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Laniarius mufumbiri photo by Lars Petersson

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Chapter in book:

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Proceeding:

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Effect of habitat disturbance on distribution and abundance of Papyrus endemic birds in Sio Port Swamp, Western Kenya

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Abstract. *Wanyonyi SN, Mwangi EM, Gichuki N. 2018. Effect of habitat disturbance on distribution and abundance of Papyrus endemic birds in Sio Port Swamp, Western Kenya. Bonorowo Wetlands 8: 51-62.* Papyrus (*Cyperus papyrus*) swamps are found patchily around the shores of Lake Victoria, mainly along with river inflows. The objective of this study was to investigate the distinct forms of habitat disturbance and their implications on the distribution and abundance of papyrus endemic birds. Data on bird counts, habitat quality, and types of disturbance were collected for six months, from October 2013 to March 2014. Total bird counts were established using Timed Species Count (TSC) and playback call technique at every fixed point. The researcher waited for 1 minute, calls of the study species were played to elicit a response of the secretive papyrus endemic birds. The number of each bird's species seen or heard within a radius of 25 meters was recorded for the next 9 minutes before transferring to the next point count. Habitat quality such as height, density, and level of maturity was determined in a 1 m^2 plot along transverse transects. Opportunistic observations were made to establish forms of disturbance present during vegetation and bird surveys. Papyrus endemic birds were highly distributed in sites with pure papyrus (55.58%) than in places with mixed plants (44.42%). The abundance of three endemic birds, White-winged Swamp-warbler, Papyrus Gonolek, and Northern Brown-throated Weaver, was significantly different in mixed and pure papyrus sites. However, the abundance of Greater Swamp-warbler was not significantly different in mixed and pure papyrus sites in Sio Port Swamp during the study period. Forms of habitat disturbance established were vegetation clearing and invasion by terrestrial and aquatic plants. As many as 76.47% of papyrus vegetation were young and regenerated (0-2 m high), 19.65% were immature papyruses (2-4 m), whereas 3.88% were tall mature papyruses (4-6 m high). The abundance of papyrus endemic birds was positively and significantly correlated with the vegetation density in height ranging from 4-6 m. Thus, any change in papyrus density changed the abundance of papyrus endemic birds. Advance management of papyrus clearing is necessary for the long-term conservation of biodiversity.

Keywords: Sio Port Swamp, habitat disturbance, habitat quality, Papyrus endemic birds

INTRODUCTION

Wetlands are ecosystems that make up terrestrial and aquatic environments, namely, water, soil, and vegetation (Lathrop 2011). Wetlands occupy about six percent of the earth's surface area (Ramsar Convention Secretariat 2006). The exact extent of Kenya's wetlands is unknown due to the lack of a wetlands inventory. Nevertheless, it is estimated to be 3-4 percent of Kenya's landmass (Kenya Wetlands Atlas 2012) that can temporarily rise to 6 percent in the rainy season (Mwakubo and Ikiara 2006; Kenya Wetlands Forum 2012).

Papyrus swamps dominated by *Cyperus papyrus* form a distinctive wetland type in tropical Africa, supporting many endemic species (Hughes and Hughes 1992). In Kenya, papyrus swamps are patchy and are found primarily along river inflows and at the mouth of main rivers and lakes (Britton 1978; Bennun and Njoroge 1999; Boar et al. 1999). Papyrus swamp occurs as intact patches of continuous fringe along the shores of Lake Victoria.

Papyrus swamps have essential ecological, hydrological, and economic functions (Mafabi 2000). The ecosystems provide water and primary productivity upon which many animal species rely for survival. Around Lake Victoria are of great significance for wildlife conservation as they host papyrus specialist birds, including the Papyrus Yellow Warbler *Chloropeta glacilirostris*, Papyrus Gonolek *Laniarius mufumbiri*, White-winged Swamp Warbler *Bradypterus carpalis*, Papyrus Canary *Serinus koliensis*, and Carruthers's Cisticola *Cisticola carruthersi* (Van de Weghe 1981; Nasirwa and Njoroge 1997; Bennun and Njoroge 1999; Mafabi 2000; Byaruhanga et al. 2001; BirdLife International 2004). Papyrus Yellow Warbler and Papyrus Gonolek are listed as globally threatened and require urgent conservation action (BirdLife International 2004).

Increased human population, especially in sub-Saharan Africa, has led to a decline in wetland goods (Balirwa 1998). Poverty amongst riparian communities has led to unsustainable encroachment on wetland ecosystems leading to continuous drainage, pollution, overexploitation, and unsustainable use of wetland resources. Africa's total region covered by papyrus swamps is approximately 4,000 km^2 (Percy FitzPatrick Institute of African Ornithology 2005). The extent of most wetlands is probably decreasing because of human encroachment and intensified land-use changes around them (Hughes and Hughes 1992; Mafabi 2000; Kairu 2001).

MATERIALS AND METHODS

Study area

Sio Port Swamp is located in the Lake Victoria North Drainage basin on the Kenya-Uganda border (Figure 1), at latitude 0.2242^0N and longitude 34.0217^0E, at an altitude of 1,130 m above sea level (Bennun and Njoroge 1999). It is located in Busia County in the western part of Kenya. Sio Port Swamp is an inland wetland, a permanent herbaceous swamp, and bog. It consists of other interconnected subsystems that drain Lake Victoria (Kenya Wetland Atlas 2012). This swamp is dominated by papyrus *Cyperus papyrus* vegetation. The swamp has an area of 400 hectares, and it is fed by River Sio, which originates from the southern slopes of Mt. Elgon (Barasa et al., 2011). The river is permanent and has a total length of 85 km and a catchment area of 1,388 km^2 (GoK 2009).

This study was carried out between October 2013 to March 2014 (six consecutive months). The study period comprised two seasons; wet (October to December) and dry (January to March). Five bird species endemic to the papyrus habitat were studied, i.e., White-winged Swamp-warbler *Bradypterus carpalis*, Papyrus Gonolek *Laniarius mufumbiri*, Greater Swamp-warbler *Bradypterus rufescens*, and Northern Brown-throated Weaver *Ploceus castanops*.

General methods

Stratification of the study site

Sio Port Swamp had vegetation ranging from tall grass to papyrus at different stages of regeneration. The most dominant plant was papyrus. Some regions had pure papyrus vegetation that was almost undisturbed, while some areas had a mixture of grass and papyrus vegetation. The variations in papyrus distribution were used as the basis for the stratification of the swamp.

Transverse transects were selected from the pathways fishers and other local people used to access the lake from the land. Five transects were identified based on the ability to penetrate the papyrus habitat without necessarily creating additional paths, which would otherwise have been tedious, expensive, and destructive. Transects had local names as Ongaro, Sio, Daniel, Busijo a, and Busijo b (Figure 1. A).

Sio, Busijo a, and Busijo b had a mixture of papyrus vegetation and grass, and they were identified as mixed papyrus (MP) (Figure 2. A). Ongaro and Daniel had almost undisturbed papyrus vegetation; they were classified as pure papyrus (PP) (Figure 2. B)

Transects were of varying lengths and had a different number of sampling points (Table 1).

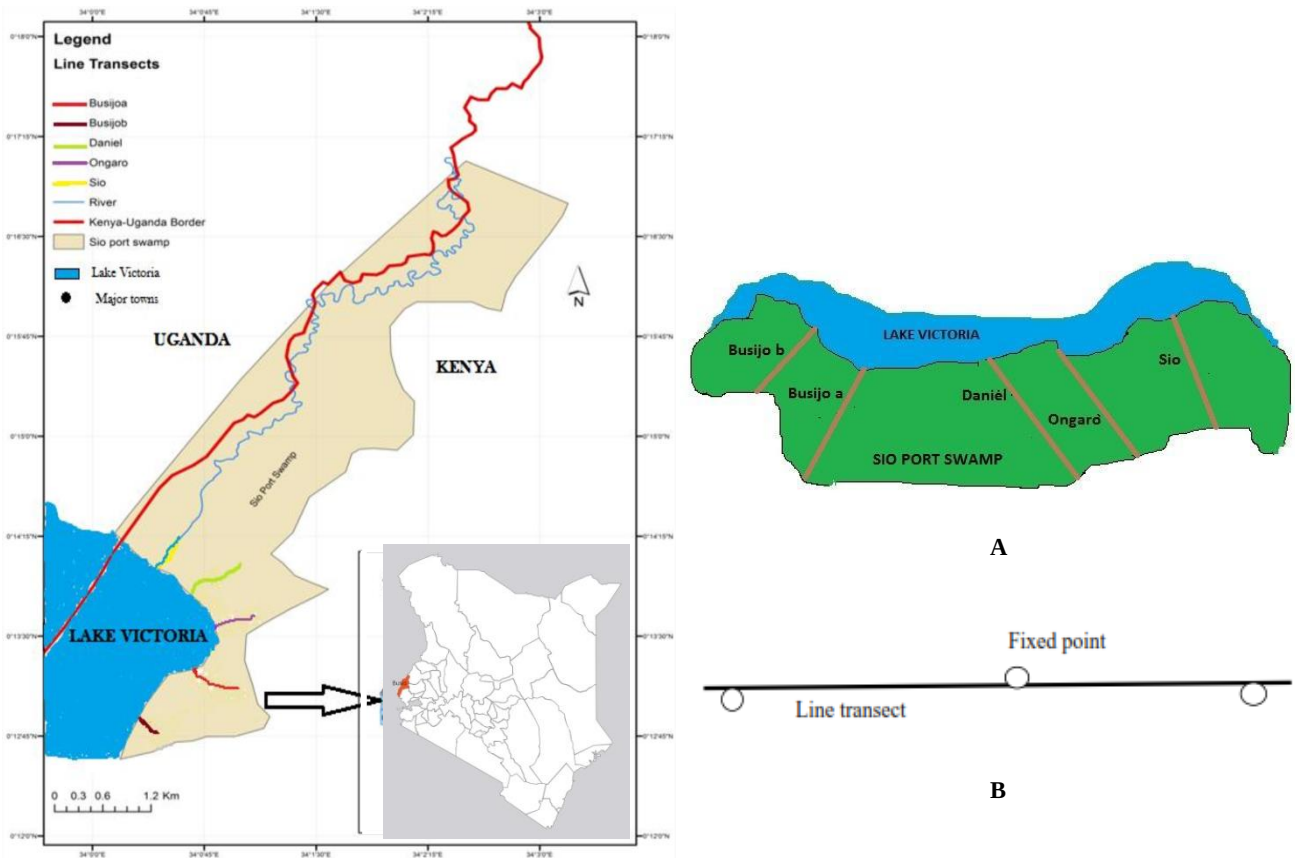

Figure 1. Study area showing features and line transects at Sio Port Swamp, Busia County, Western Kenya. A. Sketch map for the study site in Sio Port Swamp, Western Kenya, showing the transverse transects. B. Fixed points set up along a line transect

Figure 2. Sections of mixed papyrus (A) and pure papyrus stratum (B) in Sio Port Swamp, Western Kenya (Photo by SNW, Jan 2014)

Table 1. Transect name, length, and the number of points present in the Sio Port Swamp, Western Kenya

Stratum	Transect name	Transect length (m)	Number of points per transect
Mixed papyrus (MP)	Sio	300	7
Mixed papyrus (MP)	Busijo a	200	5
Mixed papyrus (MP)	Busijo b	50	2
Pure papyrus (PP)	Ongaro	200	5
Pure papyrus (PP)	Daniel	500	11

Establishment of observation points

Observation or fixed points were identified systematically according to the nature of the habitat and marked using a GPS along the transverse line transects, at least 50m apart. The observation points were set up alternating left and right along the transects (Figure 1. B).

Specific methods

Estimation of the population size of endemic birds

The birds were observed between 0700 hrs and 0900 hrs every morning of each day of the study period. Most fishers would have returned to the beach after their catch during this time. Hence there was minimal disturbance while conducting the counts.

Timed species count technique and playback calls were used to detect and estimate the number of individual bird species using the habitat. The timed species count (TSC) method involves repeated species lists. Each species is recorded the first time positively identified by either sight or sound (Bennun and Howell 2000; Sutherland 1996). The playback call technique involves playing recorded sounds of the target bird species. It is mainly used to elicit a response from secretive birds, which on hearing the calls, will call back or move in search of the 'other' bird.

At every fixed-point count, the researcher waited for 1 minute, calls of the study species were played to elicit a response of the secretive papyrus endemic birds. The number of each species of birds seen or heard within a radius of 25 meters was recorded for the next 9 minutes prior at every point count. Birds seen or heard beyond the set distance were not included. Observations were carried out in all directions, with observers standing back to back to reduce chances of double countings, such as when a bird flew from one side to the other. A pair of binoculars was used to observe cases where a bird could not be easily recognized due to interception by vegetation. The inspection was done at all the fixed points along all transects.

Identification of forms of disturbance

Opportunistic observations were made along transects to establish any disturbance present. The types of disturbance were placed into two main categories: vegetation clearing and invasion by terrestrial or invasive plants. Vegetation clearing involves vegetation cutting, cultivation, vegetation burning, and livestock grazing. The frequency of occurrence of each type of disturbance was recorded during the vegetation and bird surveys along all transects.

Determination of quality of habitat

Vegetation height and density were used to describe the habitat quality in Sio Port Swamp. The previous report indicated that local papyrus habitat-specific characteristics, i.e., height and percentage cover, provided the best means of predicting the existence of papyrus specialist birds because the birds are sensitive to papyrus physical structure (Owino and Ryan 2006). The height of papyrus culm was also described regarding the stages of maturity: young, immature, and mature (Sutton and Hudson 1981).

At every fixed point, a plot of 1m by 1m was set up using the pieces of marked wood. The number of papyrus culms in each plot was counted and recorded to give density. A long pole and part of the stick marked at different length intervals (in meters) were used to estimate the height of papyrus vegetation. The height of each stem or culm sampled was recorded in either of the three height ranges; 0-2 m, 2-4 m, and 4-6 m coinciding with the variety of young papyrus, immature papyrus, and mature papyrus, respectively.

Data analysis

Data on bird counts, vegetation density, and vegetation height were subjected to statistical analysis where the size, mean, and standard deviation were calculated. The normality was analyzed using the Shapiro-Wilk test of the p-value followed by log transformation of skewed data where necessary (Zar 2010). Data analysis was done using IBM SPSS Statistical software version 20.

The number of birds counted at each vegetation stratum was assumed to be independent. The density of individual bird species was determined by dividing the number of birds of each species by the total area sampled (5.89 ha).

The population size of individual bird species was estimated using the incomplete count method, which does not involve the number of birds occurring beyond the estimated radius (25 meters). The nature of papyrus vegetation in the habitat could not allow observations to be made beyond 25 meters. This population size (Burnham et al. 1980) methods were used where;

N = estimated bird population size

A = total area of the study site (ha)
Z = number of individuals of a species counted 24
X = total distance covered
Y = double width of radius

Analysis of Variance compared the distribution of papyrus endemic birds in points along transects determined the difference in the plenty of the endemic birds in pure and combined papyrus stratum. Furthermore, it compared vegetation density of different height ranges in mixed and pure papyrus strata.

Bar graphs were constructed using the density of endemic birds calculated in all sites to reveal the average distribution of the birds in points along transects.

Culm height and culm density determined the birds' habitat quality. These are essential characteristics for papyrus specialist birds, as they provide suitable habitat conditions for nesting and feeding (Owino and Ryan 2006). Data on vegetation height was organized into various classes (0-2 m, 2-4 m, and 4-6 m). The average height for each class was then determined in all transects for all the vegetation sampled. Correlation analysis examined the relationship between vegetation density and vegetation height. In contrast, regression analysis (performed only for significant correlation) was used to determine the relationship between the numbers of birds of each species with vegetation density.

RESULTS AND DISCUSSION

Species and abundance of Papyrus endemic bird

A total of four papyrus endemic birds, namely, Papyrus Gonolek, White-winged Swamp-warbler, Greater Swamp-warbler, and Northern Brown-throated Weaver, were observed in Sio Port Swamp and studied during the period between October 2013 and March 2014.

Four species comprised of 501 individuals (White-winged Swamp-warbler; Papyrus Gonolek; Northern Brown-throated Weaver and Greater Swamp-warbler) were recorded during the study. Out of this number, 222 were Northern Brown-throated Weaver, 114 were White-winged Swamp-warbler, 101 were Papyrus Gonolek, and 64 were Greater Swamp-warbler. Table 2 summarized the estimated density, population size, and proportion of the four endemic bird species studied in Sio Port Swamp (400 ha).

Table 2. Estimated densities and population size of papyrus endemic birds studied in Sio Port Swamp, Western Kenya (October 2013-March 2014)

Bird name	Density (birds/ha)	Estimated population size	Proportion (%)
White-winged Swamp-warbler	19.36	7,296	23
Papyrus Gonolek	17.16	6,464	20
Northern Brown-throated Weaver	37.71	14,208	44
Greater Swamp-warbler	10.87	4,096	13

Table 3. Forms of disturbance in points along transects in the Sio Port Swamp, Western Kenya (October 2013 to March 2014)

Transect name	Form of disturbance	Points where recorded
Sio	Vegetation clearing	II, IV, V, and VI
	Invasion	All points
Busijo a	Vegetation clearing	III
	Invasion	All points
Busijo b	Vegetation clearing	I and II
	Invasion	II
Ongaro	Vegetation clearing	II, III, IX, and X
	Invasion	None of the points
Daniel	Vegetation clearing	II, III, IV, and V
	Invasion	III, IV, and V

Habitat disturbance in Sio Port Swamp

Forms of disturbance in Sio Port Swamp

The types of vegetation disturbance recognized during the study were vegetation clearing and invasion by terrestrial and aquatic plants. Vegetation clearing was the most trivial form of distress compared to invasion by terrestrial and aquatic plants (Table 3).

Vegetation clearing

Vegetation clearing was mainly done by burning vegetation, livestock grazing, cutting of papyrus culms, and cultivation on the edges of the swamp. Vegetation burning was one of the most frequent forms of vegetation clearing found throughout the study period, and it occurred in patches in parts of the swamp (Figure 3). Papyrus was the primary vegetation affected. Vegetation burning was frequent in the dry season compared to the wet season.

Besides vegetation burning, vegetation cutting was also a common vegetation disturbance in Sio Port Swamp from October 2013 to March 2014. Several patches of cut papyrus were observed in different swamp parts (Figure 4). Mature and old papyruses were the main stages of growth that were cut.

Vegetation cutting was mainly done to obtain culms for making baskets, mats, and for thatching houses. Besides this, vegetation clearing was done to create fish traps within the swamp. Clearing of vegetation to set up fish traps was frequent in the transect named Daniel. Besides fishing deep in the lake, trap fishing was universal, especially by locals who exploited fish mainly for domestic use. The fish traps located across transects were primarily made of papyrus culms (Figure 5. A). Bundles of dry papyrus culms were seen piled next to the fish traps (Figure 5. B).

Vegetation was cleared along the edges of the swamp to create room for cultivation. The main crops planted were sugarcane, kales (Figure 6), and maize. The vegetables were the source of food and income for the local community.

Vegetation clearing through livestock grazing was frequent in the transect named Ongaro and Busijo b. Fifty cows and seventy-three sheep could be seen grazing along the edges of the swamp, where the ground was firm and dry from October 2013 to February 2014. These animals appeared to forage closer to the side of the swamp during

the dry season than during the wet season. Livestock grazing resulted in trampling and vegetation removal along the edges of the swamp, thereby slowing down regeneration. A large concentration of grazing animals harms plants due to selectivity and overgrazing (Kamau 2004).

Invasion by terrestrial and aquatic plants

Invasion by woody terrestrial plants was common in transects located in the mixed papyrus stratum. Hippo grass (*Vossia cuspidata*) (Figure 7. A) was the most common invasive grass growing to heights of about 3-4 m. The other widespread invasive plant was the water hyacinth (*Eichhornia crassipes*) (Figure 7. B). Other invasive plants observed in Sio Port Swamp from October 2013 to March 2014 included; morning glory (*Ipomoea stolonifera*), bulrush (family Cyperaceae), and wandering jew (*Commelina* spp.).

Figure 4. Harvested papyrus in a part of Sio Port Swamp, Western Kenya (Photo by SNW, Feb 2014)

Figure 3. Burnt vegetation in a part of Sio Port Swamp, Western Kenya (Photo by SNW, Feb 2014)

Figure 7. Invasive aquatic grass *Vossia cuspidata* at a distributary of River Sio, Western Kenya (A) and Invasive aquatic plant; water hyacinth *Eichhornia crassipes* (B) (Photo by SNW, Nov 2013 and Jan 2014)

Figure 5. Fish trap set up in Daniel transect (A), piles of papyrus culms next to a fish trap of Sio Port Swamp, Western Kenya (B) (Photo by SNW, Dec 2013)

Figure 6. Cultivation along the edges of Sio Port Swamp, stumps of sugarcane (A), kales and sugarcane (B) of Sio Port Swamp, Western Kenya (Photo by SNW, Dec 2013)

The persistence of such plants could lead to alteration of the structure of papyrus swamps in the long run. The invasion was enhanced by siltation, where the vegetation was swept down the slope from the land to the lake.

Siltation was common in Sio's transect, where River Sio enters Lake Victoria from upstream. The watercolor in this part of the swamp was brown, indicating the presence of soil particles; compared to the color of the water in other parts of the swamp—agricultural activities in the upstream facilitated siltation. However, the water's brown color faded as the Sio transect opened into Lake Victoria. This part of the swamp where sedimentation was common also had the highest rate of sand harvesting activity.

Birds' habitat quality

The quality of the birds' habitat was described regarding the structural characteristics of height and density of vegetation. The height of papyrus culms was also defined regarding the young, immature, and mature growth stages. Examples of habitat disturbance such as clearing vegetation affected the habitat quality (height and density) directly, for instance, by reducing the vegetation cover. The other form of disturbance, that is, invasion by terrestrial and aquatic plants, affected the habitat quality indirectly through, for instance, changing its vertical and horizontal structure.

Vegetation height and density are essential characteristics for breeding birds, especially papyrus specialist birds. Therefore, disturbance effects on papyrus height and density could negatively affect endemic birds.

Vegetation height in mixed and pure papyrus sites

Pure papyrus sites had the highest mean (+SD) vegetation height in all the three height ranges compared to mixed papyrus sites, as shown in Table 4. No significant difference in vegetation with a height in the range of 0-2 m (t =-2.088, df = 18, p = 0.081) both in mixed and pure papyrus sites. However, there was a significant difference in vegetation with a height in the range of 2-4 m (t =-5.966, df = 18, p = 0.000) and 4-6 m (t =-2.424, df = 9, p = 0.038) in mixed and pure papyrus sites.

Pure papyrus sites recorded the highest mean height of vegetation in all ranges compared to the mixed papyrus sites. Pure papyrus sites were least disturbed; hence the top mean height for the plant was recorded in all height ranges.

Vegetation density in mixed and pure papyrus sites.

V papyrus sites had the highest mean (+ SD) vegetation density than pure papyrus sites (Table 5). Despite the difference in the mean frequencies of the plant in mixed and pure papyrus sites, t-test results showed that they were not significantly different (t = 2.079, df =18, p = 0.052).

Mixed papyrus sites had the highest mean ($\pm$ SD) density than the pure papyrus site in all height ranges (Table 6. There was a significant difference in the density of vegetation with a height in the range of 0-2 m (t = 2.495, df = 18, p = 0.023) in mixed and pure papyrus sites.

