ASSESSING WETLANDS FUNCTIONS IN THE NIGER DELTA AREA OF NIGERIA

By

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Abstract

Until recently, wetlands were often viewed as waste lands, useful only when drained or filled. Every wetland is unique; a wetland in one part of a town may perform different functions from those in other parts though they may appear, at first glance, to be very similar. The location and size of a wetland may determine what functions it will perform. It is against this background that the study examined wetland functions in the Niger Delta, Nigeria with a view to ensuring that proper attention is given to such functions in the assessment of wetland value for various purposes, particularly compensation. The study used questionnaire instrument in collecting data. Seventy-two (72) questionnaires were retrieved out of which only fifty-five (55) of the respondents reported to have had previous experience in wetland valuation and only these were analysed. Descriptive analyses, relative importance index (RII) and principal component analysis (PCA) were employed in analysing the data collected. The study revealed that storm protection (RII = 3.65), shoreline stabilization (RII = 3.51), recreation and tourism (RII = 3.49) and climate change mitigation are the four most important wetland functions in the study area. The study equally indicates that respondents basically valued crops (80%) and land (61.8%) at the expense of services (36.4%) and functions (29.1%) of wetlands. It was concluded that wetland functions are very important components of wetland ecosystems and that Estate Surveyors and Valuers should put these function adequately into consideration when valuing these important natural resources, particularly for compensation purpose.

Keywords: *Functions, Niger Delta, Nigeria, Valuation, Wetland.*

1.0 Introduction

The value of wetland ecosystem is a direct product of the functions it performed. Hence, it is of importance to examine such functions performed by this important environmental resource. According to US Environmental Protection Agency (2008),wetlands can be thought of as "biological supermarkets." They provide great volumes of food that attract many animal species which use wetlands for part of or all of their life-cycles. Wetlands also play an important role in the *hydrologic cycle* (Bullock and Acreman, 2003). *That is, wetlands can receive, store, and release water in various ways* – physically through ground water and surface water, as well as biologically through transpiration by vegetation – and therefore function in this very important global cycle. Until recently, wetlands were often viewed as wastelands, useful only when drained or filled. It is now well known that wetlands benefit people and the natural world in remarkable ways. They provide critical habitat for wildlife, water storage to prevent flooding and protect water quality, and recreational opportunities for wildlife watchers, anglers, hunters, and boaters. These are known as "wetland functional values."

According to Lambert (2003) the interactions of physical, biological and chemical components of a wetland, such as soils, water, plants and animals, enable the wetland to perform many vital functions. He stated further that wetlands provide tremendous economic benefits, such as water supply; fisheries; agriculture, through the maintenance of water tables and nutrient retention in flood plains; timber production; energy resources, such as peat and plant matter; wildlife resources; transport; and recreation and tourism opportunities and conclude that translating these many values into economic terms is of primary importance if we are to convince both the people and policy/decision makers of the importance of these ecosystems as life-supporting systems. It is on this background that this study examined wetland functions in the Niger Delta, Nigeria.

2.0 Literature Review

Ecosystems are normally characterized in terms of their structural components and the processes that link these components (Bormann and Likens, 1969). According to Garcia, Zerbi, Aliaume, Do Chi, and Lasserre, (2003) ecosystems are complex and dynamic natural units that produce goods and services beyond those of benefit to fisheries. Structural components of the ecosystem and the surrounding landscape, such as plants, animals, detritus, soil, and the atmosphere, interact through a variety of physical, chemical, and biological processes such as the movement of air and water and the flow of energy and nutrients. Understanding how the structural components of the ecosystem and the surrounding landscape are linked together by processes is the basis for assessing ecosystem functions.

Wetlands are composed of a number of physical and chemical components such as soils, water, plant and animal nutrients. The interaction among and within these components allow the wetland to perform certain functions. Wetland functions are the capacity of ecosystem process and components to provide goods and services that satisfy human needs, directly or indirectly (Millennium Ecosystem Assessment, 2003). The level of wetland function depends on site and landscape characteristics and can be assessed independently of any human context.

