# SOCIOECONOMIC IMPACTS OF ECOHYDROLOGICAL INTERVENTIONS ON THE WETLANDS ALONG THE SOUTHEASTERN SHORE OF LAKE TANA, ETHIOPIA

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**ABSTRACT:** A study was conducted on Lake Tana shore with the aim of assessing the impacts of ecohydrological intervention on ecosystem services in terms of the socioeconomic contributions for people living along the Lake Tana shore. Three wetlands grouped as protected (intervened site), disturbed (open) and highly disturbed were selected along the Lake Tana shore for the study. The sampling sites were Gumetirs, Gedromesk and Agid Kirgna wetlands where Gedromesk and Agid Kirgna wetlands were selected as reference sites to compare the socioeconomic aspects with the intervened site of Gumetirs wetland. Qualitative and quantitative data on household characteristics, wetland contribution to the local communities and drivers of changes were collected from 90 household heads (HHDs) using a semi-structured questionnaire. Data were analyzed using SPSS software and descriptive statistics. The study revealed that crop production is the major source of livelihood which accounted for 48.9%. About 50% of the respondents were not aware of anthropogenic activities and their negative impacts on the ecosystem. Currently, both Gumetirs and Gedromesk wetlands provide more goods and services contributing to more than 97% of the total value of the wetland goods and services due to water accessibility and availability from the wetland. Wetlands' benefits were associated with the intensive human activities carried out in and around the wetlands, and the level of awareness of the local communities. Ecohydrological intervention provided an immense ecosystem service and also served as a mitigation measure against anthropogenic drivers.

**Keywords:** Ecosystem services, ecohydrological interventions, human disturbance, Lake Tana, socio-economics

## INTRODUCTION

Wetlands play a vital role in providing a wide range of ecosystem services for millions of people mainly living in developing countries (Teferi et al., 2010). Information on wetland ecosystem services, drivers of change and subsequent impacts specific to regions or areas of concern is hence essential for ensuring wise use, conservation and sustainable development (Enserink, 1999). Wetlands are lost or degraded because of What leads to wetland loss or degradation lack of awareness and knowledge on their products, functions,

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attributes and values by human, institutions and policies (Owuor et al., 2012). Human activities within the wetland or in the catchment may accelerate the rate of change or changing the natural processes posing a threat to the wetland's continued existence (Akeem and Lewiska, 2020).

Intensive agriculture with improper land use and exploitative resource management results in significant negative impacts including ecosystem deterioration in the form of water and land degradation, reduction in biological diversity, social and economic impacts, and so on (Ligdi et al., 2012). Consequently, energy flow, nutrient cycle, water cycle, biological process and socio-economic aspects which are provided by the wetlands are greatly disturbed. The degradation of wetlands results in loss of important hydrological and ecological functions. The relevant challenge, therefore, is striking a critical beneficial use of ecosystems for generating livelihoods for local communities without compromising environmental values and uses.

The wetlands in the Lake Tana area are of major significance for the whole region. They provide a myriad of goods and services for humans and animals (Zur Heide, 2012). Lake Tana basin supports different economic activities, and agriculture is the major one. Hence, it has been recognized as a major 'economic corridor' and wetlands along Lake Tana shore support the livelihoods of hundreds of thousands of people in various ways (Stave et al., 2012). However, awareness creation about the importance of wetlands in the Lake Tana Sub-basin is virtually lacking (Mengistu, 2008). A reduction of the buffering role in the ecosystem, the economic benefit and livelihoods they sustain is resulting due to the increasing degradation of wetlands around lake Tana and along the river banks (Zalewski, 2010).

The growing demand to provide evidence of successful implementation of ecohydrology solutions calls for a worldwide ecohydrology demonstration sites in order to validate and quantify the effectiveness of ecohydrological solutions (Cochran, 1977).

Lake Tana has earlier been identified and selected by UNESCO as a representative area to investigate the ecohydrological issues in Ethiopia's Nile basin (Ligdi et al., 2010). Lake Tana demonstration site which is established under UNESCO has focused on finding solutions to water quality, biodiversity, ecosystem

services degradation and resilience issues in Lake Tana, particularly those affected by anthropogenic activities. Gumetirs site was established as one of the ecohydrology demonstration site in 2010 by UNESCO African regional ecohydrology center in Lake Tana shore area.

The ecohydrological system solution demonstration site comprising the integrated activities including implementation of ecohydrology at the buffer zone of the lake to reduce point and non- point sources of pollution, recover degraded ecosystems and soils and optimization of fish-based aquaculture in the Lake Tana shore (Zalewski et al., 2009).

Information regarding the impact of ecohydrological intervention is very crucial to enhance ecosystem services and also to address human impacts on aquatic resources. However, the socioeconomic impacts of ecohydrological intervention of Lake Tana have not yet been addressed and information is lacking in this regard. Thus, this study was conducted with the aim of evaluating and quantifying the ecohydrology interventions impacts related to the socioeconomic attributes of the wetland at the shore of Lake Tana.

