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Soluble Bases and CEC Variation across Undisturbed and Disturbed Coastal Forests in Tanzania

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ABSTRACT

Understanding of different levels of soil calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), cation exchange capacity (CEC), and percentage base saturation (BS), is important in the management of forest ecosystems. However, there is limited documentation on the status of these elements in the undisturbed forest sites (CFS) crop-agriculture (ADS) and livestock grazing (DGS) disturbances in the tropical coastal forests. This chapter attempts to address this deficit by presenting soil fertility based on exchangeable bases' status and variations across undisturbed forest sites (used as a control), crop-agriculture and livestock disturbed sites in the coastal zone of Tanzania. The chapter aims to add knowledge on the management of tropical coastal forests. Indeed, this chapter shows that crop-agriculture and livestock grazing disturb soil chemical properties in tropical coastal forests. Therefore, it is essential to protect undisturbed forest while putting more efforts to restore the disturbed sites for sustainable forest management along the coastal areas.

Keywords: Soluble bases; cation exchange capacity; coastal forests; forest ecosystem; Tanzania.

1. INTRODUCTION

Forest disturbances due to human pressures and poor management systems affect forest structure and ecosystems [1,2,3]. Human induced forest disturbances and degradation affect the structure of forest ecosystems at large [4]. Indeed, human activities contribute to forest biodiversity decline or loss. The main activities contributing to forest loss, especially in the tropics include clearing land for crop-agriculture, pole cutting, charcoal burning, timber harvesting, and settlements [5,6]. Human disturbances reduce the capacity of forest to regenerate, function, and offer various ecological services [7,8,9]. However, documentation shows that some degree of disturbances are actually beneficial, as they contribute to the increase of biodiversity and nutrient circulation. Beneficial disturbances are thus considered important for long term sustainability and productivity of most ecosystems on earth. Certainly, disturbances are important in the modification of forest structures (i.e., stand parameters and species diversity), thus helping forests to undergo successional stages and maintain values. Unfortunately, in many cases these structures are affected by natural and human activities under varied environmental conditions [4].

Encroachment through human activities threatens the coastal forests, which cover an area of about 800 km^2 along the coastal zone of Tanzania [8]. These activities alter the distribution and structure of the forests. Changes in spatial and temporal patterns, and the subsequent regeneration capacity put forest management efforts in jeopardy [10,11]. Yet, studies on how coastal forests, such as those comprising the study area, respond to crop-agriculture and livestock grazing disturbances are not available.

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Human disturbance by activities such as plowing and logging greatly affect soil properties [12]. Forest disturbances for example, strongly affect soil characteristics mainly soil volume, chemistry and texture. Impacts consequences are soil degradation, soil erosion and the destruction of species, biomass and biodiversity [13]. Forest disturbances start to affect species composition, which in turns affects soils nutrients [14]. The impacts of vegetation destruction in soils nutrients pools is that, different plant species have different nutrient requirements and returns to soils [12]. Disturbances in forest affect the ecological relationship between forest vegetation and forest soils [15,16]. Therefore, in this chapter soil disturbances is defined as any physical, biological, or chemical alteration of the soil caused by forestry operations [17].

Human activities especially those involving clearance of forest vegetation pose soil to erosion, loss of organic matter and other necessary elements that are useful for vegetation growth. For example, a study by [12] shows that soil nitrogen of different ecosystems is concentrated mostly at the top 10 cm depth hence any effects on this layer would affect soil nutrients in these ecosystems. This effect is supported in [12] that soil nutrients such as phosphorus differences in different soil horizons may result from change of biological and geochemical processes at different depths after disturbances. However, in the same study, soil potassium was slightly higher in the disturbed than primary intact forest sites. Therefore, the findings in this work supports many existing literatures that disturbances on vegetation component of the ecosystems affects soil fertility. In this chapter we tried to present the variation of soil fertility across undisturbed, crop- agriculture and livestock grazing sites. Crop-agriculture and livestock grazing are used in this piece of work because these activities largely contribute to disturb coastal forest ecosystems in Tanzania [18].

The existing studies have documented on the impacts of land cover change and carbon storage [19,20,21]. Studies on soil organic carbon conducted by [22], Nitrous Oxide and Methane by [23] and plant diversity in [24] and [25]. Although a study by [26] investigated soil fertility on different land uses, documentation on the comparative differences of soluble bases and CEC across forest sites subjected to different land uses along the tropical coastal forests including those found in Tanzania is lacking. This lack of information is a challenge on the management of coastal forests in the tropics.

Inadequate information about soil soluble bases and CEC puts forests management in risk because the knowledge about the existence of forest resources is not enough to address the entire reciprocal function of soil properties and the interplays between vegetation and soils soluble bases in the ecosystems [27,28]. A chapter about soluble bases status and variation is important in the tropical coastal forests because these forests face pressure from human activities mainly crop-agriculture and livestock grazing [18]. Information generated in this chapter is crucial in contributing on the effective management and protection of tropical coastal forest ecosystems [29].