On the other hand, pure papyrus sites had the highest mean ($\pm$ SD) density of vegetation with a height in the range of 2-4 m and 4-6 m. [Table 3.5]. There was no significant difference in the density of vegetation with a height in the range of 2-4 m (t = -0.223, df = 18, p = 0.826) in mixed and pure papyrus sites. However, there was a significant difference in the density of vegetation with a height in the range of 4-6 m (t = -2.387, df = 9, p = 0.041) in the mixed and pure papyrus sites.

Mixed papyrus sites had the highest mean density of young papyrus vegetation (0-2 m high) than pure papyrus sites. Both strata had a small number of immature papyrus vegetation (2-4 m high). Tall mature papyrus vegetation (4-6 m high) was scanty in the two strata, though higher in pure papyrus sites than in mixed papyrus sites (Table 6).

Table 4. Average (+SD) height of vegetation in three ranges in mixed and pure papyrus sites in Sio Port Swamp, Western Kenya

	Height range		
Stratum	**0-2 m (n)**	**2-4 m (n)**	**4-6 m (n)**
Mixed papyrus site	1.246 + 0.439 (419)	2.45 + 2.235 (86)	4.356 + 0.167 (8)
Pure papyrus site	1.327 + 0.411 (153)	4.070 + 1.304 (61)	4.457 + 0.238 (21)

Table 5. Average (+ SD) density of vegetation in mixed and pure papyrus sites in Sio Port Swamp, Western Kenya

Site (n)	**Mean density (stems/m^2)**
Mixed papyrus site (513)	42.75 + 15.23
Pure papyrus site (235)	29.38 + 8.86

Note: n = total number of vegetation culms

Table 6. Average (+ SD) density (stems/m^2) of vegetation in three height ranges in mixed and pure papyrus sites height range in Sio Port Swamp, Western Kenya

Stratum	**0-2 m (n)**	**2-4 m (n)**	**4-6 m (n)**
Mixed papyrus sites	34.92 + 16.64 (419)	7.17 + 2.887 (86)	0 (8)
Pure papyrus sites	19.13 + 5.276 (153)	7.63 + 3.739 (61)	2.63 + 2.387 (21)

Relationship between vegetation height and vegetation density

Vegetation height in the range of 0-2 m was positively but not significantly correlated (r = 0.129, p = 0.589) with vegetation density. Vegetation height in the range of 2-4 m was negatively but not significantly correlated (r = -0.066, p = 0.787) with vegetation density. Vegetation height in the range of 4-6 m was positively correlated (r = 0.896, p = 0.000) with vegetation density; the correlation was highly significant. Regression equation produced by the relationship was y = 0.714x + 0.605, t = 4.331, p = 0.000 and the relationship was statistically significant. A change in the height of papyrus vegetation resulted in a corresponding change in the density of papyrus vegetation. However, the change was not significant for papyrus vegetation in the range of 0-2 m and 2-4 m. But, the change was significant for papyrus vegetation in the range of 4-6 m.

Distribution of papyrus endemic birds in Sio Port Swamp

The frequency of occurrence of birds along transects

The distribution of papyrus endemic birds along transects varied in various swamp parts. The delivery could have resulted from different forms of disturbance influencing the nature of vegetation along each transect.

Sio

Papyrus endemic birds did not occupy all points along Sio transects. Greater-swamp Warbler did not appear in points VI and VII along transect Sio. Northern Brown-throated Weaver was the only papyrus endemic bird recorded in point VII (Figure 8. A).

Analysis of Variance test results revealed that the distribution of papyrus endemic birds in point IV ($F_{(3, 24)}$ =3.542, p = 0.033) was significantly different. However, the distribution of the papyrus endemic birds in point I ($F_{(3, 24)}$ =2.237, p = 0.115), point II ($F_{(3, 24)}$ =0.333, p = 0.801), point III ($F_{(3, 24)}$ =1.382, p = 0.277), point V ($F_{(3, 24)}$ = 0.333, p = 0.801), point VI ($F_{(3, 24)}$ =1.022, p = 0.404) and point VII ($F_{(3, 24)}$ = 1.000, p = 0.413) was not significantly different along Sio transect.

Points II, III, V, and VI were primarily affected by clearing vegetation through burning and harvesting, which, in turn, reduced the vegetation cover hence the low number of some of the birds such as the Greater Swamp-warbler. The great invasion by terrestrial and aquatic plants was recorded in I, II, and III points. Still, it did not affect the distribution of the endemic birds along the Sio transect.

Busijo a

In transect Busijo a, all points were occupied by the papyrus endemic birds, albeit the distribution along the transect was uneven. For example, White-winged Swamp-warbler and Northern Brown-throated Weaver distribution were high in point II of the transect but low in point V of the same transect. In the spot, I of the transect, Greater Swamp-warbler, and Papyrus Gonolek were highly distributed. The distribution of Greater swamp warbler was low in point III, while that of Papyrus Gonolek was low in spot V. Point II recorded the highest distribution. In contrast, point V recorded the smallest distribution of three of the five endemic birds (Figure 8. B).

Analysis of Variance test results showed that the distribution of papyrus endemic birds in point II ($F_{(3, 24)}$ = 3.649, p = 0.030) was significantly different along transect Busijo a. However, the distribution of papyrus endemic birds in point I ($F_{(3, 24)}$ = 1.319, p = 0.296), point III ($F_{(3, 24)}$ = 2.560, p = 0.084), point IV ($F_{(3, 24)}$ = 1.718, p = 0.195) and point V ($F_{(3, 24)}$ = 0.085, p = 0.968) along transect Busijo a was not significantly different.

All points along transect Busijo a were invaded by terrestrial and aquatic plants hence the unequal distribution of the papyrus endemic birds in the five positions along the transect. Point III was the only point affected by the clearing of vegetation, thus changing the distribution of papyrus endemic birds, which was dropped at this point for most of the birds (Figure 8. C).

Busijo b

Transect Busijo b had a small number of five papyrus endemic birds. Northern Brown-throated Weaver was highly distributed in both points along the transect, followed by Papyrus Gonolek and Greater Swamp-warbler. White-winged Swamp-warbler was only distributed at one point along the transect (Figure 8.D).

The distribution of papyrus endemic birds in point I ($F_{(3, 24)} = 1.827$, $p = 0.175$) and point II ($F_{(3, 24)} = 2.078$, $p = 0.135$), was not significantly different along transect Busijo a. Two forms of disturbance that altered Point II include vegetation clearing and invasion by terrestrial and aquatic plants, while point I was only affected by vegetation removal. However, the endemic birds were lowly distributed in the two points due to low vegetation cover and low density of tall papyrus vegetation.

Daniel

Papyrus endemic birds have distributed unevenly in all points along transects Daniel. Point V recorded the lowest distribution of Papyrus Gonolek, Northern Brown-throated Weaver, and Greater Swamp-warbler. White-winged Swamp-warbler was highly distributed in position II, Northern Brown-throated Weaver, Papyrus Gonolek, and Greater Swamp-warbler were highly distributed in position III (Figure 8. E).

ANOVA results showed that the distribution of papyrus endemic birds in point III ($F_{(3, 24)} = 3.093$, $p = 0.050$) and point IV ($F_{(3, 24)} = 4.731$, $p = 0.012$) along transect Daniel was significantly different. However, the distribution of papyrus endemic birds in point I ($F_{(3, 24)} = 0.728$, $p = 0.547$), point II ($F_{(3, 24)} = 2.692$, $p = 0.074$) and point V ($F_{(3, 24)} = 0.982$, $p = 0.421$) along transect Daniel was not significantly different.

Points IV and V were affected by vegetation clearing and invasion by terrestrial and aquatic plants, hence the small number of papyrus endemic birds recorded in these points. Even though vegetation clearing was found in most of the points along the transect, papyrus endemic birds still existed in some of these points. Mature papyrus was the main stage of growth that was cut, leaving behind the young and immature papyrus that the endemic birds still inhabited.

Ongaro

Papyrus endemic birds are distributed unevenly along transect Ongaro, with some points lacking these birds. Greater Swamp-warbler, Papyrus Gonolek, and White-winged Swamp-warbler did not occur in some parts along the transect.

Greater Swamp-warbler did not occur in points II, III, IX, and X. White-winged Swamp-warbler did not happen in spots IX, X, and XI. Papyrus Gonolek did not happen in locations VIII, IX, and X. However, Northern Brown-throated Weaver occurred in all points along the transect (Figure 8. F).

Analysis of Variance test results demonstrated that the distribution of papyrus endemic birds in point I ($F_{(3, 24)} = 6.152$, $p = 0.004$), point II ($F_{(3, 24)} = 3.667$, $p = 0.030$), point V ($F_{(3, 24)} = 3.273$, $p = 0.042$), point IX ($F_{(3, 24)} = 10.000$, $p = 0.000$) and point X ($F_{(3, 24)} = 7.353$, $p = 0.002$) was significantly different along transect Ongaro. However, the distribution of papyrus endemic birds in point III ($F_{(3, 24)} = 1.425$, $p = 0.265$), point IV ($F_{(3, 24)} = 0.510$, $p = 0.680$), point VI ($F_{(3, 24)} = 2.222$, $p = 0.117$), point VII ($F_{(3, 24)} = 1.528$, $p = 0.238$) and point XI ($F_{(3, 24)} = 1.286$, $p = 0.307$) was not significantly different along transect Ongaro.

Vegetation clearing was noted in points II, III, VI, IX, and X. Tall mature papyrus was profoundly affected. Some papyrus endemic birds were not distributed in some of these points since they preferred tall, dense papyrus vegetation because they are very secretive.

Distribution of birds across Sio Port Swamp

Papyrus endemic birds were unevenly distributed across Sio Port Swamp, starting from transect Busijo a to the left to transect Sio to the right. The distribution of the majority of the papyrus endemic birds across Sio Port Swamp tends to increase. The distribution of all the endemic birds was lowest in transect Busijo b and highest in transect Ongaro (Figure 8. G).

Papyrus endemic birds were lowly distributed across the swamp, where enormous disturbance effects. The influence of disturbance on vegetation height and density lowered the quality of the habitat to support papyrus endemic bird species.

Analysis of Variance tests showed that the distribution of papyrus endemic birds; White-winged Swamp-warbler ($F_{(4, 16)} = 0.331$ $p = 0.852$), Papyrus Gonolek ($F_{(4, 16)} = 1.182$, $p = 0.367$), Northern Brown-throated Weaver ($F_{(4, 16)} = 0.826$, $p = 0.533$) and Greater Swamp-warbler ($F_{(4, 16)} = 1.907$, $p = 0.174$) was not significantly different across the swamp in all the five transects.

The abundance of papyrus endemic birds along the disturbance gradient in Sio Port Swamp

From the total 501 individuals of the target bird species, 44% were recorded in mixed papyrus sites, while 56% were found in pure papyrus sites. The abundance of individual species in the two habitats did not vary significantly (Table 7). However, the Northern Brown-throated Weaver, White-winged Swamp-warbler, and Papyrus Gonolek predominantly occurred in pure papyrus stands.

Table 7. The abundance of papyrus endemic birds in mixed and pure papyrus sites in Sio Port Swamp Oct 2013-Mar 2014

Papyrus endemic bird	Number in mixed papyrus sites	Abund. (%)	Number in pure papyrus sites	Abund. (%)
Northern Brown-throated weaver	95	39.09	127	41.78
White-winged Swamp-warbler	49	20.16	65	21.38
Papyrus Gonolek	45	18.52	56	18.42
Greater Swamp-warbler	31	12.76	33	10.86

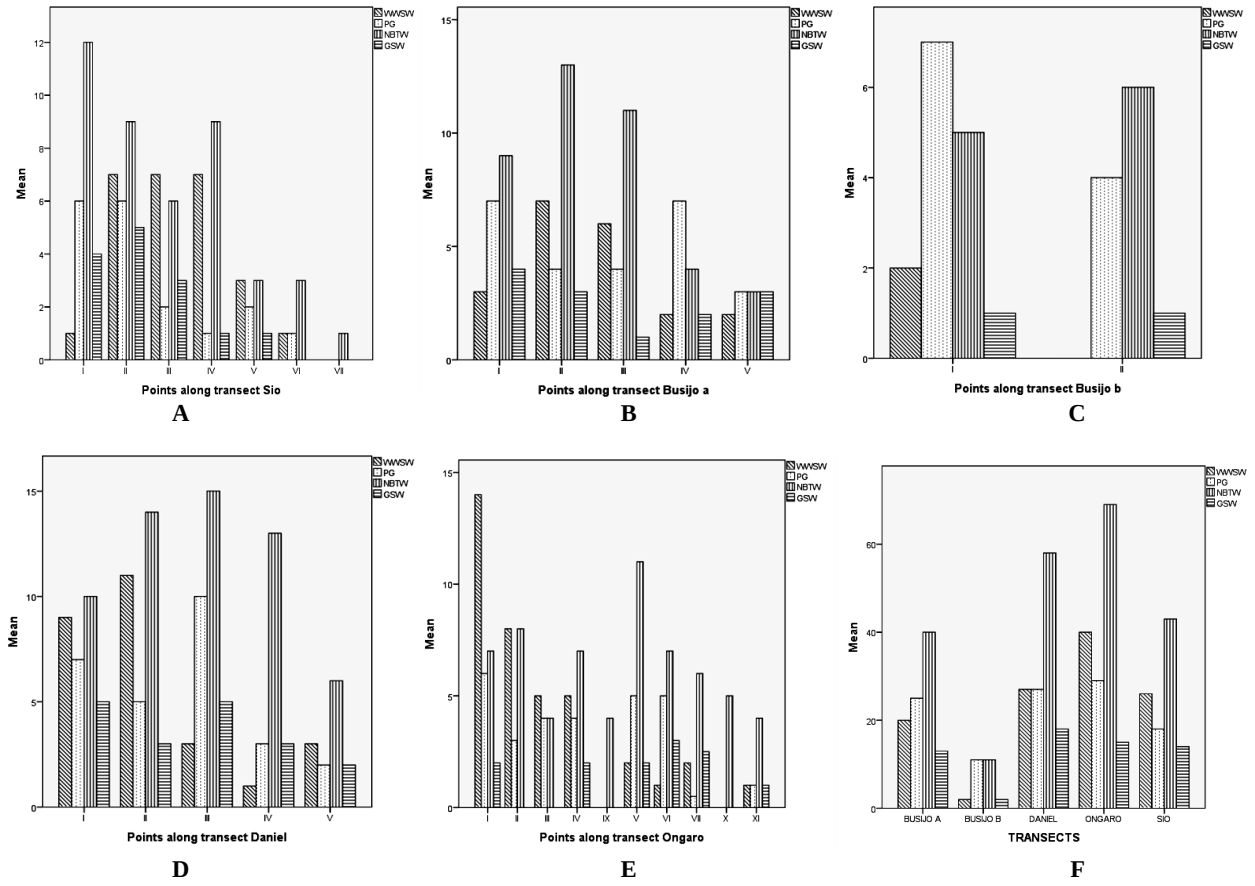

Figure 8. Distribution of papyrus endemic birds along a transect in Sio Port Swamp, Western Kenya. A. Sio (October 2013 to November 2014). B. Busijo a, (October 2013 to March 2014). C. Busijo b, (October 2013 to March 2014). C. Daniel (October 2013 to March 2014). D. Ongaro (October 2013 to March 2014). E. All five transects of Sio Port Swamp. Note: WWSW-White-winge Swamp Warbler, GSW-Greater Swamp Warbler, NBTW-Northern Brown-throated Weaver, PG-Papyrus Gonolek

Analysis of Variance tests showed that the abundance of three out of the four endemic birds White-winged Swamp-warbler ($F_{(1, 28)} = 7.376$, $p = 0.011$), Papyrus Gonolek ($F_{(1, 28)} = 5.331$, $p = 0.029$), and Northern Brown-throated Weaver ($F_{(1, 28)} = 5.734$, $p = 0.024$) was significantly different in mixed and pure papyrus sites. However, the abundance of Greater Swamp-warbler ($F_{(1, 28)} = 2.718$, $p = 0.110$) was not significantly different in mixed and pure papyrus sites.

Papyrus endemic birds preferred sites with pure papyrus over sites with mixed papyrus. Pure papyrus sites had some tall, dense papyrus culms, thus creating a suitable environment for their survival. The tall and dense papyruses were necessary for their breeding and nesting.

The relationship between the abundance of papyrus endemic birds and vegetation density

The plenty of papyrus endemic birds was positively but not significantly correlated ($r = 0.031$, $p = 0.898$) with vegetation density in the sampled locations. Therefore, an increase in vegetation density could cause an overall increasing trend in the abundance of papyrus endemic birds.

The abundance of papyrus endemic birds was negatively correlated with density of vegetation in the height range of 0-2 m ($r = -0.018$, $p = 0.941$) and 2-4 m ($r = -0.054$, $p = 0.822$), albeit not significant. An increase in the vegetation density in the height range of 0-2 m and 2-4 m would reduce the abundance of papyrus endemic birds. Thus, the high vegetation density associated with young papyrus and grass was unfavorable to papyrus endemics.

The abundance of papyrus endemic birds was positively correlated with the vegetation density in the height range of 4-6 m ($r = 0.465$, $p = 0.039$). A change in vegetation density (height range of 4-6 m) could change the abundance of papyrus endemic birds. Regression analysis between stem culm density and number of birds produced a statically significant relationship $y = 2.590x + 0.465$, $t = 2.227$, $p = 0.039$. Change in culm density explained the 44 % variation in bird abundance.

Discussion

Factors influencing the population of papyrus endemic birds

Papyrus swamps are buffers between terrestrial and aquatic ecosystems, acting as silt traps and nutrient filters conserving water quality (Gaudet 1980). Tall stems with or

without inflorescence characterize natural papyrus wetlands. They also consist of areas of green water, dense reeds of young, mature, and immature reeds interspersed with grass and other semi-aquatic herbaceous vegetation. There are also some parts with dead papyrus culms and inflorescence. The dominant vegetation in Sio Port Swamp was papyrus *Cyperus papyrus* with tall culms of about 5.5 m. Papyrus vegetation was densely distributed in some parts of the swamps, but in other regions were patchily distributed. As many as 76.47 % of papyrus vegetation were young and regenerated (0-2 m high), 19.65 % were immature (2-4 m), whereas 3.88% were tall mature papyruses (4-6 m high).

This study suggests that the population of papyrus endemic birds was influenced by the distribution of papyrus, composition of papyrus, culm height, culm density, and presence of forms of disturbance. Papyrus endemic birds were abundant in sites with a high distribution of papyrus. Pure papyrus sites, which had papyrus as the primary vegetation species, had the highest number of papyrus endemic birds than disturbed sites. Mixed papyrus sites had a mixture of vegetation, especially papyrus and grass species, such as *Vossia cuspidata*. Papyrus endemic birds had the lowest number along with the edges of the swamp. Papyrus birds respond to changes in papyrus conditions by distributing themselves in more natural papyrus stands (Owino and Ryan 2006). The population of papyrus endemic birds was influenced by the composition of papyrus vegetation that is young, immature, and mature. Pure papyrus sites are generally composed of immature and mature papyrus. Such sites are inhabited by the high population size of the papyrus endemic birds. Papyrus specialist birds exist in large numbers in tall, dense, and least disturbed papyrus stands (Owino and Ryan 2006).

This study also described that papyrus culm height influences the population of papyrus endemic birds. Pure papyrus sites had the highest average vegetation height in all height ranges compared to mixed papyrus sites. Papyrus endemic birds existed in large numbers in pure papyrus sites compared to various places. Papyrus culm density also influenced the population size of papyrus endemic birds. Pure papyrus locations had a high vegetation density in the height range of 2-4 m and 4-6 m. Mixed papyrus sites, on the contrary, had a high density of vegetation in the height range of 1-2 m. Papyrus endemic birds are significantly associated with the vegetation density in locations, especially with tall papyrus vegetation in the 4-6 m. These results indicate that the endemic birds favored dense pure papyrus vegetation over very dense mixed vegetation.

This study also showed that the presence of various forms of disturbance influenced the population density of papyrus endemic birds. Anthropogenic disturbances on habitats affected the habitat structural characteristics, especially vegetation height and density. These essential characteristics influence the distribution and abundance of papyrus endemic birds in general (Owino and Ryan 2007).

Forms of habitat disturbance, such as papyrus clearing, affected the habitat quality directly by reducing vegetation cover and height. Papyrus is usually cut to provide material to thatch roofs, build fences, and make handicrafts such as mats and trays (Maclean et al., 2003). Other forms of disturbance, such as invasion by terrestrial and aquatic plants, indirectly affected the habitat quality by altering the vertical structure. The abundance of papyrus endemic birds in mixed papyrus sites was lower than that of pure papyrus stands. The type and nature of each disturbance affected the life of the habitat, mainly vegetation cover, which affected the abundance of papyrus endemic birds. In tropical areas, species that benefit from upheaval are often widespread generalists. Generally, disturbance does not favor specialist species confined to one habitat type (Thiollay 1992; Hammer et al. 1997; Hammer and Hill 2000; Barlow et al. 2002).

Factors influencing habitat distribution and structure

From the survey conducted in Sio Port Swamp, habitat distribution was affected by the accessibility of the swamp by the locals. Areas easily accessed by the locals showed a mixture of vegetation species compared to those with minimal visits. An example of this situation is that parts of the swamp closer to the edges where the locals gathered to sell and buy fish had more of Vossia cuspidata than *Cyperus papyrus*.

Besides, accessibility encouraged activities such as livestock grazing and cultivation along the edges of the swamp, which in some areas, extended deep into the swamp. This may have contributed extensively to the presence of invasive terrestrial and aquatic plants and reduction in papyrus cover since locals use it for fuel, mat-making, and thatching of roofs (Abila 1998; Otieno et al. 1998). According to the results of this study, the structure of the habitat is influenced by the forms of disturbance present and their effect on the habitat. Clearing vegetation significantly contributed to the decrease in vegetation cover and domination of juvenile papyrus vegetation in the height range of 0-2 m and 2-4 m.

Our study also proved that the height and stage of growth of vegetation species present in a habitat disturbed the structure of the habitat. For instance, mixed papyrus sites had a higher average vegetation density value than pure papyrus sites. Most vegetation was in the range of 0-2 m. They had a smaller girth and short height than mature papyrus culms of 2-4 m and 4-6 m high, accordingly a high number per square meter. Some negative correlation was found between the number of adults and senescing culms and papyrus culm height. However, young culms are positively correlated with culm density (Maclean et al. 2006)

Impacts of human disturbance on habitats and birds

Implications for habitats. This study shows that forms of human interference such as vegetation clearing lower vegetation cover in habitats, therefore lowering their quality to support biodiversity. Papyrus habitat loss represents a potential threat to the conservation of biodiversity (Muthuri et al. 1989; Boar et al. 1999; Fishpool and Evans 2001). It was noted that the local people washed clothes along the edges of Sio Port Swamp and at the landward end of some transects. Livestock

grazing, cultivation, regular visits, and human activities along edges of the swamp led to the trampling of vegetation in such regions. Consequently, it could result in a reduction in the size of the habitat in the long run. The cuts in habitat areas have direct implications on their quality to support species (Andren 1994; Fahrig and Merriam 1994; Noss and Csuti 1997; Bender et al. 1998; Esikuri 1998; Benoit and Askins 2002; Davis 2004).

