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Determinants of Aquatic Plant Community Structure, Diversity and distribution in Wetlands of Northern Region (Ghana)

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DETERMINANTSOFAQUATICPLANTCOMMUNITYSTRUCTUREDIVERSITYANDDISTRIBUTIONINWETLANDSOFNORTHERNREGIONGHANA

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Determinants of Aquatic Plant Community Structure, Diversity and Distribution in Wetlands of Northern Region (Ghana)

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Abstract- The drivers of community structure, diversity and distribution, has generated a lot of interest among many scientists, giving the complex environmental and biological interaction, at different scales. This prompted the application of multivariate techniques to explain the factors influencing variations in wetland plant community structure, diversity and distribution, in Northern Region of Ghana. A total of 40 species were sampled and separated into four community structure (swamp forest community; shrub land community; grassland community and herbaceous community), using DCA. Herbs, grasses and trees/shrubs constituted 72.72%, 27.27% and 0.01% respectively. Change in plant community distribution was marginal, as the first two axes only explained 1.18% of the variance along a longitudinal profile of environmental gradient. Species turnover was low, indicating a far more unimodal responses of some species to a gradient of disturbances than others. Plant diversity was moderate (H′ = 1.86 - 2.66). The first two axes of CCA showed fire, farming practices, nitrogen and phosphorus, accounting for 61.29% variations in diversity and distribution. Fire and farming affected turnover of resident species, while at the same time encouraged the establishment of derived savannah species. This suggest that future intensification of farming activities and bushfire, could accelerate species extinction, with the consequent impairment on the functional status of the wetlands.

Keywords: community structure; canonical correspondence analysis; environmental gradient; diversity; spatial distribution; detrended correspondence analysis.

I. Introduction

Aquatic plants perform a vital role in wetland ecosystems, as primary producers, providing food and habitat for aquatic and terrestrial organisms (Rolon & Maltchik, 2006). Because of their intimate contact with physico-chemical parameters of water, aquatic plants are considered as one of the key indicators of wetlands health status. Many scientists have recognized a complex interaction of environmental and biological factors as the drivers of community distribution, composition and diversity, thus prompting the application of multivariate techniques to explain variations in wetland plant community (Toivonen & Huttunen, 1995; Lenssen *et al.* 2000). The factors controlling the distribution of aquatic plants have been of historical interest (e.g. Moyle, 1945) and influenced by a matrix of climatic (Walther et al. 2001; Klanderud 2005) and environmental factors (Kotze & O'Connor, 2000). Altered plant community through degradation of water quality (Heegaard et al. 2001; Seilheimer, Mahoney & Chow-Fraser, 2009), wet and dry periods (Kath, Brocque & Craig-Miller, 2010), fire (Gboloo, 1998; Smith et al. 2001), soil condition and air pollution (Wild, Neuha¨uslova´& Sofron, 2004) and altitude (Heegaard 2004) have been documented at different spatio-temporal scales. But changes in plant community along a disturbance gradient, varies at different scales because of species-specific responses and inherent ecological conditions. Although extensive research have been carried-out on some wetlands in Ghana (e.g., Attuquayefio & Wuver, 2003), environmental predictors influencing community structure, diversity and the spatial distribution is much less studied in Northern Region of Ghana. Wetlands in Northern Region of Ghana are severely exploited by communities within the catchment and as such, are of high conservation concern. It is therefore, important to model aquatic plants in relation to environmental variables, so that the effects of environmental changes can be predicted. Furthermore, few surveys have shown evidence of species range shift, linked to environmental disturbances (e.g., Nsor, Obodai & Blay, 2014). Therefore, identifying the main environmental mediating factors influencing the community structure and distribution will be important in deciding the type of conservation and management intervention to employ in order to sustain the functioning status at the local scale.

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II. Methods

a) Study area

The study was carried out in six wetlands located in the Northern region of Ghana, with their co-ordinates as follows: (i) Wuntori (N09º 08.335' W00º1 09º.685'); (ii) Kukobila (N10º 08.723' W000º 48.179'); (iii) Tugu (N09º 22.550' W000º 35.004'); (iv) Bunglung (N09º 35.576' W000º 47.443'); (v) Adayili (N09º 41.391' W000º 41.480') and (vi) Nabogo (N09º 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. All six wetlands comprised of marshes (Wuntori, Tugu and Kukobila wetlands); riparian wetlands (Adayili and Nabogo) and artificial wetland (Bunglung). 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 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.

Annual rainfall is in the range of 1000-1,300 mm/p.a. Average temperature varies between 14°C and 40°C. 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 shrub communities (*Mitragyna inermis*).

