Original Research Article

Canonical Correlation Analysis across Vegetation and Soil Properties of the Disturbed and Intact Coastal Forest Ecosystems

Abstract

Knowledge about the correlation of forest vegetation parameters and soil properties is important in forest ecosystems management. This study presents comparative initial information about canonical correlation across forest stand parameters, diversity indices and soil properties in intact forest sites (IFS), agriculture disturbed sites (ADS) and livestock disturbed sites (DGS). Data were collected from Uzigua Forest Reserve located along the coastal zone of Tanzania. Sampling plots of 25m × 25m were randomly established, from which tree inventory data and soil samples were collected. Data were subjected into Conoco in windows 4.5 software for multivariate analysis and comparisons across IFS, ADS and DGS. The correlation of tree stand parameters (TSP) and soil physical properties (SPP) was F=1.207, p=.242 in IFS, F=2.400, p=.012 in ADS and and F=0.529, p=.938 in DGS. For soluble bases and TSP were F=2.448, p=.018 in IFS, F= 0.687, p=.790 in ADS and F=0.743, p=.808 in DGS. Carbon, nitrogen and potassium (CNP) and TSP were F=0.816, p=.572 in IFS, F=0.687, p=.790 in ADS and F=.070, p=.020 in DGS. Canonical SPP and Shannon indices had F=1.103, p<.388 in IFS, F=0.520, p=.714 in ADS and F=0.932, p=.444 in DGS. The SPP and Independent Value Index (IVI) were F=0.042, p=.996 in IFS, F=0.819, p=.620 in ADS and F=0.633, p=.724 in DGS. Soluble bases and equitability were F=0.119, p=.968 in IFS, F=0.001, p=.001 in ADS and F=0.011, p=.001 in DGS. The CNP and IVI had F=4.246, p=.014 in IFS, F=2.729, p=.018 in ADS and F=2.007, p=.060 in DGS. Disturbances affect the above and below-ground ecosystems components. The mean higher canonical correlation in the non-disturbed sites indicates that crop agriculture and livestock grazing affect the interplays between forest vegetation and soil properties. Therefore, any activity that disturbs forest ecosystem affects the reciprocal relationships between the above ground forest structure and soil properties.

Keywords: Forest disturbance, forest structure, species diversity, soil properties

1.0. INTRODUCTION

Knowledge about the influence of human activities on forest structures and the correlation of vegetation (i.e. trees as used in this study) parameters and soil properties is important in forest ecosystem management [1]. This knowledge is crucial because vegetation in forest ecosystems

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Comment [u4]: define at first mention has direct influence on soil conditions [2, 3]. Nevertheless, information about the reciprocal relationships across tree stand parameters, diversity indices and composition, and soil physical and chemical properties in the tropical coastal forests is lacking [4, 5]. This deficit is contributing in jeopardizing the whole process of tropical coastal forests management. Therefore, this study was conducted to address the missing relationship between vegetation structure and soil properties of the disturbed (by farming and livestock grazing) coastal forest ecosystems [1, 6, 7].

Different processes and activities occurring in forest ecosystems affect forest structural parameters by providing favorable or unfavorable conditions [2, 6]. Disturbances affect the ecological relationship between forest vegetation and soils [8, 9, 10, 11]. In essence, human induced disturbances bring soil degradation, which is defined in this study as any physical or chemical alteration of the soils caused by different operations in forest ecosystems [1]. Disturbances in soils direct affect forest structures (i.e. the spatial arrangements diversity of various components of forest ecosystems) [7, 12, 13]. These disturbances affect the number of trees, heights of different canopy levels, diameter, spatial distribution, basal area, volume and species composition [14, 15, 16, 17].

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Although disturbances are reported to disrupt the settings of ecological components, ecologically they are sometimes essential processes, at some levels of intensity and periodicity for the long-term sustainability and productivity of forest ecosystems [5]. In this case, the impacts of disturbances are not uniform. Thus, establishing the direction of disturbances on forest structure diversity and on soil properties still is a challenge because other studies show that the structure and diversity of tree species between undisturbed and disturbed forests sometimes are not significant [3]. Indeed, a study by [4] shows that natural forests are not influenced by anthropogenic activities but by conditions of abiotic environment. However, these documentations have not mirrored the status and interplays between tree structures and soil properties in the disturbed and intact tropical coastal forests.