Impacts on birds. This study showed that human disturbance affects bird distribution and abundance. Various forms of disturbance play a key role in determining the kind of species and their respective numbers to utilize the affected sites. In general, papyrus endemic birds were most abundant in pure papyrus sites. This study demonstrated that Northern Brown-throated Weaver exists in large numbers in almost all sites, both disturbed and undisturbed. These results, therefore, indicate that papyrus specialist birds may survive to some extent in a habitat with various forms of disturbance. Still, the degree of interference will determine the abundance of these birds. Continued degradation of papyrus swamps may affect the ecological requirements of papyrus endemic birds while creating habitats for generalists and even predator species in and around the wetlands. Reduced nesting sites, for instance, may cut the breeding success of these species (Owino and Ryan 2006).

In conclusion, as many as 44% of the papyrus endemic birds utilized mixed papyrus sites while 56% employed pure papyrus sites. Therefore, pure papyrus sites were the most utilized of the two habitats. The habitat structure in Sio Port Swamp was mainly composed of papyrus *Cyperus papyrus*. However, other vegetation types such as Hippo grass, *Vossia cuspidate*, and Water hyacinth *Eichhornia crassipes* were also present. Papyrus vegetation was densely distributed deep within the swamp compared to the edges of the swamp. The primary forms of disturbance observed in Sio Port Swamp were papyrus clearing and invasion by terrestrial and aquatic plants. Papyrus endemic birds preferred sites with tall, dense, and minimum disturbed papyrus culms. Even though they seemed to be around in the concerned regions, their abundance in such areas was low and limited to the level of disturbance. Habitat disturbance alters the population size of the biodiversity supported by the given habitat. When the population size is modified, the animals or plants are distributed selectively in the different parts of the habitat, depending on habitat degradation. Their abundance is low in profoundly disturbing sites and high in the least disturbed sites. Advance management of papyrus clearing is required for the long-term conservation of biodiversity. Since papyrus vegetation is known to regenerate rapidly and has high productivity following disturbance (Muthuri et al. 1989; Boar et al. 1999), the conservation of papyrus can still be compatible with human use if papyrus clearance is regulated.

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Social capital role in the utilization of mangrove ecosystem service for ecotourism on Kutai National Park, East Kalimantan, Indonesia

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[1]Forest Resources Conservation, Program of Forestry, Sekolah Tinggi Pertanian Kutai Timur. Jl. Ahmad Dahlan, Bebika Number 18, Sanggatta Utara, East Kutai District 75611, East Kalimantan Province, Indonesia. ♥email: iinsumbada@stiperkutim.ac.id
[2]Department of Forest Resources Conservation, Faculty of Forestry, Universitas Gadjah Mada. Sleman 55281, Yogyakarta, Indonesia
[3]Department of Forest Management, Faculty of Forestry, Universitas Gadjah Mada. Sleman 55281, Yogyakarta, Indonesia

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Abstract. *Sulistyorini IS, Poedjirahajoe E, Faida LRW, Purwanto RH. 2018. Social capital role in the utilization of mangrove ecosystem service for ecotourism on Kutai National Park, East Kalimantan, Indonesia. Bonorowo Wetlands 8: 63-70.* Social capital has an important role in mangrove ecosystem preservation. Changes to mangrove ecosystem services can affect elements of social capital. Ecotourism is one of the alternatives that can be developed in the mangrove area in the National Park. The purpose of the study was to give an overview of the correlation between several elements of social capital in supporting ecotourism in mangrove areas. This study was conducted in five villages in East Kutai Regency, East Kalimantan, namely Singa Geweh, Sangkima, Teluk Singkama, Teluk Pandan and Kandolo. There were 530 respondents from the five villages involved as informants or resource persons. The data were analyzed using the Sequal Equation Modeling Partial Least Square (SEM-PLS) method with SmartPLS. Based on the initial assessment by the scoring method, five social capitals, i.e., trust, networking, community involvement, social norm, and concern to mangrove, had low criteria to support ecotourism in Kutai National Park (KNP) mangrove area. According to SEM-PLS analysis of the social capital variables, community involvement, social norms, and trust negatively affected ecotourism. Trust and community involvement were relatively low in the four villages (Singa Geweh, Sangkima, Teluk Singkama, and Kandolo). They were associated with social norms. On the other hand, concern for mangroves, education and income levels, and networking had positive effects and power to support ecosystem service of mangroves for ecotourism.

Keywords: Community, ecotourism, East Kalimantan, mangrove preservation

INTRODUCTION

The mangrove forest area in Indonesia is about 3.1 million hectares, or approximately 22.6% of the world's mangrove forest area (Giri et al., 2011). In East Kalimantan, the size of mangrove forest is about 367 thousand hectares (Noor et al. 2006). The mangrove forest of Kutai National Park (KNP), located in East Kutai District, East Kalimantan Province, Indonesia, along the coast facing the Makassar Strait, has an area of approximately 5,271.4 hectares or 2.7% of the total KNP areas of 192,709.6 hectares (Gunawan and Sayektiningsih 2014). The latest information by the KNP management unit in 2017, the mangrove area is about 4,766.3 ha or decreased by about 9.6% from the previous area. Bismark and Iskandar (2002) stated that the mangrove forest of KNP continues to experience pressure due to the increase in human activities for settlement, agriculture, and other activities. Budiarsa and Rizal (2013) explained that mangrove conversion in KNP for various activities has continued over the past two decades. The development of a new regency, especially the East Kutai Regency, is suspected to reduce KNP forests' sustainability on the coast significantly.

The mangrove ecosystem is one of several high-productivity ecosystems (Budihastuti et al., 2012). The primary productivity of mangroves ranges from 350 to 500 grams C/m^2/yr in coastal waters, and abroad proportion is founded on the coastline in the tropics (Mann 1982). Mangrove forests also provide valuable ecosystem services for coastal communities, tourist attractions, nature conservation, education, and research (Eddy et al., 2016). The mangrove forest ecosystem of KNP has a high productivity ecosystem role as a source of feed, spawning and conservation areas for aquatic organisms living in the surrounding areas such as fish, crustaceans, mollusks, and others (Budiarsa and Rizal 2014). In addition to the aquatic biota, the KNP mangrove forest is also a habitat for Proboscis Monkey (Nasalis larvatus Wurmb, 1781). It was found in the Sangatta River, French Cape, Sangkima River,, and Kanduung River (Suwarto et al. 2016). Based on this, the KNP mangrove has the potential and opportunities for conservation-based eco-tourism development. Ecotourism is also expected to be used to campaign for the protection and integrity of conservation areas.

Maintaining the existence of mangrove forests in KNP needs a sustainable development of forest utilization based on the ecotourism concept (Daryono 2014). The utilization and management of sustainable mangrove forests require a multi-dimensional and fundamental concept that can affect all categories of ecosystem services (Barnes-Mauthe et al.,

2015), known as social capital. Research on the topic of social capital has gained much attention from researchers around the world, especially in the perspective of collective action (Asmin et al., 2017). The development and changing of socio-cultural conditions of society have provided new challenges in the management of the National Park. This study aimed to provide information for the conservation policy of mangrove forests by exploring the diversity of ecosystem services value for ecotourism based on the importance of social capital, which can be further used as a guideline in the development and utilization of the mangrove forests.

MATERIALS AND METHODS

Study site description

Since 2001 the area of KNP has been 198,269 hectares, then in 2014, the area becomes 192,709.6 hectares or decreased about 5,560 hectares. Reduction of the area due to the enclave for settlement community areas such as Teluk Pandan, Kandolo, Teluk Singkama, Sangkima, South Sangatta, and Singa Geweh Village. This study was conducted in five villages located in the coastal regions of KNP. The three villages (Singa Geweh, Sangkima, Teluk Singkama) located in Sangatta Selatan sub-district and two villages (Teluk Pandan and Kandolo) located in Teluk Pandan sub-district on East Kutai Regency, East Kalimantan (Figure 1). The study period starts from September 2017 to December 2017.

Sampling and data collection

A direct interview carried out the social capital data of the community in a structured way to the respondents (guidelines with a questionnaire). Respondents were determined proportionally from the number of household heads in the five villages. The total number of respondents from the five villages was 530 households, which was two folds higher than the minimum number of samples/respondents based on the Luck and Rubin formula (Luck and Rubin 1987; Jakpar and Goh, 2012), increasing the validity of the data. Social capital has been conceptualized into three levels, i.e., micro, meso, and macro. The measurement at the micro-level was conducted at the household or individual level (Grootaert et al., 2003). The micro-level measurement (measuring household living standards) became the survey's focus in this study. Data collected included respondents' characteristics: formal education level and income level (X1). Social capital data includes trust (X2), networking (X3), social norm (X4), community involvement (X5), concern to the environment (X6), attitude or perception to the utilization of mangrove for ecotourism (Y1). The seven latent variables and the 35 indicators are described in Table 1.

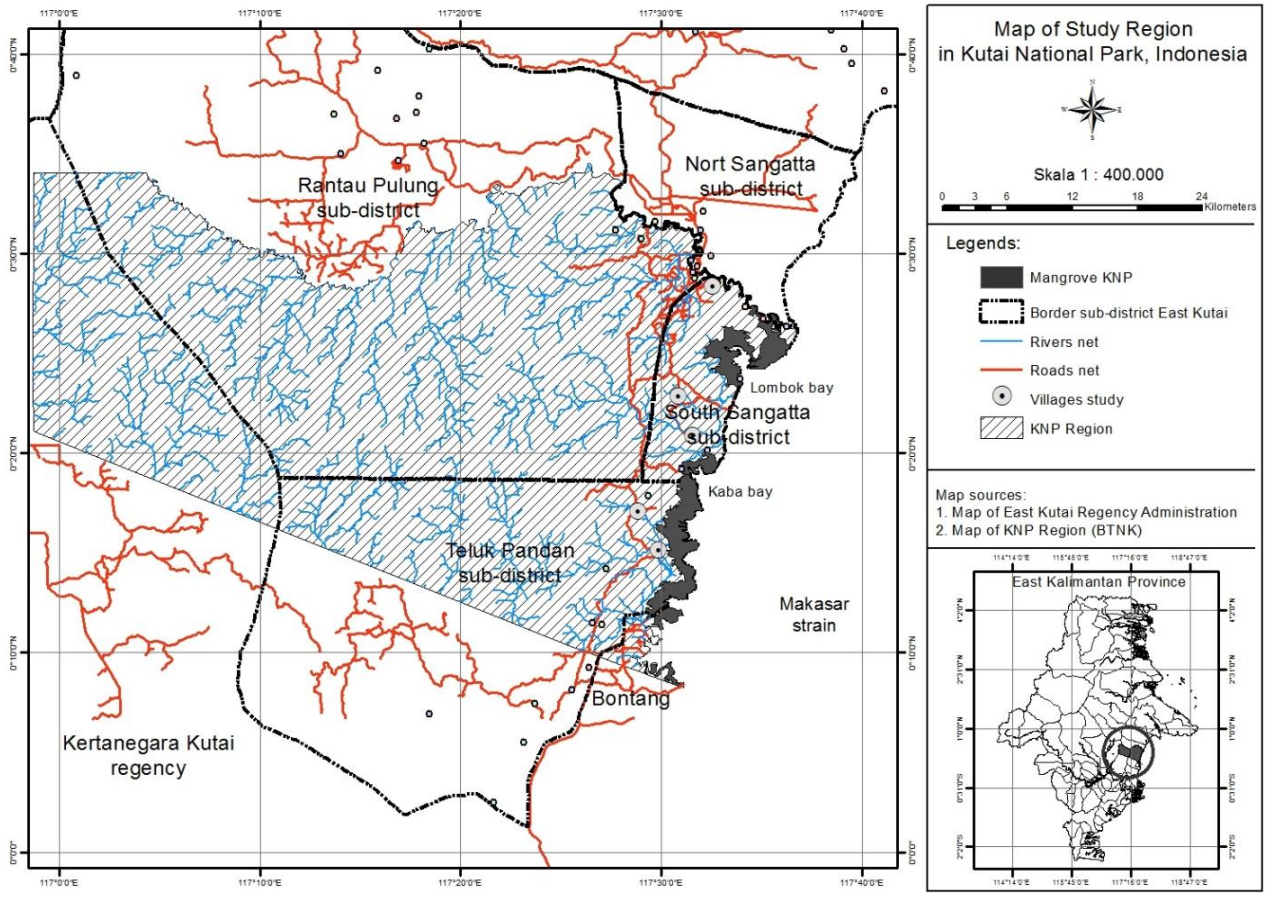

Figure 1. Location of study sites in the mangrove forest of Kutai National Park (KNP), East Kutai District, East Kalimantan, Indonesia

Table 1. Latent variables and indicators description

Latent variables	Indicator description	
Education and income level (X1)	Education level	X11
	Income level	X12
Trust (X2)	KNP management unit	X21
	Local government	X22
	Social norms/rule traditions	X23
	Public figure in local society	X24
	Fellow locals in society	X25
	Outsiders (NGO/Academics/Researcher)	X26
Networking and organization (X3)	Cooperation with KNP management	X31
	Cooperation with local government	X32
	Cooperation with Corporate	X33
	Interested with organizations in the local society	X34
	Cooperation fellow local people	X35
	Leisure to interaction with fellow local	X36
Social norms (X4)	Knowledge of social norms	X41
	Compliance with social norms	X42
	Obedience and implementing social norms	X43
	Implementation of agreed rules at the community organization	X44
	Know and obey the KNP rules	X45
	Know and follow the local government rules	X46
Community involvement (X5)	Follow the meetings initiated by KNP management	X51
	Participation in community service	X52
	liveliness in organizations/meetings in the local community	X53
	liveliness in criticizing to KNP and local government in mangrove management	X54
	Contribution of ideas to KNP and local government in mangrove management	X55
Concern to mangrove ecosystem (X6)	Knowledge that mangrove forests need to be preserved	X61
	Participation in mangrove conservation activities held by KNP management	X62
	Independently ever do mangrove conservation activities	X63
	Invite fellow local people to preserve mangroves	X64
	The closeness of fellow citizens in mangrove conservation	X65
Response to the utilization of mangrove ecosystem for ecotourism (Y1)	Knowledge of ecotourism in mangrove forests	Y11
	KNP mangrove potential can be used as a tourist attraction	Y12
	Knowing that the mangrove will be a tourist destination by KNP management	Y13
	Involvement in ecotourism activities in mangrove forests	Y14
	Interest in ecotourism in mangroves KNP	Y15

Data analysis

This research was conducted through qualitative and quantitative descriptive approaches. Data analysis of the questionnaire results refers to the Social Capital Assessment Tool (SCAT) (Krishna and Shrader 1999) with minor modifications. Social capital was categorized into five levels: very low (45-81), low (82-118), moderate (119-155), high (156-192), and very high (193-225). The interval value of each level was calculated based on the maximum (225) and minimum value (45) of all social capitals. The correlation among the community's social capital elements was assessed to identify the mangrove ecosystem services for ecotourism. The elements of social capital observed in this research were trust, social norms, social networks, involvement, and concern of the community. The correlations among the variables of the social capital element were analyzed by PLS-SEM (*Partial Least Square-Structural Equation Modeling*) using the SmartPLS 3 to determine the social capital factors triggering the mangrove ecotourism. This model performs beta values of path coefficient that describe the greater the value, the more influential. T-test for interpreting the relationship between variables is if the value of T count > T-table with (α) 0.05 (T-table = 1,96), it comes as a real effect or a significant variable to another variable.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

The majority of household respondents that participated in this survey were male. They accounted for 67% of the total respondents. Most of the respondents (58%) were within 40 years and below. The educational background of the respondents was graduated from elementary school (45%), junior high school (25%), and senior high school (19%). Most of the monthly income of the respondents was IDR 1,000,000.00 and below (49%). About 40% (199 households) of the total respondents reported the extraction of mangrove resources as their full-time occupation. The summary of the socio-economic characteristics of the respondents in the five villages is presented in Table 2.

Table 2. Summary of the socio-economic background of the survey respondents

Variable	Number of respondents (n)					Average (%)
	Singa Geweh (n = 180)	Kandolo (n = 60)	Teluk Pandan (n = 120)	Sangkima (n = 90)	Teluk Singkama (n = 80)	
Gender (%)						
Men	71	72	62	66	66	67
Women	29	28	38	34	34	33
Age group (%)						
40 years and below	67	55	69	44	54	58
41 years and above	33	45	31	56	46	42
Education (%)						
Nonformal education	7	5	3	16	15	9
Elementary school	39	40	43	53	50	45
Junior high school	33	30	33	16	14	25
Senior high school	20	23	19	14	18	19
College/university degree	1	2	3	1	4	2
Household income (IDR/Month) (%)						
IDR 1,000,000.00 and below	33	47	58	60	59	51
IDR 1,000,000.00-1,500,000.00	26	27	30	31	25	28
IDR 1,500,000.00-2,000,000.00	23	15	8	8	10	13
IDR 2,000,000.00-4,000,000.00	13	7	3	1	6	6
IDR 5.000.000 and above	4	5	1	0	0	2
Occupation (Extraction of mangrove resources) (%)	42	25	46	46	40	40

The socio-economics of the community in the five villages were relatively low, especially seen from the level of productive age, income, and education. These three things can affect social capital related to community awareness to support mangrove conservation. The people who settle down in these five villages have lived in KNP for decades. They are mostly migrants from outside Kalimantan. This condition influenced the cultural values and local wisdom, which can impact low norms and trust in social capital. Vayda and Sahur (2005) classified settlers in KNP by 3 regions, namely (i) Teluk Pandan; it was mentioned that Bugis settlers from Bone, South Sulawesi, first came in the mid-1960s, (ii) Selimpus/Kandolo area, first settled in 1974 and developed in 1977 by Bugis tribe and (iii) Sangkima area, first settled in 1924 by Bugis tribe. At that time, Sangkima was also a shifting cultivator for indigenous people, and both tribes were assimilated and settlers more and more in 1954 and 1960. According to BTNK (2005), the three villages are developed. The Governor of East Kalimantan Province has recognized them by defining them as the definitive village (Teluk Pandan, Sangkima, and Sangatta Selatan) through Decree number 06 of 1997 dated 30 April 1997. In its development, Desa Sangatta Selatan is divided into two villages, Desa Sangatta Selatan and Singa Geweh with the Decision of East Kalimantan Governor number 410.44/K.452/1999.

The local government and KNP management unit must think about how to improve the socio-economic life of the community in the conservation area. There are around 199 respondents directly related to KNP mangroves; this is a high potential in community empowerment, especially for mangrove ecotourism programs. Ecotourism certainly cannot stand alone and must be supported by other sectors such as the creative economy that can be developed and collaborated with stakeholders such as companies, local governments, academics, and non-government organizations. Hakim et al. (2017) stated mangroves are important resources, and nature-based tourism became a strategy for mangrove conservation. The success of mangrove tourism in the studied area could be due to a combination of factors, including mangrove site accessibility, local community involvement, the quality of mangrove ecosystems, and the availability of mangrove tourism programs.

Social capital valuation

Assessment by the scoring method to social capital in five villages showed that some elements of the social capital have low value, such as trust, social networking, and social norm, with an average value above 19. Generally, the five villages have not supported the strength of the social capital, including the responses of respondents to mangrove services to ecotourism scored 17.8. The strength of the social capital in this study was in a low category, with an average value of 110.5 (ranging from 82 to 118) (Table 3). The elements of trust social norm in Teluk Singkama and Kandolo had higher scores than the other three villages. The networking elements in Teluk Pandan and Kandolo villages were higher than the other three villages. Elements of community involvement concerning mangrove and mangrove services to ecotourism in Kandolo and Sangkima were higher than in the other three villages. Respondents from the village of Sangkima had a deep concern for mangroves because they are the closest village to mangrove forests and tourism location on the coast of Teluk Lombok KNP. The Kandolo village also had a deep concern for mangroves for ecotourism services because they have access to the mangroves in Teluk Kaba KNP.

Table 3. Minimal, maximal, and mean scores of the social capital variables

Social capital variables	Mean score		Mean
	Min.	Max.	
Education level	2.3	2.8	2.6
Income level	1.5	2.3	1.8
Trust	16.9	22.4	20.5
Social Networking	16.6	20.8	19.3
Social norm	16.5	22.0	20.1
Community involvement	12.5	14.9	13.9
Concern to mangrove	12.8	17.8	14.5
Mangrove services to ecotourism	17.0	18.6	17.8
Mean	96.0	121.6	110.5

The PLS-SEM (*Partial Least Square-Structural Equation Modeling*) analysis was carried out to examine the relation of indicator influence on each variable of the social capital element. The PLS-SEM has been widely used in the social sciences and was recently introduced into ecological studies (Peppler-Lisbach et al., 2015; Miguel et al., 2017). PLS is related to Principal Components Analysis (PCA), but additionally, it allows us to capture information on the relationship between predictive and target variables (Bryce et al., 2016). Based on this analysis, the Average Variance Extracted (AVE) for this study was higher than the value of 0.50 (Table 4), and the internal consistency reliability is higher than the recommended value (Hair et al. 2014; Ghozali 2014; Sözbilir 2018).

Evaluation of the initial measurement model found that the variable indicator could not reflect the construct of the latent variables. The variable had a loading factor value less than 0.5, which needs re-specification by issuing an indicator variable that did not meet the eligibility criteria to improve the validity and reliability of the model. Out of 35 total indicators, several should be deleted for each village, fourteen indicators in Teluk Singkama, ten indicators in Singa Geweh, five in Kandolo, and Teluk Pandan, and four indicators in Sangkima. After the model was re-specified, the PLS algorithm process eventually gave the results that matched the criteria of convergence validity test on the measurement model. The AVE (>0.5) showed that all variables at various significant levels had positive correlations. Composite Reliability analysis (>0.7) can state that the research model was valid and reliable (Table 4).

Social capital owned by individuals or communities is an important resource in an ecosystem that can improve the quality of ecosystem services. The stronger the social capital, the stronger the community's support for sustainable ecosystem services. The social capital tested in this study is represented by six variables, as presented in Table 5. The test had a significance level above the t-table (α 0.05; t-table 1.96). Several hypotheses do not support mangrove forests for ecotourism. The community or respondents in five villages were concerned about mangrove or mangrove services to ecotourism. Then, variable social norms supporting mangrove ecotourism were found in the two villages, i.e., Teluk Pandan and Teluk Singkama villages.

Many variables were not significant based on the analysis of respondents in each village (Table 5). Furthermore, analysis for the entirety (530 respondents) was carried out to clearly know the significant influence of the six latent variables for ecotourism mangrove services. The results were analyzed with the PLS program to re-specify the matched criteria to the convergence validity test on the measurement model (Figure 2). The evaluation of the measurement model through the load factor analysis, average variance extracted analysis value, cross-loading analysis, and composite reliability analysis can state that the research model is generalized to all objects; the research model is valid and reliable. The community involvement, social norm, and trust variables had no positive effect or were not significant to the utilization of mangrove services for ecotourism (Table 6). The overall analysis of the respondents gave slightly different results than the respondents' analysis of each village. One variable was a concern to mangroves, which positively influenced the four villages. While the networking variable had a positive impact in one village, the education and income levels variable had no positive influence in all villages.

The previous research also discovered the low social capital strength (Oktadiyani et al., 2013). The study explains the value of social capital for Kabo Jaya in Swarga Bara village is 173 (enough) and Dusun G III in Singa Gembara village is 159 (not enough). The weak social capital will dim the spirit of mutual cooperation, exacerbate poverty, increase unemployment and crime, and hinder efforts to improve human well-being (Nababan et al., 2016).