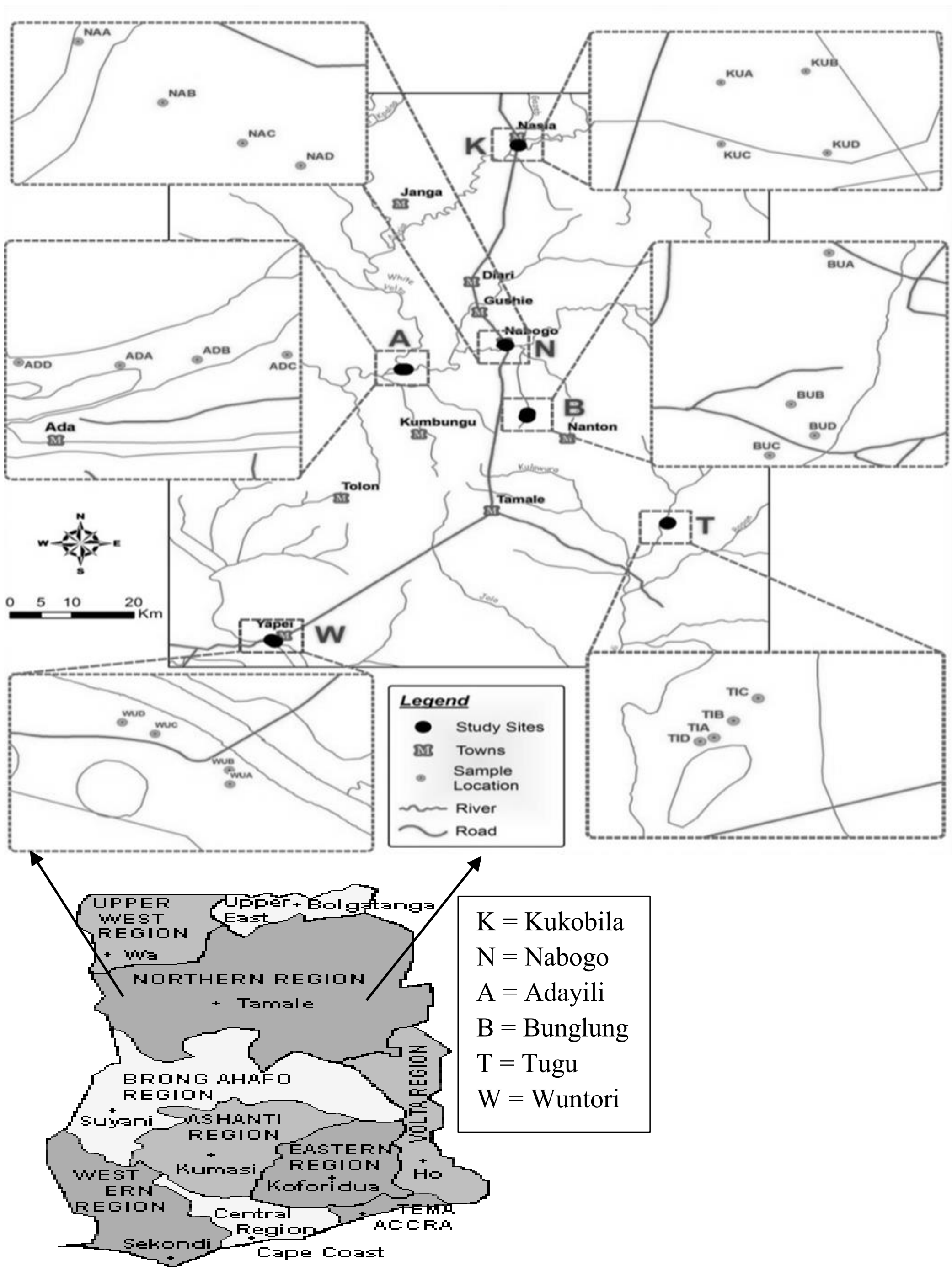

Figure 1 : Map of the study areas, showing the location of the wetlands in the floodplains of the White Volta River catchment, Northern Region

b) Vegetation sampling procedure

In order to cover a wide taxonomic range, we used the broad definition of aquatic plants, which include submerged, floating and emergent plants (herbaceous cover, shrubs and trees). Sampling of aquatic plants was carried in each of the 24 Modified-Whittaker plots (Stohlgren, Falkner & Schell, 1995) over a 2-year period. 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. The plot measures 20 m x 50 m (1000 m^2) and contains three different sizes of nested subplots. A 5 m x 20 m (100 m^2) subplot was placed at the centre of the plot, while two 2 m x 5 m (10 m^2) subplots were placed in opposite corners of the plot. The remaining ten of 0.5 m x 2 m (1 m^2) subplots are placed at the edges of the main plot. Plots were laid along an environmental gradient of the vegetation type sampled, in order to register majority of species heterogeneity. The Domin-Krajina cover abundance scale was used to estimate ground cover (see Mueller-Dombois & Ellenberg, 1974). Plants were identified up to species level, with the aid of manuals developed by Johnson (1997), Okezie & Agyakwa (1998) and Arbonnier (2004).