According to Smith, Ammann, Bartoldus, and Brinson (1995) wetland functions are the normal or characteristic activities that take place in wetland ecosystems or simply the things that wetlands do. Wetlands perform a wide variety of functions in a hierarchy, from simple to complex, as a result of their physical, chemical, and biological attributes. For example, the reduction of nitrate to gaseous nitrogen is a relatively simple function performed by wetlands when aerobic and anaerobic conditions exist in the presence of denitrifying bacteria. Nitrogen cycling and nutrient cycling represent increasingly more complex wetland functions that involve a greater number of structural components and processes. At the highest level of this hierarchy is the maintenance of ecological integrity, the function that encompasses all of the structural components and processes in a wetland ecosystem. The benefits rural people derive from wetlands are supported by the variety of environmental functions performed by these complex and sensitive environments. These functions benefit not only the people living within or nearby wetlands but also users downstream. Woodward and Wui (2001) identify two functions: habitat for aquatic species and habitat for terrestrial and avian species. McCartney, Masiyandima and Houghton-Carr (2004) identify eight major wetland functions such as storage of precipitation and runoff, groundwater discharge, groundwater recharge, sediment retention, nutrient transformation, biomass production, maintenance of biodiversity and chemical cycling. A number of goods and services provided specifically by wetlands have been identified and are now widely recognized. Wetlands can provide habitat and food for diverse range of species, aid in groundwater recharge and water retention, provide erosion and sedimentation controls between adjacent ecosystems, improve water quality through filtering sediment and metals from groundwater, and cycle nutrients to terrestrial and aqueous environments within the wetlands and between ecosystems. Wetlands are also important global sources, sinks, and transformers of various elements in the earth's various biogeochemical cycles (Mitsch and Gosselink, 2000; Greb and DiMichele, 2006).

Specifically wetlands, as transitional zones between land and water, provide a natural protection against extreme floods and storm surges. It is estimated that every kilometer of wetlands can reduce or lower storm surge by 5 – 7 centimeters (Stokstad, 2005). Wetlands benefit the people in countless ways. They help prevent flooding by slowing down and absorbing water, which might otherwise end up on properties, or in basements. Wetlands gradually release stored water to rivers and streams to maintain flow throughout the dry season, and recharge groundwater aquifers so that wells do not go dry. They protect shorelines from erosion by absorbing the shock of wave action, and preserve water quality by retaining sediment, nutrients and other pollutants. But wetlands do not exist only to serve man's needs. They provide critical habitat for a myriad of species that form a delicate and complex web of life. Frogs, salamanders, turtles, fish, insects, songbirds, waterfowl, deer and moose are just some of the creatures that depend on wetlands for food, shelter and/or breeding habitat. Adamus, Stockwell, Clairain, Morrow, Rozas, and Smith (1991) identified the functional values of natural wetlands that are important to society to include: groundwater recharge, groundwater discharge, floodwater alteration, sediment stabilization, sediment toxicant retention, nutrient removal transformation, production export, aquatic and wildlife diversity abundance, storm buffering, recreation, and uniqueness heritage. They went further to group the functions into four major categories: life support; hydrologic buffering; water quality improvements; and historical cultural significance.

Woodward and Wui (2001) and McCartney, Masiyandima and Houghton-Carr (2004) identified the various functions performed by wetlands, though not exhaustive, to include: reservoirs of biodiversity; climate change mitigation; cultural value; flood control; groundwater replenishment; wetland products; including fish and shellfish, blueberries, cranberries, timber, and wild rice, as well as medicines that are derived from wetland soils and plants; recreation/tourism; sediment and nutrient retention and export; shoreline stabilization and storm protection and water purification. On his own part, Williams (1990) identified four categories of function; physical/ hydrological, chemical, biological, and socio-economic.

In the report prepared by **Wisconsin Department of Natural Resources** (2012) **wetland functions identified include** – floral diversity, fish and wildlife habitat, flood protection, water quality protection, shoreline protection, groundwater recharge and discharge and aesthetics, recreation, education and science.

Though wetlands perform a variety of functions, not all wetlands function equally and not all wetlands perform all functions. Factors affecting wetland functions include location, size, vegetation diversity, hydrology, and disturbance level. Even though an individual wetland may not perform all wetland functions, the cumulative value of all wetlands in an entire watershed makes each important. Wetland values are the benefits to human beings that are derived from a wetland's features, processes, or setting. Wetlands are integral parts of a watershed; their position in the landscape is influenced by and influences the characteristics of a watershed. Wetlands can function as nutrient sinks, temporary water storage areas, groundwater recharge areas, and critical wildlife habitat. Natural and human-induced activities within a watershed influence the functions of natural wetlands. When these activities remain relatively constant, the functions of natural wetlands tend to exist in dynamic equilibrium with the surrounding conditions. However, changes in the established combination of natural and human-induced activities within a watershed can result in dramatic changes in the functions of natural wetlands. The effects of stormwater on a particular wetland depend, in part, on the type of wetland in question. Because of the transitional position of wetlands in the landscape, some wetlands have high biodiversity, whereas others are very productive in terms of biomass (Mitsch and Gosselink, (1993).

