenebrna* chosen based on their proximity to the wetlands. Furthermore, one village from each RKA (*Chemboard*, *Yebrage*, *Dilenta* and *Ziwal*) was purposively selected. The sample size was determined to be 10% (78 households) of the total population, adhering to the guideline proposed by Yount (2006), which suggests that for populations between

101 and 1000, a 10% sample is sufficient. These sample households were selected using a simple random sampling method. In addition to questionnaire, data were collected through focus group discussion (FGD), key informants interview (KII) and observation. Four FGD (one in each RKA consists of 10 members) were held.

The sample size for each village was determined using the proportional sampling method (refer to Table 1). The proportional sampling method is defined by the formula:

$$ni = n\left(\frac{Ni}{N}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Equation (1)}$$

Where n is the required total sample size, n_i is the sample size of a specific village, N is the total household population size of all sampled kebeles, and N_i is the population size of the specific village.

Table1. Population and sample size allocation

No	Name of villages	Total household number	Sample size
1	Ziwal	228	23
2	Yebrage	182	18
3	Chemboard	220	22
4	Dilenta	153	15
	Total	N = 783	n = 78

2.3.Data types and data collection methods

Both primary and secondary data were collected for this study. The primary data were collected using closed-ended questionnaires from 78 households. These questionnaires focused on collecting information about the various ecosystem services provided by the Chemoga Wetland Plane. These services include provisioning services such as livestock grazing, water sources, irrigation, construction materials, and sedge harvesting; regulating services like flood control and sediment accumulation; supporting services including bird habitats and biodiversity conservation; and cultural services, particularly those related to spiritual practices. In addition to the questionnaires, primary data were also obtained through Key Informant Interviews (KII) and four Focus Group Discussions (FGDs), which provided deeper insights into the community's interaction with the wetland. Secondary data were sourced from published materials, offering a broader context and supporting evidence for the study's findings.

2.4.Data analysis

Data gathered from structured questionnaires underwent analysis using SPSS 20.0 software, involving tasks such as summarizing, categorizing, coding, and comprehensive analysis. The quantitative results were effectively communicated using basic descriptive statistics: frequencies, and percentages. In contrast, qualitative data from FGD, KII, and observational data were presented narratively.

A Logit model was employed to know determinant factors affecting wetland management practices. The empirical model indicated by (Neupane *et al*, 2002).

$$P_i = F(a + bX_i) = \frac{1}{1+e^{-(\alpha+\beta X_i)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Equation (2)}$$

Where: Subscript i denotes the observation sample; P_i is the probability that an individual will make a certain choice given X_i; e is the base of natural logarithms; X_i is a vector of exogenous; variables α and β are parameters of the model, $\beta_1, \beta_2.., \beta_k$ are the coefficients associated with each explanatory variables $X_1, X_2..., X_n$. The above function can be rewritten as:

$$\ln(\frac{P}{P-1}) = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_k X_k$$ ……………………………….Equation (3)

Where: $(\frac{P}{P-1})$is the odds; β_0 is the intercept; β_1, β_2…and β_k are coefficients of the associated independent variables of X_1, X_2…and X_k.

The Description of explanatory variables used in the data analysis presented in Table 2.

Table 2. Description of explanatory variables used in the data analysis

No	Description Variable	Abbreviation	Level of independent Variables	Direction of Relation (sign)
1	Sex of respondents	SEX	Dummy	±
2	Age of respondents	AGE	Continuous	±
3	Family size of respondents	FAMSIZE	Continuous	+
4	Educational status of respondents	EDUSHH	Continuous	+
5	Farm size of the respondents	LANDSIZE	Continuous	±
6	Off-farm activities of respondents	OFFFARM	Dummy	±
7	Training	TRAING	Dummy	+
8	Distance from wetland	DISTANCE	Continuous	±
9	Perception about the wetland degradation	PERCEP	Dummy	+

3. Results and Discussion

3.1.The roles of Chemoga Wetland Plane

Chemoga Wetland Plane offers a diverse array of ecosystem services crucial to local communities. The result presented in table 3, provisioning services are significant, with 96.15% of households using the wetland for grazing and livestock drinking water, while 30.76% rely on it for human drinking. However, only 2.56% utilize it for irrigation, indicating limited agricultural dependence. Participants in the focus group discussion presented the reason as it was due to the far distance between the water source and farmlands. The wetland also provides construction materials to 20.51% of households and materials for handicrafts to 52.56%. Sedge (*Chaffe*), essential for ceremonies, is culturally significant to all households (100%). Regulating services: 100% of the respondents flood control and sediment accumulation benefit all, vital for mitigating floods and maintaining soil quality. Supporting services include biodiversity conservation, with the wetland serving as a habitat for birds that benefit all households. Culturally, it plays a central role in community life through spiritual practices and as a site for Orthodox Christian celebrations like Epiphany.