## MATERIALS AND METHODS

Geographically, Lake Tana is located in the range of 10°58' -12°47 ' N and 36°45' - 38°14' E. It is a source of Blue Nile River and has a total of around 15,000 $km^2$ drainage areas, of which the lake covers around 3,000 $km^2$ (Ligdi et al., 2010). The basin drains into the shallow freshwater Lake Tana (Ligdi et al., 2010). The sub-basin can be divided into four distinct physiographic units comprising: the lake water body (including the islands); lower catchments (shorelines and surrounding wetlands); middle catchments (flood plains and gentle hill slopes and upper catchments (low plateau plains, ridges and mountains (Turyahabwe et al., 2013)

### Sampling sites

The study was conducted from November 2019 to April 2020 at three sampling sites on the wetlands along the southeastern shore of Lake Tana. The sampling sites were specifically selected based on the reconnaissance field survey which assessed their disturbance extent by anthropogenic activities, the extent and impact of the intervention and accessibility, and availability of goods and services. Both Gedromesk

and Agid Kirgna wetlands were selected as reference sites to compare the socioeconomic aspects with the intervened site of Gumetirs wetland at the lake shore.

Gumetirs wetland is located about 5 km away from Bahir Dar city at Zenzelima Kebele in the southeast direction which is above the outlet of Abay River (Blue Nile River). Geographically, it is located at 11°37'33.4" N and 037°24'41.6" E with an altitude of 1790 m asl. It has an area of less than 5 hectares. This wetland is surrounded by cultivated crops and local residents. It is mainly dominated by *Echinochloa crassipes* and *Cyperus papyrus* plant species.

Gedromesk wetland is located adjacent to Gumetirs study site. This site is mainly surrounded by farmlands and cultivated crops. It is located at $11^0$38'47.7" N and $37^0$25'24.04" E. This wetland is used for grazing and farming land purposes mainly during the dry season. It is mainly covered by *Echinochloa* grass species.

Agid kirgna wetland is surrounded by extended farmlands. It is located in the northeastern direction of Lake Tana at the way of Bahir Dar to Gondar road in Libo Kemkem district. It is geographically located at $12^0$06'5.7" N and $37^0$37'17.1" E. It is situated between Rib and Arno Garno Rivers. This lakeshore is completely covered by water hyacinth. This site is characterized by impacts from agriculture and overgrazing pressure.

**Sampling design and data collection**

The household survey questionnaire was designed to measure: (I) the benefits obtained from the wetlands, and (II) perception of the local community about wetland benefits and ecohydrological intervention impacts on their livelihood opportunities on the wetland.

For this study, both qualitative and quantitative approach were used to quantify the socioeconomic aspects and assess local people's perception about the impacts of ecohydrological intervention on the livelihood opportunities along the shore of Lake Tana. The primary data were collected through a household survey by using structured questionnaire, interview and observation. The interviewer sometimes tried to use an indirect

approach to address some of the wetland ecosystem benefits and intervention activities to generate qualitative and quantitative data from the respondents.

The survey was undertaken systematically by selecting groups of households living around the lakeshore. Households were selected based on proximity and distance to the lakeshore. The study sites (*Kebeles*) were purposively selected since they are located in the southeastern shore of Lake Tana and have a different degree of human disturbance and benefits at each wetland. A total of 90 respondents were selected for the survey which accounted for 30 respondents from each sampling site following Cochran (1977) method. Cross-sectional interviews of household heads (HHDs) and key informants were conducted in November 2019 using clustered sampling method in the community living within a 3-km radius of each wetland (Tariku et al., 2014; Tewabe, 2014).

**Data analysis**

SPSS version 20.0 software was employed to analyze the socioeconomic data collected through structured questionnaires. The data were analyzed using descriptive statistics (mean, percentage, and frequency distribution) and Chi-square test.

## RESULTS

**Demographic characteristics of sampled household**

The findings from the structured questionnaire indicated that the majority of the respondents who participated in the study were male-headed accounting for 65.6%, while the female-headed accounted for 34.4% (Table 1). On the other hand, the mean age of respondent age was 40 with a minimum of 25 and a maximum of 61 years old. Regarding the level of education, the result showed that 58.9% of the respondents which accounted for half of the participants did not get access to formal education. On the other hand, almost three fourth of the respondents (84.4%) got married and the mean family size of the respondents was five per each family, while. 92% of the respondents were farmers compared to government employed and self-employed respondents.

**Table 1.** Socio-economic characteristics of the sampled households.

| **Socioeconomic characteristics** | Description | Percentage |
|---|---|---|
| Gender | Male | 65.6% |
| | Female | 34.4% |
| Age | Mean: 40 | |
| | Range: 25-61 | |
| Level of education | No education or basic education | 58.9% |
| | Primary education | 35.6 % |
| | Secondary education | 4.4% |
| | College or University | 1.1% |
| Social status | Single | 14.4% |
| | Married | 84.4% |
| | Divorced | 1.1% |
| Occupation | Government employed | 1.1% |
| | Self-employed | 6.7% |
| | Farmer | 92.2% |
| Family size | Mean: 5 | |
| | Range: 1-8 | |

**Sources of livelihood of sampled household in selected kebeles**

Five major sources of livelihood were identified (Table 2). On average, crop was the mainstay of livelihoods for the majority of the households which accounted for 48.9% of total respondents of the three sampling sites (kebeles). It is followed by crop, livestock (21.1%) and fodder, fruit and vegetable sales (21.1%), which are the other sources of livelihood for the local people. However, the smallest source of livelihood was rent land, which only accounted for 1.1% among the other sources of livelihoods. The inferential statistics test indicated that there was a statistically significant difference in sources of livelihood across the sites ($X2$ (12, $N = 90$) = 34.304, $p = 0.001$.