1.1 Crop-agriculture and Forest Disturbances

Coastal ecosystems especially forests are overexploited because of unsustainable use of resources as well as pressure from the growing agricultural activities [1]. Clear tree felling from intensive agriculture is associated with timber removal, and with major disturbances by using powered machinery contributes to the opening of larger sites for crop production [2] making coastal ecosystems vulnerable to disturbances. The detrimental effects of agricultural practices is deforestation, which in turn affects soils in ways such as erosion, desertification, salinization, compaction, lowering soil structure quality and loss of soil fertility [3]. Deforestation usually led to land degradation and ecological imbalance especially when clearing and burning are accompanied in deforestation methods in preparation of lands that are used for crop production [3]. Crop-agricultural activities disturb forests soils and cause high scale severity in soil and vegetation properties [4,30]. It is obvious that the ongoing agricultural practices of clearing land for crop production and improved pasture management by using uncontrolled fire accelerate the problem of forest disturbances [5].

1.2 Livestock Grazing and Forest Disturbances

Livestock grazing disturbances in forests is a concern in management because the life of every kind of human beings and civilization all over the world show well connections between these activities and forest ecosystems [6,7,8]. Livestock grazing affects species composition, ecosystem function, and socioeconomic value of forests [9]. Literature show that livestock induced disturbances might be among the major factors constraining regeneration and recruitment of species in terrestrial ecosystems [31].

The physical structure of plant communities is often changed by grazing. Defoliation by grazing herbivores alter plant height and canopy cover, and change species composition to include structurally different types of plants [32]. Defoliation can promote shoot growth and enhance light levels, soil moisture, and nutrient availability [31,10]. However, grazing animals can decrease flower and seed production directly by consuming reproductive structures, or indirectly by stressing the plant and reducing energy available to develop seeds [11]. Grazing animals can also disperse seeds by transporting them in their coats (fur, fleece, or hair), feet, or digestive tracts [11]. For some plant species, grazing may facilitate seed germination by trampling seed into the soil. Trampling and pawing disturb the soil and in some cases completely destroy soil crusts [32,12]. Trampling may also change the structure of plant communities by breaking and beating down vegetation [32]. In addition, the effect of trampling is compaction of soils, which damages plant roots, causing them to be concentrated near the soil surface [13].

Reduced vegetative cover and disturbed soil surfaces results into increased wind and water erosion [14]. The hoof-action of large grazing animals can incorporate plant materials into soils and increase organic matter. Grazers enhance mineral availability by increasing nutrient cycling within patches [18]. Also, the organic components of feces and urine from grazing animals can build soil organic matter reserves [6]. These organic components results into soils having increased water-holding capacity, increased water-infiltration rates, and improved structural stability, which can decrease soil loss by wind and water erosion [16]. Certainly, these changes may prevent plants from acquiring sufficient resources for vigorous growth [12].

2. LOCATION AND BIOPHYSICAL CHARACTERISTIC OF THE STUDY AREA

2.1 Location

This chapter presented the soil fertility information based on the study that was conducted in the coastal ecosystems located along the Coastal Zone of Tanzania. This zone stretches within 850km from the boarder of Tanzania and Kenya in in the north, and Tanzania and Mozambique in the south. This ecological area is rich in biodiversity as it has about 190 forest species, of which 92 are endemic [17]. However, as in many other tropical forests, farming (crop-agriculture), livestock grazing, timber harvesting, and charcoal production threaten these forests. As a result, these forests are disappearing at an alarming pace [18]. Because of the human activities, tropical coastal forests located in the coastal zone of Tanzania have lost about 69% of their primary vegetation [17]. If not abetted, further degradation will continue to threaten about 1500/300,000 (i.e., 0.5%) of global vascular plants found in this zone [19]. Nevertheless, crop-agriculture and livestock grazing continue to be the main human activities accelerating the rate of coastal forests degradation in Tanzania [20].

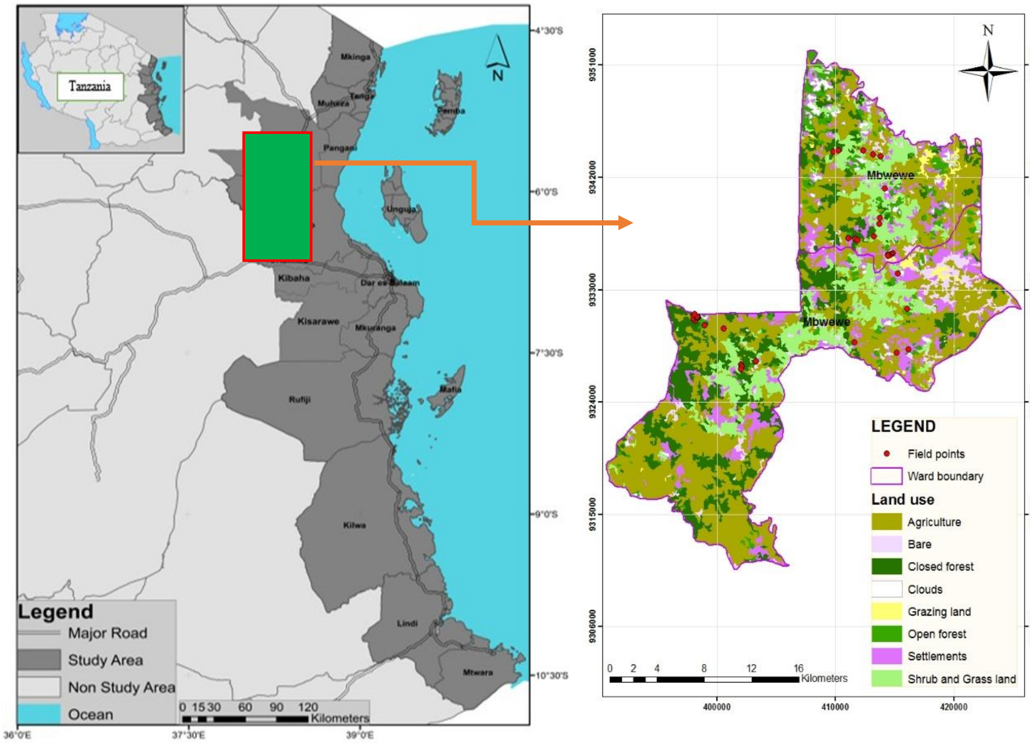
The coastal zone was purposely chosen because is among the areas with the leading forest cover loss in Tanzania particularly between 2000 and 2016 (Fig. 1 a & b). Specifically, the chapter presents information, which were obtained from the forestland cover and land use classifications for Uzigua Forest Reserve (UFR) found in Bagamoyo and Chalinze Districts, Pwani Region in the Coastal Zone of Tanzania Mainland.

