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WETLANDS DISTURBANCE IN NORTHERN REGION OF GHANA: AN INDIGENOUS CONSERVATION APPROACH

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AUTHORS' CONTRIBUTIONS

This work was carried in collaboration with my co-author. Author CAN designed the study, collected field data, managed the literature searches, wrote the protocol and interpreted the data. Author EHA equally managed the literature searches, took part in field data collection and undertook preliminary review of the draft manuscript before it was sent to the Journal for a peer review process.

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ABSTRACT

The study examined wetlands disturbances and the use of indigenous conservation approach in Northern Region of Ghana. A combination of Salafsky and Battisti model were used to quantify disturbances, while principal component analysis (PCA) was applied to synthesize environmental data in order to produce an ordination of sites based on environmental variables. A total of ten environmental disturbances (bushfire, water abstraction, animal trampling, tree felling, farming activities, grass harvesting, channel incision, hunting, illegal fishing method and grazing pressure) were identified. Disturbances were much more severe and widespread in the long dry season (6 -7 months), since most activities for instance grazing, water abstraction and grass harvesting) were carried-out. Increase in disturbance regime were observed in communities with high human population, and varied along the two main seasons. Principal component analysis (PCA) showed that farming activities, bushfires, water abstraction, animal trampling and grazing pressure were the key human-led factors that severely impacted the six wetlands. The first two axes jointly explained 66.73% variance in disturbance regime and their spatial occurrence across the sites (axis I= 38.37% and axis II = 28.36%). Although disturbances did not differ in all sites (F = 1.66, p = 0.15), the two riparian wetlands, tended to show much resilience to disturbances than the marshes and constructed wetland. Water abstraction for dry season irrigation and farming activities in the wet season, contributed in reduced water level in the swamp forest and constructed wetlands (R^2 = 0.658, p=0.05). Our results revealed that human-led disturbances have greatly impacted on the wetlands, which play a critical role in livelihood support of rural communities and a gene pool. Thus, to ensure the restoration of the functional status of wetlands, implementation of the proposed conservation intervention in this study, must be enforced by traditional/indigenous conservation approaches and possibly adopted as part of national wetland policy framework.

Keywords: Seasonality; principal component analysis; environmental disturbance; biodiversity; sustainability; policy framework; functional status.

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1. INTRODUCTION

Wetlands are among the most productive ecosystems that have contributed to the ecological balance of the environment and economic livelihood support of local communities [1]. Globally, about 1.5 - 3 billion people depend on wetlands as a source of drinking water as well as for food and livelihood security [2]. In spite of their productive and complex nature, wetlands are easily prone to influence from natural and human-led factors. Wetlands worldwide have suffered severe degradation, through agriculture expansion [2,3], bushfires [4-6] and Grazing [7-9]. Data provided by Ramsar Contracting Parties revealed that 84% of Ramsar-listed wetlands had already undergone or were threatened by ecological change [10].

The high conservation concern of wetlands in the Northern Region of Ghana Nsor & Obodai [11], create the need to give critical attention to wise use of wetlands, which not only involves the maintenance of ecological integrity, but also for sustainable development. This intervention may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations must be given critical attention [12]. The Wise use guidelines, of which Ghana is signatory to the Ramsar Convention since 1988, highlights the establishment of national wetland policies covering all problems and activities related to wetlands, including institutional and organizational arrangements, legislative and government policies, increasing knowledge and awareness of wetlands and a review of wetland priorities in a national context. Right after ratifying the Convention on wise use, several national policies and legislation such as the Fisheries Decree (1972), the Land Policy, the Water Resources Act, Ghana Vision 2020 and the Decentralization Policy, have been passed into law. In spite of the existence of these policies and decrees, governments over the years have not been able to effectively implement these guidelines for the sustenance of the functional state of wetlands, especially in the Northern Region of Ghana. This is probably due to difficulties in overcoming traditional beliefs/attitudes towards wetlands and the lack of involvement of indigenous people in policy formulation. In the Northern Region of Ghana, traditional rulers such as chiefs, clan heads and fetishes, are the sole caretakers of wetlands and sacred grooves in their traditional areas. These group of people control resource exploitation by placing limits on access, through the use of taboos and enforcement of ban. Though these measures and conservation policies are meant to harness the ecological integrity, conservation status of wetlands in Northern Region is still '*unprotected*', thus exposing them to various disturbances. The failure of "top-down" wetlands policy implementation over the years, suggest the need between governments and traditional owners/users of wetlands, to jointly work to protect and sustain the flow of resources, through integrated management and traditional governance. This paper aim at 1) assessing the overall functional status of the six sites, along a disturbance gradient, with specific emphasis on macrophyte range shift and 2) propose appropriate integrative conservation and policy measures that should be adopted in order to promote the functional status of not only six wetlands under study, but also as a regional policy framework for all wetland types. Annual rainfall in the study site is in the range of 1000-1,300 mm/p.a and the wet season lasts from June to early October, while the dry season last from November to May. Average temperature varies between 14°C and 40°C [13]. Altitude ranges between 108 – 138 meters above mean sea level. The vegetation cover is a mixture of grassland dominated by *Lersia hexandra* and woodland dominated by Mahogany (*Khaya senegalensis*) and shea tree (*Vitellaria paradoxa*) interspersed with shrubby communities of *Mitragyna inermis* and *Ziziphus abissynica*. The trees are relatively short with thick bark and occlusions, signifying their adaptation to the cyclical dry season bush fires. Crop farming, livestock rearing and fishing are the main stay of activities among the inhabitants.