Both the amount and seasonal distribution of rainfall and resulting runoff can play a role in determining the species composition, soil characteristics, and ecological functioning of inland wetlands. In the opinion of Hammer *(1992)* factors such as precipitation patterns, including the frequency, intensity, and duration of storm events, determine the quantity and timing of runoff. Other climatic factors, such as temperature, winds, relative humidity, and incident solar radiation, also affect wetlands. The location of a wetland in the landscape plays a role in the natural hydroperiod of the wetland, its retention of pollutants, and the effects of increased stormwater inputs (Brinson, 1988).

3.0 Research Methodology

The researchers employed survey method in collecting primary data. Both descriptive and exploratory approaches were used for literature review, while explanatory approach was used in analysing the data collected. Questionnaire was administered on the 120 Estate Surveying and Valuation firms in Bayelsa, Delta and Rivers States (as contained in the lists made available by the NIESV's Branch Secretaries in the three States). *The data collected were analysed and presented using tools such as frequency distributions and percentages,* relative importance index (RII) and principal component analysis (PCA) with its diverse variants. Frequency distribution was used in organising the data into a meaningful form after the completion of data collection so that a trend, if any, emerging out of the data can be seen easily.

On the other hand, relative importance index was used to measure variables that are rated against a scale to assist in assessing the significance of each factor after which the scale was transformed into an index otherwise known as relative importance index (RII) for each factor to determine the ranks of the different factors. The analysis for this study employs the relative importance index or RII formula which is evaluated as:

$$RII = \frac{\sum a_i n_i}{\sum x_j} \qquad (1)$$

Where: i = response category index

x_j = the sum of j factors 1,2,3.........N

a_i = constant expressing the weight given to the ith response

n_j = the variable expressing the frequency of the ith

4.0 Data Analysis

A total of 120 questionnaires were administered on respondent Estate Surveyors and Valuers out of which 72 were retrieved. However, only 55 of them had been involved in wetland valuation before and only these were used for the purpose of analysis as in Tables 1 – 6.

Table 1: What Estate Surveying and Valuation Firms Valued

What was Valued	Responses	
	No	Yes
Attributes of wetlands	41 (74.5%)	14 (25.5%)
Functions of wetlands	39 (70.9%)	16 (29.1%)
Land perse	21 (38.2%)	34 (61.8%)
Buildings	47 (85.5%)	8 (14.5%)
Services	35 (63.6%)	20 (36.4%)
Crops	11 (20.0%)	44 (80.0%)

Table 1 contains the list of probable elements that could be valued in wetland ecosystems. The table reveals that 80.0% of the respondents ascribe value toonly crops and 61.8% to only land, which are components of wetland environment capable of assessment, using the market support approaches. Other components that are not traded in the open market such as attributes, functions and services were rarely valued by respondent Estate Surveyors and Valuers. This could be attributable to the non-recognition of such components by NIESV guidance notes on property valuation. The preponderance of valuation of crops and land within wetland sites in the study area can be attributable to the incessant conversion of wetland sites to other uses, supported by economic justifications and pollution of wetland resources due to oil spills and gas flaring, regular occurrences in the Niger Delta region. This could also result from the compensation provisions in the Land Use Act 1978, Oil Pipelines Act 1990 and 1999 Constitution which all provided for compensation on land, buildings and crops or profitable trees at the expense of wetland components.