Table 4. Assessment of the measurement model (means, AVE, Composite Reliability=CR)

Variables	Singa Geweh			Kandolo			Teluk Pandan			Sangkima			Teluk Singkama		
	Mean	AVE	CR	Mean	AVE	CR	Mean	AVE	CR	Mean	AVE	CR	Mean	AVE	CR
(X1)	2.49	0.65	0.79	2.35	0.79	0.86	2.18	0.70	0.82	1.91	0.75	0.86	2.04	0.67	0.80
(X2)	2.81	0.62	0.87	3.74	0.52	0.84	3.51	0.54	0.88	3,5	0.75	0.90	3.54	0.60	0.75
(X3)	2.76	0.87	0.95	3.46	0.55	0.86	3.35	0.64	0.89	3.30	0.51	0.86	3.32	0.57	0.80
(X4)	2.75	0.67	0.89	3.67	0.52	0.84	3.43	0.52	0.84	3.42	0.51	0.85	3.45	0.60	0.75
(X5)	2.49	0.62	0.83	2.99	0.74	0.92	2.83	0.65	0.88	3.04	0.68	0.89	2.59	0.58	0.81
(X6)	2.68	0.57	0.80	3.02	0.52	0.80	2.68	0.60	0.82	3.56	0.52	0.83	2.56	0.51	0.81
(Y1)	3.40	0.70	0.92	3.71	0.62	0.89	3.37	0.68	0.91	3.72	0.66	0.91	3.59	0.60	0.88

Note: *) according to rule of thumb (AVE > 0.5; CR >0.7)

Table 5. Significance test model after re-specification in the five villages

Latent variables hypotheses	Singa Geweh (180 respondent)		
	Path coefficients	**t-Value**	**Supported?**
Community involvement-> Mangrove services to ecotourism	0.147	1.854	No
Concern to mangrove-> Mangrove services to ecotourism	0.254	3.541	Yes
Education and income levels-> Mangrove services to ecotourism	0.086	1.394	No
Networking-> Mangrove services to ecotourism	0.132	1.728	No
Social norms-> Mangrove services to ecotourism	0.172	1.934	No
Trust-> Mangrove services to ecotourism	0.045	0.490	No
	Kandolo (60 respondents)		
Community involvement-> Mangrove services to ecotourism	-0.111	0.532	No
Concern to mangrove-> Mangrove services to ecotourism	0.417	2.436	Yes
Education and income levels-> Mangrove services to ecotourism	0.197	1.446	No
Networking-> Mangrove services to ecotourism	0.025	0.135	No
Social norms-> Mangrove services to ecotourism	-0.114	0.632	No
Trust-> Mangrove services to ecotourism	0.220	0.930	No
	Teluk Pandan (120 respondent)		
Community involvement-> Mangrove services to ecotourism	0.165	2.006	Yes
Concern to mangrove-> Mangrove services to ecotourism	0.383	3.779	Yes
Education and income levels-> Mangrove services to ecotourism	0.078	1.029	No
Networking-> Mangrove services to ecotourism	0.101	1.013	No
Social norms-> Mangrove services to ecotourism	0.185	2.085	Yes
Trust-> Mangrove services to ecotourism	-0.078	0.877	No
	Sangkima (90 respondents)		
Community involvement-> Mangrove services to ecotourism	0.166	1.366	No
Concern to mangrove-> Mangrove services to ecotourism	0.005	0.036	No
Education and income levels-> Mangrove services to ecotourism	0.126	1.179	No
Networking-> Mangrove services to ecotourism	0.315	2.155	Yes
Social norms-> Mangrove services to ecotourism	-0.099	0.686	No
Trust-> Mangrove services to ecotourism	0.278	2.289	Yes
	Teluk Singkama (80 respondent)		
Community involvement-> Mangrove services to ecotourism	0.037	0.215	No
Concern to mangrove-> Mangrove services to ecotourism	0.395	3.142	Yes
Education and income levels-> Mangrove services to ecotourism	0.067	0.681	No
Networking-> Mangrove services to ecotourism	0.152	1.553	No
Social norms-> Mangrove services to ecotourism	0.318	2.626	Yes
Trust-> Mangrove services to ecotourism	-0.030	0.238	No

Table 6. The significance test model after re-specification to 530 respondents

Latent variables hypotheses	Result (530 respondents)		
	Path coefficients	**t-Value**	**Supported?**
Community involvement-> Mangrove services to ecotourism	0.052	1.129	No
Concern to mangrove-> Mangrove services to ecotourism	0.263	5.756	Yes
Education and income levels-> Mangrove services to ecotourism	0.110	3.012	Yes
Networking-> Mangrove services to ecotourism	0.193	3.563	Yes
Social norm-> Mangrove services to ecotourism	0.080	1.412	No
Trust-> Mangrove services to ecotourism	0.085	1.463	No

Ecosystems results from complex interactions between ecological and social processes. People affect ecosystems' capacity to deliver services that contribute to the well-being of humans and their resilience (Fedele et al., 2017). The values of mangrove ecosystem services are highly variable across study sites due to other factors, the biophysical characteristics of the site, and the socio-economic characteristics of the beneficiaries of ecosystem services (Brander et al., 2012). Involving local communities in mangrove management is an effective way of maintaining and enhancing the protection function of the mangrove forest while providing livelihood for local people (Schmitt and Norman 2015). Future governance models must involve partnerships between local custodians of mangroves and beneficiaries of the services (Lee et al., 2014). Community participation is needed to develop and preserve mangrove forests in the conservation areas. (Suprakto et al. 2014).

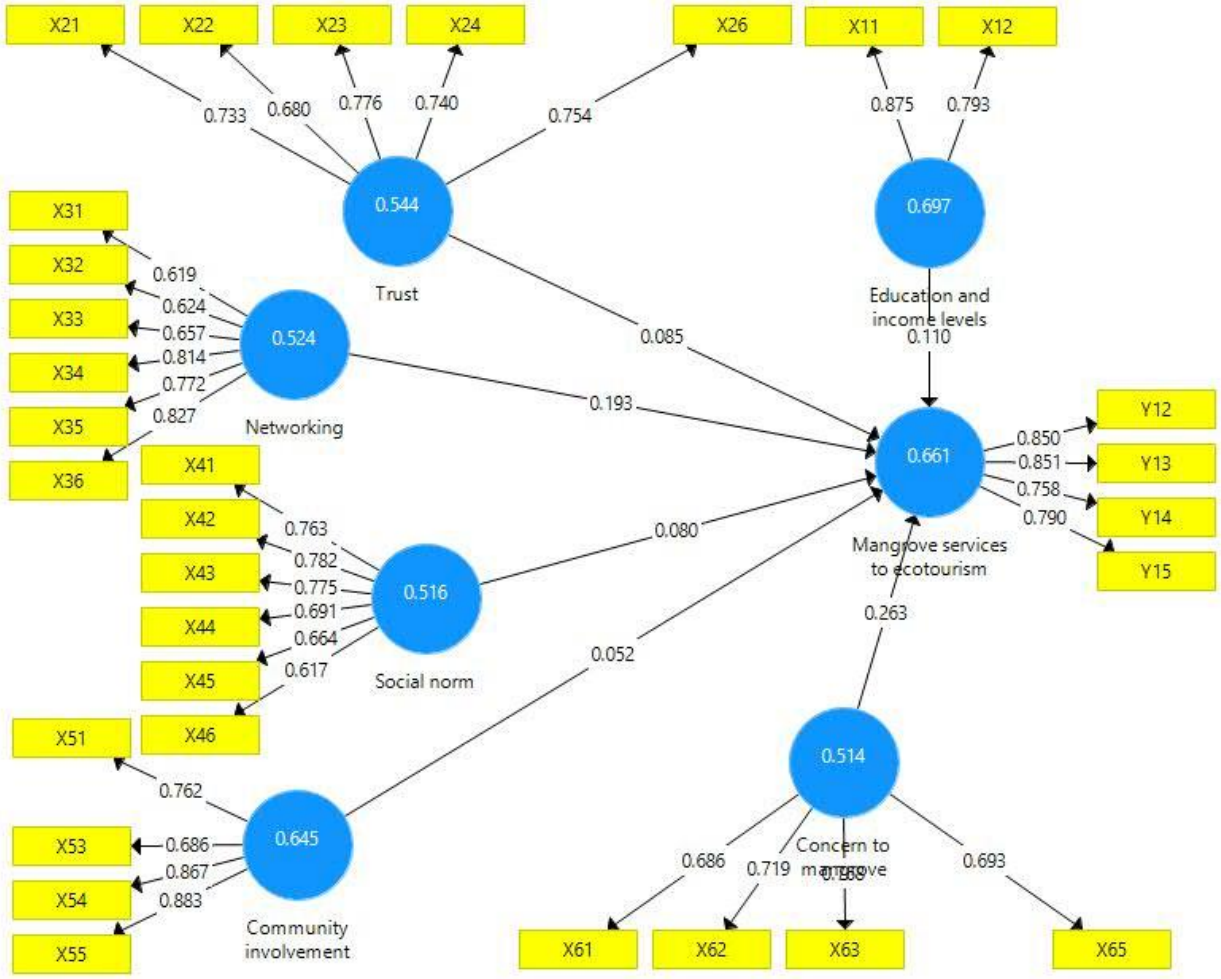

Figure 2. The convergent validity of each construct factor loadings after the re-specification

The main challenges to restoring and managing the mangrove forests are socio-economic conditions and land conflict between society, KNP, and local government (Gunawan and Sayektiningsih 2012). Community-based mangrove management will reduce conflicts. In Thailand, stand structure was superior in mangrove forests managed by communities rather than in mangrove forests are claimed for state management (Sudtongkong and Webb 2008). Mangrove tourism programs could support a conservation program. It is also crucial to involve and strengthen the participation of local communities surrounding mangrove areas. In Indonesia, national parks are the pioneer for mangrove-based recreation. In East Java, efforts to involve mangrove ecosystems in tourism packages were promoted in Alas Purwo National Park, Meru Betiri National Park, and Baluran National Park (Hakim et al., 2017). KNP in the future should be able to develop like the national park in Java. Although the social capital was still weak in supporting mangrove ecotourism, such as community involvement and trust, it can still be improved by multi-stakeholder cooperation.

In conclusion, natural tourism is one of the possible activities to be promoted in mangrove areas of national parks to increase local communities' role and preserve mangrove forests. Efforts to involve communities in mangrove conservation and tourism development were relatively poor in KNP. The low level of community involvement can be caused by weak information, socialization, and financing for activities related to mangroves in KNP. Low trust level was also associated with low community involvement and social norms support. Low social norms can occur because the values of local wisdom and local culture in the community are not well maintained. Support from the local government, KNP management units, NGOs, and surrounding companies should be improved to strengthen the community's social capital that can positively affect the conservation of mangroves and ultimately increase human well-being. Community involvement was also affected by the trust level and community knowledge related to social norms and other regulations related to national park management. Preservation and development of mangrove tourism efforts in the national park would need a particular approach for the community around the mangrove forest. The socio-ecology approach that offers a comprehensive theoretical base needs to be well developed for strategy defines the utilization of the mangrove ecosystem service for ecotourism in the national park. An interdisciplinary

approach with mixed methods to determine ecological perspectives can be a useful research strategy to improve the social function of an ecosystem system.

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Short Communication: Diversity of mosquitoes in Central Java, Indonesia that act as new vector in various tropical diseases

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Abstract. *Khariri. 2018. Short Communication: Diversity of new mosquitoes in Central Java Province that can act as vector in various tropical diseases. Bonorowo Wetlands 8: 71-74.* Mosquitoes transmit many diseases as vectors. The presence of mosquitoes is widespread worldwide, including in Indonesia, with an estimated 3100 species from 34 genera. Vector control is the main thing to do and treatment in patients. Morphological identification of mosquitoes aims to identify the character and number of species to become a picture of diversity in an area. Data collection was carried out from the 2015 Special Research Report on Vector and Reservoir Diseases (Rikhus Vektora) in Central Java Province. The data obtained were analyzed descriptively. Mosquito samples in Rikhus Vektora in 2015 in Central Java Province were collected from 3 different ecosystems, namely forest (H), non-forest (NH), and beach (P). The location of the ecosystem includes near settlements (DP) and far from settlements (JP). Mosquito samples were successfully identified as many as 29,071 tails consisting of 5 genera and 37 species. From Pekalongan, a sample of mosquitoes composed of 5 genera and 19 species was obtained. As many as 4 species of mosquitoes are species that have never been identified and reported circulation in Pekalongan. Identification of mosquitoes collected in Purworejo has 5 genera and 23 species. Mosquito samples from Pati were identified as having 5 genera and 22 species.

Keywords: Central Java, mosquitoes, tropical diseases, vectors

INTRODUCTION

Insects can play a positive role in human life, but some insects harm human health (Sabir et al., 2017). Mosquitoes are small types of insects that harm human health because they act as disease vectors. Some diseases caused by mosquitoes are still a serious health problem in society with the many losses incurred (Islamiyah et al., 2013). The presence of mosquitoes is widespread worldwide, including in Indonesia, with an estimated 3100 species from 34 genera. Some mosquitoes that became disease vectors include *Aedes aegypti* and *Aedes albopictus* causing Dengue Hemorrhagic Fever (DHF) and chikungunya, 19 mosquitoes from the Anopheles genus causing malaria, 27 mosquitoes from the genus Culex, Anopheles, *Aedes*, and Mansonia causing filariasis (Marbawati and Sholichah, 2009).

At present, there have been many reports of diseases transmitted by mosquitoes as vectors. The many losses caused by the disease so that an effort to eradicate the disease needs to be done (Sabir et al., 2017). Eradication of disease through vector control programs is the main thing to do and treatment in patients (Kazwani and Mading, 2014). Mosquito control programs as disease vectors will be maximized if there is a match between mosquitoes' behavior targeted by the control methods used (Mahdalena et al., 2016). Mosquitoes have a high diversity of species with habitats for female breeds, which are very diverse, ranging from semi-aquatic places to wide water systems (Suwito, 2007). The proper morphological identification of mosquitoes can identify the character and number of species to become a picture of diversity in an area (Fahmi et al., 2014).

Indonesia is an archipelago with a tropical climate that is heterogeneous and vulnerable to regional and global climate change. Macro and microclimate changes can affect the spread of infectious diseases, including contagious diseases of mosquito vectors. Increased humidity and rainfall are directly proportional to the increase in mosquito density, while the temperature has an optimum limit for mosquito breeding between 25-27ºC. Central Java Province is still an endemic area for several diseases transmitted by mosquitoes as a vector (Suwito et al., 2010).

MATERIALS AND METHODS

Analysis was carried out on data from the 2015 Special Research Report on Vector and Reservoir Diseases (Rikhus Vektora) in Central Java Province, Indonesia (MoH 2015). The collection of mosquito samples was carried out in 3 districts in Central Java, namely Pekalongan, Purworejo, and Pati. Mosquito samples were collected from 3 different ecosystems, namely forest (H), non-forest (NH), and beach (P). The location of the ecosystem includes near settlements (DP) and far from settlements (JP). Mosquito samples were identified and tested in the laboratory to

confirm the species and disease agents they brought. Laboratory checking using Polymerase Chain Reaction (PCR) includes dengue, malaria, chikungunya, JE, and filariasis for mosquito samples. The data obtained were analyzed descriptively.

RESULTS AND DISCUSSION

Mosquito samples were identified and tested in the laboratory to confirm the species and disease agents they brought. Laboratory tests were carried out using the Polymerase Chain Reaction (PCR) method to detect DHF, malaria, chikungunya, *Japanese encephalitias* (JE), and filariasis. The total samples of successfully identified mosquitoes were 29,071 tails consisting of 5 genera and 37 species. From Pekalongan District, there were mosquito samples consisting of five 5 and 19 species, Purworejo District consisting of 5 and 23 species, and Pati District consisting of 5 and 22 species. Complete results can be seen in Table 1.

Four mosquitoes among the 24 species found in Pekalongan District have never been identified and reported in Pekalongan District, namely *Aedes* subgenus *finlaya*, *Ar. durhami*, *Ar. kucingensis*, and *Ar. pectinatus*. The laboratory tests on samples collected from Pekalongan District obtained positive Aedes aegypti containing DHF virus as much as 26.7%, while malaria *Japanese encephalitias* (JE) filariasis examinations were negative. In samples collected from Purworejo District and Pati District, laboratory tests for detecting dengue virus, *Japanese encephalitias* (JE), malaria, and filariasis showed negative results.

Almost all regions in Central Java except Wonosobo become deadly disease-endemic areas, namely DHF. The highest cases of elephantiasis or filariasis in Central Java occur in Pekalongan City. The Central Java Provincial Health Office reported 442 cases of filariasis in the May 2017 period occurring in Pekalongan City. This figure far exceeds the cases occurring elsewhere in Central Java which only reach two digits.

DHF has become a health problem prioritized in Central Java Province because DHF cases are still the third-highest in Indonesia in 2015 (Fatati 2017). Pekalongan District is one of Central Java Province regions with a serious dengue disease problem. Pekalongan District Health Office has reported that the Incidence Rate (IR) of DHF in Pekalongan District tends to increase every year. In 2012 it increased to 15.17 / 100,000 population and increased again in 2013 to 33.6 / 100,000 population (Widiastuti and Ikawati, 2016).

Pekalongan District is also one of the regencies in Central Java Province, which is included in filariasis-endemic areas. Pekalongan District Health Office has reported that chronic filariasis continues to increase in 2011. All mosquito species can play a role in infectious filariasis. More than 23 species of mosquitoes are estimated to occur in Indonesia and become filariasis transmission vectors consisting of the genera Anopheles, *Aedes*, Culex, Mansonia, and Armigeres. Someone will show symptoms of filariasis with several bites of mosquitoes that have been infected with filaria for a long time.

Purworejo District is in Central Java Province, with the highest number of DHF patients in Java. Data from Purworejo District Health Office stated that dengue cases often appear in Purworejo District and are increasingly widespread with relatively high IR and CFR. The number of dengue cases continues to increase until 2016 to 447 patients with morbidity rates of 58 / 100,000 population. This number still exceeds the national figure of 20 / 100,000 population (Yana, 2017). The highest malaria case in Central Java also occurred in Purworejo District. A total of 6 sub-districts from 16 sub-districts in Purworejo District were included in malaria-endemic areas. This amount is the highest number of districts that have malaria endemic in Central Java Province. The six sub-districts are Bener, Bagelen, Gebang, Loano, Kaligesing, and Kemiri Sub-districts (Lestari et al., 2007).

DHF is still a serious problem in Pati District, as evidenced by 29 existing health centers that have been infected with DHF. DHF morbidity rate in Pati District in 2015 amounted to 74.9 / 100,000 population increased compared to 2014 amounting to 23.2 / 100,000 population. The highest morbidity rate in Kayen with 43 cases and the lowest in Tayu I Health Center was not found in DHF cases. Every DHF patient who reported treatment was carried out, epidemiological investigations in the field, and control efforts.

A report from the Pati District Health Office in 2015 stated that morbidity is an indicator to monitor the progress of malaria. The number of clinical malaria sufferers in Pati District in 2015 was 82 people with positive malaria, as many as 56 down compared to 2014 as many as 312 people with positive malaria 118 people. The morbidity of malaria in Pati District is more due to migration from endemic areas to Pati District. In 2015 filariasis cases were found as many as 1 people, and up to 2015, in Pati District, there were 14 cases (1 / 100,000 population).

Changes in global temperature will affect climate change and increase environmental health risks for humans. Exposure to environmental changes can cause various health problems, one of which is related to disease vectors (Yanuarini 2015). Malaria is an infectious disease that is sensitive to climate change. It is estimated that the average global temperature will increase by 1.0° -3.5°C by 2100, increasing the number of vector-borne diseases and the transmission of disease. Climate change will have a long-term and short-term impact on malaria transmission. In the short term, it can be seen in temperature and rainfall (Githeko 2000).

Table 1. Distribution of species and number of mosquitoes caught based on ecosystems

Species	Ecosystems						Total
	HDP	HJP	NHDP	NHJP	PDP	PJP	
Aedes aegypti	0	0	58	2	13	1	74
Aedes albopictus	97	131	97	91	22	12	450
Aedes poecilus	0	44	0	0	0	0	44
Aedes scutellaris	0	7	0	0	0	0	7
Aedes sp.	100	2	2	0	0	10	114
Aedes subgenus *finlaya*	0	2	0	0	0	0	2
Aedes vexans	0	0	0	10	0	45	55
Anopheles aconitus	19	2	1	1	0	0	23
Anopheles annularis	20	9	1	0	0	0	30
Anopheles balabacensis	1	34	0	0	0	0	35
Anopheles barbirostris	154	62	47	267	12	17	559
Anopheles leucosphyrus	3	0	0	0	0	0	3
Anopheles indifinitus	2	0	2	1	218	9	232
Anopheles kochi	25	1	0	4	0	0	30
Anopheles maculatus	567	191	0	0	0	0	758
Anopheles peditaeniatus	207	0	0	0	0	0	207
Anopheles tesselatus	0	0	0	1	0	0	1
Anopheles subpictus	2	0	12	7	847	1124	1992
Anopheles vagus	54	0	4	35	188	14	295
Armigeres durhami	3	1	0	0	0	0	4
Armigeres kucingensis	25	33	2	10	3	0	73
Armigeres pectinatus	1	3	0	0	0	0	4
Armigeres sp.	1	0	0	0	0	0	1
Armigeres subalbatus	51	9	118	731	57	1	967
Culex bitaeniorhyncus	0	5	1	18	1053	604	1681
Culex fuscocephalus	0	2	0	0	6	3	11
Culex gelidus	4	0	4	4	160	15	187
Culex hutchinsoni	0	0	0	0	2	0	2
Culex pseudovishnui	920	113	54	936	206	536	2765
Culex quinquefasciatus	126	10	810	562	1299	572	3379
Culex sp.	2	1	0	0	0	0	3
Culex tritaeniorhyncus	1854	373	524	2507	1165	530	6953
Culex vishnui	1086	363	251	1944	275	1230	5149
Culex sitiens	0	0	0	0	304	2370	2674
Mansonia uniformis	0	7	0	5	9	0	21
Mansonia dives	1	6	1	0	146	131	285
Malaya sp.	1	0	0	0	0	0	1
Total	5326	1411	1989	7136	5985	7224	29071

Hot and humid air is most suitable for Anopheles mosquitoes. Anopheles mosquitoes appear more frequently in the transition season, but mosquito attacks can be found for most years (Duarsa, 2008). Mosquito species that become malaria vectors have habitats influenced by environmental temperature, vegetation, altitude or topography, food availability, and even some subspecies affected by water pH and salinity. If the life of a human being is in contact with the habitat of *Anopheles mosquitoes*, there is a risk of transmission. Mosquitoes breed well if the environment is in accordance with the conditions needed by mosquitoes to breed. Environmental conditions that support the development of mosquitoes are not the same for each type/species of mosquito. *Anopheles aconitus* mosquitoes are suitable in hilly areas with non-technical terraced rice fields; many water channels overgrew with grass that inhibits water flow (Harijanto 2009). *Anopheles balabacensis* mosquitoes are ideal for hilly areas widely found in forests and plantations. Geographical and meteorological factors in Indonesia are beneficial for malaria transmission in Indonesia. The effect of this temperature is different for each species. At a temperature of 26.7ºC, the extrinsic incubation period is 10-12 days for *P. palcifarum* and 8-11 days for *P.vivax*, 14-15 days for *P.malariae*, and *P.ovale* (Yawan 2016).