2. MATERIALS AND METHODS

The study was carried out in six wetlands located in the Northern region of Ghana, with their co-ordinates as follows: (i) Wuntori (N09^0 08.335' W00^{0}1 09^0.685'); (ii) Kukobila (N10^0 08.723' W000^0 48.179'); (iii) Tugu (N09^0 22.550' W000^0 35.004'); (iv) Bunglung (N09^0 35.576' W000^0 47.443'); (v) Adayili (N09^0 41.391' W000^0 41.480') and (vi) Nabogo (N09^0 49.941' W000º.51.942') (Fig. 1). The six sites lie on the extensive floodplain along the course of the White Volta River, which has overtime become incised and modified through meandering and aligning along various topographic features. This has led to the development of streams that have diverted from the main White Volta [13]. All six wetlands were classified as close shallow marshes (Wuntori and Tugu wetlands), open deep marsh (Kukobila wetland), riparian wetlands (Adayili and Nabogo wetlands) and artificial wetland (Bunglung wetland). The hydrological regimes of the six wetlands under study were typical of permanent wetlands, whose depth at low tide did not exceed 2 m on average. Sizes of the wetlands were computed through on-screen digitizing of Landsat aerial images, obtained from google earth platform. The areas are as follows: (a)

Wuntori = 7.7 ha; (b) Kukobila = 5 ha, Tugu (c) 2.7 ha; (d) Nabogo = 7.9 ha; (e) Adayili = 6.7 ha and (f) Bunglung = 11.5 ha.