Table 2: Wetlands Functions

Functions	Responses No	Yes
Climate change mitigation	22 (40.0%)	33 (60.0%)
Groundwater replenishment	31 (56.4%)	24 (43.6%)
Sediment retention	22 (40.0%)	33 (60.0%)
Storm protection	15 (27.3%)	40 (72.7%)
Shoreline stabilisation	18 (32.7%)	37 (67.3%)
Water purification	47 (85.5%)	8 (14.5%)
Reservoir of biodiversity	25 (45.5%)	30(54.5%)
Nutrient transformation	49 (89.1%)	6 (10.9%)
Recreation and tourism	11 (20.0%)	44 (80.0%)
Storage of precipitation and runoff	23 (41.8%)	32 (58.2%)
Biomass production	39 (70.9%)	16 (29.1%)

The various wetland functions are indicated in Table 2. However, recreation and tourism (80.0%), storm protection (72.7%), shoreline stabilization (67.3%), climate change mitigation (60.0%), sediment retention (60.0%), storage of precipitation and runoff (58.2%) and reservoir of biodiversity (54.5%) are wetland functions found to be prominent in the study area. Storm surges and other coastal weather disturbances can cause immense damage through flooding and direct destruction of property, not to mention the loss of human life. The cost of maintaining artificial bank reinforcement to prevent erosion is usually very high. Seasonal flooding is a natural phenomenon in most of the world's rivers. Inland floodplains and coastal deltas are the natural "overflow" areas that slow the velocity of floodwaters, allowing the nutrients and sediments to settle. Heritage sites are able to generate considerable income from tourist and recreational uses.

Table 3: Ranking of Wetland Functions

Wetland Functions	5	4	3	2	1	Total	RII	Ranking
Climate change mitigation	12 $a_in_i = 60$	18 $a_in_i = 72$	12 $a_in_i = 36$	8 $a_in_i = 16$	5 $a_in_i = 5$	55 189	3.44	4th
Groundwater replenishment	2 $a_in_i = 10$	11 $a_in_i = 44$	15 $a_in_i = 45$	19 $a_in_i = 38$	8 $a_in_i = 8$	55 145	2.64	8th
Sediment Retention	14 $a_in_i = 70$	11 $a_in_i = 44$	11 $a_in_i = 33$	14 $a_in_i = 28$	5 $a_in_i = 5$	55 180	3.27	6th
Storm protection	21 $a_in_i = 105$	18 $a_in_i = 72$	3 $a_in_i = 9$	2 $a_in_i = 4$	11 $a_in_i = 11$	55 201	3.65	1st
Shoreline stabilization	14 $a_in_i = 70$	21 $a_in_i = 84$	6 $a_in_i = 18$	7 $a_in_i = 14$	7 $a_in_i = 7$	55 193	3.51	2nd
Water purification	3 $a_in_i = 15$	6 $a_in_i = 24$	21 $a_in_i = 63$	15 $a_in_i = 30$	10 $a_in_i = 10$	55 142	2.58	9th
Reservoirs of biodiversity	6 $a_in_i = 30$	17 $a_in_i = 68$	8 $a_in_i = 24$	11 $a_in_i = 22$	13 $a_in_i = 13$	55 157	2.85	7th
Nutrient transformation	0 $a_in_i = 0$	12 $a_in_i = 48$	13 $a_in_i = 39$	14 $a_in_i = 28$	16 $a_in_i = 16$	55 131	2.38	10th
Recreation/tourism	6 $a_in_i = 30$	27 $a_in_i = 108$	15 $a_in_i = 45$	2 $a_in_i = 4$	5 $a_in_i = 5$	55 $a_in_i = 192$	3.49	3rd
Storage of precipitation and runoff	8 $a_in_i = 40$	24 $a_in_i = 96$	9 $a_in_i = 27$	4 $a_in_i = 8$	10 $a_in_i = 10$	55 181	3.29	5th
Biomass production	2 $a_in_i = 10$	5 $a_in_i = 20$	6 $a_in_i = 18$	17 $a_in_i = 34$	25 $a_in_i = 25$	55 107	1.95	11th

Respondents were asked to rank the wetland functions in the study area. The outcome is as shown in Table 3. The table exhibits that storm protection was ranked as number one factor (RII = 3.65). Other functions ranked in order of importance are shoreline stabilization (RII = 3.51), recreation/tourism (RII = 3.49) and climate change mitigation (RII = 3.44). The ranking of storm protection as number one is not unexpected taking into consideration the fact that the Niger Delta region is subject to coastal disturbances and climatic heat. Niger Delta is dotted with various types of creeks that offer tourist attraction hence the ranking of recreation/tourism as one of the prominent wetland functions in the region.