c) Assessment of environmental factors

Random soil samples were collected with a soil augur at a depth of 15 cm, using the zigzag sampling method (Carter & Gregorich, 2006), on each Modified-Whittaker plot (Stohlgren *et al.* 1995). Three composite samples were taken from three different 25 cores in each plot. Samples were put in transparent polyethylene bags and labeled according to the code assigned to each plot and taken to the laboratory to analyze the presence of Nitrogen, Phosphorus, Potassium, Magnesium, Calcium and soil pH, using atomic absorption spectroscopy (AAS) techniques (Murphy & Riley 1962; van der Merwe, Johnson & Ras, 1984). Organic carbon was determined using the Walkley-Black method (Walkley & Black, 1934). All analyses were carried out at the Savanna Agricultural Research Institute (SARI) at Nyankpala in the Northern Region. 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) (Battisti, Luiselli & Teofili, 2009). 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 within 1.2 km radius, starting from the hydric delineated zone of the wetland. This is because all land use activities assessed were observed within the stated radius following a preliminary survey of the wetlands.

d) Statistical methods

Shannon-Weiner index was performed to determine the current status of aquatic plants, fish and bird community composition. Shannon-Weiner index equation expressed as:

$$H' = -\sum_{i=1}^{s} p_i (\ln p_i) \text{ (Shannon-Wiener, 1963)}$$

Where s is the number of species and P_i is the proportion of individuals or the abundance of the *ith* species expressed as a proportion of the total cover and *ln* is a natural logarithm (Shannon & Wiener, 1963).

A one-way ANOVA test was applied to test for the differences in species diversity/evenness and species richness from one wetland to the other, using SPSS version 16. Kruskal-Wallis test was applied to test the differences in the mean of the diversity index.

To determine the influence of environmental drivers of change on variations on community structure, diversity and spatial distribution, a canonical correspondence analysis (CCA) was performed (ter Braak, 1986), using Environmental Community Analysis (ECOM.exe) ver. 1.4 package (Henderson & Seaby, 2000). CCA is a constrained ordination method where axes are created through linear combinations of environmental variables, which makes it a useful method for detecting key variables that explain variation in species data (ter Braak, 1995). Prior to CCA, species identified and registered at <5% of the 24 sample plots were omitted from canonical correspondence analysis, because rare species typically have a less influence on results of multivariate statistics and are treated as outliers in ordinations (Gauch, 1982).

A Monte-Carlo permutation test with 9999 iterations was performed to evaluate the significance of eigenvalues for both axes 1 and 2 and the sum of all the eigenvalues (ter Braak & Verdonschot, 1995). This was to determine the significant contribution of each environmental driver of change in influencing macrophyte community structure and distribution pattern. Only axis that were statistically significant ($p<0.05$) were interpreted. Detrended correspondence analysis (DCA) (Hill & Gauch, 1980) was performed primarily to determine the compositional variation of mean ground cover, using Community analysis package version 1.41 (Henderson & Seaby, 1999). DCA techniques have the ability to handle large, complex data sets and uncover long ecological gradients, as well as help in data reduction and data exploration (Kent & Coker, 1992). Only plants sampled in the 10 of the 1m^2 sub-plots in each of the 24 Whittaker plots were subjected to CCA. One-way ANOVA was performed to determine if environmental variables differed significantly from one wetland to the other, using Statistica version 10.0.

III. Results

a) Plant community distribution gradient (DCA)

A total of 40 plant species were registered across the six sites, with Kukobila wetland recording the highest mean number of species (29.5±1.9) predominantly herbs and grasses. While Bunglung (constructed) wetland was the least in species abundance (23.5±1.04). Detrended correspondence analysis (DCA) separated aquatic plants into four floristic associations, based on variations in plant community structure and wetland type. They included swamp forest community; shrub land community; grassland community and herbaceous community (Fig. 2, Table 1). The change in plant community distribution was marginal, as the first two axes only explained 1.18% of the variance along a longitudinal profile of environmental gradient. Of the species captured in the ordination diagram, herbs, grass and shrubs/trees constituted 72.72%, 27.27% and 0.01% respectively. Plant species in group 1 (Bunglung wetland), was dominated by grassland community alongside pockets of herbaceous species (Fig. 2). *Cynodon dactylon* (Linn.) Pers. and *Deplachne fusca* (L.) P.Beauv.ex Roem were the dominant grass species, while *Polygonum salcifolium* Brouss. ex. Wiild and *Neptunia oleracea* Lour. constituted the herbaceous cover. Previous burnt tree stumps and grass tussocks affected species turnover in some of the plots. Transformed portion of the site was more than the area with cover abundance.