**Table 2**. Sources of livelihood of the sampled household heads.

| Sources of livelihood | Sample sites | | | Mean | Std. Error | Frequency | Percent (%) | Sig. |
|---|---|---|---|---|---|---|---|---|
| | Gt | Gm | Ak | | | | | |
| Crop | 9 | 12 | 23 | 14.7 | 4.3 | 44 | 48.9 | 0.001 |
| Forestry | 1 | 2 | 0 | 1 | 0.6 | 3 | 3.4 | |
| Livestock | 4 | 9 | 6 | 6.3 | 1.5 | 19 | 21.1 | |
| Rent land | 0 | 1 | 0 | 0.3 | 0.3 | 1 | 1.1 | |
| Agricultural wage | 0 | 1 | 1 | 0.7 | 0.3 | 2 | 2.2 | |
| Fodder, fruits and vegetable sales | 14 | 5 | 0 | 6.3 | 4.1 | 19 | 21.1 | |
| Small scale business | 2 | 0 | 0 | 0.7 | 0.7 | 2 | 2.2 | |

Gt=Gumetirs; Gm=Gedromesk; Ak=Agid kirgna

**Number of people that depends on the wetland resources and degree of dependency**

The results revealed that 72.2% of 1 up to 5 family sizes of the respondents was depending on the wetland resources. On the other hand, the degree of dependency of most participants (58.9%) was partial and those who fully dependent on wetland resources was found to be 36.7% (Table 3). There was no significant difference in the number of dependent families and degree of dependency on the wetlands, X2 (2, N = 90) = 1.440, p = 0.487 and, X2 (4, N = 90) = 2.853, p = 0.583, respectively.

**Table 3**. Number of dependents and degree of dependency of the sampled household heads.

| | Sample sites | | | Mean | Std. Error | Freq. | Percent (%) | Sig. |
|---|---|---|---|---|---|---|---|---|
| | Gt | Gm | Ak | | | | | |
| Number of family dependent on the wetland | | | | | | | | |
| 1-5 | 20 | 24 | 21 | 21.7 | 1.2 | 65 | 72.2 | |
| 5-10 | 10 | 6 | 9 | 8.3 | 1.2 | 25 | 27.8 | |
| Degree of dependency | | | | | | | | |
| Fully dependent | 8 | 14 | 11 | 11 | 1.73 | 33 | 36.7 | 0.583 |
| Partial dependent | 20 | 15 | 18 | 17.7 | 1.45 | 53 | 58.9 | |
| Independent | 2 | 1 | 1 | 1.3 | 0.33 | 4 | 4.4 | |

Gt=Gumetirs; Gm=Gedromesk; Ak=Agid kirgna

**Overall trends of benefits and concern of biodiversity in the wetlands**

The respondents were asked their opinion on the overall trend of benefits in the last five years and their concern about wetland biodiversity and their contribution in maintaining the healthy functioning of the ecosystem. The respondents were asked their opinion and awareness of wetland degradation. Among the three study sites, the overall trends of benefits from the wetland of Gumetirs site increased compared to Gedromesk and Agid kirgna in the last five years. Despite the overall trends of wetland benefits increased in Gumetirs site, 62.3% of the respondent stated that wetland benefits across the site were decreased. On the other side, the overall concern of the community about biodiversity was moderate (64.4%). However, the trends of benefits provided by the Agid kirgna wetland were completely decreased in the last five years (Table 4). Additionally, the respondents were asked their attitude towards wetland degradation and its cause and consequence. As a result, half (51%) of the respondents had moderate awareness about wetland degradation. The majority of the respondents in Gumetirs site had good awareness compared to the other two wetland sites. Statistically, there was a significant difference in the overall trends of benefits, $X2$ (4, N =90) = 46.542, p = 0.001, and concerns of biodiversity, $X2$ (4, N =90) = 23.203, p = 0.002 and awareness of wetland degradation, $X2$ (4, N =90) = 27.952, p = 0.003 among the sampling sites.

**Protection status of wetlands**

This section asses the protection extent of the wetlands. The finding revealed that majority of the respondents (25.6%) agreed to the fact that overgrazing, free grazing and pollution are not prohibited in the wetland (Table 5). This is especially observed in the Agid kirgna site which accounted for 56.5% compared to the remaining sites. Generally, Gumetirs site was protected properly than the other two wetlands in which farming and hunting practices are not allowed in the wetland. There was a significant difference in the protection status of the wetlands across the sampling sites, $X2$ (16, N =90) = 90.723, p = 0.003

**Table 4.** Overall trends, awareness and concerns of wetland benefits, degradation and biodiversity of the sampled households.

| | Sample sites | | | Mean | Std. Error | Freq. | Percent (%) | Sig. |
|---|---|---|---|---|---|---|---|---|
| | Gt | Gm | Ak | | | | | |
| Overall trends of benefits in the last five years | | | | | | | | |
| No change | 10 | 2 | 0 | 4 | 3.06 | 12 | 13.3 | 0.001 |
| Decreased | 5 | 21 | 30 | 18.7 | 7.31 | 56 | 62.3 | |
| Increased | 15 | 7 | 0 | 7.3 | 4.33 | 22 | 24.4 | |
| Overall concern of local people for biodiversity | | | | | | | | |
| Highly concerned | 14 | 6 | 2 | 7.3 | 3.53 | 22 | 24.4 | 0.002 |
| Moderately concerned | 14 | 24 | 20 | 19.3 | 2.91 | 58 | 64.4 | |
| Unconcerned | 2 | 0 | 8 | 3.3 | 2.4 | 10 | 11.1 | |
| Awareness of local people about wetland degradation | | | | | | | | |
| Largely aware | 15 | 7 | 0 | 7.33 | 4.33 | 22 | 24.4 | 0.003 |
| Moderately aware | 15 | 13 | 23 | 17 | 3.06 | 51 | 56.7 | |
| Largely unaware | 0 | 10 | 7 | 5.67 | 2.96 | 17 | 18.9 | |