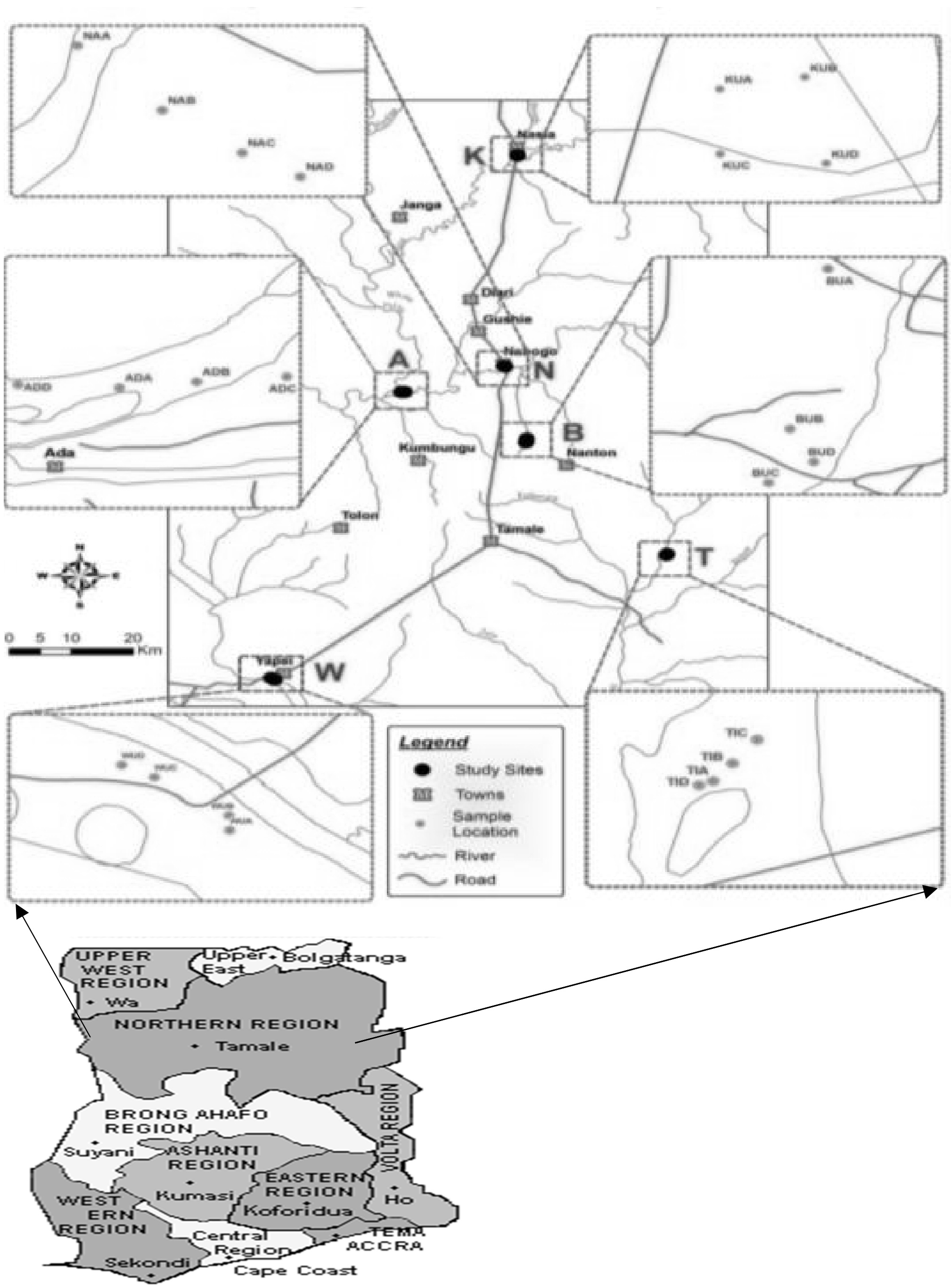

Fig. 1. Map of the study areas, showing the location of the wetlands in the floodplains of the White Volta River catchment, Northern Region. The alphabets represents names of the wetlands; K = Kukobila, N = Nabogo, A = Adayili, B = Bunglung, T = Tugu and W = Wuntori

2.1 Vegetation Sampling Techniques

Sampling of plant species was carried-out in each of the 24 Modified-Whittaker plots over a 2-year period [14]. The Modified-Whittaker plot is a vegetation sampling design that is used to assess plant communities at multiple scales. Four Whittaker plots were randomly laid in each of the six wetlands, bringing the total to 24 plots.

Plots were laid along an environmental gradient of the vegetation type being sampled, in order to register majority of species heterogeneity. The Domin-Krajina cover abundance scale was used to estimate ground cover [15]. Plants were identified up to species level, with the aid of manuals developed by Johnson [16], Okezie & Agyakwa [17] and Arbonnier [18]. The sites ware located ~ 60 km radius of the Tamale weather Station. To determine whether plant species present were typical wetlands plants or from terrestrial systems, the Prevalence Index method was employed to classify the weighted average of indicator status of sampled species as follows: obligate plants (OBL) = 1.0; facultative wetland plants (FACW) = 2.0; facultative plants (FAC) = 3.0; facultative upland plants (FACU) = 4.0 and obligate upland plants (UPL) = 5.0 [19]. Obligate wetland plants - (i.e. hydrophytes with >99% probability of occurring in wetlands); facultative wetland plants - (usually found in wetlands with an estimated probability of 67% - 99% occurrence, but occasionally found in uplands); facultative plants- (having 34% - 66% equal chance of occurring in wetlands); facultative upland plants - (usually occur outside wetlands, but occasionally found in wetlands, and obligate upland- (occur only in uplands [20]. In addition to the indicator status categories, positive (+) sign was used to indicate all facultative species categories with a frequency towards wetter ends (more frequently found in wetlands) and the negative (-) sign with a frequency towards drier ends (less frequently found in wetlands) [20]. Plant species on each plot were identified, counted and classified under the different species indicator status, to determine their relative abundance. Total number of species in each indicator status category was subsequently divided by the total number of plots on which they were sampled, in order to obtain the average for each plot. Plots that score < 3.0 were considered to be obligate wetland plants (OBL) and those that score >3.0 were designated as upland plants (FACW; FAC; FACU and UPL categories), that may have migrated into the wetlands over time. We further counted species from each of the indicator status category and expressed it as a percentage of the total species sampled, in order to determine whether the wetland plant communities are predominantly hydrophytes. Our values obtained were used to compare with the standard value of >50% cumulative cover of OBL, FACW or FAC species present in a site [19].

To avoid duplication of species count, species of the same type that were already identified and counted in previous plots were not recorded in subsequent plots in which they occurred.

To determine the mode of species range shift into wetlands, livestock droppings from the 24 plots were collected and sun dried. The droppings were subsequently broken into smaller clumps and placed on 24 soil medium containers each. Watering of the droppings was carried out in the morning at 7 am and in the evening at 5 pm daily, so as to enable plant seeds that are embedded in the droppings to germinate. Germinated seedlings, were identified and categorized as obligates, facultative and upland species. This experiment was to confirm whether grazing activities by livestock could have partly contributed in the range shift of plant in the six wetlands.