The UFR has a coverage area of 24,730 ha [21]. This forest was purposely selected to represent other forest ecosystems along the coastal zone, 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 considered among the tropical coastal forests in Tanzania [22]. The forest is under the Central Government that is represented by the Forest and Bee-keeping division of the United Republic of Tanzania, Ministry of Natural Resources and Tourism [21].

The UFR is supposed to be completely restricted from human use, serving for catchment and biodiversity conservation [21]. Unfortunately, due to poor protection and surrounding settlements, the entire forest is affected by human based activities such as harvesting trees for fuel-wood, fodder, grazing pressure and encroachments for agriculture. These activities have significantly affected this forest. Yet, this forest reserve is among a few remaining tropical coastal forests in Tanzania. Therefore, addressing the status of coastal forests contributed to generate useful information for management. This contribution is crucial in dealing with ecological management challenges emanating from crop- agriculture and livestock grazing pressures. Actually, the chapter highlights the variation on the status of soil fertility using cation exchange capacity differences to gain an understanding on how-crop agriculture and livestock grazing threaten the soils which harbors diverse plant species [23,24]. Consequently, understanding the variation of nutrients on soils affected by crop-agriculture and livestock grazing is very crucial in management of coastal forests.

2.2 Climate, Soils and Vegetation

The coastal zone of Tanzania mainland receives annual average rainfall of 917.23 mm where by the peak periods of rainfall are in January to April and November to December. Uzigua forest reserve is located in the tropical and sub-humid area with 700 mm to 1000 mm rainfall. October to May is a wet season while June to September is dry. The annual minimum temperature is 22.4°C while the maximum temperature is 31.7°C [25]. The soils are well-drained, red sand clay, loamy with brown friable top soils covered by more or less decomposed litter. The area is undulating with continuous hills with altitude ranging from 400 to 600 meters above sea level (masl) [26]. However, the current climate change and variability along the coast greatly influence temperature, rainfall, and the distribution pattern of plant species in these tropical coastal forests, and therefore the composition of the forest fragments at large [19].



a.

b.

Fig. 1. a. The coastal zone of Tanzania, b. A section of a disturbed area in the coastal zone of Tanzania

3. HUMAN DISTURBANCES ON THE COASTAL FORESTS ECOSYSTEMS

Deforestation due to human pressures and poor forest management systems affects forest structure and ecosystems [27,28,29]. Forest disturbances and degradation affect the structure of forest ecosystems at large [33]. Human activities contribute to forest biodiversity decline or loss [34]. The main activities contributing to forest loss, especially in the tropics, include clearing land for crop-agriculture, pole cutting, charcoal burning, timber harvesting, and settlements [35,36,37,29]. Human disturbances reduce the capacity of forest to regenerate, function, and offer various ecological services [38,39]. However, documentation shows that some degree of disturbances are actually beneficial, as they contribute to the increase of biodiversity and nutrient circulation. These disturbances are thus considered important for long term sustainability and productivity of most ecosystems on earth [40,41]. Definitely, disturbances are important in the modification of forest structures (i.e., stand parameters and species diversity), thus helping forests to undergo successional stages and maintain values. Unfortunately, in many cases these structures are affected by natural and human activities under varied environmental conditions [33]. The impacts of disturbances are not only observed on vegetation but also on soil nutrients including calcium, magnesium, potassium and sodium hence cation exchange capacity along the coastal zones of many tropical ecosystems.

3.1 Status of Soluble Bases on the Coastal Ecosystem of Tanzania

3.1.1 Disturbances and soluble bases

An understanding of different levels of soil calcium, magnesium, potassium, and sodium, is important in the management of forest ecosystems [42,43,44], because cation exchange capacity highly influence vegetation growth in forest ecosystems [45]. Despite the importance of these elements, little is understood about their patterns and variability in tropical coastal forest ecosystems particularly on crop-agriculture and livestock grazed land uses [46]. Disturbances on the tropical coastal forests affect soluble bases [47]. As a result, many of the tropical forests are characterized by limited soluble bases [48,49]. The variation of nutrients exists between different ecosystems because of processes such as pedogenesis variability of parent rock materials and land uses [43,44,50]. While cutting down of native vegetation to convert forestland into farms counts as one of the processes that add soil nutrients, yet this addition is considered a temporal return of mineral nutrients in soil stock [51]. Thus, any conversion of natural vegetation into crop or grazing lands contributes to alter some soil nutrients. The depletion of nutrients is severe especially when fertilizers are not used as one of the corrective measures [51]. Unfortunately, crop-agriculture in the coastal forest reserves is practiced without additional of fertilizers. Therefore, this piece of work tries to establish that forest disturbances brought by human activities or processes affect vegetation, which in turn influence nutrients biogeochemistry through variation in the quantity and chemistry of plant litter [52]. The processes of nutrients depletion begin with impacts of disturbances on litter accumulation, thus lowering the capacity of forest ecosystems to slow soil erosion and mineral nutrients leaching (the most factors for soluble nutrients loss in the tropics) [47,50].