Gt=Gumetirs; Gm=Gedromesk; Ak=Agid kirgna

**Table 5**. Protection status of wetlands of the sampled households.

| | Sample sites | | | Mean | Std. Error | Freq. | Percent (%) | Sig. |
|---|---|---|---|---|---|---|---|---|
| | Gt | Gm | Ak | | | | | |
| Protection status of the wetland | | | | | | | | |
| Fishing prohibited or regulated | 2 | 1 | 0 | 1 | 0.58 | 3 | 3.3 | |
| Biosphere reserve | 1 | 0 | 0 | 0.3 | 0.33 | 1 | 1.1 | |
| Farming is prohibited | 10 | 0 | 0 | 3.3 | 3.33 | 10 | 11.1 | 0.003 |
| Hunting prohibited | 3 | 0 | 0 | 1 | 1 | 3 | 3.3 | |
| Over grazing, free grazing and pollution prohibited | 14 | 0 | 0 | 4.7 | 4.67 | 14 | 15.6 | |
| Not yet protected | 0 | 5 | 6 | 3.7 | 1.86 | 11 | 12.2 | |
| Over grazing, free grazing and pollution are not prohibited | 0 | 10 | 13 | 7.7 | 3.93 | 23 | 25.6 | |
| Farming is not prohibited | 0 | 7 | 8 | 5 | 2.52 | 15 | 16.7 | |
| Fishing is not prohibited | 0 | 7 | 3 | 3.33 | 2.03 | 10 | 11.1 | |

Gt=Gumetirs; Gm=Gedromesk; Ak=Agid kirgna

**Major uses, anthropogenic activities and use of vegetation cover of wetlands**

The findings revealed that the majority of the respondents agreed that grazing or fodder for livestock and water supply for irrigation purpose were the two major uses of the wetland across the sampling sites (Table 6). Moreover, cultivation of crops including vegetables and fruits were the third major use of wetland for the sampled households.

**Table 6**. Major uses, anthropogenic activities and uses of vegetation cover of the wetland of the sampled households.

| | Sampling site | | | Mean | Std. Error | Freq. | Percent (%) | Sig. |
|---|---|---|---|---|---|---|---|---|
| | Gt | Gm | Ak | | | | | |
| Major uses of the wetland to the local people | | | | | | | | |
| Grazing or fodder for livestock | 10 | 11 | 12 | 11 | 0.58 | 33 | 36.7 | 0.001 |
| Reed gathering | 2 | 3 | 0 | 1.67 | 0.88 | 5 | 5.6 | |
| Cultivation of crops including vegetables and fruits | 6 | 2 | 1 | 3 | 1.53 | 9 | 10 | |
| Water supply for irrigation | 10 | 11 | 3 | 8 | 2.52 | 24 | 26.7 | |
| Fishing and culturing | 2 | 3 | 3 | 2.67 | 0.33 | 8 | 8.9 | |
| Sand mining | 0 | 0 | 3 | 1 | 1 | 3 | 3.3 | |
| Source of drinking water | 0 | 0 | 8 | 2.67 | 2.67 | 8 | 8.9 | |
| Anthropogenic activities and impacts | | | | | | | | |
| Yes | 24 | 15 | 12 | 17 | 3.61 | 45 | 50 | 0.003 |
| No | 6 | 15 | 18 | 13 | 3.61 | 45 | 50 | |
| Uses of vegetation cover for lake health | | | | | | | | |
| Aware | 18 | 13 | 13 | 14.67 | 1.67 | 44 | 48.9 | 0.329 |
| Not aware | 12 | 17 | 17 | 15.33 | 1.67 | 46 | 51.1 | |

Gt=Gumetirs; Gm=Gedromesk; Ak=Agid kirgna

Among the study sites, Agid kirgna site was highly exposed to overgrazing. About 50% of the respondents understood those anthropogenic activities and their negative impacts on the normal functioning of the ecosystem. Conversely, half of the respondents (50%) were not aware of anthropogenic activities and their

negative impacts on the normal functioning of the ecosystem health. On the other side, 48.9% the respondents understood the importance of vegetation cover for both ecosystem health but more than half (51.1%) of the respondents were not aware on the use of vegetation cover for ecosystem health. There was a significant difference in the major uses of wetland across the wetlands, X2 (12, N =90) = 34.648, p = 0.001 and awareness of anthropogenic activities and its impact, X2 (2, N =90) = 17.867, p = 0.003. However, there was no significant difference among the sampled sites in the use of vegetation cover for ecosystem health, X2 (2, N =90) = 2.223, p = 0.329.