Malaria transmission includes three main factors: patients with or without clinical symptoms, mosquitoes or vectors, and healthy humans. The local community's physical, chemical, biological, and socio-cultural factors greatly influence the spread of malaria. The interaction of weather and climate change, pond excavation, deforestation, and areas with lots of puddles, bushes, and an unhealthy environment will affect the growth of malaria agents (Hasyim 2014).

Changes in temperature, relative humidity, and rainfall resulted in mosquitoes laying more frequently and

increasing the number of DHF vectors and viruses to develop more malignantly. The cycle of marriage and the growth of mosquitoes from eggs to larvae and adult mosquitoes will be shortened so that the population will quickly rise. The presence of water reservoirs such as bathtubs, flower vases, drums, used cans, etc., will increase the number of mosquitoes laying eggs (Gama 2010).

Around 400 species of Anopheles mosquitoes have been found worldwide, and 67 species have been proven to be malaria vectors. Among 67 mosquito species, there are 22 species found in Indonesia (Munawar 2005). In Indonesia, there are 80 Anopheles mosquitoes, 19 species of which have been confirmed as malaria vectors. More than 23 species of mosquitoes become filariasis transmission vectors consisting of the genera *Anopheles*, *Aedes*, *Culex*, *Mansonia*, and *Armigeres*. Environmental factors affect filariasis vector density. The presence of *Aedes aegypti* in an area indicates the presence of the *Aedes aegypti* population in the area. The ideal environment for mosquitoes can be used as a potential place for mosquito breeding and resting places to increase the density of mosquitoes.

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The potential contribution of peri-urban wetlands to livelihood of local communities in Shinyanga Municipality, Tanzania

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Abstract. *Yusuph M, Munishi PKT. 2018. The potential contribution of peri-urban wetlands to the livelihood of local communities in Shinyanga Municipality, Tanzania. Bonorowo Wetlands 8: 75-83.* The study took place in Shinyanga Municipality, Tanzania, to assess the potential contribution of peri-urban wetlands to the livelihood of nearby communities. The specific objectives were to examine the participation of the suburban wetland ecosystems to natural capital (food production/food security), evaluate the involvement of peri-urban wetlands ecosystem to financial capital (household income), and assess the advantages received by farmer groups/associations formed around the utilization of wetlands (social capital). Information was acquired through households and farmer's group/associations questionnaires, focus group discussions, and field observations. Data were analyzed using descriptive and inferential statistics by applying correlation and t-test. As many as 79.2% of the wetland nearby communities rely on the wetlands for food. The major food crops were paddy, fruits, vegetables, and sweet potatoes. The average production levels of cereals, vegetables, and fruits were prominently higher in wetlands compared to uplands. In the case of household income, wetland cultivation (paddy, vegetables, maize, and fruits) brought about a statistically higher household annual mean income of Tshs 2,335,852/year (US$ 1,168) compared to Tshs 197,475/year (US$ 99) produced by upland cultivation. The results further suggested that 70% of the farmer groups/associations established around wetland utilization accessed loans/credit to support agricultural production as an advantage from being members. Sustainable use of peri-urban wetlands in Shinyanga Municipality produces substantial livelihoods to adjacent communities. Conservation of such wetland ecosystems is indispensable for continued contribution to livelihoods while ensuring environmental protection. Further studies are necessary to unravel the nature of social capital associated with the utilization of wetland ecosystems.

Keywords: Livelihood, local communities, Shinyanga, urban wetlands

INTRODUCTION

Wetlands have been long considered a human life form resource for an extended period on earth, providing essential resources and offering shelter and food for humans and other forms of life (Ramsar Convention Bureau 2002). Wetlands cover around 0.6% of the earth's surface (Economics for the Environment Consultancy 2005), are among the world's most biologically productive environments, and are rich in biological species diversity (Munishi and Kilungu 2004). Wetlands contribute to the livelihoods of billions of people in the world and millions of African people through services and goods to a variety of users (IWMI 2010)

such as harvesting resources (forest, forage, wildlife, and fish), livestock grazing, and water supply (Dugan 1990). Africa wetlands cover about 4% of the total area of the landscape (Gichuki and Macharia 2006) in Eastern. Tanzania is a country gifted with unique wetland resources in which wetland ecosystems spanned about 10% of the country. These ecosystems range from large lake systems to river floodplains, deltaic mangrove formations, and associated catchments (Maltby 1986). Wetlands in Tanzania are a productive area in agricultural production, fish production, and source of pasture for livestock (Kashaigili 2006). Apart from agriculture and fishing, wetlands have vital importance in economic, social, cultural, and biological values. They generate income and employment for households and communities living near the wetlands.

The Government of Tanzania has demonstrated its concern towards the wise use of wetlands via local communities involved in managing and recognizing wetlands as primary natural resources, ecosystem services, and biological values by ratifying the Ramsar convention on wetlands in 2000 (MNRT 2003; 2004). Over the past ten years, there has been an increasing influx of people into wetland areas as a coping strategy, especially in regions where uplands are predominantly identified by low agricultural potential, dominated by low-quality soils, and unpredictable rainfall due to climate change (Turyahabwe et al. 2013).

The objectives of this research were to: (i) Examine the contribution of peri-urban wetland ecosystems to natural capital (land)-food production/food security. (ii) Evaluate the participation of local wetlands ecosystem to financial wealth-household income. (iii) Assess the benefits received by groups/associations of farmers (formal/ informal) formed around the utilization of wetlands (social capital) in the study area.

MATERIALS AND METHODS

Theoretical framework

Overview of Sustainable Livelihood Approach (SLA)

The study was designed based on the conceptual framework of the Sustainable Livelihood Approach (SLA), which has been employed since the late 1990s as a development intervention and formed a central concept of the UK's Department for International Development's (DFID) strategy during the early years of the New Labour government in the UK (Morse et al. 2009). The call for an emphasis on sustainable livelihoods was set out in the 1997 White Paper on international development: refocus the international development efforts on eliminating poverty and encouraging economic growth, which benefits the poor society. We will do this through support for global sustainable development targets and policies that create sustainable livelihoods for poor people, promote human development and conserve the environment (DFID 1997). Chambers and Conway (1992) described that a livelihood comprises the capabilities, assets (stores, claims, resources, and access), and activities necessary for a means of living. A sustainable livelihood can survive and recover from shocks and stress, maintain or enhance its capabilities and assets, and give sustainable livelihood opportunities for the next generation.

Furthermore, livelihood contributes net benefits to other livelihoods at the local and global levels and in the short and long term. The theory takes much concern on equity of sustainable livelihood where people rely on those assets/capitals for their daily survival. Scoones (1998) mentioned five investments of sustainable livelihood, which were *natural capital* (natural resource stocks: soil, air, water, genetic resources) and environmental services (hydrological cycle, pollution sinks), *human capital* **(**skills, knowledge, labor includes good health and physical capability), *economic or financial capital* (cash, savings, credit/debit, and other economic assets), *physical capital* (infrastructure (roads, buildings), production equipment and technologies) and *social capital* (networks, social claims, social relations, affiliations, associations).

The application of sustainable livelihood theory to peri-urban wetland ecosystem

There is an interlink between peri-urban wetlands, which act as the primary asset with the sustainable livelihood of communities living adjacent to wetland landscapes. Such interrelationship associated with three capitals was helpful in the study's objectives whereby peri-urban wetland offered those of capitals that assure sustainable livelihood of local communities that utilized these small wetlands. The three capitals were natural capital (which provides water, fish, animal forage, land for food production, and environmental services), financial wealth (household income generated from the natural capital product (soil), and social capital (group membership and association membership capital from wetland soil products) (Figure 1).

Furthermore, there was a close interlink between three capitals by which natural capital in terms of land capital which used for food production and then ensuring food security to the livelihood of local communities who utilize peri-urban wetland. The surplus foods that are produced lead to the generation of household income, and that financial capital turns back also to the production of food. Financial capital facilitates the formation of social capital, which leads to the creation of groups and association memberships. On the other hand, social capital promotes back to the local communities' financial capital and natural capital (ensuring food security). In the end, those three capitals influenced the sustainable livelihood of local communities and the existence of peri-urban wetlands.

Description of the study area

Geographical location

Shinyanga Municipality is bordered to the north by the Mwanza Region, east by the Kishapu District, south by the Shinyanga Rural District, and west by the Kahama District. It is one of the districts of the Shinyanga Region of Tanzania; the District lies between latitude 3º 20' and 3º45' South of the Equator and longitude 33^0 20' and 35º 35' East of the Greenwich Meridian (URT 2013). The study was done in four villages of Mwalugoye, Old Shinyanga, Chamaguha, and Mwagala (Figure 2).

The district covers a total area of about 548 square kilometers which is about 1.1% of the whole area square of the Shinyanga region (URT 2007). Administrative the District has about three divisions and 17wards, 19 Villages, 25 Mitaa, and 95 Hamlets. The topographical region is flat lowland with small hills in the North West and West. The district has a gentle slope in the North, South, and the East. The Municipality area is separated into two main regions, the urban properly covering 25 square kilometers and the rural area with 523 square kilometers. The rural area of the district covers 95.4 percent of the total land area while the urban proper covers the remaining (Shinyanga Municipal Profile 2014).

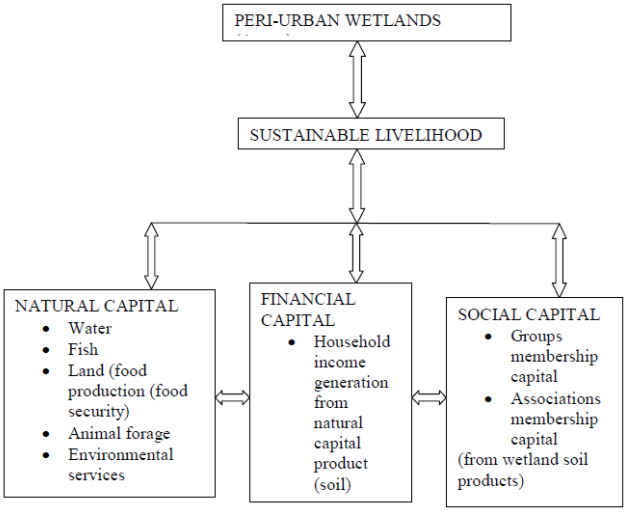

Figure 1. A conceptual framework for sustainable livelihood analysis of peri-urban wetland assets/capital. Source: Author construct with many contributions from The UK's DFID Sustainable Livelihoods framework (DFID 1997)

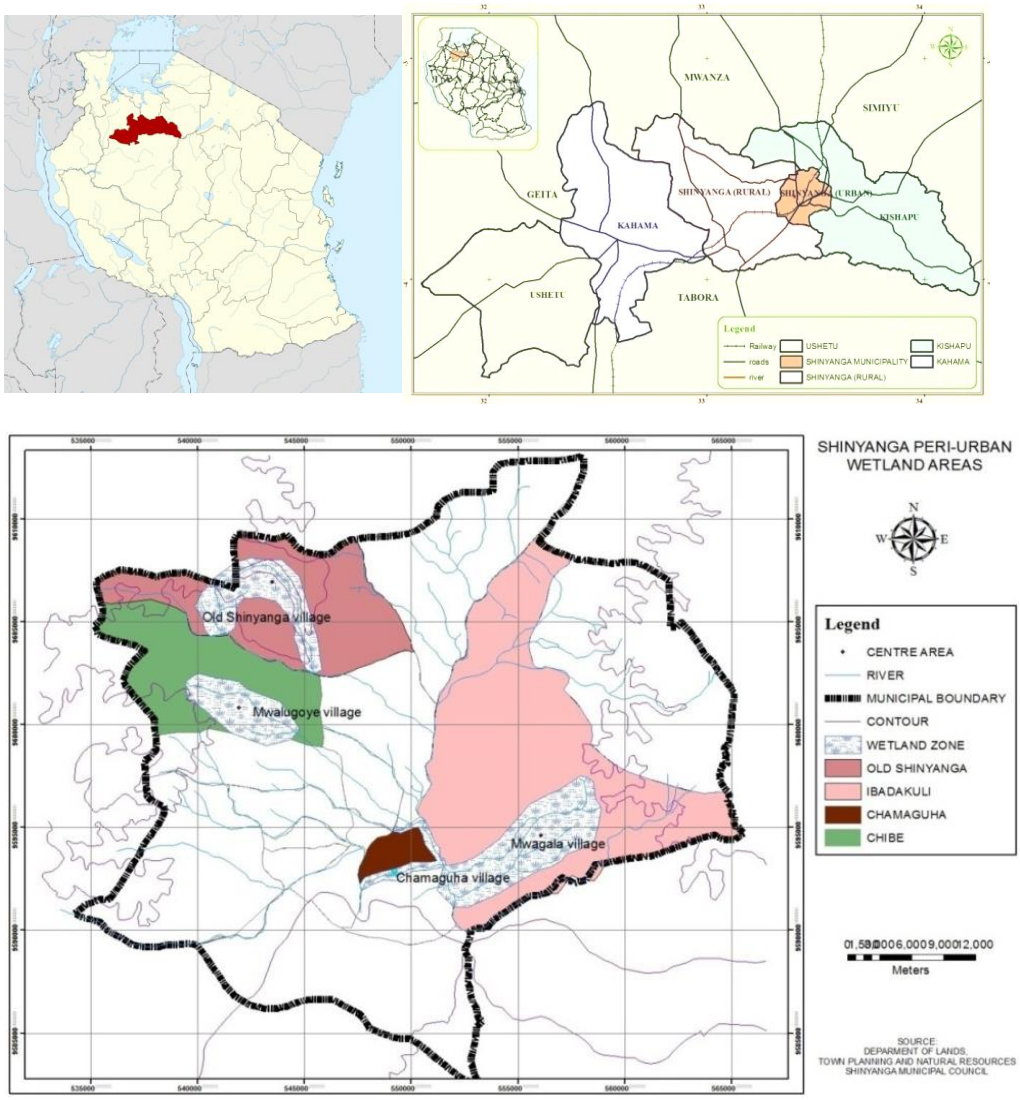

Figure 2. A map of Shinyanga Municipal Council displaying three study villages; Mwalugoye, Old Shinyanga, Chamaguha and Mwagala

Population

The council population is 161,391 people, as provided by the 2012 Population Census and Housing report, which consists of 78,655 males and 82,736 females with an average household of 4.8 persons (URT 2013). In 2013, the projected population was estimated to be 165,749 based on an inter-census annual growth rate of 2.7%.

Climate

In general, the municipality experiences a tropical weather characterized by two seasons: the rainy season that starts in October and ends in December of the same year, and then the dry season. The seasons, again, it launches in March the following, the year coming to an end in April or early May. The dry season begins in May to mid-October and January to February (Shinyanga Municipal Profile 2014). Average rainfall per year ranges between 600-1000mm (URT 2007). The maximum average temperature ranges between 20°C to 31°C, and minimum temperatures averages between 18°C to 24°C.

Vegetation and soil

Shinyanga was extensively forested with Acacia, miombo species, and forest products and services in the early 1920s (Malcolm 1953). But nowadays, the vegetation is mainly of acacias bush with *panicum* and *Chlorisgayana* as the significant grass species. Natural legumes like tropical kudzu are sparsely distributed in the grazing land. The soil is clay, but in some areas, clay-loam soils are observed (Shinyanga Municipal Profile 2014).

Social, economic activities

The primary activities in the district are Agriculture, industries, livestock keeping, mining, and business. The food crops grown are paddy, maize, sorghum, sweet potatoes, cassava, millet, and to some extent, cotton is also cultivated as a cash crop in the study area (NBS 2002). The livestock are mainly cattle, sheep, goats, donkeys, pigs, and poultry (URT 2007). The primary ethnic group of the study area is the Wasukuma.

Sampling procedures

Purposive sampling was applied to select wards that have wetlands because not all wards in Shinyanga Municipal have wetlands. The chosen wards were sampled using simple random sampling to get four wards. Then, purposive sampling was applied again within four wards to obtain wetlands villages because not all communities have wetlands. The villages with wetlands were sampled using simple random sampling to get four villages where the study was conducted. The four sampled communities were selected purposely based on accessibility and proximity to the wetland.

The selected villages were Mwalugoye, Old Shinyanga, Mwagala, Chamaguha. Households were taken as sampling units, whereby 30 families were chosen randomly in each town to get a total sample size of 120. The 30 houses were taken as sampling units in every four communities because the nature of the study required doing so. After all, the study focused on families who own land in wetlands and upland and village registers. There was no data for the number of families who own property in wetlands and uplands. Therefore, 30 households were selected randomly in each village to get a total sample size of 120, which is considered an adequate number to fulfill the requirements of efficiency, reliability, and representativeness (Kothari 2010). Purposive sampling was also conducted to get farmer groups/associations which utilize wetland farmland from four selected villages. There were about 36 groups/associations involved in wetland agriculture in four communities, where there were nine groups/associations for each town. From 9 groups/associations, five groups/associations were randomly sampled to represent the whole sample size in each city. Therefore, to get a sample size of 20 groups/associations for four communities, Mwalugoye, Old Shinyanga Chamaguha, and Mwagala.

Data collection

Primary and secondary data were collected for this study. The secondary data sources were books, journals, records from Web resources, Sokoine National Agriculture Library (SNAL), and Regional and Municipal Agricultural, Planning, and Natural resources offices. The primary data were taken to fill the gap of whatever was not found from secondary data. The preliminary data were obtained through questionnaires, field observations, focus group discussion (FGD) using checklists of probe questions, and critical informant interviews at the district level. Collecting data involved many steps: reconnaissance survey, questionnaire survey, focus group discussion, key informant interviews, and participant field observation.

Reconnaissance survey

This was done to get the whole picture of the research location. This stage involved visiting wetland farms, choosing sample units, and pre-testing questionnaires. Five households were randomly selected and interviewed to pre-test the poll to check the reliability and validity of the questions. This was also done for farmer groups/ associations where one group/association was randomly selected and interviewed from each identified village.

Questionnaire survey

Questionnaire forms were distributed for each household sampling unit and farmer groups/associations. Interviews were done face-to-face where the researcher had to reach the respondents at their place and sometimes to their farmland when the head of the household was on the farm.

The questionnaire was made to acquire information from leaders of families regarding the contribution of wetland products to the household's income and food security. The data included, among others, household social economic characteristics, amount of food produced in wetland crops and upland crops, the total size of the wetland farm, and cash earned from wetland agricultural products and upland agrarian products. Unit price per bag/Tenga was estimated using (Tshs) and converted into USD. Types and amounts of a variety of foods produced or harvested were measured using units familiar to local people such as *"debe,"* "*kopo*," *"tengas*," etc., and those units were converted into standard units (kgs). Interviews were face-to-face with the groups/association members. Each group/association organized and agreed on the right place to meet. The questionnaire was made to acquire information from each group regarding the benefits received by members who utilize the wetlands through groups/associations.

Key informants

Interviews with key informants knowledgeable on wetland and upland agricultural activity were performed using a checklist. These included the District Agriculture Officer, District Natural Resources Officer, and District Planning Officer. The information required included a standard period of food shortage and food availability, general social and economic characteristics of the well-being of households in the district regarding the source of income, occupation, food, management of wetland by government, and accessibility of the wetlands to adjacent communities.

Participant field observation

Field observations by the researcher are significant because they aid the researcher in contrasting the information given by respondents and the actual situation in the field (Kajembe and Wiersum 1998). The data collected included the general condition of crop farming, types of food grown in the wetlands and uplands, and the size of wetland farmland.

Focus group discussion

Focus group discussion (FGD) was applied because it provides precise information from different knowledgeable persons. The method involved the use of a checklist to facilitate discussions. FGD involved Ward/ Village Executive Officers, Ward/Village Extension Officers, Village Committees, Environment Committee leaders, men and women, elders, middle-aged, youth, and famous people in

the village. Ten participants for group discussion came from each community. The information discussed included the sort of food crops grown in wetlands, parameters affecting wetland crop production, crop calendar for plants cultivated in wetlands, and types of food crops grown in the swamps. Others were the standard period of food shortage, coping strategies for food shortage, and strategies to sustain wetlands.

Data analysis

Content analysis

The PRA data, such as participant observation, were analyzed by content analysis. The recorded dialogues were broken down and put into a meaningful argument then conclusions were drawn. Data from FGD and key informants were analyzed with the assistance of people in the field. The FGD and critical informants' data were presented in the elusive form. The data were used to add information to the questionnaire tool.

Questionnaire data

Statistical Package for Social Sciences (SPSS) software was applied for descriptive statistics and Excel for windows software. The descriptive statistical analysis included arithmetic mean, standard deviation, frequencies, and percentages. The t-test was used to compare the mean value of household cash income and amounts of foods acquired from wetland fields and upland fields. This study tested the correlation of group/association formed factors (in terms of registration and average income per member) against the benefits of wetland utilization (in terms of Government support and food security).

RESULTS AND DISCUSSION

Socio-economic characteristics of sampled household respondents

The main characteristics considered were age, marital status, gender, main economic activities, education level, household size, and residence duration (Table 1).

Gender and age

The results show that about 72.5% of respondents were males, and 27.5% were females. This means that men are the majority as household heads because the study was considered heads of households. It has been argued that with African society's traditions, males will appear as household heads (Bwana 1996; Magembe 2007). Gender relations are a significant factor in respect to household activities with a connotation on household production and income. Male and females contribute to the family income and ensure food security through wetland agricultural activities.

The proportion of respondents aged group 39-60 was 54.2%, followed by 18-38 (29.2%). This indicated that most people in the surveyed area were energetic enough to contribute to agriculture production in wetlands farming. The age distribution of a community determines to a large extent the potential productive force in a city. Household members are considered economically productive at the age of 16 to 64 years (Mtenga 1999). Also, the respondents aged over 60 agriculture probably because they are deemed unfit in offering workforce according to Ishengoma (1998).

Marital status

Approximately 75% of the respondents were married couples, 4.2% were single, 6.6% were separated, 10.8% were widowed, and 3.3% were divorced. These results concur well with the Tanzania Bureau of statistics 2014 that more than 50% of Tanzania Mainland adults are married, given that married couples have more mouths to feed. The use of wetlands to produce food and income to feed the family will likely increase with the increasing number of married couples. Since most of the respondents are married, the utilization intensity of the wetlands is expected to be high.