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Therefore, this study was conducted based on the fact that there is relationship across above-ground forest structures and soil physical and chemical properties. This relationship is grounded on the fact that the above-ground forest status determines the below-ground forest systems and vice versa through process, which accelerates soil erosion, oxidation and destruction of biomass [6]. In respect to soils, anthropogenic activities especially those involving clearance of forests (

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exposing soils to erosion), loss of organic matter and other necessary elements useful for vegetation growth [7]. These activities affect soil properties because they influence the biological and geochemical processes at different depths after human disturbances, as results, all these processes affect vegetation statuses and functions [7].

The above-ground forest disturbances are related with underground status because there is a close relationship between forest and land use management on species diversity and soils conditions [9]. For example, low species diversity in disturbed areas is associated with low values of soil elements such as carbon, nitrogen and phosphorus [10]. Thus, there is a strong relationship between disturbances on plant species composition and impacts on soil parameters [21, 22]. Understanding the impacts of human activities on the coastal forests of Tanzania is crucial because these activities have affected the structure and biodiversity of these forests for more than 50 years [8]. It is obvious that human activities affect the coastal biodiversity, which is composed of over 10,000 plant species, hundreds of which are recognized as nationally endemic [24, 25, 26]. Indeed, crop agriculture and livestock grazing have been considered in this work because are the major activities, which threaten species diversity along the coastal zone of Tanzania [19, 23]. These activities are forms of land uses, which have caused variation in habitat conditions characterized by biogeography and disturbance levels, which in turns affect part or entire coastal ecosystems [3, 14, 27].

It is important to find correlation between trees parameters, which are found above-ground and soil properties, which represent the below-ground forests variables so as to understand their interplays. This understanding is important in gauging the dynamics of the above-ground forests structure and environmental variables [11]. The study focused on agriculture and livestock grazing disturbances on forests ecosystems because these forms of land uses cause high scale severity in soils and vegetation properties [25, 30]. Indeed, these activities are accompanied by clearing/ cutting trees because of intensive production of agricultural products thus exposing vulnerability of the coastal ecosystem to disturbances effects [12]. Moreover, livestock grazing affects species composition and ecosystem function by feeding and trampling on vegetation [13]. The impacts of agriculture and livestock grazing are large especially when there is agriculture intensification and reduced grazing areas [33, 34]. Within low carrying capacity of the forests ecosystems, farming activities and livestock grazing destroy plant species and destruct soils [34].

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In addition, these activities expose the land to erosion and nutrients loss [13, 33, 34]. Therefore, it is imperative to establish information about forest structure and soil relationship in forest management because vegetation and soils are interconnected and exert interdependent effects on each other [3, 4].

This work presents the basic information on how the existing forest species are canonically correlated with the soil properties. This is the first kind of study done on the disturbed coastal forest ecosystems after human activities disturbances exclusion. This study was guided by hypothesis which states that, there is positive relationship between the above-ground forest structures and soil properties subjected into different management practices along the tropical coastal forest ecosystems. Furthermore, the study sought to answer the following question: How forest parameters (density, height, basal area and volume, and species composition and diversity) are canonically correlated with bulk density, soil texture, soluble and non-soluble bases across intact forest, crop-agriculture and livestock disturbed sites?

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2.0. MATERIALS AND METHOD

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2.1. Description of the Study Area

This study was conducted in Uzigua Forest Reserve (UFR) found in Bagamoyo and Chalinze Districts, Pwani Region in the Coastal Zone of Tanzania Mainland. The UFR is located between 50 58 '00" S and 38 04 '00" E (Figure 1) with a coverage area of 24,730 ha [14]. This forest was purposely selected to represent other forests along the coastal, which have been encroached mainly for crop-agriculture and livestock grazing. Certainly, this forest is within 100 km from the coast of Indian Ocean, and thus, is considered to be among the tropical coastal forests in East Africa [15]. This forest reserve is supposed to be completely restricted from human use, serving for catchment and biodiversity conservation [14]. Unfortunately, due to poor protection and surrounding settlements, the entire forest is affected by anthropogenic activities such as harvesting trees for fuel-wood, fodder, grazing pressure and encroachments for agriculture. These activities are threatening this forest like many other coastal forests, which are documented to harbor diverse plant species that make them, and hence included as one of the 34-world biodiversity hotspots that need special conservation measures [37, 38].