2.1.1 Environmental assessment

Identifying how many and which types of human-induced disturbances or threats are present and their regime is important when assessing the status of wetlands of high conservation concern for efficient management [21,22]. In this regard, ten environmental drivers of change were assessed. They included: bushfire, water abstraction, animal trampling, tree felling, farming activities, grass harvesting, channel incision, hunting, crude fishing method and grazing pressure. Using a hierarchical classification of threats (HCT) developed by Salafsky et al. [22], all threats identified and comprehensively documented (contains all possible items, at least at higher levels of the hierarchy), consistent (ensures that entries at a given level of the classification are of the same type), expandable (enables new items to be added to the classification if they are discovered) and exclusive (allows any given item to only be placed in one cell within the hierarchy. A score ranging 1–4 was used to assess the scope and severity of every threat. A ''*scope*'' hereby referred to as the percentage ratio of the study area affected by a specific threat within the last 5 years (where 100% correspond to total site area: χ ha) [23]. The scores were assigned as follows: 4 = the threat is found throughout (50%) the site; 3 = the threat is spread in 15–50% of the site; 2 = the threat is scattered (5–15%); and 1= the threat is much localized (<5%). Assessment of the area disturbed was carried out well beyond the delineated zone of wetlands, where most land use activities take place.

Information on cultural beliefs, taboos and community values were determined through focused group discussion among wetland users, whereas oral interviews was conducted among clan heads, fetish priests and chiefs".

2.1.2 Statistical analysis

A Principal component analysis (PCA) was used to synthesize environmental data in order to produce an ordination of sites based on environmental variables alone [24]. Analyses was performed on a Community Analysis Package (CAP) version. 1.52 [25]. A linear regression model was applied to determine the relationship between farming activities on water abstraction and bushfire, using Excel Statistical Package version 13 (Windows 8.1). A Student t-test was used to determine the significant influence of grazing and farming practices on animal trampling and bushfire respectively.

3. RESULTS

A total of ten environmental disturbances, namely; bushfire, water abstraction, animal trampling, tree felling, farming activities, grass harvesting, channel incision, hunting, crude fishing method and grazing pressure, were identified across the six wetlands, as threats or potential threats (Table 1, Fig. 2). From the ranking of severity of disturbances, grazing pressure, bushfire, farming activities and water abstraction, appeared as severe threats to wetlands functional status (Fig. 2). Severity of disturbances regime occurred in wetlands nearer to communities with high population pressure, and varied along the two main seasons (wet and dry seasons). Although environmental disturbances did not differ significantly in all wetlands (F = 1.66, p= 0.15), the two riparian wetlands tended to show much resilience to disturbances than the natural marshes and the constructed wetland. Principal component analysis (PCA), showed that grazing activities, animal trampling and crude fishing method, were much pronounced in Kukobila, Tugu and Adayili wetlands, located in highly populated communities along component I (Fig. 3). These disturbances occurred throughout the year, however, they were much more severe and widespread in the long dry season (~ 6 - 7 months), since these wetlands served as the only source of watering point and forage abundance for the livestock in the catchment area during these period. Increased pressure on wetland exploitation, tended to reflect in low abundance of obligate wetland species (OBL) (35%) (for example *Cyperus distans, Nymphaea micrantha* and *Ipomea aquatica*), compared to 40% dominance of facultative wetland species (FAWC) (for example *Leersia hexandra, Ludwigia hyssopifolia* and *Echinochloa pyramidalis*), facultative species - FAC = 35%, facultative upland – FACU = 20% and obligate upland – UPL = 27.5%, sampled in the 24 Whittaker plots (Table 2). Obligate wetland species, cumulatively scored < 3.0, with an average of 1.3 species/plot. While the remaining three plant categories (FAWC, FAC, FACU and UPL registered a cumulative score of > 3.0, with an average of 3.2, 4.0 and 3.2 sp/plot respectively (Table 3, Fig. 3). These species largely from neighbouring terrestrial systems, showed a gradual shift into wetter areas (F =3.33; p=0.117), through the development of morphological and physiological adaptive mechanisms (Table 3, Fig. 3).

Water abstraction for dry season irrigation and farming activities in the wet season, contributed in reduced water level in the Nabogo swamp forest and Bunglung constructed wetlands (R^2 = 0.658, p= 0.05) (Fig. 5). Severe patchiness brought about by previous and recent bushfires, were common in the improved marshes of Wuntori and Kukobila wetlands and the Nabogo swamp forest. However, increase in bushfires was not directly influenced by the expansion of land clearing for farming activities (R^2 = 0.337, *Student t-test* = 0.438, p=0.679) (Fig. 6). Hunting, grass harvesting, tree felling and channel incision, did not appear as major threats on the functional status of the six wetlands, as their severity were less and only limited to smaller steep sections of the two swamp forest wetlands (Fig. 3). The first two axes (component I = 38. 37 and component II = 28.36) jointly accounted for 66.73% variance in disturbances regime and their occurrence across the six sites (Table 4).