Table 4: Communalities

	Initial	Extraction
Climate Change Mitigation	1.000	.657
Groundwater Replenishment	1.000	.663
Sediment Retention	1.000	.440
Storm Protection	1.000	.731
Shoreline Stabilization	1.000	.707
Water Purification	1.000	.759
Reservoirs of Biodiversity	1.000	.741
Nutrient Transformation	1.000	.692
Recreational/Tourism	1.000	.564
Storage of Precipitation and Runoff	1.000	.504
Biomas Production	1.000	.733

Extraction Method: Principal Component Analysis.

Further examination was conducted to establish wetland functions in the Niger Delta. This was done using principal component analysis. The analysis in Table 4 indicates the amount of variance in each variable that is accounted for by extracting only that proportion that is due to the common factors and shared by several items. Initial communalities are estimates of the variance in each variable accounted for by all components or factors. Extraction communalities are estimates of the variance in each variable accounted for by the components. The communalities in Table 4 are all high indicating that the extracted components represent the variables well.

Table 5: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.123	28.390	28.390	3.123	28.390	28.390
2	1.782	16.202	44.592	1.782	16.202	44.592
3	1.170	10.639	55.231	1.170	10.639	55.231
4	1.115	10.138	65.369	1.115	10.138	65.369
5	.987	8.970	74.339			
6	.865	7.859	82.198			
7	.720	6.542	88.740			
8	.464	4.218	92.958			
9	.320	2.910	95.868			
10	.244	2.219	98.087			
11	.210	1.913	100.000			

Extraction Method: Principal Component Analysis.

The total variance explained components of principal component analysis was extracted and contained in Table 5 which shows the variance explained by the initial solution (initial eigenvalues). Under the initial eigenvalues, the total column gives the amount of variance in the original variables accounted for by each component and it shows that each of the factors have eigenvalue higher than 1. On the other hand, the percent of variance column gives the ratio of the variance accounted for by each component of the total variance in all of the variables. In Table 5, eigenvalues greater than 1 was extracted and this shows that the first four principal components (climate change mitigation, groundwater replenishment, sediment retention and storm protection) form the extracted solution accounting for 65.4% of the total variability in the original eleven components (variables) so that the complexity of the data set can considerably be reduced using the extracted components.