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2.2. Data Collection

Data collection was conducted by stratification field inventory approaches [25, 40]. Land use classification was carried out to determine the land uses based on human activities mainly crop-agriculture (ADS), livestock grazing (DGS) and intact forest sites (IFS). These land uses were obtained from satellite images and by using normalized difference vegetation index.

2.3. Collection and Analysis of Vegetation Data

Sites for plot establishment and collection of data were randomly selected. Seventy (70) small quadrants of 25m × 25m size were established for collection of adult tree data. Within these plots, 2m × 2m subplots were established for collection of seedlings, saplings and shrubs data [41, 42]. From these plots, stems with a diameter of ≥ 20cm at breast height (dbh) (approximately 1.34m above the ground) were categorized as tree species. All tree species with < 20cm were considered as regenerates in the following subdivisions (i) seedlings involved only trees with < 0. 40m height; (ii) saplings included trees from ≥ 0.40m to <1m heights and (iii) shrubs represented woody species with a diameter of ≥ 10cm thickness and the height ranging from ≥ 1m to ≤ 5m as adopted from [42, 43].

2.4. Trees Stand Parameters' Analysis

Trees found in the study area were identified at species level using field guidebooks with the help of local and qualified botanists. From tree species checklists (i) a number of live trees per unit area (N/ha), (ii) basal area (BA) of live trees (m^2/ha), and (iii) volume of live trees (m^3ha^{-1}) were calculated following a methodology laid down by [17]. Computation of BA was carried by $BA = ((dbh)^2 \times \pi)/4$; where dbh = diameter at breast height and π = 3.14; the volume was calculated as $v = ghf$; where v = volume estimation (m^3/ha), g = basal area of the tree/seedling/saplings (m^2/ha), h = height of the tree (m) and f = form factor (0.5). This form factor was used as an average for natural forest factor, which ranges between 0.4 and 0.6 [18]. The computed values for each tree stand parameter were subjected to Canoco 4.5 data analysis software for correlation calculations

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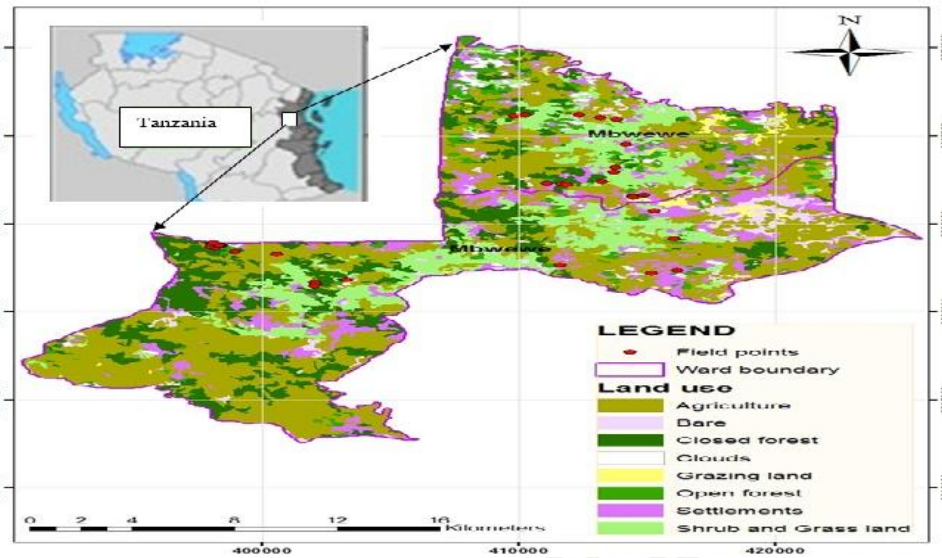

Figure 1: A map of the study area [16].