Species distribution in the three improved sites (Wuntori, Kukobila and Tugu marshes) in group 2, constituted a mosaic of grass and herbaceous communities. The three sites were typically closed systems, as their surface were virtually covered with emergent/floating aquatic plants (e.g., *Pistia stratiotes* Linn. and *Nymphaea micrantha* Linn.). Systematic distribution of *Ceratophyllum demersum* L., *P. stratiotes* Linn., *N. micrantha* Linn., *Cyperus spacelatus* (Rottb) and *Schizachyrium sanguinum* (Retz.) Alston. respectively, reflects a gradient of assemblage change in the longitudinal wetness profile. *C. demersum* L. was the only submerged species and formed a dense intertwined mat. Few shrubs namely; *Mitragyna inermis* (Wiild.) Kuntze. *Mimosa pygra* L. and *Salacia recticulata* were sparsely distributed along the fringes of less wetness condition.

In group 3 distribution diagram, *S. reticulate* L., *Vitex crysocarpa* (Planch. Ex Benth), *Ziziphus abyssinica* Hochst. ex A. Rich. and *M. inermis* (Wiild.) Kuntze. represented typical trees and shrub communities from the Adayili and Nabogo riparian systems (Fig. 2). Spatial distribution of species reflects a gradient of assemblage change in a vertical profile of wetness condition. For instance, *Syzygium guineense* (Wild) D.C and *S. reticulate* which had a ¼ of their stems below surface water level, were found at the foothills of stream bank, while *V. crysocarpa* (Planch. Ex Benth), *Z. abyssinica* and *M. inermis*, were at a much higher ground of less saturation. Pockets of grass and herbaceous species such as *D. fusca* (L.) P.Beauv.ex Roem., *Leersia hexandra* Sw. and *Scoparia dulcis* L., formed the undergrowth. Total species turnover was low (0.026±0.058), indicating that some species exhibited far more unimodal responses to a gradient of environmental disturbances than others. This observations led to the use of CCA, to deduce the major environmental factors that influenced variations in species assemblage.

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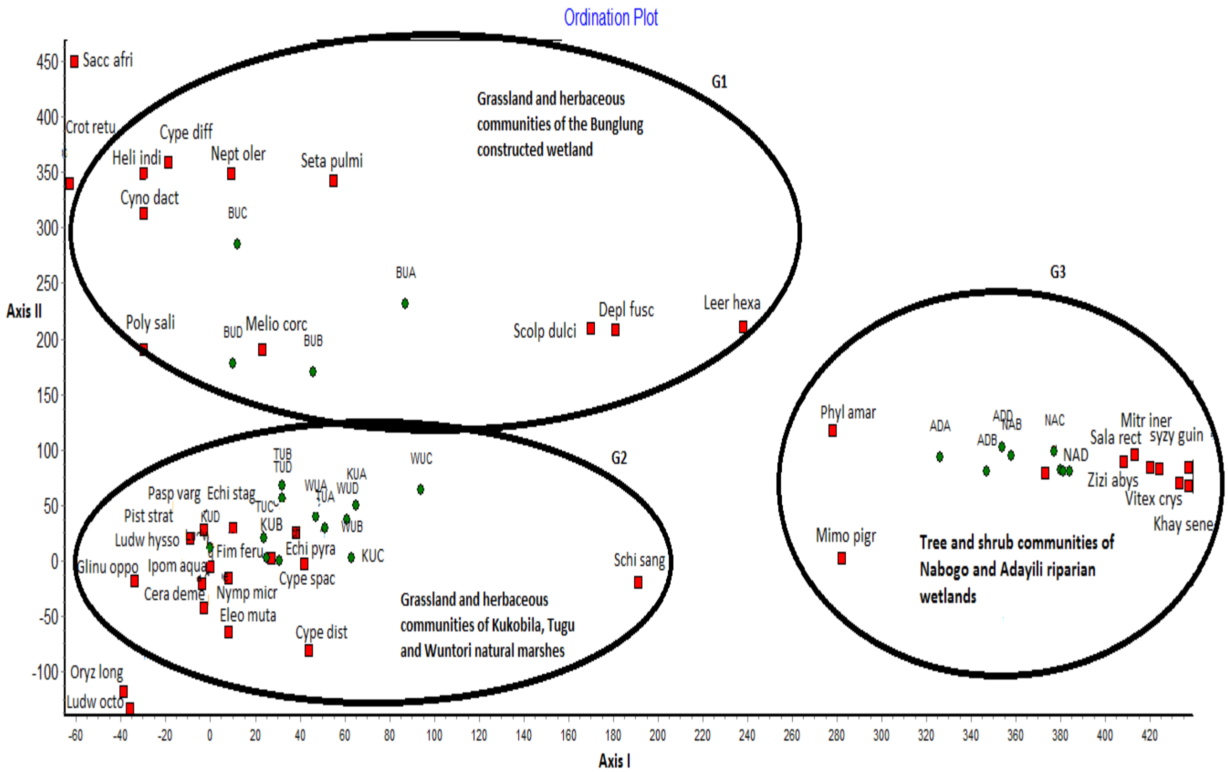