Table 1. Socio-economic characteristics of the respondents in study villages

Category	% of respondents (n=30)				
	Mwalugoye	Old Shinyanga	Chamaguha	Mwagala	All (N=120
Gender					
Male	83.3	66.7	76.7	63.3	72.5
Female	16.7	33.3	23.3	36.7	27.5
Age class					
18-38	33.3	36.7	23.3	23.3	29.2
39-60	43.3	50.0	60.0	63.3	54.2
Above 60	23.3	13.3	16.7	13.3	16.7
Marital status					
Single	10.0	3.3	0.0	3.3	4.2
Married	63.3	80.0	83.3	73.3	75.0
Separated	6.7	6.7	6.7	6.7	6.7
Widowed	16.7	6.7	10.0	10.0	10.8
Divorced	3.3	3.3	0.0	6.7	3.3
Education level					
Non-formal education	20.0	23.3	23.3	20.0	21.7
Adult education only	0.0	0.0	3.3	10.0	3.3
Primary education	63.3	56.7	50.0	60.0	57.5
Secondary education	16.7	16.7	13.3	10.0	14.2
Tertiary education	0.0	3.3	10.0	0.0	3.3
Main economic activities					
Trading and small business	0.0	13.3	13.3	13.3	10.0
Formal employment	3.3	10.0	6.7	3.3	5.8
Crop farming only	56.7	33.3	36.7	30.0	39.2
Crop farming & livestock keeping	40.0	43.3	43.3	53.3	45.0
Household size					
1-3 persons	20.0	33.3	23.3	10.0	26.7
4-6 persons	36.7	43.3	63.3	67.7	49.2
7-9 persons	36.7	16.7	10.2	16.7	21.7
10-12 person	6.7	6.7	3.3	6.7	2.5
Residence duration					
1-20 years	10.0	6.7	20.0	6.7	10.8
21-40 years	46.7	36.7	23.3	26.7	33.3
41-60 years	30.0	43.3	43.3	53.3	42.5
Above 61	13.3	13.3	13.3	13.3	13.3

Education level

The education level of the respondents is shown in Table 1. most of the respondents attained primary education (57.5%). The proportion of those with secondary school (14.2%), tertiary education (3.3%), and adult education (3.3%) was relatively low. Besides, 21.7% of the respondents had no formal training. A school directly influences people's knowledge and participation in natural resources management. It promotes the utilization of natural resources suggests (1999) indicates that an increase in education level increases awareness, thereby creating positive attitudes values and thus motivating people to manage natural resources sustainably.

Maro (1995) argued that education plays a significant role in the socio-economic development of any society. It fosters human creativity and innovations in natural vegetations management into traditional systems of land use management. Kajembe and Luoga (1996) described no development without education. The increase in the level of education also raised respondents' options to meet their livelihoods. In this study, the majority of the population had a primary education which may entail unsustainable utilization of the wetlands due to limited conservation knowledge. Most of the respondents who completed primary school were involved in wetland farming compared to those who attained a relatively higher education level.

Main economic activities

The primary economic activities of the respondents include crop farming, livestock keeping, and small business (Table 1). The majority of respondents practiced a combination of crop farming and livestock keeping (45.0%), crop farming only (39.2%). Few respondents were involved in small businesses (10.0%) and formal employment (5.8%). Wetland farming and livestock were the significant activity by the majority of the population resulting in the intensive utilization of wetlands for farming and livestock grazing.

Traditionally Wasukuma is agriculturist and livestock keeper in Tanzania. The major plants grown in the study area were paddy, maize, cassava, sweet potatoes, vegetables (spinach, amaranthus, mchicha, cabbage), and fruits (tomatoes and watermelon). Livestock includes goats and cattle. Interviews and participant observations demonstrated that crop production was complemented by other small businesses, including the selling of agricultural products such as rice, tomatoes, maize, sweet potatoes, and vegetables.

Household size

The majority (49.2%) of households had about 4-6 persons per household, followed by 1-3 persons (26.7%), 7-9 persons (21.7), and 10-12 (2.5%) (Table 1). Family size is an essential feature for determining the extent to which labor power is necessary for food production and income. It reflects the household's access to sufficient food, income, and other basic needs. Yanda et al. (2005) reported that available labor influences wetland productivity. This implies that households with large family sizes are likely to have more labor force enough to utilize wetland resources than small family sizes effectively. However, Lorri and Kavishe (1990) argued that big family size contributed to food insecurity in Tanzania.

Residence duration

The majority (42.5%) of the population had 41-60 years of residence in the area, followed by 21-40 years (33.3%). This indicated that indigenous people possessed most of the wetland farmlands, hence contributing to full utilization of wetland resources for an extended period.

Location of farmland and land holdings in wetland and upland farmland

About 56.7% of the population possessed farmlands in wetlands and uplands, thereby undertaking wetland and upland cultivation, while a good proportion (36.7%) own farms in the swamp. Upland agriculture was done by a relatively low number of the population (Table 2) showing that wetland cultivation is undertaken by a substantially large number of the people. The high percentage of wetlands utilization was because most wetlands are fertile and have sufficient access to water throughout the year which convinces more yields. The results are in line with those of Majule (2007) who reported that majority of farmers would have both wetland and upland farmland because both wetland and upland complement each other as a crucial source of livelihood.

Table 2. Location of farmland and land holdings in wetland and upland farmland in study villages

Item	% of Respondents (n=30)				
	Mwalugoye	Old Shinyanga	Chamaguha	Mwagala	All (N=120)
Location of farmland					
Wetland	20.0	26.7	36.7	36.7	36.7
Upland	10.0	6.7	3.3	6.7	6.7
Both	70.0	66.7	60.0	56.7	56.7
Size of land (wetland)					
0.00	**10.0**	**6.7**	**3.3**	**6.7**	**6.7**
Below 0.5ha	6.7	3.3	10.0	6.7	6.7
0.5-1.5ha	26.7	26.7	36.7	46.7	34.2
1.6-2.5ha	20.0	40.0	33.3	33.3	31.7
2.6-3.5ha	16.7	16.7	13.3	6.7	13.4
Above 3.5ha	20.0	6.7	3.3	0.0	7.5
Size of land (upland)					
0.00	**20.0**	**26.7**	**33.3**	**33.3**	**28.3**
Below 0.5ha	3.3	10.0	3.3	3.3	5.0
0.5-1.5ha	6.7	6.7	6.7	3.3	5.8
1.6-2.5ha	10.0	10.0	20.0	6.7	11.7
2.6-3.5ha	13.3	6.7	20.0	13.3	13.3
Above 3.5ha	46.7	40.0	16.7	40.0	35.8

Note: 0.00 mean respondents who did not own farms in either wetlands or uplands

Moreover, the majority of farmers (65.9%) owned plots of between 0.5-2.5ha in wetland areas while in upland regions majority of farmers (35.8%) have a plot of above 3.5ha and also the majority (28.3%) of respondents who were surveyed did not have plots in upland areas. Most of the respondents have small portions of farms in wetland areas because of the massive demand of these farmlands connected with their productivity. Sarris et al. (2006) also reported that smallholder farming in Tanzania is characterized by the average size of cultivated land of between 1ha and 3ha. During an interview with key informants and FGD, not all members of communities studied have access to wetland farms due to a shortage of farmland in wetlands.

Contributions of Peri-urban Wetland Ecosystems to Natural Capital (Land)-Food Production/Food Security

Types and amount of food crops produced in peri-urban wetlands

Most of the communities who live adjacent to local wetland resources rely on the wetlands in obtaining their food for sustaining their livelihoods (Table 3). Food crops grown in sub-urban wetland farmlands in Shinyanga Municipality are mainly cereal crops (rice and maize), vegetables (spinach, mchicha, cabbage, eggplant, green pepper, Chinese cabbage), root crops (sweet potatoes and cassava), and fruits crops (tomatoes, watermelon, and sugarcane). Further analysis demonstrated that production of cereals was the highest followed by fruits and root crops. Table 4 shows that vegetable ranked the lowest in production.

T-test showed that average production levels of cereals, vegetables, and fruits were significantly higher in wetlands ($p< 0.001$). The production of root crops, on the contrary, was not significantly different between the two sites. These findings are similar to previous observations which indicated that 80% of cereals were produced in wetland areas in Illubabor Ethiopia (Abort and Hailu 2000).

Additionally, during focus group discussions it was stated that wetland crop productivity was affected by various constraints such as lack of appropriate water management especially during dry seasons in each year causing water scarcity among wetland resource users.

People in the study area depended mostly on rice and maize as their staple foods. Rice varieties grown in the area included hybrids such as*"Katani," "Omana," "Kahogo," and "Super."* Sugar cane is also produced in Mwalugoye and Old Shinyanga villages as one of the commercial crops contributing significantly to household income. Vegetables and fruits are grown particularly during dry seasons after harvesting paddy, and in that period people rely on river Mhumbu as the nearest water source for Chamaguha and Mwagala villages.

The contribution of wetland cultivation to household food availability.

The usage of wetlands ensures food supply throughout the year for the majority of the adjacent communities. About 75% of the neighboring people produce food from the wetland fields the whole year. A small proportion produces food for at least three up to six months a year (Table 5). Vegetables, fruits, and sweet potatoes are produced throughout the year whereas most cereals (paddy and maize) are produced for only six months, and root crops are for three months. Sweet potatoes are the primary crop grown in large quantities in both wetland and upland farm fields.

During FGD it was reported that the months where households experience food shortage were from October-February and during this times most of the houses depended on root crops particularly sweet potatoes which were preserved after the harvesting period (michembe) for reducing household food shortage.

The contribution of Peri-urban wetlands to financial capital-household income

The average annual household income contributed by agriculture production in wetlands amounted to Tshs of 1 114 583.33 (US$ 557) from paddy, Tshs 849 500 (US$ 425) from fruits and Tshs 214 583.33 (US$ 107) from vegetables and Tshs 157 185 (US$ 79) from maize. It makes a total mean value annual income of Tshs 2 335 852 (US$ 1168) (Table 6). It was reported during FGD that paddy production gives farmers high income because its output is as high as compared to other crops and the market for paddy is available.

Table 3. Farmland depended for obtaining food for community livelihood

Item	Frequency	Percent
Wetland	95	79.2
Both wetland and upland	25	20.8
Total	**120**	**100.0**

Table 4. Comparison of the average household amount of food produced from wetland and upland farmland field in study villages

Yield production in kg		t-test		
Type of crop	Wetland	Upland	t-value	Sig. (2tailed)
Cereals	Mean	2542.92	392.83	0.000***
	SD	103.97	41.09	
Fruits	Mean	591.00	5.75	0.000***
	SD	59.59	2.15	
Root crop	Mean	308.17	311.50	0.092 Ns
	SD	39.75	40.79	
Vegetable	Mean	203.21	2.79	0.000***
SD	25.33	0.70		

Note: *** =Significant at$P\leq 0.001$, Ns = Not significant at $P\geq 0.05$

Table 5. Periods of production of different crops in a year in peri-urban wetlands in the study area

Time length	Frequency	Percent
Three months	6	5.0
Six months	24	20.0
All around the year	90	75.0
Total	120	100.0

T-test analysis (Table 6) shows a significantly higher (P≤0.001) household income from wetland cultivation than upland cultivation for paddy, vegetables and fruits production. The reasons behind such differences might be attributed to the fact that most respondents invest more in wetlands because of the availability of more fertile soil and adequate water in wetland areas. This proposition is in resemblance to the study carried out in Sri Lanka which indicated that farmers chose to use wetlands due to fertile agricultural land and the ability to control the water (moisture) (Nagabhatla et al. 2006).

Another study in Singida described similar reason that farmers utilize wetlands for rice cultivation due to the high yields and high soil fertility, which in turn contributed to household cash income (Yanda et al. 2005). Moreover, there was no significant difference for cash income generated from maize productions between wetlands and upland farmlands since the cash income generated from maize crop is relatively higher in both sites.

Social capital benefits accruing from utilization of wetlands

There are substantial social capital benefits that occur from the utilization of wetlands including associations (formal/informal) formed around the usage of wetlands. Thirty-six farmer groups/associations have been developed in the four villages of Mwalugoye, Old Shinyanga, Chamaguha and Mwagala. Figure 3 shows about 75% of 20 sampled groups/associations generate income from wetlands farming, credits/microfinance (15%), salary/ wages (5%) and the rest 5% from investment/business. Wetland production, therefore, makes a significant and substantial income earner farmer's group/association members. According to group members, paddy which was produced from wetlands generates the highest income compared to the other crops.

Benefits received by farmer groups/associations

Figure 4 shows the benefits that farmer groups received from being members of particular associations. Such benefits contain access to loans/credits (70%), access to agriculture inputs (10%) and access to agricultural extension services (5%). This implies the formation of farmers in groups/associations is related to benefits that would not be available without the associations. Loans received from within associations (Table 7) support agricultural activities through hiring farmland, buying farming inputs and paying farm laborer.

Relationship between registration of groups/ associations and government supports

In this benefit, a correlation test was used to measure relationship between groups/association registration and government supports. Non-parametric bivariate correlation analysis showed a significant positive correlation between groups/associations registration and government support (r = 0.681, P = 0.01) which means that groups/associations which were registered by government received more government supports in various aspects such as agricultural inputs (power tillers, water pump, pesticides, seeds and incentive fertilizers), adequate agricultural extension services and small to medium size loans. This is because farmers who organized themselves into registered groups use more effectively the benefits from the municipal compared the unregistered groups.

Table 6. Comparisons of mean total cash income earned from wetland and upland agricultural products in study villages

Mean value in Tshs			Test statistic	
Type of crop	Wetland	Upland	t-value	Significance
Paddy/rice	1,114,583.33	73,666.67	7.783	0.000***
Maize	157,185.00,	118,558.33	1.748	0.083Ns
Vegetables	214,583.33	0.00	7.177	0.000***
Fruit crops	849,500.00	5,250.00	5.523	0.000***

Note: *** = Significance at P≤0.001, Ns = Not Significance at P≥0.05

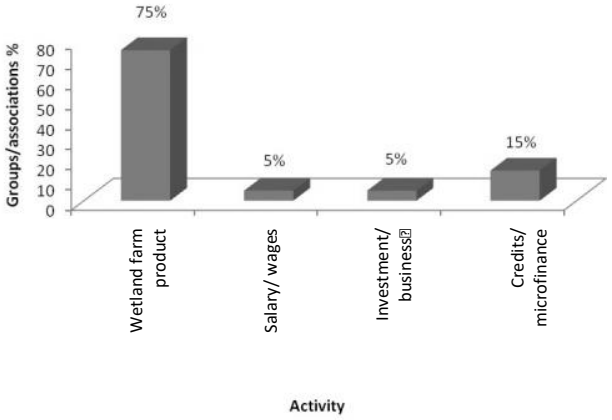

Figure 3. Primary source of income for group/association members in study villages

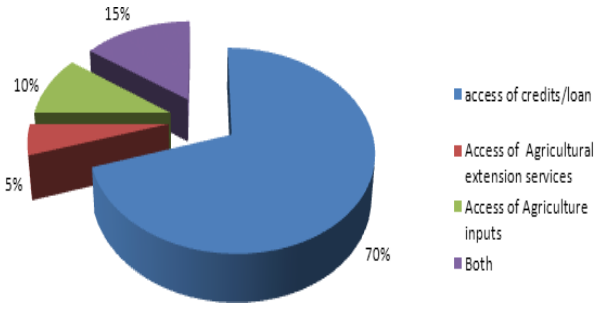

Figure 4. Benefits received by wetland farmer's

Table 7. Sources of loans for farmers group/associations in study villages

Item	Frequency	Percent
Within the group/association	14	70.0
Banks	1	5.0
Small loan institutions	3	15.0
Both	2	10.0
Total	20	100.0

Relationships between average income per group/ association members and food security in their households

There was significant positive correlation between average income per group member and food security ($r = 0.862$, $P = 0.01$). This means that members of groups who had higher average income were more food secure throughout the year. This implies that higher income from wetland agricultural crops contributes to household food security among group members. Most farmers in groups depend on rice crop production as their main source of income and food. The income farmer's groups/association generate is used to buy food hence ensuring food security in their household.

Conclusion

Peri-urban wetlands contribute substantially to household food security through production of various agricultural crops which grow well in wetland areas. Peri-urban wetlands contribute substantial household income through selling of crops produced in wetlands. Farmer associations formed around wetland utilization obtain substantial benefits associated with social capital including loans/credit facilities and various forms of government support.

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Environmental and socioeconomic impact of cage aquaculture at Kpeve Tornu section of the Volta Lake, Ghana

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Abstract. *Mensah VF, Annang TY, Ofori BD. 2018. Environmental and socioeconomic impact of cage aquaculture at Kpeve Tornu section of the Volta Lake. Bonorowo Wetlands 8: 84-95.* Sufficient data on the financial viability of cage aquaculture in Ghana is limited. Little is also known about the effects of fish farming on the Volta Lake on fishing communities. This study, therefore, sought to investigate these relevant issues at Kpeve Tornu, a fishing society in Afadjato South District in the Volta Region. Laboratory analysis of physicochemical parameters suggested no significant differences between water quality parameters from four fish farms and two control locations. A cost-benefit analysis performed on five cages of volume 360 cubic meters each was 1.34 in the first production cycle. In contrast, a gross margin of 104.41 percent in the second production cycle suggests that the cage aquaculture industry in Ghana was financially viable. The cage aquaculture industry also positively impacted the livelihoods of Kpeve Tornu in regions of recruitment, poverty alleviation, trade, and food security. Cage fish farm owners did not comply fully with aquaculture rules. Aquaculture rules were effective on fingerlings and aquaculture-related chemicals producers. Still, the regulations on fish farmers needed a review because there were no definitions for intensive and semi-intensive fish farming in the aquaculture rules of Ghana.

Keywords: cage aquaculture, environment impact, socioeconomic impact, Volta Lake

INTRODUCTION

Cage culture is described by Bocek (n.d.) as the process of raising fish in an enclosed container that keeps the fish in an existing water body while allowing water exchange and waste removal into the surrounding water body. Beveridge (1987) stated that the environmental impacts of cage culture are often ignored and rarely subjected to research or investigation.

In Ghana, cage culture plays an increasingly important role in fish production, involving many small-scale farmers, private individuals, private companies, investors, and local institutions. Aquaculture has contributed significantly to the economy of Ghana. Ten percent of the population is predicted to be involved in the fishing industry from urban and rural regions where women dominate the post-harvest activities (FAO 2005). Although most cage farmers operate on a small scale, farmers consider aquaculture a source of income. Hence, fish produced are mainly sold instead of consumed by their family.

Fish farming in floating cages affected water quality. Phuong (1998) reported that cultured cage fish are entirely dependent on formulated diet, and the waste produced from this consumption is dumped directly into the water body. Consequently, Pillay (1992) reported that cage culture contributes nutrients, organic matter (Biochemical Oxygen Demand), and turbidity, which results in the deterioration of the quality of water and biota downstream. Considering that formulated feed is relative to a considerable carbohydrate and protein level, nutrient loading from the culture of Nile tilapia waste is thought to be high in cages. Debris such as organic matter, particulate matter, and suspended solids may result in significant massive sediment accumulation and Biochemical Oxygen Demand around the location of cage culture systems (Ali et al. 2006).

As a consequence of rapid expansion in the cage culture project in the Kpeve Tornu section of the Volta Lake, water quality was concerned to have deteriorated to affect other lake users in the region. The establishment of fish cages at the Kpeve Tornu region of the Volta Lake raised concerns about water pollution since most of the people of the host society relied on the same water source for drinking, washing, cooking, fishing, fishing transportation, and entertainment. Another notable point is that the Kpeve Headwork, a Ghana Urban Water Company facility, takes water from the surrounding cage culture region to treat consumers in four different administrative districts in the Volta Region.

This study aims at achieving four main specific objectives, i.e., (i) Assess the level of pollutants from fish cages into the lake. (ii) Predict the cost and returns (cost-benefit ratio and gross margin) related to the cage culture industry in the first and second production cycles, respectively. (iii) Evaluate the socioeconomic impacts of the cage culture project on the livelihoods of people in Kpeve Tornu Society. (iv) Assess the compliance levels of fish farmers with aquaculture rules.

MATERIALS AND METHODS

The study area

The profile of the Kpeve Tornu community

Kpeve Tornu is located on an inlet of the Volta Lake at the south-eastern part of Afadjato South District in the Volta Region of Ghana. This small fishing society is most conspicuous with physical features of the region are the Akwapim-Togo-Atakora ranges, which made the eastern boundaries between Afadjato South and Ho West Districts, south of latitude 3.028'N.

The majority of the people participate in fishing activities for their livelihood, while few participate in trading and peasant farming. The people's livelihoods primarily relied on the Volta Lake because it was their primary water source for drinking, washing, cooking, fishing, recreation, and others.

Assessing water quality parameters

Water samples were taken at six locations in the cage culture region; four fish farms, and two non-caged regions 800 meters upstream and downstream of the cage region (as control locations) for laboratory analyses and comparison of the level of ammonia, suspended solids, total phosphorus, total nitrogen, copper, dissolved solids and organic matter following standard methods. Dissolved oxygen (DO), turbidity, conductivity, pH, and temperature were measured during the data acquisition. The selection of the distance of control locations was based on research findings. The environmental effect of cage culture on sedimentation (Nash 2001; Carrol et al. 2003) and water quality (Guo and Li 2003) are mostly limited to within 50 m.

Water samples were obtained at two months intervals (from December 2013 to April 2014). Four cages were chosen randomly as a representative sample of the cage culture region and two control locations. Three water samples were obtained from each location and then measured, and the average values were calculated for each part. The results from the six sampling locations were compared to define any significant differences.

Sterilized containers were used to prevent contamination of samples during sampling, handling, and storage, and working conditions were carefully chosen. Water samples were collected at each sampling location into a plastic bucket for in-situ measurements of temperature, pH, conductivity, and total dissolved solids were recorded in-situ using HANNA Temp/pH/EC/TDS meter (Model HI 99301). The DO was measured using a DO meter (Model Milwaukee MW600). Turbidity was determined using HACH 2100P turbidimeter and the reading recorded in Nephelometric Turbidity Units (NTU). Fieldwork was conducted between 7.00 am, and 8.00 am on each sampling day.

Laboratory analysis

A 1.5-liter pre-treated plastic container filled with water at each sampling location was kept on ice in an ice chest before transporting them to the laboratory. This water was subsequently used in the laboratory for ex-situ analysis. Water samples that were not analyzed immediately were stored in a refrigerator below 4 ºC. The samples must be analyzed within five days to avoid inaccuracy.

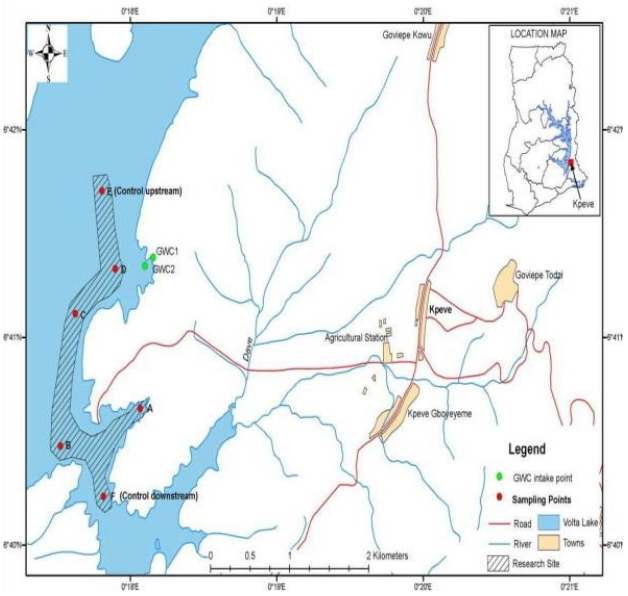

Figure 1. A map shows the Kpeve Tornu section of the Volta Lake and water sampling locations. Source: Department of Geography and Resource Development, University of Ghana, Accra (2014)

The chemical properties of the water samples were evaluated at the Ecological Laboratory of the Institute for Environment and Sanitation Studies, University of Ghana. The parameters defined were as follows: nitrate-nitrogen, phosphate, copper, ammonia-nitrogen, total suspended solids, organic matter (BOD). The analysis was carried out using a HACH DR/2010 UV Spectrophotometer. All the laboratory measurements were performed following standard methods (APHA 1998; WHO 1989 and UNESCO/WHO 1978).