Activities that cause land cover change for example those associated with deforestation cause soluble bases depletion and extinction of some plant species in the tropics hence limiting the development of forest ecosystems [53,54]. Because of the roles played by soluble bases in controlling soil acidity and plant community welfare, an understanding about soluble elements quantities and variation is crucial in forest management [55].

3.1.2 Variations of soluble bases across land uses

The tested hypotheses in this chapter shows that there is significant variation of soluble bases, cation exchanges capacity and base saturation across forests sites subjected into different management practices (Tables 1, 2 3 and 4). This variation supports the findings by other researchers that spatial nutrients variations are contributed by land use management options [56]. From the findings and reviewed literature, we establish that soluble bases vary because of different land uses and management supporting the documentation by [57].

Across the study sites, agriculture and grazed sites have lost soluble bases, the conditions, which in this work is associated with loss of vegetation (Lehmann et al. 2003). The effects of land use and management systems on soil fertility and chemical properties presented in this chapter is in agreement with some observations made by [45] and [56]. The evidence that intact soil sites harbor higher bases than disturbed sites has been clearly observed in Ca, Mg and CEC where by these bases and CEC were high in CFS than in ADS and DGS unlike the K, Na and BS.

The variation shows that disturbances affect soluble bases differently across land uses. The significant differences of Ca and Mg in CFS and, DGS and ADS is a good indicator of impacts of disturbances on these two major soluble bases in the tropical coastal forests. The interpretation is that Ca and Mg highly get lost in disturbed than in the intact sites [51].

Low amount of Ca and Mg in ADS than in DGS shows that converting land into crop- land and grazing land use makes soil vulnerable to soil erosion and leaching and uptakes by crops [54,58,59]. Low amount of Ca and Mg in ADS and DGS partially shows that human activities in these land uses disturb nutrients through conversion of forests into other land uses. Indeed, [49], support low quantities of soluble bases in disturbed soils by indicating that soluble bases in disturbed (cropped and grazed sites) have declined. The loss is contributed by vegetation loss, whereby loss of vegetation influences soil chemical properties by manipulating the distribution and concentrations of soluble bases unlike in the intact forest sites where trees and other vegetation contribute to increase exchangeable bases in the soils [52,45].

This chapter establishes that low base elements in disturbed sites is partially explained by loss of vegetation or the removal of soil elements from the soil by crop harvests or livestock grazing and leaching [59]. A combination of these three factors (i.e. clearing vegetation, crop harvests and grazing) affects the status of nutrients in the coastal forests; in turn, these factors affect forests ecosystems because of the interdependence between above and below ground forests ecosystem components. For example, variations of Ca, Mg, K and Na between CFS and the disturbed sites indicate that conversion of forests in other land uses results into release of nutrients locked in vegetation mainly in the form of woody [49].

The wooden locked nutrients are released into soils and animals where they are temporarily stored before getting lost [51]. Therefore, crop-agriculture and grazing disturb vegetation and litter hence soil nutrients in the tropics. Higher quantity of soluble bases in intact sites is a good indicator that undisturbed sites maintain nutrients circulation than the disturbed ones agreeing the findings of [60].

Indeed, the variation across soluble bases in response to disturbances shows that nutrients loss is not uniform throughout all soluble bases. For example, across the study sites, K and Na were low in all land uses compared to Ca and Mg. Low K and Na is the condition reported in the tropical forests because of the origin of the soils, high rainfall and high temperatures effects [61]. These environmental factors when combined with crop-agriculture and livestock grazing pressure affect more K and Na in the tropics than other soluble bases [61]. It shows that human activities accelerate the loss of K in the tropics, in turn low K affects carbohydrate and protein formation in forests trees [62]. In this view, human activities cause K deficiency in forest ecosystems partly threatening the productivity of these forests [63,62].

Calcium had higher correlation with almost all other soluble especially in CFS. This correlation indicates that intact forest sites have the capacity to retain nutrients than disturbed sites in agreement with [51]. Soluble bases such as Ca and Mg showed a positive and strong correlation across all the land uses except in ADS. The negatively correlated Ca and Mg in ADS is in line with [55].

The interplays of nutrients because of disturbances is used to indicate that certain activities accelerated loss of some nutrients. For example, the negative correlation of Ca and Mg in ADS than in any other land uses is useful to show that there are more declines in Mg than Ca in the disturbed forests sites supporting the findings in [47]. The main reason for high loss of Mg than Ca is that, the former base is vulnerable to leaching than the latter in disturbed sites [64]. Because crop-agriculture and livestock grazing contribute to disturb forests sites by affecting vegetation and accelerating soil erosion and leaching, it is recognized that crop agriculture and livestock grazing contribute to loss of Mg than Ca through leaching [52,55]. The positive and negative correlation findings on soluble bases in the intact forests and disturbed sites are also reported in [65]. Therefore, there is no uniformity in nutrients trends and dynamics other than variation across forests sites when exposed to different land use.