Figure 2 : Species-site DCA ordination showing ground cover distribution pattern, separated into three groups along axes I & II. The red squares represent abbreviated plant species (e.g., *Cype distans* = Cype dist), the green circles represent sample sites and the arrows represent each of the environmental variables plotted pointing in the direction of maximum change of explanatory variables across the six wetlands. The abbreviations denote different sample plots in the six wetlands. WUA-WUD = Wuntori wetland at Yapei; TUA-TUD = Tugu wetland; KUA-KUD = Kukobila wetland; BUA BUD = Bunglung wetland; ADA-ADD = Adayilli wetland and NAA- NAD = Nabogo wetland. Mean = 0.026±0.05

Table 1 : Socioecological classification of plant species into three community structure across the six sites. Species assigned with asterics (*) are typical aquatic plants

N = 40 species

Grassland community	Herbaceous community	Trees and shrubland community
Brachiaria mutica (Forsk.) Stapf.	*Ceratophyllum demersum* L. *	*Khaya senegalensis* (Desr.) A. Juss
Cyperus difformis Linn.*	*Pistia stratiotes* Linn. *	*Mitragyna inermis* (Wiild.) Kuntze
Cyperus distans L.F. *	*Nymphaea micrantha Linn.* *	*Mimosa pigra* L.
Cyperus spacelatus (Rottb) *	*Ipomea aquatica* (Forssk) *	*Salacia reticulata* L.
Cynodon dactylon (Linn.) Pers.	*Ludwigia octovalvis* (Jacq.) Raven*	*Syzygium guineense* (Wild) D.C.
Fimbristylis ferruginea (L.) Vahl.	*Ludwigia hyssopifolia* (G. Don) Exell.	*Vitex crysocarpa* (Planch. Ex Benth.)
Imperata cylindrica (L.) P. Beauv.	*Neptunia oleracea* Lour. *	*Ziziphus abyssinica* Hochst. ex A. Rich
Leersia hexandra Sw.	*Polygonum salicifolium* Brouss. Ex.Wiild*	
Pennisetum polystachion (L.) Schult	*Helioptropium indicum* Linn.	
Oryza longistaminata A. Chev.&Roehr*	*Phyllanthus amarus* Schum.&Thonn.	
Paspalum varginatum L. *	*Scoparia dulcis* L.	
Echinochloa stagnina (Retz.) P. Beauv.	*Crotalaria retusa* L.	
Deplachne fusca (L.) P.Beauv.ex Roem	*Glinus oppositifolius* (L.)	
Echinochloa pyramidalis (Lam.) Hitchc. & Chase	*Meliochia corchorifolia* L.	
Setaria pumila (Poir.) Roem & Schult	*Mormodica chrantia* Linn.	
Sacciolepsis Africana C.E. Hubb. & Snowden		
Scirpus grossus Linn. F.		
Schizachyrium sanguineum (Retz.) Alston.		

b) Variations in species diversity along a disturbance gradient

Overall, plant diversity was moderately high across the six sites and ranged between (H′ = 1.86 - 2.66) (Fig. 3). Although, species diversity was higher in the wet season than the dry season (*F-test* = 4.318, p<0.064), variations among the sites, did not differ significantly (One-way ANOVA test p>0.05). On average, all the three marshes (Kukobila, Wuntori and Tugu) tended to be the most diverse (H′ = 2.231±0.110 - 2.656±0.079), followed by the two riparian wetlands – Adayili (H′ = 1.865±0.110) and Nabogo (H′ = 1.895±0.078) and Bunglung wetland (H′=1.857±0.260). Variations in diversity across the six sites, simultaneously followed a disturbance intensity gradient and differed significantly in their evenness distribution (*t* = -16.511, p<0.05). Heavily impact sites such as the two riparian systems and Bunglung constructed wetland, largely reflected in their low diversity index.