**Income contribution of wetlands for the sampled households**

Livelihood sources such as fish, grass, fruits and vegetables, Cyprus papyrus reed, milk, biogas, fattening and compost were significant ecosystem services provided by the wetland (Table 7). The result showed that the majority of the respondents (31.1%) gained 1-10kg fish product per year. Comparatively, more fish products were obtained in Gumetirs site compared to Gedromesk and Agid kirgna. However, 48.9% of the respondents did not get fish throughout the year from the wetland. There was a significant difference across the site in fish products, X2 (8, N =90) = 28.829, p = 0.002. Similarly, a wetland in Gumetirs site provided more grass production than the other two reference sites. There was a significant difference, X2 (10, N =90) = 65.524, p = 0.001 in grass production among the sampling sites. On the other hand, results showed that wetlands were valued as major cultivation site of vegetables and fruits even though more yield was obtained in both Gumetirs and Gedromesk sites with an amount of between 1500- 2500kg per year. However, fruit and vegetable productions not much produced in Gedromesk site but nothing in Agid kirgna sampling site. Statistically, there was a significant difference, X2 (8, N =90) = 84.586, p = 0.001 in fruits and vegetation production among sampling sites.

**Table 7**. Types of income gained by the sampled household heads per year

| | Sample site | | | Mean | Std. Error | Freq. | Percent (%) | Sig. |
|---|---|---|---|---|---|---|---|---|
| | Gt | Gm | Ak | | | | | |
| Products obtained from the wetlands per year | | | | | | | | |
| **Fish** | | | | | | | | 0.002 |
| 1-10 kg | 17 | 9 | 2 | 9.33 | 4.33 | 28 | 31.1 | |
| 10-20 kg | 3 | 5 | 1 | 3 | 1.15 | 9 | 10 | |
| 20-30 kg | 4 | 2 | 2 | 2.67 | 0.67 | 8 | 8.9 | |
| 30-400 kg | 0 | 0 | 1 | 0.33 | 0.33 | 1 | 1.1 | |
| nothing | 6 | 14 | 24 | 14.67 | 5.21 | 44 | 48.9 | |
| **Grass** | | | | | | | | |
| 100-150 ton | 3 | 0 | 0 | 1 | 1 | 3 | 3.3 | |
| 150-250 ton | 7 | 0 | 0 | 2.33 | 2.33 | 7 | 7.7 | |
| 250-300 ton | 4 | 2 | 0 | 2 | 1.15 | 6 | 6.6 | 0.001 |
| 300-350 ton | 7 | 9 | 0 | 5.33 | 2.73 | 16 | 17.8 | |
| 350-400 ton | 7 | 6 | 0 | 4.33 | 2.19 | 13 | 14.4 | |
| nothing | 2 | 13 | 30 | 15 | 8.14 | 45 | 50 | |
| **Fruits and vegetables** | | | | | | | | |
| Below 500 kg | | | | 4 | 4.33 | | 13.3 | |
| 500-1500 kg | 3 | 10 | 0 | 4.33 | 1 | 13 | 14.4 | |
| 1500- 2500 kg | 12 | 3 | 0 | 5 | 3.84 | 15 | 16.7 | 0.001 |
| above 2500 kg | 11 | 3 | 0 | 4.67 | 3.38 | 14 | 15.6 | |
| nothing | 1 | 5 | 30 | 12 | 8.39 | 36 | 40.0 | |
| ***Cyperus papyrus* reed** | | | | | | | | |
| 50-100 ton | | | | 3.33 | 2.03 | | 11.1 | |
| 100-150 ton | 3 | 0 | 0 | 1 | 1 | 3 | 3.3 | |
| 150-200 ton | 5 | 1 | 0 | 2 | 1.53 | 6 | 6.7 | 0.002 |
| 200-250 ton | 9 | 0 | 0 | 3 | 3 | 9 | 10 | |
| above 250 ton | 7 | 0 | 0 | 2.33 | 2.33 | 7 | 7.8 | |
| nothing | 3 | 22 | 30 | 18.33 | 8.01 | 55 | 61.1 | |
| Milk | | | | | | | | |
| 500 L | 1 | 2 | 13 | 5.33 | 3.84 | 16 | 17.8 | |
| 500L-1000 L | 1 | 3 | 0 | 1.33 | 0.88 | 4 | 4.4 | |
| 1000L-1500 L | 1 | 8 | 0 | 3 | 2.52 | 9 | 10 | 0.003 |
| above 1500 L | 16 | 3 | 0 | 6.33 | 4.91 | 19 | 21.1 | |
| nothing | 11 | 14 | 17 | 14 | 1.73 | 42 | 46.7 | |
| **Biogas** | | | | | | | | |
| 1000-2000 Birr saving | 6 | 1 | 0 | 2.33 | 1.86 | 7 | 7.8 | |
| 2000-3000 Birr saving | 3 | 0 | 0 | 1 | 1 | 3 | 3.3 | |
| 3000-5000 Birr saving | 4 | 2 | 0 | 2 | 1.15 | 6 | 6.7 | 0.002 |
| above 5000 Birr saving | 3 | 1 | 0 | 1.33 | 0.88 | 4 | 4.4 | |
| nothing | 14 | 26 | 30 | 23.33 | 4.81 | 70 | 77.8 | |
| **Fattening** | | | | | | | | |
| 1500-2500 Birr | 0 | 2 | 0 | 0.67 | 0.67 | 5 | 5.6 | |
| 2500-3500 Birr | 1 | 4 | 0 | 1.67 | 1.2 | 2 | 2.2 | 0.001 |
| 500-1500 Birr | 2 | 0 | 0 | 0.67 | 0.67 | 2 | 2.2 | |
| more than 4500 Birr | 20 | 8 | 0 | 9.33 | 5.81 | 28 | 31.1 | |
| nothing | 7 | 16 | 30 | 17.67 | 6.69 | 53 | 58.9 | |
| **Compost** | | | | | | | | |
| 500-1000 Birr | | 1 | 0 | 1.33 | 0.88 | 4 | 4.4 | |
| 1000-2000 Birr | 1 | 2 | 0 | 1 | 0.58 | 3 | 3.3 | 0.004 |
| more than 2000 Birr | 21 | 10 | 0 | 10.33 | 6.06 | 31 | 34.4 | |
| nothing | 5 | 17 | 30 | 17.33 | 7.22 | 52 | 57.8 | |