2.5. Trees Diversity Indices Analysis

The study computed species diversity indices for all species. Included in diversity indices analyses were the Shannon-Weiner diversity, Shannon-Weiner equitability, Simpson diversity and importance value index (IVI). Each of the diversity components were computed as follows: (i) Shannon-Weiner diversity index was computed as $H' = \Sigma Pi \times ln\ Pi$, where H is the index of diversity; *Pi* is the decimal fraction of a relative basal area, and $\sum$ is the summation symbol[19], (ii) Equitability (evenness) index calculated as $H'E = H'/Hmax$, where H_{max} defined as lnS (species richness). (iii) Simpson index was computed as $D = \sum(ni/N)^2$, where D is the index of dominance, ni is the number of individuals of species 'i' in the sample, *N* is the total number of individuals (all species) in the sample and $\sum$ = the summation symbol [20], (iv) The IVI of tree species was obtained from the sum of the relative frequency, density and basal area [21].

2.6. Collection of Soil Samples

Soil samples were collected from same plots, which were used for collection of vegetation data. Soil samples were collected by using the Edelman auger at 1-30cm (topsoil) [1, 22, 23]. The soil samples in each quadrant were then mixed together to make one composite sample to eliminate variability. Fresh air and oven-dried weights were determined and further laboratory analyses were conducted for each soil parameter.

2.7. Determination of Soil Chemical Properties

The determination of total nitrogen (TN) followed the Kjeldahl acid-digestion procedures [24, 25] (ii) Soil total carbon were analysed by the Walkley-Black Procedures. Potassium Dichromate ($K_2Cr_2O_2$) and concentrated Sulphuric Acid (H_2SO_4) used to produce the reaction and products as shown in this chemical equation: $2Cr_2O_7^{2-} + 3C^0 + 16H^+ \rightarrow 4Cr^{3+} + 3CO_2 + 8H_2O$ [22]. In computing the results, a correction factor of 1.33 was applied to adjust the organic carbon recovery because of incomplete oxidation in Walkley-Black combustion procedures. Available P was determined by the Bray-II method [23]. The Ammonium Acetate (1M NH4OAc) (pH 7.0) was used to extract exchangeable calcium (Ca), potassium (K) magnesium (Mg) and sodium (Na). Then K content was determined by using flame photometer while ethylenediaminetetraacetic acid (EDTA) titration was done to measure Ca and Mg [24].

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2.8. Determination of Physical Properties

Bulk density was calculated as the dry weight of soil divided by its volume (gcm^3) [25]. Soil samples were sieved through a 2mm sieve and then soil texture (ST) (silt = 2-20µm, clay < 2µm) were determined by using the pipette method as described by [25]. The resulting data were presented as percentage sand, silt and clay by plotting the percentage ratio of each textural class using the ST triangle [26]. For the determination of electrical conductivity (EC), the preparation of 1:5 (soil: water) was done and the solution was put in rotary shaker for one hour. Then this solution was put in the centrifuge at 8000 to10000 rotation per minute, for about 10 minutes then a clear solution was decanted and the EC was measured in the decanted solution after calibrating the instrument by means of Potassium Chloride (0.01M KCl). The EC meter was used to get EC values [31, 32, 33].

2.9. Multivariate Data Analysis

The tree and soil data were subjected into Canoco software following the procedures in [27] . In this work, detrended canonical correspondence analysis (DCCA) were used to obtain multiple linear regressions and optimal linear combination between tree parameters and soil variables. The computation of these variables in the DCCA facilitated the possibility to test the null models by Monte-Carlo permutation on each set of data. This method was chosen because it permitted

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the whole community composition data to be carried out and produced the results that are much more informative about species and environmental variables reaction [28, 29]. The F-ratio was used to test the significance of correlation at 5% confidence interval.

3.0. RESULTS

The models of plant species parameters are summarized as a function of environmental variables (physical and chemical properties of soil) and the correlation of significance for each set of variables. By using the F-ratio, it was possible to show which parameters are the most important by ranking their values in each sets of correlation.

3.1. Tree Stand Parameters and Soil Physical Properties

There were strong positive correlation between soil physical properties (SPP) and tree stand parameters (TSP) across the land uses. The Monte Carlo test of significance of all canonical axes in IFS was F = 2.400, $p < .012$ for STP and SPP. In ADS, the F- test was 0.529, $p = .938$. In DGS, the significance of all canonical axes was F = 1.207, $p = .242$. The species- environment correlation between STP and SPP for individual axis had the average values in the order of 0.435, 0.248 and 0.338 for IFS, ADS and DGS respectively. (Table 1).