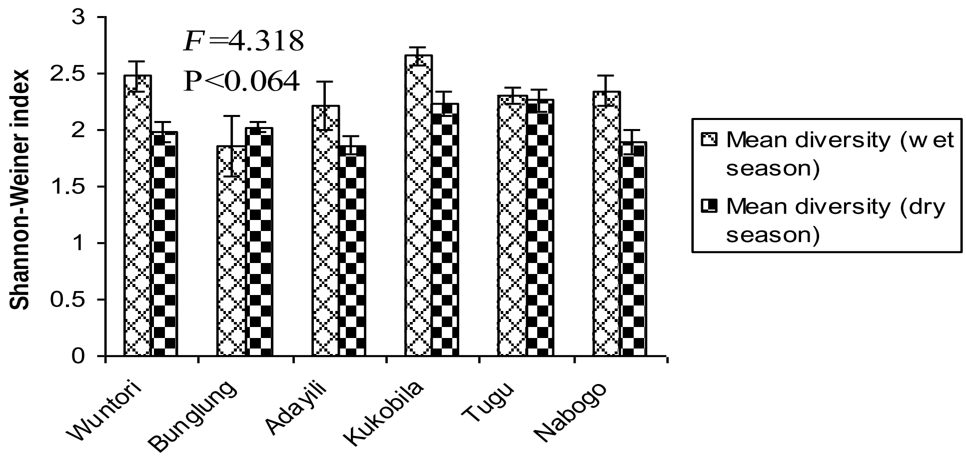

Figure 3 : Plant community, showing seasonal variations in diversity index among the six wetlands in the dry and wet seasons

c) Predictors of aquatic plant community structure, composition and distribution (CCA)

Canonical correspondence analyses revealed that the impact of environmental factors on plant distribution in each of the six sites differed significantly (p < 0.05), following Monte Carlo permutation test. The inherent environmental conditions in each of the six wetlands, jointly explained 61.29% (R^2 = 0.61, p<0.05) of variability in plant distribution pattern, by the two axes (axis I = 24.84 and axis II = 36.45) (Fig. 4, Table 2). Since axes I and II accounted for more than 50% of the variation in ground cover data, as recommended by ter Braak (1986), axis III. Magnesium and bushfire were highly correlated in axis I and constituted the most important environmental gradients on plant community distribution, while in axis II, farming activities, potassium and nitrogen were the key environmental factors. CCA analysis diagram showed the various groups of plant communities' distribution according to the type of environmental mediating factors and the type of wetland sampled. We noticed that *S. guineense* (Wild) D.C. *Salacia reticulate* and *Z. abyssinica* from the riparian systems, on the left half of the ordination diagram strongly correlated with fire and erosion intensity, while *V. crysocarpa* Planch. Ex 10 Benth, *Khaya senegalensis* (Desr.) A. Juss., *Pennisetum polystachion* (L.) Schultes, *Imperata cylindrica* (L.) P. Beauv. and *Phyllanthus amarus* Schum. & Thonn were rather influenced by soil pH. Erosional features and channel incision, were prominent in portions of the stream bank that had less ground cover and mostly invaders. Although erosional features were prominent, they were not widespread as this was evident in the weak correlation on both axes I and II (Table 3). Patchiness from previous burnt undergrowth were common, as farmers periodically used fire for land preparation along the stretch of the wetlands.

High magnesium concentration, intense farming and grazing activities was observed in Bunglung constructed wetland found on the right lower half of the diagram. With the exception of obligate species like *Cyperus difformis* Linn. and *P. salicifolium* Brouss. ex. Wiild, the rest of the species were of derived savannah origin and mostly associated with disturbed terrestrial areas. For instance, we observed a strong correlation between *Sacciolepsis Africana* C.E. Hubb. & Snowden., *Crotolaria retusa* L. and *Helioptropium indicum* Linn. and farming activities (p<0·05) along axis I, while *P. salicifolium* Brouss. ex. Wiild., *L. hexandra* Sw. and *N. oleracea* Lour rather showed a strong association with magnesium on the same axis (p<0·05). The natural marshes of Kukobila, Wuntori and Tugu on the upper centre of the CCA diagram, exhibited optimal levels of nutrient loads and hence were not polluted. This was evident from the abundance of *P salcifolium* Brouss. ex. Wiild. which is an indicator of a less polluted wetland.

Majority of species not represented in the ordination diagrams grew in habitats with average conditions of the environmental factors investigated.