Gt=Gumetirs; Gm=Gedromesk; Ak=Agid kirgna

The majority of households obtained Cyprus papyrus reed mainly from Gumetirs site by either selling raw papyrus materials or after value addition through mat making. More production was obtained from the Gumetirs wetland which totally accounted for 38.9% by many households. Despite more respondents have got papyrus from Gumetirs wetland and Gedromesk wetland, there was nothing obtained papyrus reed products in Agid kirgna wetland which accounted for 61.1%. There was a significant difference, X2 (10, N =90) = 73.382, p = 0.002 in Cyprus papyrus production across the study sites. Similarly, products such as milk, biogas, fattening and compost were mainly obtained from Gumetirs wetland which accounted for nearly 90% of all product types compared to other sites. According to the result from chi-square test, there was a strong evidence of significant difference in milk products, X2 (8, N =90) = 56.919, p = 0.003; biogas, X2 (8, N =90) = 28.300, p = 0.002; fattening, X2 (8, N =90) = 50.122, p = 0.001 and compost, X2 (6, N =90) = 44.893, p = 0.004 products across the sample sites.

Among the alternative questions under the changes in the wetland area, 66.67% of the respondents answered the prominent cause of change in wetland area was recession farming and conversion to agricultural land especially in Gedromesk site and Agid kirgna site (Table 8). Moreover, there was a significant difference, X2 (4, N =90) = 73.257, p = 0.001 in changes in wetland area across sample sites. On the other side, the majority of the respondents identified the building of a dam (48.9% respondents) and change in land use (41.11% respondents), as the cause of change in water regime. There was a significant difference in change in water regime, X2 (4, N =90) = 13.518, p = 0.003 and water quality, X2 (6, N =90) = 86.514, p = 0.002. Nearly, 60% of the respondents answered that exploitation was mainly observed in Gedromesk site and Agid kirgna sites due to overgrazing of the wetland vegetation in and around the wetland area. On the other hand, 33.33% of the respondents agreed that the main alien species was water hyacinth, especially in Agid kirgna. Moreover, there was a significant difference, X2 (4, N =90) = 61.181, p = 0.003 in the invasion of alien species across sampling sites in the wetlands.

From the interviewed respondents, 22.22% of them agreed that prohibition of free grazing and recession farming as a management strategy. There was a significant difference, X2 (8, N =90) = 60.238, p = 0.001 in the management strategies which were recommended by sampled respondents for each study site.

**Table 8**. Changes in area, water regime and quality, exploitation, alien species, and management strategies of the wetlands.

| | Sampling sites | | | Mean | Std. Error | Freq. | Percent (%) | Sig. |
|---|---|---|---|---|---|---|---|---|
| | Gt | Gm | Ak | | | | | |
| **Changes in wetland area** | | | | | | | | |
| Land conversion to urban areas | 2 | 0 | 0 | 0.67 | 0.67 | 2 | 2.22 | 0.001 |
| Conversion into agricultural land | 2 | 28 | 30 | 20.00 | 9.02 | 60 | 66.67 | |
| No change | 26 | 2 | 0 | 9.33 | 8.35 | 28 | 31.11 | |
| Land conversion to industrial area | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| **Changes in the water regime** | | | | | | | | |
| Dam | 16 | 14 | 12 | 14 | 1.15 | 44 | 48.9 | 0.003 |
| Drainage | 0 | 0 | 6 | 2.00 | 2.00 | 6 | 6.66 | |
| Irrigation | 13 | 15 | 12 | 13.33 | 0.88 | 40 | 44.44 | |
| **Change in water quality** | | | | | | | | |
| Nutrient enrichment | 0 | 1 | 0 | 0.33 | 0.33 | 1 | 1.11 | 0.002 |
| Fertilizer/Pesticide/Herbicide | 2 | 8 | 14 | 8.00 | 3.46 | 24 | 26.67 | |
| Changes in land use | 0 | 21 | 16 | 12.33 | 6.33 | 37 | 41.11 | |
| No change | 28 | 0 | 0 | 9.33 | 9.33 | 28 | 31.11 | |
| **Exploitation** | | | | | | | | |
| Overfishing | 13 | 10 | 0 | 7.67 | 3.93 | 23 | 25.56 | 0.001 |
| Overhunting | 14 | 0 | 0 | 4.67 | 4.67 | 14 | 15.56 | |
| Overgrazing | 3 | 20 | 30 | 17.67 | 7.88 | 53 | 58.89 | |
| **Alien species** | | | | | | | | |
| Water hyacinth | 0 | 0 | 30 | 10.00 | 10.00 | 30 | 33.33 | 0.003 |
| Other invasive weeds | 2 | 9 | 0 | 3.67 | 2.73 | 11 | 12.22 | |
| No alien species | 28 | 21 | 0 | 16.33 | 8.41 | 49 | 54.44 | |
| **Management strategies** | | | | | | | | |
| Vegetation restoration | 4 | 5 | 10 | 6.33 | 1.86 | 19 | 21.11 | 0.001 |
| Management of hunting | 13 | 3 | 0 | 5.33 | 3.93 | 16 | 17.78 | |
| Management of fishing | 13 | 2 | 0 | 5.00 | 4.04 | 15 | 16.67 | |
| Prohibit free grazing | 0 | 10 | 10 | 6.67 | 3.33 | 20 | 22.22 | |
| Prohibit recession farming | 0 | 10 | 10 | 6.67 | 3.33 | 20 | 22.22 | |