3.1 Identified Threats to Wetlands and Proposed Application of Local by-laws and Taboos in Conservation Intervention

Though, this study focused largely on aquatic macrophytes, we included sustainable exploitation of fish resources in our proposed conservation intervention, since there is scientific evidence of dwindling fish catch and diversity in the same study area [Nsor et al. *unpublished*]. The severity of threats and/or potential threats observed, reflects on the current functional status of the six wetlands. Traditional leaders and fetish priests (locally known as "*Tindana"*) over the years have used taboos such as pacification of wetland *lower deities* or "*gods*", to manage sustainable exploitation of wetland resources. In this case, 1-2 month period in the wet season is observed as a period of ritual sacrifice for the wetland *gods* and hence wetland users were prohibited from undertaking all resource exploitation activities during this period with the exception of herb extraction for medicinal purposes. However, this has not yielded satisfactory results, due to the rising population pressure in communities close to the wetlands under study. Following these observation, we proposed key conservation interventions (Table 3), to be enforced by chiefs and fetish priests. The strict enforcement of these conservation measures were to be superintended by chiefs or fetish priests or clan heads.

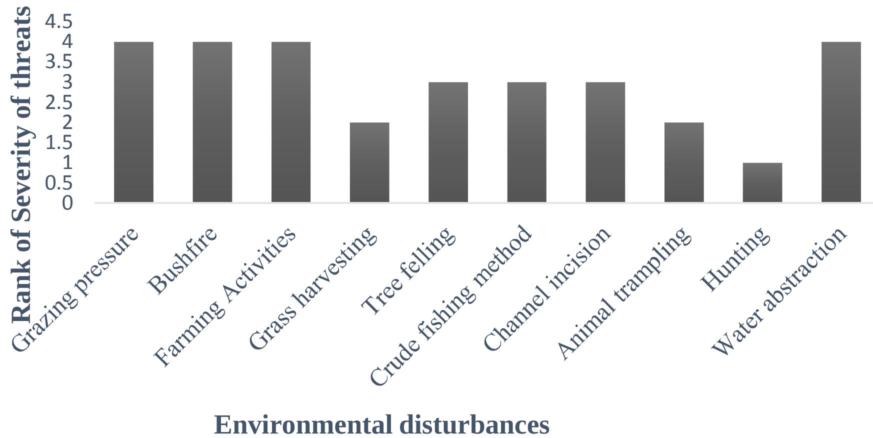

Fig. 2. Environmental disturbances, showing the relative severity of threats across the six wetlands

Table 1. Rank of environmental disturbances identified on the basis of severity across the six wetlands

Wetland classes

Treats	**Close shallow marshes**		**Open deep marshes**	**Riparian systems**		**Constructed wetlands**
	a. Wuntori	**b. Tugu**	**c. Kukobila**	**d. Adayili**	**e. Nabogo**	**f. Bunglung**
Grazing pressure	4	3	4	3	1	4
Bushfire	3	4	3	2	4	2
Farming activities	1	2	4	3	4	4
Grass harvesting	2	1	3	1	2	3
Tree felling	4	3	2	1	3	2
Illegal fishing methods	3	2	4	4	3	2
Channel incision	3	1	2	4	2	3
Animal trampling	2	2	3	3	2	3
Hunting	2	1	3	1	2	1

Status of disturbances severity: 4 = the threat is found throughout (50%) the site; 3 = the threat is spread in 15–50% of the site; 2 = the threat is scattered (5–15%); and 1, the threat is much localized (<5%). Source of ranking after Battisti et al. (2009) and Salafsky et al. (2009)

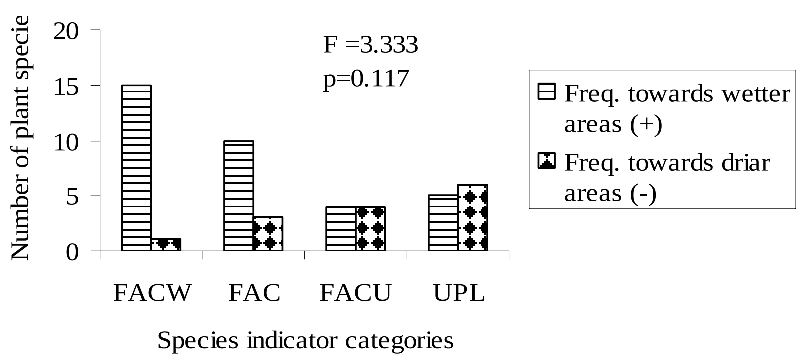

Fig. 3. Indicator species status showing the frequency of species shift towards wetter and drier areas
The abbreviations denote the fallowing: Facultative wetland plants (FACW); Facultative plants (FAC); Facultative upland plants (FACU) and Obligate upland plants (UPL)