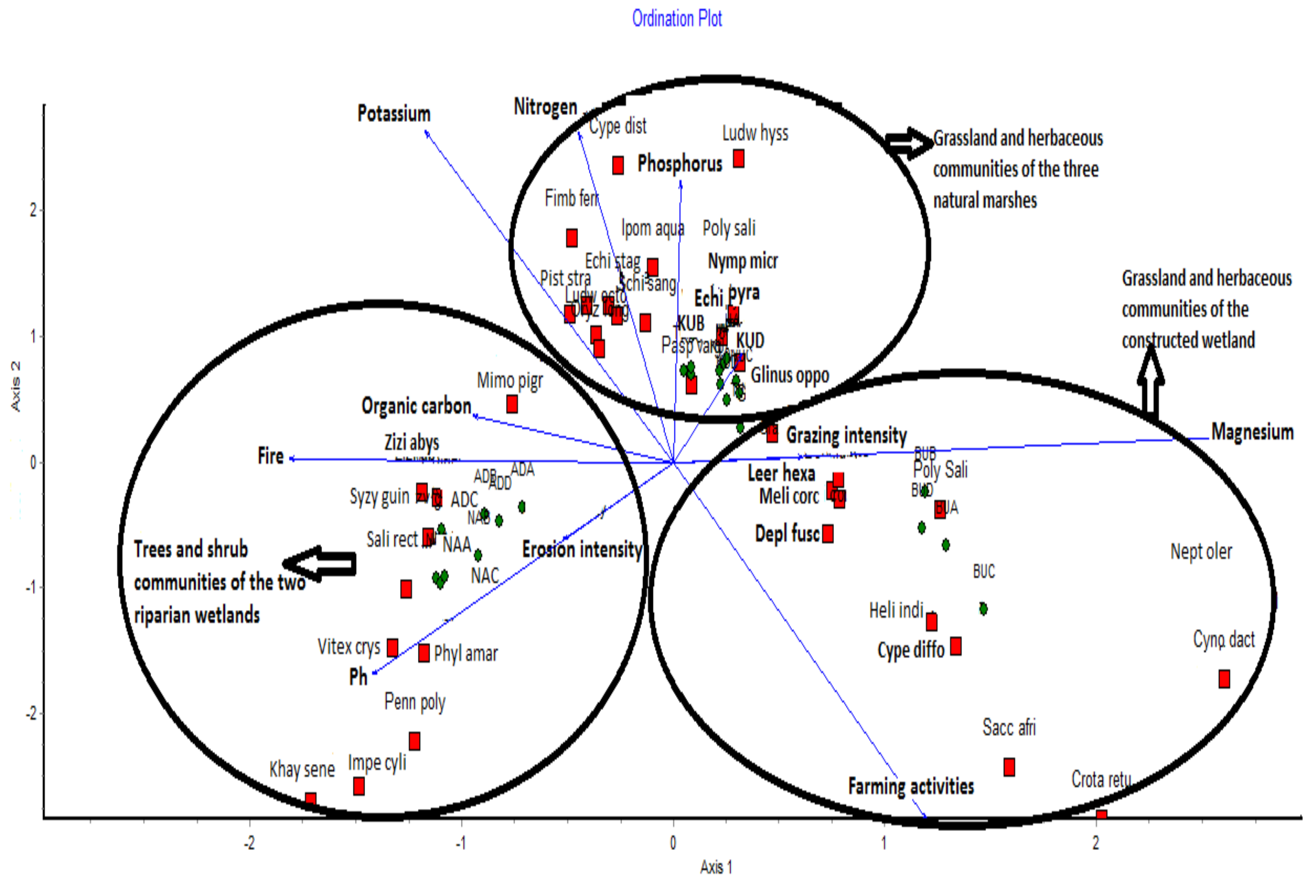

Figure 4 : Canonical correspondence analysis (CCA) ordination diagram, showing the influence of environmental factors on species range shift, explained by the first two axes (Axis I =24.84 & Axis II =36.45) and accounted for 61.29%cumulative percentage variance across the six sites (R^2 = 0.61, p<0.05). The red squares represent abbreviated plant species (e.g., *Cyperus difformis* = Cype diff, *Leersi hexandra* = Leer hexa), the green circles represent sample sites and the arrows represent each of the environmental variables plotted pointing in the direction of maximum change of explanatory variables across the six wetlands. The abbreviations denote different sample plots in the six wetlands. WUA-WUD = Wuntori wetland at Yapei; TUA-TUD = Tugu wetland; KUA-KUD = Kukobila wetland; BUA-BUD = Bunglung wetland; ADA-ADD = Adayilli wetland and NAA- NAD = Nabogo wetland

Table 2 : Canonical coefficients and the correlations with the first three axes of the environmental variables of the canonical correspondence analysis (CCA) for the six sites. Percentage variance of species, explained by the first two axes of explanatory variables. Inter-set correlations were significant ($p < 0.05$) for the two axes, following Monte Carlo permutation test