Gt=Gumetirs; Gm=Gedromesk; Ak=Agid kirgna

## DISCUSSIONS

The fertile shores of Lake Tana have provided provisioning, structural, regulating and cultural values for the local communities for thousands of years.

There are huge differences among the wetlands studied. Gedromesk and Agid kirgna sites are highly affected by agricultural activities and overgrazing. Their buffer zone vegetation was highly degraded by overgrazing, drainage and recession agriculture mainly during the dry season. Agid kirgna wetland is devoid of buffer vegetation. Gedromesk wetland is relatively covered by Echinochloa plant species. However, Gumetirs wetland is dominantly covered by Echinochloa meadow and Cyprus papyrus reed.

In the study sites, the majority of the household sources of incomes are mainly originated from within and around the wetlands directly or indirectly. These include crop farming, forestry production, livestock rearing, and land renting, and growing of fruits, vegetables, and grass and papyrus reeds production. On the other hand, crop production was found to be the most source of livelihood for the local communities in the study sites. This result showed that crop production is the common agricultural practice to generate income for the local community. This is because wetlands have fertile soils as a result of regular sediment deposition during flood events (Verhoeven and Setter, 2010). The local community perceives crop production has higher income compared to other livelihood types. Due to this reason, households demand more farming land to get more products. The local people need to expand the crop farming area beyond their previous territory of land. Furthermore, this suggests that local households are less likely to depend on other sources of livelihoods and more likely depend on crop production mainly the cultivated one. As a result, the local community increases pressure to nearest lake shore areas to cultivate more crops. It was evidenced that degradation of water quality and biodiversity increases when they apply fertilizer and pesticide chemicals to crop farming. With regards to site specific, fruit, vegetable and grass for fodder were produced more in Gumetirs sampling site. The sources of livelihoods mainly affect the number of families that depend on the wetlands. The result revealed that the number of a family that depends on the wetland ranged from 1-5 person per family.

On the other hand, on average, 62.3% of the respondents agreed that the overall trends of benefits in the last five years decreased even though Gumetirs wetland benefits increased. The majority of the local households

lack well understanding and adopting sustainable use of wetland resources. On average, the majority of the respondents are not concerned highly about those anthropogenic activities and impacts. Lack of adequate knowledge and awareness about wetlands results in wetland deterioration from overexploitation and thereby affects their sustainable existence (Tewabe, 2014). The low level of community awareness concerning wetlands and their benefits also accelerates the loss of wetlands in the country (Unbushe, 2013).

The majority of the respondents in Gumetirs sites are highly concerned and largely aware of biodiversity and the impacts of anthropogenic activities. This implies that Gumetirs site provides better ecosystem services compared to the other two reference sites. This is most probably due to the awareness raising effort together with other intervention activities at the lakeshore of the wetland. On the other hand, the local households in Gumetirs site have better concern and awareness of biodiversity and anthropogenic activities impacts on the ecosystem than the other two sites. Public awareness creation is one of the most important ways to conserve wetlands and enable the public to be more environmentally conscious (Mohammed, 2015). For successful conservation and management, the participating local communities should be fully aware of the importance of wetlands as part of water cycles, as well as the nature and effects of human impacts (Williams, 2002). However, awareness creation about the importance of wetlands in the Lake Tana Sub-basin is virtually lacking (Mengistu, 2008).

Moreover, the Gumetirs site was found in good protection status as compared to the other wetlands. This is due to community participation and coordination with integrated water resource management organizations on using the water and land resources sustainably, which is in line to the report by Andrade and Rhodes (2012) which revealed that the higher the level of community participation, the higher their compliance to the resource conservation; community inclusion is a must for long-term conservation.

The protection status of the wetlands indicates that many respondents agreed that free grazing and pollution are not prohibited in Gedromesk and Agid kirgna wetlands. This in turn easily degrades and minimizes the benefits provided by wetlands. Comparatively, free grazing, overgrazing and pollution is strictly prohibited

in Gumetirs site. As a result of proper protection in Gumetirs site, wetland benefits are sustainable throughout the year.

On average, across the site, grazing and crop production are the major use of the wetlands. The result showed that in Gumetirs site grass production, vegetable and fruit, chat (*Catha edulis*) production and reed gathering were the major uses of the wetland. Many of these products demand more water during the dry season. Comparatively, there is less water abstraction in Gedromesk and Agid kirgna sites because of few water demanding products around the wetlands.

Half of the respondents (50%) understand that anthropogenic activities have great impacts on the sustainable use of wetland benefits and overall ecosystem health.