Table 2. Plant species showing the application of Cronk and Siobhan-Fennessy (2001) and Tiner (1999) model to categorize species under different indicator status* = dryland weeds of arable and plantation crops/derived savanna. Indicators of frequency species shifting towards wetter areas is denoted by (+) and towards drier areas by (-) signs

Obligate sp.	Facultative wetland sp.	Facultative sp.	Facultative upland sp.	Obilgate upland sp.
Cyperus difformis	*Cynodon dactylon+*	*Brachiaria mutica+*	*Crolaria retusa* -*	*C. retusa*-*
Cyperus spacelatus	*Deplachne fusca*+*	*C. retusa*-*	*Echinochloa pyramidalis+*	*D. fusca*+*
Cyperus distans	*Echinochloa stagnina+*	*Cynodon dactylon+*	*Imperata cylindrica*-*	*Heliotropium indicum*+*
Ceratophyllum demersum	*E. pyramidalis+*	*Deplachne fusca*+*	*H. indicum*+*	*I. cylindrica*-*
Eleocharis mutata	*Fimbristylis ferruginea*+*	*E. pyramidalis+*	*Ludwigia hyssopifolia*+*	*Khaya senegalensis-*
Ipomea aquatica	*Helioptropium indicum*+*	*H. indicum*+*	*Mormodica chrantia*-*	*L. hyssopifolia*+*
Ludwigia octovalvis	*Leersia hexandra+*	*Pennisetum polystachion*-*	*P. polystachion * -*	*M. chrantia* -*
Neptunia oleracea	*L. hyssopifolia*+*	*Salacia reticulate+*	*Schizachyrium sanguineum*+*	*P. polystachion *-*
Nymphaea micrantha	*Mitragyna inermis+*	*Scoparia dulcis*+*		*S. sanguineum*+*
Oryza longistaminata	*Mimosa pigra+*	*S. sanguineum*+*		*Setaria pumila*+*
Polygonium salicifolium	*P. polystachion*-*	*Syzygium guineense+*		*Z. abyssinica –*
Paspalum varginatum	*Phyllanthus amarus +*	*Vitex crysocarpa+*		
Pistia stratiotes	*Scoparia dulcis*+*	*Ziziphus abyssinica -*		
	Setaria pumila+*			
	Saciolepsis Africana +			
	Salacia reticulate +			
35%	40%	32.5%	20%	27.5%

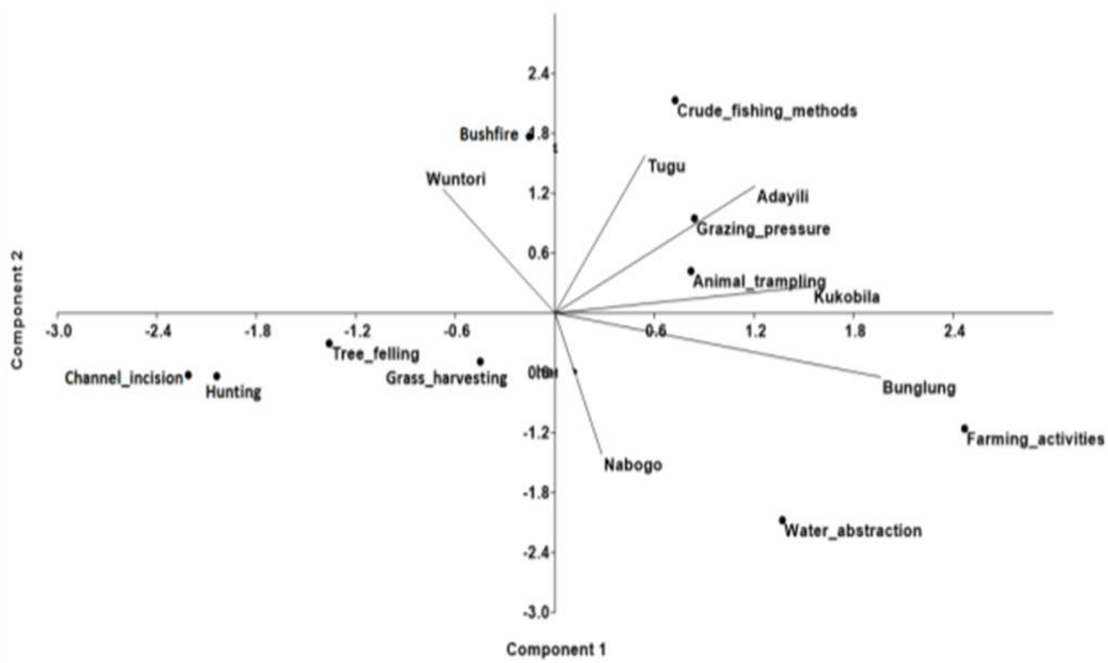

Fig. 4. Principal component analysis, showing the occurrence of different environmental disturbances measured *in situ* in the six wetlands. The first axis explains 38.37% and the second axis 28.36% of the spatial distribution of disturbances. Thick circles (•) represent environmental disturbances, while thick lines (─) represent wetlands