Table 1. Soluble bases variation across land uses

LU	Ca		Mg		K		Na	
	mean	*p*	mean	*p*	mean	*p*	mean	*p*
CFS vs. ADS	3.75 ± 0.99	<.001	0.80 ± 0.17	<.001	0.03 ± 0.06	<.680	0.01 ± 0.01	<.240
CFS vs. DGS	3.11 ± 1.07	<.001	5.87 ± 0.42	<.001	0.55 ± 0.09	<.001	0.31 ± 0.04	<.001
ADS vs. DGS	0.63 ± 0.58	<.280	6.67 ± 0.39	<.001	0.52 ± 0.09	<.001	0.31 ± 0.04	<.001

Where: p = p-value

Table 2. The variation of CEC and BS across CFS, ADS and DGS

Land use	CEC		BS	
	mean	p-value	Mean	p-value
CFS vs. ADS	2.61 ± 0.84	< .030	10.29± 3.74	< .010
CFS vs. DGS	13.74 ± 1.59	< .001	5.86 ± 2.67	< .030
ADS vs. DGS	16.36 ± 2.19	< .001	36.03± 5.26	< .400

Table 3. Paired soluble bases correlation between across land uses

LU	Ca		Mg		K		Na	
	r	*p*-value	r	*p*	r	*p*	r	*p*
CFS vs. ADS	0.373	<.010	0.135	<.365	0.247	<.094	0.042	<.780
CFS vs. DGS	0.074	<.623	0.320	<.028	0.074	<.622	0.421	<.003
ADS vs. DGS	0.288	<.050	0.463	<.001	0.051	<.734	0.075	<.616

Where: r = Correlation value, p = p-value

Table 4. Paired sample correlation of CEC and BS across land uses

LU	CEC		BS	
	r	*p*	r	*p*
CFS vs. ADS	0.279	<.058	0.538	<.000
CFS vs. DGS	0.079	<.596	0.082	<.584
ADS vs. DGS	0.613	<.000	0.263	<.001

Where: r = Correlation value, p = p-value

3.1.3 Soluble bases, CEC and BS vs. elevation levels

Soil fertility varies with elevation variations. The variation is real as indicated by differences on levels of Mg in ADS, Ca, in ADS, CEC in ADS, and Na in CFS and BS in DGS (see Table 5). These variations show that Mg and Ca were low at high elevation (350 to 600m) across the study area meaning that agricultural activities that were carried out at high elevations posed some potential risk for soluble bases depletion [55]. The low variations of nutrients in CFS against elevation could be associated with less leaching on nutrients in the CFS across different elevations. The variation of nutrients in DGS against elevation compared to other land uses shows non-significant values. This little variation partially explains that, grazed land contains some vegetation especially woods, which contribute to recycle soil nutrients, and partially returning the nutrients through animal feces [66,67,49].

Although DGS had less variation of nutrients across the elevation, it is established that low nutrients availability at high elevation (350 to 600 m) contributed to limit vegetation growth, which upon grazing pressure it resulted into loss of soil nutrients more than the lower bottoms. This limited supply of nutrients in-turn promotes nutrients insufficiency for wood production and thus livestock grazing continues to be among the factors affecting soluble bases in tropical coastal forests [54,57].

Table 5. Correlation of Ca, Mg, K, Na, CEC and BS with elevation

LU and Elevation	Ca		Mg		K		Na		CEC		BS	
	r	*p*	r	*p*	r	*p*	r	*p*	R	*p*	r	*p*
Elevation and CFS	1	0.250	0.04	0.794	0.09	0.539	0.14	0.365	0.08	0.615	0.05	0.750
Elevation and ADS	0.18	0.222	0.25	0.095	0.02	0.987	0.08	0.589	0.15	0.329	0.01	0.972
Elevation and DGS	0.04	0.775	0.03	0.863	0.02	0.890	0.03	0.851	0.05	0.727	0.12	0.418

Where: r = Correlation value, p = p-value

3.1.4 Soluble bases CEC, BS and UFR sustainability

Although in this chapter we lacked baseline quantities of soluble bases, CEC and BS to make a comparison of whether the variation and quantities are sufficient or not to sustain UFR, still the current variation used to establish soluble bases in the coastal forests. The available data on Ca and Mg, CEC and BS are useful in predicating sustainability of coastal forests relationships because these factors largely control forest ecosystems by affecting the distribution of plants in forests [55]. Higher amount of Ca and Mg (for example) in CFS is a good indication that the uptake and recycling of these nutrients by trees and other vegetation is not in excess than the amount lost by leaching in disturbed soils [55]. Again, high amount of Ca and Mg in CFS is a good indicator that CFS health is promising because these two soluble bases are important in natural sustainability of forest ecosystems.

In order that coastal forests maintain the forest capacity to retain nutrients, protecting the remnant of these forests and recovering disturbed sites is an important worldwide approach [68,24,8]. It is essential to implement the common strategies used locally and globally for examples applying approaches such as excluding human settlements, crop-agriculture, and livestock grazing [69,70,71,72]. These efforts aim to allow the regeneration of trees and other vegetation to return soil nutrients since tropical forests have a pronounced power of self-maintenance through regeneration [73].

It is important to protect vegetation in intact forests sites and restore disturbed sites to rejuvenate the lost nutrients and prevent further degradation of forests ecosystems. Protection and restoration must aim in improving the amount of soluble bases because these elements largely govern soil acidity and, consequently plant species composition [55]. Improvement on the composition of species in turn affects forest soils nutrients [55]. Protection and restoration efforts might contribute into providing the function of reducing runoff, soil and nutrient loss and improvement of nutrients circulation in coastal tropical forests [65]. Improvements on forest ecosystems should not necessarily need addition of base elements, rather it can be done by avoiding further disturbances, protecting the intact sites and restoring disturbed sites by taking the advantage of natural forest capacities to recycle nutrients [73].