On average 51.1%, majority of the respondents positively recognize that vegetation cover is important. Most respondents perceived that vegetation cover serves as fodder for their livestock. But few of the respondents recognize that vegetation cover is important for fish as a source of food, and breeding ground, nutrient uptake, stabilize water temperature as well as to keep water quality and quantity. This finding is somewhat similar to Wondie (2018). However, about 50% of respondents were not aware of the use of vegetation cover. As a result, the vegetation cover within and around the lakeshore may be prone to continuous degradation of macrophytes.

It is good to note that much of the wetland resources were obtained from the Gumetirs. Wetland benefits such as fish, vegetables, fruits, grass, papyrus reed, milk, biogas, fattening, and compost productions are some of the wetland benefits used by the local households.

Both Gumetirs and Gedromesk currently provide more goods and services such as cultivation of Chat, Cabbage, Mango and Avocado, grass (fodder) production and milk production predominantly provided by Gumetirs wetland contributing to more than 97% of the total value of the wetland goods and services for the local people.

More fruits and vegetables were obtained in Gumetirs wetland due to water accessibility and availability from the wetland. This implies that the community who lives around this wetland has multiple livelihoods. Hence, well-managed wetlands are among the most productive ecosystems which provide the opportunity for sustainable development, helping to meet the needs for improved living standards in developing countries like Ethiopia (Tafa, 2018).

Furthermore, the importance of this study point towards the change in the wetland area, water regime and quality, extent of exploitation, the invasive species invasion condition, and the management strategies. On average, 66.67 % of respondents agreed that the main causes of change in wetland's area are the conversion of wetland into agricultural land through recession farming. Due to this reason, the area of land has been shrinking from time to time. Degradation and loss of wetland is now a big threat to the benefits provided by the wetland for the local community. Similarly, according to Minale and Kameswara (2011) reported that most of the wetlands in the catchment have been continuously declined, while the farming lands and settlement areas have been increasing.

In the studied sites, the change in wetland regime could be caused by the building of a dam, drainage of water to expand agricultural land, channelization, and abstraction of water for irrigation purposes. It increases and decreases the water level depending on the season. Wetland water level decreases during the dry season. In this case, the expansion of recession farming also increases. The change in water quality in the wetland is caused by both changes in land use and nutrient (fertilizer, pesticide, and herbicide) runoff from agricultural fields. Nutrient runoff might be mainly caused by the severe upland erosion in the catchment. The discharges of surplus nutrients in the upper catchment easily enter into the wetland through flooding. The nutrients in the lake without vegetation cover causes eutrophication which affects living things in the water. Additionally, a high load of sediment affects the growth and regeneration of macrophytes.

According to the respondents, the main cause of exploitation in the wetlands is overgrazing. Grazing pressure has damaged wetlands especially in Gedromesk and Agid kirgna sites quite badly. This, in turn,

has an impact on the vegetation cover and enhances eutrophication due to livestock's wastes. When grazing continuous livestock trample and compact the soil destroys natural vegetation, affects the infiltration capacity of the soil, and erode drainage channels leading to gullies and water outflow (McKee, 2007).

Weed infestation in wetlands is a big problem particularly on the northeast shore of Lake Tana. Water hyacinth is the most invasive and destructive weed found in Agid kirgna. As a result of complete coverage of water hyacinth, the previous benefits provided by Agid kiregna wetland for the local community are being impaired. The overall ecosystem health and benefits are under risk. Nearly, 60% of the respondents agreed that overexploitation was mainly observed in Gedromesk and Agid kirgna sites. As a result, many lakeshore areas of macrophytes were replaced by invasive weeds such as water hyacinth especially in Agid kirgna site (33.33%). Invasive species are one of the major threats to biodiversity in the world due to their effect on the homogenization of the ecosystems (Enserink, 1999).

The result indicates that on average the majority of the respondents share that the most management strategies to conserve and safeguard the wetland ecosystem and benefits are the prohibition of overgrazing and recession farming. The intensive cultivation and free grazing activities in Shesher and Welala wetlands, for example, resulted in drastic shrinkage of their coverage (Atnafu et al., 2011). Recession agriculture is still considered as an advanced mode of development for many people.

Generally, the survey result indicates that the majority of the sampling sites are mainly affected by the changes in the area, water quality and quantity, and the invasion of invasive species. As a result, goods and services provided by the wetlands have decreased and the wetland faces several challenges as a result of human activities on the wetlands. Activities such as recession farming, crop cultivation, free grazing, intensive agricultural land use, nutrient runoff from the upland catchment, unregulated fishing, and illegal hunting are some of the major causes of wetland degradation.

According to the respondents, Gumetirs site was found in a good ecological condition compared to the other two wetlands. In Gumetirs site, free grazing is not allowed rather cut and carries of Echinochloa grass species and Cyprus papyrus reeds are utilized in a sustainable and manageable way.

## CONCLUSION AND RECOMMENDATIONS

Overall, the socioeconomic survey result confirmed that the ranges of wetland benefits significantly related to the degree of disturbance and awareness level of the local community. As a result of human disturbances, wetland benefits varied among sites along the wetlands. This study confirmed that low disturbed wetland supports more socioeconomic benefits than moderately and highly disturbed wetlands. All but the protected (intervened) wetlands were found to be degraded associated with the degree of human disturbances. The result of this study also assured that the presence of better ecosystem services indicate that the wetland is found in good conditions. As recommendation, emphasis should be given to the factors which may lead to the degradation of wetland benefits within and its catchment especially with regards to recession farming, overharvesting, overgrazing and invasion of water hyacinth.

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