Furthermore, both the focus group discussion and the key informant interview underlined the Chemoga Plane Wetland's crucial role in safeguarding local farmlands from flood risks. Beyond flood mitigation, the wetland serves as a sacred site and a vital water source for Orthodox Christians to observe Epiphany rituals, reflecting its cultural significance in community life. Moreover, the wetland supports a rich biodiversity of diverse bird species that depend on its resources for sustenance, habitat, and shelter. This ecological function not only enhances local biodiversity but also shows the wetland's importance as a thriving ecosystem supporting various wildlife populations. Thus, beyond its immediate ecological benefits, the Chemoga Plane Wetland plays a multifaceted role in cultural practices, flood protection, and biodiversity conservation within the local community. Previous studies have emphasized the essential roles of wetlands in various aspects, including as sources of drinking water for both humans and livestock (Wondie, 2018; Assessment, 2005), irrigation (Hedjal *et al*, 2018), celebrations of Epiphany (Allen, 2022), handicrafts, flood control and sediment retention (Wondie, 2018; Verhoeven & Setter, 2010)). These findings shows the multifaceted services that wetlands offer to local communities.

Table 3. Ecosystem services of Chemoga Wetland Plane

Services	Wetland resource HH respondents					
	Beneficiary		Non_beneficiary		Total	
	Frequency	(%)	Frequency	(%)	Frequency	(%)
Provision Service						
Livestock grazing	75	96.15	3	3.85	78	100
Livestock watering	75	96.15	3	3.85	78	100
Human drinking water	24	30.76	54	69.24	78	100
Irrigation	2	2.56	76	97.44	78	100
Hatch roof	16	20.51	62	79.49	78	100
Handicraft	41	52.56	37	47.44	78	100
Sedge (*Cheffe)* for ceremony	78	100	0	0	78	100
Regulation service						
Flood control	78	100	0	0	78	100
Sediment accumulation	78	100	0	0	78	100
Supporting Service						
Habitat for birds	78	100	0	0	78	100
Cultural Services						
Spiritual Services	78	100	0	0	78	100

3.2.Management Practices in the Chemoga Plane Wetland

Based on the focus group discussion and the key informant interview, famers were implementing soil and water conservation strategies on their farmlands, which are considered as sources of sediments deposited into the Chemoga Plane Wetland. In addition to implementing different structural measures (e.g. ditches "*Tekebkeb"*) on their farmlands, farmers also planting trees along their farmlands and fencing water sources (springs). Thus, the implementation of land and water management strategies can reduce the amount and rate of sediment deposition into the wetland. Traditional ditches made to allow excess water to infiltrate easily and control sedimentation on wetland.

Moreover, planting tree around spring source and gully areas are traditional utilized practices in the study area. Moreover, naturally growing indigenous trees protected spring source. In addition, some farmers are trying to prevent gully expansion in the wetland by planting fast growing trees. Moreover, communities fenced springs heads to prevent the entrance of livestock, which used for drinking water and grass harvesting. These findings present the diverse ecosystem services derived from wetlands by surveyed households, encompassing essential survival needs such as water provision, alongside cultural practices and economic activities like handicrafts and livestock management. The findings are supported by Rafaai et al. (2024) and Camacho-Valdez et al. (2020), who reported that wetlands provide a broad spectrum of ecosystem services. These vital ecosystems play a key role in environmental preservation by replenishing and releasing groundwater, fostering biodiversity, and mitigating flood risks.

In addition to the above traditional management strategies, some new introduced wetland management measure such as constructing Terrace, Trench and Cut off drain that are under implementation in the study area. However, most of these management strategies are introduced not directly related to wetland, rather to protect soil erosion from cultivated lands, but have positive impacts on the Chemoga Plane Wetland. All these soil management strategies used to control soil erosion from cultivated fields, by then reduce sediment loads into the wetland. In the focus group discussion farmers explained that they are constructing terrace and other structural measures on their farmlands every year through public works to protect soil erosion. Hence, the applications of both indigenous and introduced conservation measures on the surrounding farmlands have positive impacts on the Chemoga Plane Wetland by reducing the potential deposition of sediment. Our findings align with those of Mekonnen et al. (2017), who found that terraces are effective in reducing sediment loads in water bodies.

3.3. Community Participation in Wetland Management Work

Table 4 presents the proportion of community participation on soil and water conservation works around the Chemoga Plane Wetland. The survey result showed that about 69.3% of the respondents participated in the soil and water conservation works. Whereas, 30.7% of households not participating in soil and water conservation activities may face barriers such as lack of awareness, economic constraints, land tenure issues, limited access to resources, and social or cultural factors. However, in the group discussion they reflected that the local communities themselves are responsible for the management of the Chemoga Plane Wetland resources to use it sustainably in the future. Wetland management is a multifaceted endeavor encompassing the protection, restoration, and responsible utilization of these invaluable ecosystems. One notable aspect of this management approach involves implementing conservation measures, both indigenous and introduced, in the surrounding farmlands. These measures yield positive impacts on wetlands such as the Chemoga Plane Wetland by effectively mitigating the potential deposition of sediment. The role of management practice reduces sediment deposition reported by (O'geen *et al,* 2010; Skagen *et al,* 2008).