4. CONCLUSIONS

The chapter concludes by showing that there is significant spatial chemical attributes variation of calcium, magnesium potassium as well as sodium, cation exchange capacity and base saturation across closed forest, crop agriculture and livestock grazing disturbances. These elements were significantly different among sites. From chemical variations of soluble bases as representative of soil chemical properties, it shows that disturbed forest sites have low nutrients than undisturbed sites. These variations indicate that soils in the disturbed sites at high elevation ranging between 350 to 600m are well conserved for essential nutrients to maximize forest vegetation growth and development along the ecological gradients. Some variations are recorded and expected to change because the effects of disturbances can be short or long-term occurring over decades or centuries. The variation across forest sites shows that forest disturbances affects an integral relationship between vegetation and soils. This relationship is vital because soil gives vital support such as provision of moisture, nutrient and anchorage to vegetation while vegetation provides protective cover and nutrient maintenance. Certainly, the chapter shows that disturbances can eliminate some species and species composition while some disturbances bring changes in succession pathways, which are beneficial to maintain energy flow, nutrient cycling, species, genetic and structural diversity. Therefore, it is suggested that further studies should be carried out to identify soils, correlation of soil elements in the tropics in different land uses. These studies should aim to establish a trend of nutrients at risk because of human activities mainly crop-agriculture and livestock grazing, and suggest possible remedies for sustainable coastal forests across different regions and landscapes in Tanzania and elsewhere globally.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kebede AS, Brown S, Nicholls RJ. Synthesis Report : The implications of climate change and sea-level rise in Tanzania − The coastal zones. Global Climate Adaptation Partnership (GCAP), (No," Kebede, A. S., Brown, S. Nicholls, R. J.). 2010;32.
   Available:http://economics-of-cc-in tanzania.org/images/Tanzania_Synthesis-Report Dar es Salaam
2. Attiwill PM. The disturbance of forest ecosystems: The ecological basis for conservative management. For. Ecol. Manage. 1994;63(2–3):247–300.
3. Anyanwu JC, Egbuche CT, Amaku GE, Duruora JO, Onwuagba SM. The impact of deforestation on soil conditions in Anambra State of Nigeria. Agriculture, Forestry and Fisheries. Special Issue: Environ. Appl. Sci. Manag. a Chang. Glob. Clim. 2015;4(3–1):64–69.
4. Elliott KJ, Harper CA, Collins B. Herbaceous response to type and severity of disturbance. In Sustaining Young Forest Communities, Managing Forest Ecosystems 21, C. H. Greenberg, Ed. Otto, NC, USA: Springer Science+Business Media B.V. 2011;97–119.
5. Ligate EJ, Wu S, Chen C. The status of forest ecosystem services and their management : The case of Uzigua forest reserve in Tanzanian coastal forests. Nat. Resour. Conserv. 2017;5(2):21–32.
6. Runsten L, et al. Using spatial information to support decisions on safeguards and multiple benefits for REDD+ in Tanzania. Dar es Salaam, Tanzania. 2013;1-9.
7. FAO. FRA-Global Forest Resources Assessment 2015. Desk reference, Rome, Italy; 2015.
8. World Bank. Managing coasts with natural solutions. Washington, DC; 2016.
9. Ayers MP, Lombardero MJ. Assessing the consequences of global change for forest disturbance from herbivores and pathogens. Sci. Total Environ. 2000;262:263–286.
10. Franklin JF, et al. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. For. Ecol. Manage. 2002;155(1–3):399–423.
11. Wallander RT, Olson BE, Lacey JR. Spotted knapweed seed viability after passing through sheep and mule deer. J. Range Manag. 1995;48:145–149.
12. Belsky AJ, Gelbard JL. Livestock grazing and weed invasions in the Arid West. Bend (OR): Oregon Natural Desert Association. Oregon Nat. Desert Assoc. 2000;31.
13. Dormaar WD, Willms JF. Effect of forty-four years of grazing on fescue grassland soils. Journal of Range Management. 1998;52:122–126.
14. Belnap J, Gillette DA. Vulnerability of desert biological soil crusts to wind erosion: The influences of crust development, soil texture, and disturbance. J. Arid Environ. 1998;39:133–142.
15. Holland EA, Parton WJ, Detling JK, Coppock DL. Physiological responses of plant populations to herbivory and other consequences of ecosystem nutrient flow. Am. Nat. 1992;140:685–706.
16. Hubbard RK, Newton GL, Mill G. Water quality and the grazing animal. J. Anim. Sci. 2004;82: 255–263.
17. Howell KM, et al. Biodiversity surveys of poorly known coastal forests of Southeastern Tanzania and Zanzibar. Dar es Salaam, Tanzania; 2012.