Approximately 500 ml of water sample was stirred for precisely 2 minutes, then poured into a one-liter beaker stirred, and 25 ml aliquots were poured into a sample cell prepared. The sample was swirled, and the reading was recorded with a spectrophotometer set at 810 nm, which has previously been calibrated using 25 ml of demineralized water as the blank.

The turbidity of the samples (15 ml) was calculated using a portable turbidimeter (Model 2100P).

The 5-day BOD test was employed, consisting of filling with sample an airtight bottle of the specified size and incubating it at a specific temperature for five days. DO was measured initially after incubation, and the BOD was computed from the difference between the initial and final DO (APHA 1995).

The nitrate amounts in each sample were measured using nitrate powder pillows in a direct reading Hach Spectrophotometer (Model DR. 2010). Twenty-five milliliters of the sample were weighed into the sample cell. One Nitraver 5 Nitrate Reagent Powder Pillow was applied to the sample and vigorously shaken for 1 minute. The solution was permitted to react for 5 minutes, after which another cell was filled with 25 ml of only the sample (blank). After 5 minutes, the blank sample was placed in the spectrophotometer for calibration (zeroing). The

prepared sample was then transferred to the cell holder to determine the nitrate level at 500 nm. The sample cell was filled with 25 ml of sample, and one Phos Ver 3 Phosphate Powder Pillow reagent was applied to the cell content and swirled immediately for two minutes. Another sample cell (serving as the blank) was filled with 25 ml of sample and put into the cell holder to calibrate it. The level of phosphorus was determined at 890 nm. One hundred ml of the sample was moved into a clean 250 ml Erlenmeyer flask. The contents of one chloride 2 Indicator Powder Pillows were applied and swirled to mix. The delivery tube tip was placed into the solution, and the flask swirled while titrating with silver nitrate from a yellow to red-brown obtained.

Powder Pillows were used to measure copper levels in a direct reading Hach spectrophotometer (Model DR. 2000). Ten milliliters of the sample were weighed into the sample cell. One Cu Ver I Copper Reagent Powder Pillow was poured into the sample cell then swirled to mix. The solution was allowed to react for 2 minutes, then 10 ml of the sample was added. Then the prepared sample was put into the cell holder of the spectrophotometer to determine the copper level at 560 nm (Hach Company, 2001a).

Assessment of financial viability of cage aquaculture

Primary benefit-cost ratio analysis was done to determine the economic feasibility of the cage culture project. The benefit-cost ratio was acquired by dividing the returns (sales) by the total cost of production (fixed cost and variable cost).

$$\text{Benefit-Cost Ratio} = \frac{\text{Returns on investment}}{\text{Total cost of production}}$$

The first production cycle predicted the primary benefit-cost ratio analysis to incorporate the cost incurred on fixed inputs. The gross margin was acquired by subtracting the variable cost from returns on investment by estimation during the second production cycle. Five cages were used to gather data on value and profits for the two production cycles. We modified an approved framework for the data collection and estimation on the financial viability of cage aquaculture in Ghana. This framework was designed by the Water Research Institute (Ghana) in 2009 in collaboration with the World Fish Center in Malaysia (Ofori et al. 2009).

Five entities included in the aquaculture industry in the region were chosen to represent various industry interests and provide relevant information to establish financial inputs and gains using a designed framework. The selection criterion was based on bookkeeping records. The industry interests were Partnership (Catchrite Farms), Sole Proprietorship (3 'As' Agri Solutions), Direct Foreign Investor (Worldings Investment Ghana Limited), Training and Consultancy (Global Agricultural Foundations), and the Best Farmer-Based Organization in Ghana (2013) namely Volta Lake Fish Farmers Association.

Assessment of the impact of cage culture business on the livelihoods of the people of Kpeve Tornu

Twenty-five percent of the adult population was selected from the fish farming society to assess the people's knowledge on the impacts of the cage culture projects. One hundred and three respondents were chosen because Kpeve Tornu was estimated to be 763 with an adult population of 412 based on the district adult population rate in September 2013. Gender issues were considered in the selection process as 51.5% of the respondents were women, and 48.5% were male during the interview process. The quota sampling used was according to the composition of males and females in the district population estimates.

The questionnaire designed to gather relevant information was tested on twenty-one society members for modification. Data collected included the impact of cage farming activities on (1) fishing activities in the society, (2) water transport, (3) job, (4) cultural values, and (5) other relevant social activities.

Socioeconomic characteristics and compliance rules of fish farmers socioeconomic aspects of eighteen randomly selected cage farmers out of twenty-nine known farmers were interviewed to obtain relevant information. Relevant environmental rules and documents concerning the fish farming projects were investigated. Notable among them were the Fisheries Act of 2002 (Act 625), Environmental Protection Agency Act, 1994 (Act 490), Environmental Rules Assessment, 1999, (LI 1652), Public Health Act of 2012 (Act 851), Aquaculture Rules of Ghana, 2010 (LI 1968), and the Abuja Declaration on Sustainable Fisheries and Aquaculture in Africa.

Statistical data gathering and analysis

Fieldworks were carried out between December 2013 and April 2014, when the people in the society relied on most on the Volta Lake for livelihood opportunities like fishing and farming. All relevant quantitative data on water quality parameters and also to generate data presentation were stored in Microsoft Excel. The data were DO, BOD, turbidity, conductivity, suspended solids, dissolved solids, pH, copper, nitrate, ammonia, phosphate, and temperature.

Recorded measurements from the field were statistically analyzed using the Statistical Package for Social Scientists (SPSS) software package (version 20.0). The survey was coded and built on SPSS to generate figures, graphs, tables, differences in water quality parameters, and the socioeconomic background of fish farmers besides people living in Kpeve Tornu.

Data collected on water quality parameters were analyzed using the SPSS Software Programme (version 20.0). The significant differences were calculated at the probability of 0.05. A Global Positioning System (GPS) Model was used to point the coordinates of the sampling locations and generate the study region map.

RESULTS AND DISCUSSION

Water quality parameters

The average values for the sampling locations were A 0.77 mg/L, B 0.6 mg/L, C 0.66 mg/L, D 0.47 mg/L, control upstream 0.93 mg/L and control downstream 0.5 3mg/L (Figure 2).

Figure 3 displays the average values for phosphate level at the sampling locations were A (1.93 mg/L), B (1.04 mg/L), C (1.24 mg/L), D (1.02 mg/L), control upstream (0.93 mg/L) and control downstream (0.33 mg/L).

Figure 4 shows the average values for the sampling locations s were A 0.067mg/L, B 0.083mg/L, C 0.04mg/L, D 0.07mg/L, control upstream 0.07 mg/L and control downstream 0.06 mg/L.

DO levels varied in the study region in December 2013, with location B showing the lowest value of 3.21 mg/L and location D recording the highest amount of 4.1 mg/L. Other measurements were A 3.5mg/L, B 3.92 mg/L, control upstream 3.97 mg/L and control downstream 4.02 mg/L. DO values ranged between 5.59 mg/L for location B and 6.2 mg/L for control downstream with locations A, C, D, and control upstream recording 6.1 mg/L, 5.89mg/L, 5.85 mg/L, and 5.79 mg/L, respectively in February 2014. DO levels in April, 2014 were A 6.9 mg/L, B 7.9 mg/L, C 7.5 mg/L, D 7 mg/L, control upstream 7.2 mg/L, and control downstream 7.1 mg/L. The average values for the sampling locations s for DO were A 5.5 mg/L, B 5.6 mg/L, C 5.8mg/L, D 5.7 mg/L, control upstream 5.7 mg/L, and control downstream 5.8mg/L (Figure 5).

The average readings for the sampling locations s were A 7.5, B 7.4, C 7.8, D 7.4, control upstream 7.5, and power downstream 7.6 (Figure 6). The differences in the results were not significant, suggesting that the fish farming activities in the study region did not significantly affect water quality in the region.

The results suggest fluctuating figures in the BOD recorded at the study locations. However, it is notable that location A recorded the highest levels of BOD in the three months. The average values for 1.45 the sampling locations were A 1. mg/L, B 1.98 mg/L, C 2.0 mg/L, D mg/L, control upstream 1.5 mg/L and control downstream 1.3 mg/L (Figure 7).

The average values for the sampling locations were A 3.0 NTU, B 2.7 NTU, C 2.7 NTU, D 3.0 NTU, control upstream 2.3 NTU, and control downstream 2.3 NTU (Figure 8). This suggests that cage aquaculture slightly impacts turbidity in the study region, but this is of little significance. There were also no significant differences between fish cage locations and control locations.

Figure 9 shows the average values for the sampling locations were A 4.3mg/L, B 4.7mg/L, C 6.0mg/L, D 5.0mg/L, control upstream 5.7 mg/L and control downstream 5.0mg/L. The results suggest variety in the levels of suspended solids in the study region with time. Nevertheless, differences between sampled locations were not significant.

The average values as demonstrated in Figure 10 for the sampling locations were A (33.3mg/L), B (32.0mg/L), C (31.3mg/L), D (33.0mg/L), control upstream (33.0 mg/L) and control downstream (34.3mg/L). No significant differences (ANOVA; $P < 0.05$) were observed in the level of dissolved substances in the six sampled locations.

The average values for the sampling locations were A 69 µS/cm, B 68 µS/ cm, C 68 µS/ cm, D 70 µS/ cm, control upstream 68 µS/cm and control downstream 70 µS/cm (Figure 11). Results suggest that differences in the electrical conductivity in the study region were not significant between December 2013 and April 2014.

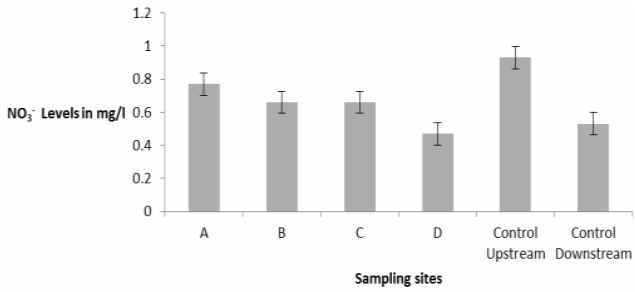

Figure 2. Graph showing variations in average nitrate values at the various sampling points

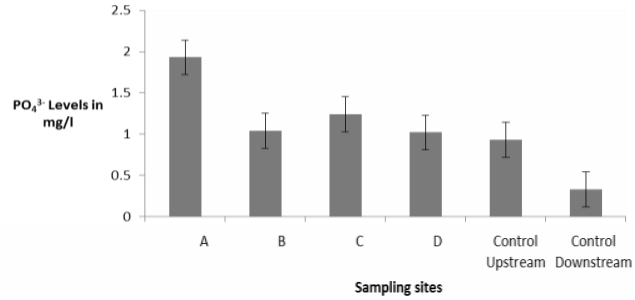

Figure 3. Graph showing the variations in average phosphate levels at the various sampling points

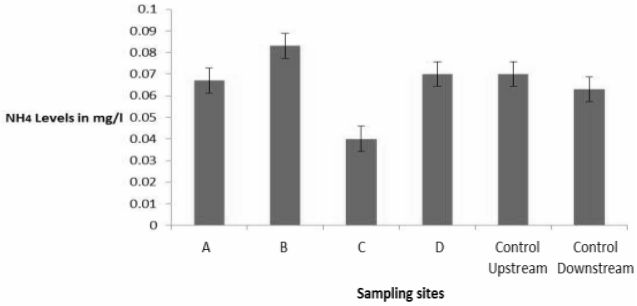

Figure 4. Graph showing variations in average ammonium levels at the various sampling points

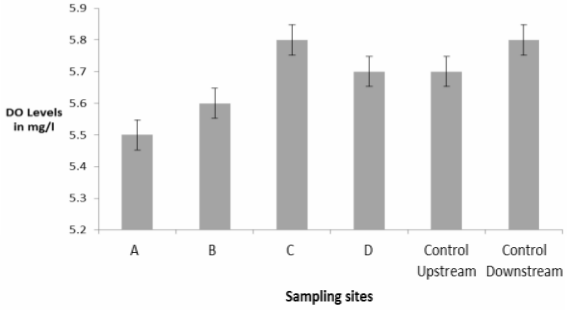

Figure 5. Graph showing variation in average dissolved oxygen levels at the various sampling points

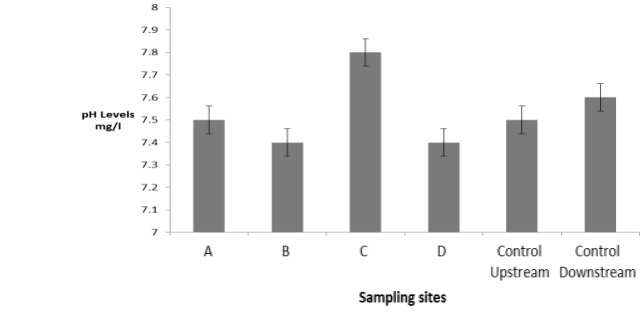

Figure 6. Graph showing variation in average pH levels at various sampling points

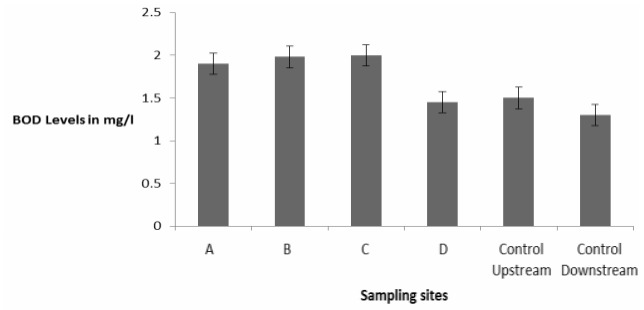

Figure 7. Graph showing variations in average BOD levels at the various sampling sites

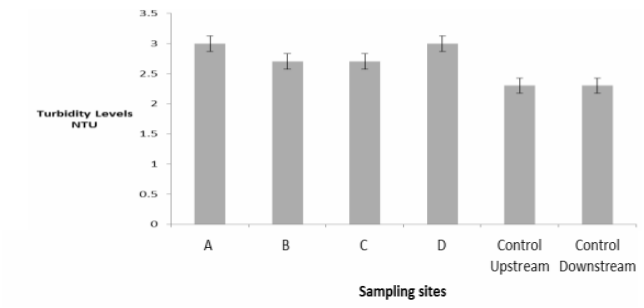

Figure 8. Graph showing variations in average turbidity levels at various sampling points

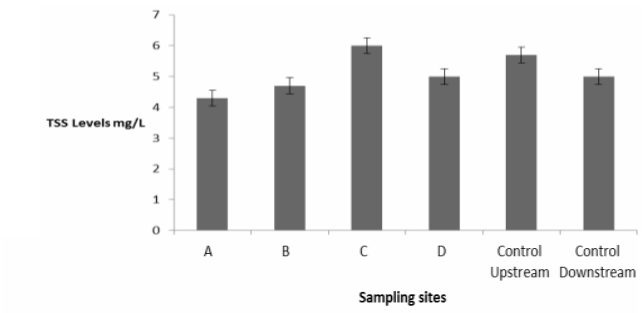

Figure 9. Graph showing variations in average suspended solids levels at the various sampling points

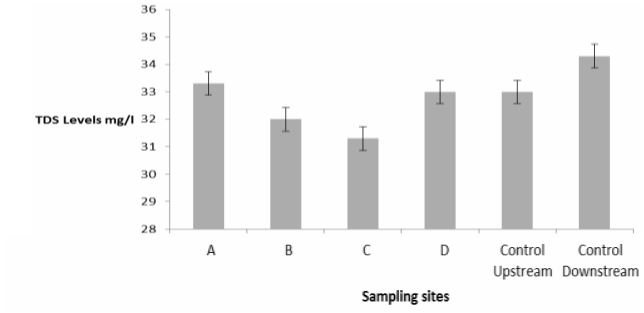

Figure 10. Graph showing variations in average total dissolved solids levels at the various sampling points

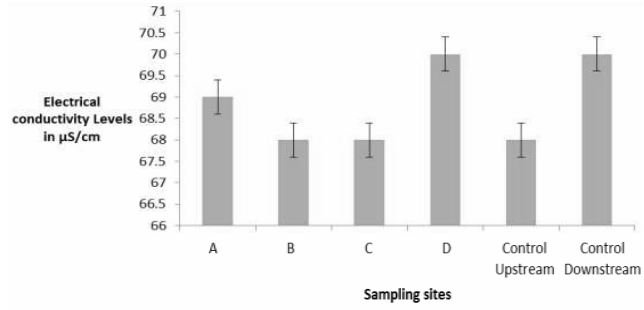

Figure 11. Graph showing variations in average conductivity levels at the various sampling sites

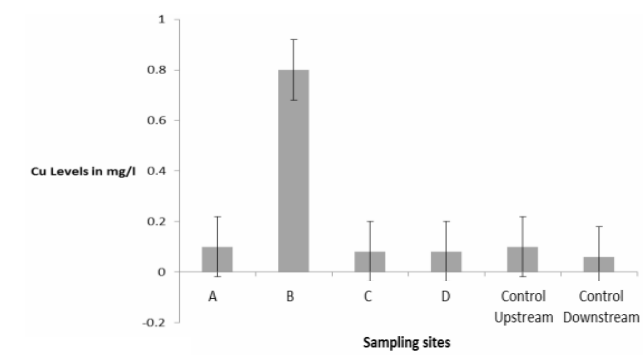

Figure 12. Graph showing variations in average copper levels at the various sampling sites

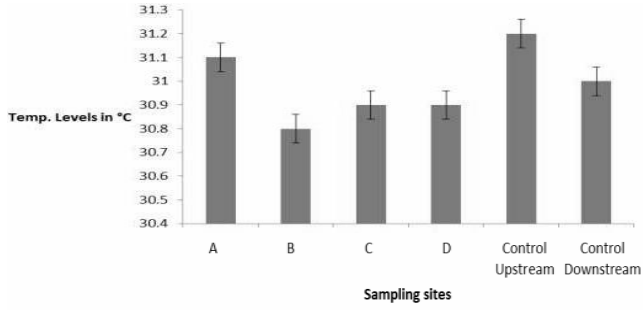

Figure 13. Graph showing variations in average temperature levels at the various sampling sites

The average values for the sampling region were A (0.1mg/L), B (0.8mg/L), C 0.08mg/L, D 0.08mg/L, control upstream 0.1 mg/L and control downstream 0.06mg/L (Figure 12). The results showed low levels of copper levels with no significant differences (ANOVA; $P< 0.05$) between sampling locations.

Figure 13 shows the average values for the sampling locations were A (31.1 °C), B (30.8 °C), C (30.9 °C), D (30.9 °C), control upstream (31.2 °C) and control downstream (31.0 °C). The results suggest no significant differences between temperature levels at the six sampling locations, indicating that cage aquaculture activities do not affect water temperature levels in the study region.

Financial viability (cost-benefit ratio and gross margin) of cage aquaculture in the study area

The economic viability of an industry entity determines how economically sustainable the industry venture is. The cost-benefit ratio was calculated during the first production cycle, whereas the gross margin was computed in the second production cycle. Expenditure for the five selected industry entities in the study region for five single cages of size 360 cubic meters each fell between GH₵ 22,941.00 for Volta Lake Fish Farmers Association to GH₵ 51,625.00 for Global Agricultural Foundation. The average expenditure was 34,573.00. Revenue levels fell between GH₵ 28,800.00 and GH₵ 91,980.00 for Volta Lake Fish Farmers Association and Global Agricultural Foundation, respectively, with average revenue for the five industry entities of GH₵ 48,176.00. The average net income for the same period (January 2014) was GH₵ 13,603.00. The cost-benefit ratio ranged between 1.11 for 3 A'S Agri Solutions and 1.78 for Global Agricultural Foundation, and 1.34 on average. Table 1 shows returns on investment were 10.87% for 3 A'S Agri Solutions and 78.17% for Global Agricultural Foundation, with an average of 33.818% for the five industry entities.

The expected expenditure for the second production cycle for the next six months ranged from GH₵ 11,883.00 for Volta Lake Fish Farmers Association to GH₵ 40,967.00 for Global Agricultural Foundation, an average expenditure for the five industry entities was GH₵ 23,506.00. Table 2 displays the average expected revenue was GH₵ 48,176.00 with an average net income of GH₵ 24,670.00. The average gross margin calculated in percentage was 104.41%.

Impact of cage aquaculture on the livelihood of people in fish farming communities

Socio-economic background of the people

Fifty-one people representing 49.5% who fall within 18-35 years were interviewed, followed by thirty-five middle-aged people (36-59 years) representing 34% and 17 older adults representing 16.5%. The figures indicated a substantial youth population in the society. The Kpeve Tornu society is a settler society, and a few aged people may be leaving the town for their original homes.

Fifty males and fifty-three females were interviewed in the society. The ratio reflects the sex composition in the region. Thirty people randomly interviewed had no formal education, with thirty-five ending their knowledge at the primary school level. Twenty-nine of them have either attained or dropped out at the junior high school/middle school level. Nine of them, representing 7.8%, reached or completed senior high or technical schools, and one person attained a tertiary level of education.

Table 1. Expenditure and returns on investment in the first production cycle (in GH₵)

Business entity	1st production cycle (6 months)				
	Expenditure	Revenue	CBR	Net Income	Returns (%)
1. 3 A'S Agri Solutions	31,118.00	34,500.00	1.11	3,382.00	10.87
2. Catchrite Farms Ltd.	32,743.00	39,600.00	1.21	6,857.00	20.94
3. Global Agricultural Foundations	51,625.00	91,980.00	1.78	40,355.00	78.17
4. Worlding Investment (GH) Ltd.	34,438.00	46,000.00	1.36	11,562.00	33.57
5. Volta Lake Fish Farmers Association	22,941.00	28,800.00	1.26	5,859.00	25.54
Average	34,573.00	48,176.00	1.344	13,603.00	33.818

(1 GH₵ = US$ 0.41623)

Table 2. Expenditure and returns on investment in the second production cycle (in GH₵)

Business entity	2nd Production Cycle (6 Months)			
	Expenditure	Revenue	Net income	Gross margin
3 A'S Agri Solutions	19,860.00	34,500.00	14,640.00	73.72
Catchrite Farms Ltd.	21,485.00	39,600.00	18,115.00	84.31
Global Agricultural Foundations	40,967.00	91,980.00	51,013.00	124.52
Worlding Investment (GH) Lt.	23,335.00	46,000.00	22,665.00	97.13
Volta Lake Fish Farmers Association	11,883.00	28,800.00	16,917.00	142.36
Average	23,506.00	48,176.00	24,670.00	104.41

(1 GH₵ = US$ 0.41623)

The economic activities of the people in the society were mainly trading (28.2%), farming (19.4%), fish farming (14.6%), farming and fishing (5.8%), fishing (4.9%), fishing and fish farming (4.9%), farming and fish farming (3.9%), farming, farming and trading (2.9%), fishing and fish farming (1.9%). 10.7% of the people participated in other economic activities such as masonry, carpentry, and dressmaking. Only 2.9% of the people were unemployed. Most people are also involved in multiple economic activities. 64.1% of the people interviewed have stayed in the society for more than ten years, 12.6% of the interviewees have lived in the city for six to ten years. 21.4% of them have been in the city for one to five years, and less than 2% of the people interviewed lived in the town for less than one year. The figures indicated that a vast majority of the people (64.1%) have stayed in the society for longer than ten years. There was also an influx of people into the city in the last five years, indicating an attraction of people towards the fish farming activities in the city since people who have stayed in the society between one to five years are more than those within six to ten years.