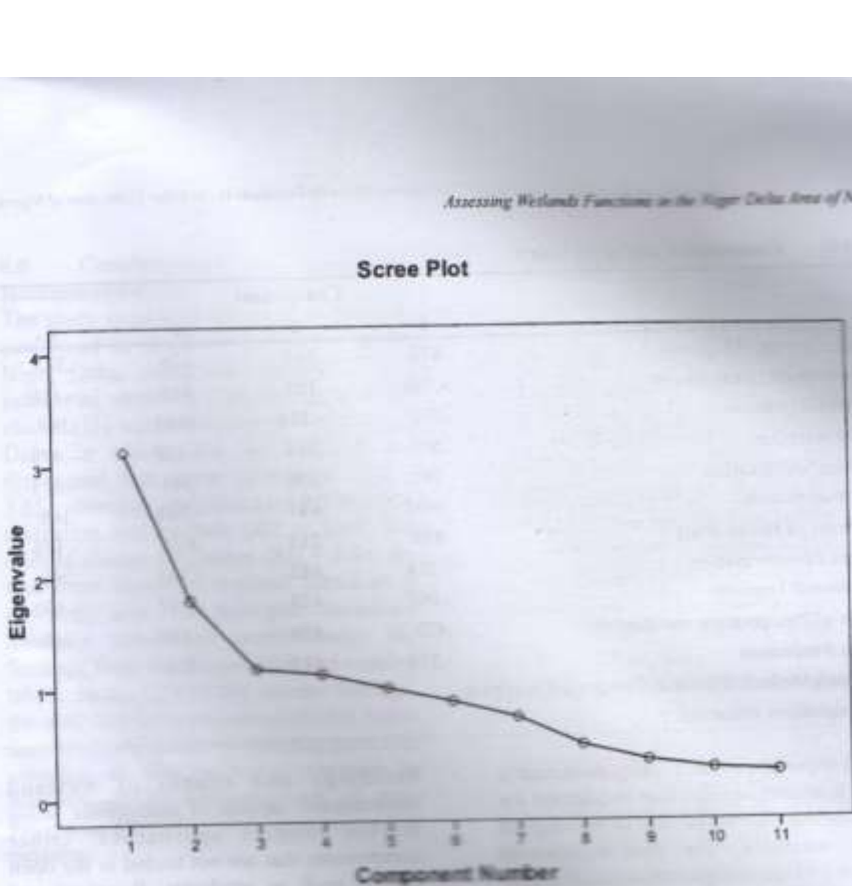

*Fig 1:*Scree Plot for Wetland Functions in the Niger Delta

The scree plot in Fig. I was used to display the relative magnitude of the eigenvalues of the correlation matrix. By graphing the eigenvalue against the component number, it established the number of components that should be retained. The figure shows that only the first four components (climate change mitigation, groundwater replenishment, sediment retention and storm protection) are the major wetland functions in the Niger Delta and should therefore be retained. Though four components accounted for what happened in the other seven components, the curve begins to tail off after the third component. It could therefore be deduced from the graph that each successive component, after the first four, accounted for smaller and smaller amounts of the total variance.

Table 6: Component Correlation Matrix

	Component			
	1	2	3	4
Climate Change Mitigation	.679	.204	.126	.372
Groundwater Replenishment	-.779	.122	.138	-.150
Sediment Retention	.272	-.134	-.163	.567
Storm Protection	.502	.251	-.432	-.479
Shoreline Stabilisation	.707	.376	.244	-.073
Water Purification	-.697	.487	-.088	.168
Reservoirs of Biodiversity	.457	.215	.672	-.186
Nutrient Transformation	-.214	.682	-.333	.265
Recreational/Tourism	-.007	.625	-.112	-.400
Storage of Precipitation and Runoff	.473	.438	-.145	.260
Biomas Production	-.515	.415	.508	.193

Extraction Method: Principal Component Analysis.
a. 4 components extracted.

Table 6 shows the rotated component matrix of the four components that accounted for 65.4% of the total variability in the original eleven variables. The first component (climate change mitigation) is most highly correlated with shoreline stabilisation (0. 707) and storm protection (0. 502), however it is less correlated with recreational/ tourism. The second component (groundwater replenishment) is most highly correlated with nutrient transformation (0. 682) and recreational/tourism (0.625), the third component (sediment retention) is most highly correlated with reservoirs of biodiversity (0. 672) and the fourth component (storm protection) is most highly correlated with sediment retention (0.567) Table 6 reveals that the correlations between the four components are not very strong.

5.0 Discussion of Findings

The study, using both primary and secondary sources of data, examined wetland functions in the Niger Delta of Nigeria. The data collected was collated and analysed as shown in tables 1 – 6 and Fig. 1. This section of the work discussed the findings from the analysis carried out. It was evident from the study that Estate Surveyors and Valuers valued components (land, buildings and crops) of wetland environment capable of assessment, using market support approaches. Other components that are not traded in the open market such as attributes, functions and services were rarely valued by respondents. Prominent wetland functions in the study area include recreation and tourism (80.0%), storm protection (72.7%), shoreline stabilization (67.3%), climate change mitigation (60.0%), sediment retention (60.0%), storage of precipitation and runoff (58.2%) and reservoir of biodiversity (54.5%). This was corroborated by the relative importance index (RII) conducted on the functions which revealed that storm protection (RII = 3.65), shoreline stabilization (RII = 3.51), recreation and tourism (RII = 3.49) and climate change mitigation (RII = 3.44) are four most important wetland functions in the study area. The principal component test conducted showed that the first four components (climate change mitigation, groundwater replenishment, sediment retention and storm protection) form the extracted solution that accounted for 65.4% of the total variability in the original eleven components (variables). The scree plot also confirmed this.

6.0 Conclusion and Recommendations

The study examined the various functions performed by wetland ecosystems in the Niger Delta, using both descriptive and inferential statistics. The study identified eleven (11) wetland functions in the Niger Delta. In ranking the functions, it was discovered that storm protection (RII = 3.65), shoreline stabilization (RII = 3.51), recreation and tourism (RII = 3.49) and climate change mitigation (RII = 3.44) are four most important wetland functions in the study area. The principal component analysis conducted corroborates the findings from the frequencies and ranking tables. In the light of the various findings, the study therefore recommends that Estate Surveyors and Valuers should pay particular attention to the functions provided by wetlands in the determination of their values especially for compensation purposes

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