18. Devi SL, Yadava PS. Floristic diversity assessment and vegetation analysis of tropical semievergreen forest of Manipur, North East India. Trop. Ecol. 2006;47(1):89–98.
19. Mligo C, Lyaruu H, Ndangalasi H. Vegetation community structure, composition and distribution pattern in the Zaraninge Forest. J. East African Nat. Hist. 2009;98(2):223–239.
20. Kimaro J, Lulandala L. Forest cover and land use change in Ngumburuni. J. Environ. Ecol. 2013;4(2):113–125.
21. United Republic of Tanzania (URT). National forest resources monitoring and assessment of Tanzania 2015. Dar es Salaam, Tanzania; 2015.
22. Godoy FL, Tabor K, Burgess ND, Mbilinyi BP, Kashaigili JJ, Steininger MK. Deforestation and CO2 emissions in coastal Tanzania from 1990 to 2007. Environ. Conserv. 2012;39(01):62–71.
23. IUCN. IUCN-Red List Categories and Criteria: Second Edi. Gland, Switzerland and Cambridge, UK; 2012.
24. Mligo C. Conservation of plant biodiversity of Namatimbili forest in the southern coastal forests of Tanzania. Int. J. Biodivers. Conserv. 2015;7(3):148–172.
25. URT. Tanzania in Figures, Dar es Salaam, Tanzania; 2016.
26. Silayo AM, Tarimo DA, Kweka MCT, Muganda ARE. Impacts of human induced activities on species composition and diversity in Miombo woodlands of Bagamoyo district, Tanzania. J. Korean Assoc. African Stud. 2006;2:223–243.
27. Guerrero PC, Bustamante RO. Can native tree species regenerate in *Pinus radiata* plantations in Chile? Evidence from field and laboratory experiments. For. Ecol. Manage. 2007;253(1–3): 97–102.
28. Halter R. The use versus availability of wood extraction at the Baga II Forest Reserve Border Adjacent to Kizanda Village in the West Usambara Mountains, Tanzania. Independent Study Project (ISP) Collection. Paper 2350. Independent Study Project (ISP) Collection. 2016;25.
29. Bonari G, Acosta ATR, Angiolini C. Mediterranean coastal pine forest stands: Understorey distinctiveness or not? Forest Ecology and Management. 2017;391:19–28.
30. Tomppo E, et al. Article A sampling design for a large area forest inventory: Case Tanzania. Can. J. For. Res. 2014;18:931–948.
31. Rogan J, Miller J. Integrating GIS and remotely sensed data for mapping forest disturbance and change. Underst. For. Disturb. Spat. Pattern Remote Sens. GIS Approaches. 2006;133–170.
32. Fleischner TL. Ecological costs of livestock grazing in Western North America. Conservation Biology. 1994;8:629–644.
33. Bargali K, Bisht P, Khan A, Rawat YS. Diversity and regeneration status of tree species at Nainital Catchment, Uttarakhand, India. Int. J. Biodivers. Conserv. 2013;5:270–280.
34. Van Der Werf GR, et al. Global fire emissions and the contribution of deforestation, savanna, forest, agricultural, and peat fires (1997-2009). Atmos. Chem. Phys. 2010;10(23):11707–11735.
35. Defries R, et al. From plot to landscape scale: Linking tropical biodiversity measurements across spatial scales. Front. Ecol. Environ. 2010;8(3):153–160.
36. Majumdar K, Datta BK. Vegetation types, dominant compostion, wood plant diversity and stand structure in Trishna Wildlife Sancuary of Nothereast India. J. Environ. Biol. 2014;36:409–418.
37. Keenan RJ, Reams GA, Achard F, de Freitas JV, Grainger A, Lindquist E. Forest ecology and management dynamics of global forest area: Results from the FAO global forest resources assessment. For. Ecol. Manage. 2015;352:9–20.
38. Thompson I, Mackey B, McNulty S, Mosseler A. Forest resilience, biodiversity, and climate change; A synthesis of the biodiversity/resilience/stability relationship in forest ecosystems. Secretariat of the Convention on Biological Diversity, Montreal, Technical Series no. 43; 2009.
39. Joyi O, Utanga MM, Dindi OO, Ynekulu JA, Ahman EB. The effect of forest fragmentation on tree species abundance and diversity in the Eastern Arc Mountains of Tanzania. Appl. Ecol. Environ. Res. 2015;13(2):.
40. Kalaba FK, Quinn CH, Dougill AJ. Carbon storage, biodiversity & species composition of Miombo woodlands in recovery trajectory after charcoal production and slash & burn agriculture in Zambia’s Copperbelt. SRI Pap. No.40, Cent. Clim. Chang. Econ. Policy Work. Pap. No.119. 2012;1–39.
41. Kijazi M, Lusambo L, Matura S, Seki H. Green economy in biosphere reserves; Biodiversity Survey In East Usambara Biosphere Reserve Tanga Region, Tanzania. Dar es Salaam, Tanzania; 2014.