Table 4. Households participated in SWC activities

Are you participated in wetland management (soil and water) activities?	Frequency	Percent (%)
Yes	54	69.3
No	24	30.7

Total	78	100.0

3.4. Factors Affecting Households' Adoption of Wetland Conservation Measures

The logit model has shown (Table 5) that household family size, education, training, and farmers' perception of wetland degradation as well as soil and water degradation, significantly and positively affecting farmers' adoption of wetland/soil and water conservation practices. On the other hand, age of the respondents, distance from the wetland and involvement of household in off-farm activities negatively and significantly affecting farmers' wetland/soil and water management practices. While sex and farmland size of the respondents showed insignificant influence on the adoption of wetland conservation practices.

The age of the household head negatively affects the adoption of wetland conservation practices. Specifically, for each additional year in the household head's age, the likelihood of adopting a conservation structure decreases by a factor of 0.664, as indicated by the odds ratio. This finding aligns with Gebreyesus (2016), who observed that increasing age could adversely affect farming activities. In contrast, family size positively influences the adoption of conservation practices, suggesting that larger families, with their greater labor resources, are more likely to implement these measures (Eskandari-Damaneh et al., 2020). Furthermore, educated household heads are significantly more likely to adopt conservation measures, with the adoption rate being over 0.006 times higher compared to their illiterate counterparts. This supported by Miheretu & Yimer's (2018) assertion that education enhances the ability to engage in soil conservation practices as adaptive measures. On the other hand, households involved in off-farm activities are less likely to embrace conservation structures due to the labor demands of these activities, which compete with on-farm tasks (Wafula et al., 2016). This highlights a significant challenge in promoting conservation practices within agricultural settings.

Table 5. Determinants of wetland management practices

Variables	B	S.E	Wald	Sig.	Odds
SEX	-0.474	1.162	0.166	0.683	0.622
AGE	-0.409	0.112	13.354	0.000 **	0.664
FAMSIZE	0.972	0.343	8.048	0.005 **	2.643
EDUCLE	5.136	1.831	7.870	0.008 **	0.006
LANDSIZE	-0.781	0.805	0.942	0.332	0.458
OFFFARM	-2.659	0.959	7.697	0.006 **	0.070
TRAING	1.250	0.852	2.155	0.042*	3.491
DISTANCE	-1.026	0.596	2.962	0.005**	0.358

PERCEP	3.295	1.229	7.192	0.007 **	6.984
Constant	16.994	5.379	9.980	0.002 **	-

N= 78, Pseudo R^2 = 0.72, LR Chi (df= 8) = 91.959, Correctly predicted = 89.2%; **, * significant at 1%, 5%, respectively.

As anticipated, the logistic regression analysis revealed a significant relationship: farmers engaged in training programs on natural resource conservation strategies demonstrate a higher propensity to adopt wetland management practices compared to their non-trained counterparts. Access to such training substantially increases the likelihood of farmers adopting soil and water management practices. The regression results quantified this effect, showing that trained farmers exhibit approximately a 3.491-fold higher likelihood of adopting conservation measures than their untrained peers. This underscores the pivotal role of training in equipping farmers with critical knowledge for implementing effective management strategies on their farmlands and homesteads (Eshetu *et al*., 2021; Dangia and Dara, 2020).

Moreover, the analysis identified a negative correlation between the distance of wetlands or farmlands from household heads' residences. Controlling for other variables, household heads residing closer to their wetlands or farmlands are 0.358 times more likely to adopt these conservation practices compared to those residing farther away. This proximity effect suggests that closer proximity facilitates greater interaction and daily access, thereby promoting more proactive and effective management. Additionally, wetlands situated near household residences are more likely to undergo frequent and thorough management compared to those located at a distance (Kahsay, 2011).

4. Conclusions and Recommendations

The Chemoga Wetland Plane was providing essential ecosystem services crucial for their livelihoods and cultural practices. Provisioning services like grazing and drinking water for both human and livestock additionally, the wetland supports local economies through construction materials and handicraft (mat) supplies, and plays a central role in spiritual and religious traditions such as Orthodox Christian celebrations of Epiphany. Its contributions to flood control, sediment regulation, and biodiversity conservation further highlight its ecological significance. Management practices, both indigenous and introduced, have demonstrated positive impacts on wetland management. To sustain wetland ecosystem services, it is crucial to enhance community engagement by promoting local participation through awareness campaigns and partnerships. Implementing strategies for integrated wet land management, including sustainable land use practices and habitat restoration is essential. Supporting education and training programs to build skills for effective wetland management and conservation is also vital. Furthermore, enforcing a policy framework that protect wetlands and promote sustainable practices is necessary.

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