Table 1: Canonical correlation between Soil Physical Properties and Tree Stand Parameters across Land Uses

	SPP vs. TSP in IFS				SPP vs. TSP in ADS				SPP vs. TSP in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.02	0.00	0.00	0.00	0.01	0.01	0	0	0.01	0.00	0.00	0.00
LG	0.36	0.19	0.11	0.19	0.19	0.14	0.08	0.08	0.31	0.21	0.15	0.15
SEC	0.55	0.45	0.42	0.32	0.36	0.25	0.18	0.20	0.45	0.36	0.26	0.28
CPVS	13.60	14.60	14.90	15.00	3.70	4.10	4.20	4.30	4.30	4.60	4.90	5.00
CPVSER	70.90	83.60	0.00	0.00	58.60	74.50	0.00	0.00	61.90	75.20	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

3.2. Tree Stand Parameters and Soil Chemical Properties

The canonical multivariate data analysis showed a Monte Carlo test of significance of all canonical axes between the correlation of soluble bases (Ca, Mg, K and Na) and tree stand parameters (density, height, basal area and volume (TSP)) as F = 2.448, $p = .018$ in IFS, F= 0.687, $p = .790$ in ADS and F = 0.743, $p = .808$ in DGS. The average species- environmental correction was 0.338 in IFS, 0.305 in ADS and 0.288 in DGS (Table 2). The Monte Carlo test of significance of all the canonical axes for the correlation between non-soluble elements (carbon, nitrogen and phosphorus-(CNP)) and TSP were F = 0.816, p = .572 in IFS, F = 0.687, p = .790 and F= .070, p = .020 in DGS. The average of species- environmental correlations was 0.47 in IFS, 0.223 in ADS and 0.392 in DGS (Table 3).

Table 2: Canonical Correlation between Soluble Base and Tree Stand Parameters

	Soluble Bases and TSP in IFS				Soluble Bases and TSP in ADS				Soluble Bases and TSP in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
LG	0.31	0.21	0.15	0.15	0.24	0.07	0.17	0.17	0.24	0.07	0.17	0.17
SEC	0.45	0.36	0.26	0.28	0.42	0.25	0.23	0.25	0.42	0.25	0.23	0.25
CPVS	4.30	4.60	4.90	5.00	4.00	4.40	4.40	4.40	4.00	4.40	4.40	4.40
CPVSER	61.90	75.20	0.00	0.00	71.50	80.40	0.00	0.00	71.50	80.40	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

Table 3: Canonical Correlation between CNP and Tree Stand Parameters

	CNP vs. TSP in IFS				CNP vs. TSP in ADS				CNP vs. TSP in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.04	0.01	0.00	0.00	0.03
LG	0.16	0.10	0.04	0.68	0.27	0.09	0.14	0.78	0.34	0.23	0.24	0.87
SEC	0.48	0.21	0.19	0.01	0.36	0.26	0.28	0.01	0.57	0.49	0.49	0.02
CPVS	2.70	4.20	4.40	42.80	6.20	6.60	6.80	34.20	8.10	8.90	9.10	28.80
CPVSER	49.50	77.50	0.00	0.00	85.50	89.70	0.00	0.00	88.00	94.10	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

3.3. Diversity Indices and Soil Physical Properties

The multivariate diversity indices had a positive correlation with soil physical properties (SPP). The canonical Monte Carlo tests of significance of all canonical axes in the correlation between SPP and Shannon index showed that F = 1.103, $p < .388$ in IFS, F = 0.520, p = .714 in ADS and F = 0.932, p = .444 in DGS. The average species-environmental correlation between SPP and Shannon index was 0.248 in IFS, 0.085 in ADS and 0.170 in DGS (Table 4).