Primary sources and uses of water in the community

Table 3 shows that 9.7% of the people in the city depend solely on pipe-borne water while 19.4% rely on lake water. As many as 70.3% combine lake water and pipe-borne for various purposes.

Only 5.8% of the people in the society did not utilize the lake water for livelihood purposes. Water from the lake was used primarily for drinking, cooking, and washing (94.2%). Figure 14 shows other uses, including water transport (84.4% of the people), recreation (25.2%), as well as a libation (traditional worship) (11.7%), and irrigation (2.9%).

Perception/Assessment of people on the impacts of cage aquaculture on their livelihood and water quality

Table 4 shows that 93.2% of the people in the city have the perception that cage aquaculture did not affect their activities in the city. 6.8%, however, the remaining thought they were affected by the cage aquaculture industry in the city.

One percent of the people thought cage aquaculture affected recreation, while another 1% believed that aquaculture adversely affected fishing activities close to society. The following response indicates that the majority of the people thought the environment was not negatively affected by fish farming in floating cages (Table 5).

The people's assessment of the attitude of fish farmers toward the water environment in the area were as follows: proper (64.1%), average (8.7%) and poor (13.7%), and 13.7% of the people were not sure as to whether the fish farmers handled the environment well or not. The majority of the respondents seemed to be satisfied with the way fish farmers dealt with the lake water during their farming activities.

Benefits of cage aquaculture to the society

The respondents agreed that fish farming has dramatically improved living conditions in the city, particularly in employment, revenue, food, and trade regions. This implies that the cage aquaculture industry has positively impacted people's livelihood. Women in society benefitted more than the men from cage farming activities since they are highly employed to assist in harvesting activities than men.

From Table 15, 43.7% of the people interviewed did not benefit directly from the cage aquaculture industry in society. The rest have direct benefits from fish farming activities. 4.9% gained from casual employment, food, income, and fish trade. 6.8% benefited from the fish trade. 27.2% benefited from permanent employment, income, and food. 17.5% gained from casual jobs, income, and food.

The respondents requested livelihood assistance from fish farm owners to increase their living conditions, including the establishment of more fish farms in the region (33%), health facilities (18.4%), support for educational projects (16.5%), and road construction (11.7%). Three female respondents also asked for the employment of females in permanent fish farming jobs such as the feeding of fish in cages and diving to mend fishnets. A few respondents (6.8%) called on fish farm owners to be law-abiding and avoid chemical usage. The rest (10.7%) had no idea what fish farmers should do to help their society.

Table 3. Main sources of water for the people in the community

Main sources of water	Frequency (No. of people)	Percent (%)
Pipe-borne water	10	9.7
Lake water	20	19.4
Pipe-borne and lake water	73	70.9
Total	103	100.0

Table 4. Assessment respondents on the negative impact of cage aquaculture on livelihood opportunities

Response	Frequency	Percent (%)
Yes	7	6.8
No	96	93.2
Total	103	100.0

Table 5. Perception of people on whether cage aquaculture causes pollution

Response	Frequency	Percent (%)
Yes	19	18.4
No	68	66.0
Not certain	16	15.5
Total	103	100.0

Table 6. Registration of fish farmers in the study area

Registration of business	Frequency	Percent (%)
Yes	10	55.6
No	8	44.4
Total	18	100.0

Aquaculture regulations and compliance levels of fish farm owners

Not all fish farmers have registered their industry entity. The fish farming industry's income varies since the industry is capital intensive. Compliance with aquaculture rules by fish farmers has not been encouraging.

Socio-economic background of cage farm owners in the study region

All the fish farm owners in the study region interviewed were males. The results indicated that most fish farmers in the region are highly educated -industry. All the farm owners in the study region engaged in other economic activities apart from fish farming. Fish farming, therefore, was their secondary economic activity. 50% of the fish farm owners were government workers, while the rest were self-employed.

Registration of fish farming industry in the study region

Ten out of the eighteen respondents have registered their industry entities with various authorities such as the Local Assemblies, the Registrar General's Department, and the Fisheries Commission. Table 6 shows that eight of them have not registered their industries. The data implies that some fish farms in the study region were operating without registration and that some of these fish farmers were not following rules on aquaculture in Ghana.

Primary sources of capital for fish farming business in the study area

Fish farmers combined three different funding sources in their market (Table 16). Four of them depend solely on personal savings; two rely only on bank loans. Two others combine personal savings and bank loans. Six of them enter into an industry partnership with their savings, while four combine personal savings and bank loans and are in an industry partnership (Figure 16).

Financial viability of cage aquaculture industry in the study region

All the fish farm owners confirmed that cage aquaculture was financially viable even though it is capital intensive. 83.3% of respondents admitted that they reinvested part of their income in the fish farming projects, while 16% occasionally reinvested part of their profit in fish farming. The findings suggest that fish farming in floating cages on Volta Lake was financially viable. This explains the purpose of reinvesting gains back into production to expand the industry for more profits. All fish produced in the study region were sold in Ghanaian markets, and none was exported. Tilapia produced in the region has high demand in Ghanaian markets.

Compliance with aquaculture rules in the study region

Most fish farmers in the study region do not comply with aquaculture rules in Ghana. The Aquaculture Rules of Ghana, 2010 (LI 1968) directs all prospective farmers to acquire three main documents before operating aquaculture projects. These are the acquisition of Environmental Permit from Environmental Protection Agency, Water Use Permit from Water Resources Commission, and Aquaculture Establishment Certificate from the Fisheries Commission. The Abuja Declaration on Sustainable Fisheries and Aquaculture in Africa advocates sustainable aquaculture through integrated water resource management and locally available legislation to protect the environment.

No fish farming entity complied fully with the rules governing aquaculture projects in Ghana. In total, fourteen respondents kept records in different forms, while four had no legal documents to back their fish farming projects. Three fish farming groups had environmental permits, water resource use permits, and aquaculture establishment certificates, and none of the organizations had an environmental management plan (Figure 17). Only one respondent did not provide knowledge and skill training for field workers to safeguard against environmental damage. The rest made provisions for training workshops for their workers.

Challenges facing aquaculture industry in the study region

The farm owners enumerated the challenges facing the aquaculture industry in the study region. These were inadequate capital for investment, high feed prices, mismanagement, poaching, and fish mortality.

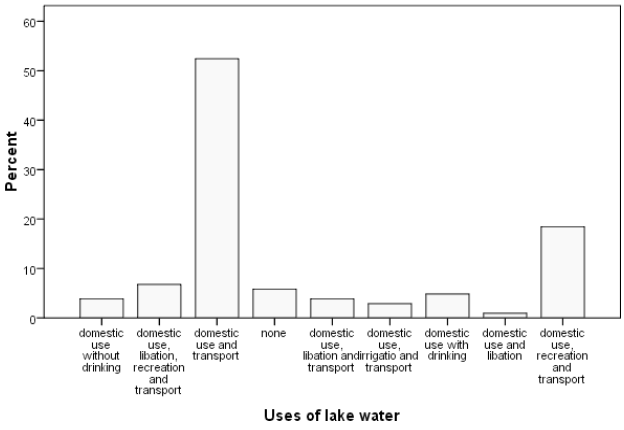

Figure 14. Primary uses of the lake water in the society

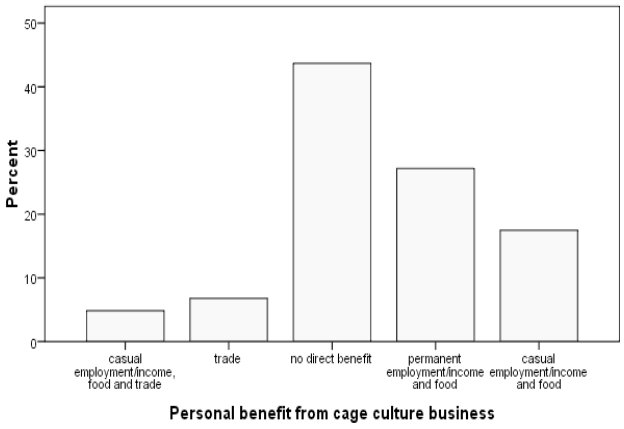

Figure 15. Personal benefits from fish farming

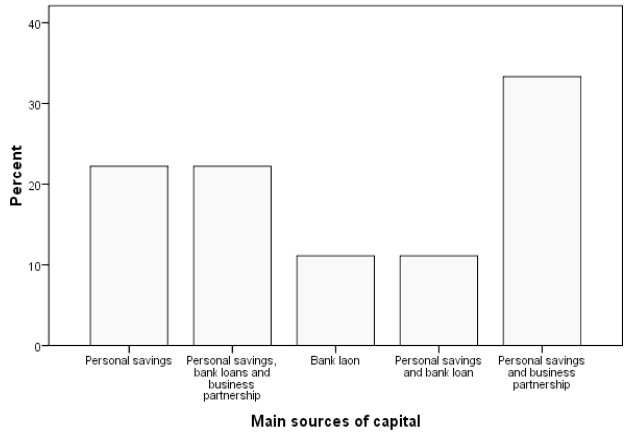

Figure 16. Primary sources of capital for the aquaculture industry

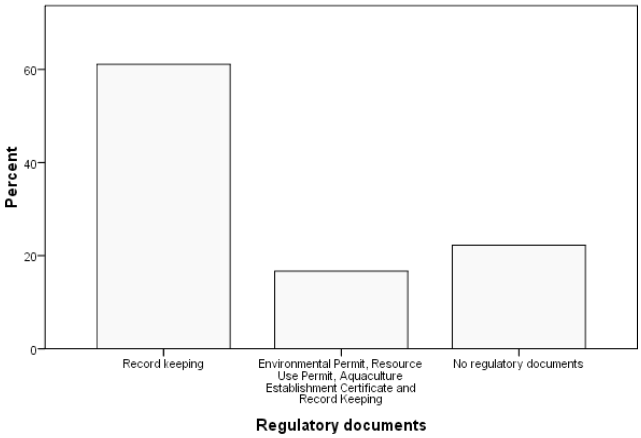

Figure 17. Compliance with aquaculture rules in the study region

Discussion

Water quality parameters

It comprised of protein (≥ 52%), fat (≥ 14%), moisture (≤ 10%), minerals (≤ 12%) and other trace elements (≤ 10%). These fish feed content could have contributed to water quality deterioration (Ali et al. 2006). Other natural biological processes also contribute to the degradation of waste produced in aquaculture ponds (Gross et al., 2000).

The total nitrate level between the four fish cage farms and the two control locations did not show significant variations (ANOVA; P< 0.05). The results indicate that nutrient inputs from the tilapia cages in the study region do not critically impact the lake water quality. The nitrate figure measured was below the World Health Organisation WHO (1993, 1998) standards for drinking water quality (10 mg/L), indicating that the lake water is within drinking water level. Denitrifying bacteria possess the natural ability to change nitrate-nitrogen into gaseous nitrogen that may be lost into surrounding air (Gross et al., 2000). Similarly, Effendie et al. (2005) reported on the impacts of fish farming in floating cages on water quality said undetectable values of nitrates in water under net cages.

The phosphate levels in the study region increased slightly in subsequent months from December 2013 to April 2014, with location A maintaining the highest values in all three months. This implies a slight effect of the fish farm at location A on water quality. The highest recorded amounts of phosphate at location A might be attributed to the higher feed inputs at location A, a region of the lowest depth of the sampling regions at an average of 5.2 meters. The fish farm at location A provided a high quantity of feed (13.8 tons per cage). However, there are no significant differences between cage locations and control locations. Phosphate may be eliminated through adsorbing into water sediments or precipitating directly as insoluble calcium phosphate ($CaPO_4$) from water (Masuda and Boyd 1994).

The average values of ammonium level for all sampling locations showed no significant differences (ANOVA; P< 0.05) between fish farms and control locations. Thus, the results imply that the ammonium level was insignificant in the study region. Water quality in the study region is good compared to WHO and Ghana Standards Authority Water Quality Standards (Table 7). It has the natural ability to assimilate waste products from fish cages (Boyd 2006).

Average DO levels fell at recommended levels for aquatic productivity. The results also suggest fluctuation levels of DO level in the four fish farms and the control locations indicating that the study region was not significantly affected by fish farming activities in the study region. Therefore, significant differences (ANOVA; P< 0.05) do not exist between the four fish farms and the two control locations. Water currents naturally minimize oxygen depletion in natural waters (Brooks and Mahnken 2003). In previous research, Alston et al. (2005) detected no significant differences in DO levels between cage farms and control locations in Puerto Rican waters.

The pH value for all the sampling locations during the comparative study was nearly neutral to basic. The finding reveals that the lake water quality is good for aquaculture productivity based on WHO Standards (pH 6.5 – 8.5) and similar to another report by Spicer (1997), which measured the pH between 6.0 and 8.0. Differences in the results were not significant (ANOVA; P< 0.05), suggesting that the fish farming activities in the study region did not significantly impact water quality in the region. Helsley (2000) suggested that the environmental impacts of open water aquaculture systems are negligible.

The results show fluctuating figures in the organic matter recorded at the study locations. However, we note that location A recorded the highest levels of organic matter in all three months, indicating higher rates of decomposition in location A, possibly due to higher levels of waste feeds around the location in question. The average values, however, show no significant variations between sampling locations. Turbidity levels varied slightly between the three months but not substantially between-study locations. Turbidity levels fell below WHO (1993, 1998) standards of 5.0, indicating that the water quality in the study region was not affected by fish farming activities.

The results recorded suggest variations in the levels of suspended solids in the study region with time. However, differences between sampled locations were not significant.

The results support earlier works that found no significant impacts of nutrient inputs from cages on the level of suspended solids in adjacent waters (Pitta et al. 1999, Alston et al. 2005).

Results show no significant differences in total dissolved substances at the six sampling locations. Alston et al. (2005) detected no significant differences between cage farms and the control location. Results in average electrical conductivity values indicate that differences in the electrical conductivity in the study region were not significant. Conductivity was also far below WHO Standards of 700 µS/cm for drinking water. This implies that fish farming in floating cages in the study region has no significant impact on lake water quality.

The average values in copper levels showed no significant variations. The copper level was also below WHO Standards (2.0 mg/L) for drinking water quality, indicating that the lake water is within drinking water quality and was not significantly affected by fish farming activities in the study region. Copper in specific levels is toxic to some aquatic organisms such as algae and has been used in fish feed formulation to prevent the fungal attack on fishnets (Brooks and Mahnken 2003).

Winsby et al. (1996) detected no difference in copper level in fishnet and a control location of 700 meters away from the fishnet. Nash (2001) also recorded the level of copper in fish cages at levels less than approved standard norms.

Average water temperatures suggest no significant differences between temperature levels at the six sampling locations and that cage aquaculture activities do not significantly impact water temperature levels in the study region. The previous report by Alston et al. (2005) also found no significant differences in water temperatures between fish cages and control locations.

Financial viability of cage aquaculture in the study region

The records from financial inputs and expenditure in the first production cycle suggested that the average cost-benefit ratio of cage aquaculture indicates the industry in the region is financially viable. The differences in profit margins could have been mainly due to differences in stocking density and the amount of fish feed used per cage. It was found that farmers used an imported feed from almost the same sources; feed rationing is different from one fish farm to another. In a report, the FAO (2005) indicated that fish farming provides a significant source of income for farmers in Ghana.

The expected inputs and outputs indicated that the likely average expenditure for the second production cycle was reduced by 32 percent. This was mainly due to fixed data which attracted relatively no cost in the second production cycle. The results also implied that the cage aquaculture industry in Ghana is financially viable with high-profit margins in the second production cycle. Ofori et al. *(*2009) indicated that farmers in Ghana who averagely produce substantial amounts of fish all year round earn a significant amount of income through the aquaculture industry.

Impact of cage aquaculture on the livelihood of people in fish farming communities

The figures indicated a substantial youth population in the city 48.5% of the people interviewed were males, while 51.5% were females. The ratio reflected the sex composition in the study region. The 2010 population census of Ghana estimated that women constitute 51.3% of Ghana's population (Ghana Statistical Service 2011).

The study indicated a low level of education in the study region. This is in line with a survey conducted in Bangladesh on the livelihood status of the indigenous people who produced fingerlings for fish farmers and put the people's illiteracy level at 64% (Gupta and Haque 2011). Another study in Croatia on fish farmers record 3.45% as fish farmers attaining high schools (Mrcelic and Sliskovic 2010).

The economic activities of the people in the society involved farming, fishing, fish farming, and trading, with a few engaging in artisanship such as carpentry, masonry, and dressmaking. This was an indication that the people's livelihood greatly depended on Volta Lake. Béné and Russell (2007) maintained that a large set of different activities exist even within the same fishing communities along the Volta Lake and emphasized that farming combined with fishing constitutes the most important economic activities in fishing communities.

The majority of the people in a society largely depended on the lake for livelihood purposes, including water transport, recreation, libation (traditional worship), and irrigation. The results suggested that the Volta Lake contributes mainly to the livelihood status of the people in fish farming communities.

The study revealed that 93.2% of the people in society believed that cage aquaculture does not negatively affect their livelihood opportunities. Only 6.9% were with the impression that fish farming in floating cages negatively impacts water quality, recreation, and fishing activities. They perceived that the level of cages in the regions affected the lake's beauty and hampered the setting of fish traps in regions close to the shoreline. This indicated that fish farming activities did not negatively impact people's livelihoods of the majority of society members in the study region. The majority thought the water environment was not adversely affected by fish farming in floating cages. This confirmed the assertion that cage aquaculture impacts on the water environment are negligible. According to Pitta et al. (1999), the environmental impacts of cage aquaculture on natural water resources are not statistically significant.

The people's assessment of the attitude of fish farmers in the region towards the water environment was encouraging. This indicated that most of the respondents endorsed how fish farmers handled the environment in the region. The results revealed that fish farming in floating cages has dramatically improved living conditions in society, especially in regions of employment, revenue, food, trade, and poverty alleviation. The society charged a fee before establishing fish cages close to the society. The tax is used for social development. This implies that the

cage aquaculture industry has positively impacted the livelihood of the people.

The results also indicated that fish farming has benefited individuals in regions of casual employment, permanent employment, income, and fish for household consumption, trade, and poverty alleviation. Women dominated the fish farming activities since their services were more needed during harvesting periods. Women in society are employed for harvesting, conveying, sorting and grading, weighing, fish gutting, recording, and packaging. This helps to improve the economic conditions of women in the study region.

The respondents demanded livelihood assistance from fish farm owners to improve their living conditions. These included the establishment of more fish farms in the region and other livelihood support services such as education, health, road construction, and avoidance of chemical usage in cage aquaculture. The appeal from the society maybe because the society members were aware of the financial gains in the fish farming industry and the fact that the society was deprived of essential amenities.

Aquaculture rules and compliance levels of fish farm owners

All the fish farm owners interviewed were males, middle-aged people. The finding supports the earlier work conducted by Asmah (2008) that men dominate fish farming in Ghana. Most fish farmers in the study region are highly educated industry.

All the farm owners in the study region engaged in other economic activities apart from fish farming. Precisely, 50% of the fish farm owners were either government workers or self-employed industry. Fish farming, therefore, was their secondary economic activity. This reveals that most Ghanaians do not regard fish farming as a permanent job, resulting from the fact that the industry venture is capital intensive and associated with a few challenges. Even though many Ghanaians are interested in the aquaculture industry, most people see the industry as part-time economic activity.

Rules on aquaculture in the region were not fully complied with by fish farmers since many fish farms in the study region were operating without registration. Some farmers may also not be aware of the available rules because of the lack of intensive public awareness and education.

Personal savings, bank loans, and individual contributions through industry partnership dominated sources of funding for the aquaculture industry. The findings indicated that sources of financing for aquaculture ventures vary due to their capital-intensive nature. Limited financial resources for aquaculture development in Ghana constraints aquaculture productivity, according to Hiheglo (2008).

All the fish farm owners surveyed agreed that cage aquaculture is financially viable even though it is capital intensive. This is an indication that the fish farming industry in Ghana can contribute mainly to the socio-economic development of Ghana. Ofori et al. *(*2009) and FAO (2005) agree that fish farming generates substantial income for fish farmers.

Most fish farm owners reinvest part of their profits into cage aquaculture. This suggests that fish farming in floating cages on Volta Lake is financially viable. It also shows that fish farmers expand their industry for more profits.

The findings from the study suggest that no fish farmer complied fully with aquaculture rules in Ghana. The Aquaculture Rules of Ghana, 2010 (LI 1968) directs all prospective farmers to obtain three main documents before operating an aquaculture project. These are the acquisition of Environmental Permit from Environmental Protection Agency, Water Use Permit from the Water Resource Commission, and Aquaculture Establishment Certificate from the Fisheries Commission. The Abuja Declaration on Sustainable Fisheries and Aquaculture in Africa also advocates sustainable aquaculture through integrated water resource management and locally available legislation to protect the environment.

Provisions were made for training workshops in cage aquaculture activities for workers. The skill and knowledge training may be helping to reduce the environmental impacts of cage aquaculture on the water environment.

The main challenges recognized with the aquaculture industry in the study region were inadequate capital for investment, high feed prices, mismanagement, poaching, and fish mortality.

This implies that one has to deal with these challenges before the full benefits of aquaculture can be realized. Hiheglo (2008) listed poaching and lack of credit and other financial resources among the challenges facing aquaculture development in Ghana.

Conclusion

Cage aquaculture is defined by fish farming in floating cages whereby fish and other aquatics are kept in enclosures that permit the exchange of water and waste products between the cage and the water environment around the cage. Cage aquaculture greatly contributes to the socio-economic development in regions of employment, income generation, foreign exchange, and food security. Cage aquaculture adversely impacts the water environment leading to deterioration in water quality. Other experts, however, found no significant effects of cage aquaculture on water quality.

Only less was known of the impacts of cage aquaculture on the Volta Lake and the communities close to cage aquaculture environments. Information on the financial viability of fish farming in floating cages was not readily available in the Ghanaian industry environment. Also, aquaculture regulatory compliance levels were not reported among fish farm owners. The study, thereby, sought to provide answers to these relevant issues.

Kpeve Tornu in the Volta Region of Ghana was chosen as the study region because tilapia cages were densely concentrated in this society. The Ghana Water Company also sourced water from the same region for commercial purposes to serve four administrative districts in the Volta Region. Water samples were taken from four fish farms,

analyzed, and compared with two control locations between December 2013 and April 2014. Twenty-five percent of adult inhabitants in the society were interviewed to assess the impacts of the fish farming projects on their livelihood opportunities. Five industry entities were selected for data on cost and returns in the cage aquaculture industry for cost-benefit analysis. Sixty percent of fish farm owners were also interviewed to assess the compliance levels with aquaculture rules.

Results showed that significant differences did not exist in water quality parameters at fish farms and control locations. There was also a positive impact of fish farming on members in employment, income generation, and fish for household consumption. The study demonstrated that cage aquaculture was financially viable in Ghana even though it was capital intensive. Aquaculture rules were effective on fingerlings and aquaculture-related chemicals producers. Still, the rules on fish farmers needed a review since there were no definitions for intensive and semi-intensive fish farming in the aquaculture rules of Ghana. Compliance levels also required improvement.

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