Table 3. Summary of indicator species categories, showing their relative abundance of dominance among the 24 Whittaker plots

Indicator sp. status	No of species	No. of plots dominated	Av. sp/plot	
Obligate wetland sp. (OBL)	13	10	1.3	< 3.0
Facultative wetland sp. (FAWC)	16	5	3.2	> 3.0
Facultative sp. (FAC)	13	4	3.3	
Facultative upland sp. (FACU)	8	2	4.0	
Obligate upland sp. (UPL)	11	3	3.2	
Number of Whittaker plots		24		

Table 4. Principal Component Analysis, showing the relative contribution of each of the components in to the explanation of total variation in the environmental data

	Component I	Component II	Component III
Eigenvalues	2.323	1.723	1.584
% variance	38.375	28.361	19.057

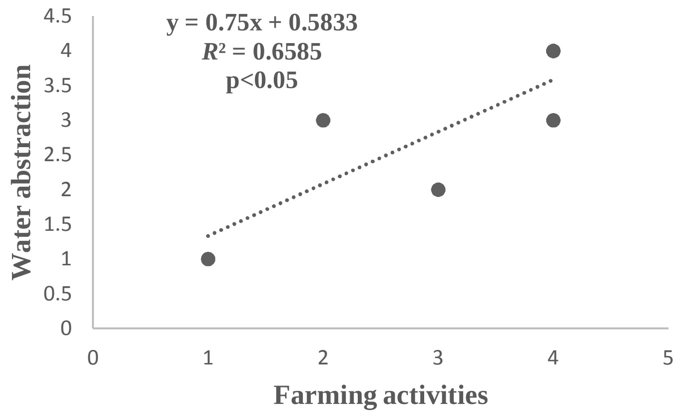

Fig. 5. Relationship between farming activities and water abstraction across the six wetlands

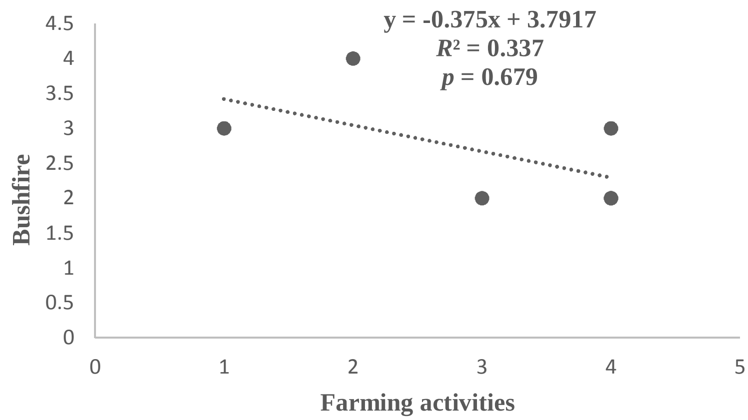

Fig. 6. Influence of farming activities on the incidences of bushfires across the six wetlands

Table 5. Identified threats to wetlands and proposed indigenous governance conservation intervention in the six wetlands

Threats	Conservation intervention
1. Bushfires	i) Creation of fire belts about 100 m radius from the delineated zone of wetlands; ii) Herdsmen, farmers and hunters in the communities and surrounding areas, must uphold to the ban on indiscriminate bush burn on wetlands designated as "*lower deities or small gods*"; iii) Enforcement of prescribed or control burning, for purposes of stimulating early vegetation growth for grazing.
2. Grazing pressure/animal trampling	i) Approximately 30 cattle/herd permissible for grazing on a rotational basis, only in the dry season; ii) As part of the grazing regime, a three-year fallow period be strictly followed, to allow for recovery of vegetation from grazing intensity.
3. Farming practices	i) Strict adherence of farming activities beyond 1 km of the delineated zone (buffer zone);
4. Water abstraction	i) Construction of mini dams and dug-outs within the floodplains of the White Volta, to store excess water during flood events. This can be used as an alternative source of water for irrigation activities.
5. Illegal fishing method	i) Wetland users must observe all ritual performance by the chief fetish priest, which signals the beginning of the close season (i.e., spawning season between July-October, where fish harvest is prohibited); ii) Only recommended net size approved by the Fisheries division of the Ministry of Food and Agriculture be used for fish harvesting; iii) Use of hexagonal cage-like baskets (locally called "*Aha"*) in shallow parts of wetlands and all channels in the wet season, be used in harvesting matured fish in smaller quantities; iv) Construction of dikes (2 x 2 m dimension) along the banks of the White Volta River (about 30 m away from the fringes of the River), to serve as draw-down refugia for fish, that can be harvested fish that may have migrated into these sites during flood events.
6. Grass harvesting/tree felling	i) Preservation of trees and shrubs within 1 km radius of the wetlands; ii) Planting of multipurpose fast growing trees (e.g., Kassod tree - *Cassia siamea*; White lead tree - *Leucaena lecocephala* and moringa tree - *Moringa oleifera*), that thrive in degraded sites, erratic rainfall and prolong draught; iii) Harvesting of grass as thatch materials be carried out on a rotational basis, in order ensure regeneration of vegetation. Alternatively, hay and silage, can be used as alternative source of feed for livestock.
7. Channel incision	i) Stone bunding technique: This involves the use of stones or boulders, arranged in a terrace form, against the direction of flow of water into the channels during rainstorm. Alternatively, channel incision are filled up with boulders. The stones are interspersed with plant residue. This method is particularly effective for wetlands with geomorphic setting typical of valley-bottom or hill slopes. The distance from one terrace stone bund to the other is approximately 1-5 m; *ii)* Construction of gabions as reinforcement across the flow direction of water, in swamp forest wetlands (riparian systems).