42. Laiho R, Penttilä T, Lainest J. Variation in soil nutrient concentrations and bulk density within Peatland. Silva Fenn. 2004;38(1):29–41.
43. Pulla S, Riotte J, Suresh HS, Dattaraja HS, Sukumar R. Controls of soil spatial variability in a dry tropical forest. PLoS One. 2016;11(4):1–20.
44. Sarmadian F, Keshavarzi A, Malekian A. Continuous mapping of topsoil calcium carbonate using geostatistical techniques in a semi-arid region. Aust. J. Crop Sci. 2010;4(8):603–608.
45. Pal S, Panwar P, Bhardwaj DR. Soil quality under forest compared to other land-uses in acid soil of North Western Himalaya, India. Ann. For. Res. 2013;56(1):187–198.
46. Yavitt JB, Harms KE, Garcia MN, Wright SJ, He F, Mirabello MJ. Spatial heterogeneity of soil chemical properties in a lowland tropical moist forest, Panama. Aust. J. Soil Res. 2009;674–687.
47. Johnson DW, Miller WW, Susfalk RB, Murphy JD, Dahlgren RA, Glass DW. Forest ecology and management biogeochemical cycling in forest soils of the eastern Sierra Nevada Mountains, USA. 2009;258:2249–2260.
48. Dalling JW, Heineman K, Lopez OR, Wright SJ, Turner BL. Nutrient availability in tropical rain forests: The paradigm of phosphorus limitation. 2016;261–273.
49. Heineman KD, Turner BL, Heineman KD, Turner BL, Dalling JW. Variation in wood nutrients along a tropical soil fertility gradient variation in wood nutrients along a tropical soil fertility gradient. New Phytol.; 2016.
50. Kaspari M, Yanoviak SP. Biogeography of litter depth in tropical forests: Evaluating the phosphorus growth rate hypothesis. Funct. Ecol. 2008;22(1996):919–923.
51. Moreira A, Fageria NK. Soil chemical attributes of Amazonas State, Brazil. Commun. Soil Sci. Plant Anal. 2009;40:2912–2925.
52. Hobbie SE, Eissenstat DM, Chadwick OA, Hale CM, Mark G. Linking litter calcium, earthworms and soil properties: A common garden test with 14 tree species. Ecol. Lett. 2005;8:811–818.
53. Kirby KR, Potvin C. Variation in carbon storage among tree species: Implications for the management of a small-scale carbon sink project. For. Ecol. Manag. 2007;246(2):208–221.
54. Vourlitis GL, Lobo FDA. Low soil nutrient availability can limit tree growth and forest expansion into savanna because nutrient availabil- ity may be insufficient for wood production. Plant Soil. 2015;389:307–321.
55. Kabrick JM, Goyne KW. Landscape determinants of exchangeable calcium and magnesium in Ozark highland forest soils. Soil Sci. Soc. Am. J. 2011;75(1):164–180.
56. Xia S, Chen J, Schaefer D, Detto M. Scale-dependent soil macronutrient heterogeneity reveals effects of litterfall in a tropical rainforest. Plant Soil; 2015.
57. Yeshaneh GT. Assessment of soil fertility variation in different land uses and management practices in Maybar watershed. Int. J. Environ. Bioremediation Biodegrad. 2015;3(1):15–22.
58. Johnson DW, Todd DE, Trettin CF, Mulholland PJ. Decadal changes in potassium, calcium, and magnesium in a deciduous forest soil. Soil Sci. Soc. Am. J. 2008;72:1795–1805.
59. Page BD, Mitchell MJ. Influences of a calcium gradient on soil inorganic nitrogen in the Adirondack Mountains, New York. Ecol. Appl. 2008;18(7):1604–1614.
60. Quesada CA, et al. Basin-wide variations in Amazon forest structure and function are mediated by both soils and climate. 2012;2203–2246.
61. Yawson DO, Kwakye PK, Armah FA, Frimpong KA. The dynamics of potassium (K) in representative soil series of Ghana. ARPN J. Agric. Biol. Sci. 2011;6(1):48–55.
62. Blanchet G, et al. Spatial variability of potassium in agricultural soils of the canton of Fribourg, Switzerland. Geoderma. 2017;290:107–121.
63. Gairola S, Sharma CM, Ghildiyal SK, Suyal S. Chemical properties of soils in relation to forest composition in moist temperate valley slopes of Garhwal Himalaya, India. Environmentalist. 2012;32(4):512–523.
64. Sun X, et al. Correlated biogeographic variation of magnesium across Trophic levels in a terrestrial food chain. PLoS One. 2013;8(11):8.
65. Kizza CL, et al. Soil and nutrient losses along the chronosequential forest recovery gradient in Mabira Forest Reserve, Uganda. African J. Agric. Res. 2013;8(1):77–85.
66. Lehmann J, Pereira J, Steiner C, Nehls T, Zech W, Glaser B. Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: Fertilizer, manure and charcoal amendments. Plant Soil. 2003;343–357.

67. Khan ZI, Hussain A, Ashraf M, Mcdowell LR. Mineral status of soils and forages in Southwestern Punjab-Pakistan: Micro-minerals. Asian-Aust. J. Anim. Sci. 2006;19(8):1139–1147.
68. Potter C. Global assessment of damage to coastal ecosystem vegetation from tropical storms. Remote Sens. Lett. 2014;5(4):315–322.
69. Redford KH, Fearn E. Protected areas and human displacement: A conservation perspective. Working Paper No. 29, Wildlife Conservation Society, NY. 2007;29:152.
70. Navroodi IH. Effects of livestock exclusion on forest tree regeneration (Case study: Ramsar district 1 – Iran). J. For. Sci. 2015;61(1):1–6.
71. Tadesse G, Zavaleta E, Shennan C, FitzSimmons M. Prospects for forest-based ecosystem services in forest-coffee mosaics as forest loss continues in southwestern Ethiopia. Appl. Geogr. 2014;50:144–151.
72. Schieltz JM, Daniel IR. Evidence based review: Positive versus negative effects of livestock grazing on wildlife. What Do we Really Know? Environ. Res. Lett. IOP Publ. 2016;11(11):1–8.
73. Sundarapandian S, Swamy PS. Short-term population dynamics of tree species in tropical forests at Kodayar in the Western Ghats of Tamil Nadu, India. In Proceedings of the International Academy of Ecology and Environmental Sciences. 2013;3(3):191–207.

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