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Table 4: Canonical Correlation between Soil Physical Properties and Shannon Index

	SPP vs. Shannon in IFS				SPP vs. Shannon in ADS				SPP vs. Shannon in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	0.02	0.00	0.09	0.09	0.01	0.00	0.05	0.05	0.05	0.05	0.10	0.10
SEC	0.31	0.34	0.33	0.01	0.22	0.01	0.01	0.00	0.29	0.29	0.01	0.00
CPVS	9.70	9.70	90.70	91.30	4.80	4.80	83.70	94.10	8.30	8.50	95.80	95.30
CPVSER	99.80	0.00	0.00	0.00	100.00	0.00	0.00	0.00	172.20	100.00	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

The canonical correlation between SPP and equitability showed that F = 0.093, *p* = .978. The results showed zero correlation between SPP and equitability in ADS and DGS. Indeed, the species-environment correlation was almost zero in ADS and DGS (Table 5). Interestingly, the canonical correlation between SPP and IVI showed that F = 0.042, *p* = .996 in IFS, F = 0.819, *p* = .620 in ADS and F= 0.633, *p* = .724 in DGS. The average of species-environmental correlation between SPP and IVI was 0.015 in IFS, 0.098 in ADS and 0.065 in DGS (Table 6).

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Table 5: Canonical Correlation between Soil Physical Properties and Equitability

	SPP vs. Equitability in IFS				SPP vs. Equitability in ADS				SPP vs. Equitability in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEC	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CPVS	0.90	0.90	94.10	99.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CPVSER	99.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Where: EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

Table 6: Canonical Correlation between Soil Physical Properties and Independent Value Index

	SPP vs. IVI in IFS				SPP vs. IVI in ADS				SPP vs. IVI in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	0.02	0.00	0.16	0.16	0.01	0.00	0.03	0.03	0.04	0.01	0.21	0.16
SEC	0.06	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.26	0.07	0.00	0.00
CPVS	0.40	0.40	87.90	95.50	7.10	7.10	57.40	79.90	3.50	3.60	50.20	69.00
CPVSER	90.90	0.00	0.00	0.00	96.50	0.00	0.00	0.00	93.50	100.00	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, IVI= Importance Value Index, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation

3.4 Diversity Indices and Soil Chemical Properties

The canonical results showed that there were weak but positive correlations between soil chemical properties and diversity indices. The correlation between soluble bases and Shannon showed a correlation as in (Table 7) across IFS, ADS and DGS land uses. The Monte Carlo test of all the canonical axes showed that F = 0.574, *p* = .680 in IFS, F = 0.410, *p* = .804 in ADS and F = 0.910, *p* = .480 in DGS. Similarly, the results showed a weak correlation between soluble bases and equitability across the land uses (Table 8).The canonical test of significance for all canonical axes between soluble bases and equitability showed that F = 0.119, *p* = .968 in IFS while ADS had F = 0.001, *p* = .001 in DGS the results showed that F = 0.011, *p* = .001. There were positive correlations between soluble bases and IVI (Table 9). In IFS, F = 0.083, *p* = .986, in ADS, F = 0.750, *p* = .664 while in DGS F = 0.374, *p* = .956.

Table 7: Canonical Correlation between Soil Bases and Shannon Index

	Soluble Bases vs. Shannon in IFS				Soluble Bases vs. Shannon in ADS				Soluble Bases vs. Shannon in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	0.01	0.01	0.09	0.09	0.01	0.00	0.05	0.05	0.01	0.00	0.05	0.05
SEC	0.18	0.18	0.00	0.00	0.28	0.00	0.00	0.00	0.28	0.00	0.00	0.00
CPVS	3.00	3.30	78.90	89.60	7.80	7.80	96.40	95.80	7.80	7.80	96.40	95.80
CPVSER	92.90	92.00	0.00	0.00	94.00	0.00	0.00	0.00	90.00	0.00	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

Table 8: Canonical Correlation between Soluble Bases and Equitability

	Soluble Bases vs. Equitability in IFS				Soluble Bases vs. Equitability in ADS				Soluble Bases vs. Equitability in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	0.00	0.00	0.03	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
SEC	0.06	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CPVS	0.30	0.30	84.40	99.10	3.20	3.20	97.60	92.20	0.00	0.00	0.00	0.00
CPVSER	84.70	0.00	0.00	0.00	99.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