4. DISCUSSION

Our assessment of the six wetlands, provided a valuable insight that catchment land use activities can have far reaching consequences on wetlands ecological integrity and human livelihood. Documented disturbances in this study, namely; bushfire, farming activities, grazing pressure, water abstraction and crude fishing methods, were largely driven by population increase and expansion of settlements, coupled with low levels of rainfall in recent times and the general impoverished terrestrial soils. These disturbances had severely threatened the ecological integrity of the wetlands, particularly the three Natural marshes (Kukobila, Tugu and Wuntori wetlands). For instance, the gradual establishment of facultative and obligate upland species (dryland species) in wetland conditions (non-native species), through the use of specialized physiological and morphological adaptive mechanisms, created a nitch competition for resource utilization with obligate species that have already shown signs of sensitivity to slight habitat perturbation. It is therefore most likely that obligate (hydrophyte) population such as *Nymphaea micrantha* which were less abundant, may be extinct when current disturbances intensifies, and further raising the issue of conservation concern among wetlands from the study area. Natural floristic diversity in wetlands are noted to have decreased ~~in~~ as result of increasing human pressure on wetlands [26]. Prasad et al. [27] revealed that wetlands in India, as elsewhere are increasingly facing several anthropogenic pressures, such as rapidly expanding human population, large scale changes in land use/land cover and improper use of watersheds. Severity of altered wetland systems in this study was so because, seasonal lag time for the cyclical disturbances were short, and hence a fallow period for the functional restoration of wetlands following disturbances, was almost non-existent. Continuous burn of wetlands, which have become an annual ritual, over the years transformed trees and shrub communities along the fringes of the wetlands to grassland, while crude method of fishing, equally contributed in reducing fish stock and disrupted hydrological regime. Turner et al. [28] showed how burning process has ability to cause nutrient loss, through volatilization and leaching, and/or export ash particles by updrafts, while Smith et al. [29] demonstrated the effect of burning on aboveground biomass. Water abstraction, especially in the two marshes (Kukobila and Wuntori wetlands in 2011 - 2012), disrupted the hydrological regime, and which consequently led to the creation of desiccated hydric soils and the recruitment of invasive species. Expansion of farmlands, led to the reduction of vegetation cover along the banks of the Swamp forest wetlands, which hitherto served as habitat for birds (e.g., the Northern red horn-bill - *Tockus erythrorhynchus*), reptiles (e.g., African python – *Python sebae*) and mammals (e.g., River otter – *Lontra canadensis*) and provided soil stability on the banks of the systems. With the increase in human population along these fishing communities, more of the habitats were likely to be fragmented, leading to loss of both flora and fauna species and further raising the stakes of conservation concerns. The occurrence of channel incisions, modified flow of water, through diversions and percolation into subsurface. Conservative data indicate that approximately 90% of the wetlands in southern Brazil have disappeared in the last century [30]. This is a consequence of a strong habitat fragmentation due to agricultural expansion [31]. The loss of wetlands and their biodiversity, imposed social-economic challenges to human populations of local communities (especially those living on the edge of the environment), whose livelihoods are directly linked to this ecosystem.

5. CONCLUSION

From the assessment of the wetlands functional status, it is clear that human-led disturbance have impacted on this ecosystem that play a critical role in livelihood support of rural communities, as well as maintain a stable ecological balance. Thus, to ensure the restoration of the functional status of wetlands, sustainable exploitation of biodiversity resources and implementation of the proposed conservation intervention in Table 3, must be enforced by traditional authorities and possibly adopted as part of national wetland policy framework. It is also crucial that traditional/indigenous knowledge and cultural values should be integrated in wetlands management.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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