	Axis I	Axis II	Axis III
pH	-0.367*	-0.261	0.065
Organic carbon	-0.244	0.056	0.153
Nitrogen	-0.115	0.405*	0.163
Phosphorus	0.009	0.346*	0.233
Potassium	-0.303*	0.406*	0.045
Calcium	0.085	0.132	-0.139
Magnesium	0.772*	0.035	-0.101
Fire	-0.469*	0.002	-0.197
Grazing intensity	0.157	0.005	0.167
Erosion	-0.134	-0.095	0.127
Farming activities	0.311*	-0.441*	0.075
Canonical eigenvalues for cover	0.733	0.342	0.198
Pearson correlation sp-envtal scores	0.81	0.88	0.84
Cumulative percentage variance	24.84	36.45	43.16
% variance explained (61.29%)	24.84	11.6	6.71
Number of species (response variables)	40		
Number of environmental variables	11		
Total variance in species data	2.951		

IV. Discussion

The global loss of wetlands has driven interest in the number of research aim at understanding the patterns of biodiversity in wetlands, including aquatic plants (Lougheed *et al.* 2001; Smith & Haukos, 2002; Heegaard *et al.* 2004). This survey represents one of the most complete dataset that attempts to determine the effects of environmental factors on the aquatic plant community in wetland systems at a relatively local scale in Northern region of Ghana. The findings in this study showed that environmental factors namely; magnesium, phosphorus, nitrogen, fire and farming activities, were the predictors of species diversity and spatial distribution across the six sites. This was confirmed by the CCA explanatory variables accounting for 61.29% cumulative species variance across the six sites (R^2 = 0.61, $p<0.05$). Altered plant community through degradation of water quality (Heegaard et al. 2001; Seilheimer *et al.* 2009), wet and dry periods (Kath *et al.* 2010), fire (Gboloo, 1998; Smith *et al.* 2001), soil condition and air pollution (Wild *et al.* 2004) and altitude (Heegaard *et al.* 2004) have been documented at different spatio-temporal scales. Al though climatic variability (Walther, Burga & Edwards, 2001; Klanderud, 2005) have historically contributed in controlling the distribution of aquatic plants (e.g. Pearsall, 1920; Moyle, 1945), environmental factors (Kotze & O'Connor, 2000) have been shown to be a major determinant influencing community distribution. Species response to disturbance scenarios are varied on the basis of inherent ecological conditions and species type. For instance, while species like *P. stratiotes*, *C. difformis* Linn. and *P. salicifolium* were susceptible to fire, *S. guineense* (Wild) D.C. *S. reticulate* and *Z. abyssinica* from the riparian systems, were rather resistant to fire. Incidences of fire and farming activities in the marshes and Bunglung (constructed) wetland, affected the turnover of resident species, while at the same time encouraged the establishment of species of neighbouring derived savannah such, as *S. Africana* C.E. Hubb. & Snowden. *Crotolaria retusa* and *H. indicum* Linn. This suggest the competitive advantage of derived savannah species over aquatic species in the utilization of limited below and above ground resources. With the resultant change in community structure and composition, the wetlands are probably on a transformational trajectory. This observation was confirmed by the findings of Nsor *et al.* (2014) in their study of species range shift dynamics in the same sites. The authors found that of the 40 species sampled, facultative (40%) and obligate upland species (27.5%) were in excess of 67.5%, compared to 35% obligate species (typical aquatic plants). Assessment of environmental impact among the six sites, suggest that Bunglung (constructed) wetland may undergo a rapid transformation in community structure and diversity, as a result of the weak responses of species to disturbances. Studies in the Everglades wetlands have shown evidence of wetlands fires completely destroy vegetation and resident seedbank (Smith *et al*. 2001).While in some cases, species like saw grass (*Cladium jamaicense*) have persisted under fire, by periodically eliminating successional species (Loveless, 1959). Over the last 50 years, agricultural activities in have caused the extinction of wetlands plants (Kopeć *et al*. 2008). And one of the causes of agricultural activities in altering the ecosystem of wetlands, is through nutrient enrichment (Matson *et al*. 1997). But the findings in this study, indicated that farming activities did not correlate with N and P concentration. Thus the optimal levels of the nutrient loads especially in the three marshes, possibly explained the appreciable abundance of typical aquatic plants and their structural distribution. Phosphorus availability is a critical factor regulating plant species distributions in the (Davis, 1994). The observed disturbances gives an indication that future intensification of farming activities and bushfire, could potentially increase the rate of species extinction of typical aquatic plants sensitive to slight disturbances. This phenomenon could consequently impair the functional status of the marshes, unless strict conservation and management measures are put in place to check on human-led activities.

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