Table 9: Canonical Correlation between Soluble Bases and Independent Value Index

	Soluble Bases vs. IVI in IFS				Soluble Bases vs. IVI in ADS				Soluble Bases vs. IVI in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	0.03	0.02	0.21	0.15	0.03	0.02	0.21	0.15	0.08	0.08	0.06	0.06
SEC	0.27	0.14	0.00	0.00	0.27	0.14	0.00	0.00	0.99	0.99	0.00	0.00
CPVS	3.20	3.70	59.60	79.60	3.20	3.70	59.60	79.60	97.40	98.60	99.50	99.10
CPVSER	76.90	98.00	0.00	0.00	76.90	98.00	0.00	0.00	97.00	98.00	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, IVI= Importance Value Index, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

The canonical correlation was positive between CNP and Shannon index across IFS, ADS and DGS (Table 10). The correlations were shown by F = 0.127, *p* = .002 in IFS, F = 0.254, *p* = .002 in ADS and F = 0.097, *p* = .002 in DGS. There were almost no established correlations between CNP and equitability across IFS, ADS and DGS (Table 11). The CNP and IVI had positive correlation as shown in (Table 12). The test of significance of all the canonical axes were F = 4.246, *p* = .014 in IFS, F = 2.729, *p* = .018 in ADS and F= 2.007, *p* = .060 in DGS.

Table 10: Canonical Correlation between CNP and Shannon Index

	CNP vs. Shannon in IFS				CNP vs. Shannon in ADS				CNP vs. Shannon in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	0.08	0.08	0.06	0.06	0.05	0.05	0.05	0.05	0.10	0.10	0.10	0.10
SEC	0.99	0.99	0.00	0.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00
CPVS	97.40	98.60	99.50	91.10	99.30	99.50	99.80	99.10	99.70	99.00	99.10	89.20
CPVSER	73.70	90.00	0.00	0.00	75.70	90.00	0.00	0.00	90.80	90.00	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

Table 11: Canonical Correlation between CNP and Equitability

	CNP vs. Equitability in IFS				CNP vs. Equitability in ADS				CNP vs. Equitability in DGS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	0.02	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEC	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CPVS	23.50	23.50	90.50	97.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CPVSER	90.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation.

Table 12: Canonical Correlation between CNP and IVI

	CNP vs. IVI in IFS				CNP vs. IVI in ADS				CNP vs. IVI in ADS			
Axes	1	2	3	4	1	2	3	4	1	2	3	4
EV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	0.10	0.10	0.16	0.16	0.01	0.01	0.03	0.03	0.06	0.03	0.19	0.17
SEC	0.48	0.48	0.00	0.00	0.52	0.24	0.00	0.00	0.46	0.19	0.00	0.00
CPVS	23.30	23.60	90.20	98.00	14.20	16.40	56.10	76.00	11.10	11.60	43.10	60.10
CPVSER	77.00	90.00	0.00	0.00	87.70	90.00	0.00	0.00	89.50	90.00	0.00	0.00

Where: SPP = Soil physical properties, TSP = Tree Stand Parameters, IFS = Coastal Forest Sites, ADS = Agriculture Disturbed sites, IVI= Importance Value Index, EV = Eigen values, LG = Lengths of gradient, SEC = Species-environment correlations, CPVS = Cumulative percentage variance of species data, CPVSER = Cumulative percentage variance of species-environment relation

4.0. DISCUSSION

4.1. Correlation between Stand and Soil Properties

The canonical correlation between sets of variables studied in this work has revealed various outcomes. The significant canonical variation between the above ground forest structure and soil properties across the studied sites shows that tropical forests vary because of the interaction between floristic and environmental properties [28, 29]. The heterogeneity in correlation indicates that not all forest structures and diversity indices respond equally to soil parameters. Our results indicate that there are some direct and indirect relations between the above and below ground forest ecosystems as documented in [28]. From these findings, it is obvious that any disturbances on environment affect stand and soil physical properties. Indeed, these findings in this view supports [29, 30].

The ecological interpretation of the gradients represented by the canonical axes shows that majority of plants positively correlated with soil properties supporting the findings in [31]. These

Comment [u17]: Do not personalize research with words like "our, I, we, us etc" change "our" to "The" results can be used to suggest that any alternation of soil physical properties in the tropical coastal forests affects species welfare, which in turn has influence on soil properties (i.e. bulk density , electric conductivity and soil texture in this work) in agreement with [10]. From these findings, it can be predicted that any land use change, which affects the tree stand parameters has some impacts on soil nutrients [9, 33]. It is from this predicted and established reciprocal relationship where the results revealed strong correlation of stand parameters in closed forest site than in the disturbed ones. Therefore, for proper management of coastal tropical forests, management programs for both the below and above grounds must consider ecosystems concurrently.

4.2. Correlation between Diversity and Soil Properties

There was positive correlation between diversity indices with soil chemical properties (soil nutrients) and soil physical properties as well as equitability and nutrients across land uses. These correlation values show that soil and above ground forest properties are characterized by the same dynamics directions in the coastal forests like in many other forest ecosystems [34, 29]. The positive correlations in Shannon index and soluble bases, Shannon and soil physical properties, equitability and soil physical properties, independent value index and soil physical properties are important in showing that each kind of forest diversity is affected by soil factors contrary to observations made in [32] . This controversy is possibly resulting from variations in geographical locations and nature of vegetation. Regardless of this controversy, it should be noted that the relationship across soil properties and diversity indices can be used to indicate the direction of vegetation and soil interplays because vegetation influences the chemical and soil physical properties [33].

The low correlations between trees stand parameters and soluble bases unlike that observed across carbon, nitrogen and phosphorus might be useful to predict that loss of vegetation affects more the non-soluble nutrients than soluble bases. For this prediction to qualify, it requires more studies because soil factors and or vegetation have some impacts on each other as documented in many tropical forests [34]. Interestingly, these variations can contribute into interpreting soil and diversity dynamics and complexity in agreement with [35, 28]. Conversely, the observation trees stand parameters had no significant correlation with soluble bases agree the results of [32]. The implication of these findings in forest management is that some nutrients are affected more than others during and after disturbances. Moreover, it shows that different nutrients in different locale are affected differently; hence, production of nutrients during and post disturbances requires temporally and spatially set assessments. Therefore it is hard to permanently establish nutrients status as supported in [3, 4].

However, lack of correlation across tree density, heights, basal area and volume, and soluble bases should be considered with some precautions because tree growth in forests is highly influenced by elements such as Ca, Mg, K, Na concentration [36]. Meaning that, any impacts on vegetation have impacts on soil soluble bases supporting [37]. Therefore, this study come up with the observation that more work needed to be done particularly investigating the reasons for lack of correlation between tress stand parameters and some diversity indices (more specifically the equitability and independent value index) with soluble bases as were not discovered in this study. In this case, this study partially suggests the use of correlation between equaitability and simposns to explain and predict the interpplays between tropical coastal forests above ground structures in relations to soluble bases status.

The correlations between vegetation and soil properties established in this study indicate that disturbances cause changes on above ground species, which in turn have impacts on soil properties. The magnitude of impacts mostly likely differ across a set of nutrients and prevailing locale charactersitics. Therefore, the use of information on the relationship between above ground and soil properties to suggest management operations in forest is important but some precautions, which address a full range of the above and below ground forests ecosystems welfare, are required. With this suggested remarks, certain parameters such as higher Shannon-Weiner could be used as a good indicator of abundant regenerating vegetation in the disturbed sites after exclusion agreeing with the results in [38] unlike equitability or Simpsons index.

5.0. CONCLUSIONS

The canonical multivariate data analysis between forest structure (species variables) and soil properties (environmental variables) showed significant positive correlation across the land uses. The mean average shows that there is higher positive relationship in non-disturbed sites than the disturbed ones. The established correlations are the results of variations in forests ecosystem management, which bring forest disturbances emanating from crop-agriculture and livestock grazing. The correlations across tree stand parameters, diversity indices and soil properties established in this study set a ground, which is useful to make some predictions of forest structures and soil statuses dynamics in the tropical forest ecosystems. In addition, these correlations can also be used to inform foresters, environmentalists, agriculturists, livestock keepers and police makers that management efforts and plans of coastal forests must focus on addressing the below and above ground forests structures.

9.0. REFERENCES

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